NIST NCSTAR 1-1A
Federal Building and Fire Safety Investigation of the World Trade Center Disaster

Design and Construction of Structural Systems

(Appendices A-G)

David A. Fanella
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NIST National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce

Appendix A
SUPPORTING DOCUMENTS FOR CHAPTER 2

This appendix contains the supporting documents that are referenced in Chapter 2 of this report. All of the documents contained in this appendix are reproduced with permission of The Port Authority of New York and New Jersey. Table A–1 contains a summary of supporting documents and their location within this appendix. The footnote numbers given in the table correspond to those in Chapter 2.

Table A–1. Supporting documents for Chapter 2.

Footnote Number	Document Title	Page(s)
Section 2.1 – Building Codes Used In Design		
1	Letter dated May 15, 1963 from Malcolm P. Levy (Chief, Planning Division, World Trade Department) to Minoru Yamasaki (Minoru Yamasaki & Associates)	132
2	Letter dated February 18, 1975 from Joseph H. Solomon (Emery Roth & Sons) to Malcolm P. Levy (Chief, Planning Division, World Trade Department)	133
3	Letter dated September 29, 1965 from Malcolm P. Levy (Chief, Planning Division, World Trade Department) to Minoru Yamasaki (Minoru Yamasaki & Associates)	136

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THE PORT OF NEW YORK AUTHORITY

111 Eighth Avenue at 15th Street New York 11 N.Y.

ALGONQUIN 5-1000

WORLD TRADE CENTER

Malcolm P. Levy
CHIEF, PLANNING DIVISION

Richard C. Sullivan
DIRECTOR

May 15, 1963

Mr. Minoru Yamasaki
Minoru Yamasaki & Associates
1025 East Maple Road
Birmingham, Michigan

Dear Yama:

At a recent meeting with Mr. John Kyle, Chief Engineer, the subject of New York City Code compliance was further amended as follows:

"All consulting engineers and architects working on the World Trade Center have been instructed to comply with the Code in preparing their designs. Questions have arisen, however, in areas where the Code is not explicit. It was agreed that in such cases and, where technological advances make portions of the Code obsolete, the consultants may propose designs based on acceptable engineering practice. All such instances will be called to the attention of The World Trade Center Planning Division. When preliminary designs have been completed, the Chief Engineer will review all design concepts with the appropriate municipal agencies before the consultants proceed with the final design".

Sincerely,

Malcolm P. Levy
Chief, Planning Division

LF:db
cc: Mr. J. Roth (ERS)

(2.1)

EMERY ROTH & SONS
850 THIRD AVENUE, NEW YORK, N. Y 10022 (212) 753-1733

RICHARD ROTH, Sr., F. A. I. A.
HARRY J. HARMAN, A. I. A
RICHARD ROTH, Jr., A. I. A., R. I. B. A.
JOSEPH H. SOLOMON, A. I. A.

JULIAN ROTH
ADMINISTRATION
ESTELLE BEAL
CONTROLLER
PHILIP MARTINES
CHIEF DRAFTSMAN

February 18, 1975

Mr. Malcolm P. Levy
General Manager
World Trade Center Operations
Port Authority New York, New Jersey
1 World Trade Center
New York, New York 10047

RE: WORLD TRADE CENTER

Dear Mal:

In accordance with the instructions issued by the Port Authority at the start of the project, construction drawings for the World Trade Center were to conform with requirements of the Building Code of New York City, and any variations therefrom were to be called to the attention of the Port Authority for final decision and authorization. This procedure has been followed in production of the contract drawings and, with the exceptions authorized by the Port Authority noted below, the drawings are in accordance with the new Building Code adopted in December, 1968. The Building Department reviewed the tower drawings in 1968 and made six comments concerning the plans in relation to the old code. Specific answers noting how the drawings conformed to the new code with regard to these points were submitted to the Port Authority on March 21, 1968.

We were instructed by the Port Authority to deviate from code with respect to the following areas:

1. Omission of vents from closed shafts. Noted to the Port Authority by letter dated April 20, 1967.

2. Demising partitions to stop at suspended ceiling or bottom of truss instead of running from slab to slab. Noted to the Port Authority by letters dated November 9, 1967 and June 6, 1969 with response on December 12, 1967. Prior instruction on procedure from Port Authority dated January 26, 1966.

SENIOR ASSOCIATES: VICTOR GORLACH · FRED HALDEN · BERNARD KESSLER, A. I. A. · PHILIP ZINN, A. I. A.
ASSOCIATES: DOUGLAS FERNANDEZ · BEN GLADSTEIN · ROBERT S. GOLDBERG, R. A. · ARTHUR O. HECHT · JOHN LEOTTA
JOSEPH LoSCHIAVO, JR. · JOHN H. MILLER · SAL ORLANDO · VICTOR C. SCALLO, A. I. A. · JOHN J. SECRETI, JR.

3. Omission of fire protected openings on exterior walls with separation of less than 30 feet. Noted to Port Authority by copy of letter to MYA dated January 26, 1966.

4. Treatment of concourse level as "Underground Street" noted by letter to the Port Authority on April 6, 1971, January 11, 1972 and May 7, 1973.

Fire detection and protection requirements specified for the World Trade Center meet or exceed Building Code requirements prior to the adoption of Local Law #5. Most other office towers in the City of New York meet the minimum code requirements:

A. Telephone system for Fire Department use connecting pump room and gravity tank room with all floors. A six inch gong provided at permanent telephone at pump room, first floor and gravity tank room. Telephone jacks at all other floors protected by break glass boxes.

B. Standpipe signalling device: an eight inch gong located in the pump room and every 10 floors in the elevator shaft; an approved closed circuit strap key enclosed in a sheet metal box at each telephone station for fire department use.

The Building Code permits the use of louvered doors on toilet rooms, janitor and electric closets located in 1 hour rated corridors. There is no size limit specified for the louver, but the Board of Standards and Appeals permits louvers of 2 square feet in 3/4 hour rated doors (which are required in 1 hour rated partitions). Up until about 1968 most office buildings had 1 hour minimum rated enclosures and louvered doors in telephone closets and sleeves or small slots through the floor. Since 1968, about 25 percent still have louvers in the doors. In more recent buildings the floor openings have been slabbed over.

Since corridor construction is required by code to be 1 hour rated, it follows that louvered doors were acceptable in tele-

EMERY ROTH & SONS -3- February 1[illegible] 1975

phone closets. Corridor partitions in the Trade Center Towers, however, were designed to meet 2 hour rated construction at the request of the Port Authority, to forestall any problems with dead end limitations in the new code. It would require investigation of individual floor tenant layouts to determine if the dead end limitation of 50 feet for 1 hour construction has been exceeded.

The original contract drawings, dated 7/31/67 and the Contract Bid Sets dated 12/18/67 and 2/9/68 indicate 2 hour rated enclosures for the telephone closets with louvers in a FPSC, 1-1/2 hour label door. The hollow metal door specification written in 1967 and received by the Port Authority on 10/24/67 called for fusible link dampers on louvers in labeled doors. Letters to the Port Authority dated 8/23/67 and 9/6/67 in-cated that variances had been obtained for omission of dampers and requested instruction regarding this advice. The requirement for dampers was deleted from the final draft of the specification reviewed by the P.A. in May, 1968. Re quirement to meet provisions of underwriter's labs, B.S.A. and Building Department was retained, however, for doors with F.P.S.C. and hourly ratings.

Based on Port Authority comments on drawings received 4/17/69 and pursuant to a letter from the Port Authority to Tishman Construction Company dated 4/28/69 instructing that such changes be made, the wall of the telephone closet was changed to 1 hour rated construction on 5/23/69 and the door was changed to F.P. with a 1-1/2 hour rating. Since the telephone closet was no longer a shaft with a 2 hour rated enclosure, all floor openings left for future installation of cables had to be firestopped. This admonition was reiterated in a letter to the Port Authority dated June 25, 1973.

Please inform us if any additional information is desired.

Sincerely,

EMERY ROTH & SONS

Joseph H. Solomon

JOSEPH H. SOLOMON

JHS:am

CC: Mr.R. Monti, Chief Engineer/ PA

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R 110-4

THE PORT OF NEW YORK AUTHORITY

111 Eighth Avenue at 15th Street New York NY 10011 cc R.40-1

620.8233

WORLD TRADE CENTER

Malcolm P. Levy
CHIEF, PLANNING DIVISION

Richard C. Sullivan
DIRECTOR

September 29, 1965

Mr. Minoru Yamasaki
Minoru Yamasaki & Associates
1025 East Maple Road
Birmingham, Michigan 48011

Dear Yama:

We have decided to adopt the new Building Code presently existing in second and third draft form for The World Trade Center.

The Roth office is requested to revise floor plans as quickly as possible and on an accelerated basis to comply with the provisions of this code. It is my understanding that the present drawings have been prepared to permit rapid conversion to the new code. Generally the tower core should be redesigned to eliminate the fire towers and to take advantage of the more lenient provisions regarding exit stairs. No other major change to the core should be undertaken without review by this office.

The structural consultants are instructed, by copy of this letter, to revise structural design in accordance with the more realistic criteria for partition weight allowance. The majority of interior partitions, as noted in a previous letter, will consist of reinforced gypsum plank.

The Roth office is requested to provide me with the dates on which we can expect revised floor plans and also to indicate any changes in design schedule caused by these instructions.

Sincerely,

Malcolm P. Levy

cc: R. Baum (JBB), J. Loring (JRLA), J. Roth (ERS), J. Skilling and L. Robertson (WSHJ)

Similar letter sent to Mr. Julian Roth (ERS)

Appendix B
SUPPORTING DOCUMENTS FOR CHAPTER 3

This appendix contains the supporting documents that are referenced in Chapter 3 of this report. All of the documents (with the exception of the Laclede Steel Company correspondence) contained in this appendix are reproduced with permission of The Port Authority of New York and New Jersey. Table B–1 contains a summary of supporting documents and their location within this appendix. The footnote numbers given in the table correspond to those in Chapter 3.

Table B–1. Supporting documents for Chapter 3.

Footnote Number	Document Title	Page(s)
	Section 3.3 – Damping Unit Tests	
2	Letter dated June 22, 1967 and enclosure from Don Caldwell of 3M to Peter Chen of SHCR (WTCI-501-L; reproduced without appendices that are contained in WTCI-501-L)	139
3	"Test Program for World Trade Center Viscoelastic Damping Units," by Stephen H. Crandall of MIT, May 20, 1968 (WTCI-501-L)	146
4	"Test of Viscoelastic Damping Units for World Trade Center Tower Buildings," S.H. Crandall and L.E. Wittig, April 23, 1969 (Box 9, 233 Park Ave.)	158
5	Letter dated August 29, 1968 from Leslie E. Robertson of SHCR to Malcolm P. Levy of PONYA (WTCI-501-L)	179
6	Letter dated May 22, 1969 from Leslie E. Robertson of SHCR to Malcolm P. Levy of PONYA (WTCI-501-L)	182
7	Letter dated June 2, 1969 from Stephan H. Crandall of MIT to John M. Kyle of PONYA (WTCI-501-L)	185
8	"World Trade Center Report No. DU-3, Viscoelastic Damping Units," by SHCR, June 2, 1969 (WTCI-501-L: reproduced without appendices that are contained in WTCI-501-L)	189
9	Letter dated November 5, 1971 from Malcolm P. Levy of PONYA to Don Caldwell of 3M (WTCI-513-L)	196
	Section 3.4 – Floor Truss Tests	
10	Letter dated April 3, 1969 from David B. Neptune of the Laclede Steel Company to W.C. Borland of PONYA (WTCI-503-L)	197
11	Internal Laclede Steel Company memo dated May 15, 1969 from David B. Neptune to R.D. Bay (part of WTCI-82-I)	198
12	Internal Laclede Steel Company memo dated September 7, 1967 from J.R. Paul to A.C. Weber (WTCI-85-I)	202
13	Letter dated August 10, 1967 from A. Carl Weber of the Laclede Steel Company to Wayne Brewer of SHCR (WTCI-235-L)	203
14	Letter dated April 19, 1968 from Wayne A. Brewer of SHCR to R.M. Monti of PONYA (WTCI-87-I)	205
15	Internal Laclede Steel Company memo dated March 18, 1969 from David B. Neptune to R.D. Bay (part of WTCI-82-I)	207
	Section 3.5 – Stud Shear Connector Tests	
16	Letter dated November 3, 1969 from James White of SHCR to Lester S. Feld of PONYA (part of WTCI-253-L)	208
17	Contract dated January 6, 1970 from Guy F. Tozzoli of PONYA to Roger G. Slutter of the Fritz Engineering Laboratory, Lehigh University (part of WTCI-253-L)	210

3M COMPANY

GENERAL OFFICES • 2501 HUDSON ROAD • ST. PAUL, MINNESOTA 55119 • TEL. 733-1110

Industrial Tape Division

June 22, 1967

Dr. Peter Chen
Skilling, Helle, Christiansen & Robertson
230 Park Avenue
New York, New York

Dear Peter:

Attached are two copies of a report explaining the results of our tests on full size dampers. I trust these will reach you in adequate time for your study before our meeting next Tuesday, June 27, 1967, in St. Paul.

Very truly yours,

Don

D. B. Caldwell
Project Engineer
Acoustic Products

I. Introduction

Vibrational motion of tall buildings and structures can be damped out by the employment of dampers as non-load carrying elements in the structure.

Most of the dampers are designed so that they convert part of the mechanical energy into heat and thus reduce the amplitude of motion. The medium in which this transfer of energy takes place is generally either a viscoelastic material or liquid.

In this report we discuss only a particular damper employing a viscoelastic material as the damping medium.

II. Damper Shape and Desired Characteristic

In general the damper is comprised of two viscoelastic layers bonded between three rigid surfaces, planar on at least one surface (Figure 1).

The damper will be placed such that the application of the load generates shear deformation in viscoelastic material such as shown in Figure 1.

Due to specific requirements of the World Trade Center, the dampers should meet the following requirements within the temperature range 72-78°F and up to 50% R.H. (see technical specification).

a. Average Stiffness

The damper should have a total average stiffness of at least 12,000 lbs. axial load at the specified frequency of 0.1 C/sec. and at a deflection of 0.02".

b. Average Loss Factor (tan δ)

The average damping factor or loss tangent should be at least 0.6 at 0.1 C/sec.

c. Fatigue

After 100 cycles at 20×10^{-3} amplitude and 0.1 C/sec. G" shall not decrease by more than 20% when the damper temperature has returned to its initial value (first cycle).

d. Ultimate shear strength

The damper, when loaded in shear should be able to withstand 48,000 lbs. of load - this includes both static plus dynamic load.

e. Static and dynamic deformation

Maximum amplitude of vibration i.e. viscoelastic shear deformation will be around 20×10^{-3} inches dynamic and 30×10^{-3} inches static.

In order to fullfill the above mentioned requirements a viscoelastic material with the proper dimension was selected. Figure 1 shows the actual damper with all the dimensions.

III. Test Objective and Procedure

a. Test objective

For the purpose of establishing the effectiveness and the efficiency of dampers the following properties were selected for evaluation.

1. G", loss shear modulus as a function of temperature (T) and fatigue cycle (N).
2. W_1 and W_{100} and W_t, work done in the first and one hundreth cycles and total work done in 100 cycles respectively.
3. Temperature rise accompanying fatigue (100's and 1000 cycles)
4. Loss tangent as a function T and N.
5. G' and G* storage and complex shear modulus as a function of T and N.
6. Total heat production in viscoelastic material.
7. Ultimate shear strength.

b. Test procedure

Tenty-two full size dampers were prepared for testing. For the purpose of monitoring the temperature of viscoelastic material in the damper a thermocouple was imbedded in the center of viscoelastic part as shown in Figure 2.

- Page 3

The shear deformation was detected by an L.V.D.T. which was attached to the damper in such a way that the coil of the L.V.D.T. was rigidly fastened to the stationary part of the damper while the core was clamped to the moving part of the damper, when cyclic load was applied, as shown in Figure 2.

Tests were carried out at two different locations and on two similar closed loop-feed back machines. Four 'ampers were tested at M.T.S. Corporation in Minneapolis and 18 samples were evaluated at Materials Research Laboratory Inc. in Chicago.

The testing environment, as far as temperature and humidity control is concerned, was not ideal.

In general the following test procedures were followed at both laboratories.

The damper was rigidly mounted, between the machine ram and the load cell and the L.V.D.T. was connected through ram control panel to the X axis of an X-Y chart recorder. The output of the load cell was made to drive the Y axis of the chart. By the use of micrometer head (Figure 2) the L.V.D.T. was calibrated so that one inch of chart in the X axis represented .004 inches of shear deformation. Load cell was also calibrated electronically such that one inch of chart was equivalent to 4000 pounds in the case of MTS machine and 5000 pounds for MRL machine.

Temperatures were recorded by the use of two TC's and a two channel recorder in which one channel recorded viscoelastic temperature and the other monitored the environment temperature. An ice bath was used as a temperature reference point.

The machines were set on strain control. Signal from L.V.D.T. was compared to a preassigned signal from function generator which was set on sine function with $20x10^{-3}$ inch maximum amplitude and .1 C/sec frequency.

Before the start of test run the recorder was calibrated and the output of both TC 1 and TC 2 were recorded. Tests were conducted on each damper for 1 to 100 cycles and in one special case a 1000 cycle test was performed. After a 100 cycle test the damper was left to cool down and tested at the initial (first cycle) temperature.

IV. Analysis of Test Results

The results obtained from these tests were in the form of hysteresis loops (H.L.) - force vs. displacement as shown in Figure 3. Assuming that the linear viscoelastic theory is applicable to this case, the relationships between dynamic properties of damper for the case of controlled **sinusoidal** displacement of the form

$$\ell = \ell_0 \operatorname{Sin} \omega t$$

are as follows:

$$\gamma = \gamma_0 \operatorname{Sin} \omega t \qquad 1$$

$$\sigma = \sigma_0 \operatorname{Sin} (\omega t + \delta) \qquad 2$$

$$G'' = \frac{\sigma_0}{\gamma_0} \operatorname{Sin} \delta \qquad 3$$

$$G' = \frac{\sigma_0}{\gamma_0} \operatorname{Cos} \delta \qquad 4$$

$$D = \tan \delta = G''/G' \qquad 5$$

$$G^* = (G'^2 + G''^2)^{1/2} \qquad 6$$

$$W_1 = \pi G'' \gamma_0^2 V \qquad 7$$

where;

ℓ = dicplacement (in.)

ℓ_0 = maximum displacement (in.)

ω = angular velocity (rad/sec)

t = time (sec)

σ = shear stress (psi)

σ_0 = maximum shear stress (psi)

$\gamma = \ell/T$ = shear strain (in./in.) T = thickness of v.e. material (in.)

$\gamma_0 = \ell_0/T$ = maximum shear strain (in./in.)

G', G" and G* = storage, loss and complex shear modulus (psi)

D = tanδ = loss tangent

W_1 = dissipated energy in one cycle (in-lb.)

V = $2A_vT$ = total volume of v.e. material (in^3)

A_v = viscoelastic shear area (in^2)

The areas of H.L.'s were measured by a planimeter and the dissipated energy in one cycle, W_1 was calculated as follows:

$$W_1 = A_p C_1 C_2$$

where

A_p = area of the H.L. (in^2)

C_1 = force scale factor (lbs/in)

C_2 = displacement scale factor (in/in)

knowing the total volume of viscoelastic material V and also the maximum strain γ_o the value of G" can be readily calculated from Equation 7 i.e.

$$G'' = W_1/\pi \gamma_o^2 V$$

By substituting G" in Equation 3 Sinδ and consequently tanδ is calculated i.e.

$$\tan\delta = \frac{G''\gamma_o}{[\sigma_o^2 - (G''\gamma_o)^2]^{1/2}} = \frac{W_1}{[(\pi\gamma_o\sigma_o V)^2 - W_1^2]^{1/2}}$$

also from Equations 5 and 6 we obtain G' and G*.

Ultimate shear strength were measured on a 60,000 lbs. capacity universal testing machine, and during testing load-deflection was recorded.

Calculations were also made in regard to heat generation and subsequent storage and dissipation of heat. Total heat generated was obtained by assuming a linear relationship between dissipated energy W and the number of fatigue cycles, N.

From this linear relationship the total energy dissipated in 100 cycles will be

$$W_{total} = \frac{W_1 + W_{100}}{24} \times 100 \quad \text{ft-lb}$$

and the heat generated Q_t in

$$Q_t = W_{total}/778.2 \text{ BTU}$$

The total heat generated Q_t can be divided into two parts, 1) heat stored in the viscoelastic material, Q_s and 2) heat dissipated through conduction, convection and radiation to other parts of the system, Q_d i.e.

$$Q_t = Q_s + Q_d \qquad 9$$

Since we measured the temperature rise and also know the physical properties such as density and specific heat of the viscoelastic material, Q_s can readily be calculated. The following formulas were used in this analysis.

$$Q_s = M_{ve}C\Delta T \qquad 10$$

$$Q_t - Q_s = Q_d$$

Tables 1 to 4 represent the numerical results and Figures 4 to 7 represent the graphical presentation of these results.

V. Conclusion

Although the number of test runs on full size dampers are insufficient for a precise statistical analysis, nevertheless the following conclusions can be drawn from the results.

G" and consequently energy dissipation per cycle W are inversly proportional to temperature. The relationship seems to be approximately linear. The relationship of temperature rise to fatigue cycle is also, for the first one hundred cycles, approximately linear, but due to the fact that most of the generated heat is dissipated to the environment, it seems that after 400 cycle (see results on 1000 cycle test) a steady state is approached. It is therefore safe to assume that G" or W per cycle remain relatively constant afterwards.

The effect of temperature on loss tangent in this range (70-82°F) seems to be negligible although a slight increase in loss tangent with temperature is noticable (Figure 6).

It should be observed that the temperature in the v.e. material was measured in a transient state and the actual temperature in the v.e. material was possibly slightly higher than those shown, but the difference cannot be more than 1.0° or at most 1.5°F.

Test Program

for

World Trade Center Viscoelastic Damping Units

Proposed by

Stephen H. Crandall

May 20, 1968

2

1. Test Samples

Fifty-two sample damping units shall be fabricated and delivered to the Acoustics and Vibration Laboratory, Room 5-024, M.I.T. These units shall be identical to those which are to be supplied for installation in the World Trade Center towers under Contracts WTC-219.00 and WTC-224.00, except that each test sample shall have one thermocouple embedded in the viscoelastic material. The thermocouple specifications shall be delivered to Professor Crandall.

The test samples shall be numbered according to a random pattern and ten of the units shall be sent to the Port of New York Authority for storage and subsequent testing for aging effects.

2. Test Objectives

The major portion of the test shall be devoted to determining the statistical distribution of the following basic mechanical properties of the damping units:

Loss factor for steady cycling at 0.1 Hz.

Dynamic stiffness for steady cycling at 0.1 Hz.

Ultimate load when deformed at the rate of 0.5 in. per min.

Ultimate displacement when deformed at the rate of 0.5 in. per min.

Thirty samples shall be tested to determine these properties. Before beginning these tests four samples shall be cycled for 10,000 cycles (if failure does not occur earlier) to determine the possibility of fatigue failures for the dampers. If fatigue failures do occur in these four samples, it will be proposed that some of the thirty samples for the basic

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statistical tests be used to obtain additional fatigue information (after loss factor and dynamic stiffness measurements have been made). These samples will not then be available for the ultimate load test under deformation at the rate of 0.5 in. per min. The decision as to how many samples to divert to fatigue testing in this manner shall be made by Professor Crandall in consultation with all interested parties.

In addition to the fatigue test and the basic test for statistical distribution, supplementary tests shall be made on the remaining eight samples to obtain additional engineering information concerning the behavior of the damping units. These supplementary tests are designed to elicit information on how the energy absorbtion of a damper is affected by:

(i) Preload on the damper.

(ii) Preliminary high frequency cycling.

3. Test Facilities

All cycling tests shall be performed on a special test frame in which one or two damping units can be cyclically deformed as the structure is sheared by a motor-driven eccentric. The test frame shall simulate the average local elasticity of the damping-unit connectors in the World Trade Center towers. The amplitude of the test-frame deformation shall be controlled by the size of the eccentric. The amplitude of the damping unit deformation depends on the dynamic stiffness of the damping unit and will vary from element to element and will vary with temperature for any one element. Damping unit test amplitudes shall be specified in terms of an <u>equivalent amplitude</u> measured on a steel dummy unit whose stiffness is 650,000 pounds per inch. The frequency of the cycling shall be controlled by the choice of sprockets in the chain drive between the motor-driven reducer and the eccentric drive-shaft. Forces in the damping units shall be measured by strain-gage load cells and deformations of the units shall be measured by L.V.D.T.[1]s. Force-displacement curves shall be recorded on an on-line X-Y plotter. The special test structure shall be disassembled at the conclusion of the tests and sent to the New York Port Authority for storage.

The ultimate load tests shall be performed on a manually operated hydraulic testing machine with a capacity of 100,000 pounds. The instrumentation shall be the same as in the cycling tests. The operator shall endeavor to maintain the rate of deformation at a nearly uniform rate as close as possible to 0.5 in. per min. The actual rate of deformation shall be recorded.

4. Specifications for Fatigue Tests

These tests on four units chosen at random shall be performed prior to the basic statistical tests described in Section 5 below.

(a) The cycling rate shall remain within ± 2% of a fixed value lying within the range from 0.08 to 0.11 Hz (4.8 to 6.6 cycles per minute).

(b) The mean load on the damping unit during a cycle shall be zero.

(c) The cyclic amplitude of the test-frame displacement shall remain within ± 2% of a fixed value lying within the following ranges.

(i) Two damping units shall be tested with equivalent amplitudes in a range from 0.018 to 0.022 inches.

(ii) Two damping units shall be tested with equivalent amplitudes in the range from 0.027 to 0.033 inches.

(d) The ambient temperature and humidity and the temperature of the viscoelastic material shall be recorded at hourly intervals during the fatigue tests.

(e) Force-displacement curves for each specimen shall be recorded by an on-line X-Y plotter at hourly intervals during the fatigue tests. Clocktime and cycle number shall be noted.

(f) If at the end of 10,000 cycles a unit has not obviously failed and its force-displacement curve has not altered dramatically the cycling shall be stopped and the unit shall be removed from the cycling test structure and placed in the ultimate-load test machine. There it shall be subjected to an approximately uniform rate of deformation as near to 0.5 in. per min. as possible. Force and displacement shall be recorded until failure occurs.

If all four units survive 10,000 cycles and if their subsequent ultimate loads are each greater than 35,000 pounds it shall be concluded that fatigue is not a serious hazard and no further considerations shall be given to fatigue in this test program.

If, however, one or more of the four units fail to meet the above requirements, it shall be necessary to consider very carefully whether additional fatigue testing should be carried out. Such additional fatigue tests would be carried out (on random samples from the 30 basic statistical test-samples) in lieu of the ultimate-load test.

5. Specifications for Basic Statistical Tests

These tests shall be performed on thirty specimens. To determine dynamic properties of the damping units under uniform cycling each sample shall by cycled for 100 cycles at a uniform rate. The sample shall then be allowed to cool down to its initial temperature before going through two additional cycles. Force-displacement curves and temperature data shall be recorded as described below. After the cycling test each sample shall be deformed to failure in an ultimate-load test (if additional fatigue testing is decided upon, some fraction of the samples shall be given fatigue tests in lieu of ultimate load tests).

The following specifications apply to the tests for dynamic properties under uniform cycling.

(a) The cycling rate shall remain within ± 2% of a fixed value lying with the range from 0.08 to 0.11 HZ (4.8 to 6.6 cycles per minute).

(b) The mean load on the damping unit during a cycle shall be zero.

(c) The cyclic amplitude of the test-frame displacement shall remain within ± 2% of a fixed value lying within the following ranges.

(i) Twenty units shall be tested with equivalent amplitudes in the range from 0.018 to 0.022 inches.

(ii) Ten units shall be tested with equivalent amplitudes in the range from 0.027 to 0.033 inches.

(d) The ambient temperature and humidity and the temperature of the viscoelastic material shall be recorded for the 1^{st}, 10^{th}, 20^{th}, 50^{th}, 100^{th} and 101^{st} cycles for each specimen.

(e) Force-displacement curves shall be recorded by an on-line

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X-Y plotter for the 1^{st}, 2^{nd}, 10^{th}, 20^{th}, 50^{th} and 100^{th} cycles for each specimen. At the end of the 100^{th} cycle, the deformation shall be suspended until the viscoelastic material returns to its initial temperature, plus or minus 0.2° F. The time required to reestablish the initial thermal condition shall be recorded. Then cycling shall be resumed for an additional two cycles. Force-displacement curves for cycles 101 and 102 shall be recorded.

The following specifications apply to the ultimate-load test.

(f) The damping units shall be transferred from the cyclic-test frame to a 100,000 pound hydraulic test machine. Half of the units shall be tested in tension and half in compression.

(g) Ambient temperature and humidity and the temperature of the viscoelastic material shall be recorded at the beginning of each ultimate-load test.

(h) The testing machine shall be manually controlled to provide a nearly uniform rate of deformation as near as possible to 0.5 inches per minute.

(i) Force-displacement curves to failure shall be recorded on an on-line X-Y plotter. The time history of displacement shall also be obtained.

(j) Failure modes shall be noted and photographed where informative.

6. Supplementary Tests

Four specimens shall be tested to investigate the effect of preload on the energy absorbtion of the damping units. These tests shall be similar to the cycling portion of the basic test with the exception that instead of cycling about a mean load of zero the cycling shall take place around non-zero tensile and compressive loads.

The specifications for the preload test are given below.

(a) The cycling rate shall remain within ± 2% of a fixed value lying with the range from 0.08 to 0.11 Hz (4.8 to 6.6 cycles per minute).

(b) The damping units shall be inserted into the test frame in such a manner that the mean deformation of the element during the cycle takes on the following values.

(i) One unit shall be tested with a cyclic mean equivalent elongation in the range between 0.009 and 0.011 inches.

(ii) One unit shall be tested with a cyclic mean equivalent elongation in the range between 0.018 and 0.022 inches.

(iii) One unit shall be tested with a cyclic mean equivalent compression in the range between 0.009 and 0.011 inches.

(iv) One unit shall be tested with a cyclic mean equivalent compression in the range between 0.018 and 0.022 inches.

(c) The cyclic amplitude of the test frame shall remain within ± 2% of a fixed value which shall produce an equivalent amplitude within the range from 0.018 to 0.022 inches.

(d) The ambient temperature and humidity and the temperature of the viscoelastic material shall be recorded for the 1^{st}, 10^{th}, 20^{th}, 50^{th}, 100^{th} and 101^{st} cycles for each specimen.

(e) Force-displacement curves shall be recorded by an on-line X-Y plotter for the 1^{st}, 2^{nd}, 10^{th}, 20^{th}, 50^{th}, and 100^{th} cycles for each specimen. At the end of the 100^{th} cycle, the deformation shall be suspended until the viscoelastic material returns to its initial temperature, plus or minus 0.2° F. The time required to reestablish the initial thermal condition shall be recorded. Then cycling shall be resumed for an additional two cycles. Force-displacement curves for cycles 101 and 102 shall be recorded.

Four specimens shall be tested to investigate the effect of higher frequency cycling on the energy absorbtion of the damping units. Each specimen shall by cycled for ten cycles at the standard amplitude and frequency. Then the frequency shall be increased and the amplitude decreased (or left unchanged) and the units cycled for 100 cycles before returning to the standard amplitude and frequency. Force-displacement curves shall be recorded before and after the high frequency cycling as described below.

Specifications for the high-frequency test are given below.

(f) All four specimens shall be cycled for ten cycles at a fixed frequency between 0.08 and 0.11 Hz with an equivalent amplitude between 0.018 and 0.022 inches.

(g) Ambient temperature and humidity and the temperature of the viscoelastic material shall be recorded for the 1^{st} and 10^{th} cycles.

(h) Force-displacement curves shall be recorded on an on-line X-Y plotter for the 1^{st} and 10^{th} cycles.

(i) For two samples the equivalent amplitude shall be decreased to a fixed value within the range from 0.009 to 0.011 inches and the cycling frequency shall be increased to

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(i) A value between 0.23 and 0.27 Hz for one sample.

(ii) A value between 0.46 and 0.54 Hz for one sample.

For the other two samples the equivalent amplitude shall be maintained within the range 0.018 to 0.022 inches and the cycling frequency shall be increased to

(iii) A value between 0.23 and 0.27 Hz for one sample.

(iv) A value between 0.46 and 0.54 Hz for one sample.

The specimens shall be cycled for 100 cycles at the higher frequencies indicated.

(j) Ambient temperature and humidity and the temperature of the visco-elastic material shall be recorded at the 1st, 10th, 20th, 50th and 100th high-frequency cycles.

(k) Force-displacement curves shall be recorded for the 1st, 50th, and 100th high-frequency cycles.

(l) The frequency and equivalent amplitude for each specimen shall now be returned to the values established in (f) above. The time elapsed while making this change shall be noted. The specimens shall then be cycled for ten cycles as in (f). The measurements in (g) and (h) shall be repeated.

7. Report of Test Results

The dynamic characteristics of the viscoelastic damping units as determined by these tests shall be reported as follows. For each of the parameters listed below a statistical distribution diagram shall be given along with values for the mean and standard deviation.

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(a) For the first and one hundred and first cycles of steady cycling at nominal frequency of 0.1 Hz and nominal equivalent amplitude of 0.02 inches (and 0.03 inches) the following parameters.

(i) Dynamic stiffness

(ii) Loss tangent

(iii) Energy dissipated

(b) For ultimate testing at a nominal rate of displacement of 0.5 inches per minute (tension and compression) after previously enduring 102 cycles at nominal frequency of 0.1 Hz and nominal equivalent amplitude of 0.02 inches (and 0.03 inches) the following parameters.

(i) Ultimate strength in pounds

(ii) Ultimate deformation in inches

The results of the fatigue investigation shall be described. Either the ability of these units to endure repeated loadings shall be verified or an S-N type diagram shall be given.

The results of the preload investigation shall be described. The energy absorbtion capabilities of a preloaded damping unit shall be graphically compared with that of a unit without preload. The results of the high-frequency cycling test shall be described. The energy absorbtion of a damping unit before and after high-frequency cycling shall be graphically compared.

An analysis shall be made of the effects of ambient temperature and element temperature on the dynamic characteristics of the damping units. Graphs shall be plotted of actual element displacement, cyclic energy loss and loss tangent as a function of element temperature.

In addition to giving dynamic characteristics for the damping units separately a discussion shall be given of the cyclic test frame and its interaction with the damping units. The force and displacement of the eccentric driver shall be recorded for certain cases so that the total energy input to the frame can be compared with the loss in the damping units.

All original X-Y plots. with necessary identification shall be included in the report.

Test of Viscoelastic Damping Units
for World Trade Center Tower Buildings

by S. H. Crandall
L. E. Wittig

Summary

Tests have been performed on 39 samples of the viscoelastic damping units proposed by 3-M for the World trade Center Towers to determine the distribution of their mechanical properties and to ascertain their effectiveness under a range of off-design operating conditions. It was found that although there is considerable variability of properties from unit to unit in a batch and from one batch to another, the energy absorbing capabilities of the elements are generally adequate to provide the expected damping under design conditions and that the elements do perform satisfactorily under limited variations of: loading conditions; speed of oscillation; duration of oscillation and ambient temperature.

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I. Introduction

In order to control the tendency of the World Trade Center Towers to sway under the action of high winds it is planned to increase the inherent structural damping of the buildings by attaching viscoelastic damping elements at the major structural joints connecting floors and columns. The damping elements are bolted between the columns and the lower members of the floor trusses in such a way that the elements are forced to elongate (or shorten) whenever the buildings sway. These damping elements have been designed by Skilling, Helle, Christiansen and Robertson (SHCR) and fabricated by Minnesota Mining and Manufacturing Company (3-M). See Reference [1] for background information and the results of tests by 3-M on 22 prototype units. The present series of tests has been conducted to supplement and to serve as an independent check on these earlier tests.

Twenty units were tested according to a basic or standard test which closely paralleled the earlier 3-M tests. The standard test consists of two parts: a cycling test and an ultimate test. In the cycling test an element's elongation and force is monitored for 100 cycles as it undergoes simple harmonic motion at the design amplitude and frequency. From these measurements it is possible to evaluate the following important mechanical parameters for the elements: the dynamic stiffness k (kips/inch), the energy dissipated per cycle W(inch-lbs) and the loss tangent, tan ϕ, and to observe how these parameters change during a period of steady cycling which lasts for 100 cycles (16.7 minutes for the design frequency of 0.1 Hz). In the ultimate test the element is stretched (or compressed) at the steady rate of 0.5 inches per minute until failure occurs. The elongation and force history are monitored and the ultimate values of each are recorded.

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In addition to the standard test, 19 additional tests were performed to investigate the endurance capabilities of the elements and to investigate their operation under conditions different from the design conditions prescribed in the standard tests. The conditions tested included variations in amplitude and frequency, variations in ambient temperature and the effect-of-superposing a static preload on the simple harmonic loading employed in the standard cycling test.

The principal differences between the standard cycling tests of this report and those of reference [1] arise from the differences in test facilities. The tests of Reference [1] were performed in a servo-controlled testing machine which maintained a fixed (single) amplitude of 0.020 inches throughout the test. The tests described herein were performed in a specially built test frame (see Fig. 1) which was intended to simulate the structural environment which the elements will see when they are fastened in place in the World Trade Center Towers. During the test the frame is periodically sheared by a motor driven eccentric (see Fig. 2). The amplitude of the frame shear is controlled by the "throw" of the eccentric. The damping element under test (see Fig. 3) is forced to expand and contract as the frame is sheared. The element elongation amplitude depends on the relative stiffness of the frame and of the element itself. The precise relation is somewhat complicated and is developed in Appendix A. It is sufficient here to realize that for the same frame shear (same sized eccentric) the element elongation amplitude for a soft element will be greater than for a stiff element.

In order to describe the frame shear in a meaningful way the elongation amplitude of an aluminum alloy "dummy" element (see Fig. 4) with a

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stiffness of 600 kips/inch was measured and c e equivalent amplitude. During the actual tests the elongation amplitude for the visco-elastic elements were greater or less than the equivalent amplitude depending on the stiffness of the element under test. Three different sized eccentrics were employed. The standard tests were performed using an eccentric which produced an equivalent amplitude of 0.019 inches. The other eccentrics produce equivalent amplitudes of 0.010 inches and 0.023 inches. The frequency of cycling during the standard tests was approximately 0.1 Hz (actually 0.0989 Hz). This corresponds to a period of 10 seconds per cycle (actually 10.11 seconds per cycle). Other tests were also run at two and a half times this frequency, and at five times this frequency.

II. Description of Tests

A. Test Frame

All cyclic tests were performed on a special test frame (see Fig. 1). This special frame was constructed for these tests because it was felt that the damping units should be tested in a structural environment similar to that in which the dampers will be installed in the World Trade Center Towers. The test frame allows the damping units to deform more naturally than they would deform if tested in a standard testing machine. For example, the damping units tend to rotate somewhat when they are elongated in either the test frame or in their building environment. A standard testing machine, however, would not allow such rotational motion. The test frame also permitted us to check the effect of small misalignments in the installation of the dampers.

The test frame is geometrically quite similar to the truss-outer wall portion of the buildings. Damping units are held in the test frame

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with 1-inch diameter A490 bolts in single shear on one end and with 7/8 inch diameter A325 bolts in double shear on the other end, corresponding to their installation in the buildings. A 1300 ft-lb. impact wrench was used to tighten the bolts (see Fig. 5) according to turn-of-the-nut regulations [2]. The main requirement of these regulations is that after the nut has been brought up tight with a hand wrench the power wrench is applied to turn the nut through an additional 180°. New bolts were used for each test and shim material was used when needed for proper alignment.

When testing the damping units, the whole test frame was deformed sinusoidally by a motor driven eccentric (see Fig. 2). The equivalent amplitude referred to in the various tests is the elongation amplitude that a lossless elastic member with a stiffness of 600,000 lbs./in. would experience if it were to be bolted into the test frame instead of a damping unit (a more complete discussion of the stiffness of the test frame and its affect on the elongation amplitude of a damping unit is given in Appendix A).

The test frame was located in a temperature controlled room. The temperature and humidity were recorded during all tests. For all tests, except when specially noted, the temperature has held at 75°F ± 3°F.

B. Standard Cycling Tests

The most common test that was performed is referred to as the standard statistical test. This test was carried out on the test frame described above. The equivalent amplitude during this test was 19 mils (one mil equals 0.001 inches); the period per cycle was 10.11 seconds. The standard test was intended to be somewhat similar to tests performed by 3M Company so that our results could be compared to their results.

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During a standard test the damping units were cycled 100 times and data was taken on the 1st, 2nd, 10th, 20th, 50th and 100th cycles. The units were then allowed to relax for 20 minutes and more data was taken on the 101st and 102nd cycles.

Damper extensions and contractions were measured with an LVDT (linear variable differential transformer).. The LVDT was mounted as shown in Fig. 3 so that the total motion between the two ends of the damper was measured along the central axis. It should be noted that in this respect these tests differ from those of 3-M where only the relative motion between two internal points within the damper was measured. The axial force applied to the damper was measured with a strain gage dynamometer located in the angles that connect the dampers to the truss. The temperature of the viscoelastic layer was monitored by a thermocouple embedded in the viscoelastic material. The LVDT and the force gage were calibrated for each test.

Outputs from the LVDT and the force gage were fed into the same x-y recorder shown on the left of Fig. 6. Because of the viscoelastic behavior of the damper there is a phase shift between the force signal and the elongation signal. The phase shift causes the force-elongation plot to form a closed hysteresis loop during each cycle of oscillation. The area of the loop is directly proportional to the energy dissipated during the cycle. The loss factor and the dynamic stiffness of the damper can also be determined from this plot. The output from the thermocouple was fed into a second x-y recorder shown in the right in Fig. 6 and plotted as a function of time.

During one test the rotational motion of the damper and the moment applied to the damper were measured. From this information the amount of energy absorbed by the damper due to rotational motion was calculated.

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C. Special Cycling Tests

Besides the standard statistical tests, some additional cyclic tests were performed to determine further properties of the damping units. Four different types of tests were carried out: (i) endurance tests, (ii) preload tests, (iii) higher frequency tests, and (iv) one endurance test at an elevated temperature.

The purpose of the endurance tests was to check the fatigue life of the damping units. These tests were quite smmilar to the standard tests described earlier except that the total number of cycles was much greater. Two tests were run with an equivalent amplitude of 10 mils for 10,000 cycles, and two tests were run with an equivalent amplitude of 19 mils until fatigue was noticed.

The preload tests were performed by bolting the damping units into the test frame when the frame was slightly deformed from its neutral position. This procedure forces the damper to oscillate about a nonzero mean displacement. Such a condition could easily arise in the World Trade Center Towers if the swaying oscillation took place about a static sway due to the steady state wind components. These tests were also performed in a manner similar to that of the standard test. However, during the four preload tests the mean equivalent pre-elongations were approximately $\pm$ 10 mils and $\pm$ 20 mils.

The higher frequency tests were conducted to see if oscilla-tions at frequencies corresponding to the higher modes of the buildings would cause any deterioration in the effectiveness of the dampers. Higher test frequencies were obtained by changing the sprockets of the motor transmission system. During these tests the damper specimens were first cycled 10 times at the standard frequency of 0.1 Hz and at

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the standard equivalent amplitude of 19 mils. The frequency of the forced oscillation was then changed to either 0.25 Hz or to 0.50 Hz; the equivalent amplitude was either held the same or reduced to 10 mils. The specimens were cycled 100 times under these new conditions. After these 100 cycles the frequency wss returned to 0.10 Hz and the equivalent amplitude was returned to 19 mils. The specimens were cycled 10 more times to see if there was any noticeable change in the damper properties since the original 10 cycles.

The last special cyclic test that we performed was an endurance type test with the exception that the ambient temperature was 10°F above the normal 75°F. The results of this single test were discussed in some detail in a preliminary report which is included here as Appendix D.

D. Ultimate Load Tests

All of the damping units from the standard statistical tests and the endurance tests were subjected to an ultimate load test. The ultimate load test consists of stretching or compressing the dampers until they are physically broken. The purpose of these tests was to see if the specimens still met the acceptance levels established by 3M Company after they had been through the cyclic tests. These tests were performed on a manually controlled hydraulic testing machine with a capacity of 200,000 pounds (Figs. 7, 8). The axial force and elongation of the damper were recorded on an x-y recorder during the test. An additional x-y recorder was used to monitor the rate of axial elongation of the specimen. This rate of axial extension was held as close as possible to 0.5 inches per minute. Half of the specimens from the standard statistical tests were broken in tension and half were broken

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in compression. All of the specimens from the endurance tests were broken in tension. The grips for these tests used 1 inch diameter A490 bolts in single shear at one end of the specimen and 7/8 inch diameter A325 bolts in double shear at the other end. From the recorded results statistical information on the ultimate loads and the ultimate extensions of the dampers has been obtained.

III. Results of Tests

A. Standard Statistical Tests

The major portion of this test program was devoted to measuring some basic mechanical properties of the damping units. The damping unit properties that were obtained are their loss factor, dynamic stiffness, ultimate load, and ultimate extension. The amount of energy dissipated per cycle by the dampers and the amplitude of the periodic displacement between the ends of the damping units was also measured. Statistical distribution curves for the dynamic stiffness, loss factor, energy absorbed per cycle and the amplitude of the periodic displacement are given in Figures 9, 10, 11 and 12. The results of the ultimate load tests are discussed in Section III-C. For sake of comparison, results of tests conducted by 3M Company are included in the same figures.

The data used for the statistical information of this investigation was taken from measurements made during the tenth cycle of oscillation. Hysteresis loops recorded during first and second cycles were usually not closed, and therefore, data from these first two cycles is not as accurate as data from the tenth cycle. Also, since it is quite probable that oscillation of the Trade Center Towers will occur in groups of several cycles (this is typical of narrow band random vibration), we feel that the tenth cycle information is more meaningful. The results of tests

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conducted by 3M Company were taken from tables in Reference 1. For the dampers they tested, we plotted the results corresponding to the first test on each individual damper that was tested at an ambient temperature of 75°F ± 3° F. Nineteen of their tests fell in this category.

The mean value and the standard deviation for each of the damper properties are listed along with their distribution curves. The most important single parameter is W the energy loss per cycle. In our opinion the average value W = 574 inch. lbs. (with a standard deviation of 72 inch. lbs.) is satisfactory for the proposed application. It may be noted that the mean values of dynamic stiffness and loss factor that we measured (i.e., 555 kips/inch and 0.836 respectively) are above the levels (400 kips/inch and 0.7 respectively) stated in the Qualification Requirements [3]. The spread of the distributions about the mean is quite large. In the case of the loss factor the standard deviation (0.168) is sufficiently large that had these dampers been representative of the samples used to determine Acceptance [3] there is a good chance that the initial sample would not meet the manufacturing control limit for loss factor.

As was mentioned earlier, the output signal from a thermocouple imbedded in the viscoelastic material was also recorded. The results of this measurement unfortunately were usually somewhat erratic. Some temperature data did make sense insofar as it showed a gradual increase in the temperature of the viscoelastic layer as the test progressed (see for example the records of damping specimen No. 19 included in Appendix B). In general, however, most of the records were not useful. The reason for this may be that some of the thermocouples were in actual physical contact with the metal of the damping units, whereas others were not.

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Originally we had planned to run the 101st and 102nd cycle of the standard test after the thermocouple indicated that the specimen had returned to room temperature. Because of the difficulties with the thermocouple we decided to let the specimen recover for twenty minutes. before running the last two cycles. Twenty minutes was chosen because it was the approximate duration of the first 100 cycles of the test.

All of the thermocouple records displayed a periodic pattern. They show that the viscoelastic layer both heats up and cools down once during each full cycle of oscillation. This behavior was at first rather surprising. We expected that the record would show two peaks per cycle instead of just one. Two peaks would occur if the viscoelastic layer could not tell a positive shear from a negative shear. The probable explanation for the observed behavior is that the viscoelastic material is anisotropic - i.e., its properties are a function of direction.

Figure 13 shows how the properties of a typical damping unit change during a standard test. In general the stiffness of the element tends to decrease while the energy dissipated per cycle, the loss tangent, and amplitude of displacement all tend to increase. After a 20 minute rest (cycles 101 and 102) the element properties have shown a recovery in the direction of their original values. We computed the average fatigue loss between the 10th and 100th cycles of the standard tests and found it to be about 11%. The fatigue loss is the percentage change in the loss modulus G". It is also equal to the percentage change in W/δ^2 where W is the energy loss per cycle and δ is the elongation amplitude.

From bending moment measurements made while testing specimen No. 1, the energy dissipation due to rotational motion of the damper was calculated to be about 19% of the dissipation due to axial motion.

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The effect of misaligning the damper specimen in the test frame was also investigated. Misalignments of the order of 1/4 inch, so that the dampers can be easily pushed into place by hand, appear to have a negligible affect on the amount of energy which the dampers absorb.

For the benefit of future users of the test frame, a sample of the data reduction for a standard test has been included in Appendix B.

B. Special Cycling Tests

Four different endurance tests were conducted. Two of these tests were run with an equivalent amplitude of 10 mils, and two were run with an equivalent amplitude of 19 mils. The results of a low amplitude test are shown in Figure 14. As can be seen, the properties of the damping element did not change appreciably in the course of 10,000 cycles. The properties did fluctuate somewhat, but this was probably due to small changes in the ambient temperature. During the second low amplitude endurance test, the frequency of oscillation was increased so that the total rate of energy dissipation would be about the same as it was during the high amplitude endurance tests. Even after this higher rate of energy dissipation the specimen did not appear to be damaged.

The results of a high amplitude (19 mils equivalent amplitude) endurance test are shown in Figure 15. These results show that there is some definite damage to the damper at about the 1000th cycle. This test was probably too severe. SHCR estimate that on the average there will be only 15 cycles a year with amplitudes greater or equal to to amplitude used in this test. Furthermore, the test frame used in these tests tends to overstretch the damper when it softens (see Appendix A). For the above reasons it appears that chances of fatigue failure of the dampers are unlikely.

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All of the tests conducted for this report were made with the assembly bolts of the dampers in a finger tight condition. After the element mentioned above had fatigued, we found that tightening the assembly bolts seemed to restore some of the life of elements. Also, we found that if the assembly bolts were only finger tight before the element was bolted into the test frame, then vibration caused by the impact wrench completely loosened them. For these reasons we highly recommend that the assembly bolts of the damping units be kept tightened at all times. We also checked to see if tightening the assembly bolts affected the amount of energy dissipated by the dampers, and found that tightening them decreased the energy dissipated about 10%.

The preload tests indicated that forcing the dampers to oscillate about a nonzero mean displacement does not appear to reduce their effectiveness. The average energy dissipated during the 10th cycle of the preload tests was 581 in. lbs., whereas the average energy dissipated during the 10th cycle of a standard test was 574 in. lbs.

Figure 16 shows the results of a typical high frequency test. The overall results of the high frequency tests demonstrate that intermediate oscillations at higher frequencies do not appear to change the effectiveness of the dampers at the standard frequency of 0.1 Hz.

Besides the tests discussed above, a few other tests were performed. One series of tests that is of some interest is a set of three 100 cycle tests at an equivalent amplitude of 23 mils on damping unit No. 3. At the end of the third test some definite changes in the damper properties were noticed. The results of these tests are included in Appendix C.

C. Ultimate Load Tests

The results of a typical ultimate load test are shown in Figures 17 and 18. The curves which are shown are for an element that

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was tested in tension. Two peaks appear in the load-elongation curve (Fig. 17) because after one side of the element separated the other side continued to load for a while longer. The displacement vs. time curve (Fig. 18) shows that the rate of elongation was quite close to the desired 0.5 inch per minute.

Statistical distribution curves for the ultimate loads and ultimate extensions of dampers from the standard statistical tests are shown in Figures 19 and 20. The results of 13 tests conducted by 3M Company and reported in Reference 1 are also shown.

It may be noted that the average ultimate load (47.7 kips) that we measured is greater than the value (45 kips) stated in the Qualification Requirements [3]. The spread of the distribution is quite large. The standard deviation (9.3 kips) is sufficiently large that had these dampers been representative of the samples used to determine Acceptance [3] there is a good chance that the initial sample would not meet the manufacturing control limit for ultimate shear strength. In our tests half of the units were broken in tension and half were broken in compression. The average ultimate load for the tension units only was 51.0 kips and the average ultimate load for the compression units only was 44.4 kips. The average for both tension and compression was 47.7 kips.

The most common mode of failure for the specimen was separation at the bond between the metal and the viscoelastic material. All of the elements that were tested in tension, and about half of the elements tested in compression, failed in this manner. Another mode of failure that occurred during the compression tests was for the viscoelastic bond to break on one side of the element and then for the other side of the element to buckle (Fig. 21). Only one element that was tested buckled

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on both sides. The buckling and the breaking of the viscoelastic bonds were the only modes of failure that occurred.

Ultimate load tests were also conducted on the elements from the endurance test. The two elements from the low amplitude (10 mils equivalent amplitude) endurance tests both broke at loads that were slightly higher than the average ultimate load of 47,700 lbs. However, the two elements from the high amplitude (19 mils equivalent amplitude) endurance tests broke at loads of 22,000 lbs. and 14,000 lbs. which is considerably lower than average. This further verifies that prolonged cycling of the damping units at high amplitudes does result in permanent damage.

IV. Conclusions

The most important characteristic of the damping elements is their capacity to absorb energy under oscillations at amplitudes and frequencies which are probable for the World Trade Center Towers. Ideally they should absorb adequate energy no matter when the oscillations occur or what the ambient conditions are during the oscillations. In our tests we have not been able to cover all possible operating conditions but we have shown that this particular batch of elements do absorb an average of W = 574 inch-lbs under standard test conditions with respect to amplitude, frequency and temperature. Furthermore, the energy absorbtion is not significantly impaired by modest variations in amplitude, frequency and temperature.

Our major concern in the beginning centered around the endurance capability of the elements. We found that the elements could withstand 10,000 cycles of 10 mils equivalent amplitude with no indication of permanent damage. At large equivalent amplitudes (19 and 23 mils) we did

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obtain evidence that prolonged cycling caused a growing breakdown of the bond between the viscoelastic material and the steel which was reflected by a reduction of the element's stiffness and its ultimate load capacity. See data for Specimens No. 3, No. 4 and No. 5. In spite of the alteration of properties which occurs we conclude that the units will provide adequate energy absorbtion for at least 1000 cycles of 19 mils eouivalent amplitude at temperatures in the vicinity of 75°F. When the ambient temperature is in the vicinity of 85°F the bond breakdown is apparently accelerated somewhat. At this temperature (see Appendix D) it appears that the units will provide adequate energy absorbtion for 500 cycles of 19 mils equivalent amplitude. If present estimates of the number of large oscillations to be expected are not excessively optimistic, it does not appear that there is any real danger of a loss in element effectiveness due simply to the accumulation of cycles of oscillation.

An unknown factor is the effect of aging on the viscoelastic elements. Our tests were completed within a six month period. We had no opportunity to observe any long time deterioration of the elements.

Another unknown factor is the effect of extreme heat or extreme cold on the viscoelastic elements.

When the elements are installed in the towers it is essential that the bolts be tightened meticuluosly. Any slip in the joints would vitiate the usefulness of the dampers. Careful alignment of the element attachment points should be maintained. Our tests indicated that up to 1/4" of misalignment did not affect the energy absorbtion capability of the element. We recommend that the element assembly bolts be tightened with a small hand wrench after installation rather than being left finger-tight. This may decrease the energy absorbed by the element in small amplitude cycles by up to 10 percent but it will serve to protect

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the element against deterioration under large amplitude cycles.

Because of the wide spread in damper properties from batch to batch and from unit to unit within a batch, it is suggested that a program of testing sample units be instituted to check on element parameter values as the various batches are delivered. The most important single parameter is the energy dissipated in a cycle of 10 seconds duration under a known equivalent amplitude. It is this parameter which is directly proportional to the increase in overall tower damping ratio provided by the damping unit. It would be desirable if W, the energy loss per cycle, for 19 mils equivalent amplitude was never less than 400 inch lbs. A desirable average value of W for all batches would be 575 inch lbs. (i.e., about the same as that of the batch reported on here).

V. Suggestions for Further Testing

A program of periodic testing of random samples of installed elements and of the stored unused elements should be instituted. All the endurance tests performed so far have been accelerated life tests. The effect of the passage of years on used or unused elements is still an unknown factor.

The calcualted effectiveness of the dampers depends on the magnitude of the local frame stiffness almost as much as it does on the damping unit parameters. If the local frame stiffness were only 200 kips/inch instead of the design value of 600 kips/inch (as was the case for the test frame) the energy absorbed by the damper would only be one-fourth of that predicted. In the case of the test-frame this was compensated for by using a larger eccentric. In the actual towers no such compensation is possible. Therefore, it seems imperative to check

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the actual stiffness of the local frame at a few typical damping element locations as soon as possible. If the actual frame stiffness is significantly smaller than the design stiffness the damping units would have to be redesigned. To measure the local frame stiffness one could substitute a turnbuckle and a forcegage for the damping unit and then use the LVDT from the test frame to measure the contraction as the turnbuckle was tightened.

There are a number of tests which would be very interesting to the profession and which would be useful for the benefit of future designers. These are listed below in the order of their desirability.

1) The natural frequencies, damping ratios and mode shapes of the towers should be measured. These can be measured in a few days time by simultaneously recording the outputs of two sensitive seisometers placed at various locations in the buildings and then digitally processing the tapes. Such a service is available from the Structural Sciences Division of Earth Sciences (A Teledyne Company). See literature in Appendix E. The damper oscillation has been designed on the basis of a natural mode and natural frequency computed during the early design of the building and on the basis of an educated guess as to the inherent damping of the towers. A comparison with the measured values would be very informative.

2) Permanent recorders should be installed near the tops of both buildings to monitor the motions (acceleration levels) throughout a period of several years. This would provide valuable feedback for the elaborate wind tunnel and statistical studies which were employed to arrive at the levels of motion used in the design of the damper installation. This would also give the building owner increasing confidence in the sway resistance of his building (if the design is in fact successful and the motion amplitudes remain small).

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There are slow speed tape recorders which go continuously and only need to have the tape changed once every three months, and there are other instruments like strong motion seismographs which remain inactive most of the time and only begin to record when a certain threshold level is reached. See Appendix E for literature.

3) One or two damping units in the towers could be modified so that they could provide force and motion signals at the damper which could be compared with the tower motion. In the simplest modification all that would be necessary would be to replace the pair of angle irons running from the element to truss by the instrumented angle irons from the test frame. The force and elongation signals would provide energy loss loops which permit an estimation of how much damping the viscoelastic units were actually providing. These results would be even more meaningful if the local building frame stiffness had been verified *in situ* with a turnbuckle as described above.

References:

1. SHCR Report No. DU-1, The World Trade Center _Viscoelastic Damping Units_, July 17, 1967.

2. Specification for Structural Joints Using ASTM A325 or A490 Bolts. Approved by Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation, September 1, 1966. Endorsed by American Institute of Steel Construction, Inc. Endorsed by Industrial Fasteners Institute.

3. Technical Specifications for Visco-Elastic Damping Units for the World Trade Center, 3786.

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

August 29, 1968

Mr. Malcolm P. Levy
Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York, New York 10011

Reference: The World Trade Center
MIT Test Program

Dear Mal:

On the afternoon of August 28, 1968, the writer visited MIT to examine the damping unit test rig and to evaluate progress to date.

First, in response to inquiries from MIT, the writer transmitted the following information:

1. All high-tensile bolts must be tightened using the turn-of-the-nut technique.

2. For 1" ASTM A490 bolts, required torque could be 1400 ft-lbs or higher.

3. Washer requirements for ASTM A325 high-tensile bolts are as follows:

   a. With holes 1/16" larger than the nominal bolt diameter, no washers are required.

   b. For all other cases, 7/16" thick plate washers are required under both bolt head and nut.

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Mr. Malcolm P. Levy 2 August 29, 1968

4. Washer requirements for ASTM A490 high-tensile bolts are as follows:

   a. With holes not more than 1/8" larger than the nominal bolt diameter, standard hardened washers are required under both bolt head and nut.

   b. For all other cases, 1/2" thick plate washers are required under both bolt head and nut.

This information was given to Mr. Larry Wittig, as Professor Crandall was not expected in the laboratory for the remainder of the week.

Next, the equipment was examined and the following comment submitted to Mr. Wittig:

1. The quality of welding varies from poor to inexcusable. Every defect known to the writer and detectable by casual visual examination was found in profusion. Since stress levels are very low, the quality of welding may not adversely affect test results. Still, the writer recommended that key welds be cleaned by wire brush and examined from time to time throughout the test program.

2. The device intended to provide transverse stability is totally inadequate if stiffness in the transverse direction is required. Suitable techniques for improving the transverse stiffness were proposed, should remedies be required.

3. The basic geometry of the "trusses" is far from ideal. The writer pointed out eccentricities which should affect truss stiffness by a substantial margin. Such eccentricities, of course, will not exist in the building construction.

4. The lack of adequate stiffness in the test frame was discussed. The introduction of flange bending, the effects of stress concentration and the like, and the effects of the quality of welds (see 1. above) on the behavior of the frame were discussed in some detail.

5. Mr. Wittig pointed out that the drive bearing lacked the capability to resist side thrust and that his repeated efforts had been unsuccessful in preventing the drift of the bearing. This drift results in a sudden impact on the test rig, causing transverse oscillation and rendering the rig useless. Mr. Wittig stated that he was prepared to order a new bearing and that delivery of such bearing should be accomplished within a week.

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Mr. Malcolm P. Levy 3 August 29, 1968

6. It was noted that bolt sizes do not always compare to the requirements shown in the Drawings. Mr. Wittig pointed out that AISC values for the lesser bolts indicate that bolt slip should not occur. The writer pointed out the statistical behavior of such bolts, the difficulty in measuring the detecting bolt slip and the necessity of preventing such slip. and

It was observed that no meaningful work had been accomplished or would be accomplished for at least a week or two. Mr. Wittig stated that he would be returning to regular classroom work at the end of the third week in September. When the writer pointed out that the test work would still be under way, Mr. Wittig indicated that he intends to continue his participation in the test program and that additional help could be obtained. It is the writer's opinion, not expressed to Mr. Wittig, that it is unlikely that any useful testing will be accomplished within the next three or four weeks.

Other than as expressed above, the writer found the equipment to be sound and of good design. Probably more important, Mr. Wittig appears to be dedicated and resourceful.

It is the writer's opinion that much of the original intent of the test program may be lost because of deficiencies in the test equipment. Specifically, the writer doubts that the assembly will adequately duplicate conditions as they will exist in the building. Still, with all of its defects, the equipment may be substantially closer to such a simulation than was accomplished by the program conducted by 3M under the supervision of SHCR.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Leslie E. Robertson

LER:s
cc: Mr. Lester Feld, PNYA
Dr. Stephen Crandall, MIT
Mr. Larry Wittig, MIT

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

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Manager
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Joseph F. Jackson

May 22, 1969

Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York, New York 10011

Attention: Mr. Malcolm P. Levy

Reference: The World Trade Center
Damping Units

We have reviewed the report, "Test of Viscoelastic Damping Units for World Trade Center Tower Buildings", by S. H. Crandall and L. E. Wittig, dated April 23, 1969. This is an excellent report confirming in a general way the test results obtained by SHCR-3M. Also, this report gives additional data which are relevant to an evaluation of the performance of the damping units in the system environment of the intended installation.

From the photographs of the specimens in Figures 8 and 21, we surmise that an additional bolt hole was made at M.I.T. in the structural bar of each specimen to fit the test jig of the ultimate strength test. This additional hole overlaps the original bolt hole. The overlapping holes probably would not influence the strength so long as the forces are transmitted by friction. Should a major slip of the bolts occur, there is no doubt that the overlapping hole will affect the ultimate strength either in tension or compression. In appendix C, the ultimate strength of Specimens No. 14 and No. 16 were recorded as 49,000 lbs. and 48,000 lbs., respectively, whereas the corresponding Force-Elongation curves indicate maximum forces of 57,000 lbs. and 38,500 lbs., respectively. The reason for the discrepancy is not clear to us. In any case, the conclusions of the report are not affected by these two comments.

We would like to note that the Ultimate Strength in compression and in tension of this test series has a mean value of 47.7 kips with a standard deviation of

FRANK HOELTERHOFF
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CHARLES SANDUSKY
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ERNEST T. LIU
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SEATTLE OFFICE: 1840 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Port of New York Authority
Attention: Mr. Malcolm P. Levy - 2 - May 22, 1969

9.3 kips and that this combination of values would have failed to meet the Acceptance Requirements proposed in our letter dated May 2, 1969. The results of the compression tests conducted by 3M Company had a mean of 54.1 kips with a standard deviation of 4.5 kips and these values would meet the proposed requirement of mean Ultimate Strength = 45.0 +1.5 (S.D.) kips in compression. This comment should be considered prior to forwarding copies of this document to 3M for their use. Also, when conditions will permit, it is important that a copy be forwarded to 3M as this information cannot help but assist 3M in meeting their contractual commitments.

While we concur with most of the conclusions stated in Section IV of the report, it is clear that Messrs. Crandall and Wittig are not structural engineers, as their suggestions are not wholly practical. We wish to comment on this section as follows:

1. The program of periodic testing of random samples of the installed and of the stored unused dampers has long been in the test program for WTC and was discussed both at MIT and at Mr. Kyle's office.

2. It is neither necessary nor practical to test the local frame stiffness as proposed in this report. It is not practical because of the structural interconnection of column-to-column and of truss-to-truss through the structural ties of spandrel, bridging and slab. It is not necessary as the column stiffness plays only a minor role in the system and because the truss stiffness can be calculated with considerable accuracy. Previous calculations for uniformly loaded trusses have been verified through load testing of actual trusses. In short, the only way to perform this test requires that many trusses be loaded simultaneously (as would occur in the real building) or else a structural separation must be provided around a single truss by cutting both the slab and the bridging - this latter technique should not be considered. We do not feel that the cost of this proposed test is warranted.

3. Additional tests are cited which would be of interest to the profession. In this regard, we have two thoughts:
   a) SHCR is preparing a paper to be delivered before the ASCE, or similar organization, discussing the use of such dampers in building construction and presenting a method of analysis for such dampers. The paper will, of course, be presented to PNYA for its review in the light of any impact it may have on the rentability or other facet of The World Trade Center.
   b) SHCR, with PNYA concurrence, has contacted AISC with the view of obtaining technical and/or financial assistance in the performance of post-construction testing. SHCR will, of course, pursue this question further with AISC in the months ahead.

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

Port of New York Authority
Attention: Mr. Malcolm P. Levy -3- May 22, 1969

We note that our copy of this report does not include Appendix E. We assume that other omissions, if any, have no bearing on the conclusions of the report.

We will report to you further as our proposals for additional testing become solidified. In the interim, should you have further questions, do not hesitate to call.

Very truly yours,

SKILLING, HELLE, CHRISTAINSEN, ROBERTSON

Leslie E. Robertson

cc: Messrs. L. S. Feld, PNYA
J. M. Kyle, PNYA
S. H. Crandall, MIT
L. E. Wittig, MIT

LER/ld

STEPHEN H. CRANDALL
PROFESSOR OF MECHANICAL ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE MASSACHUSETTS

June 2, 1969

Mr. John M. Kyle, Chief Engineer
The Port of New York Authority
111 Eighth Avenue at 15th Street
New York, New York 10011

Dear Mr. Kyle:

This letter is written in response to the letter from Mr. L. E. Robertson of SHCR dated May 22, 1969, and addressed to Mr. M. P. Levy. In his letter Mr. Robertson raises some questions in connection with our report "Test of Viscoelastic Damping Units for World Trade Center Tower Buildings" by Crandall and Wittig, April 23, 1969. I shall try to answer these questions.

With regard to the ultimate tests the explanation in the report is somewhat abbreviated. Let me give some further details here. The testing machine we used had a large dial which indicated the force applied to the specimen by a hydraulic drive. For static and slow-speed testing this force is read off point by point by the operator. Since our rate of loading was fairly rapid we made no attempt to obtain the force history from the dial. We did, however, record the maximum reading of this dial for each test (this was facilitated by having the pointer drive a marker which remained at the highest level). In order to record the force history we used strain gages on the test fixture. The gages for the compression test are visible in Fig. 8 of the report. For the tension tests the test fixture made use of the normal bolt holes of the element and was long enough to provide adequate length for the gage section. In the tension tests there was good agreement (within one or two kips) between the ultimate load registered on the dial of the testing machine and the peak of the force-displacement curve based on the strain gage signals. In the case of the compression tests we had to compromise on the length of the test fixture. Too long a fixture would encourage buckling of the element and too short a fixture would compromise the strain gage test section. In order to gain a little length we moved the bolts a little closer by drilling an extra hole in the element as shown in Fig. 21. Note that there is full bearing for the bolts for compressive loads. In the case of the compression tests there was more discrepancy between the

-2-

ultimate load registered on the dial of the testing machine (this value is noted at the bottom of figures such as Fig. 17) and the peak of the force-displacement curve. The greatest discrepancies (specimens 14 and 16) occurred where compressive failure was accompanied by large amounts of buckling. The sense of the discrepancy was opposite in these two cases.

Our interpretation of this discrepancy is that because of the short gage length our strain gages (which were calibrated for perfectly axial loading) are no longer correct when a large bending moment is superposed. We, therefore, considered the machine dial reading to provide the best estimate of the ultimate load in these cases. The values given by the machine dial reading were used in constructing Fig. 19 and in calculating the mean and standard deviation.

We are in agreement with Mr. Robertson regarding most of his comments with the one exception concerning the necessity and practicality of testing the local frame stiffness. We would like to repeat our recommendation that the local frame stiffness be checked as soon as possible. The effectiveness of the [illegible] damping system operation could be jeopardized by inadequate local frame stiffness. Furthermore, it will be difficult if not impossible to assess the performance of the system when it is in operation if the magnitude of the local stiffness remains unknown.

We think that Mr. Robertson has overestimated the difficulties involved in making this measurement. We had been thinking in terms of one evening's work. This was under the assumption that the major contribution to the local stiffness was truly local. Mr. Robertson points out that there may be considerable diffusion of load from truss to truss. This means that instead of measuring only one load and one deflection it will be necessary to measure one load and a number (possibly 6 to 12) of deflections. This is still an entirely reasonable proposition in terms of time and money.

In more detail what we are proposing is that as soon as a tower has risen to the point where a floor which is to have dampers installed (and for which the design local stiffness has been computed) is structurally complete the test would be performed by installing an instrumented turn-buckle in the damper location of one of the central trusses. The deflection measured by an LVDT across this unit would be recorded as the tensile force was raised from zero up to 30 kips, say. The load would then be removed and the LVDT moved to the adjacent element location. Again the load would be put on and the deflection recorded to obtain the corresponding influence coefficient. The procedure would then be repeated.

-3-

The LVDT would be moved from station to station until the influence coefficient was no longer measurable. Using superposition and this set of influence coefficients it is a simple matter to predict the deflection of the entire truss-system when loaded uniformly at all the stations. If time is available it would be desirable to repeat the entire measurement at other "typical" locations (e.g., on the same floor but on other faces of the building). Ideally this test should be performed when construction is not going on (e.g., night shift, holiday) so as to minimize background noise..

I trust that these comments will be helpful to you.

Sincerely yours,

Stephen H. Crandall
Professor of
Mechanical Engineering

SHC:mr

cc: Mr. Yontar

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THE WORLD TRADE CENTER

Report No. DU-3

VISCOELASTIC DAMPING UNITS

Introduction

The importance of the action of wind on tall buildings has been generally recognized for many years. This action was traditionally conceived and treated as static forces by the community of building designers. However, measurements on existing buildings by various investigators have shown that the responses of tall buildings to strong wind are predominantly dynamic. More recently, the static and dynamic responses of the twin towers of The World Trade Center were studied by means of static and aeroelastic models in a micro-meteorological wind tunnel [1]. The experiments showed that, for the wind directions critical for the structural design, the deflections, and hence the stresses, are primarily caused by dynamic oscillation of the building. It has been established that the amplitudes of the oscillation are inversely proportional to the square root of the critical damping ratio for lightly damped buildings in turbulent wind.

The critical damping ratios intrinsic in buildings were measured by several researchers. A table of the data found in the literature is included in Appendix 1. Based on the reported data, it was estimated that the intrinsic critical damping ratio of The World Trade Center towers is [redacted] for design against excessive stresses. In order to increase the mechanical damping of the towers, viscoelastic damping units were developed for installation in the floor system. These damping units have been

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

June 2, 1969 Page 2

described previously in Report DU-1 [2]. The viscoelastic damping units are expected to increase the building damping from [redacted] to [redacted] which was assumed in the structural design of the towers. The contribution of the damping units to building damping was calculated in Report DU-1 and is further summarized in Appendix 2. The expected number of cycles of oscillation per year is also given in Appendix 2 for the damping units having amplitudes of deformation exceeding given amounts.

Testing Programs

Two testing programs have been carried out for the prototypes of the viscoelastic damping units. In Program I, twenty-two prototypes of the damping units were tested by Minnesota Mining and Manufacturing Company (3M Company) in May 1967 [2]. In Program II, thirty-nine prototypes were tested at M.I.T. by Dr. S. H. Crandall and Mr. L. E. Wittig in 1969 [3]. Whereas the prototypes in Program I are subjected to cyclical axial deformation in the form of a sine function at 0.1 Hz with constant amplitude of 0.020 inch, Program II attempts to simulate the system environment of the intended installation which consists of the exterior column, the viscoelastic damping unit, and the floor truss system.

The testing conditions of the two programs are compared in Table 1. The results of the standard tests are compared in Table 2.

Evaluation of the Prototypes

The specimens in Test Program I have dynamic stiffnesses which have a higher mean value and a higher coefficient of variation than those in Test

June 2, 1969 Page 3

TABLE 1

COMPARISON OF TWO TESTING PROGRAMS

	PROGRAM I	PROGRAM II
1. Number of specimens	22	39
2. Displacement - time function	Sinusoidal	Sinusoidal
3. Displacement amplitude	0.020" constant amplitude measured across viscoelastic slab.	Variable, measured across damper seat and damper extension. Constant equivalent amplitude of 0.010", 0.019", or 0.023", if damper is replaced by an elastic rod of axial stiffness equal to 600 kips inch.
4. Rotational motion	No	Yes. Caused by vertical motion of one end of test frame.
5. Standard test	100 cycles at 0.1 Hz and at 0.020" amplitude, then an extra cycle when temperature of viscoelastic slab returns to the room temperature.	100 cycles at 0.1 Hz and at equiv. amplitude of 0.019", two extra cycles after a rest of 20 minutes. Room temperature at 75±3°F.
6. Endurance test	1000 cycles at 0.020" amplitude.	10,000 cycles at equiv. amplitude of 0.010"; 2,600 cycles at equiv. amplitude of 0.019"
7. Frequency of cycling	0.1 Hz	0.1 Hz, 0.25 Hz, 0.50 Hz
8. Mean displacement	None	Zero for standard tests. Special tests at mean displacements of +0.011", -0.0125", +0.023", and -0.021".
9. Room temperature	75 ± 5°F with 18 tests at 75 ± 3°F.	75 ± 3°F. One special test at 85°F.
10. Frame stiffness	Not applicable.	192 kips/inch (computed stiffness at 47th Floor is 600 kips/inch).
11. Rate of loading for Ultimate Strength Test	Not reported. All bolts in double shear.	0.50 inch/minute (approx.) Bolted connections same as in design for field installation.

June 2, 1969 Page 4

TABLE 2

COMPARISON OF RESULTS OF TWO TESTING PROGRAMS

STANDARD TESTS	PROGRAM I	PROGRAM II		
1. Dynamic Stiffness (kip/inch)				
Mean	825	555		
Standard deviation	122	62		
Coefficient of variation	0.15	0.11		
2. Loss Tangent				
Mean	1.38	0.84		
Standard deviation	0.18	0.17		
Coefficient of variation	0.13	0.20		
3. Ultimate Strength (kips)	Compression	Compression	Tension	All
Mean	55.0	45.0	50.4	47.7
Standard deviation	3.1	4.9	10.6	9.3
Coefficient of variation	0.06	0.11	0.21	0.1

June 2, 1969 Page 5

Program II. The differences can be attributed to the greater scatter of test temperatures, to the slightly lower mean value of the test temperatures (73.7^{o}F) and to the use of several different formulations of the viscoelastic material in Test Program I. The damping units of Program II have a mean dynamic stiffness of 555 kips per inch at 75^{o}F, which is very close to the optimun value of [redacted] kips per inch. At the same time the coefficient of variation equal to 0.11 is very satisfactory.

The specimens in Test Program I have a mean loss tangent of 1.38 which is much better than the design minimum mean of 0.70. Futhermore, the specimens are quite uniform in the loss tangent with a coefficient of variation equal to 0.13. The specimens in Test Program II have a mean loss tangent of 0.84 with a coefficient of variation of 0.20. This is satisfactory, since the mean loss tangent of the universe represented by these specimens would be greater than 0.77 with a probability of 0.95 according to the t-Distribution.

The ultimate strength obtained in Test Program I has a mean of 55.0 kips and a coefficient of variation of 0.06, which indicated high strength and good uniformity. If the dynamic stiffness of the damping unit, K_d, remains below the design value of [redacted] kips per inch, the maximum design force in the damping unit, F_d would not exceed 34 kips (Appendix 3). If K_d reaches 900 kips per inch, maximum F_d would reach 40.9 kips. In such a case, about 20% of the damping units represented by Test Program II would be near or over the breaking point. The reasons for this discrepancy of ultimate strength between the two test programs are not clear. Perhaps, the difference in the test jigs is the source of the discrepancy. Fortunately, the results of Test Program II indicate some positive correlation between

June 2, 1969 Page 6

dynamic stiffness and ultimate strength. In fact, the coefficient of correlation between these two parameters is +0.42. This means that the damping units which have low ultimate strength tend to have low dynamic stiffness also. Since maximum force in the damping unit decreases with decreasing dynamic stiffness, the probability of breakage of the damping units under the maximum design wind condition is small if the results of Test Program II are representative of the production units. [redacted]

The special tests of Program II indicate that the damping units are satisfactory with respect to fatigue, to higher frequencies of oscillation and to a temperature rise of 10°F above 75°F.

Conclusions

The two test programs of the prototypes indicate that the damping units in the floor system will provide an expected increase of [redacted] in the critical damping ratio of The World Trade Center towers. [redacted]

June 2, 1969 Page 7

References

1. The World Trade Center Wind Report, Final Chapter, July, 1966, by Worthington, Skilling, Helle, & Jackson, Consulting Engineers, New York, N. Y. (now Skilling, Helle, Christiansen, Robertson).

2. Viscoelastic Damping Units, Report No. DU-1, The World Trade Center, July 17, 1967, by Skilling, Helle, Christiansen, Robertson, Consulting Engineers, New York, N. Y.

3. Test of Viscoelastic Damping Units for World Trade Center Tower Buildings, April 23, 1969, a report to The Port of New York Authority by S. H. Crandall and L. E. Wittig.

THE PORT OF NEW YORK AUTHORITY

World Trade Department

November 5, 1971

Minnesota Mining & Manufacturing Corp.
3M Center
St. Paul, Minnesota 55101

Attention: Mr. Don Caldwell

Re: THE WORLD TRADE CENTER - CONTRACT WTC-224.00 -
TESTING OF 12 DAMPING UNITS REMOVED FROM
FLOORS 26, 27, 29 & 30 - TOWER A

Gentlemen:

This will confirm oral information given to you by our Mr. Feld on 11/4/71:

3M is to perform an equivalent Acceptance Test series on the subject group of units (see Schedule X1 attached). These units were all installed in November of 1970 and remained in place for the past year in unheated space throughout a "cold" winter. We are attempting to ascertain if the units have actually been affected by the "cold" and are in fact capable of passing an equivalent acceptance test. The number and sequence of testing for loss factor and stiffness, fatigue loss and ultimate strength are to be determined by 3M.

We would appreciate your expediting this series of tests upon receipt of the units. All work is to be performed under the unit price provisions for testing under the subject contract. Please advise this office as to your testing schedule.

Sincerely,

Malcolm P. Levy

cc: Messrs. W. Borland, D. Brown, P. Chen(SHCR), I. Feld, R. Monti, J. White(SHCR), F. Wernecke - all w/att.

Laclede Steel Company

General Offices Laclede Building
St. Louis, Missouri 63101

69

CONTRACT WTC-221.00
WORLD TRADE CENTER
THE PORT OF NEW YORK AUTHORITY
LACLEDE CONTRACT 67-J-31801

DATE April 3, 1969

TRANSMITTAL LETTER NO. 10

Mr. W. C. Borland
Coordinator of Construction
The World Trade Center
The Port of New York Authority
111 Eighth Avenue
New York, New York 10011

TRANSMITTAL OF FLEXURAL TESTS

Transmitted herewith is one copy each of the sequentially numbered flexural test reports listed below. Submission is in accordance with the sixth paragraph of Paragraph 105.102 "Resistance Welding" of our Contract WTC-221.00.

Flexural Test No.	Date of Test
23	12/17/68
24	12/17/68
25	12/17/68
26	12/19/68
27	12/19/68
28	12/31/68
29	12/31/68
30	1/ 7/69
31	1/ 7/69
32	1/ 7/69
33	1/24/69
34	1/24/69
35	1/24/69

For David B. Nystrom
Robert D. Bay
Director of Technical Services

CC: Mr. James White
Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10017

Mr. Al Guttentag, Project Engineer
Tishman Realty & Construction Co., Inc.
30 Church Street - 11th Floor
New York, New York 10007
(COPY NOT SENT)

May 15, 1969

R. D. BAY

RE: WTC-221.00
FLEXURAL TESTS
SHIPMENT NO. 2

The results of all Flexural Tests performed for Shipment No. 2 are shown on the attached sheet 1 of 2 dated May 15, 1969. This sheet shows the comparative deflections for incremental loads of 500 lbs. for each truss tested. Sheet 2 of 2 gives the backup data for Sheet 1.

David B. Neptune

lp

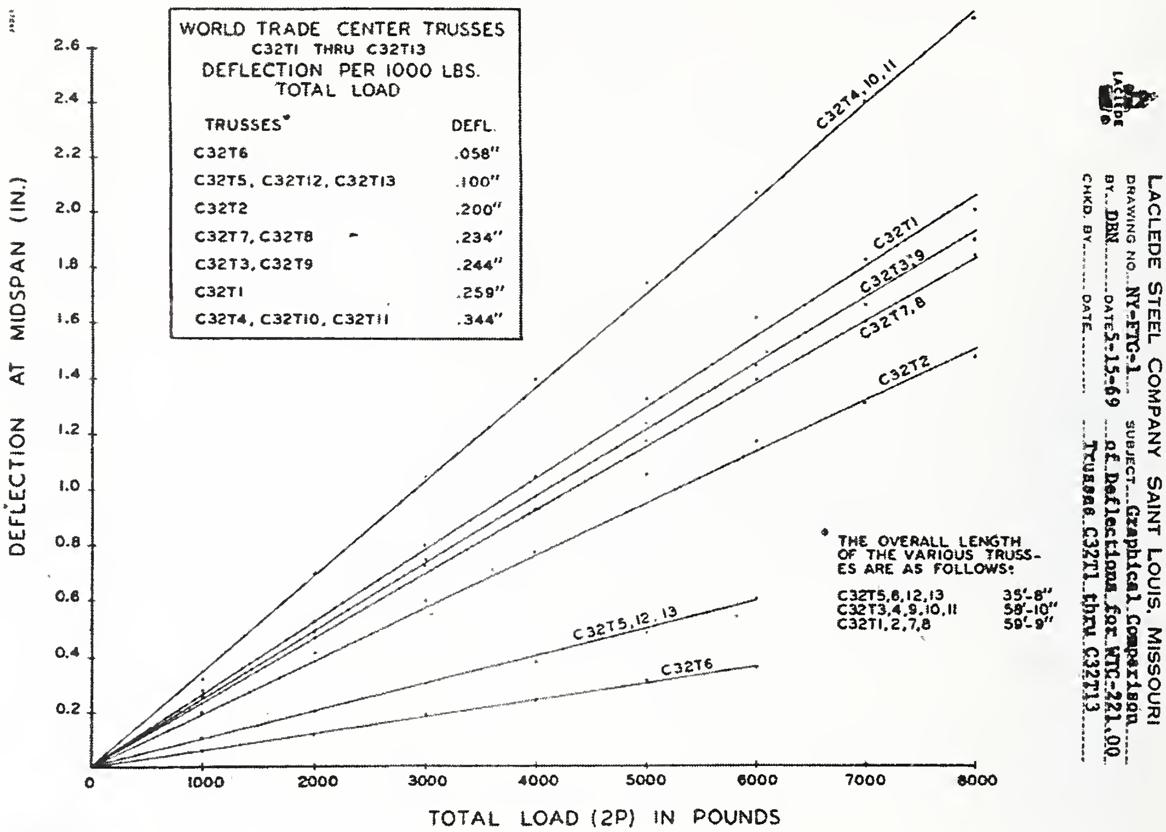
WORLD TRADE CENTER
FLEXURAL TESTS
NOS. 23 THRU 40

May 15, 1969
Page 1 of 2

Comparative Deflections+ in Inches for
Incremental Target Loads of 500 Pounds

(1) TRUSS MARK NO.	(2) TEST NO.	(3) DESIGN DEFL In.	(4) DESIGN LOAD Psf	TARGET LOAD IN POUNDS (5)									
				500	1000	1500	2000	2500	3000	3500	4000	4500	5000
C32T1A	24	2.000	58	.246	.551	.802	1.060	1.335	1.605	1.910	2.170	2.447	2.751
C32T2A	23	2.063	62	.207	.408	.595	.775	.997	1.165	1.335	1.535	1.752	1.962
C32T3	27	2.063	62	.262	.490	.715	.995	1.178	1.414	1.646	1.888	2.120	2.367
C32T4	29	0.750	62	.370	.708	1.029	1.357	1.683	2.033	2.372	2.743	-	-
C32T5	33	0.375	54	.104	.201	.299	.395	.500	.602	-	-	-	-
C32T6	35	0.938	62	.064	.118	.171	.226	.279	.334	.390	.446	-	-
C32T7A	25	2.063	62	.281	.510	.747	.977	1.227	1.440	1.675	1.920	2.174	2.437
C32T8A	26	2.000	62	.286	.541	.807	1.083	1.321	1.575	1.839	2.122	2.400	2.700
C32T9	28	1.938	62	.261	.501	.742	.983	1.233	1.462	1.700	1.943	2.208	2.445
C32T10	30	1.688	62	.360	.711	1.042	1.371	1.699	2.023	2.377	2.729	-	-
C32T11	31	1.313	62	.400	.742	1.070	1.414	1.756	2.095	2.437	2.793	-	-
C32T12	32	0.250	62	.113	.204	.293	.385	.478	.570	-	-	-	-
C32T13	34	0.438	62	.109	.199	.289	.378	.467	.554	-	-	-	-
C32T14AL	38	2.000	58	.281	.565	.841	1.103	1.377	1.649	1.921	2.226	2.490	2.812
C32T16AL	39	2.063	62	.273	.511	.738	.977	1.214	1.465	1.716	1.987	2.241	2.519
C32T21L	40	1.375	62	.416	.765	1.117	1.464	1.825	2.165	2.575	2.917	-	-
C32T23L	36	0.375	54	.116	.224	.326	.430	.533	.638	-	-	-	-
C32T26L	37	0.875	62	.072	.134	.195	.258	.322	.387	.449	.513	-	-

+Values represent maximum deflection at midspan


WORLD TRADE CENTER TRUSSES
C32T1 THRU C32T13
DEFLECTION PER 1000 LBS. TOTAL LOAD
TRUSSES* DEFL.
C32T6 .058"
C32T5, C32T12, C32T13 .100"
C32T2 .200"
C32T7, C32T8 .234"
C32T3, C32T9 .244"
C32T1 .259"
C32T4, C32T10, C32T11 .344"
* THE OVERALL LENGTH OF THE VARIOUS TRUSSES ARE AS FOLLOWS:
C32T5,6,12,13 35'-8"
C32T3,4,9,10,11 58'-10"
C32T1,2,7,8 59'-9"
C32T4,10,11
C32T1
C32T3,9
C32T7,8
C32T2
C32T5,12,13
C32T6
DEFLECTION AT MIDSPAN (IN.)
TOTAL LOAD (2P) IN POUNDS
LACLEDE STEEL COMPANY SAINT LOUIS, MISSOURI
DRAWING NO. NY-FTC-1
SUBJECT Graphical Comparison of Deflections for WTC-221.00 Trusses C32T1 thru C32T13
BY DBN
DATE 5-15-69
CHKD. BY
DATE

NOTES

(1) There are three different lengths of trusses tested. These three lengths are shown below along with the mark numbers of the trusses which have that particular length.

59'9"	58'11"	35'8"
C32T1A	C32T3	C32T5
C32T2A	C32T4	C32T6
C32T7A	C32T9	C32T12
C32T8A	C32T10	C32T13
C32T14AL	C32T11	C32T23L
C32T16AL	C32T21L	C32T26L

(2) Refer to this test number to obtain more information about the truss and the test results.

(3) Refer to S.H.C.R. drawing number 7-AB1-54 dated 2-15-68 and revised 11-25-68 which gives the camber at midspan for each type of 32" truss.

(4) Refer to Laclede Contract WTC-221.00 (October, 1967) pages TF1-2, 3, 4 and 21. Design loads were not given for trusses C32T14AL, 16AL, 21L, 23L and 26L. Their design loads were obtained from Gene Chorny of S.H.C.R.

(5) Two equal, concentrated loads were applied to each truss. Each load was applied at a panel point. The target load shown in the Table on page one is the magnitude of each applied concentrated load; the total load on the truss would be double this value. This target load is not the actual load at which the deflection listed below it occurs because the load cell reading in pounds does not equal the load applied to the truss by each hydraulic jack. The target load is very close to the actual load and is used for clarity in the table. The corresponding actual load for each target load is as follows:

Target Load	Actual Load
500	499.8
1000	999.6
1500	1499.8
2000	1999.2
2500	2499.0
3000	2998.8
3500	3498.6
4000	3998.4
4500	4498.2
5000	4998.0

For information on testing procedures, equipment used and positioning of loads for each truss, refer to Flexural Test Sheets Nos. 23 thru 40.

CC: R. D. Bay
J. R. Paul

September 7, 1967

A. C. WEBER

WORLD TRADE CENTER
SHEAR KNUCKLE TEST

Enclosed are Sheets 1 and 2 dated September 7, 1967.

Sheet 1 of 2 gives the results of transverse loading of shear knuckles. Lightweight concrete similar to the type to be used on the World Trade Center was used in this test. Specimen #2 (compressive strength of 2600 psi at 27 days) failed at 30,100#. Support brackets were not used on this test and rotation of the slabs obviously lowered the ultimate capacity. Specimen #1 had a 6 day compressive strength of 1330# and a total shear capacity of 37,070#. The side slabs were restrained from rotation on Specimen #1. The average shear transfer per knuckle for the two tests was 16,800#.

Sheet 2 of 2 gives the results of longitudinal loading of shear knuckles. Standard concrete (average strength of 3800 psi) was used in this test. The average maximum load resisted by five specimens was 55,230# or 27,615#/shear knuckle.

J. R. Paul

sak

Laclede Steel Company

General Offices, Arcade Building

St. Louis, Missouri 63101 August 10, 1967

Mr. Wayne Brewer
Skilling, Helle, Christiansen
and Robertson
230 Park Avenue
New York, New York 10017

Dear Wayne:

Shear Connectors
World Trade Center Floor Trusses

We are sorry that you could not get to St. Louis last Tuesday to witness some of the testing on the shear members and the application of the fireproofing to the painted open web trusses.

I presume Jim White has told you about the application of the insulating material on the joists which apparently worked very well.

In our conversation with the plastering contractor who handled the test application and the representatives of the Zonolite Division of the W. R. Grace Company, it seems that the loss because of the round webs was far less than they anticipated and total loss of material with the system as they applied it would be under 15%. This application involves less material than a solid section of the same dimensions and is no different from angle or structural section trusses attempted previously.

For your information, on the shear member testing we have averaged the bearing values for the shear members with 2,850 psi concrete and find that a 28,810# average value has been obtained with some running as high as 33,000#. This is well over the 17 kips we discussed and since the bearing of the shear members is solely a function of the concrete compressive strength, the 3,000# material you have specified for the World Trade Center towers should find excellent transference of top chord compression stresses to the floor slab. On one of the tests witnessed by Jim White of a six-day concrete with a strength of only 1,330 psi

DE STEEL COMPANY

Mr. Wayne Brewer
Skilling, Helle, Christiansen
and Robertson   Page 2   August 10, 1967

the loading across or normal to the shear members developed a 18,500# average value for shear connector bearing.

One of these specimens is being retained to 28 day strength although we are not too sure that the very lightweight mix will be developing much more than 1,800# to 2,000# in the concrete.

Dr. Galambos at Washington University who has been performing the Steel Joist Institute composite joist and truss tests, has told us, and I believe confirmed this to Jim White, that approximately the same shear value for the Laclede extended web connectors could be expected in all directions when the shear connector is attached in a normal concrete top slab. This means with the 3,000# concrete we could expect a 28 kips transference value across, as well as in line with the extended web panel point shear member.

As an aside, I believe Dr. Galambos told Jim White that in his tests he has had no measurable stress in the steel top chords of Laclede joists and trusses indicating that the shear members have been sufficiently good to take all the compression in the concrete top slab of the composite design.

We hope to be hearing from you shortly regarding sizing of members and the design of transverse trusses in the tower corners where it seems likely that shear members may be limited as you had planned it, to the primary floor trusses with transverse trusses furnished without extended web panel points.

Yours very truly,

LACLEDE STEEL COMPANY

Carl Weber

A. Carl Weber
Vice President

ACW:pjz

cc: Mr. Jim White
Skilling, Helle, Christiansen and Robertson

Mr. Lester Feld
Port of New York Authority

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers · *230 Park Avenue, New York, N. Y. 10017* · *Mu. 9-8874*

John B. Skilling · *Helge J. Helle* · *John V. Christiansen* · *Leslie E. Robertson*

Consultants
Harold L. Worthington
Joseph F. Jackson

April 19, 1968

Mr. R. M. Monti
Port of New York Authority
Office of the Construction
Manager – Room 1119
30 Church Street
New York, New York 10007

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Load Tests

Dear Ray:

Attached are load test sketches 1BV and 1BH dated 4/16/68, prepared by Laclede Steel Company.

The test pieces and procedures indicated on these sketches are acceptable for use in tests to establish the strength of the 24T to C32T truss connections, subject to the following additional requirements:

<u>Sketch 1BV</u>

1. C32T top chords 7"± apart.

2. Tests be conducted with weld X of 1/4"x3", 5/16"x3" and 3/8"x3".

3. Two sets of tests to be conducted –

   a. with "knuckle" restrained as shown on 1BV. (SHCR feels that a load cell can be substituted for the restraint shown, if practical.)

   b. without "knuckle" restrained. This will allow evaluation of the joint strength for the construction loading conditions.

WAYNE A. BREWER
P. R. A. FOSTER
FRANK HOELTERHOFF
ROBERT E. LEVIEN
V. A. PRISADSKY
KENT R. ROGERS
CHARLES RANDUSKY
WILLIAM D. WARD
E. J. WHITE, JR.
LORENTS L. WIDING

SEATTLE OFFICE: 1040 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

WTCI-87-I

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

Mr. R. M. Monti April 19, 1968

Sketch 1BH

1. Tests to be conducted with weld X of 1/4"x3", 5/16"x3" and 3/8"x3".

2. Load to be applied 1/2" from top of angle (center of gravity).

3. Support of C32T web members close to top chord, as shown on 1BH, will require test results to be adjusted for the flexibility of these web members. We understand that this support location is limited by the test machine size. This location of the support will, however, allow an evaluation of the lateral bending of the vertical leg of C32T top chord angle, and is therefore acceptable.

Except for weld X sizes to be tested, these additional requirements were discussed with Carl Weber by telephone on 4/18/68. Information in boxes on 1BV and 1BH was added by SHCR.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Wayne A. Brewer

WAB:s
cc: Messrs. A. C. Weber, B. Bay, Laclede
Mr. L. S. Feld, PNYA
Mr. A. J. Guttentag, TRCC

Enclosure

CC: T. M. Chura
D. B. Neptune
File Copy

March 18., 1969

R. D. BAY

RE: TESTS FOR BEARING CAPACITY OF WORLD TRADE CENTER TRUSSES

The attached sheets summarize the tests conducted Friday, March 7 at the Madison plant. These tests are broken down into two groups. Group No. 1 consists of seven (7) tests on various bearing ends of scrapped trusses to determine the bearing capacity of our World Trade Center trusses. The results of these tests are on page one while a general sketch of how the bearing end was tested is shown on page three (Figure 1). The following is a summary of the test results:

1. Only one test resulted in a broken weld and this was at a load 18K greater than the load which caused the initial bending of the angles.
2. Using a 2" plate instead of a 4" plate for the bearing surface results in a more critical loading condition and an earlier angle deformation.
3. The core end withstands a greater load before failure than the column end. This can probably be attributed to a smaller L/R ratio and a more compact section.
4. Arc welding the bottom of the vertical VI strut decreases the possibility of a weld failure. The failure which occurs is then a failure of the bearing angle which begins to deform noticeably at approximately 30K.

Group No. 2 consists of four (4) tests on bearing ends having only arc welding joining the web and angles together; i.e., no resistance welding was used. The purpose of these tests was to determine the strength of repaired bearing ends that would be welded onto our trusses at the jobsite. Two types of tests were performed. The first type of test shown in Figure 2-A, page 4 tested the capacity of the end as a unit. The second type of test shown in Figure 2-B, page 4 tested the strength of each joint in the bearing end. The results of these tests seem to indicate that those bearing ends arc welded to the trusses at the jobsite will be strong enough to support the required load if the welding is performed by a qualified welder under good supervision.

David B. Neptune

ds

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu. 9-8874

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

November 3, 1969
File: WTC-235C

Mr. Lester S. Feld
Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York, New York 10011

Reference: The World Trade Center
Contract WTC-235.00, Bethlehem Fabricators
Stud Shear Connector Capacity with Rollform Type "B" Steel Deck

Dear Lester:

At your request, we are forwarding to your attention the following information regarding a test program to establish the capacity of 3/4 inch diameter by 4½ inch long stud shear connectors when welded through the valleys of Rollform Type "B" steel deck.

Two 15 foot long test beams conforming to Attachment #1 are required. During the testing operation, the load-deflection and load-slip behavior for each beam should be determined using three (3) 0.001 dial gages and eight (8) SR-4 type A-1 strain gages in accord with Attachment #3.

Load should be applied in 4 kip increments and readings at all gages should be recorded before the next increment of load is applied.

Six 4'-3" long pushout specimens are required in accord with Attachment #2, four (4) with steel deck and two (2) with solid slabs. The load-slip behavior of each specimen should be determined by using two (2) 0.001 inch dial gages, one for each pushout slab. Dial gages should be mounted as shown in Attachment #2, and readings should be recorded for each 4 kip increment of loading.

Lightweight concrete required for the test specimens and test cylinders will amount to approximately 85 cubic feet. We recommend use of Nytralite lightweight aggregate, Master Builders Pozzolith 100R and MBVR, and Type III (high-early) cement of the brand on hand at the local ready mix concrete source chosen to supply the 110 pound (air dry weight) f'c = 3000 psi concrete for the test specimens.

ROBERT E. LEVIEN
PAUL S. A. FOSTER
FRANK HOELTERHOFF
KENT H. ROGERS
CHARLES A. BANDUSKY
WILLIAM D. WARD
E. J. WHITE, JR.
LORENTS L. WIDING

RICHARD CHAUNER
ERNEST T. LIU
JOSTEIN NES
V. A. PRISADSKY
HAROLD D. ROST
RICHARD E. TAYLOR

SEATTLE OFFICE 1040 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

Port of New York Authority
Attention: Mr. Lester Feld -2- November 3, 1969

The recommended concrete mix is as follows:

Cement (Type III)	540 #
Sand*	1275 #
Lightweight Aggregate** (3/4" to #4)	900 #
Admixture	Pozzolith 100R 24 oz. MBVR 3 to 5 oz.
Water	36 gallons
Air Content	6 per cent

* Natural sand, fineness modulus 2.40 to 2.70, specific gravity of 2.65 assumed.
** Nytralite aggregate, specific gravity of 1.45 assumed.

Based on the above, a minimum of 3000 pounds of Nytralite aggregate will be required. Barring unforeseen events, Nytralite could provide aggregate at the test location upon three (3) days notice. Pozzolith 100R and MBVR are available upon a notice of one or two days.

Regarding concrete test cylinders, the following number of cylinders should be provided for each batch of concrete used to fabricate pushout and beam test specimens:

4 - 6 x 12 cylinders - test at three (3) days
4 - 6 x 12 cylinders - test at seven (7) days
4 - 6 x 12 cylinders - test on day of pushout tests
4 - 6 x 12 cylinders - tensile splitting tests per ASTM-A496

2 - 6 x 12 cylinders-air dry weight-cure seven (7) days moist, then dry 21 days at 73.4±2 degrees fahrenheit, 50 ± 2 percent humidity.

Regarding mechanical properties of the 12WF 27 test beam members, two tensile coupons should be taken from the bottom flange of each test beam centered from the web and centered on the quarter span point. Two tensile coupons should be taken from the web of each test beam at mid-height of the web, with one coupon centered on the quarter point of each beam. The test coupons should conform to ASTM A307, Figure 4, and should be longitudinal specimens.

Mechanical properties of four (4) 3/4 inch diameter by 4 1/2 inch long stud shear connectors should be determined in accord with AWS D1.0-69, Section 430.

The remaining specifics regarding fabrication and testing of materials and stud shear connector test specimens can be finalized at meetings with the Bethlehem Fabricators and the personnel at the testing facility.

Very truly yours,
SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

James White
JW:ans

THE PORT OF NEW YORK AUTHORITY
111 Eighth Avenue at 15th Street New York, N.Y. 10011

World Trade Department

Guy F. Tozzoli, Director   Telephone (212) [illegible]

CONFORMED COPY

January 6, 1970

Fritz Engineering Laboratory
Lehigh University
Bethlehem, Pennsylvania 18015

Attention: Professor Roger G. Slutter
Chairman, Operations Division

Re: THE WORLD TRADE CENTER - Contract WTC-721.00
Laboratory Services - Stud Shear Connector
Capacity with Roll Form Type "B" Steel Deck

Gentlemen:

I. The undersigned, The Port of New York Authority (hereinafter called the "Authority") hereby offers to retain the Fritz Engineering Laboratory (hereinafter called the "Laboratory") to perform stud shear connector capacity tests using Roll Form Type "B" steel deck for The World Trade Center being constructed by the Authority in New York City including:

A. All tests as outlined in the attached letter of November 3, 1969 from Mr. James White of Skilling, Helle, Christiansen, Robertson to our Mr. Lester S. Feld.

B. Supervision of installation of deck and studs on steel specimens.

C. Furnishing of concrete forms, reinforcing steel, Type III Cement, sand and water for all concrete slabs and specimens.

D. Casting and curing of concrete slabs and specimens.

E. Submittal of six (6) copies of the Test Report to the Authority to the attention of Mr. Malcolm P. Levy, Chief of Planning and Construction Division, The World Trade Center, Room 300, 111 Eighth Avenue, New York, New York 10011.

II. The Authority has arranged for the following items to be furnished by others and delivered to the Laboratory by November 19, 1969:

A. Two (2) 15 foot long test beams with steel deck and studs installed by others prior to delivery.

B. Four (4) 4'-3" long pushout specimens with steel deck and studs installed on both flanges by others prior to delivery.

C. Two (2) 4'-3" long pushout specimens with studs installed on both flanges by others prior to delivery.

D. Approximately 3000 pounds of Nytralite Light-weight Aggregate.

E. Approximately two gallons of Master Builders Pozzolith 100R and MBVR for use as admixture.

III. As full compensation for the performance of all your obligations herein, the Authority agrees to pay the Laboratory the sum of the following amounts:

(a) A unit price of $2000.00 per 15 foot beam test for each of the two beam tests required.

(b) A unit price of $400 per pushout tests for each of the six required pushout tests.

The Laboratory shall not perform any services beyond the point at which the total payments to be made hereunder exceeds $6400.00, unless expressly authorized by the Director to perform such services in a writing which expresely recognizes that said amount of $6400.00 will be exceeded. In the event said writing specifies a maximum total amount for services hereunder, this Agreement shall be deemed amended to substitute said amount for the aforesaid amount of $6400.00.

IV. Within 15 days after the receipt from the Laboratory of the Test Report, the Director will estimate and certify to the Authority the amount of compensation due to the Laboratory. The Authority will within fifteen (15) days after the date of such certification of the Director advance to the Laboratory, by check, the sum certified.

V. No certificate or payment shall at any time preclude the Port Authority from showing that such certificate or payment was incorrect or from recovering any money paid in excess of that lawfully due.

VI. The Laboratory shall not issue or permit to be issued any releases, advertisements, or literature of any kind which refer to

THE PORT OF NEW YORK AUTHORITY

Fritz Engineering Laboratory - 3 - January 6, 1970

the services performed hereunder, unless you first obtain the written approval of the Authority. Such approval may be withheld if for any reason the Director, in his sole discretion, believes that the publication of such information may be harmful to the public interest or in any way whatsoever undesirable.

VII. The Laboratory shall promptly and fully inform the Director of any patents or disputes, whether existing or potential, of which you have knowledge, relating to any idea, design, method, materials, equipment, or other matter involved in the services hereunder.

VIII. All drawings, specifications, reports, computations, records, data, charts, documents or other papers, or any type whatsoever, whether in form of writing, figures or delineations, which are prepared by the Laboratory at any time, either prior or subsequent to signature of this Agreement, by the Authority, its Commissioners, officers, agents or employees, is not given in confidence and may be used or disclosed by or on behalf of the Authority without liability of any kind.

IX. All information of any nature whatsoever which is in any way connected with the services performed in connection with this Agreement, regardless of the form of communication which has been or may be received from the Laboratory at any time, either prior or subsequent to signature of this Agreement, by the Authority, its Commissioners, officers, agents or employees, is not given in confidence and may be used or disclosed by or on behalf of the Authority without liability of any kind.

X. Under no circumstances shall the Laboratory communicate in any way with any department, board, agency, commission, or other organization whether governmental or private in connection with the services to be performed hereunder except upon prior written approval and instructions of the Director provided, however, that data from manufacturers and suppliers of materials shall be obtained by you when and as you find such data necessary, unless otherwise instructed by the Director.

XI. This Agreement being based upon your special qualifications for the services herein contemplated, any assignment or other transfer of this Agreement or of any part hereof or of any monies due or to become due hereunder without the express consent in writing of the Director shall be void and of no effect as to the Authority.

XII. The Director, at his option, may, at any time, and with or without cause, terminate this Agreement as to any services not yet rendered. The Laboratory shall have no right of termination as to services under this Agreement without just cause. Termination by either party shall be by registered letter addressed to the other at its address hereinbefore set forth. Should this Agreement be so terminated, Fritz Engineering Laboratory - 4 - January 6, 1970

the Laboratory shall receive no compensation for any services not performed, and the Laboratory shall be paid as full compensation for services performed an amount computed as above set forth.

XIII. This Agreement shall be effective as of November 14, 1969. All of the services hereunder shall be performed as expeditiously as possible. The services shall in any case be completed on or about February 1, 1970. Time is of the essence of performance of all your services under this Agreement.

Any services performed for the benefit of the Authority by the Laboratory at any time, if expressly and duly authorized by the Director, shall be deemed to be rendered under and subject to this Agreement (unless referrable to another express, written, duly executed agreement), and no rights or obligations shall arise out of such services except as may be provided for under this Agreement.

XIV. The entire Agreement between us is contained herein and no change in or modification, termination or discharge of this Agreement in any form whatsoever shall be valid or enforceable unless it is in writing and signed by the party to be charged therewith in the manner hereinbefore expressly provided shall be effective as so provided.

If the foregoing meets with your approval, please indicate your acceptance by signing the enclosed copy of this letter in the lower left-hand corner and returning it to the attention of Mr. Malcolm P. Levy, Chief, Planning and Construction Division, The World Trade Center, Room 300, 111 Eighth Avenue, New York, New York 10011.

Very truly yours,

THE PORT OF NEW YORK AUTHORITY

Guy F. Tozzoli

Guy F. Tozzoli, Director
World Trade Department

FRITZ ENGINEERING LABORATORY
LEHIGH UNIVERSITY

By R. G. Slutter

Title Director, Operations Division

Date January 21, 1970

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Appendix C
SUPPORTING DOCUMENTS FOR CHAPTER 4

This appendix contains the supporting documents that are referenced in Chapter 4 of this report. All of the documents contained in this appendix are reproduced with permission of The Port Authority of New York and New Jersey. Table C–1 contains a summary of supporting documents and their location within this appendix. The footnote numbers given in the table correspond to those in Chapter 4.

Table C–1. Supporting documents for Chapter 4.

Footnote Number	Document Title	Page(s)
1	Memorandum of Understanding Between the New York City Department of Buildings and the PANYNJ, 1993	216
2	Supplement to Memorandum of Understanding Between the New York City Department of Buildings and the PANYNJ, 1995	221

THE PORT AUTHORITY OF NY & NJ

One World Trade Center
New York, New York 10048

Law Department

Jeffrey S. Green
General Counsel

Lawrence S. Hofrichter, Chief
Finance Division
(212) 435-6220
(201) 961-6600 x6220

November 5, 1993

THE PORT AUTHORITY OF N.Y. & N.J.
TENANT CONSTRUCTION REVIEW UNIT
RECEIVED
NOV 09 1993
NOTED__________
REFERRED TO__________

Charles G. Sturcken, Deputy General Counsel
The New York City
Department of Buildings - Executive Offices
60 Hudson Street
14th Floor
New York, New York

Dear Mr. Sturcken:

Enclosed please find a fully executed original of the Memorandum of Understanding between the Port Authority and the New York City Department of Buildings.

For your information, the gubernatorial review period for the enclosed agreement will end at midnight Wednesday, November 17, 1993. It has been a pleasure working with you on this matter.

Very truly yours,

Walter M. Frank
Deputy Chief, Finance Division
Law Department

Enclosures

cc: William H. Goldstein, Deputy Executive Director, Capital Programs

bcc: J.S. Green, P.S. Cooper (51N), A.A. DiNome (68S), E.J. Fasullo (72S), L.S. Hofrichter, F.J. Lombardi (72S), C.J. Maikish (35E), A.J. Raiola, S.T. Van de Walle

MEMORANDUM OF UNDERSTANDING BETWEEN THE NEW YORK CITY DEPARTMENT OF BUILDINGS AND THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

This Memorandum shall govern the relationship between the New York City Department of Buildings (the "Department") and the Port Authority of New York and New Jersey (the "Port Authority"), both parties entering into this agreement with the intention to establish procedures to be followed by the Port Authority for any building construction project ("Project"), to be undertaken by the Port Authority or any of its tenants at buildings owned or operated by the Port Authority and located in the City of New York (the "City), to assure conformance of Projects at such buildings with the standards set forth in the New York City Building Code (the "Code").

While the facilities of the Port Authority, an agency of the States of New York and New Jersey, are not technically subject to the requirements of local building codes, the long-standing policy of the Port Authority has been to assure that its facilities meet and, where appropriate, exceed Code requirements.

The purpose of this Memorandum is not only to restate that long-standing policy as part of an understanding with the City but to provide specific commitments to the Department, as the agency of the City responsible for assuring compliance with the Code, regarding procedures to be undertaken by the Port Authority for any Project at its facilities in the City to assure that the buildings owned or operated by the Port Authority within the City are in conformance with the Building Standards contained in the Code.

Accordingly, the Department and the Port Authority hereby agree as follows:

1. Port Authority Review. To assure conformance with the building standards set forth in the Code at the time of the design and construction of any Project, the Port Authority shall, in the case of each Project, thoroughly review and examine all plans in connection with such Project for conformance with the building standards set forth in the Code. Plans prepared for Projects to be undertaken by Port Authority tenants shall be prepared and sealed by a New York State licensed professional engineer or architect retained or employed by tenant; plans prepared for Projects to be undertaken by the Port Authority shall be prepared by a New York State licensed professional engineer or architect employed or retained by the Port Authority. The Port Authority's examination of plans shall be conducted by New York State licensed architects and engineers retained or employed by the Port Authority. The Port Authority engineer or architect approving the plans for any Project from the standpoint of Code conformance shall be a New York State licensed architect or engineer who shall not have assisted in the actual preparation of such plans.

2. Project File. The Port Authority shall maintain a file (the "Project File") for each Project which file shall at all times contain the most recently

1

prepared drawings, plans and any other documents required in connection with the review of the Project from the standpoint of Code conformance. In the case of any Project being effectuated by a tenant of the Port Authority (a 'Tenant Project') such file shall also include the Tenant Alteration Application prepared by the Tenant. In the case of any project administered by a line department of the Port Authority, such file shall include any construction application prepared in connection with such Project. The Line Departments of the Port Authority are currently its World Trade, Aviation, Interstate Transportation, Port, and Regional Development Departments.

3. Project Certification. For each Tenant Project, the Port Authority shall require the Tenant to obtain the certification of a New York State licensed architect or engineer that such Project was constructed in accordance with the approved plans and specifications for such Project. For any Project effectuated by the Port Authority, the Chief Engineer or his successor in duties shall certify that the Project was constructed in accordance with the approved plans and specifications for the Project. Certifications for each Project shall be maintained in the Project File.

4. Copies of Project File. The Department may at any time request the Port Authority to provide it with a copy of any Project File and the Port Authority shall promptly provide a copy of the Project File to it.

5. Variances. The Port Authority shall promptly advise the Department of any Project approved by the Chief Engineer of the Port Authority which involves, in the judgment of the Chief Engineer of the Port Authority or his successor in duties, a variance from the clear requirements of the Code. In the event that the Department disagrees with the manner in which questions of Code conformance have been or are proposed to be dealt with in connection with such Project, it may so advise the Authority. The Port Authority shall seek expeditiously to resolve the matter. Any matter of Code conformance in connection with such Project which the Department believes involves an unacceptable variance from the requirements of the Code shall be subject to the further review of the Port Authority Board of Commissioners. The Commissioners shall be advised of the Department's views on the matter.

6. Inspections and Surveys. The Port Authority shall continue to conduct or cause to be conducted all building inspections, during both construction and post-construction periods, required under the Code. In addition, the Port Authority will continue to perform structural integrity inspections on a cyclical basis for all of its structures located in the City.

7. Port Authority Responsibility. As indicated above, the purpose of this Agreement is to set forth certain basic understandings between the Department and the Port Authority. It is understood, however, that the Port Authority with its tenants shall continue to bear the responsibility for life safety in buildings at its facilities and nothing in this Agreement is intended to impose any obligations of inspection or review on the Department. The Department shall refer back to the Chief Engineer of the Port Authority any requests for

2

information or interpretation which it may receive from tenants of the Port Authority with respect to any Project.

8. No Personal Liability. No Commissioner, officer, agent or employee of the Port Authority or the Department shall be held personally liable under any provision of this Agreement or because of its execution or attempted execution or because of any breach or alleged breach thereof.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be signed, sealed and attested.

ATTEST:

Secretary

DATE: 11/3/93

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

By: Stanley Brezenoff
Executive Director

ATTEST:

FRANK M. SCHWARTZ
Notary Public, State of New York
No. 41-4632586
Qualified in Queens County
Commission Expires January 31, 19 95

DATE: 10/28/93

THE NEW YORK CITY DEPARTMENT BUILDINGS

By: Stewart D. O'Brien
Acting Commissioner

3

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

Commercial Litigation Division (68E)

Memorandum

Chief ... 's Office

Received ___ Date Out 10/1...

To: J... Lombardi

Action

☐ Please ...

☐ Prepare ... signature

☐ Review and ...

☑ For your ...

Comments

Dirisi... + Ingro

OCT 18 A11 : 02

TO: Lysa Meduri, Acting Secretary

FROM: Walter M. Frank

DATE: October 16, 1995

SUBJECT: Transmittal of Letter Agreement - NYC Department of Buildings

Copy to: J. Green, N. Chanfrau, P. Cooper, W. Goldstein, H. Henschel, F. Lombardi

Transmitted for the official records of the Port Authority is a Letter Agreement between the Port Authority and the New York City Department of Buildings providing for a change to the recent Supplement to the Basic Memorandum of Understanding between the Department and the Port Authority in connection with the Port Authority's Tenant Self-Certification Program at the World Trade Center.

Walter M. Frank
Deputy Chief
Commercial Litigation Division

WMF:gk

Encl.

THE PORT AUTHORITY OF NY & NJ

One World Trade Center
New York, N.Y. 10048

William H. Goldstein
Deputy Executive Director
Capital Programs
(212) 435-8415
(201) 961-6000 x8415

September 15, 1995

Honorable Joel A. Miele, Sr., Commissioner
Department of Buildings
City of New York
60 Hudson Street
New York, New York 10013

Dear Commissioner Miele:

As you know, the Port Authority of New York and New Jersey (the "Port Authority") and the New York City Department of Buildings (the "Department") recently executed a supplement (the "Supplement") to the Memorandum of Understanding between the Department and the Port Authority to provide that the Port Authority's tenant at the World Trade Center could, in lieu of any review by the Port Authority, use New York State licensed architects or engineers meeting qualifications to be established by the Port Authority to: (A) prepare and review such tenant's plans for the construction of any project and certify that such plans conform with the building standards set forth in the New York City Building Code and (B) certify that such project has been constructed in accordance with the approved plans and specifications for such project.

As you also know, the Supplement provides that the person or firm performing the review and certification described in (A) above shall not be the same person or firm providing the certification described in (B) above. A copy of the Supplement is attached.

This letter will-confirm the agreement of the Port Authority and the Department that, notwithstanding the last sentence of paragraph 1 of the Supplement, a single licensed consultant may make both certifications described in (A) and (B) of such paragraph, except where the alteration would change the character of the occupancy group under paragraph 27-237 of the New York City Building Code which would have been applicable to such space had such space been located in a privately owned building.

If the foregoing meets with your approval, please be good enough to sign this letter on behalf of the Department where indicated below and return one of the originals to me. In light of the fact that three originals of the Supplement were furnished to the Department, we have, for your record purposes, executed in total four originals of this letter.

Very truly yours,

William H. Goldstein
Deputy Executive Director
Capital Programs

THE NEW YORK CITY DEPARTMENT OF BUILDINGS

AGREED

BY: ______________________
Commissioner

SUPPLEMENT TO MEMORANDUM OF UNDERSTANDING BETWEEN THE NEW YORK CITY DEPARTMENT OF BUILDINGS AND THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

In November, 1993 the New York City Department of Buildings (the "Department") and the Port Authority of New York and New Jersey (the "Port Authority") entered into the attached Memorandum of Understanding (the "Memorandum") establishing certain procedures for the purpose of helping to assure conformance of construction projects to be undertaken at buildings owned or operated by the Port Authority in New York City with the standards set forth in the New York City Building Code.

Recently, the Department implemented its own optional plan review system providing for professional certifications of applications and plans and subsequent construction work falling under its jurisdiction.

The purpose of this Supplement to the Memorandum is to provide under the Memorandum for the adoption by the Port Authority of a procedure under which any Port Authority tenants at the World Trade Center may utilize New York State licensed architects or engineers to certify, in lieu of any review by the Port Authority, that (i) the tenant's construction plans are in conformance with the standards set forth in the New York City Building Code, and (ii) construction has been performed in accordance with such plans, it being understood that the persons making the certifications described in (i) and (ii) shall not be the same.

Accordingly, the Department and the Port Authority hereby agree that the Memorandum is amended as follows:

1. Professional Certification. Notwithstanding anything to the contrary in the Memorandum, the Port Authority may, in lieu of any reviews or certifications by the Port Authority provided for in the Memorandum, provide procedures pursuant to which its tenants at the World Trade Center may utilize New York State licensed architects or engineers meeting qualifications to be established by the Port Authority to (A) prepare and review such tenant's plans for the construction of any project and certify that such plans conform with the building standards set forth in the New York City Building Code and (B) certify that such project has been constructed in accordance with the approved plans and specifications for such project. The person or firm performing the review and certification described in (A) above shall not be the same person or firm providing the certification described in (B) above.

2. Other Provisions. Except as provided herein, all the terms and conditions of the Memorandum shall remain in full force and effect.

3. No Personal Liability. No Commissioner, officer, agent or employee of the Port Authority or the Department shall be held personally

liable under any provision of this Supplement or because of its execution or attempted execution or because of any breach or alleged breach thereof.

IN WITNESS WHEREOF, the parties hereto have caused this Instrument to be signed, sealed and attested.

ATTEST:

SECRETARY

DATE: 6/7/95

THE PORT AUTHORITY OF NEW YORK AND NEW JERSEY

By: ______________________
Executive Director

WITNESS:

FRANK M. SCHWARTZ
Notary Public, State of New York
No. 41-4632586
Qualified in Queens County
Commission Expires Jan. 31, 19 97

DATE: 6/1/95

THE NEW YORK CITY DEPARTMENT OF BUILDINGS

By: ______________________
Commissioner

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Appendix D
SUPPORTING DOCUMENTS FOR CHAPTER 5

This appendix contains the supporting documents that are referenced in Chapter 5 of this report. All of the documents contained in this appendix are reproduced with permission of the The Port Authority of New York and New Jersey. Table D–1 contains a summary of supporting documents and their location within this appendix. The footnote numbers given in the table correspond to those in Chapter 5.

Table D–1. Supporting documents for Chapter 5.

Footnote Number	Document Title	Page(s)
	Section 5.3 – Damping Units	
2	Letter dated July 16, 1964 from Alan G. Davenport of WSHJ to Carl A. Dahlquist of 3M (WTCI-450-L)	226
3	Letter dated November 23, 1964 from Richard D. Steyert of WSHJ to Carl A. Dahlquist of 3M (WTCI-450-L)	227
5	Internal correspondence dated February 1966 by Richard D. Steyert of WSHJ (WTCI-450-L)	231
7	Letter dated October 31, 1966 from Don Caldwell of 3M to James White of WSHJ (WTCI-501-L)	232
8	Letter dated October 30, 1967 and enclosure from Leslie E. Robertson of SHCR to John H. Kyle (Chief Engineer), PONYA (WTCI-501-L)	240
10	Letter dated April 4, 1969 from Leslie E. Robertson of SHCR to Malcolm P. Levy of PONYA (WTCI-501-L)	248
11	"Specification for Viscoelastic Damping Units" dated October 6, 1969 (PONYA 1969) (WTCI-501-L)	252

WORTHINGTON, SKILLING, HELLE & JACKSON

Consulting Civil and Structural Engineers • 1801 Washington Bldg., Seattle, Wash. 98101 • Ma. 3-7223

Harold L. Worthington • John B. Skilling • Helge J. Helle • Joseph F. Jackson • John V. Christiansen

July 16, 1964

Mr. Karl Dahlquist
3-M Company
Minnesota Mining and Manufacturing Company
2501 Hudson Road
Minneapolis, Minn.

Reference: Viscoelastic Damping Material

Dear Mr. Dahlquist:

We have an important requirement for a viscoelastic material suitable for damping low frequency mechanical vibrations. It is proposed that this material shall be used in a sandwich between two surfaces and the load will be applied to the damping material by shear. The frequency of vibration is in range 0.1 - 1.0 cycles per second. The operational temperature range will be 0° F - 80° F. It will have a chemical and mechanical stability such that its action is unimpaired over the course of many years.

We would be grateful if you could suggest what range of materials might be available for such a purpose, their approximate cost and all their pertinent mechanical properties. We have a hunch that an asphaltic or rubber based material might be suitable.

We require to know the storage and loss moduli (c.f. p. 36-18 of "Shock and Vibration Handbook" by Harris and Crede, McGraw-Hill, 1959) over the above operating temperatures and frequencies. (We are looking for a material with a loss modulus probably of the order of 10^4 lb/sq. in.) We would also like to know the chemical composition of the material and its melting point.

If the material is adopted it will be used in considerable quantities. We would be grateful, therefore, if you would also indicate approximately bulk costs and availability. Your early reply to this inquiry will be appreciated.

Yours very truly,

Alan G. Davenport Ph.D.

AGD:ab

COPY

FRANK HOELTERHOFF
ROBERT S. LEVIEN
V. A. PISADORY
LESLIE ROBERTSON
CHARLES LANDBURY
WILLIAM J. WARD
LORENTS L. WEIDING

A WASHINGTON CORPORATION FURNISHING ENGINEERING SERVICES BY AND UNDER THE SUPERVISION OF REGISTERED PROFESSIONAL ENGINEERS

WORTHINGTON, SKILLING, HELLE & JACKSON

Consulting Civil and Structural Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

Harold L. Worthington • John B. Skilling • Helge J. Helle • Joseph F. Jackson • John V. Christiansen • Leslie E. Robertson

November 23, 1964

Mr. C. A. Dahlquist
Minnesota Mining and Manufacturing Company
2501 Hudson Road
Minneapolis, Minnesota

Reference: Viscoelastic Damping Material

Dear Mr. Dahlquist:

Thank you for the information which you provided during our phone conversation of November 11. We have enclosed a sheet which lists the types of viscoelastic damping materials and the properties desired. We have also enclosed a sheet which reviews the properties of the #466 Transfer Tape.

We would greatly appreciate any information which you would be able to provide on other materials produced by the Minnesota Mining and Manufacturing Company. Such information would be appreciated at your earliest convenience.

COPY

Sincerely yours,

WORTHINGTON, SKILLING, HELLE & JACKSON

Richard D. Stoyert

cc: Mr. Caldwell

RDS:cd

P. S. A. FOSTER
FRANK HOELTERHOFF
ROBERT K. LEVIEN
V. A. PRISADSKY
KENT D. ROGERS
CHARLES SANDUSKY
WILLIAM D. WARD
E. J. WHITE, JR.
LORENZ L. WIDING

SEATTLE OFFICE: 1840 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

WORTHINGTON, SKILLING, HELLE & JACKSON

Consulting Civil and Structural Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

Material: #466 Transfer Tape

Producer: Minnesota Mining and Manufacturing Company

Parameters: G_2 from 200 to 300

from 1.2 to 1.5

t = .0015 in.

Max $\stackrel{\circ}{=}$ 20

Cost: $1.52 to $2.00/sq. yd.

Additional Properties: Bonds to steel, wood, or concrete

COPY

Call To Mr. Dahlquist Nov. 10
Gen. Office 700 Grand Ave, Ridgefield N.J.

WORTHINGTON, SKILLING, HELLE & JACKSON

Consulting Civil and Structural Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

Physical & Mechanical Properties Required of Visco-Elastic Material

1. Type A. Ease of placement into void either by pouring or pumping under pressure and/or heat and capable of bonding to concrete, steel or wood.

   Type B. Available in sheets.

2. A high degree of durability and stability under normal operating conditions for extended periods. (It is possible that the containing space can be sealed hermetically.)

3. Non-combustible.

Parameters Desired

1. Loss of modulus in shear, G_2 $10^2 - 10^5$
   Loss factor , $n = G_2/G_1$
   for temperature range $30^\circ - 80^\circ$ F.
   vibration frequency .1 - 1.0 cycles/second.

2. Stress or strain or fatigue limitations. Thermo Plastic Low

3. Cost.

Note: Quantities to be used 1,000 c. f. plus or minus by a factor of 10.

Adhesive — # 466 Transfer. Tape
Pressure Sensitive, on high contact
Boughton tape.
Comes on line
.03" Usually
1½ Thousands
$\epsilon \simeq 20$ @ 30° $G_2 \simeq 200 - 300$
Cntr. $n = 1.2, 1.5$
Very Smooth 1 thousands
Use AC Bond Tape

c. 1.52 To 2.00 / yd²

WORTHINGTON, SKILLING, HELLE & JACKSON	THE WORLD TRADE CENTER THE PORT OF NEW YORK AUTHORITY	DATE II.66	Sheet No.
	MINORU YAMASAKI & ASSOC. EMERY ROTH & SONS	PREPARED BY RPS	
Civil & Structural Engineers	MINORU YAMASAKI, ARCHITECT RICHARD ROTH, ARCHITECT	APPROVED	

<u>REVIEW OF STATUS OF DAMPING WORK DONE BY R. STEYERT</u>

<u>Work done prior to Nov. '65</u>

Well ordered and filed

<u>Work done subsequent to Nov '65</u>

Not yet ordered

<u>Key calculations of interest</u>

On truss $\frac{WD}{4}\big|40$ to $\frac{WD}{4}\big|44$ and $\frac{WD}{4}\big|49$

<u>Note:</u> Although I have cross checked this work sufficiently to feel it is consistent with the assumptions made, these few pages should be carefully checked and understood by someone else. The work is of a simple nature, not involving the computer.

On column $\frac{WD}{2}\big|25$ to $\frac{WD}{2}\big|29$

<u>Note:</u> I have checked this work, but not extensively. There appears to be a discrepancy between Dick Taylor's work and my work in this area. The work is of a simple nature, not involving the computer.

...CTON, SKILLING, ...LE & JACKSON ...ivil & Structural Engineers	THE WORLD TRADE CENTER THE PORT OF NEW YORK AUTHORITY	DATE II. 66	Sheet No.
	MINORU YAMASAKI & ASSOC. — MINORU YAMASAKI, ARCHITECT · EMERY ROTH & SONS — RICHARD ROTH, ARCHITECT	PREPARED BY RDS	
		APPROVED	

Contact with 3M-Company

There has been a long series of calls over the past months. Contact has been with Don Caldwell and Alex Donaldson. There is a file of notes on these conversations. Dick Taylor has been in on all recent conversations. The general status is the following:

Initial tests for selection of visco-elastic material have been completed. The material tentatively selected has $G' = 445$ psi, $\eta = .63$ @ $T = 10$ sec. @ 23°C.

Initial cost estimates were made and revised. Initially truss damper unit was $75. and column damper $65. As revised, Truss damper is $65. and column damper $55.

Testing of an assembled truss damping unit has been completed and results agree with theoretical predictions. We should now review our design of the damper unit and forward this design to 3-M. 3-M is anxiously awaiting a go-ahead on the column damping system. At present they are up in the air about our intentions. They also are quite anxious to get suggestions from us on a testing program for the column unit. I should think a visit from our office would be helpful to facilitate an exchange of information and to maintain 3-M interest in the project.

3M is interested in a fatigue study of the damper unit to be done by an independent laboratory. The cost may be a few thousand dollars. Who assumes these costs must be clarified

3M COMPANY

GENERAL OFFICES • 2501 HUDSON ROAD • ST. PAUL, MINNESOTA 55119 • 111 733-1110

Industrial Tape Division

October 31, 1966

Mr. James White
Worthington, Skilling, Helle & Jackson
230 Park Avenue
New York, New York 10017

Dear Jim:

The paragraphs below contain our proposal for the qualification section of the specification, a revised Acceptance Testing and Sampling Plan and a section on the burning and melting of the visco-elastic material. In addition, confirming our telephone conversation of 10/4, we agree to loosen the location tolerance of the four corner holes in the T-Sections from ± 1/64" to ± 1/32". Our Engineering Department is producing revised drawings which will be sent to you when complete.

Substitute the following paragraphs for section three entitled "Qualification of Dampers" that was contained in the rough specification outline given you at the time of your visit:

"A damper may be qualified by presentation of data gathered from tests of at least one damping unit. The tests must be conducted according to the following procedure and meet the requirements listed in this specification. Report the values in sections 9, 10, 11 and 14

MINNESOTA MINING AND MANUFACTURING COMPANY

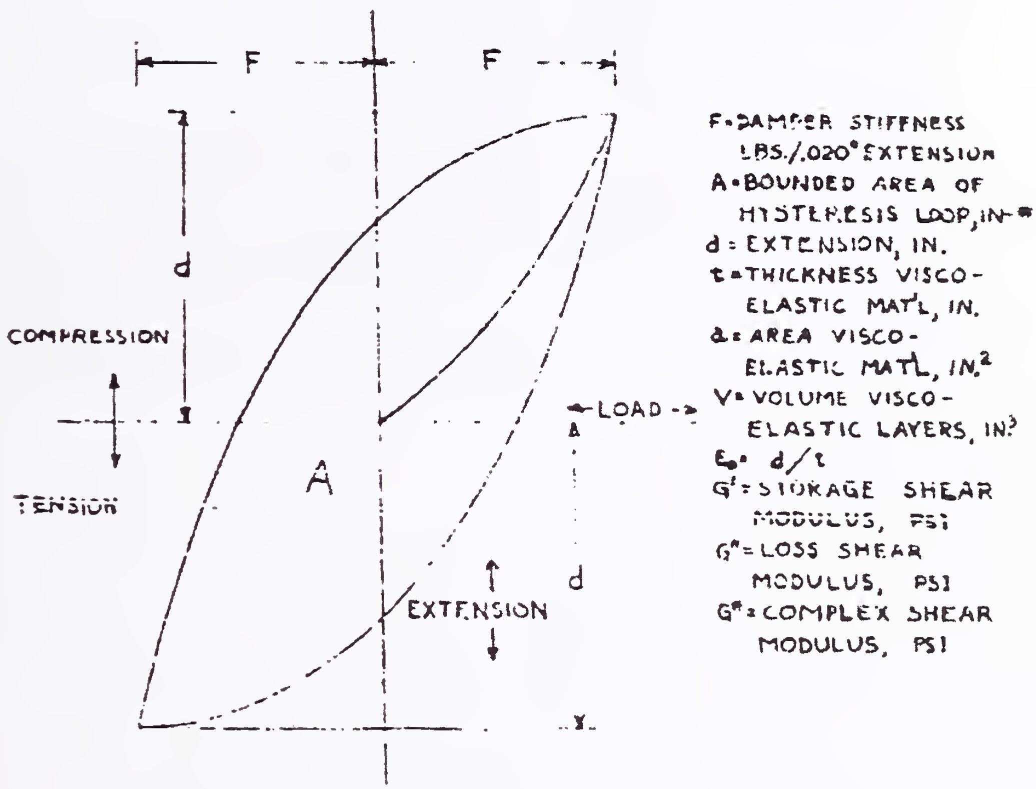
QUALIFICATION TESTING PROCEDURE

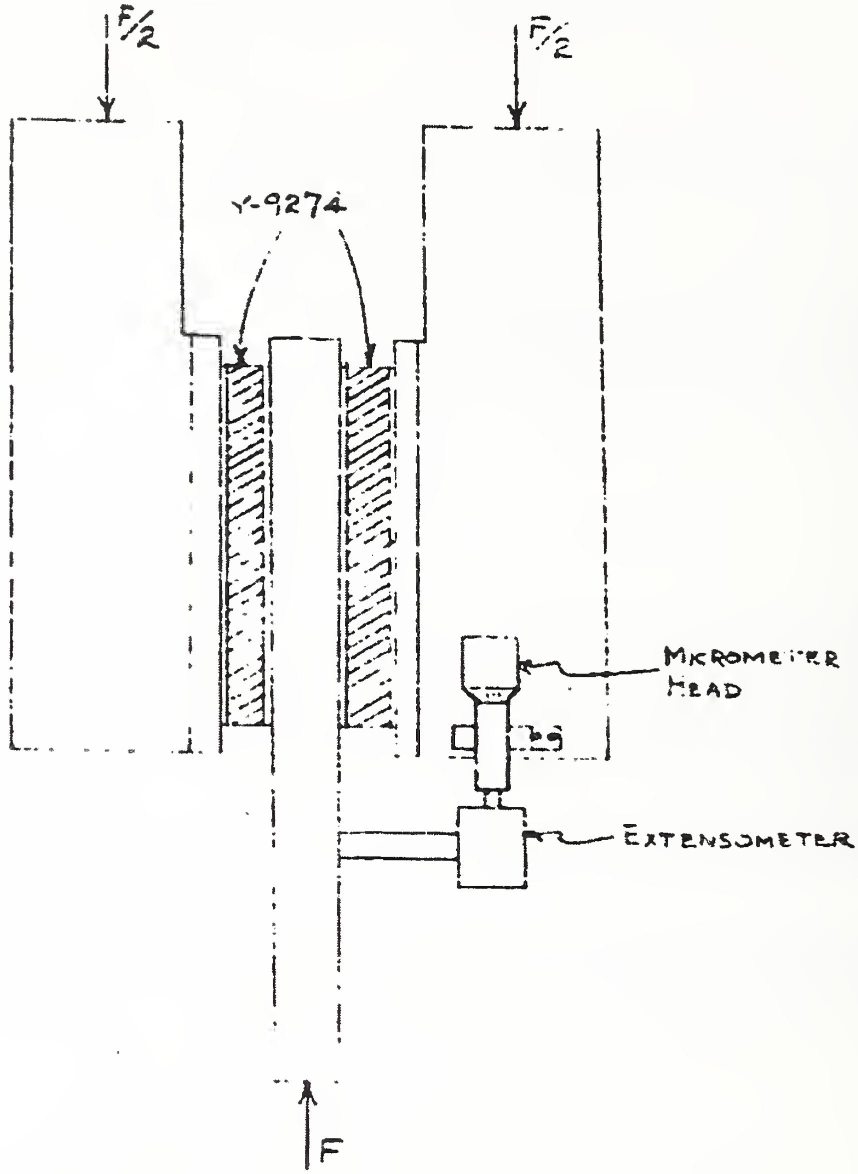
1. Clamp an assembled full scale damper in the jaws of the Instron.

2. Bolt the micrometer head to one of the T-sections of the damper using previously drilled holes. Bolt the arm holding the extensometer to the bar. (See attached sketch)

3. Connect the output of the extensometer to the chart recorder.

4. Record the displacement and force in one side of the damper (the two sides are assumed identical) alternately in compression and tension for one complete cycle. The Instron is reversed at the pre-selected displacement of .020" both in compression and tension. A typical hysteresis loop is shown on the bottom of this page.




F/2
F/2
Y-9274
MICROMETER
HEAD
EXTENSOMETER
F

5. Measure the bounded area of the loop. Calculate the strain, ε_o and volume, V, in the visco-elastic layers.

6. Calculate G" from the equation $G'' = \frac{A}{\pi \varepsilon_o^2 V}$

7. Calculate G* from the equation $G^* = \frac{\frac{F}{a}}{\frac{d}{t}}$

8. Calculate G' from the equation $(G')^2 = (G^*)^2 - (G'')^2$

9. Calculate loss tangent, tan δ, from the equation.

$$\tan \delta = \frac{G''}{G'}$$

10. Record the value F taken from the chart recorder.

11. Run at least 100 successive cycles of the hysteresis loop test at a displacement amplitude of 0.020". Calculate the loss modulus, G", as shown above, for the first and the last cycles. Calculate the percent change of the last cycle from the first.

12. Place an assembled damper in the jaws of a Baldwin test machine (of at least 60,000 pounds capacity in tension and/or compression) with the bar end extending downward.

13. Record the force necessary to cause shear rupture of the visco-elastic bonded area when a compressive load is applied axially to the ends of the damper unit.

14. Calculate the ultimate shear strength of the unit by dividing the total force exerted by the area of the visco-elastic material."

Substitute the following under the section entitled "Acceptance Testing and Sampling Plan".

<u>ACCEPTANCE TESTING & SAMPLING PLAN:</u>
"The plan assures that dampers having average loss tangent, stiffness, fatigue resistance and ultimate shear strength values less than the guaranteed minimums will not be accepted more than 5% of the time.

<u>Lot:</u> A lot shall consist of all dampers made from the same lot of visco-elastic material by the same process and to be submitted for acceptance testing at one time.

<u>Sampling:</u> Dampers shall be selected at random from each lot at the rate of one per day for loss factor, stiffness and ultimate shear strength determinations and at the rate of one per lot for fatigue resistance.

If the quality level of dampers is consistently high, the sampling rate may be reduced upon presentation of proof that such reduced rate offers at least the same quality assurance and upon approval of the engineer.

<u>Acceptance:</u> After the sample dampers have been tested in accordance with all procedures listed in the Qualification section and have passed the requirements listed in the Documentation of Performance section of the specification, the lot is deemed to have been accepted by the contractor.

If the acceptance test data differs from the qualification test data because of the relatively small number of tests used for qualification, the engineer may change the acceptance requirements or grant a waiver if in his judgment the dampers are still suitable for their intended purpose.

In the event a lot is rejected, the following procedure will be followed:

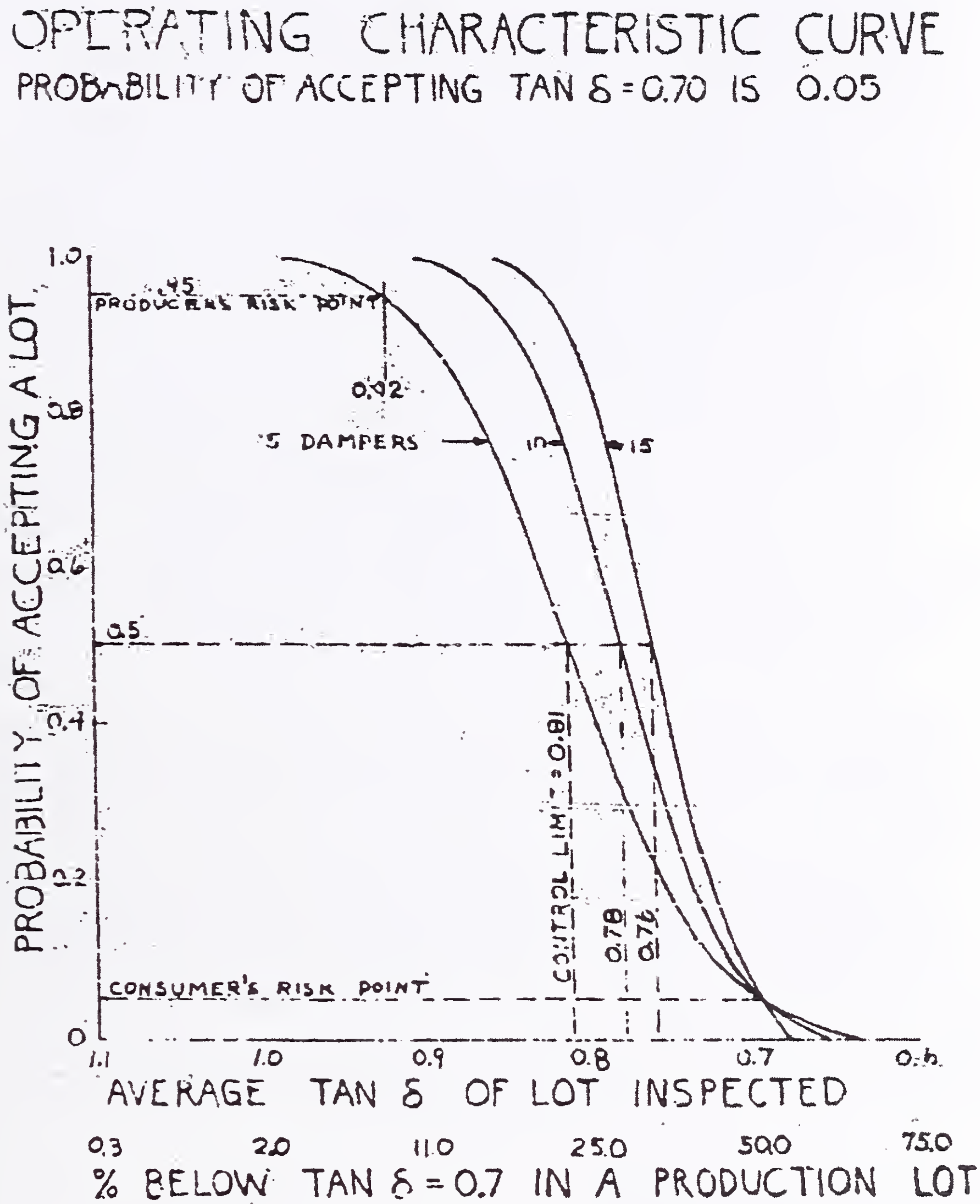
1. Take an additional sample from the lot composed of dampers chosen at random at the rate of one from each days production (one per lot for fatigue resistance).

2. If the cumulative average of the first and second samples are equal to or below the control limit for the combined sample, take a third sample from the lot composed of dampers chosen at random at the rate of one from each days production (one per lot for fatigue resistance).

3. If the cumulative average for samples one, two and three is equal to or below the control limit for the total combined sample, the entire lot is rejected."

We estimate that our production will be 80 dampers per day or 400 dampers per normal week, thus, the normal sample size will be five.

We are submitting the attached graph and explanatory remarks to illustrate the Acceptance Testing and Sampling Plan. Obviously a similar graph applies to stiffness, ultimate shear strength and fatigue resistance.


OPERATING CHARACTERISTIC CURVE
PROBABILITY OF ACCEPTING TAN δ = 0.70 IS 0.05
PROBABILITY OF ACCEPTING A LOT
1.0
0.8
0.6
0.5
0.4
0.2
0
.95
PRODUCER'S RISK POINT
0.02
5 DAMPERS
10
15
CONTROL LIMIT = 0.81
0.78
0.76
CONSUMER'S RISK POINT
1.1
1.0
0.9
0.8
0.7
0.6
AVERAGE TAN δ OF LOT INSPECTED
0.3
2.0
11.0
25.0
50.0
75.0
% BELOW TAN δ = 0.7 IN A PRODUCTION LOT

1. The curve gives <u>average</u> values of <u>lots</u> that have been estimated from samples of five (chosen at random at a rate of one per day) per lot. We are using average values to describe the minimum quality you can receive in preference to values for single dampers because:

   a. The buildings respond to the average damping of all dampers acting in concert.

   b. The performance requirements to insure no single damper falling below, for example, a loss tangent of 0.7 are much greater. This point can easily be seen by referring to the abscissa showing that at an average loss tangent of the lot equal to 0.7 50% of that lot will be below .7. It would be necessary to have an average of approximately 1.1 to insure that essentially no individual dampers are below a loss tangent of 0.7.

2. It is impossible to conclude anything about the performance of individual dampers from these curves. This means that you must accept the chance that some dampers may be released with very low values, though the average of the sample will exceed the control limit of 0.81 and the probability of accepting a lot average of .7 is only 5%.

3. As an example, assume a lot of dampers whose true average loss tangent is 0.9. This means that 11% produced in that lot would have loss tangents below 0.7. This would be true on all production lots having the same estimated average loss tangent. It further means that approximately 91% of the time these lots will be accepted. You would <u>receive</u> .91 x 11% or 10 dampers under .7 loss tangent.

4. In a lot, the control limit for the sample of five is .81 based on laboratory experience to date. This can be seen from the 50% probability on the five damper sample curve occurring at a loss tangent of .81. A lot having this average control limit would be rejected.

5. We feel that the abscissa titled "Percent Below Loss Tangent of 0.7 in Production Lot" is a valuable addition to the graph. It reveals our quality variability (lab experience) to you. You can calculate variability from the operating characteristic curve according to the following method:

   a. Note that the "5% point" (the chosen statistical limit) occurs at loss tangent = 0.7.

   b. Note that the control limit equals .81.

   c. Then, $.81 - .70 = .11 = 1.645\ \sigma_{\overline{5}}$.

   d. From this $\sigma_{\overline{5}} = .067$

   e. $\sigma_I = \sigma_{\overline{5}} \cdot \sqrt{5} = .15$

   f. For several values of loss tangent calculate loss tangent - .7. For example, when loss tangent = .8 we get $\frac{.8 - .7}{.15} = .67$

   g. Then from a table of normal probabilities, the percent below .7 is taken. For the above example, this percentage is 25.

6. The average loss tangent for experimental dampers tested to date is 1.1. It is obvious that we really have a high confidence of meeting the minimum loss tangent of 0.7. Using the five damper sample plan, the producer's risk point (95% probability of accepting, 5% chance of rejecting unknown to 3M) occurs at a loss tangent of .92. The consumer's risk point occurs at a loss tangent of 0.7 (5% chance of accepting a lot whose true average is below 0.7).

Add section nine entitled "Burning, Melting and Toxicity", to the specification: "The heat of combustion of the visco-elastic material shall not exceed 8500 calories per gram. Combustion of the visco-elastic material shall not produce gaseous products worse than those from typical vinyl wire insulation. In the event the temperature in a fire is short of that required for combustion, the visco-elastic material shall not melt and/or drip causing a hazard to fire fighters."

I am not sure that we gave you the heat of combustion figure for Y-9274. Measured on two samples the average was 7,646 calories per gram. While we expect this to vary somewhat from lot to lot and test to test, the variation should be very small. The 8500 figure gives plenty of margin.

The products of combustion of Y-9274 are similar to those from burning wood. For example, there is no phosgene as from combustion of vinyl plastic. The enclosed piece of typical heavy duty wiring coated with vinyl insulation and the accompanying piece of our visco-elastic material wrapped around the bare wire gives graphic proof that Y-9274 will not cause a problem due to dripping. Both were exposed for fifteen minutes at 550°F. You can see that the vinyl coating dripped seriously whereas the Y-9274 showed not the slightest sign of dripping. I would expect that it will burn before it drips.

In discussing aging let us first separate aging into environmental aging and chemical stability. We are not concerned with environmental aging because of the absence of difficult factors in the buildings. Our experience with chemical stability of materials in the same polymer family would indicate an expected damper life of at least ten years and probably up to about twenty years in the absence of environmental factors. This includes all components of the damping unit. I would expect that over this period of time, the loss factor and stiffness would remain quite constant. If there is a change we would expect it to be in the direction of increased stiffness and lowered loss factor but where the product of loss factor and stiffness would increase. Polymers in the Y-9274 family can be compared in aging ability to silicone elastomers, but are slightly poorer than these rubbers.

I have decided to make these bald statements without hedging or qualification, but with the firm addition that they in no way constitute a guarantee and are simply estimates.

Very truly yours,

Don

D. B. Caldwell
Project Engineer
Acoustic Products

DBC:dfs

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

John B. Skilling • *Helge J. Helle* • *John. V. Christiansen* • *Leslie E. Robertson*

October 30, 1967

Consultants
Harold L. Worthington
Joseph F. Jackson

Mr. John M. Kyle
Chief Engineer
Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York, New York 10011

Reference: The World Trade Center
Damping Units

Dear Jack:

Enclosed is a program outlining a test series to be used for the damping units between floor and column elements of The World Trade Center.

We had hoped that a much more comprehensive program could be developed. However, test equipment specifications have proven to be a much higher hurdle than had been expected because of the difficulty in allowing for reasonable flexibility in selecting a laboratory and for contracting for the work. We have, therefore, deleted this facet of the program and have left the responsibility for outlining test equipment response and the like to the laboratory.

Looking back over the history of the development of these damping units, it is apparent that SHCR should have proposed the test series that you have requested. We are, then, grateful to you for anticipating this requirement and directing our thoughts toward this program.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

Leslie E. Robertson

LER:s
cc: Mr. Malcolm P. Levy

WAYNE A. BREWER
P. S. A. FOSTER
FRANK HOELTERHOFF
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KENT R. ROGERS
CHARLES SANDUSKY
WILLIAM D. WARD
E. J. WHITE, JR.
LORENTS L. WIDING

SEATTLE OFFICE: 1840 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

THE WORLD TRADE CENTER

Report No. DU-2

PROTOTYPE TEST PROGRAM

OF

VISCOELASTIC DAMPING UNITS

October 27, 1967

PROTOTYPE TEST PROGRAM OF
VISCOELASTIC DAMPING UNITS

I. Introduction

Viscoelastic damping units have been developed for installation in the floor system of The World Trade Center towers. The need for and the theory of the damping units have been covered in a previous report, "Viscoelastic Damping Units" Report No. DU-1 by Skilling-Helle-Christiansen-Robertson. Also included in Report No. DU-1 are the results of the prototype testing conducted by Minnesota Mining and Manufacturing Company. Since this viscoelastic damping system is certainly one of the few applications ever made, if not the first, in the field of tall buildings, it is desirable to have more independent test data on the performance of the damping units. This report will cover the requirements of the proposed test program.

II. Damping Units

The damping unit consists of two viscoelastic slabs, 4" x 10" x 0.05", bonded alternately among three steel pieces, as shown in Figure 1. Steel for the tees shall conform to the requirements of ASTM A36, and steel for the center plate shall conform to the requirements of ASTM A36 or AISI C1020 (hot rolled). The surfaces of the tees to be bonded shall be machined flat within 0.005 TIR and the thickness of the flange after machining shall be 0.438" minimum. The viscoelastic slabs shall be of 3M Brand Vibration Damping Elastomer ØY-9274, produced by Minnesota Mining and Manufacturing Company. Bonding agents between the steel surface and the viscoelastic slab shall be selected by Minnesota Mining and Manufacturing Company and

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shall be identical to the bonding agents to be used in the final production of the damping units.

The ends of the structural tees shall be connected to the test jig by two ASTM A490 bolts, 1" diam., in double shear; the other end of the unit shall be connected to the test jig by two ASTM A490 bolts, 3/4" diam., in double shear. Two hardened washers shall be used with each A490 bolt. All bolts shall be tightened by the turn-of-nut method. The structural tees shall have four assembly bolts, 1/4" diam., conforming to the requirements of ASTM A307.

The damping unit and its fasteners will then be identical to the damping units to be installed in the buildings, supplied under Contracts WTC-219.00 and WTC-224.00. For the test specimens described herein, the steel pieces shall be fabricated by a contractor to be selected by the Port of New York Authority and fabrication of the damping units shall be done by Minnesota Mining and Manufacturing Company after negotiation carried out for this work. The testing shall be done by a laboratory selected by SHCR and approved by PNYA.

Forty test specimens of the damping units shall be fabricated. Each specimen shall be marked with the date of fabrication and with a number from one to forty assigned according to the order in the sequence of final assembly of the damping units. Thirty specimens shall be selected at random and shall be tested in the test program to be described in this report. The remaining ten specimens shall be stored by the Port of New York Authority at relative humidity of 40% ± 10% and at ambient temperatures of 75°F ± 3°F. These ten stored units will be used for the evaluation of the aging effects in a way similar to the guarantee testing of the final production units.

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III. <u>Monitoring of Fabrication and Testing Operation</u>

All work shall be done under the surveillance of the S-H-C-R Resident Engineer who will be assigned to the production fabrication and field installation operations and should be witnessed by one or more representatives of the Port of New York Authority. A representative of Minnesota Mining and Manufacturing Company should be invited to witness the tests. The testing agency shall submit evidence to and receive approval of Skilling-Helle-Christiansen-Robertson for the suitability and accuracy of the testing apparatus to be used in the performance of the tests and shall submit and certify laboratory data sheets. The S-H-C-R Resident Engineer shall prepare comprehensive report to describe and evaluate all phases of the test program for the Port of New York Authority.

IV. <u>Test Parameters</u>

For the purpose of evaluating the effectiveness of the damping units, the following parameters shall be measured:

1. Absolute dynamic stiffness of the damping units, defined as the force amplitude required to cause unit sinusoidal displacement amplitude of the ends of the damping unit.
2. Loss factor of the damping units, defined as the tangent of the phase angle by which the relative displacement of the ends of the damping unit lags behind the applied force in sinusoidal loading.
3. Ambient temperature and temperature of the viscoelastic slab.
4. Temperature changes in the viscoelastic slab vs. cycles of oscillation during four hundred cycles at constant amplitudes of displacement.

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5. Maximum displacement and ultimate strength of the damping units in compression.

V. <u>Tests for Dynamic Stiffness and Loss Factor</u>

1. The ambient temperature and the temperature of the viscoelastic slabs at the beginning of each test shall be 75°F ± 3°F. The temperature of the viscoelastic material shall be measured by a thermocouple embedded in an edge of the slab.
2. The ambient relative humidity shall be 40% ± 5%.
3. Each specimen shall be subjected to sinusoidal variation of axial displacement between the two ends of the damping unit. The frequency of the sine function shall be 0.100 ± 0.005 cycles per second. There shall be no static force bias on the specimen. Twenty specimens shall be tested at amplitudes of 0.020 inch and another ten specimens shall be tested at amplitudes of 0.030 inch. All specimens shall be tested for one hundred and two cycles of displacement except two specimens as specified in Section V.6 below.
4. Force-displacement curves of each specimen shall be recorded by an on-line X-Y plotter for the 1st, 2nd, 10th, 20th, 50th, and the 100th cycles. At the end of the 100th cycle, testing shall be halted. Testing shall resume when the temperature of the viscoelastic slab returns to its initial temperature plus or minus 0.2°F. Force-displacement curves of each specimen shall be recorded for the 101st and 102nd cycles. The time elapsed between the 100th and the 101st cycles shall also be recorded.
5. The ambient temperature and the temperature of the viscoelastic slab

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shall be recorded for the 1st, 10th, 20th, 50th, 100th, and 101st cycles for each specimen.

6. One specimen shall be selected at random from the specimens to be tested at 0.020" amplitude and another specimen shall be selected at random from the specimens to be tested at 0.030" amplitude for extended testing as follows: Sinusoidal displacement shall continue to be applied beyond the 102nd cycle until the 500th cycle. Force-displacement curves as well as the ambient temperature and the temperature of the visco-elastic slab shall be recorded for the 200th, 300th, 500th, and 500th cycles.

VI. Tests of Maximum Displacement and Ultimate Strength

1. The ambient temperature and the temperature of the viscoelastic slabs at the beginning of each test of Section VI shall be 75°F ± 3°F.
2. After testing in accordance with Section V, each specimen shall be loaded to failure in axial compression at constant displacement rate of 0.48 inch per minute. The force-displacement curve shall be recorded by using an on-line X-Y plotter for each specimen.
3. The mode of failure of each specimen shall be noted, e.g., shear failure through bonding agent or shear failure of 3/4" diam. bolt. Where informative, the failed specimens shall be photographed.

VII. Evaluation of Test Result & Final Report

The prototype damping units shall be considered satisfactory if the results of the test specimens meet the following requirements:

1. The mean value of the loss factor of all specimens for the first cycle shall be at least seven-tenth (0,7).

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2. The mean value of the absolute dynamic stiffness of all specimens for the first cycle shall be at least 400,000 pounds per inch but less than 800,000 pounds per inch.
3. The standard deviation of the absolute dynamic stiffness of all specimens for the first cycle shall not exceed:

$$\text{(a)} \quad \frac{1}{3}\,\overline{K}_d - 60{,}000 \text{ pounds per inch}$$

$$\text{and} \quad \text{(b)} \quad 400{,}000 - \frac{1}{3}\,\overline{K}_d \text{ pounds per inch}$$

   where $\overline{K}_d$ is the mean value of absolute dynamic stiffness.
4. The limits set forth in (1), (2) and (3) above shall also be applied to the 101st cycle.
5. Ultimate strength of the damping units as measured in Section VI shall have a mean value not less than 48,000 pounds and a standard deviation not greater than $\left\{ \frac{1}{3}\,\overline{P} - 12{,}000 \right\}$ pounds, where $\overline{P}$ is the mean ultimate strength in pounds.
6. Maximum displacement at ultimate strength as measured in Section VI shall have a mean value not less than 0.16 inch and a standard deviation not greater than $\left\{ \frac{1}{3}\,\overline{D} - 0.04 \right\}$ inch, where $\overline{D}$ is the mean value of the maximum displacement in inch.

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Manager
Wayne A. Brewer

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Harold L. Worthington
Joseph F. Jackson

April 4, 1969

Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York, New York 10011

Attention: Mr. M. P. Levy

Reference: The World Trade Center
Contract WTC-224.00, 3M
Viscoelastic Damping Units

Gentlemen:

We have reviewed the draft of Contract WTC-224.00, Viscoelastic Damping Units for North and South Towers, dated November 1, 1968. Our comments on this draft contract are the subject of this letter.

1. Draft page 3 <u>COMPENSATION</u>:
The number of damping units to be installed in North and South Towers is 19,423, exclusive of units required for Acceptance Tests and Guarantee Tests. The Guarantee Tests require 360 units. The number of units required for Acceptance Tests is variable and it depends on the quality of the submitted lots and on the number of days of production. Units which are not damaged in the Acceptance Tests will be returned to inventory. However, since it is expected that damping units will be damaged in the ultimate strength tests, all such specimens should be discarded.

In order to control the upper limit of the cost of Acceptance Tests we suggest that the contract include a clause such as, "Vendor shall not be paid the fees for acceptance tests performed on lots which are rejected as a result of the tests."

FRANK HOELTERHOFF
ROBERT E. LEVIEN
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Port of New York Authority
Attention: Mr. M. P. Levy

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April 4, 1969

2. Draft page 4 EXTRA MATERIALS AND DELETED MATERIALS:
The unit price schedule in Section B implies that the total price of 19,999 units is $653,967.30 whereas the total price of 20,000 units is $622,000.00. A schedule of unit prices for the deleted units would remedy this situation.

3. Draft pages 9, 10, 11, 12:
The dates for the delivery of the components and for the delivery of the damping units must be corrected.

4. Draft page 18 GUARANTEE BY THE VENDOR:
The number of units in Section C must be made consistent with the number given in Draft page 3.

5. Draft page A-5 Items to be Excluded from this Contract:
Section 2 should read, "Field bolts in the webs of tees and field bolts in the ends of 4" x ½" nominal bars."

6. Draft page A-9, Section 3.1.4:
Change S for Shear Stress to lower case s.

7. Draft page A-10:
   a. Delete the equation for Fatigue Loss in accordance with the proposed revisions of Section 4.0.
   b. Change s for standard deviation to upper case S in order to agree with Eq. 1.

8. Draft page A-11:
   a. In the first equation for S, X should be $\bar{X}$.

We would like to recommend the following revisions of Section 4.0, Requirements and Section 5.0, Quality Assurance. The aims of these provisions are: (1) to control the dispersion of the Stiffness and of the Ultimate Strength of the damping units and (2) to include in the Fatigue Test those parameters which are most pertinent to the system performance of the damping units in the building.

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Port of New York Authority
Attention: Mr. M. P. Levy

- 3 -

April 4, 1969

1. Draft page A-11:
   a. Two paragraphs following Eq. 2 shall read as follows:
   "The Manufacturing Control Limit for the Loss Factor of an Acceptance Lot or of a Guarantee Lot shall be calculated by substituting the value of S from Eq. 2 and the appropriate value of the $t/\sqrt{n}$ from Table I, in Eq. 1."

2. Draft page A-11:
   4.1.3 Fatigue Test: The requirements of Loss Factor and Stiffness in 4.1.1 and 4.1.2 shall also be met for the 100th cycle.
   4.1.4 Ultimate Strength: The Ultimate Strength shall be at least 45,000 pounds at 75°F.

3. Draft page A-12:
   4.2.2 Stiffness: The average Stiffness at 75°F shall be greater than ($6,000 + 2.0S$) but less than ($20,000 - 2.0S$) pounds per 0.020" damper deflection, where S is the standard deviation of the sample calculated from Eq. 2.
   4.2.3 Fatigue Test: The requirements of Loss Factor and Stiffness in 4.2.1 and 4.2.2 shall also be met for the 100th cycle.
   4.2.4 Ultimate Strength: The average Ultimate Strength at 75°F shall be at least ($45,000 + 2.0S$) pounds, where S is the standard deviation of the sample calculated from Eq. 2.
   4.3.1 Loss Factor: The average Loss Factor shall be at least 0.70.
   4.3.2 Stiffness: The average Stiffness at 75°F shall be greater than ($6,000 + 2.0S$) but less than ($20,000 - 2.0S$) pounds per 0.020" damper deflection, where S is the standard deviation of the sample calculated from Eq. 2.
   4.3.3 Fatigue Test: The requirements of Loss Factor and Stiffness in 4.3.1 and 4.3.2 shall also be met for the 100th cycle.
   4.3.4 Ultimate Strength: The average Ultimate Strength at 75°F shall be at least ($45,000 + 2.0S$) pounds, where S is the standard deviation of the sample from Eq. 2.
   5.2.1 General: After the sampled dampers have been tested in accordance with Section 5.4 and the requirements given in Section 4.2 have been met, the lot is deemed to have been accepted by the Engineer. When a lot has been accepted, the sampled dampers which are not damaged in the testing for Loss Factor, Stiffness or Fatigue shall be returned to regular inventory. Specimens which have been tested for Ultimate Strength shall be discarded.

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Port of New York Authority
Attention: Mr. M. P. Levy

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April 4, 1969

4. Draft pages A-13 and A-14:
   5.2.3 (1) Change "Fatigue Loss" to "Fatigue".
   (3) Change "Manufacturing Control Limit for that test" to "Acceptance Requirements in 4.2".
   (5) Change "Manufacturing Control Limit" to "Acceptance Requirements".
   (6) Change "Manufacturing Control Limit" to "Acceptance Requirements".
   (9) Change "Manufacturing Control Limit" to "Acceptance Requirements".

5. Draft page A-15:
   5.3.1 Delete the sentence, "Lots of dampers having average values of .... more than one time in twenty after three samples." In the last paragraph of 5.3.1 change "destroyed" to "damaged".

6. Draft pages A-16 and A-17:
   5.3.3 (1) Change "at the rate of three for each 160 dampers" to "at the rate of one for each 50 dampers". Change "Fatigue Loss" to "Fatigue".
   (3), (5), (8), (9) Change "Manufacturing Control Limit" to "Guarantee Requirements".
   5.3.4 Change "prefix" to "suffix".

7. Draft page A-23:
   5.4.5.1 (11), (12) Change upper case S to lower case s.

8. Draft pages A-24 and A-25:
   5.4.5.2 Fatigue: Delete paragraphs (5) and (6). Add the following: "(5) Calculate Loss Factor and Stiffness for the 100th cycle by following the procedures given in 5.4.5.1."

9. Draft page A-25:
   5.4.5.3 Ultimate Strength: Revise paragraph (1) to read, "Follow 5.4.2".

10. Draft page A-26:
   5.4.5.3 (7) Use these values in calculating the mean and the standard deviation of the sample.

If you have any question concerning this review, we would be pleased to discuss the specification with you.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Leslie E. Robertson
rr/tc

10/6/69

SPECIFICATION

FOR

VISCOELASTIC DAMPING UNITS

CHAPTER ONE

GENERAL CONDITIONS

0.01 GENERAL

This Specification relates generally to the detailing, furnishing and application of Viscoelastic materials, bonding adhesive, protective aprons and 1/4" bolts, shims, spring lock nuts, and washers required to assemble the Components, furnished by others and machined by the Contractor, into Damping Units for the North Tower (Tower A) and the South Tower (Tower B) of the World Trade Center being constructed by the Authority in the City of New York.

This Specification requires the doing of all things necessary or proper for or incidental to manufacture of said Damping Units, as shown on the Contract Drawings in their present form. In addition, all things shown on the Contract Drawings even though not expressly mentioned in this Specification and all things mentioned in this Specification even though not shown on the Contract Drawings are required.

In the event that any requirements of the Specification appear to conflict with the requirements of the Contract Drawings or Contractor's Shop Drawings, the requirements of the Specification shall prevail.

0.02 WORKMANSHIP AND MATERIALS

Materials and workmanship shall in every respect be in accordance with the best modern practice and whenever the Contract Drawings, Specification or directions of the Engineer admit of a doubt as to what is permissible or fail to note the quality of any construction, the interpretation which calls for the best quality construction is to be followed. Materials shall be new materials and may be purchased from any qualified source, domestic or foreign, provided they meet the Contract requirements.

In case of discrepancy between a description or requirement in the Contract Drawings and Specification for any material or equipment and a catalog number or other designation for the same material or equipment (even though stated to be acceptable), the description or requirement shall control.

The right to use all patented material, compositions of matter, manufactures, apparatus, appliances, processes of manufacture or types of construction required in connection with this Contract shall be obtained by the Contractor without separate or additional compensation whether the same is patented before, during, or after the performance of the Contract.

0.03 APPROVALS BY ENGINEER

Any approval by the Engineer of any materials, workmanship, plant equipment, drawings, program, methods of procedure, or of any other act or thing done or furnished or proposed by the Contractor to be done or furnished in or in connection with the performance of the Contract shall be construed merely to mean that at that time the Engineer knows of no good reason for objecting thereto; and no such approval shall release the Contractor from his full responsibility for the accurate and complete performance of the Contract in accordance with all the terms thereof.

0.04 ERRORS AND DISCREPANCIES

If, in the performance of the Contract, the Contractor discovers any errors or omissions in the Contract Drawings or Specification, or in the work undertaken and executed by him, he shall immediately notify the Engineer and the Engineer shall promptly verify the same. If with the knowledge of such error or omission and prior to the correction thereof, the Contractor proceeds with any work affected thereby, he shall do so at his own risk and the work so done shall not be considered as work done under and in performance of this Contract unless and until approved and accepted.

0.05 PATENTS

The right to use all patented materials, composition of matter, manufactures, apparatus, appliances, processes of manufacture, or types

Page 2

of construction as part of the sale shall be obtained by the Vendor without separate or additional compensation whether the same is patented before, during, or after the performance of this Contract.

0.06 INSPECTIONS

Testing and storage operations in connection with this Contract shall be at all times and places subject to the inspection of the Engineer, acting personally or through his Inspectors.

The Contractor, at his own expense, shall furnish such reasonable facilities and give such assistance for inspection as the Engineer may direct. The Contractor shall secure for the Engineer and his Inspectors free access to those parts of factories, plants or warehouses in which such testing and storage operations are conducted and shall give at least ten days' notice to the Engineer of his intention to commence initial acceptance and five year testing and recommencement after any suspension of testing of more than a week.

0.07 NO CONFIDENTIAL DISCLOSURES - PROPERTY OF AUTHORITY

The Contractor agrees that all information of any nature whatsoever, regardless of the form of the communication, received from the Contractor (including its officers, agents or employees) by the Authority, its Commissioners, officers, agents, employees, or consultants, and notwithstanding any statement therein to the contrary, has not been given in confidence and may be used or disclosed by or on behalf of the Authority without liability of any kind except as may arise under letters patent of the Contractor, if any.

All drawings, data, and other papers of any type whatsoever, whether in the form of writing, figures or delineations, which are specifically prepared and required in the performance of this Contract and submitted to the Authority shall become the property of the Authority. The Authority shall have the non-exclusive right to use or permit the use of all such drawings, data and other papers and any ideas or methods represented thereby for any purpose shall be deemed to have been given in confidence. Any statement or legend to the contrary in connection with such drawings, data or other papers and in conflict with the provisions of this paragraph shall be void and of no effect.

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0.08 CONTRACT DRAWINGS

The Contract Drawings which accompany and form part of this Specification are separately numbered and entitled as follows:

DRAWING NUMBER	DRAWING TITLE	ORIGINAL DATE	REVISED DATE
DA-1	Damping Unit - Structural Tees	9-16-66	8-29-69
DA-2	Damping Unit - Structural Bars	9-16-66	8-29-69
DA-3	Viscoelastic Damping	10-27-67	5-20-69

The Contract Drawings do not show all of the details of the Materials and are intended only to illustrate the character and extent of Materials. Accordingly, they may be supplemented during the performance of the Contract by the Engineer, or by the Contractor subject to the approval of the Engineer, to the extent necessary to further illustrate the Materials.

In the event that any requirements of the Contract Drawings conflict with the requirements of the Contractor's Shop Drawings, the requirements of the Shop Drawings shall prevail.

After the Contract has been executed, the Contractor will be furnished with one set of sepias of the Contract Drawings without charge.

0.09 PORTION OF MATERIALS SHOWN ON CONTRACT DRAWINGS, TO BE DETAILED, FURNISHED, MACHINES, ASSEMBLED AND DELIVERED UNDER THIS CONTRACT

A. ITEMS TO BE INCLUDED IN THIS CONTRACT

1. Machining of Components furnished by others consisting of structural tees and bars.

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2. Application of protective aprons to the visco-elastic material, bonding adhesive and visco-elastic material to the tee flange face and both sides of the nominal 4" x 1/2" bar to the thickness and lengths specified under this Contract.

3. The assembly of two tees and one bar into Damping Units after application of the Viscoelastic material using shims and 1/4" bolts, spring lock nuts, and washers to be furnished by the Vendor under this Contract.

4. The shipping and bundling of completed Damping Units on wood skids used for delivery of steel components segregated as to type of Damping Units. Each bundle to contain approximately 104 Type "A" or 104 Type "B" Damping Units and to be marked in accordance with detailed instructions from the Engineer.

5. Tests in accordance with the Contract.

B. <u>ITEMS NOT TO BE FURNISHED OR PERFORMED BY VENDOR</u>

1. Structural tees and bars.

2. Field bolts in web of tee and field bolts in end of 4" x 1/2" nominal bar.

3. Painting of Damping Units.

4. Installation of Damping Units in Towers of The World Trade Center.

0.10 <u>COMPONENTS FURNISHED BY OTHERS</u>

A. The Components consisting of the structural tees and bars shown on the Contract Drawings will be fabricated by others from steel conforming to ASTM A 36 - 63T or ASTM A 572, Grade 42.

B. Fabrication tolerances on Components will conform to the requirements of the AISC Specification adopted April 17, 1963 entitled "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings" as supplemented by the specific requirements contained in the Contract Drawings, Specification and paragraphs C, D, and E of this numbered clause.

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C. STRUCTURAL TEES - SPECIAL REQUIREMENTS

(a) No deviation from absolute flatness in excess of 1/32 inch over the entire flange surface.

(b) No deviation from absolute flatness in excess of 1/32 inch over the 4 inch extended area of the web.

(c) No deviation from perpendicularity of the 4 inch extended area of the web to the area to be machined in excess of 1/32".

(d) No deviation from perpendicularity of the entire area of the web to the area to be machined in excess of 1/16 inch.

(e) The 4 inch extended area of the web shall be parallel within 1/16 inch to the two center lines of the 1/2 inch diameter holes extending in the lengthwise (12 inch) direction of the area to be machined.

(f) Holes for erection bolts and assembly bolts accurately located as shown in the Drawings.

(g) Each piece free of loose and unbroken bubbles of mill scale, loose rust, dirt, and other foreign material.

(h) No trade marks of any type whatsoever shall be used.

D. STRUCTURAL BARS - SPECIAL REQUIREMENTS

(a) No deviation from absolute flatness in excess of 1/32 inch over entire surface of each side.

(b) Holes for assembly bolts accurately located as shown in the Drawings.

(c) Each piece free from loose and unbroken bubbles of mill scale, loose rust, dirt, and other foreign material.

(d) No trade marks of any type whatsoever shall be used.

E. CERTIFICATION

On all components furnished by others, certification shall be provided to the contractor that all the requirements of this clause and the Contract Drawings & Specification have been met.

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CHAPTER TWO

TECHNICAL REQUIREMENTS

1.0 GENERAL

The Contractor referred to in this Specification is the Minnesota Mining and Manufacturing Company.

The Engineer referred to in this Specification is defined under clause numbered 2 of the Contract entitled "Definitions".

2.0 MATERIALS

2.1 VISCOELASTIC MATERIAL

3M Brand Vibration Damping Elastomer, Y-9274, as produced by Minnesota Mining and Manufacturing Company, is approved for use in fabricating viscoelastic Damping Units. Other viscoelastic materials suitable for such fabrication may also be submitted for approval by the Engineer. The request for approval of other viscoelastic materials shall be accompanied by full technical data on the material, including documentation of performance characteristics of the actual viscoelastic Damping Units proposed for use in the work. In any case, however, and notwithstanding the above stated approval for said 3M brand or any Engineer's approval for any other material, whatever material is used shall be considered satisfactory under this Contract only if it meets all the requirements of this Contract in addition to the requirements of this paragraph.

2.2 STEEL

Viscoelastic Damping Units will be fabricated from tees and bars furnished by others using the Contract Drawings listed under clause numbered 0.08 entitled "Contract Drawings" and Contractor's Shop Drawings listed in Section 2.4 of this numbered clause.

2.3 1/4" DIAMETER ASSEMBLY BOLTS

All 1/4" diameter assembly bolts used in the work shall conform to ASTM A-307 "Standard Specification for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners". ASTM A-307 bolts shall be tightened until the spring lock nuts are partially compressed. All washers shall be flat, smooth and conform to the dimensions and properties required in the Drawings and applicable Specifications.

2.4 CONTRACTOR'S SHOP DRAWINGS

The following Contractor's Shop Drawings are approved for fabrication of viscoelastic Damping Units:

DRAWING NUMBER	DESCRIPTION	DATE
12-2435-0001-9	Damper Assembly Type A	September 3, 1969
12-2435-0002-7	Damper Assembly Type B	September 3, 1969
12-2435-0011-8	Structural Tee Mill Spec.	September 3, 1969
12-2435-0013-4	Structural Bar Type A Mill Spec.	September 3, 1969
12-2435-0015-9	Structural Bar Type B Mill Spec.	September 3, 1969

2.5 BONDING ADHESIVE

Scotchweld Brand Structural Adhesives EC 1614 and 3520 as produced by Minnesota Mining and Manufacturing Company are approved for bonding the viscoelastic material to the steel surfaces.

2.6 PROTECTIVE APRONS

Scotch Brand Pressure Sensitive Tape #465 as produced by Minnesota Mining and Manufacturing Company is approved for protective aprons at the ends of the viscoelastic material.

3.0 DEFINITION OF TERMS

3.1 DAMPER PERFORMANCE

Page 8

3.1.1 FIXED CONDITIONS		NOMINAL VALUES
t =	temperature	75° ± 3°F.
l =	displacement amplitude	0.020"
T =	thickness of each viscoelastic slab	0.050"
f =	frequency	0.1 cycle per sec.
γ =	maximum shear strain	0.4 inches/inch
W =	width of each visco-elastic slab	4.0"
L =	bonded length of each viscoelastic slab	10.0"
$A_{v.e.}$ =	viscoelastic shear area	2WL = 80 sq. in.
V =	volume of viscoelastic material	2WLT = 4 cu. in.

3.1.3 MEASURED PARAMETERS

F = stiffness = one-half of the double amplitude of the axial force in the damper subjected to a sinusoidal displacement with an amplitude of 0.020 inch at 0.1 Hz — lbs./0.020"

A_L = area of hysteresis loop — inches^2

Ultimate Strength is that axial compressive force, expressed in pounds, on the ends of the damper necessary to cause shear failure of the viscoelastic bonded area when the force is applied at a rate of 0.5 inch per minute.

3.1.4 CALCULATED PARAMETERS

s =	Shear Stress	lbs./inch^2	$= \frac{F}{A_{v.e.}}$
G* =	Complex Shear Modulus	lbs./inch^2	$= \frac{s}{\gamma}$
G" =	Loss Shear Modulus	lbs./inch^2	$= \frac{A_L C_1 C_2}{\pi \gamma^2 V}$
G' =	Elastic Shear Modulus	lbs./inch^2	$= [(G^*)^2 - (G'')^2]^{1/2}$

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$$D = \text{Loss Factor} = \frac{G''}{G'}$$

3.2 <u>REQUIREMENT AVERAGE</u>

The Requirement Average is the limiting average value of the specified parameter determined from a given sample as set forth in the equations given for each parameter.

The subscript i stands for an individual damper.

n = the number of dampers in the sample under consideration.

k = the number of accepted lots.

The symbol σ stands for the standard deviation accumulated over all test dampers.

The standard deviation σ_i is defined by the working equation:

$$\sigma_i = \left(\frac{\sum_1^n x_i^2 - \frac{\left(\sum_1^n x_i\right)^2}{n}}{(n-1)} \right)^{1/2} \qquad \text{EQUATION 1}$$

Where the Requirement Average is the basis for Acceptance the standard deviation for the first lot shall be calculated from a special group of ten dampers that is made and tested exactly as the dampers comprising the first Acceptance lot.

The standard deviation for all subsequent Acceptance lots shall be continuously and cumulatively adjusted by pooling the standard deviations of the accepted lots by Equation 2.

$$\sigma_{i\,\text{pooled}} = \left(\frac{\sum_1^k \sigma_i^2 \,(n_i - 1)}{\sum_1^k (n_i - 1)} \right)^{1/2} \qquad \text{EQUATION 2}$$

The Requirement Average for the first 5 Year lot, for each applicable parameter, shall be calculated using the completely pooled standard deviation of all Acceptance lots.

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The Requirement Average for all subsequent 5 Year lots shall be continuously and cumulatively adjusted by pooling the standard deviation of all Acceptance lots with the standard deviations of all accepted 5 Year lots by Equation 2.

4.0 REQUIREMENTS

4.1 ACCEPTANCE REQUIREMENTS

All requirements must be met

4.1.1 LOSS FACTOR

Requirement Average = $0.7 + 0.948\sigma_i$ when n = 5
Requirement Average = $0.7 + 0.670\sigma_i$ when n = 10
Requirement Average = $0.7 + 0.547\sigma_i$ when n = 15

4.1.2 STIFFNESS

$6000 + 1.25\sigma_i <$ Requirement Average $< 20,000 - 1.25\sigma_i$ when n = 5
$6000 + 1.25\sigma_i <$ " " $<$ " " σ_i when n = 10
$6000 + 1.25\sigma_i <$ " " $<$ " " σ_i when n = 15

4.1.3 ULTIMATE STRENGTH

Requirement$_i$ $>$ 40,000 at 75°F. when n = 5
If 0 or 1 damper fails the lot is accepted
If 2 fail take a second sample of 5 dampers
All must pass .

4.1.4 FATIGUE TEST: The stiffness requirement shall become:

$5400 + 1.25\sigma_i <$ Requirement Average $< 22,000 - 1.25\sigma_i$ when n = 5
$5400 + 1.25\sigma_i <$ Requirement Average $< 22,000 - 1.25\sigma_i$ when n = 10
$5400 + 1.25\sigma_i <$ Requirement Average $< 22,000 - 1.25\sigma_i$ when n = 15

4.2 FIVE YEAR REQUIREMENTS

4.2.1 LOSS FACTOR

Requirement Ave. = $0.63 + 0.948\sigma_i$, when n = 10
Requirement Ave. = $0.63 + 0.670\sigma_i$, when n = 20
Requirement Ave. = $0.63 + 0.547\sigma_i$, when n = 30

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4.2.2 STIFFNESS

$5400 + 1.25\sigma_i <$ Requirement Ave. $\leq 22{,}000 - 1.25\sigma_i$ when n = 10
$5400 + 1.25\sigma_i <$ " " $\leq$ " " σ_i when n = 20
$5400 + 1.25\sigma_i <$ " " $<$ " " σ_i when n = 30

4.2.3 ULTIMATE STRENGTH

Requirement $> 36{,}000$ at 75°F. when n = 13. If 0, 1, 2, or 3 dampers fail the lot is accepted. If 4 fail take a second sample of 13 dampers. All must pass.

5.0 QUALITY ASSURANCE

5.1 ACCEPTANCE

5.1.1 GENERAL

After the sample dampers have been tested in accordance with Section 5.3 and the requirements given in Section 4.1 have been met the Acceptance lot, as defined below, is deemed to have been accepted by the Engineer.

When a lot has been accepted, the sample dampers not damaged in testing shall be delivered to the Authority.

5.1.2 LOT

An Acceptance Lot shall consist of all dampers made in each calendar week from the same lot of viscoelastic material by the same process and to be submitted for Acceptance testing at one time.

5.1.3 SELECTION OF SAMPLES

5.1.3.1 Loss Factor, Stiffness & Fatigue

(1) Dampers shall be selected from each Acceptance Lot at random at the rate of three per day until the lot is complete.

(2) Test one-third of these dampers for Loss Factor, Stiffness, and Fatigue in accordance with Section 5.3.

(3) If the averages of the test results meet the Acceptance Requirements, the lot is accepted for these requirements.

(4) If the average of the test results for any of the tests does not meet the Acceptance Requirements in Section 4.1, take another third of the dampers selected under (1) and test them in accordance with Section 5.3 for the failed requirements.

(5) If the averages of the test results for the original group and second group of samples meet the Acceptance Requirements, the lot is accepted for these requirements.

(6) If the average of the test results for any of the tests of the original and second group of samples does not meet the Acceptance Requirements, take the last third of dampers selected under (1) and test them in accordance with Section 5.3 for the failed requirements.

(7) If the averages of the test results for the original, second and third groups of samples meet the Acceptance Requirements, the lot is accepted for these requirements.

(8) If the average of the test results for any of the tests of the original, second, and third group of samples does not meet the Acceptance Requirements, the lot is rejected.

5.1.3.2 <u>ULTIMATE STRENGTH</u>

(1) Dampers shall be selected from each Acceptance lot at random at the rate of two per day until the lot is complete.

(2) Test one-half of these dampers for Ultimate Strength in accordance with Section 5.3.

(3) If the individual test results meet the Acceptance Requirements the lot is accepted for this requirement.

(4) If the individual test results do not meet the Acceptance Requirements take the other half of the dampers selected under (1) and test them in accordance with Section 5.3.

(5) If the individual test results for the original and second groups of samples meet the Acceptance Requirements the lot is accepted for this requirement.

(6) If the individual test results of the original and second group of samples do not meet the Acceptance Requirements, the lot is rejected.

5.1.4 IDENTIFICATION

All dampers shall be permanently imprinted with an identification code of the type shown below:

ALL DAMPERS				ACCEPTANCE TEST DAMPERS
DAMPER TYPE	PDTN. LOT #	YEAR	DAY	SUFFIXED
A	2	7	174	A

The letters and numerals shall be between 1/4" and 1/2" in height and shall be located in a uniform manner. The identification shall be imprinted once on the exposed surface of the web of each structural tee.

5.2 FIVE YEAR TESTING

5.2.1 GENERAL

Not less than 5 years nor more than 5 years and 3 months after all the dampers in a given 5 Year lot have been manufactured, the samples selected from that lot and stored by the Contractor shall be tested. Dampers for 5 Year tests shall be stored by the Contractor in conformance with conditions given in Section 5.3.

After the samples from a 5 Year lot have been tested in accordance with Section 5.3 and the requirements given in Section 4.2 have been met, the lot is deemed to have passed the 5 Year test.

When a 5 Year lot has been accepted, the sample dampers not damaged in testing shall be delivered to the Authority.

5.2.2 LOT

A 5 Year lot shall consist of one-fourth of the total number of accepted dampers in this Contract, there being four such lots and each being selected as the first, second, third, and last fourth, in sequence of manufacture.

5.2.3 SELECTION OF SAMPLES

5.2.3.1 Loss Factor and Stiffness

(1) Dampers shall be selected from each 5 Year lot at random at the rate of one for each 160 dampers produced until a total of 30 from each lot is reached. Test specimens shall be selected from Type A dampers only.

(2) Test one-third of these dampers for Loss Factor, Stiffness and Fatigue according to Section 5.3.

(3) If the averages of the test results meet the 5 Year Requirements, the lot is accepted for these requirements.

(4) If the average of the test results for any of the tests does not meet the 5 Year Requirements in Section 4.2 take another third of the dampers selected under (1) and test them in accordance with Section 5.3 for the failed requirements.

(5) If the averages of the test results for the original group and second group of samples meet the 5 Year Requirements, the lot is accepted for these requirements.

(6) If the average of the test results for any of the tests of the original and second group of samples does not meet the 5 Year Requirements, take the last third of dampers selected under (1) and test them in accordance with Section 5.3 for the failed requirements.

(7) If the average of the test results for the original, second and third groups of samples meet the 5 Year Requirements the lot is accepted for these requirements.

(8) If the average of the test results for any of the tests of the original, second and third group of samples does not meet the 5 Year Requirements, the lot is rejected.

5.2.3.2 ULTIMATE STRENGTH

(1) Dampers shall be selected from each 5 Year Lot at random at the rate of 1 for each 200 dampers produced until a total of 26 from each lot is reached. Test specimens shall be selected from Type A dampers only.

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(2) Test one-half of these dampers for Ultimate Strength in accordance with Section 5.3.

(3) If the individual test results meet the 5 Year Requirements, the lot is accepted for this requirement.

(4) If the individual test results do not meet the 5 Year Requirements, take the other half of the dampers selected under (1) and test them in accordance with Section 5.3.

(5) If the individual test results for the original and second groups of samples meet the 5 Year Requirements, the lot is accepted for this requirement.

(6) If the individual test results of the original and second group of samples do not meet the 5 Year Requirements, the lot is rejected.

5.2.4 IDENTIFICATION

Guarantee test dampers shall be identified as in Section 5.1.4 except that the suffix "A" shall be replaced with a number, one through four, corresponding to the Guarantee Lot number and the capital letter "G".

5.3 TEST METHODS

5.3.1 STEEL FAILURE

If the steel components of a damper deflect during any of the tests that test may be declared no test and another test specimen substituted for it.

5.3.2 CONDITIONING

All test dampers shall be maintained at 30% relative humidity and 75°F. ± 3°F. from the time of manufacture until the time of testing.

5.3.3 TESTING TEMPERATURE

All tests shall be conducted at a temperature of 75°F. ± 3°F. as determined by a thermocouple inserted in an edge of the viscoelastic damping material. Record the test temperature. The dampers shall have been in a temperature of 75°F. ± 3°F. for at least eight hours before testing.

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5.3.4 REPORTING VISCOELASTIC WIDTH

The measured values of Stiffness, hysteresis loop area (A_L) and Ultimate Strength shall be corrected for a common bonded visco-elastic width of eight inches by using the multiplying factors listed in Table I below:

TABLE I

IF BONDED WIDTH OF VISCOELASTIC SLAB IS	MULTIPLY THE TEST RESULTS OF STIFFNESS A_L & ULTIMATE STRENGTH BY
7-6/16"	1.085
7-7/16"	1.076
7-8/16"	1.067
7-9/16"	1.058
7-10/16"	1.049
7-11/16"	1.040
7-12/16"	1.032
7-13/16"	1.024
7-14/16"	1.016
7-15/16"	1.008
8"	1.000
8-1/16"	.992
8-2/16"	.984

5.3.5 REPORTING TEMPERATURE FOR STIFFNESS

The corrected results of Stiffness determined in Section 5.3.4 shall be further corrected for a common temperature of 75°F. by adding the product of the temperature difference and the temperature coefficients listed in Table II below:

TABLE II

IF TEST TEMPERATURE (°F) IS	USE TEMPERATURE COEFFICIENT (lbs./°F) OF
72.0	-865
72.5	-880
73.0	-900
73.5	-935
74.0	-1000
74.5	-1000
75.0	----
75.5	+1000
76.0	+1000
76.5	+1065
77.0	+1100
77.5	+1140
78.0	+1165

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5.3.6 TEST PROCEDURES

Where more than one test is performed on the same damper, they shall be conducted in the order given in this section.

5.3.6.1 Loss Factor & Stiffness

(1) Bolt an assembled damper in the special jaws attached to the test machine. Use new high tensile steel bolts for each test specimen.

Use 1" diameter ASTM A490 bolts for attaching the tee end of the damper and 7/8" ϕ A-490 bolts (Type A units) or 1 1/4" ϕ A-490 bolts (Type B units) for the bar end. Tighten all nuts until all four jaws and the specimen are firmly together, then tighten each nut an extra one-half turn.

(2) Bolt the micrometer head to one of the T-sections of the damper using previusly drilled holes. Bolt the arm holding the extensometer to the central bar of the damper. See Figure 1 .

(3) Connect the output of the extensometer to the X-Y chart recorder.

(4) After calibrating the system and determining there is no static force bias on the damper, set the test machine on strain control and apply sinusoidal deformation to the viscoelastic layers by alternating tensile and compressive axial force on the ends of the damper with a period of 10 $\pm$ 0.5 seconds. The force on the ends of the damper shall be sufficient to produce a shear displacement amplitude of 0.020" in the viscoelastic damping layers. A typical hysteresis loop is shown in Figure II.

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FIGURE I

General Sketch of Test Set up

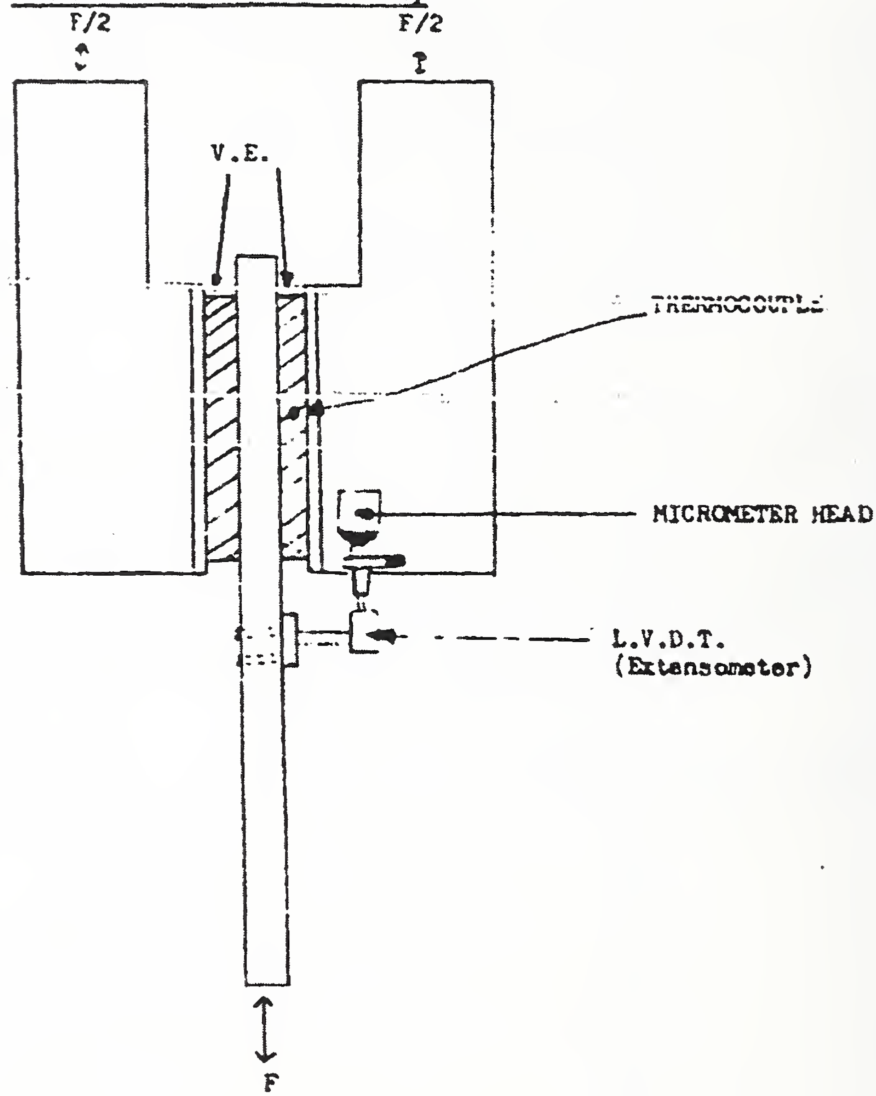

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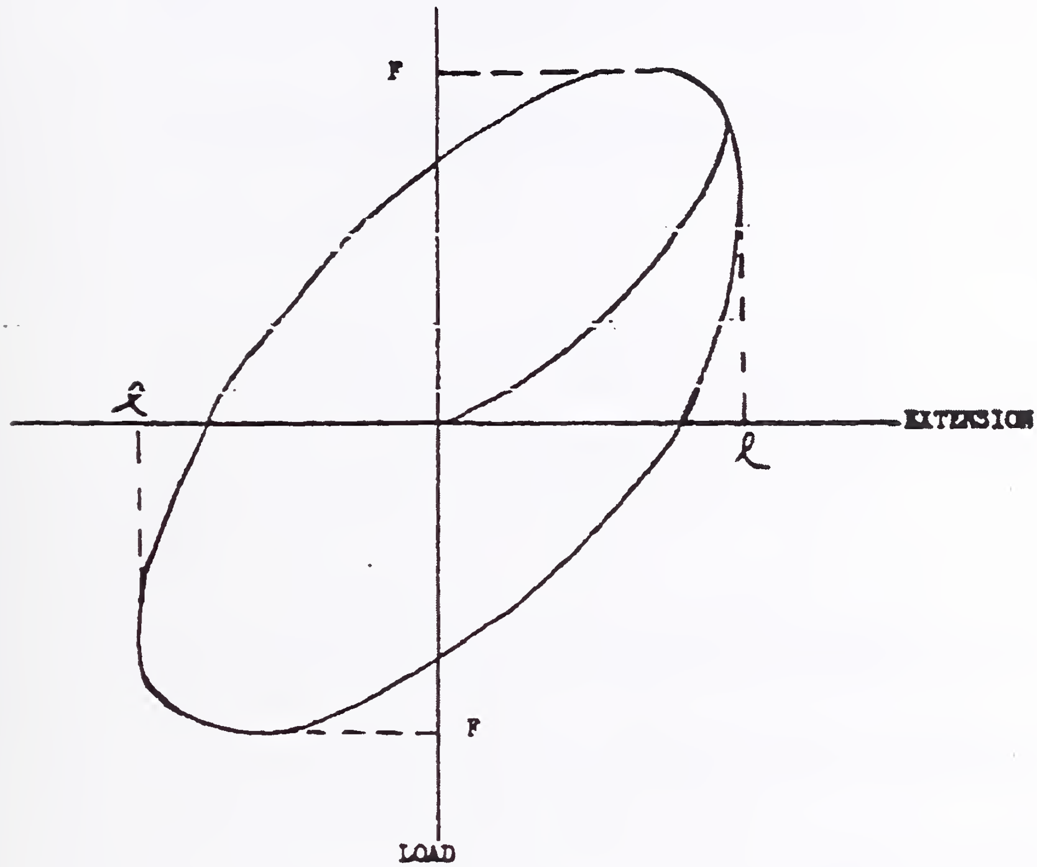
FIGURE II

A TYPICAL HYSTERESIS LOOP



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(5) Record the value of F from the X-Y chart recorder.

(6) Calculate results from Step (5) to a common visco-elastic width of 8" following the procedure given in 5.3.4 and record separately.

(7) Calculate results from Step (6) to a common temperature of 75°F. according to the procedure given in 5.3.5. Use these values in calculating the Requirement Average according to the procedure given in 3.2.

(8) Measure the bounded area of the hysteresis loop with a planimeter.

(9) Calculate the results from Step (8) for a common viscoelastic width of 8" following the procedure given in 5.3.4 and record separately.

(10) Calculate the Loss Shear Modulus, G", from

$$G'' = \frac{A_L C_1 C_2}{\pi \gamma^2 v}$$

using the values of A_L from Step (9).

(11) Calculate the shear stress, s, from

$$s = \frac{F}{A_{v.e.}}$$

using the values of F from Step (6).

(12) Calculate the complex shear modulus, G*, from

$$G^* = \frac{s}{\gamma}$$

(13) Calculate the Elastic Shear Modulus, G', from

$$G' = [\ (G^*)^2 - (G'')^2\ ]^{1/2}$$

(14) Calculate Loss Factor, D, from

$$D = \frac{G''}{G'}$$

Use these values in calculating the Requirement Average according to the procedure given in 3.2.

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5.3.6.2 FATIGUE TEST

(1) Measure and record the temperature of the viscoelastic material immediately before starting the Fatigue Loss measurements.

(2) Following the detailed procedures given in Section 5.3.6.1 run 99 successive cycles of the hysteresis loop (Loss Factor and Stiffness) test.

(3) Return the damper to the temperature measured under (1) $\pm$ 1°F.

(4) Run the 100th. cycle as in (2).

(5) Following the procedures given in 5.3.6.1 calculate Stiffness for the 100th. cycle.

5.3.6.3 ULTIMATE STRENGTH

(1) Follow 5.3.3.

(2) Bolt an assembled damper in the special jaws attached to the test machine. Use new high tensile steel bolts for each test. Use 1" diameter ASTM A 490 bolts for attaching the tee end of the damper and 7/8" diameter A-490 bolts (Type A units) or 1 1/4" diameter A 490 bolts (Type B units) for the bar end. Tighten all nuts until all four jaws and the specimen are firmly together, then tighten each nut an extra 1/2 turn.

Remove the four assembly packaging bolts. Do not remove shims.

(3) Set the test machine on lineal deformation control at a speed of 0.5"/min. and apply a compressive load axially to the ends of the damper until shear failure of the viscoelastic bonded area occurs.

(4) Use the X-Y chart recorder to make a continuous permanent record of the load-deflection relationship.

(5) Record the maximum load shown on the chart.

(6) Calculate results from Step (5) for a common viscoelastic width of 8" following the procedure given in 5.3.4. This is the Ultimate Strength.

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Appendix E
SUPPORTING DOCUMENTS FOR CHAPTER 6

This appendix contains the supporting documents that are referenced in Chapter 6 of this report. All of the documents contained in this appendix are reproduced with permission of The Port Authority of New York and New Jersey. Table E–1 contains a summary of supporting documents and their location within this appendix. The footnote numbers given in the table correspond to those in Chapter 6. Documents in the table without footnote numbers are referenced in the main body of Chapter 6.

Table E–1. Supporting documents for Chapter 6.

Footnote Number	Document Title	Page(s)
	Section 6.3.1 – Floor Trusses	
–	Fabrication and inspection requirements from the contract between the Port Authority and Laclede Steel Company for the floor trusses used in WTC 1 and WTC 2 (WTCI-71-I)	276
	Section 6.3.2 – Box Core Columns and Built-up Beams	
–	Fabrication and inspection requirements from the contract between the Port Authority and Stanray Pacific Corporation for the box core columns and built-up beams used in WTC 1 and WTC 2 (WTCI-244-L)	299
1	Letter dated June 5, 1967 from Leslie E. Robertson of SHCR to Malcolm P. Levy of PONYA (WTCI-491-L)	309
2	Draft contract between United States Testing Company and PONYA dated August 25, 1967 (WTCI-493-L; first page of the contract and Appendix 1 of this document]	319
3	Letter dated April 5, 1967 from Leslie E. Robertson of SHCR to Malcolm P. Levy of PONYA (WTCI-489-L)	325
4	Letter dated September 21, 1967 from R. M. Monti of PONYA to R. E. Morris of the Stanray Pacific Corporation (WTCI-490-L)	330
5	Letter dated November 13, 1967 from R. M. Monti of PONYA to R. E. Morris of Stanray Pacific Corp. (WTCI-498-L)	332
	Section 6.3.3 – Exterior Wall from Elevation 363 ft to the 9th Floor Splice	
6	Letter dated October 21, 1966 from PDM to James R. Endler of Tishman Realty and Construction Company Inc. (part of WTCI-745-L; second page and enclosure appears to be missing)	335
–	Amendments made to initial quality control program submitted to PONYA by PDM (parts of WTCI-744-L)	336
7	PDM specifications for welding procedures (parts of WTCI-741-L)	347
8	Letter dated October 4, 1967 from R. M. Monti of PONYA to H. M. Fish of PDM (WTCI-745-L)	364
	Section 6.3.4 – Exterior Wall Above 9th Floor Splice	
–	Fabrication and inspection requirements from the contract between the Port Authority and Pacific Car and Foundry Co. for the exterior walls used in WTC 1 and WTC 2 (WTCI-242-L)	366
9	Letter dated July 8, 1967 from R. C. Symes of Pacific Car and Foundry to R. M. Monti of PONYA (part of WTCI-748-L)	372
10	Letter dated July 13, 167 from James White of SHCR to R. M. Monti of PONYA (part of WTCI-748-L)	373
	Section 6.3.5 – Rolled Columns and Beams	
–	Fabrication and inspection requirements from the contract between the Port Authority and Montague-Betts Company, Inc. for the rolled columns and beams used in WTC 1 and WTC 2 (WTCI-243-L)	379

CHAPTER THREE

FABRICATION OF STRUCTURAL STEEL

01 GENERAL

301.100 Structural steel shall be fabricated complete as shown in the Drawings and in approved details shown in the shop drawings.

301.200 The steel furnished for each location shall have a minimum yield point equal to that scheduled in the Drawings, and shall be selected from the applicable steel specifications listed in Chapter Two, MATERIALS.

301.300 All steel shall be ASTM A36 for locations where a specific strength requirement is not stated in the Drawings.

02 IDENTIFICATION

302.100 The Contractor shall identify all steel which will be used in the work beginning at the mill and shall maintain identification at all times thereafter including during fabrication. The method used shall make both the grade and yield point of the steel readily identifiable. Identification shall be maintained after fabrication.

302.200 The Contractor shall identify each member or assembly with a system of marks. Each mark shall be clearly indicated in the shop drawings. The system of identification marks for fabricated structural steel shall be a permanent system such as stamping and be approved by the Engineer In addition, the contractor shall paint erection marks on each piece.

SPECIFIC REQUIREMENTS

303.100 Flame cutting by hand shall not be performed without the Engineer's approval. Handcut surfaces shall be made smooth by chipping, planing or grinding.

303.200 Fabricated material containing sharp kinks or bends shall be rejected. Material straightened prior to fabrication shall be carefully examined for signs of distress or other defects before being placed in fabrication. Distressed or otherwise defective material shall not be used in the work.

303.300 Where required by the Contract Documents, surfaces shall be milled, or finished by other approved means. All finishing shall be clearly shown in the shop drawings.

303.400 Bolt holes and similar holes shall be punched, drilled, sub-punched or sub-drilled and reamed, and shall not be made or enlarged by gas cutting.

303.500 Holes required by the Erector, and shown on the Drawings prior to approval of Shop Drawings shall be furnished without cost.

4 FABRICATION TOLERANCES

304.100 Fabrication tolerances shall conform to the requirements of the AISC Specification and AWS D1.0, as supplemented by specific requirements contained in the Drawings and Specifications. In no case shall tolerances exceed those obtainable by the best modern shop practice

SPECIAL REQUIREMENTS

Floor trusses shall be fabricated to fall within the tolerances listed below:

1.	Camber at midspan	$\pm$ 3/8 inch
2.	Deviation from design depth	$\pm$ 1/4 inch
3.	Longitudinal deviation of panel point along chord	$\pm$ 1/4 inch
4.	Vertical deviation of panel point from longitudinal axis	$\pm$ 1/4 inch
5.	Deviation in over-all length	$\pm$ 3/8 inch
6.	Maximum sweep (in inches)	$\frac{\text{over-all length (in feet)}}{40}$

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05 QUALITY CONTROL AND INSPECTION:

105.100 Supervision and Inspection

All fabrication and welding of floor trusses shall be subject to continual visual inspection, surveillance and supervision by responsible, qualified Contractor's supervisory personnel. These personnel will check for dimensional conformance to applicable details, proper manufacturing procedures, correct settings of automated controls, and will ensure that required weld strengths and specified quality of all finished material fabricated under this Contract conforms to the Specifications and to this Quality Control Program.

105.101 Material Test Reports

With minor exceptions, all steel employed in the fabrication of trusses will be produced in the furnaces and mills of The Contractor. A copy of each applicable certified mill test report showing heat number, chemistry, and physical properties for all steel truss components will be transmitted to The Engineer and to S-H-C-R by the Contractor, regardless of the source of the material.

105.102 Resistance Welding

All interior truss panel points will be connected by electronically controlled resistance welding designed to provide a minimum of two times the strength of the connected members at full design load.

All angle chords will be cleaned by shot blasting to ensure that contact surfaces are scale-free prior to production line resistance welding.

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All production line panel point welds will undergo "on-line" non-destructive testing by hydraulic wedge action testers which apply pre-determined, accurately measured test forces. The force applied by the wedge action tester will subject the welds tested to a minimum force across the welds of 2.25 times the calculated design force carried by the highest loaded member at the subject joint. The wedge action testing device is arranged so that the test force is applied to the two welds on one side of each panel point, resulting in mechanical inspection of 50% of all production line welds.

In addition, production line panel point welds on completed trusses will be spot-checked by vertical double shear tests. These spot-check tests will include the first completed truss in each run of a given style and a minimum of one truss for each 200 trusses in a run of a given style. Panel point welds will be subjected to test loads equal to or exceeding two times the summation of the design forces in all members at the subject joint. In trusses selected for vertical double shear tests, each joint in the truss will be tested. All trusses passing vertical double shear tests will be returned into the production line and incorporated into the work.

All panel point welds failing either the wedge action test or the double shear test will be repaired by adding hand welded fillet welds at all four chord-web intersections at each applicable panel point. Repair arc welding will be under the supervision and surveillance of supervisory personnel who are certified welders in accordance with Appendix D, Part II Welder Qualification, of AWS D1.0-66. All repair welds will be subjected to the double shear test. Repair welds which fail to provide a minimum of two times the calculated design strength of the connected members will be rejected.

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Full scale load tests will be performed on completely fabricated truss components. A minimum of one load test will be made for each identified truss style designated on Design Data Sheets D105-T1 through D105-ET10, inclusive (see Pages 0-11 and 0-12). Test loads will be applied by hydraulic loading in a test frame designed for this purpose. Load will be measured by electric load cells and center span deflection will be checked by dial gages. Deflection and recovery data will be measured and recorded for each increment of load application or removal for at least one load test of each style referred to above. Deflection at design load and maximum applied load will be recorded for all load tests. One copy of the report of each load test, whether successful or unsuccessful, will be forwarded to The Authority.

105.103 Physical Tension Tests

Tension tests on truss components, chord angles, and webs will be performed at random on selected sample members included in the normal truss fabrication. Reports of these tests will be forwarded to the Engineer and to S-H-C-R.

105.104 Marking

All trusses will be subjected to final inspection by The Contractor's Quality Control personnel. Trusses which conform to the requirements of the foregoing Quality Control and Inspection program and to the Specifications will be marked by a painted erection mark for each type of truss. Identification tags will be affixed to each truss or each bundle of trusses of the same style and erection mark

105.105 Access to Plant

Free access to the plant of the truss manufacturer and

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the available inspection and test facilities will be offered the qualified inspectors representing the Authority for observation of the test and inspection procedures outlined herein.

105.106 Additional or Extra Tests

Any testing requested beyond that identified herein shall be for the account of the Authority.

CHAPTER FOUR

WELDING OF STRUCTURAL STEEL

401 GENERAL REQUIREMENTS

401.100 Welding of structural steel shall conform to the requirements of the AISC Specification and AWS D1.0, except where the AISC Specification of AWS D1.0 is specifically modified or supplemented by information included in the Drawings or Specifications.

402 QUALIFICATION AND CERTIFICATION OF WELDERS

402.100 Welders and welding operators (except resistance welding machine operators) shall have passed the applicable AWS qualification tests prescribed in AWS D1.0, Appendix D, Parts II and III. AWS qualification tests shall be supervised and witnessed by an agency approved by the Engineer. The approved agency shall issue certified test reports which describe the tests performed and indicate the results of the tests. Certification papers issued by the approved agency shall clearly state the types of work the certified welder or welding operator is qualified to perform. Certification is to be achieved in the 12 months preceding the date the subject welder begins work under the Contract. AWS qualification tests and certification shall be paid for by the Authority and witnessed by the Engineer's designated representative.

'03 WELDING PROCEDURE SPECIFICATIONS AND JOINT QUALIFICATIONS

403.100 Joints conforming to the details specified in AWS D1.0, Articles 209, 210, 211, 212, 213 and 214 and welded in accordance with the

requirements of Sections 3 and 4 of AWS D1.0 are designated prequalified with the following exceptions:

403.101 Partial penetration butt welds

403.102 Welds in steels with yield points exceeding 50 ksi.

403.200 The Contractor shall develop welding procedure specifications for all welded joints. No joint shall be welded until the welding procedure specification for that joint has been approved by the Engineer.

403.300 For steels with specified yield points exceeding 50 ksi, welding procedure specifications shall be qualified in accordance with Article 502, AWS D1.0. No work containing a joint requiring qualification shall be fabricated before welding procedure specifications for that joint are qualified by the Contractor and approved by the Engineer. Records of procedure tests shall be maintained by the Contractor. Test reports shall be certified by the Contractor and submitted to the Engineer for examination.

404 PREHEAT AND INTERPASS TEMPERATURES

404.100 Preheat and interpass temperatures shall be those specified in the welding procedure specifications prepared by the Contractor and approved by the Engineer.

405 WELDING ELECTRODES AND FLUX

405.100 Manual welding electrodes shall be those scheduled in the Drawings and shall in all cases be those specified in the approved welding procedure specifications.

405.200 Welding electrodes and flux for submerged arc welding shall conform to Section 202, MATERIALS.

405.300 Gas metal-arc welding materials, where approved for use in the work, shall conform to Section 202, MATERIALS, and to the requirements of the approved welding procedure specification.

405.400 Electronically controlled resistance welding of truss panel points shall be approved provided the submitted quality control provisions for weld strength and consistency are satisfied.

Resistance welds shall consist of four point scale free welds developed by pressure contact of beaded chord angles and round web sections. Where fillers and single web intersections occur, two point welds shall be developed by pressure contact.

Welding cycle, welding pressure and current applications shall be electronically controlled to assure uniform scale free resistance welds in all cases to develop the strength required in single or double shear.

Certification as to the weld strength as required by the submitted quality control program shall be made available to the Engineer.

CHAPTER THREE

FABRICATION OF STRUCTURAL STEEL

301 GENERAL

301.100 Structural steel shall be fabricated complete as shown in the Drawings and in approved details shown in the shop drawings.

301.200 The steel furnished for each location shall have a minimum yield point equal to that scheduled in the Drawings, and shall be selected from the applicable steel specifications listed in Chapter Two, MATERIALS.

301.300 All steel shall be ASTM A36 for locations where a specific strength requirement is not stated in the Drawings.

302 IDENTIFICATION

302.100 The Contractor shall identify all steel which will be used in the work beginning at the mill and shall maintain identification at all times thereafter including during fabrication. The method used shall make both the grade and yield point of the steel readily identifiable.

302.200 The Contractor shall identify each member or assembly with a system of marks. Each mark shall be clearly indicated in the shop drawings. The system of identification marks for fabricated structural steel shall be approved by the Engineer

.03 SPECIFIC REQUIREMENTS

303.100 Flame cutting by hand shall not be performed without the Engineer's approval. Handcut surfaces shall be made smooth by chipping, planing or grinding.

303.200 Fabricated material containing sharp kinks or bends shall be rejected. Material straightened prior to fabrication shall be carefully examined for signs of distress or other defects before being placed in fabrication. Distressed or otherwise defective material shall not be used in the work.

303.300 Where required by the Contract Documents, surfaces shall be milled, or finished by other approved means. All finishing shall be clearly shown in the shop drawings.

303.400 Bolt holes and similar holes shall be punched, drilled, sub-punched or sub-drilled and reamed, and shall not be made or enlarged by gas cutting.

303.500 Holes required by the Erector, and shown on the Drawings prior to approval of Shop Drawings shall be furnished without cost.

Page 3-02A

303.600 The Contractor may substite tees cut from rolled shapes in lieu of tees built up from plates at the beam and girder seat connections in the drawings. Tees cut from rolled shapes shall be of a thickness and grade equal to or greater than the thickness and grade of plates presently shown in the drawings.

303.700 Where box beams in this Contract connect to columns by means of a beam seat and top flange connection plate, the top flange connection plate may at the Contractor's option be shipped loose with the box beam. No shims for "loose" top flange connection plates are required.

303.800 The Contractor may elect to shop splice box core columns at each floor, at a point 3' -0" above the floor line. The edge preparation and welding at these shop splices shall conform to the edge preparation and welding shown for field splices at box core columns in Drawing Book #3. Each individual section shall be milled, welded up, and then the completed column shaft shall be milled to final length.

303.900 The Contractor may substitute a type 300 column, using plates of the same grade, equivalent area and section modulus, for the type 400 box columns with a middle web. In this case, the Contractor shall provide any transitional section required to suit the type 400 or type 500 columns below the 9th story splice. All fillet welds shall be in accordance with Drawing Book #3.

304 FABRICATION TOLERANCES

304.100 Fabrication tolerances shall conform to the requirements of the AISC Specification and AWS D1.0, as supplemented by specific requirements contained in the Drawings and Specifications. In no case shall tolerances exceed those obtainable by the best modern shop practice.

305 SPECIAL REQUIREMENTS

305.100 Fabrication tolerances shall conform to the tolerances shown on Sheets 3-04 through 3-05 inclusive. Where specific tolerances are not shown on Sheets 3-04 through 3-05 tolerances shall conform to the requirements of the Specifications.

305.200 Cut edges of steel shall be free of burrs, overhangs, gross laminations, excessive slag inclusions and similar defects. Where necessary, cut edges shall be repaired by means described in the Contractor's quality control and testing program. Where required to maintain weld quality, corners of plates shall be eased and cut edges shall be ground. Work of this nature shall be outlined in the Contractor's quality control and testing program and shall be described in detail in the Contractor's welding procedure specifications.

305.201 Repairs at gas cut edges made as follows will be approved by the Engineer:

Where serrations are not deeper than 1/8", edge shall be hit with a grinder and sharp edges removed. Where serrations exceed 1/8", the serrations shall be filled in with weld metal uniform in appearance; however, grinding will not be required except in areas where beams frame to column faces.

305.300 In certain locations in the Drawings, slotted or oversize holes are specifically required. Where the Contractor elects to use slotted or oversize holes not shown in the Drawings, the use of slotted or oversize holes shall be subject to the Engineer's approval.

305.400 The Engineer will provide for the Contractor's use a table of correction factors which the Contractor shall use to determine the correct as-fabricated dimensions of structural steel members. The correction factor for columns will be the sum of the correction for temperature at time of fabrication and the correction due to shortening under load. Correction factors will be based on a standard temperature of 70 degrees Fahrenheit. The minimum increment of correction to be included in the table of correction factors will be 1/16", said tables to be mailed to the Contractor on June 30, 1967.

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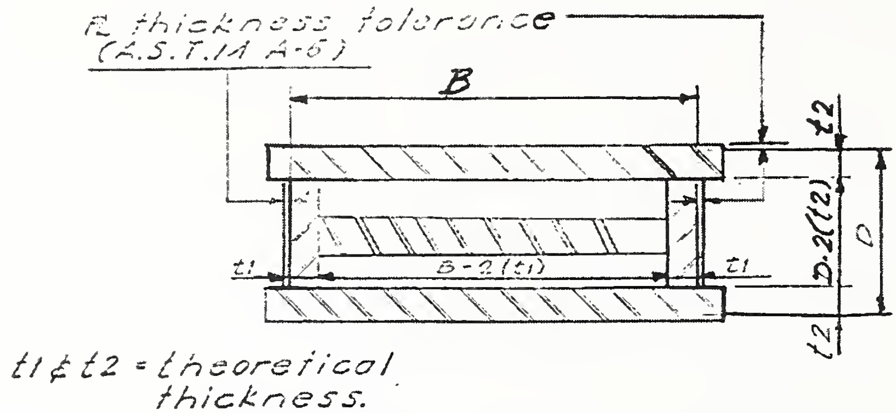
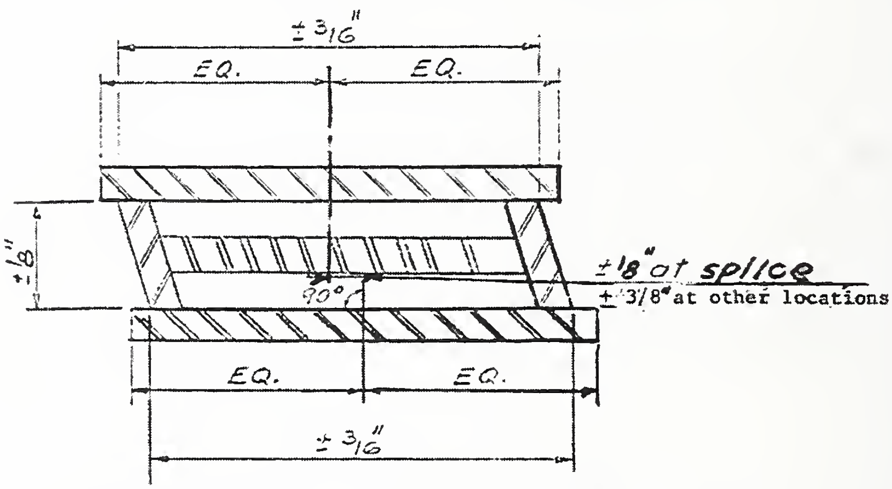
5-10-67



DETAILING DIMENSIONS



Compression joints which depend upon contact bearing, when assembled in the shop, shall bear evenly with respect to the centroid of the contact area. At least 75 per cent of the entire contact area shall be in full bearing and the separation of any remaining portion shall not exceed 0.01 inch except adjacent to toes of flanges where a localized separation not exceeding 0.025 inch is permissible.

DEPTH, WIDTH AND OUT-OF-SQUARE TOLERANCES
(CORE COLUMN TYPE 400 & 500)

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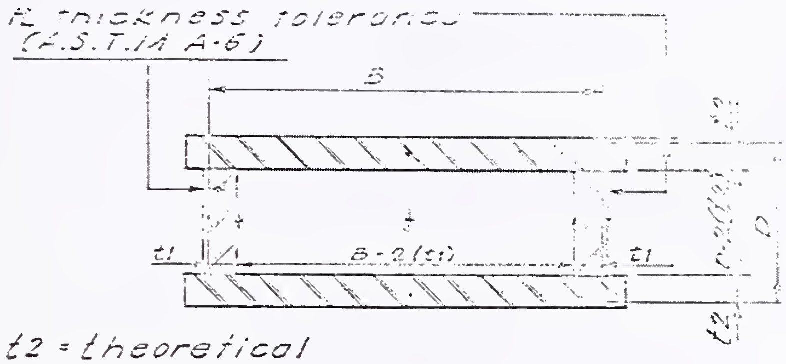
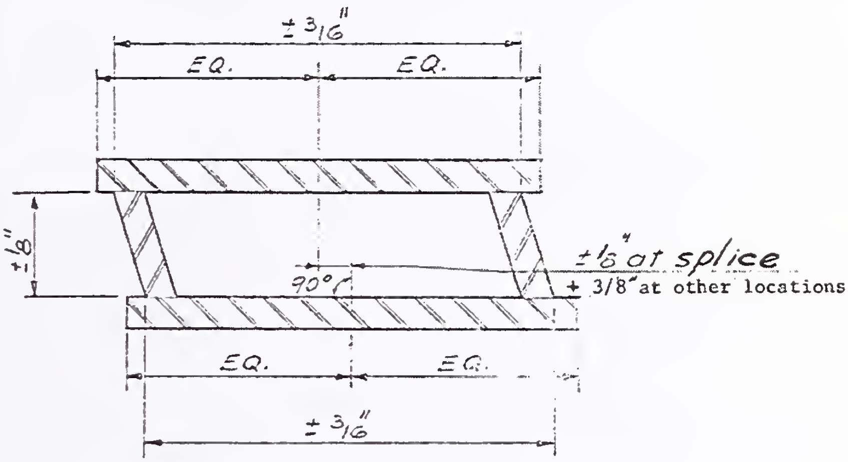
5-10-67



t1 & t2 = theoretical thickness.

DETAILING DIMENSIONS



Compression joints which depend upon contact bearing, when assembled in the shop, shall bear evenly with respect to the centroid of the contact area. At least 75 per cent of the entire contact area shall be in full bearing and the separation of any remaining portion shall not exceed 0.01 inch except adjacent to toes of flanges where a localized separation not exceeding 0.025 inch is permissible.

DEPTH, WIDTH AND OUT-OF-SQUARE TOLERANCES

(CORE COLUMN TYPE 300)

CHAPTER FOUR

WELDING OF STRUCTURAL STEEL

401 GENERAL REQUIREMENTS

401.100 Welding of structural steel shall conform to the requirements of the AISC Specification and AWS D1.0, except where the AISC Specification or AWS D1.0 is specifically modified or supplemented by information included in the Drawings or Specifications.

402 QUALIFICATION AND CERTIFICATION OF WELDERS

402.100 Welders and welding operators shall have passed the applicable AWS qualification tests prescribed in AWS D1.0, Appendix D, Parts II and III. AWS qualification tests shall be supervised and witnessed by an agency approved by the Engineer. The approved agency shall issue certified test reports which describe the tests performed and indicate the results of the tests. Certification papers issued by the approved agency shall clearly state the types of work the certified welder or welding operator is qualified to perform. Certification shall have been achieved immediately preceding the date the subject welder begins work under the Contract. AWS qualification tests and certification shall be paid for by the Authority and witnessed by the Engineer's authorized representative.

403 WELDING PROCEDURE SPECIFICATIONS AND JOINT QUALIFICATIONS

403.100 Joints conforming to the details specified in AWS D1.0, Articles 209, 210, 211, 212, 213 and 214 and welded in accordance with the

requirements of Sections 3 and 4 of AWS D1.0 are designated as prequalified.

403.200 The Contractor shall develop welding procedure specifications for all types of welds such as: manual, semi-automatic and automatic procedures for fillet, butt and groove welds. No welding shall be done until the welding procedure specification for that type of weld has been approved by the Engineer.

404 PREHEAT AND INTERPASS TEMPERATURES

404.100 Preheat and interpass temperatures shall be those specified in the welding procedure specifications prepared by the Contractor and approved by the Engineer.

405 WELDING ELECTRODES AND FLUX

405.100 Manual welding electrodes shall be those scheduled in the Drawings and shall in all cases be those specified in the approved welding procedure specifications.

405.200 Welding electrodes and flux for submerged arc welding shall conform to Section 202, MATERIALS.

405.300 Gas metal-arc welding materials, where approved for use in the work, shall conform to Section 202, MATERIALS, and to the requirements of the approved welding procedure specification.

THE WORLD TRADE CENTER

105 INSPECTION, QUALITY CONTROL AND TESTS

105.100 Quality Control and Tests (see Contractor's letter of 6/2/67 attached hereto)

105.101 The Contractor shall comply with the quality control and testing program annexed hereto and forming a part hereof during the course of the work to assure that all work conforms to the Contract Documents.

105.102 Materials Control

All steel plates and shapes are subject to visual inspection on receipt into the material receiving yard.

Unsatisfactory material is identified at this point and referred to the Engineering Department for disposition.

Copies of mill test reports are received by the Quality Control Department. Heat numbers on all steel items are identified and compared to mill test reports to verify use of proper material.

Heat numbers are transferred to each main component by paint stick prior to cutting.

105.103 Material Preparation

All cutting, burning, punching, drilling operations, etc., are subject to continuous visual inspection by the Contractor.

105.104 Welding

Welders are to be qualified in accordance with Appendix "D" of American Welding Society Codes D1.0-66 and D2.0-66.

If Authority requires welders to be re-certified, Authority will pay the cost of re-certification.

Each welding operator is assigned a steel stencil identification symbol. Each welding operator shall stamp for identification purposes each weld as it is completed.

Preheat temperatures shall be checked by appropriate "tempsticks" prior to performing welds.

105.105 Testing by Contractor

Non-destructive testing of welds shall be accomplished by either magnetic particle and/or dye penetrant methods. The method selected shall be at the discretion of the quality control supervisor of the Contractor.

Time of such testing and selection of welds to be tested shall be the responsibility of the quality control supervisor. However, these functions will be carried out in a manner so as to provide a minimum of delays to the production operation.

Non-destructive testing shall be performed on 100% of the members during initial operations and then adjusted so as to provide a maximum of 10% coverage of all shop welds. The Contractor shall furnish all testing machines, testing machine operators and testing materials required for the Contractor's quality control and testing program.

105.106 Welding Inspection

All preheat and welding operations shall be performed under the continuous visual supervision of welding supervisors and quality control inspectors.

105.107 Built-up Members

On completion of fit-up and prior to welding, inspect for material size, thickness and dimensional conformance with applicable shop drawings and tolerances in accordance with the specifications.

Inspect for layout of mill line for shop splice.

Inspect welding of built-up members per 105.106.

Perform non-destructive testing per 105.105.

Perform final inspection of built-up members for full compliance with Contract documents. Final acceptance to be signified on record shop drawing for each member inspected.

105.108 Building Components (Columns and Beams)

On completion of fitting of detail material to built-up members (105.107, inspect detail for material size, thickness, hole size, gauge, spacing, location and dimensional conformance with applicable shop drawings and tolerances in accordance with the specifications.

Inspect welding of detail material per 105.106.

Perform non-destructive testing per 105.105.

Inspect fit-up of shop splice (when applicable) for multi-piece members.

Inspect welding of shop splice per 105.106.

Perform non-destructive testing per 105.105.

Inspect layout of final mill lines per applicable shop drawings.

Perform final inspection of each building component for full compliance with Contract documents.

Final acceptance to be signified on record shop drawing for each member inspected.

105.109 The Contractor shall submit mill test reports to the Engineer for all material used in the work.

The Contractor shall report the location and quality of all corrective work.

105.200 The Authority's inspection will be provided at no cost to the Contractor and is intended to assure conformance of Contractor's fabricating operations and procedures with Contract documents. The Authority to also provide mill inspection of materials to assur complete compliance with A.S.T.M. specifications as well as special requirements of Stanray Pacific Corporation regarding quality and tolerance.

105.201 Shop Inspection

The Authority will provide continuous visual inspection of all operations.

Inspection is to be progressive and concurrent with Contractor's quality control operation.

Non-destructive testing as performed by Contractor (see 105.105) will be observed and witnessed by Port Authority inspectors.

105.202 Final Inspection and Acceptance(Built-up Members)

On completion of fabrication, the Authority will perform final inspection of each built-up member for full compliance with Contract documents. Inspect for material size, thickness, weld size and workmanship. Final acceptance to be signified on record shop drawing each member inspected.

Building Components (Columns and Beams)

On completion of fabrication and prior to shipping, the Authority will perform final inspection of each building component for full compliance with Contract documents. Inspect shop splicing (when applicable); fit-up of clips, lugs, brackets, etc.; material sizes and thicknesses; hole size, gauge and spacing; location, dimensional conformance, welding and workmanship. Final acceptance to be signified on record shop drawing for each building component inspected.

106 DEFECTIVE WORK

106.100 Defective and unsuitable work and all work failing to conform to the Contract documents shall, where permitted by the Engineer, be made good at the Contractor's expense. Work may be rejected, regardless of previous approval in shop drawings, inspection or inclusion in a certificate of payment, provided that after final inspection and acceptance by the Authority as provided in 105.202, the Contractor shall have no responsibility or liability for any defect whatsoever, except latent defects which a reasonably prudent inspection would not disclose and any errors in the shop drawings furnished by Contractor.

STANRAY PACIFIC CORPORATION
subsidiary of STANRAY CORPORATION

11633 SOUTH ALAMEDA STREET · LOS ANGELES, CALIFORNIA 90002 · (213) 566-2111

THE PORT OF NEW YORK AUTHORITY
RECEIVED
JUN 8 1967
WORLD TRADE DEPARTMENT
WORLD TRADE CENTER
PLANNING DIVISION

June 2, 1967

Mr. Lester Feld
The Port of New York Authority
111 Eighth Avenue at Fifteenth Street
New York, New York

Subject: World Trade Center
Contract No. WTC 217.00 - Revised Quality Control Program

Dear Lester:

Enclosed you will find two copies of the Welding Procedures to be incorporated into our Quality Control Program which is outlined in section 105 of Contract No. WTC 217.00. This constitutes our entire Quality Control and Testing Program.

The Inspection Requirements referred to as item 2 C in your letter of May 25, is now completed and will be mailed to you on Monday, June 5.

Yours very truly,

STANRAY PACIFIC CORPORATION

F. E. Allen
Controller

dh
Encl.

June 2, 1967

STANRAY PACIFIC CORPORATION

WELDING PROCEDURES

Manual Fillet Welds - Low Hydrogen Electrodes

Weld Type: MF-1

Material:	A36
Electrodes:	E7018
Weld Position:	1F; 2F, 3F
Electrode Size:	3/16" and 7/32"
Amperage:	3/16" - 200 to 275 7/32" - 260 to 340
Voltage:	3/16" - 21 to 25 7/32" - 22 to 26
Preheat:	To 3/4" T - Nominal Temperature Over 3/4" T - 100° F per inch thickness to 250° F Maximum
Current:	D.C. reverse polarity, or A.C.

Weld Type: MF-2

Material:	A36
Electrodes:	E7028
Weld Position:	1F and 2F
Electrode Size:	3/16" and 1/4"
Amperage:	3/16" - 225 to 310 1/4" - 325 to 430
Voltage:	3/16" - 23 to 27 1/4" - 24 to 29
Preheat:	To 3/4" T - Nominal Temperature Over 3/4" T - 100° F per inch thickness to 250° F Maximum
Current:	D.C. reverse polarity or A.C.

Manual Fillet Welds - Iron Powder Electrodes

Weld Type: MF-3

Material:	A36
Electrodes:	E7024
Weld Position:	1F and 2F
Electrode Size:	3/16" and 1/4"
Amperage:	3/16" - 230 to 310 1/4" - 325 to 430
Voltage:	3/16" - 23 to 28 1/4" - 24 to 30
Preheat:	To 3/4" T - Nominal Temperature Over 3/4" T - 100° F per inch thickness to 250° F Maximum
Current:	A.C. or D.C.

WELDING PROCEDURES

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Fillet Welds - Semi Automatic Innershield Wire

Weld Type: IS-1

Material:	A36
Electrodes:	NS-3M Flux Core
Weld Position:	1F and 2F
Electrode Size:	0.120"
Amperage:	425 to 550
Voltage:	28 to 36
Preheat:	To 3/4" T - Nominal Temperature Over 3/4" T - 100° F per inch thickness to 250° F maximum
Current:	D.C. reverse polarity

Fillet Welds - Tandem Wire Submerged Arc

Weld Type: SA-1

Material:	A36
Electrodes & Flux:	A.S.T.M. - A558
Weld Position:	Flat
Electrode Size:	7/32" and 3/16"
Amperage:	7/32" - 750 to 950 3/16" - 700 to 850
Voltage:	7/32" - 35 to 40 3/16" - 35 to 40
Preheat:	To 3/4" T - Norminal Temperature Over 3/4" T - 100° F per inch thickness to 250° F maximum
Current:	7/32" - D.C. straight polarity 3/16" - A.C.

Fillet Welds - Triple Wire Submerged Arc

Weld Type: SA-2

Material:	A-36
Electrodes & Flux:	A.S.T.M. - A558
Weld Position:	Flat
Electrode Size:	3/16", 3/16" and 5/32"
Amperage:	3/16" Lead Wire, 1000 to 1200 3/16" No. 2 Wire, 850 to 1000 5/32" No. 3 Wire, 750 to 900
Voltage:	3/16" Lead Wire, 35 to 40 3/16" No. 2 Wire, 38 to 43 5/32" No. 3 Wire, 40 to 46
Preheat:	To 3/4" T - Nominal Temperature Over 3/4" T - 100° F per inch thickness to 250° F maximum
Current:	Lead Wire: D.C. straight polarity No. 2 Wire: A.C. No. 3 Wire: A.C.

WELDING PROCEDURES

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Complete Penetration Welds, Manual Electrodes
Partial Penetration Welds, Manual Electrodes

Weld Type: MB-1

Joint Specification: A.W.S. D1.0, Appendix E2 and E4

Material:	A36
Electrodes:	E7018
Weld Position:	1G; 2G; 3G
Electrode Size:	5/32" and 3/16"
Amperage:	5/32" - 150 to 200 3/16" - 180 to 260
Voltage:	5/32" - 20 to 26 3/16" - 22 to 27
Preheat:	To 3/4" T - Nominal Temperature Over 3/4" T - 100° F per inch thickness to 250° F Maximum
Current:	D.C. reverse polarity or A.C.

Complete Penetration Welds, Semi Automatic Innershield
Partial Penetration Welds, Semi Automatic Innershield

Weld Type: IS-2

Joint Specification: A.W.S. D1.0, Appendix E2 and E4

Material:	A36
Electrodes:	NS-3M
Weld Position:	1G and 2G
Electrode Size:	0.120"
Amperage:	425 to 500
Voltage:	26 to 30
Preheat:	To 3/4" T - 70° F Over 3/4" T - 100° F per inch thickness to 250° F maximum
Current:	D.C. reverse polarity

WELDING PROCEDURES

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Complete Penetration Welds, Manual and Semi Automatic
Partial Penetration Welds, Manual and Semi Automatic

Weld Type: CB-1

Joint Specification: A.W.S. D1.0, Appendix E2 and E4

Material:	A36
Electrodes:	Manual - E7018 root passes
	Semi Automatic - NS3M Innershield
Weld Position:	1G and 2G
Electrode Size:	E7018 - 5/32"
	NS3M - 0.120"
Amperage:	5/32" E7018 - 150 to 220
	NS3M - 475 to 500
Voltage:	E7018 - 22 to 25
	NS3M - 28 to 32
Preheat:	To 3/4" T - 70° F
	Over 3/4" T - 100° F per inch thickness to 250° F maximum
Current:	D.C. reverse polarity

Manual Fillet Welds - Low Hydrogen Electrodes

Weld Type: MF-S1

Material:	A572, Grade 50
Electrodes:	E7018
Weld Position	1F, 2F, 3F
Electrode Size:	5/32" and 3/16"
Amperage:	5/32" - 150 to 200
	3/16" - 200 to 250
Voltage:	5/32" - 20 to 24
	3/16" - 21 to 25
Current:	D.C. reverse polarity or A.C.
Preheat:	To 3/4" T - 70° F
	Over 3/4" T - 100° F per inch thickness to 250° F to 300° F maximum interpass temperat
Temperature Control:	"Tempil-Stik" Crayons or equal

WELDING PROCEDURES

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Weld Type: MF-S2

Material:	A572, Grade 50
Electrodes:	E7028
Weld Position:	1F and 2F
Electrode Size:	3/16" and 7/32"
Amperage:	3/16" - 220 to 300
	7/32" - 250 to 350
Voltage:	3/16" - 23 to 27
	7/32" - 23 to 28
Current:	D.C. reverse polarity or A.C.
Preheat:	To 3/4" T - 70° F
	Over 3/4" T - 100° F per inch thickness to 250° F maximum. 300° F maximum interpass temperat
Temperature Control:	"Tempil-Stik" Crayons or equal

Semi Automatic Fillet Welds - Innershield Electrodes

Weld Type: IF-S1

Material:	A572, Grade 50
Electrodes:	NS3M Flux Core
Weld Position:	1F and 2F
Electrode Size:	0.120"
Amperage:	425 to 500
Voltage:	28 to 36
Preheat:	To 3/4" T - 70° F
	Over 3/4" T - 100° F per inch thickness to 250° F maximum. 300° F maximum interpass temperatu
Temperature Control:	"Tempil-Stik" Crayons or equal

Submerged Arc Fillet Welds - Dual Tandem Wire

Weld Type: SA-S1

Material:	A572, Grade 50
Electrodes & Flux:	A.S.T.M. - A558
Weld Position:	Flat
Electrode Size:	7/32" and 3/16"
Amperage:	7/32" - 850 to 950
	3/16" - 800 to 900
Voltage:	7/32" - 35 to 40
	3/16" - 35 to 40
Current:	7/32" - D.C. straight polarity
	3/16" A.C.
Travel Speed:	30 to 36 inches per minute
Preheat:	To 3/4" T - 70° F
	Over 3/4" T - 100° F per inch thickness to 250° F maximum. 300° F maximum interpass temperat
Temperature Control:	"Tempil-Stik" Crayons or equal

WELDING PROCEDURES

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Submerged Arc Fillet Welds - Triple Tandem Wire

Weld Type: SA-2S

Material:	A-572, Grade 50
Electrodes & Flux:	A.S.T.M. - A558
Weld Position:	Flat
Electrode Size:	3/16", 3/16" and 5/32"
Amperage:	3/16" lead wire - 1100 to 1200
	3/16" No. 2 wire - 900 to 1000
	5/32" No. 3 wire - 850 to 900
Voltage:	3/16" lead wire - 40
	3/16" No. 2 wire - 43
	5/32" No. 3 wire - 46
Current:	Lead wire - D.C. straight polarity
	No. 2 wire - A.C.
	No. 3 wire - A.C.
Travel Speed:	45" per minute
Preheat:	To 3/4" T - 70° F
	Over 3/4" T - 100° F per inch thickness to 250° F maximum. 300° F maximum interpass temperature
Temperature Control:	"Tempil-Stik" Crayons or equal

Complete Penetration Welds - Manual, Low Hydrogen Electrodes
Partial Penetration Welds - Manual, Low Hydrogen Electrodes

Weld Type: MB-S1

Material:	A572, Grade 50
Electrodes:	E7018
Weld Position:	1G, 2G, 3G
Electrode Size:	5/32" and 3/16"
Amperage:	5/32" - 150 to 200
	3/16" - 175 to 260
Voltage:	5/32" - 20 to 26
	3/16" - 22 to 27
Current:	D.C. reverse polarity, or A.C.
Preheat:	To 3/4" T - 70° F
	Over 3/4" T - 100° F per inch thickness to 250° F maximum. 300° F maximum interpass temperature
Temperature Control:	"Tempil-Stik" Crayons or equal

WELDING PROCEDURES

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Complete Penetration Welds - Semi Automatic Innershield
Partial Penetration Welds - Semi Automatic Innershield

Weld Type: IB-S2

Material:	A572, Grade 50
Electrodes:	NS3M Flux Core
Weld Position:	1G and 2G
Electrode Size:	0.120"
Amperage:	425 to 500
Voltage:	30 to 34
Current:	D.C. reverse polarity
Preheat:	To 3/4" T - 70° F Over 3/4" T - 100° F per inch thickness to 250° F maximum. 300° F maximum interpass temperature
Temperature Control:	"Tempil-Stik" Crayons or equal

Complete Penetration Welds - Manual Electrode and Semi Automatic
Partial Penetration Welds - Manual Electrode and Semi Automatic

Weld Type: CB-S2

Material:	A572, Grade 50
Electrodes:	Manual - E7018 Semi Automatic - NS3M Flux Core
Weld Position:	1G and 2G
Electrode Size:	E7018 - 5/32" NS3M - 0.120"
Amperage:	5/32" E7018 - 150 to 220 NS3M - 450 to 500
Voltage:	5/32" E7018 - 22 to 26 NS3M - 28 to 32
Current:	D.C. reverse polarity
Preheat:	To 3/4" T - 70° F Over 3/4" T - 100° F per inch thickness to 250° F maximum. 300° F maximum interpass temperature
Temperature Control:	"Tempil-Stik" Crayons or equal

WELDING PROCEDURES

PAGE-8-

CRITERIA FOR ADJUSTING PERCENTAGE OF NON-DESTRUCTIVE TESTING

Non-destructive testing of welds will be performed using either the dye penetrant and/or the magnetic particle process. Welds will be checked for performance with applicable ASTM specification. Non-destructive testing of welds will be performed on 10% of all members.

100% of the linear footage of each weld will be checked on the first 10 columns and on the first 10 beams fabricated. Provided that all welds checked are found to be acceptable, then 100% of the linear footage of each weld on 5 columns and on 5 beams out of the next 10 fabricated will be checked. Providing at this point that all welds checked have been found to be satisfactory, then 10% of the linear footage of each weld on one member out of each 4 fabricated will be inspected for the balance of the contract.

Each unacceptable weld will be examined,using the previously described non-destructive methods, for its complete length. For each weld found to be unsatisfactory an additional like weld will be examined on an additional member.

The Port of New York Authority
111 Eighth Avenue
New York, New York 10011

The World Trade Center

FABRICATED STEEL

Contract WTC-217.00

June 6, 1967

ADDENDUM #D2

This addendum should be physically annexed to the Form of Proposal, but the Form of Proposal will in any case be construed as though this addendum had been so physically annexed and all addenda issued will be considered incorporated in the Form of Proposal.

In Drawing Book #3, Page 56, dated 9/12/66, revise the last two items in the table to read as follows:

t *	Weld #2
2-7/8" through 3-7/8"	1/2" **
4" through 8"	5/8" **

* For Weld #2, t is the thickness of the thicker plat , connected by the weld.

** Indicates "deep penetration" fillet welds using Stan. Pacific Corporation procedures as documented in letter of May 23, 1967 from H. F. Kjeruf to L. S. Feld are acceptable.

Guy F. Tozzoli
Guy F. Tozzoli
Director
World Trade Department

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8574

John B. Skilling *Helge J. Helle* • *John. V. Christiansen* • *Leslie E. Robertson*

Consultants
Harold L. Worthington
Joseph F. Jackson

June 5, 1967

Mr. Malcolm P. Levy
Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York, New York 10011

Reference: The World Trade Center
Contract WTC-217.00, Stanray Pacific
Inspection, Testing, Coordination and
Supervision at Fabricating Plant

Gentlemen:

Contract WTC-217.00 contains provisions stipulating that irrevocable title to "built-up members" and to "building components" passes to PNYA after the completion of detailed inspection and acceptance by PNYA. The contract also states that PNYA assumes all risk for loss or damage of fabricated units after they are placed in the hands of the shipper. These contract provisions, coupled with the major use of steel produced in Japan and England, make it necessary for PNYA to implement a comprehensive program of supervision, coordination, inspection and testing of the work performed by Stanray Pacific Corporation. The coordination function assumes particular importance because of the large quantities of steel to be supplied from abroad. Stanray Pacific must receive delivery of this steel in time to meet the approved progress schedule which, in turn, forms an integral part of the overall progress schedule for The World Trade Center.

Accompanying this letter is a comprehensive program for supervision, coordination, inspection and testing based on the use of the personnel and facilities of a local independent testing agency supervised by a Resident Engineer. We propose that PNYA implement the program outlined herein under the supervision of professional engineers in the employ of SHCR.

WAYNE A. BREWER
P. B. A. FOSTER
FRANK HOELTERHOFF
ROBERT E. LEVIEN
V. A. PRISADSKY
KENT A. RODGERS
CHARLES SANOUSKY
WILLIAM D. WARD
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LORENTS L. WIDING

SEATTLE OFFICE: 1048 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

– 2 –

The Resident Engineer will be in a position to work closely with the mill, the detailer, the fabricator and the shipper. His responsibility will be limited to that of reviewing and reporting on the work and to directing the activities of the testing and inspection agency. He will establish full-time residence at the fabricating plant, beginning approximately 5 weeks prior to the beginning of fabrication and will remain in residence until such time as PNYA and SHCR determine that weekly visits are sufficient.

The program proposed herein will provide PNYA with all the necessary documentation required to assure that the work conforms to the Contract Documents, and at the same time, will give PNYA early notice of potential delays in the work, thereby providing PNYA maximum opportunity to preclude these delays.

For convenience, we have attached Xerox copies of previous correspondence concerning Contract WTC-217.00.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

included:

1. 6/5 · L. Feld
Deep Penetration fillet welds

2. 5/27 – M. Levy
Inspection

3. 5/31 – M. Levy
Mill Inspection

4. 5/29 M. Levy
Inspection
(Summary of ... work)

5. 4/5 M. Levy
Mill Insp. of
Gr. Steel

Leslie E. Robertson

LER:e
cc: Mr. A. Schreier, PNYA
Mr. J. Solomon, ERS
Mr. L. Feld, PNYA
Mr. J. Endler, Tishman
Mr. W. Cosinuke

COORDINATION, SUPERVISION, INSPECTION AND TESTING

OF FABRICATED STRUCTURAL STEEL

Stanray Pacific, Contract WTC-217.00

A. Scope

1. Supervision, coordination, inspection and testing activities must be performed during the course of the work in order to ensure proper interpretation of the technical provisions of the contract, to provide PNYA assurance through adequate documentation that fabricated steel conforms to the Contract Documents, and to assure on-time delivery of fabricated steel to PNYA by identifying potential sources of delay at the earliest possible moment.
2. Detailed inspection by check list and by non-destructive testing must be performed prior to final acceptance of:
   a) each "built-up member" and
   b) each "building component"

   to enable PNYA and SHCR to identify unacceptable fabricated items prior to final acceptance, such acceptance being irrevocable under the terms of the contract.

B. Personnel

1. Supervision, coordination, inspection and testing activities shall be managed by a Resident Engineer (a professional engineer employed full time by SHCR).
2. Inspection and testing activities shall be performed by qualified and experienced technicians in the full time employ of an independent testing agency retained and paid by PNYA. The testing agency shall submit to PNYA and SHCR detailed resumes of the qualifications and experience of each man proposed for assignment to the work.

C. Records and Drawings

1. The fabricator shall provide the Resident Engineer with one copy of each of the following:
   a) Each advance bill for mill order
   b) Each bill of lading for shipment of steel plate

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c) Each certified mill test report

d) Each typical detail sheet

e) Each approved erection plan

f) Each approved steel detail drawing as corrected to reflect any and all approval notations.

g) Each shop bill of material

h) Each fastener and welding material list

i) Each shipping bill or bill of lading or both for completely fabricated and accepted components

j) The fabricator's Quality Control Program for the work.

k) Test documents certifying qualification in accordance with the provisions of AWS D1.0-66 for each

(1) welder,

(2) welding machine operator, and

(3) welding procedure specification applicable to the work.

2. PNYA and SHCR will provide the Resident Engineer with the following:

a) A complete set of contract documents including all revisions to the contract documents

b) One print of each approved or corrected shop drawing

c) One copy of the current approved fabrication schedule

d) One copy of each mill inspection report

3. The Resident Engineer will:

a) Prepare a daily report of his activities, and will submit these reports weekly, or more often where special conditions warrant

b) Maintain a complete up-to-date file of all welding certification documents

c) Maintain a complete file of test and inspection reports prepared by the independent testing agency.

d) Maintain complete and orderly files of all other data provided to the Resident Engineer by the fabricator, PNYA and SHCR.

4. The independent testing agency will prepare test and inspection reports on a daily basis. Test reports shall record the results of each test or related group of tests and shall clearly identify each member or component tested, type of test made, and results of each test. Individual inspection reports shall be made for each inspector's work and shall specifically note each member or component inspected, specific items included in the inspection, and results of the inspection

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D. Supervision

1. Supervision shall be performed by the Resident Engineer.
2. Supervision shall include:
   a) A complete study of the fabricator's quality control procedures, proposed fabrication procedures, provisions for storage of incoming material, for completed "built-up members" and for "building components," and provisions for loading and shipping of completed "building components". This study will be made by the Resident Engineer prior to the beginning of fabrication. The Resident Engineer will submit a complete report and analysis of his findings to SHCR and PNYA prior to the beginning of fabrication.
   b) Liaison between PNYA and SHCR on the one hand, and Dovell Engineering Company on the other, regarding the preparation and approval of shop drawings.
   c) Ensure proper interpretation of the Drawings and Specifications by assistance to the fabricator. Where the Resident Engineer determines that a ruling from the Engineer is in order, he will expedite receipt of the Engineer's ruling by immediately reporting all pertinent data to SHCR and PNYA.
   d) Direction of the work performed by the independent testing agency and its inspectors. The scope of inspection and testing is defined in Part 6 of this outline. Should conditions occur during the course of the work which, in the judgment of the Resident Engineer, warrant additional inspection or tests, the Resident Engineer shall have the authority to order such additional inspection or tests as he deems necessary. The Resident Engineer shall report to SHCR and PNYA immediately all such instances.
   e) Continual surveillance of the quality of the work including
      (1) Checking material as received and stored in the receiving and storage yard for
         (a) Grade, heat number and marking
         (b) Condition
         (c) Dimensions
         (d) Method of storage
      (2) Cross-checking of certified mill test reports against material received at the receiving and storage yard. Items (a) and (b)

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shall be performed immediately upon receipt of material at the receiving and storage yard.

(3) Random checking during fabrication of width, length and thickness of plate, layout work, edge preparation, jigs and templates, welding of main members, preparation of detail material, welding of detail material, distortion control, milling of columns, and other items as required.

(4) Surveillance of the fabricator's quality control program as actually implemented by the fabricator, including review of any reports prepared by the fabricator for submission to SHCR and PNYA.

(5) Continual direction of inspection and testing work performed to ensure adherence to the amounts of inspection and testing outlined in Parts 6 F and 7 G herein.

E. Coordination

1. Coordination shall be performed by the Resident Engineer with the assistance of inspectors from the independent testing agency.

2. Coordination shall include

a) Continual scrutiny of the approved progress schedule.

b) Organization of advance bills of material into groups based on dates material must be delivered to conform to progress schedule.

c) Review of bills of lading for shipment of material against advance bills of material and approved progress schedule.

d) Check of material actually on hand in receiving and storage yard against a), b), and c) above. The Resident Engineer shall notify the fa[illegible]cator, SHCR and PNYA immediately upon discovery of any discre[illegible]acy or omission.

e) Check [illegible] each unit from the beginning of fabrication until loaded for [illegible]pment. The date and time shall be clearly recorded on the Res[illegible]nt Engineer's copy of the applicable shop drawing and erection dr[illegible]ng for

([illegible]) beginning of fabrication

[illegible] final acceptance of "buil[illegible]-up member"

(3) final acceptance of "building component"

(4) completion of loading for shipment.

The Resident Engineer shall notify the fabricator, SHCR and PNYA immediately should any unit fall behind schedule, and shall notify

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

SHCR and PNYA promptly of the date fabricated components actually leave the fabricator's yard.

F. Inspection

1. Inspection shall be performed by qualified and experienced structural steel inspectors in the full time employ of the independent testing agency.
2. Only inspectors approved by PNYA and SHCR shall be assigned to the work. Approval will be based on review of detailed résumés of each inspector's qualifications, experience and ability to perform the required work.
3. Generally, one full time inspector shall be assigned to each work shift. The Resident Engineer shall have the authority to increase the number of inspectors working in a given shift in accordance with amount of inspection work to be performed, or to reduce or increase the hours worked by any inspector as work load varies.
4. Duties of inspectors will be as follows:
   a) Assisting the Resident Engineer as required in analyzing and cross-checking advance bills of material, bills of lading for material and certified mill test reports
   b) Checking each plate upon arrival at the receiving and storage yard for
      (1) Heat number and specification conformance
      (2) Condition
         (a) Edge defects (laminations, slag inclusions)
         (b) Surface defects
         (c) Damage (bends, kinks)
   c) Checking of "built-up members" during fabrication
      (1) Plates
         (a) Heat number and yield point.
         (b) Length, width and thickness
         (c) Tolerance conformance
         (d) Edge and surface defects
      (2) Jigs, templates and positioners
         (a) Suitability
         (b) Dimensional accuracy
         (c) Alignment
      (3) Welding
         (a) Edge preparation
         (b) Fit-up (proper use of tack welds. diaphragm plates, jigs)

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(c) Position for welding

(d) Flux, electrode, preheat, type of welding equipment, voltage and amperage for conformance to welding procedure specification

(e) Visual check of 100% of completed welds

(f) Select lengths of weld for non-destructive testing to be performed after member cools

(4) Fully welded members shall be checked after cooling for conformance to the required tolerances (camber, sweep, out-of-square)

(5) Finishing

(a) Theoretical centerline

(b) Milling of first end for perpendicularity to theoretical centerline

c) Check layout of length for milling second end including corrections to theoretical length for temperature and shortening under load

(d) Check of perpendicularity to theoretical centerline of second end

(e) Final check of actual length after milling is complete

d) Checking of "building components" during fabrication

(1) Heat number and yield point of detail material

(2) Proper size and weight of steel sections or thickness of plate

(3) Layout of detail material for proper location of holes, copes and cuts

(4) Fit-up of detail material

(a) Proper fit-up for welding

(b) Proper location off theoretical column centerline

(5) Visual check of 100% of detail welding

(6) Select lengths of detail welds for non-destructive testing

e) Final check

(1) Check main material for dimensions

(a) Length

(b) Width

(c) Thickness

(2) Check main material for conformance to steel spec. A36, etc.

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(3) Check basic dimensions
   (a) Overall length
   (b) Sweep, camber, out-of-square
   (c) Theoretical centerline
   (d) Finished surfaces for 90° angle to centerline

(4) Check detail material
   (a) Length, width, thickness, copes
   (b) Hole patterns, edge preparation, etc.
   (c) Conformance to steel specifications
   (d) Location in relation to theoretical centerline
   (e) Location longitudinally
   (f) Freedom of edges from burr, lamination, slag inclusion, etc.
   (g) Cleaning of steel
   (h) Protection of milled surfaces
   (i) Accurate and clear marking

(5) Checking will be against structural drawings wherever possible. Results of inspection will be recorded on the Resident Engineer's record set of shop drawings.

Testing

1. Testing activities will be performed by personnel in the full time employ of the testing laboratory. Non-destructive testing will be performed by persons fully qualified, experienced and capable in the non-destructive testing technique used.
2. Testing activities fall into two categories:
   a) Non-destructive testing performed at the material receiving and stor yard and in the fabricating works
   b) Testing performed at the testing laboratory
3. Non-destructive testing may be divided into five categories
   a) Visual inspection (including measurements)
   b) Dye penetrant inspection
   c) Magnetic particle inspection
   d) Ultrasonic inspection
   e) Radiographic inspection
4. Visual inspection will ascertain the locations where other types of testing will be employed.

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

5. Dye penetrant inspection will be used as a random spot check of welds where such inspection is judged desirable by either the inspector or the Resident Engineer.
6. Magnetic particle inspection will be used to inspect a minimum of 5 percent of all member and detail welds.
7 Ultrasonic inspection will be used where the Resident Engineer determines special conditions warrant this type of inspection.
8. Radiographic inspection will not be required for the subject work.
9. Testing performed at the testing laboratory falls into three categories:
   a) Testing of specimens for welder and welding machine operator qualification tests
   b) Mechanical tests of steel plate or weld metal
   c) Chemical (check) analysis of steel plate or weld metal

   It is anticipated that only a) above will be required. However, should special conditions warrant, the Resident Engineer shall have the authority to call for tests listed under b) and c) in the number judged necessary by the Resident Engineer.

SKILLING–HELLE–CHRISTIANSEN–ROBERTSON

D R A F T 8/25/67

United States Testing Company
1514 Park Avenue
Hoboken, New Jersey

Gentlemen:

The undersigned, The Port of New York Authority, hereinafter referred to as the "Authority", hereby offers to retain The United States Testing Company, hereinafter referred to as "U. S. Testing" to furnish to the Authority for such periods of time as the Construction Manager or Assistant Construction Manager of the World Trade Center of the Authority, hereinafter called the "Manager" may require, the services of such number of experienced and qualified steel inspectors and field and laboratory technicians who are qualified to perform the services listed In Appendix 1 attached hereto and forming a part hereof in connection with such quantities of steel to be incorporated in the World Trade Center being constructed by the Authority in the City of New York as may be fabricated by the Stanray Pacific Corporation at their facilities located in Los Angeles, California and at the direction of the Manager to perform physical and chemical tests on foreign steel samples which will be forwarded to the U. S. Testing Laboratories in Hoboken, New Jersey. U. S. Testing shall not, without its further consent, either express or implied, be obligated to furnish such services after December 31, 1970.

The Authority will obtain entrance for U. S. Testing to fabrication shops where U. S. Testing is required to perform its services and will furnish to U. S. Testing necessary technical specifications, drawings, shipment dates, and other information required for it to perform its services hereunder.

APPENDIX NO. I

SCOPE OF DUTIES

F. Inspection

1. Inspection shall be performed by qualified and experienced structural steel inspectors in the full time employ of the independent testing agency.

2. Only inspectors approved by PNYA shall be assigned to the work. Approval will be based on review of detailed resumes of each inspector's qualifications, experience and ability to perform the required work.

3. Generally, one full time inspector shall be assigned to each work shift. The Supervising Engineer to be supplied by the Authority shall have the authority to increase the number of inspectors working in a given shift in accordance with amount of inspection work to be performed, or to reduce or increase the hours worked by any inspector as work load varies.

4. Duties of inspectors will be as follows:

   a) Assisting the Supervising Engineer as required in analyzing and cross-checking advance bills of material, bills of lading for material and certified mill test reports

   b) Checking each plate upon arrival at the receiving and storage yard for

      (1) Heat number and specification conformance

      (2) Condition

         (a) Edge defects (laminations, slag inclusions)

         (b) Surface defects

         (c) Damage (bends, kinks)

   c) Checking of "built-up members" during fabrication

      (1) Plates

         (a) Heat number and yield point

         (b) Length, width and thickness

         (c) Tolerance conformance

         (d) Edge and surface defects

(2) Jigs, templates and positioners

(a) Suitability

(b) Dimensional accuracy

(c) Alignment

(3) Welding

(a) Edge preparation

(b) Fit-up (proper use of tack welds, diaphragm plates, jigs)

(c) Position for welding

(d) Flux, electrode, preheat, type of welding equipment, voltage and amperage for conformance to welding procedure specification

(e) Visual check of 100% of completed welds

(f) Select lengths of weld for non-destructive testing to be performed after member cools

(4) Fully welded members shall be checked after cooling for conformance to the required tolerances (camber, sweep, out-of-square)

(5) Finishing

(a) Theoretical centerline

(b) Milling of first end for perpendicularity to theoretical centerline

(c) Check layout of length for milling second end including corrections to theoretical length for temperature and shortening under load

(d) Check of perpendicularity to theoretical centerline of second end

(e) Final check of actual length after milling is complete

d) Checking of "building components" during fabrication

(1) Heat number and yield point of detail material

(2) Proper size and weight of steel sections or thickness of plate

(3) Layout of detail material for proper location of holes, copes and cuts

(4) Fit-up of detail material

(5) Visual check of 100% of detail welding

(6) Select lenghs of detail welds for non-destructive testing

e) Final check

(1) Check main material for dimensions

(a) Length

(b) Width

(c) Thickness

(2) Check main material for conformance to steel spec. A36, etc.

(3) Check basic dimensions

(a) Overall length

(b) Sweep, camber, out-of-space

(c) Theoretical centerline

(d) Finishes surfaces for 90° angle to centerline

(4) Check detail material

(a) Length, width, thickness, copes

(b) Hole patterns, edge preparation, etc.

(c) Conformance to steel specifications

(d) Location in relation to theoretical centerline

(e) Location longitudinally

(f) Freedom of edges from burr, lamination, slag inclusion, etc.

(g) Cleaning of steel

(h) Protection of milled surfaces

(i) Accurate and clear marking

(5) Checking will be against structural drawings wherever possible. Results of inspection will be recorded on the Supervising Engineer's record set of shop drawings.

f) Witness and certify qualification of Welders

g) Check Contractor's invoices for quantities of acceptable material

G. Testing

1. Testing activities will be performed by personnel in the full time employ of the testing laboratory. Non-destructive testing will be performed by persons fully qualified, experienced and capable in the non-destructive testing technique used.

2. Testing activities fall into two categories:

   a) Non-destructive testing performed at the material receiving and storage yard and in the fabricating works

   b) Testing performed at the testing laboratory

3. Non-destructive testing may be divided into five categories

   a) Visual inspection (including measurements)

   b) Dye penetrant inspection

   c) Magnetic particle inspection

   d) Ultrasonic inspection

   e) Radiographic inspection

4. Visual inspection will ascertain the locations where other types of testing will be employed.

5. Dye penetrant inspection will be used as a random spot check of welds where such inspection is judged desirable by either the inspector or the Supervising Engineer.

6. Magnetic particle inspection will be used to inspect a minimum of 5 per cent of all member and detail welds.

7. Ultrasonic inspection will be used where the Resident Engineer determines special conditions warrant this type of inspection.

8. Radiographic inspection will not be required for the subject work.

9. Testing performed at the testing laboratory falls into three categories:

   a) Testing of specimens for welder and welding machine operator qualification tests

   b) Mechanical tests of steel plate or weld metal

   c) Chemical (check) analysis of steel plate or weld metal

   It is anticipated that only a) above will be required. However, should special conditions warrant, the Supervising Engineer shall have the authority to call for tests listed under b) and c) in the number judged necessary by the Supervising Engineer.

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-3874

John B. Skilling • Helge J. Helle • John V. Christiansen • Leslie E. Robertson

Consultants
Harold L. Worthington
Joseph F. Jackson

April 5, 1967

Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York 11, New York

Attention: Mr. Malcolm P. Levy

Reference: The World Trade Center
Mill Inspection of Japanese Steel

Gentlemen:

Verification that structural steel produced in Japan conforms to the Specifications for The World Trade Center falls into four broad categories as follows:

1. testing and inspection performed by the mill,
2. work which will be performed by SHCR,
3. work which may be performed by an independent testing laboratory under contract to PNYA, and
4. work which is the specific responsibility of the fabricator.

First, following standard ASTM procedures, the mill is required to perform chemical and physical testing to assure itself and document to the purchaser that the requirements of the applicable material specification have been met. Each heat is analyzed for chemical composition by ladle analysis and physical tests are made in accordance with the requirements of the applicable material specification. For instance, ASTM A302 requires tension and bend testing of each plate as rolled, while ASTM A36 requires tension and bend testing of each heat. The results of these tests are recorded on a mill test report bearing a statement certifying the correctness of the data reported

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- 2 -

under which the signature of the Chief Metallurgist or other authorized agent of the mill appears. The correctness of the mill test report may be further attested by the signature of a notary public. The purchaser may have finished material representing each heat checked for chemical composition by check analysis. While this is rarely done in commercial building construction, it is occasionally required in bridge and governmental work. Check analysis is normally performed at the mill, at additional cost, and is sometimes witnessed by an independent testing laboratory. ASTM specification requirements are broader for check analysis than for ladle analysis.

Second, SHCR must, as structural engineers for The World Trade Center, review the documentation of all certified mill test reports to assure that steel conforms to the requirements of the Specifications. The procedure is not involved, consisting of a careful cross-check of all documentation to assure that all material used in the work has been tested and that the results of the tests conform to the requirements of the Specifications.

Third, an independent testing laboratory may be retained to verify, to the extent deemed necessary by the Chief of the Planning and Construction Division of The World Trade Center, the accuracy of the certified mill test reports by witnessing tests made at the manufacturing mill. All work performed by the independent testing laboratory should be accomplished on a random sampling basis. In the event that, through the sampling techniques, instances of nonconforming material are discovered, the number of tests witnessed should be increased, as should the number of check analysis tests requested. Conversely, if, as is to be expected, the sampling technique proves the mill test reports satisfactorily represent the material and conform to the Specifications, the percentage of tests witnessed may be reduced. The number of tests witnessed should not, in any case, be reduced below 5 percent. Witnessing of tests should be performed on the basis outlined below, first for Stanray Pacific material, and then for Pacific Car and Foundry material.

Stanray Pacific
Contract WTC-217.00
(includes ASTM A36 and F_y = 42 ksi steel)

1. Chemistry

   a. Witness 5 percent of the ladle analysis tests performed by the mill to assure conformance with ASTM A6 and the chemical requirements of the steel specification.

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- 3 -

b. Witness 25 percent of the check analysis tests performed by the mill to assure conformance with ASTM A6 and the requirements of the steel specification. Steel to be subjected to check analysis shall be selected by the independent testing laboratory and should represent about one out of each six heats from which steel is supplied for use in the work.

2. Physical Properties

a. Witness 10 percent of tensile tests performed by the mill to assure conformance to the requirements of the steel specification, ASTM A6, and the applicable portions of ASTM A370.

b. Witness 10 percent of bend tests performed by the mill to assure conformance to the requirements of the steel specification, ASTM A6, and the applicable portions of ASTM A370.

3. Conditioning

a. Should the manufacturer elect to repair plates in accordance with ASTM A6, the testing laboratory should witness 100 percent of the conditioning work to assure conformance to ASTM A6.

4. Marking

a. The testing laboratory should check the marking of steel plate for conformance with ASTM A6 and the Specifications, and for proper representation on a certified mill test report.

Pacific Car and Foundry
Contract WTC-214.00

1. Chemistry

a. Witness 10 percent of the ladle analysis tests performed by the mill to assure conformance with ASTM A6 or ASTM A20, as applicable, and the chemical requirements of the steel specification.

b. Witness 25 percent of the check analysis tests performed by the mill to assure conformance with ASTM A6 or ASTM A20, as applicable, and the requirements of the steel specification. Steel to be subjected to check analysis should be selected by the independent testing laboratory and should represent about one out of each four heats from which steel will be supplied for use in the work.

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- 4 -

2. Physical Properties

   a. Witness 15 percent of the tensile tests performed by the mill to assure conformance to the steel specification, ASTM A6 or ASTM A20, as applicable, and to the applicable portions of ASTM A370.

   b. Witness 15 percent of the bend tests performed by the mill to assure conformance to the steel specification, ASTM A6 or ASTM A20, as applicable, and to the applicable portions of ASTM A370.

   c. Witness 20 percent of the Charpy impact tests performed by the mill, where required by the steel specification.

   d. Witness 10 percent of the Brinell Hardness tests, where required by the steel specification.

   e. Witness 10 percent of the grain size tests, where required by the steel specification.

   f. Witness all retests, where allowed by the steel specification.

3. Conditioning

   a. Should the manufacturer elect to repair plates in accordance with ASTM A6 or ASTM A20, as applicable, and the provisions of the steel specification, the testing laboratory should witness all conditioning work to assure conformance to the applicable specification requirements.

4. Marking

   a. The testing laboratory should check the marking of steel plate for conformance to ASTM A6 or ASTM A20 and the Specifications, and for proper representation on a certified mill test report.

5. Distribution of Sampling

   a. The percentages of sampling outlined above refer to the total amount of steel required for Contract WTC-214.00. Proportionately, more of the sampling should be applied to the higher yield point materials, with the greatest density of sampling applied to the quenched and tempered steels.

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

- 5 -

Last, but of prime importance, the structural steel fabricator must assure himself that all steel conforms to the requirements of the Specifications. The fabricator should do this through the review of mill test reports, checking of material against the mill test reports, and the performance of additional tests where the fabricator deems necessary. In addition, the fabricator must check all plate for correct dimensions, satisfactory finish and freedom from unacceptable laminations.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

Leslie E. Robertson

LER:c

THE PORT OF NEW YORK AUTHORITY
111 Eighth Avenue-at 15th Street, New York, N.Y. 10011

Construction Manager's Office
30 Church Street - Rm. 1119
New York, New York 10007

Malcolm P. Levy, Chief, Planning & Construction Division
R. M. Monti, Construction Manager Telephone (212) 620-7918

World Trade Department
Guy F. Tozzoli, Director
Richard C. Sullivan, Director, The World Trade Center

September 21, 1967

Stanray Pacific Corporation
11633 South Alameda Street
Los Angeles, California 90002

Attention: Mr. R. E. Morris

Re: The World Trade Center - Contract WTC-217.00 - For East Superintendence Co.

Gentlemen:

In reply to your letter of September 12, 1967, the international inspection agency, Superintendence, Inc., of New York City, through their affiliate firms in Japan and Great Britain, have been retained to provide the foreign mill inspection. This inspection, in addition to providing the normal review of mill test reports and visual inspection of material prior to shipment, includes: a detailed check for dimensional tolerances performed on a random basis on a minimum of 10% of the plates and 20% of the shapes; the witnessing of a minimum of 10% of the chemical tests and between 10% and 20% of the physical tests performed by the mill as required by the specifications; independent check analysis on samples from 10% of the heats; and witnessing 10% of the loading of material aboard the carrying vessel to assure proper storage.

For information, and in the hope of being of some assistance to you, Superintendence has been instructed to furnish you with copies of all inspections and reports made on materials furnished under your contract. As you can see from the above, they do not perform 100% inspection and thus, in most cases, would not be in a position to inform you of material shortages.

Our mill inspection does not relieve you of your obligations

Stanray Pacific Corporation September 21, 1967

Attention: Mr. R. E. Morris

under the subject contract. However, we will continue as above to offer any assistance we can.

Sincerely,

R. M. Monti
Construction Manager
The World Trade Center

Copy to: Messrs. J. R. Endler (TRCC)
R. Van Stolk (Superintendence Co.)
L.E. Robertson (SHCR)

THE PORT OF NEW YORK AUTHORITY

World Trade Department
Guy F. Tozzoli, Director

Malcolm P. Levy, Chief, Planning & Construction Division

R. M. Monti Construction Manager Telephone (212) 267-[illegible] Office of the Construction Manager 30 Church St., New York, N.Y. 10007

November 13, 1967

Stanray Pacific Corp.
11633 South Alameda Street
Los Angeles, California 90002

Attention: Mr. R.E. Norris

Subject: WORLD TRADE CENTER - CONTRACT WTC 217.00 - MILL INSPECTION

Gentlemen:

As you know, the Port Authority as part of its overall quality control program on fabricated steel for the World Trade Center, has established a policy of providing mill inspection at all sources, whether foreign or domestic. The scope of this inspection includes independent checking of chemical and physical properties on a random basis. In order to implement this program, each fabricator has been requested to have their suppliers make available to our inspection agency, extra samples. Our inspectors will collect a representative percentage of these samples for independent testing. Some of the testing will be performed by the agency inspecting at the mill, and in the case of foreign sources, some of the samples will be forwarded to the United States for testing.

The independent testing portion of the mill inspection program will be performed as follows:

A. Domestic Sources

1. Steel with yield points less than 50,000 psi - One tension test and one check analysis on samples selected at random from 1 out of 10 heats.

2. Steel with yield points of 50,000 psi and higher - One tensile, one bend test and a check analysis on samples selected at random from 1 out of 10 heats.

Stanray Pacific Corp. November 13, 1967

B. Foreign Sources

1. Steel with yield points less than 50,000 psi - One tension test and one check analysis on samples selected at random from 1 out of 10 heats to be performed abroad. In addition, one sample suitable for a tension test from 1 out of 4 heats will be shipped by the Authority's Inspection Agency to a laboratory in the United States for tensile test and check analysis.

2. Steel with yield points of 50,000 psi and higher - One tensile test, one bend test and a check analysis on samples selected at random from 1 out of 10 heats to be performed abroad.

   In addition one set of samples suitable for machining into a tensile specimen and a bending specimen will be selected at random from 1 out of 4 heats and will be shipped by the Authority's Inspection Agency to a laboratory in the United States for further testing.

It can be seen from the above, that basically the samples fall into two categories:

1. Steel with yield points below 50,000 psi in which case only a sample suitable for machining into a tensile test specimen will be required. (Check analysis specimens can be obtained from the tensile sample.)

2. Steel with yield points of 50,000 psi and above, in which case a set of samples suitable for machining into a tensile and a bend specimen will be required. (Again check analysis can be made on the tensile sample.)

The only difference between foreign and domestic sources is that on foreign steel a larger percentage of the total number of heats will be tested. Kindly reinstruct your supplier and request that they confirm their concurrence to supply the required samples. Since the unmachined samples for independent testing can be obtained by the mill at the same time that they take their samples for testing as required by the applicable specification, no additional handling will be required and no additional costs should be incurred. If you think it advisable, I have no objection to your forwarding a copy of this letter to your suppliers.

-3-

Stanray Pacific Corp. November 13, 1967

Kindly implement the above procedure immediately on all present and future mill orders and please keep the undersigned advised on any problems that you may experience.

Very truly yours,

for R.H. Monti
Construction Manager
The World Trade Center

CC: J. Endler (TRCC), L. Robertson (SCHR), M. Levy

CABLE PITTDEMOIN
TELEX 000 734

PDM Pittsburgh-Des Moines Steel Company

Engineers
Fabricators
Constructors

NEVILLE ISLAND · PITTSBURGH, PENNSYLVANIA 15225 · AREA CODE 412
PHONE 3..-5000

October 21, 1968

Tishman Realty and Construction Co., Inc.
666 Fifth Avenue
New York, New York 10019

Attention: Mr. James R. Endler,
Assistant Vice President

Reference: The World Trade Center
Quality Control and Testing Program
Structural Steel - Packages I, III & IV

Gentlemen:

We are pleased to transmit herewith our proposed Quality Control and Testing Program for Packages I, III and IV of the Project. We will appreciate early review and comment on this Program so that any adjustments which may be desired can be incorporated into our proposals.

We have had to make important assumptions as to the amount of radiographic or ultrasonic testing of welds which will be required to maintain acceptable quality throughout the work. Therefore, the amount of such testing specified in the enclosed Program is not an expression of judgment on our part as to whether said amount of testing will guarantee a quality level consistent with the service required. Responsibility for this judgment rests with the Owner.

Generally, our weld quality control program is based on the "spot-examination" principle. The quality of welding produced to meet spot-examination requirements will approach that which would be produced for 100 percent inspection. However, spot examination will not insure work of predetermined quality level throughout, and work accepted under spot-examination requirements may still contain defects which might be disclosed under further examination. If all unacceptable weld defects which would be revealed by radiographic or ultrasonic inspection must be eliminated from the structure or specific portions thereof, then 100 percent inspection must be employed, and must be included as a factor in the cost of production.

HAMMOND PRODUCTS

CABLE: PITTDEMOIN
TELEX: 086-734

PDM

Pittsburgh-Des Moines Steel Company

Engineers
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NEVILLE ISLAND · PITTSBURGH, PENNSYLVANIA 15225 · AREA CODE 412
PHONE 331-3000

November 28, 1966

Tishman Realty and Construction Company, Inc.
666 Fifth Avenue
New York, New York 10019

Attention: Mr. James R. Endler, Ass't. Vice President

Reference: The World Trade Center
Quality Control and Testing Program
Structural Steel - Packages I, III & IV
Amendment No. 1, dated November 25, 1966

Gentlemen:

Enclosed is Amendment No. 1 to our proposed Quality Control and Testing Program for Packages I, III & IV of the Project. This Amendment is submitted in response to the Worthington, Skilling, Helle and Jackson letter dated October 27, 1966. With reference to the comments listed in that letter, our action in each case has been as follows:

1. Information contained in the first comment has been incorporated into our program by revision of paragraph SP-5.03, Supplemental Provisions.

2. An organization chart for the PDM Quality Control Department has been added as Appendix A to the program.

3. Qualification standards for testing personnel have been outlined in added paragraph SP-1.05.

4. Paragraph SP-5.11 has been added to cover ultrasonic testing procedure.

5. ASTM and AWS standards have been referenced by revision of paragraph SP-5.04, and addition of paragraphs SP-5.12 and SP-5.13.

HAMMOND PRODUCTS

Pittsburgh-Des Moines Steel Company

Tishman Realty and Construction Co., Inc. Nov. 28, 1966
Page 2.

6. Description of production methods, jigs, templates and other means of dimension control have been added as Appendixes B, C and D, and paragraph SP-6.03 has been added referring to these appendixes.

7. Paragraph SP-4.02 has been revised to provide for material delivery in accordance with ASTM A6 and A20 both.

8. A statement regarding life of the proposed painting system has been added as paragraph SP-8.05.

9. Procedures for cutting, de-burring and edge preparations for welding have been outlined by revision of paragraph SP-4.05 and addition of paragraph SP-4.06.

10. Paragraph SP-5.10 has been added to describe the use of welding procedure specifications and joint welding procedure qualification tests in quality control work.

This Amendment No. 1 also incorporates a revised section on Radiographic Inspection into the body of the PDM Quality Control Program. This revision was completed shortly after our original submittal of the Program.

We hope this Amendment will be considered satisfactory response to the comments on our Program, and that the Program may therefore have final approval. We will be pleased to discuss the matter further; however, and will make any additional changes which may be deemed necessary.

Yours very truly,

PITTSBURGH-DES MOINES STEEL COMPANY

James C. Dods

James C. Dods,
Special Products Department

JCD/k

Atts.

CABLE: PITTDEMOIN
TELEX: 080-734

Pittsburgh-Des Moines Steel Company

Engineers
Fabricators
Constructors

NEVILLE ISLAND · PITTSBURGH, PENNSYLVANIA 15225 · AREA CODE 412
PHONE 331-3000

December 23, 1966

Tishman Realty & Construction Company, Inc.
666 Fifth Avenue
New York, New York 10019

Attention: Mr. James R. Endler

Reference: The World Trade Center
Quality Control and Testing Program
Amendment No. 2

Gentlemen:

We acknowledge receipt of the Worthington, Skilling, Helle & Jackson letter dated December 20, 1966 regarding our Quality Control Program for the World Trade Center. In accordance with the statement therein that the text of the Program "should be changed", and in compliance with your request by letter dated December 21, 1966, we submit herewith Amendment No. 2, revising our Program to incorporate the items called for by the Engineers, and we will proceed to evaluate our earlier proposals to determine what influence this change may have on them.

Yours very truly,

PITTSBURGH-DES MOINES STEEL CO.

James C. Dods
Special Products Dept.

JCD/k/lsb

Atts.

HAMMOND PRODUCTS

PITTSBURGH-DES MOINES STEEL COMPANY
QUALITY CONTROL AND TESTING PROGRAM

THE WORLD TRADE CENTER

AMENDMENT No. 2 December 23, 1966

The Pittsburgh-Des Moines Steel Company Quality Control and Testing Program for the World Trade Center, dated October 19, 1966 with Amendment No. 1, dated November 25, 1966 is revised as described hereinafter in response to letter dated December 20, 1966 from Worthington, Skilling, Helle & Jackson to Tishman Realty and Construction Company. This Amendment also includes correction of a typographical error in the original Program.

1. Under Section SP-5 WELDING, delete paragraph SP-5.05 on page S-5, and substitute therefor the following:

   SP-5.05 Fillet welds will be inspected as follows:

   a. At least fifty percent (50%) of all fillet welds on quenched and tempered steels will be subjected to magnetic particle inspection 48 hours or more after welding.

   b. At least ten percent (10%) of all fillet welds in steels other than quenched and tempered steels will be subjected to magnetic particle inspection.

2. In Amendment No. 1, Paragraph SP-5.04, Change the first sentence to read as follows: "Inspection of welding by PDM Quality Control Personnel will conform to the requirements of Section 6, AWS D1.0-66".

3. Under Section SP-5, WELDING, in Paragraph SP-5.07b, ninth line, Change "twenty percent (20%)" to "ten percent (10%)".

CABLE PITTDEMOIN
TELEX 000 734

Pittsburgh-Des Moines Steel Company

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PHONE 331-3000

June 2, 1967

Tishman Realty and Construction Co., Inc.
666 Fifth Avenue
New York, New York 10017

Attention: Mr. Norbert Weinstein

Reference: The World Trade Center
Contract WTC-213.00
Quality Control and Testing Program

Gentlemen:

In response to the letter dated May 16, 1961, from Mr. James White of Skilling-Helle-Christiansen-Robertson, we submit herewith Amendment No. 3 to the PDM Quality Control and Testing Program.

Some explanatory comment is in order concerning the dimensional control and checking procedures and the revision to Paragraph SP-6.03 in this Amendment No. 3. Mr. White and myself discussed this matter by telephone on May 16, 1967 and due to that conversation it is my understanding now that the information desired here should describe PDM Quality Control Department inspection procedures rather than actual work procedures as covered by Appendix C. Therefore, we have omitted reference to the Appendix and have revised Paragraph 6.03 so that it now concerns inspection procedures. Since approved shop drawings are used for developing these procedures, they cannot be described at this time.

We hope you will find this submittal satisfactory, and that our Quality Control and Testing Program may now be considered an acceptable reference for use with the executed Contract and Technical Specifications.

Yours very truly,

PITTSBURGH-DES MOINES STEEL COMPANY

J. C. Dods,
Special Products Department

Atts.

cc: Mr. James White
Skilling-Helle-Christiansen-Robertson

HAMMOND PRODUCTS

PITTSBURGH-DES MOINES STEEL COMPANY

QUALITY CONTROL AND TESTING PROGRAM

THE WORLD TRADE CENTER

AMENDMENT NO. 3 JUNE 1, 1967

The Pittsburgh-Des Moines Steel Company Quality Control Program for The World Trade Center, dated October 19, 1966, with Amendment No. 1 dated November 25, 1966 and Amendment No. 2 dated December 23, 1966, is revised as described hereinafter in response to letter dated May 16, 1967 from Skilling-Helle-Christiansen-Robertson.

1. In Paragraph SP-5.03 on page 5 of Amendment No. 1, delete the entire last sentence: "The complete penetration butt welds.... bridge quality welds." and substitute therefore: "The complete penetration butt welds at the tops of the ninth story spandrels will conform to AWS D2.0-66, Article 409."

2. In Paragraph SP-5.11 on page 6 of Amendment No. 1, delete the entire first sentence: "Ultrasonic inspection .... of weldments." and substitute therefore: "Ultrasonic inspection of weldments will be governed by ASTM Standard E164-65, Standard Method for Ultrasonic Contact Inspection of Weldments, and by the PDM Quality Control Manual Section entitled Ultrasonic Inspection. Where there are conflicting requirements, the provisions of ASTM Standard E164-65 will govern".

   Also in paragraph SP-5.11, delete the entire last sentence: "(The PDM Quality Control..... added when complete)".

QUALITY CONTROL AND TESTING PROGRAM
THE WORLD TRADE CENTER
AMENDMENT NO. 3

PAGE 2.
6-1-67

3. In Amendment No. 1, page 7, delete Paragraph SP-6.03 entirely and substitute therefor:

SP-6.03 PDM Quality Control Personnel will perform such inspections and dimensional checks as they consider necessary to maintain proper control of dimensions and to insure production of column panels which comply with the Specifications and meet the tolerances described therein. Procedures governing control and inspection will be developed to meet the requirements of this Contract, based on approved shop drawings.

4. In Paragraph SP-1.03 on page S-1 of the original Program, delete the entire sentence: "This Program.... of the Project". and substitute therefor: "This Program will govern Structural Steel Fabrication for Contract WTC-213.00, Fabricated Steel, Exterior Wall from Elevation 363 to the ninth story splice, North and South Towers".

5. In Paragraph SP-4.06 on page 4 of Amendment No. 1, in the eleventh and twelfth lines, delete the words ".... to the satisfaction of PDM Quality Control Personnel".

6. Attached is PDM Quality Control Manual Section entitled Ultrasonic Inspection dated 12-15-66, which is hereby made a part of this Quality Control and Testing Program.

12-15-66

1-D-e
Page 1

PITTSBURGH-DES MOINES STEEL COMPANY

QUALITY CONTROL MANUAL

NON-DESTRUCTIVE TESTING

ULTRASONIC INSPECTION

U - 1 GENERAL

U.1.1 - This is a procedure for ultrasonically testing and inspecting welds for internal discontinuities by the reflection method using pulsed waves introduced by direct contact of a search unit with the weldment.

U - 2 METHODS

U.2.1 - Shear Wave Testing

Shear wave inspection shall be performed to a 3% notch sensitivity. The test is conducted using angle projection transducers 45° to 85°; the selection of the angle being dependent on either or both the thickness and the geometry of the weldment.

U.2.2 - Longitudinal Wave Testing

Longitudinal wave inspection can be performed to a near 100% sensitivity with a #4 micro-inch surface finish and at 2½ mc, otherwise satisfactory results depend to a large extent upon the condition of the test surface.

U - 3 EQUIPMENT

U.3.1 - Electronic apparatus capable of producing, receiving and displaying high frequency electrical pulses at frequencies of 1 to 2.25 mc is normally satisfactory for most welds.

U.3.2 - The search units shall be capable of reversibly transforming electrical vibrations to sound vibrations within themselves as well as transmitting and receiving vibrations in the material being tested.

U.3.3 - The couplant between the transducer and the test surface shall have good wetting properties and shall be selected, if conditions permit, from the following list:

Oil	Glycerin	Silicones
Water	Grease	White Lead

U.3.4 - Reference plates will be provided for determining and checking instrument sensitivity, for instrument calibration and for comparison with defect indication. Each plate shall have artificial defects and all defects permanently marked.

12-15-66

1-D-e
Page 2

ULTRASONIC INSPECTION

U - 4 SURFACE PREPARATION

U.4.1 - Hot rolled surfaces require removal of any loose adherent scale or other foreign matter. Conditioning of the surface can be accomplished by sandblasting, grinding or belt sanding to provide at least a 250 RMS surface finish.

U.4.2 - The base material surfaces to be used for inspection shall also be cleaned of weld spatter and roughness on each side of the weld for a minimum distance of six (6) inches. Weld surface irregularities which are beyond the normal patterns, shall be removed from both the inside and outside surfaces. The deposited weld metal shall merge smoothly into the base metal without undercuts, sharp ridges, or valleys.

U - 5 ULTRASONIC INDICATIONS OF WELD DISCONTINUITIES

U.5.1 - The maximum magnitude of a signal indicating a weld discontinuity shall be recorded as a percentage of the height of the signal from the hole in the reference weldment. The height of the signal is some indication of the size of the discontinuity. This method of estimating the size of the discontinuity shall be used when flaw dimension is smaller than one-half of the dimension of the crystal.

U.5.2 - A reflection that is always visible with movement of the transducer transversely to the discontinuity indicates depth which may be measured. Likewise a reflection that is always visible with movement of the transducer longitudinally to the discontinuity indicates length which can also be measured. This method of estimating the size of the flaw shall be used when the discontinuity dimension is larger than one-half of the dimension of the crystal.

U.5.3 - Locations of the flaw with respect to the surface of the plate are determined by the position of the signal on the tube and the location of the transducer with respect to the weld.

U.5.4 - Flaws in base metal are possible sources of misinterpreted indications. These areas will be searched with normal incident longitudinal wave test methods to determine the presence of such imperfections.

U.5.5 - Small reflections from the weld area are generally apparent to indicate that the sound is penetrating the weld.

U - 6 PROCEDURE FOR CHECKING BUTT WELD DISCONTINUITIES

U.6.1 - Discontinuities longitudinal to the weld, move the transducer slowly to and from the weld with mainly a transverse (with respect to weld) movement and at such a rate that the operator can clearly see and identify the signals. The transducer should be rotated slightly in the plane of the metal surface in both directions to obtain maximum signals.

12-15-66.

1-D-e
Page 3

ULTRASONIC INSPECTION

Use just enough longitudinal movement to advance the transducer parallel to the weld no more than one transducer width per transverse cycle. The total minimum transverse movement should be sufficient to fully cover the entire cross-section of the weld. Normally check both sides of the weld from one surface only, but in special cases a more complete investigation from both surfaces is required.

U.6.2 - Discontinuities Transverse to the Weld

If the weld is smooth, and satisfactory contact can be made, move transducer slowly along top of weld with the ultrasonic beam parallel to the weld. If satisfactory contact cannot be made on the weld, place the transducer on the base metal surface at the edge of the weld, and angle the transducer slightly to obtain the same effect, move the transducer at such a rate that the operator can clearly see and identify the reflection.

U - 7 PROCEDURE FOR CHECKING MISCELLANEOUS WELDS

U.7.1 - Branch or nozzle, flange to shell, corner and other full penetration welds can be inspected with an angle beam using procedure in U.6.1 or U.6.2 above, when the methods are adaptable to the geometry of the weldment.

U.7.2 - Inspection of fillet welds, attachment welds, and other welds not requiring full penetration can be generally inspected with an angle beam by procedures in U.6.1 or U.6.2. The signal must be carefully distinguished to avoid interpreting reflections from the geometry of the part as being indications of discontinuities. In all scanning, if a defect indication is obtained approaching in amplitude that of the reference plate, the adjacent area shall be scanned sufficiently to establish the size and location of the discontiniuty.

U - 8 STANDARDS FOR ULTRASONIC INSPECTION

U.8.1 - Any crack, lack of fusion, incomplete penetration, inclusion, or cavity which is indicated by a reflection equal to or greater than 80 per cent of the applicable reference hole and which has a linear dimension as indicated by the transducer movement exceeding:

1/4 inch for thickness up to 3/4 inch.
1/3 of the thickness for plate 3/4 inch to 2-1/4 inch.
3/4 inch for thicknesses over 2-1/4 inch.

is unacceptable.

U - 9 REPORTS OF INSPECTION

U.9.1 - The report of ultrasonic inspection shall be made after re-inspection of any areas requiring weld removal or weld repairs. The reports contain the following information:

12-15-66

1-D-e
Page 4

ULTRASONIC INSPECTION

1. Inspection date.
2. Instrument settings.
3. Height of general signals from parent metal and deposited metal.
4. Purchasor's order number and drawing number.
5. Sketch containing physical outline of weldment with location of repaired areas.
6. A table of the inspection results coordinated with a sketch estimating size, length, depth and location of flaws.

THE PORT OF NEW YORK AUTHORITY

World Trade Department
Guy F. Tozzoli, Director

Malcolm P. Levy, Chief, Planning & Construction Division

R. M. Monti, Construction Manager   Telephone (212) [illegible]   Office of the Construction Manager   [illegible] Church St. New York, N.Y. [illegible]

March 11, 1968

Pittsburgh-Des Moines Steel Company
Neville Island
Pittsburgh, Pennsylvania 15225

Attention: Mr. H. M. Fish

Re: The World Trade Center - Contract WTC 213.00
Welding Procedure Specifications

Gentlemen:

This will confirm approval of your submitted "Welding Procedure Specification DB 119-172 (WPS-1)", revised February, 1968, and Joint Qualification Sheets SA-3, 56-30, 58-36, 58-42, 60-35, 62-2 and 62-80, as noted on SHCR letter dated February 28, 1968.

F.— R. M. Monti
Construction Manager
The World Trade Center

cc: J. Gramer (RWH)
J. White (SHCR)

CABLE: PITTDESMOIN
TELEX: 086 734

PDM Pittsburgh-Des Moines Steel Company

Engineers
Fabricators
Constructors

NEVILLE ISLAND · PITTSBURGH, PENNSYLVANIA 15225 · AREA CODE 412
PHONE 331-3000

February 15, 1968

Mr. R. M. Monti
Construction Manager
Room 1119
The Port of New York Authority
30 Church Street
New York, New York 10007

Re: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138

Gentlemen:

Enclosed herewith please find two (2) copies of Welding Procedure Specification DB119-172, WPS1 revised in accordance with Mr. James White's comments in his letter of December 19,1967 to Mr. R. M. Monti; and, our Mr. A. C. Hogan's telephone conversation with Mr. Jostein Nes on February 12, 1968.

In response to comment No. 13 of Mr. Whites letter, joint M4 is noted to weld in the flat position and is prequalified according to AWS D1.0 and D2.0. We assume that the reference was intended for joint M5. Based on this assumption joint M5 has been voided.

Also enclosed are additional welding procedures and qualifications for your consideration. Procedure SA3 is a combination manual-submerged arc joint, approval of which was given by Mr. Nes. Joint qualifications 56-20, 58-26, 58-42, 60-35, 62-2 and 62-80 are all previously qualified joints which we feel have the prerequisites for use on this contract.

HAMMOND PRODUCTS

Pittsburgh-Des Moines Steel Company

-2-

Mr. R. M. Monti
The World Trade Center February 15, 1968

Welding on this phase will start shortly so your early consideration of the above items will be appreciated.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

H. M. Fish

H. M. Fish, Project Manager

rw

cc: Mr. H. A. Tessler

Mr. Al Guttentag
w/one copy of DB119-172

Skilling-Helle-Christiansen-Robertson
Attn: Mr. James White
w/one copy of DB119-172

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu 9-[illegible]

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

February 28, 1968

Consultants
Harold L. Worthington
Joseph F. Jackson

Port of New York Authority
Office of the Construction
Manager - Room 1119
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti, Construction Manager

Reference: The World Trade Center
Contract WTC-213.00, Pittsburgh-Des Moines
Welding Procedure Specification DB 119-172 (WPS-1)
and Joint Qualifications

Gentlemen:

We have reviewed the PDM letter dated February 15, 1968 and approve Welding Procedure Specification DB 119-172 (WPS-1), revised February, 1968 in its present form, and also approve joint qualification sheets SA-3, 56-30, 58-36, 58-42, 60-35, 62-2 and 62-80.

We understand that PDM is not going to employ either joint M4 or M5 described in the joint welding procedure sheets included with their previous submittal of welding procedures and joint qualifications.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

James White

JW:s
cc: Mr. H. M. Fish, PDM
Mr. L. E. Feld, PNYA

[illegible]

SEATTLE OFFICE [illegible] WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

CABLE: PITTDESMOIN
TELEX: [illegible]

PDM Pittsburgh-Des Moines Steel Company

Engineers
Fabricators
Constructors

NEVILLE ISLAND • PITTSBURGH, PENNSYLVANIA 15225 • AREA CODE 412
PHONE 331-3000

March 6, 1968

Mr. R. M. Monti
Construction Manager
Room - 1119
The Port of New York Authority
30 Church Street
New York, New York 10007

Re: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17108

Gentlemen:

We are sending you for approval two (2) copies of our weld procedure for joints M4 and M5 revised March 6, 1968. These joints should be made a part of our Welding Procedure Specification DS119-172 submitted to you with our letter of February 15, 1968.

Please let us have your approval of joints M4 and M5 as soon as possible.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

H. M. Fish, Project Manager

cc: Mr. H. A. Tessier
Manager, Project Planning
The Port of N.Y. Authority
Room 800
111 Eighth Avenue
New York, New York 10011

Mr. Al Guttentag
Tishman Realty & Construction Co.
11th Floor, 30 Church Street
New York, New York 10007
w/one (1) copy of M4 & M5

PITTSBURGH-DES MOINES STEEL COMPANY

Rev. 3-6-68

WELDING PROCEDURE – BUTT WELDS

PROCEDURE SPECIFICATION

JOINT NO. M-4
AWS TYPE B-U2

Material Specification A7, A36, A441 *

Welding Process Shielded Metal-Arc

Manual or Machine Manual

Position of Welding Flat

Filler Metal Specification ASTM A233

Filler Metal Classification E7013 or E7028

Submerged Arc Weld Metal Grade ---

Gas for Gas Shielded Arc ---

Single or Multiple Pass Multiple

Single or Multiple Arc Single

Welding Current AC or DC+

Root Treatment Backing Strip

Preheat Temperature As Required by Material Thick.

Postheat Temperature None

Prequalified by AWS D1.0 & D2.0

* All Carbon and Low Alloy Steels

≤ 50,000 psi Yield

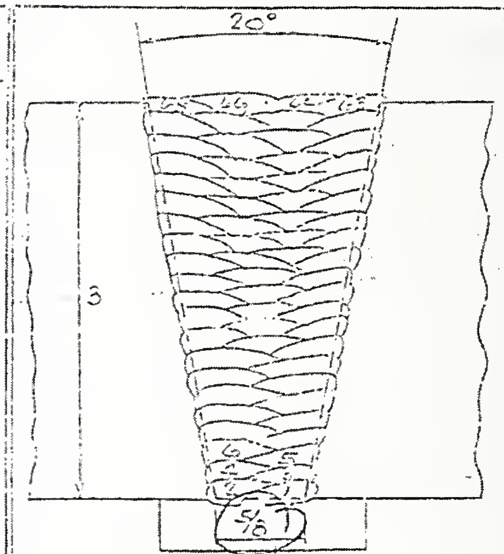
SKILLING-HELLE
CHRISTIANSEN-ROBERTSON
Structural & Civil Engineers

☑ APPROVED
☐ APPROVED AS NOTED
☐ RESUBMIT
☐ REJECTED

Date 3/13/68 By JW

WELDING PROCEDURE

PASS NO.	ELECT SIZE	WELDING CURRENT AMPERES	WELDING CURRENT VOLTAGE	SPEED OF TRAVEL
1-2	5/32	180-220	22-26	
3-4	3/16	250-325	24-28	
5-8	7/32	350-400	26-30	
9-62	1/4	375-475	28-32	



1/2 per. AWS D1.0
AWS. D2.0

This procedure may ...
American Welding Society building code or bridge specification.

PDM

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

August 23, 1968

Mr. R. M. Monti
Construction Manager
Room - 1119
The Port of New York Authority
30 Church Street
New York, New York 10007

Re: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17155

Gentlemen:

We are submitting for your approval two (2) copies of our welding procedure qualification for joints 67-67, 67-68 and 67-70. Upon approval these joints will become part of our welding procedure specification DB119-172.

Please return one (1) copy stamped with the engineers approval or notify us by letter of your acceptance.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

H. M. Fish, Project Manager

cc: Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10007
Attn: Mr. James White w/one (1) copy of joints

Mr. Al Guttentag
Tishman Realty & Construction Company
11th Floor, 30 Church Street
New York, New York 10007

75TH ANNIVERSARY

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Consulting ...uctural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

John B. Skilling • Helge J. Helle • John. V. Christiansen • Leslie E. Robertson

Consultants
• Harold L. Worthington
Joseph F. Jackson

September 23, 1968

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, N.Y.

Attention: Mr. R. M. Monti, Construction Manager

Reference: The World Trade Center
Contract WTC-213.00, Pittsburgh-Des Moines
Welding Procedure Specification, DB119-172
Sections WPS-1, WPS-2, WPS-3

Gentlemen:

We have reviewed PDM Welding Procedure Specification DB119-172, Sections WPS-2 and WPS-3 as transmitted with the PDM letter dated May 22, 1968, as well as revised pages 5 and 6 of Section WPS-1, also transmitted with the May 22, 1968 PDM letter. Pursuant to our review, we wish to comment as follows:

I Welding Procedure Specification DB119-172, WPS-3

1. Page 1, paragraph 4.0 FILLER METAL AND FLUX. The second sentence should be revised to read, "Materials for welding ASTM A514 steels to steels with lower yield strength shall conform to the applicable provisions of DB119-172, WPS-1 or WPS-2, whichever specification includes the lower yield strength material".

2. Page 1, paragraph 4.1.1, third sub-paragraph should be revised to read, "A welder shall have in his possession at any time only that quantity of electrodes which can be used within thirty minutes after removal from the storage oven, and in no event shall electrodes be used for welding A514 steels when the time of exposure to the air exceeds 60 minutes". This is consistent with the recommendations found in the USS publication ADUSS01-1205 titled "USS" T-1 Constructional Alloy Steels", item 6 found on page 59 under Care of Covered Electrodes.

WAYNE A. BREWER
P. S. A. FOSTER
FRANK HOELTERHOFF
ROBERT E. LEVIEN
V. A. PRISACKEY
KENT N. ROGERS
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LORENTS L. WIKING

SEATTLE OFFICE: 1940 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

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- 2 -

3. Page 1, paragraph 4.1.1, fourth sub-paragraph should have an additional sentence added stating, "Electrodes which come in contact with water, grease or dirt shall be scrapped".

4. Page 2, paragraph 4.2, Submerged Arc Process, should have a second sentence added stating, "Flux for submerged arc welding shall be kept dry and if exposed to water, grease or dirt shall be discarded".

5. Page 2, paragraph 6.1 Procedure Qualifications, second sentence should be revised to read, "Procedure qualification tests will be conducted, supervised, reported and certified by PDM and may be witnessed by an independent testing agency approved by the Engineer".

6. Page 2, paragraph 7.1, second sentence should be revised to read, "Performance qualification tests shall be conducted, supervised, reported and certified by PDM and may be witnessed by an independent testing agency approved by the Engineer".

7. Page 2, paragraph 7.2, Welder's Certificate should be revised to read, "PDM will provide for each welder or welding operator a certificate or certificates which indicate the results of performance tests and state the process and type of welding for which the welder is qualified. Certification approved by the Authority for each welder shall have been achieved within a three month period preceding the date the welder begins work on Contract WTC-213.00".

8. Page 2, paragraph 7.2.1, should have an additional sentence added stating, "When a welder has not performed welding utilizing a given process for a period of 90 days, PNYA or SHCR may require that the welder be requalified for the process and welding positions in question".

9. Page 3, paragraph 9.1, second line should be revised to read. " with approved shop drawings, Specifications and welding procedure".

10. Page 4; PREHEAT AND INTERPASS TABLE should be modified as shown on the following page.

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Page 3 September 23, 1968

*Thickness	Manual Shielded Metal-Arc & MIG	Submerged Arc Carbon Steel Wire & Alloy Flux
To 1/2" Incl.	**50 ° F. Min.	**50 ° F. Min.
Over 1/2" to 1" Inc.	**50 ° F. Min.	200 ° F. Min.
Over 1" to 2" Incl.	150 ° F. Min.	300 ° F. Min.
Over 2"	200 ° F. Min.	400 ° F. Min.

Maximum Preheat and Interpass Temperature 425° F.

*Thickness of thickest part at point of weld.
** Welding at plate temperature below 100° F. requires assurance that moisture is not present in vicinity of joint.

11. Page 5, paragraph 13.4.1, should be revised to read, "Bead size and arrangement will be as shown in the Welding Procedure Specification sheets for the applicable weld joint, within the limits of permissible variations allowed by AWS D1.0-66 or AWS D2.0-66, whichever is applicable.

12. Page 5, paragraph 13.4.2, first sentence shall be revised to read, "Weld reinforcement as deposited will not be less than flush nor more than 1/8 inch, except that where applicable, the provisions of Appendices E-1, E-2 and E-3, AWS D1.0-66 shall apply".

13. Page 5, paragraph 13.6, Defects, fourth line should be revised to read, "prescribed by the applicable provisions of the Specifications, approved PDM Quality Control Program and this welding procedure specification. Those defects discovered through non-destructive testing should be retested by the same non-destructive testing technique after the defective weld metal has been removed and replaced".

14. Page 6, paragraph 14.1, second line should be revised to read, "in the approved shop drawings, by symbol RT or UT, a minimum of 100% of the first 10%.

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Page 4 September 23, 1968

15. Page 6, paragraph 14.1, second sub-paragraph should be revised to read, "Where the extent of defects so indicates, the Authority's representative may require that spot examination of the affected welds be increased, even to one hundred percent (100%) if necessary, until satisfactory quality is achieved. Upon establishment of satisfactory quality, the rate of RT or UT inspection, may be reduced again to the specified percentage".

16. Page 6, paragraph 14.1.1, fourth line should read "Inspection". Where there are conflicting requirements, the provisions of AWS D2.0-66 will govern".

17. Page 6, paragraph 14.1.2, should be revised to read, "Ultrasonic Inspection will be governed by PDM Quality Control Manual, Section 1-D-c (revised 3-11-68) entitled "Ultrasonic Inspection, as based on "Appendix U, Ultrasonic Examination of Welds (UT)", pages 14-20 inclusive, of the "Winter 1967 Addenda, ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels". The requirements of Section UA-903 of the ASME Addenda shall apply to the work.

18. Page 6, paragraph 14.2, third line should be revised to read, "MT inspected forty-eight (48) hours or more after welding".

II Welding Procedure Specification DB119-172, WPS-2

1. Page 1, paragraph 4.0 FILLER METAL AND FLUX. Starting in the fourth line, add a new sentence stating "Allowable moisture content and exposure times stated in DB119-172, WPS-3 will control whenever material under this specification is joined to ASTM A514 steel".

2. Top of page 2, second line after the word "above" add a new sentence stating, "Electrodes which come in contact with water, grease or dirt shall be scrapped".

3. Page 2, paragraph 6.1, second sentence should be revised to read, "Procedure qualification tests will be conducted, supervised, reported and certified by PDM and may be witnessed by an independent testing agency approved by the Engineer".

4. Page 3, paragraph 7.1, second sentence should be revised to read, "Performance qualification tests shall be conducted, supervised, reported and certified by PDM and may be witnessed by an independent testing agency approved by the Engineer".

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Page 5 September 23, 1968

5. Page 3, paragraph 7.2, Welders Certificate shall be revised to state in the first line, "PDM will provide".

6. Page 3, paragraph 7.2.1, shall have an additional sentence added stating, "When a welder has not performed welding using a given process for 90 days, PNYA or SHCR may require the welder to be requalified for the process and welding positions in question".

7. Page 3, paragraph 9.1, second line should be revised to read, "with approved shop drawings, Specifications and welding procedure".

8. Page 4, paragraph 10.3, should read, "period of high wind unless welders and work are suitably protected".

9. Page 5, paragraph 12.4.2, first sentence, shall be revised to read, "Weld reinforcement as deposited will not be less than flush nor more than 1/8 inch, except that where applicable, the provisions of Appendixes E-1, E-2 and E-3, AWS D1.0-66 shall apply".

10. Page 5, paragraph 12.6, starting in the third line should read, "arcair gouging or grinding, and repaired and re-examined as prescribed by the applicable provisions of the Specifications, approved PDM Quality Control Program and this welding procedure specification (DB119-172, WPS-2. Those defects discovered through non-destructive testing technique after the defective weld metal has been removed and replaced".

11. Page 5, paragraph 13.1 starting in the second line after "UT" should read, "a minimum of 100% of the first 10%".

12. Page 6, paragraph 13.1.2, should read, "Ultrasonic Inspection will be governed by PDM Quality Control Manual, Section I-D-e, (revised 3-11-68) entitled "Ultrasonic Inspection, based on "Appendix U, Ultrasonic Examination of Welds (UT)", pages 14-20 inclusive, of the "Winter 1967 Addenda, ASME Boiler and Pressure Vessel Codes, Section VIII, Unfired Pressure Vessels". The requirements of Section UA-903 of the ASME Addenda shall apply to the work".

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Page 6 September. 23, 1968

III Welding Procedure Specification, DB119-172, WPS-1

Through our review of procedures WPS-3 and WPS-2, we have the following additional comments on Procedure WPS-1 approved by SHCR letter of February 28, 1968, as well as PDM's revisions to page 5 and page 6 dated 5-21-68 and superseding their previous revision to page 5 dated 5-10-68:

1. Page 2, paragraph 4.1.1, fourth sub-paragraph (third from top of page 2) should have a second sentence added stating, "Electrodes which come in contact with water, grease or dirt shall be scrapped".

2. Page 3, paragraph 9.1, second line should read, "with approved shop drawings, Specifications and welding procedure".

3. Page 4, paragraph 10.3, second line should read, "Periods of high-wind unless both welders and work are suitably protected".

4. Page 5, paragraph 12.4, should remain as stated in the February, 1968 addition of WPS-1, with the following modifications:
   a) paragraph 12.4.2 should read, "The depth and width of weld deposit for each bead shall conform to Sections 405 and 406 and other specific provisions of AWS D1.0-66 or AWS D2.0-66, whichever is applicable".
   b) it would be permissible to replace paragraph 12.4.3 in the original document with paragraph 12.4.2 of the 5-21-68 revision, inasmuch as the initial submission by PDM represents a quality of work in excess of the requirements of either AWS D2.0-66 or AWS D1.0-66. Such permission should not be misconstrued to mean a relaxation in the requirements for good workmanship, but rather a correction of specific rules to conform to the welding codes included in the Specifications. The first sentence of paragraph 12.4.2 in the 5-21-68 Revision should read, "Weld re-inforcement as deposited will not be less than flush nor more than 1/8 inch, except that where applicable, the provisions of Appendixes E-1, E-2 and E-3, AWS D1.0 -66 shall apply".

5. Page 5, paragraph 12.6, starting in the fourth line should read, "prescribed by the applicable provisions of the Specifications, the approved PDM Quality Control Program and this welding procedure specification (DB119-172, WPS-1). Defects discovered through non-destructive testing should be retested by the same non-destructive testing technique after removal and replacement of the defective weld metal".

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Page 7 September 23, 1968

6. Page 5, paragraph 13.1, 5-21-68 revision, starting after "UT" in the second line should read, "a minimum of 100% of the first 10%".

   Page 6, paragraph 13.1.2 should read, "Ultrasonic Inspection will be governed by PDM Quality Control Manual, Section 1-D-e, entitled "Ultrasonic Inspection" based on "Appendix U, Ultrasonic Examination of Welds (UT)", pages 14-20 inclusive, of the "Winter 1967 Addenda, ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels". The requirements of Section UA-903 of the ASME Addenda shall apply to the work".

Contingent upon incorporation of all the above comments into PDM Welding Procedure Specifications DB119-172, WPS-1, WPS-2 and WPS-3, SHCR approves the text of these welding procedure specifications. It should be noted that many of the comments have been made to achieve clarity or conformity to the contract documents and reflect the provisions of AWS specifications, manufacturer's recommended practice, information contained in the project Specifications and similar related information, and are not intended as a change in the quality of work required under the contract.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

James White

JW:lm

cc: Mr. Lester Feld, PNYA
Mr. M. M. Fish, PDM

P.S. Page 1, paragraph 4.0 Filler Metal and Flux. The following text should be added to paragraph 4.0: "The following welding materials shall be used for welding steels listed under Section 2.0, either together or in combination and for welding these steels to higher strength steels included in DB119-172, WPS-2 or WPS-3. Allowable moisture content and exposure times stated in DB119-172, WPS-3 will control whenever material included in this specification is joined to ASTM A514 steel."

STANRAY PACIFIC CORPORATION
subsidiary of STANRAY CORPORATION

11633 SOUTH ALAMEDA STREET · LOS ANGELES, CALIFORNIA 90002 · (213) 566-2111

THE PORT OF NEW YORK AUTHORITY
RECEIVED
JUN 8 1967
WORLD TRADE DEPARTMENT
WORLD TRADE CENTER
PLANNING DIVISION

June 2, 1967

Mr. Lester Feld
The Port of New York Authority
111 Eighth Avenue at Fifteenth Street
New York, New York

Subject: World Trade Center
Contract No. WTC 217.00 - Revised Quality Control Program

Dear Lester:

Enclosed you will find two copies of the Welding Procedures to be incorporated into our Quality Control Program which is outlined in section 105 of Contract No. WTC 217.00. This constitutes our entire Quality Control and Testing Program.

The Inspection Requirements referred to as item 2 C in your letter of May 25, is now completed and will be mailed to you on Monday, June 5.

Yours very truly,

STANRAY PACIFIC CORPORATION

F. E. Allen

F. E. Allen
Controller

dh
Encl.

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu. 9-8874

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Consultants
Harold L. Worthington
Joseph F. Jackson

September 13, 1968

Port of New York Authority
Office of the Construction
Manager – Room 1119
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, Pittsburgh Des-Moines
Approval of Welding Procedure Specification
Sheets and Procedure Qualification Tests

Gentlemen:

Attached hereto, please find a listing of all PDM Welding Procedure Sheets and Welding Procedure Qualification Records submitted to SHCR for approval, to date.

The date of approval by SHCR of each procedure description or qualification test is noted, as well as the description of the PDM correspondence to which each approved procedure sheet was attached.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

JW:ja
att.
cc: Messrs. L. S. Feld, PNYA
H. M. Fish, PDM
W. Thomas, PTL
bcc: R. Gink, PNYA
bcc: L. E. Littlefield, SHCR

WAYNE A. BREWER
P. B. A. FOSTER
FRANK HOELTERHOFF
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KENT R. ROGERS
CHARLES SANDUSKY
WILLIAM D. WARD
E. J. WHITE, JR.
LORENTS L. WIDING

SEATTLE OFFICE: 1960 WASHINGTON BUILDING SEATTLE, WASHINGTON 98101

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Mr. R. M. Monti, PNYA -2- September 13, 1968

SUMMARY OF PDM

WELDING PROCEDURE SPECIFICATION SHEETS

AND

PROCEDURE QUALIFICATION SHEETS

PDM Joint Designation	SHCR Approval	Remarks
M1-M3, M6-M8; SA1, SA2, SA3; F1-F7; 59-32, 60-11; 56-30; 58-36, 58-42; 60-35, 62-80; 62-6	2/28/68	Accompany WPS-1 and WPS-1 Revised February 1968.
M4, M5 62-80 (Rev) F60, S55A, S55B	3/13/68 4/ 9/68 4/25/68	
M60, S60 67-44, 67-48 S-T1, F-T1	9/13/68	Accompany PDM letter of 5/22/68. WPS-1 Rev. 5-21-68 (p. 5 & 6) & WPS-3, May 1968
F60A, M60A, S60A; 67-45, 67-47, 67-65; 67-73, 67-50A, 67-70A; 67-73A	9/13/68	Accompany PDM letter of 6/13/68.
S70; 62-80A, 63-7; 67-66, 67-73	9/13/68	PDM letter of 7/17/68.
67-50, 67-72, 67-72A; 67-76, 67-77	9/13/68	Accompany PDM letter of 8/13/68.
67-51, 67-69; 67-75, 67-75A	9/13/68	Accompany PDM letter of 8/19/68.
67-67, 67-68, 67-70	9/13/68	Accompany PDM letter of 8/23/68.

Office of the Construction Manager
30 Church Street, New York City

October 4, 1967

Pittsburgh-Des Moines Steel Company
Neville Island
Pittsburgh, Pennsylvania 15225

Attention: H.M. Fish

Reference: WORLD TRADE CENTER - WTC 213.00 - Inspection and Scheduling

Gentlemen:

This will confirm my telegram of October 4th wherein you were advised that the Pittsburgh Testing Laboratory of Pittsburgh, Pennsylvania will be providing inspection for the Port Authority on the above referenced contract. The inspection will include mill inspection at your suppliers plants as well as fabrication inspection at your shop.

Reference is made to your September 26, 1967 letter regarding mill inspection procedures and your proposed form for conveying information on scheduling.

Pittsburgh Testing Laboratory will be advised to notify you immediately if any defective material is discovered in the course of their mill inspection, so as to enable you to take the necessary action with your suppliers.

The instructions you propose to issue to your suppliers appear to cover our inspection requirements except that if the mill will furnish additional test samples for physical tests it will not be necessary to require half a broken tensile specimen. P.T.L. can obtain their own sample from the physical sample.

Pittsburgh-Des Moines Steel Company — October 4, 1967

Your proposed form for conveying mill order and fabrication information as requested by Mr. Endler of the Tishman Realty and Construction Company appears to contain all of the information requested by Mr. Endler. However, we would suggest that it might be more reasonable to list more than one column on each sheet so as to reduce the total number of sheets. Such a format would serve as preliminary information for the Authority prior to your submission of a Contract Progress Schedule as provided for on Page 0-03, Clause 0.008 of the Contract Specifications.

Very truly yours,

R.M. Monti
Construction Manager
The World Trade Center

cc: J. Endler (TRCC), M. Levy, [illegible]

bcc: Brown, Cosinuke, Feld, Robertson (SHCR), Smith

RGG:kd

CHAPTER THREE

FABRICATION OF STRUCTURAL STEEL

301 GENERAL

301.100 Structural steel shall be fabricated complete as shown in the Drawings and in approved details shown in the shop drawings.

301.200 The steel furnished for each location shall have a minimum yield point equal to that scheduled in the Drawings, and shall be selected from the applicable steel specifications listed in Chapter Two, MATERIALS.

301.300 All steel shall be ASTM A36 for locations where a specific strength requirement is not stated in the Drawings.

302 IDENTIFICATION

302.100 The Contractor shall identify all steel which will be used in the work beginning at the mill and shall maintain identification at all times thereafter including during fabrication. The method used shall make both the grade and yield point of the steel readily identifiable. Identification shall be maintained after fabrication.

302.200 The Contractor shall identify each member or assembly with a system of marks. Each mark shall be clearly indicated in the shop drawings. The system of identification marks for fabricated structural steel shall be approved by the Engineer

303 SPECIFIC REQUIREMENTS

303.100 Flame cutting by hand shall not be performed without the Engineer's approval. Handcut surfaces shall be made smooth by chipping, planing or grinding.

303.200 Fabricated material containing sharp kinks or bends shall be rejected. Material straightened prior to fabrication shall be carefully examined for signs of distress or other defects before being placed in fabrication. Distressed or otherwise defective material shall not be used in the work.

303.300 Where required by the Contract Documents, surfaces shall be milled, or finished by other approved means. All finishing shall be clearly shown in the shop drawings.

303.400 Bolt holes and similar holes shall be punched, drilled, sub-punched or sub-drilled and reamed, and shall not be made or enlarged by gas cutting.

303.500 Holes required by the Erector, and shown on the Drawings prior to approval of Shop Drawings shall be furnished without cost.

304 FABRICATION TOLERANCES

304.100 Fabrication tolerances shall conform to the requirements of the AISC Specification and AWS D1.0, as supplemented by specific requirements contained in the Drawings and Specifications. In no case shall tolerances exceed those obtainable by the best modern shop practice.

305 SPECIAL REQUIREMENTS

305.100 Fabrication tolerances shall conform to the tolerances shown on Sheets 3-04 through 3-17 inclusive. Where specific tolerances are not shown on Sheets 3-04 through 3-17 tolerances shall conform to the requirements of the Specifications.

305.200 Cut edges of steel shall be free of burrs, overhangs, gross laminations, excessive slag inclusions and similar defects. Where necessary, cut edges shall be repaired be means described in the Contractor's quality control and testing program. Where required to maintain weld quality, corners of plates shall be eased and cut edges shall be ground. Work of this nature shall be outlined in the Contractor's quality control and testing program and shall be described in detail in the Contractor's welding procedure specifications.

305.300 In certain locations in the Drawings, slotted or oversize holes are specifically required. Where the Contractor elects to use slotted or oversize holes not shown in the Drawings, the use of slotted or oversize holes shall be subject to the Engineer's approval.

305.400 The Engineer will provide for the Contractor's use a table of correction factors which the Contractor shall use to determine the correct as-fabricated dimensions of structural steel members. The correction factor for columns will be the sum of the correction for temperature at time of fabrication and the correction due to shortening under load. Correction factors will be based on a standard temperature of 70 degrees Fahrenheit.

THE WORLD TRADE CENTER

Page 1-11

105 INSPECTION, QUALITY CONTROL AND TESTS

105.100 Quality Control and Tests

105.101 The Contractor shall comply with the quality control and testing program annexed hereto and forming a part hereof during the course of the work to assure that all work conforms to the Contract Documents.

105.102 The Contractor shall continually review his quality control and testing program against experience gained during the course of the work. Where the Contractor desires revisions to his quality control and testing program, he shall submit the proposed revisions to the Engineer for approval. The Contractor shall not make changes in the approved quality control and testing program without the Engineer's approval. The Contractor may, at his option, perform quality control and testing in addition to that required by the approved quality control and testing program.

105.103 The Contractor shall maintain complete records of all quality control and testing performed by the Contractor. Records shall be kept in report form, and shall include the results of all visual control of the work, the results of all tests and measurements, and certification that equipment, materials and methods conform to the Specifications or to procedure specifications approved by the Engineer. The Contractor shall state in writing his certification regarding the completeness and authenticity of each quality control and testing document. The Contractor's certification shall be attested by the full written legible signature of the party in responsible charge of the work for the Contractor and the technician actually performing the work.

105.104 The Contractor shall submit mill test reports to the Engineer for all material used in the work.

105.105 The Contractor shall report the location and quality of all corrective work.

105.106 The Contractor shall furnish all testing machines, testing machine operators and testing materials required for the Contractor's quality control and testing program.

105.200 Inspection

105.201 Inspection is intended to assure that the Contractor's quality control and testing program maintains conformance to the Contract Documents.

105.202 Inspection will consist of a random sampling of the work and will, to the degree possible, follow immediately the performance of the work. Inspection is intended, for the most part, to consist of surveillance and evaluation of the Contractor's quality control and testing program.

105.203 The Contractor shall furnish the Engineer free access to the work. The Contractor shall cooperate with the Engineer to allow Inspection.

105.204 The Contractor shall furnish, free of charge, all electrical power, turning or moving of members, hoisting, staging and other facilities required for Inspection. The Authority will provide testing machines, testing machine operators and testing materials used for Inspection.

105.205 The Contractor shall notify the Engineer a minimum of six (6) working days in advance of the beginning of work subject to Inspection. This requirement applies to each location at which work is performed, and to each resumption of work after any interruption or suspension of work. The Contractor shall pay the actual cost of salaries and travel expenses, in reasonable amounts, incurred because work is not ready for Inspection at the time stated by the Contractor.

105.206 The Contractor shall not in any manner construe Inspection to relieve the Contractor of any of his responsibilities under the Contract.

Pacific Car and Foundry Company

80 SOUTH HUDSON · SEATTLE, WASHINGTON 98134 · RO 2-7440

July 8, 1967 PCF #666-14

THE PORT OF NEW YORK AUTHORITY
Room 300
111 Eighth Avenue
New York, New York

Attention: Mr. R. M. Monti
Construction Manager

Reference: World Trade Center
Contract WTC-214.00
Project D-666

Gentlemen:

Please find enclosed two (2) copies of each of the following documents:
1. Quality Control Procedures - Revision 1, July 7th, 1967.
2. Welding Procedure - Revision 1, July 7th, 1967.

These procedures have been revised to suit your comments and those of Messrs. Skilling, Helle, Christiansen, Robertson. In the welding procedure we have also included Appendix B, Welder Certification form, as requested in your letter of June 14, 1967. In the quality control procedure we have added a section (part II, page five) which more fully defines the extent and methods of inspection which we propose for this contract.

We now request your formal approval of these documents. A copy of this letter and procedures has been forwarded directly to Mr. L. Robertson of Skilling, Helle, Christiansen, Robertson.

Yours very truly,

PACIFIC CAR AND FOUNDRY COMPANY

R. C. Symes, Project Engineer
Structural Steel Division

RCS/ap
encl.
cc: L. Robertson (SHCR)
J. Endler (Tishman)
J. Pigott
A. Philippy
D. Erickson

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers · *230 Park Avenue, New York, N. Y. 10017* · *Mu. 9-5874*

John B. Skilling · *Helge J. Helle* · *John V. Christiansen* · *Leslie E. Robertson*

Consultants
Harold L. Worthington
Joseph F. Jackson

July 13, 1967

Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York, New York 10011

Attention: Mr. R. M. Monti, Construction

Reference: The World Trade Center
Contract WTC-214.00, Pacific Car & Foundry
Quality Control and Testing Program

Gentlemen:

We have reviewed the documents: 1) Quality Control Procedures, Revision 1, July 7, 1967, and 2) Welding Procedures, Revision 1, July 7, 1967, forwarded with the PCF letter of July 8, 1967.

Based upon our review, we approve the PCF Quality Control and Testing Program contingent upon the incorporation into the program of the attached charts prepared by SHCR titled "Weld Inspection Rates" and subject to the specific conditions listed hereafter:

1. The weld numbers and designations used in the charts "Weld Inspection Rates" (Sheets No. 1-4 inclusive attached hereto) are those numbers and designations appearing in Drawing [illegible] in its current form as of July 15, 1967.

2. The first three full penetration spandrel butt welds (Weld #10) performed by each new welding machine operator or weldor will be subjected to ultrasonic testing.

3. Where a spandrel butt weld is rejected, all welds made by the same welder or welding machine in the subject panel, the panel produced immediately previous to the subject panel, and the panel produced immediately after the subject panel, will be tested by the ultrasonic testing technique.

WAYNE A. BREWER
P. O. A. FOSTER
FRANK HOELTERHOFF
ROBERT E. LEVIEN
V. A. PRISADORY
KENT R. ROGERS
CHARLES SANOUSKY
WILLIAM O. WARD
E. J. WHITE, JR.
LORENTS L. WIDING

SEATTLE OFFICE: 1840 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

- 2 -

4. Approval of the PCF Quality Control and Testing Program does not include approval of any welding process or procedure subject to AWS qualification tests (see Sheet WS-11A), and does not include approval of Drawings WS-11B and WS-11C.

5. Visual inspection shall be carried out by certified PCF inspection personnel on 100% of all types of welds included in the work.

Very truly yours,

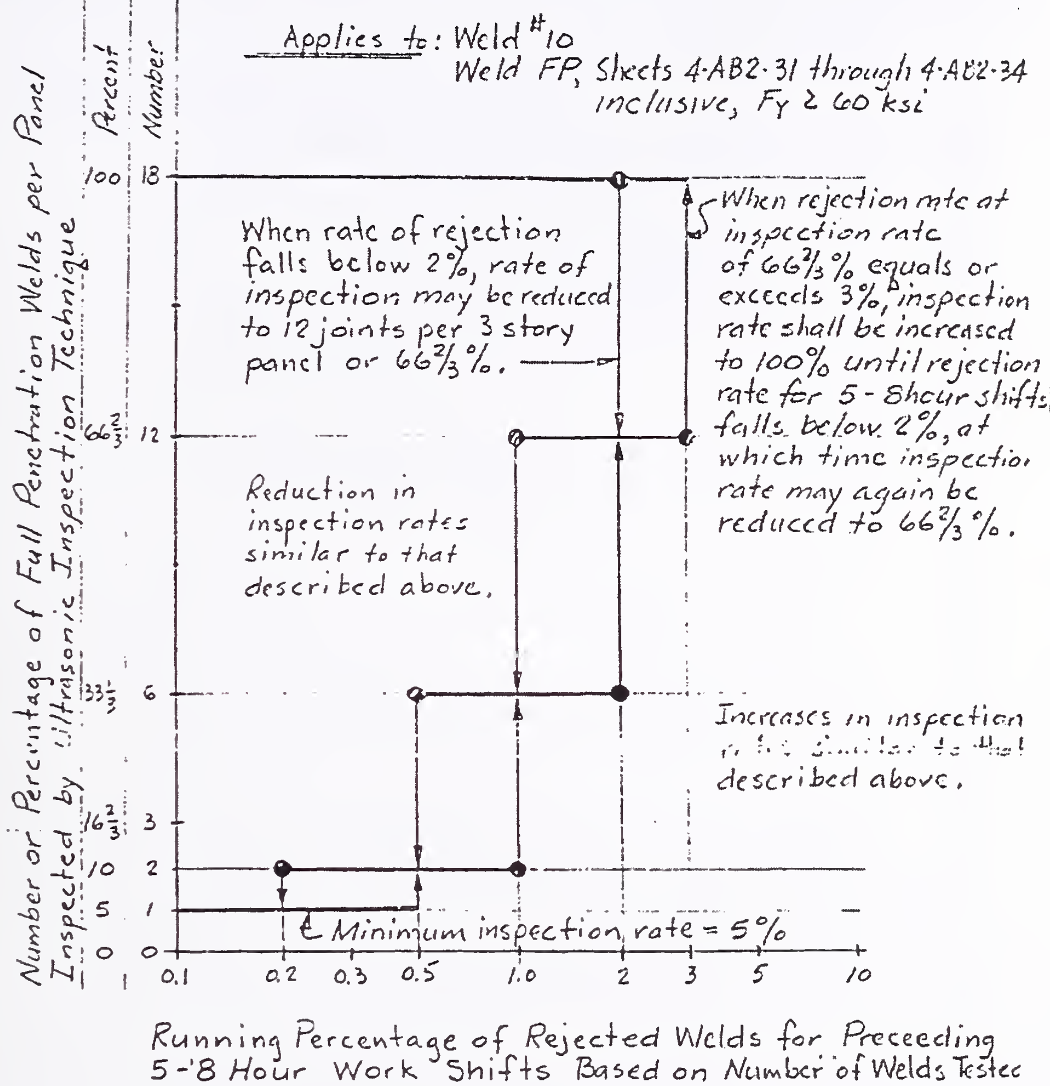
SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

James White

JW:e
cc: Mr. M. Levy
Mr. L. Feld
Mr. W. Cooinuke
Mr. M. Springer

SKILLING HELLE CHRISTIANSEN ROBERTSON Structural & Civil Engineers	PRO CONTRACT WTC 214 0	DATE 1·12·67	Sheet No.
	WELD INSPECTION RATES	PREPARED BY JWV	1 OF 4
		APPROVED	

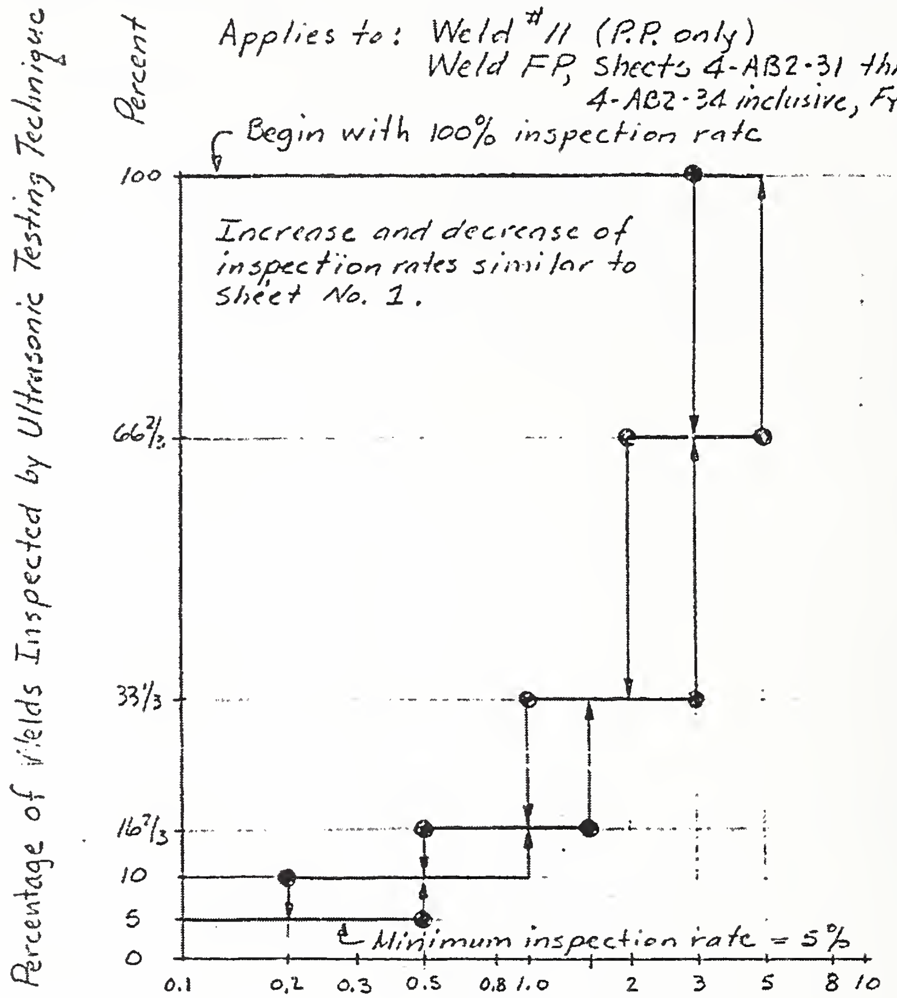
Applies to: Weld #10
Weld FP, Sheets 4-AB2-31 through 4-AB2-34 inclusive, $F_Y \geq 60$ ksi



Note: Weld #10 shall conform to the provisions of AWS D2.0-66.

SKILLING HELLE CHRISTIANSEN ROBERTSON Structural & Civil Engineers	PR CONTRACT WTC 2 .00	DATE 7-13-67	Sheet No.
	WELD INSPECTION RATES	PREPARED BY JW APPROVED	2 OF 4

Applies to: Weld #11 (P.P. only)
Weld FP, Sheets 4-AB2-31 through 4-AB2-34 inclusive, Fy < 60 ksi

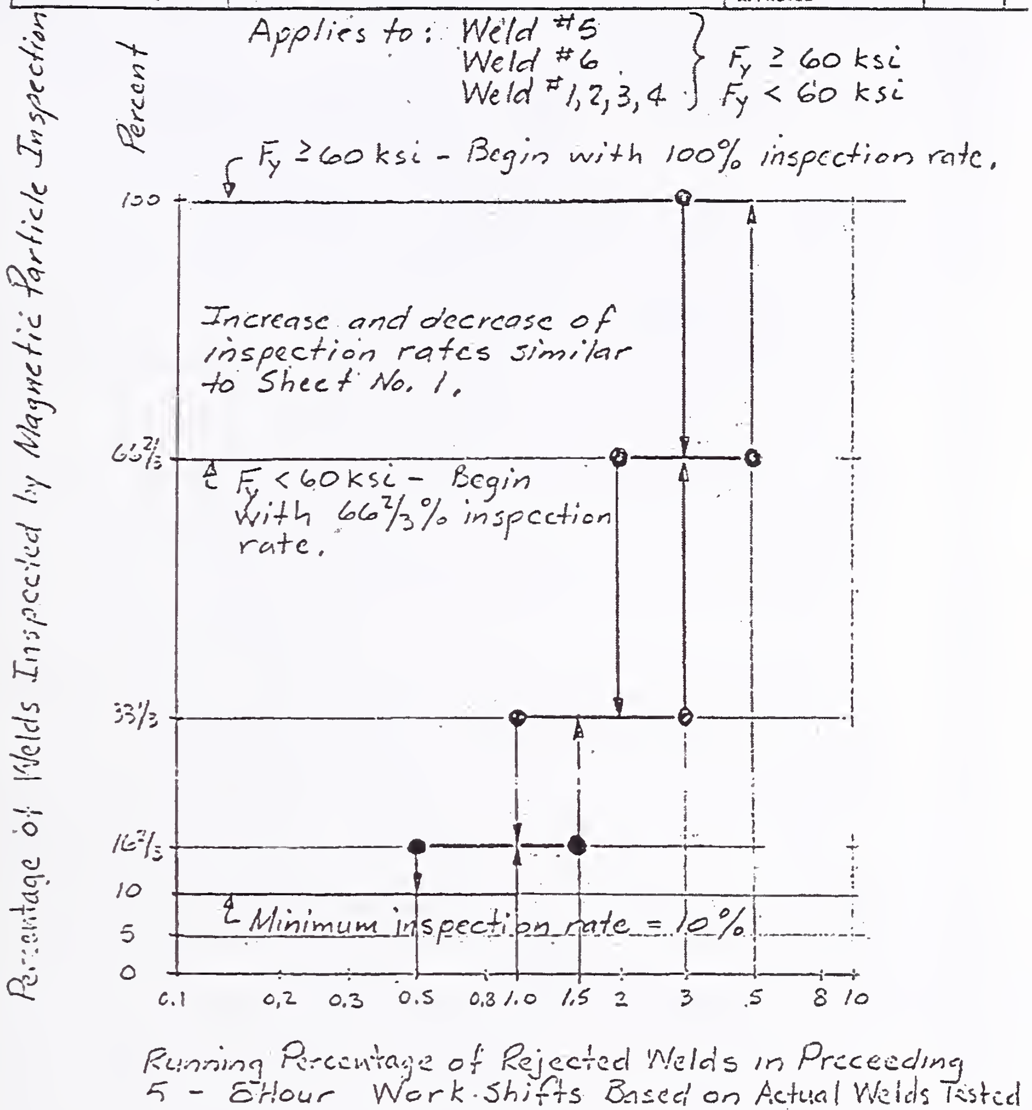


Running Percentage of Rejected Welds in Preceeding 5 - 8 Hour Work Shifts Based Number of Welds Tested

SKILLING HELLE CHRISTIANSEN ROBERTSON
Structural & Civil Engineers

PRO CONTRACT WTC-2	DATE 7-13-67	Sheet No.	
WELD INSPECTION RATES	PREPARED BY:	3 of 4	
	APPROVED		

REV. 7-15-67

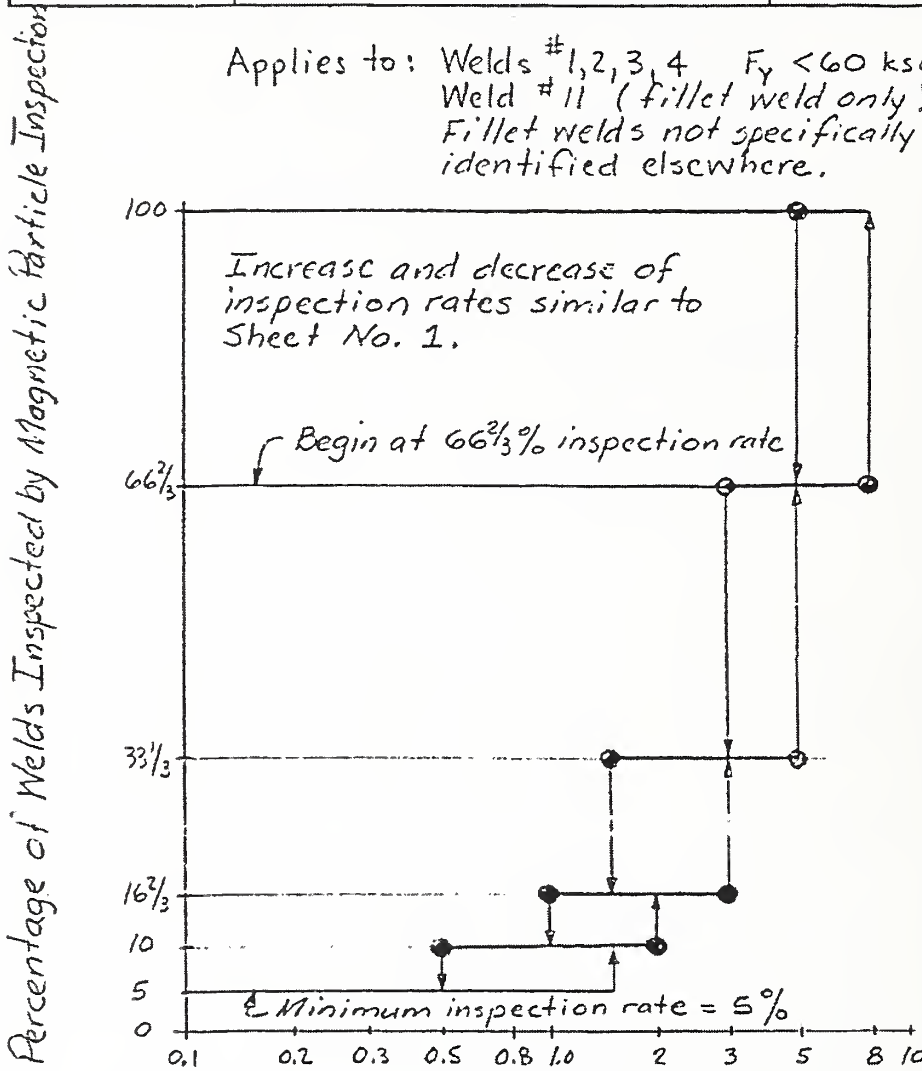


Note: Welds #1, #2, #3, #4 shall be inspected for 1'-0" length beginning at column ends.

REV. 7·15·67

KILLING HELLE CHRISTIANSEN ROBERTSON Structural & Civil Engineers	PROJ WTC CONTRACT 219 O	DATE 7·13·67	Sheet No.
	WELD INSPECTION RATE	PREPARED BY / APPROVED	4 OF 4

Applies to: Welds #1,2,3,4 F_Y < 60 ksi
Weld #11 (fillet weld only)
Fillet welds not specifically identified elsewhere.



Running Percentage of Rejected Welds in Preceeding 5- 8 Hour Work Shifts Based on Number of Welds Tested

Note: Welds #1,2,3,4 shall be inspected for 1'-0" length beginning at column ends.

CHAPTER THREE

FABRICATION OF STRUCTURAL STEEL

01 GENERAL

301.100 Structural steel shall be fabricated complete as shown in the Drawings and in approved details shown in the shop drawings.

301.200 The steel furnished for each location shall have a minimum yield point equal to that scheduled in the Drawings, and shall be selected from the applicable steel specifications listed in Chapter Two, MATERIALS.

301.300 All steel shall be ASTM A36 for locations where a specific strength requirement is not stated in the Drawings.

302 IDENTIFICATION

302.100 The Contractor shall identify all steel, other than A.S.T.M. A36, which will be used in the the work beginning at the mill and shall maintain identification at all times thereafter including during fabrication. The method used shall make both the grade and yield point of the steel readily identifiable. Identification shall be maintained after fabrication.

302.200 The Contractor shall identify each member or assembly with a system of marks. Each mark shall be clearly indicated in the shop drawings. The system of identification marks for fabricated structural steel shall be a permanent system approved by the Engineer. In addition, the Contractor shall paint erection

304 FABRICATION TOLERANCES

304.100 Fabrication tolerances shall conform to the requirements of the AISC Specification and AWS D1.0, as supplemented by specific requirements contained in the Drawings and Specifications. In no case shall tolerances exceed those obtainable by the best modern shop practice.

305 SPECIAL REQUIREMENTS

305.100 Cut edges of steel shall be free of burrs, overhangs, gross laminations, excessive slag inclusions and similar defects. Where necessary, cut edges shall be repaired by means described in the Contractor's quality control and testing program. Where required to maintain weld quality, corners of plates shall be eased and cut edges shall be ground. Work of this nature shall be outlined in the Contractor's quality control and testing program and shall be described in detail in the Contractor's welding procedure specifications.

305.200 In certain locations in the Drawings, slotted or oversize holes are specifically required. Where the Contractor elects to use slotted or oversize holes not shown in the Drawings, the use of slotted or oversize holes shall be subject to the Engineer's approval.

305.300 The Engineer will provide for the Detailer's use a table of correction factors which the Detailer will use to determine the correct as-fabricated dimensions of columns. This correction factor for column shortening under load is to be included in the dimensions shown on the Shop Drawings. A separate correction for temperature at time of fabrication is to be made by the Contractor based on a standard temperature of 70 degrees Fahrenheit for steel members.

CHAPTER FOUR

WELDING OF STRUCTURAL STEEL

401 GENERAL REQUIREMENTS

401.100 Welding of structural steel shall conform to the requirement of the AISC Specification and AWS D1.0, except where the AISC Specification or AWS D1.0 is specifically modified or supplemented by information included in the Drawings or Specifications.

402 QUALIFICATION AND CERTIFICATION OF WELDERS

402.100 Welders and welding operators shall have passed the applicable A qualification tests prescribed in AWS D1.0, Appendix D, Parts II and III. AWS qualification tests shall be supervised and witnessed by an agency approved by the Engineer. The approved agency shall issue certified test reports which describe the tests performed and indicate the results of the tests. Certification papers issued by the approved agency shall clearly state the types of work the welder or welding operator is qualified to perform. Certification shall be achieved immediately preceding the date the subject welder begins work under the Contract. AWS qualification tests and certification shall be paid for by The Authority and witnessed by the Engineer's Representative.

403 WELDING PROCEDURE SPECIFICATIONS AND JOINT QUALIFICATIONS

403.100 Joints conforming to the details specified in AWS D1.0, Articles 209, 210, 211, 212, 213 and 214 and welded in accordance with the

405.200 Welding electrodes and flux for submerged arc welding shall conform to Section 202, MATERIALS.

405.300 Gas metal-arc welding materials, where approved for use in the work, shall conform to Section 202, MATERIALS, and to the requirements of the approved welding procedure specification.

WORLD TRADE CENTER

Page 1-13

105 INSPECTION, QUALITY CONTROL AND TESTS

105.100 Quality Control and Tests

105.101 The Contractor shall comply with the quality control and testing program of Montague-Betts Company, Inc., dated June 9, 1967, as such program is revised in the respects indicated in the letter from Skilling-Helle-Christiansen-Robertson dated June 23, 1967, to the extent necessary to obtain the approval of the Engineer. The aforesaid program and letter are annexed hereto and form a part hereof.

105.102 The Contractor shall continually review his quality control and testing program against experience gained during the course of the work. Where the Contractor desires revisions to his quality control and testing program, he shall submit the proposed revisions to the Engineer for approval. The Contractor shall not make changes in the approved quality control and testing program without the Engineer's approval. The Contractor may,at his option, perform quality control and testing in addition to that required by the approved quality control and testing program.

105.103 The Contractor shall maintain complete records of all quality control and testing performed by the Contractor. Records shall be kept in report form, and shall include the results of all visual control of the work, the results of all tests and part, to consist of surveillance and evaluation of the Contractor's quality control and testing program.

105.203 The Contractor shall furnish the Engineer free access to the work. The Contractor shall cooperate with the Engineer to allow Inspection.

105.204 The Contractor shall furnish, free of charge, all electrical power, turning or moving of members, hoisting, staging and other facilities required for Inspection. The Authority will provide testing machines, testing machine operators and testing materials used for Inspection.

105.205 The Contractor shall notify the Engineer a minimum of six (6) working days in advance of the beginning of work subject to Inspection. This requirement applies to each location at which work is performed, and to each resumption of work after any interruption or suspension of work. The Contractor shall pay the actual cost of salaries and travel expenses, in reasonable amounts, incurred because work is not ready for Inspection at the time stated by the Contractor.

105.206 The Contractor shall not in any manner construe Inspection to relieve the Contractor of any of his responsibilities under the Contract.

QUALITY CONTROL PROGRAM

THE WORLD TRADE CENTER
CONTRACT WTC-226.00
FABRICATED STEEL
ROLLED CORE COLUMNS, INTERIOR COLUMNS
LOUVER WALL STRUTS AND ROLLED BEAMS
NORTH & SOUTH TOWERS

THE PORT OF NEW YORK AUTHORITY
NEW YORK, NEW YORK

SUBMITTED BY
MONTAGUE-BETTS COMPANY, INC.
JUNE 9, 1967

RECEIVING (under the direct supervision of Yard Foreman)

a. Materials will be checked as unloaded for conformance with mill order and shipping papers.

b. Materials will be stacked on blocks off of the ground in predetermined storage areas.

c. Bay numbers will be recorded for future reference in locating materials as needed.

d. Remarking size, length and grade will be done as necessary.

e. Each piece or bundle will be marked with the letters PONYA.

f. Discrepancies in quantity, length or grade will be reported immediately for replacement.

PREPARATION (under the direct supervision of Yard Foreman)

a. Cutting to size will be by sawing, shearing or machine flame burning.

New pieces will be marked to maintain proper identity.

c. lumn ends will be milled as required and protected against normal weathering with a mixture of one part white lead, one part linseed oil and two parts lard.

FABRICATION (under the direct supervision of Shop Foreman)

a. Layout and fitting will be performed by Fitters working with necessary Helper(s).

b. Detail parts will be tack welded for location.

c. Holes will be punched, drilled or subpunched and reamed.

d. Copes, blocks, notches, etc., will be accomplished by hand burning and grinding smooth.

e. Overhangs, gross laminations, excessive slag inclusions and similar defects will be corrected by grinding or Arcair gouging and built up as necessary with weld metal.

f. Material will be cleaned of oil, grease, dirt and foreign matter only.

g. Pieces will be marked as shown on shop drawings using DuPont #65-3010 white metal primer on a background of Tnemec #99 red metal primer; marks will be between 3" to 4" high and background 4" larger than complete mark.

6-9-67

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers · *230 Park Avenue, New York, N. Y. 10017* · *Mu. 9-8874*

John B. Skilling · *Helge J. Helle* · *John. V. Christiansen* · *Leslie E. Robertson*

Consultants
Harold L. Worthington
Joseph F. Jackson

June 23, 1967

Mr. Lester S. Feld
Port of New York Authority
World Trade Center Planning
111 Eighth Avenue
New York, New York 10011

Reference: The World Trade Center
Contract WTC-226.00, Montague-Betts
Quality Control Program

Dear Lester:

We have reviewed the Quality Control Program submitted by Montague-Betts and have the following comments:

1. Receiving

   Material received should be checked against the certified mill test reports for size, grade, heat number and color code. One copy of each certified mill test report should be submitted to PNYA and to SHCR. Where applicable, mill test reports should be marked to indicate non-conforming material and the disposition of same. Where possible, off heat material should be described, in writing, prior to receipt of certified mill reports.

2. Fabrication

   Overhangs, gross laminations, excessive slag inclusions and similar defects should be defined and repair procedures for these defects should be outlined. The location and quality of all repairs should be reported.

3. Welding

   Certification papers for each welder and welding machine operator should be submitted to PNYA and to SHCR. These papers should include all positions and processes to which each welder will be assigned.

WAYNE A. BREWER
P. S. A. FOSTER
FRANK HOELTERHOFF
ROBERT E. LEVIEN
V. A. PRISADSKY
KENT R. ROGERS
CHARLES SANDUSKY
WILLIAM D. WARD
E. J. WHITE, JR.
LORENTS L. WIDING

SEATTLE OFFICE: 1840 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

- 2 -

Welding procedure specifications must be prepared and qualification tests performed by the fabricator, where applicable. One copy of each welding procedure specification and report of qualification tests should be forwarded to PNYA and to SHCR for approval.

Preheat and interpass temperatures must conform to the welding procedure specification where specific preheat and interpass temperature requirements are included in the welding procedure specification.

All welds should receive 100 percent visual inspection.

Non-destructive testing of welds has not been described, and may be divided into three classes:

1. Fillet welds
2. Partial penetration welds
3. Full penetration welds

The quality control program should describe the amount of welding to be tested, and the techniques to be used, such as dye penetrant, magnetic particle or ultrasonic. All testing of welds should be documented in inspection reports, one copy of each report to be forwarded to PNYA and to SHCR.

4. Inspection

The amount of periodic inspection of work in progress and the persons performing this inspection should be described.

The inspection of finished work should be documented in reports, with one copy of each report to be submitted to PNYA and to SHCR.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

James White

James White

JW:e
cc: Mr. H. Weinstein
Mr. W. Cosinuke

Appendix F
SUPPORTING DOCUMENTS FOR CHAPTER 7

This appendix contains the supporting documents that are referenced in Chapter 7 of this report. All of the documents contained in this report are reproduced with permission of The Port Authority of New York and New Jersey. Table F–1 contains a summary of supporting documents and their location within this appendix. The footnote numbers given in the table correspond to those in Chapter 7.

Table F–1. Supporting documents for Chapter 7.

Footnote Number	Document Title	Page(s)
	Section 7.1 - Overview	
1	General instructions from Malcolm P. Levy of PONYA to prime contractors for WTC contracts (WTCI-239-P)	390
	Section 7.2 – Erection Marks and Marking System	
2	General instructions on erection marks and marking system for structural steel from the Port Authority to steel fabricators/suppliers for WTC 1 and WTC 2 (WTCI-495-L)	395
	Section 7.3 – Quality Control and Inspection Program	
3	Memo dated July 26, 1968 from David L. Brown of PONYA to James White of SHCR (WTCI-515-L)	400

THE PORT OF NEW YORK AUTHORITY
111 Eighth Avenue-at 15th Street, New York, N.Y. 10011

World Trade Department
Guy F. Tozzoli, Director
Richard C. Sullivan, Director, The World Trade Center

Malcolm P. Levy, Chief, Planning & Construction Division   Telephone (212) 620-8233

GENERAL INSTRUCTIONS TO CONTRACTOR
FOR WORLD TRADE CENTER CONTRACTS

To Prime Contractors

The following information is directed to your attention in order that you may acquaint yourself with the procedure the Port Authority desires to follow upon execution of the contract.

After execution of the contract, you are requested to direct communications as follows:

Subject Matter	Addressee	Copies
All correspondence pertaining to administration of contract other than that specifically required below to be directed elsewhere. This includes correspondence on contract changes, matters pertaining to field problems, including changes stemming from field conditions, job progress and schedule.	To: Mr. J. Endler, Assistant Vice-Pres., Tishman Realty & Construction Co., Inc. 11th Floor, 30 Church Street, New York, N.Y. 10007	Submit original and one copy to Mr. Endler and two copies to Mr. Monti
All correspondence pertaining to administration of contract which involves additional expenditures or credits, requests for approval of subcontractors, and notification for off-site inspection of materials and equipment, etc.	To: Mr. R.M. Monti, Construction Manager, Room 1119, The Port of New York Authority, 30 Church Street, New York, N.Y. 10007	Submit original and two copies to Mr. Monti and one copy to Mr. Endler.

THE PORT OF NEW YORK AUTHORITY

Subject Matter	Addressee	Copies
Shop drawings and catalog cuts.	To: Mr. Marvin Altman, Architectural Coor., Tishman Realty & Construction Co., Inc. 11th Floor, 30 Church Street, New York, N.Y. 10007	For information on number of copies of shop drawings, size required, etc., see Contract Specification clause entitled, "Working Drawings and Catalog Cuts." Submit original drawings to Mr. Altman, one copy of each transmittal letter to Mr. Monti, and one copy to Mr. H.A. Tessler, Manager, Project Planning, Room 300, The Port of New York Authority, 111 Eighth Avenue, New York, N.Y., 10011.
Approval of equipment and material including samples, purchase orders, lists of materials and equipment proposed to be furnished under the contract and proposals for substitutions for specified material or equipment.	To: Mr. Monti	Direct original copy of all correspondence to Mr. Monti, one copy to Mr. Tessler, and one copy to Mr. Endler. For further instructions on inspection of material see clauses of specifications entitled "Inspections and Rejections" and "Workmanship and Materials".
Insurance Matters	To: Mr. Charles P. Levinson, Insurance Manager, Room 1005 The Port of New York Authority, 111 Eighth Avenue, New York, N.Y. 10011	Direct original to Mr. Levinson, with copies to Mr. Monti, and Mr. Endler.
A report of all accidents arising in connection with the work must be made to the Port Authority.	To: Mr. W.F. Gillespie, Claims Attorney, Room 1163, The Port of New York Authority, 111 Eighth Avenue, New York, N.Y. 10011	Direct original to Mr. Gillespie with copies to Mr. Monti and Mr. Endler.

THE PORT OF NEW YORK AUTHORITY

Please note the following requirements:

1. Under the clause of the contract entitled "Inspections and Rejections", you are required to furnish lists of material and equipment furnished under the contract. Such lists of material and equipment to be installed under the contractor must bear the vendor's name, manufacturer's name, trade name, style designation, catalog number and any other information necessary to completely identify the item.

   All lists of materials and equipment must be submitted within ninety days from receipt of letter of acceptance of contract.

   Requests for changes in materials and equipment from those specifically mentioned in the contract specifications must be submitted within a minimum of forty-five days of the approved date the contractor's schedule specifies as the time for implementation for the particular item.

4. All correspondence, shop drawings, purchase orders, samples, catalog cuts, etc., must bear the Port Authority contract number and be referenced to specification section.

5. All correspondence must come to the Port Authority or Tishman Realty & Construction Co. Inc., through you as the prime contractor. Correspondence submitted directly to the Port Authority or Tishman by subcontractors or materialmen will be given no consideration.

6. Request for approval of material and equipment will not be honored and no inspection made until the subcontractor placing orders for such material or equipment has been approved.

7. You are requested to prepare a list of the shop drawings, catalog cuts and samples which will be submitted for approval as required by the specifications. This list should be sent by you to Mr. Altman, with copies to Mr. Monti and Mr. Tessler with dates indicating when you will submit the items for approval. The dates which you establish on this list should be those which you feel necessary in order to meet the required completion date for all work under the contract. It is requested that this list be submitted within forty-five days of receipt of this letter.

   Also a list of items which will be inspected at source will be developed jointly within ninety days of the date of this letter.

8. In order that work under the contract may proceed expeditiously, it is urgent that you submit the names of your subcontractors for approval without delay. Forms requesting approval of subcontractors must include the following information:

   A. Name and address of subcontractor.

   B. The amount of the subcontract, including the analysis of the subcontractor's bid on forms furnished by the Port Authority. No approval of the subcontractor will be issued without the analysis of subcontractor's bid.

THE PORT OF NEW YORK AUTHORITY

\- 4 -

C. An accurate description of the work involved.

D. Three references on work of similar nature previously performed by subcontractor.

Malcolm P. Levy, Chief
Planning & Construction Division
The World Trade Center

November 7, 1967

Mr. Herman Winters
Drier Structural Steel Co., Inc.
32-50 Vernon Blvd.
Long Island City, New York 11106

Re: The World Trade Center - Contract WTC-211.00 -
Shop Drawing Procedures and Marking Systems

Dear Mr. Winters:

Enclosed for your information and use are letters and procedures previously sent to other fabricators on the WTC Towers. These procedures were developed jointly with Nassau Bridge Detailers starting in April 1967.

Sincerely,

Lester S. Feld
Planning Engineer

Enclosures:

1. Erection marks and marking system for structural steel in the WTC Towers - Pages 1 - 10 inclusive dated 10/1/67
2. Letter of June 16, 1967 on Erector's Derrick Division
3. Drawings S-KA-1000 and S-KB-1000 dated 5/25/67
4. Index to Marks System - dated 10/15/67 (2 pages)

cc: Messrs. J. Endler (TRCC), J. White (SHCR) - w/encl. #1

bcc: Messrs. D. Brown, R. Cogde, M. Levy, R. Monti, H. Tessler

LSF:jw

ERECTION MARKS AND MARKING
SYSTEM FOR STRUCTURAL STEEL
IN
THE WORLD TRADE CENTER
NORTH AND SOUTH TOWERS

Rev. 4/28/67
Rev. 10/1/67

1. Each mark shall be painted in accordance with the Specifications in the same position on each piece, as the mark appears on the erection drawing. All marks shall be followed by the Erector's Derrick Division. See Item 20 below.

2. Exterior Wall Columns (Below the 1st Story Splice)

Use the column number shown on the design drawing suffixed with the column tier number. Examples:

(a) 301 (S5-S1) - Indicates - Col. 301 from Tier S5 (El. 242) to splice above Tier S1 (El. 294').

(b) 330 (S1-1) - Indicates - Col. 330 (On center-line of Tower) from splice in Tier S1 to splice above first floor.

Tier marks are in accordance with Architect designation wherein:

S - Service Level - El. 294'
S1 - Sub-Level 1 - El. 284'
S2 - Sub-Level 2 - El. 274'
S3 - Sub-Level 3 - El. 264'
S4 - Sub-Level 4 - El. 253'
S5 - Sub-Level 5 - El. 242'

3. Exterior Wall Columns - (Above 1st Story Splice)

Use the column number shown on the design drawing suffixed with the column tier: Examples:

(a) 330 (1-4) - Indicates - Column 330 (on center-line of Tower) from the 1st Story Splice to the splice above the 4th floor, that is, from El. 318' to El. 363'.

(b) 330 (4-9) - Indicates - Panel 330 (On center-line of Tower) from the 4th Story Splice (El. 363') to the 9th Story Splice (El. 418.96). Note this is a "Column Tree Panel" to be fabricated by P.D.M. Steel Co. and the panel mark used is the middle column number of the three columns comprising the column tree.

(c) 200 $^{(18-20)}$ - Indicates - Panel 200 - A corner panel at N.E. Corner of Tower from the 18th Story Splice to the 20th Story Splice. This is a corner column spandrel panel to be fabricated by PC&F, and here again the panel number used is the middle column number of the three columns comprising the column tree.

4. Core Columns

Use the column number shown on the design drawing suffix with the column tier number. Examples:

(a) 501 $^{(S5-S2)}$ - Indicates - Corner core column 501 from Tier S5 (El. 242) up to the splice above tier S2 (El. 274').

(b) 605 $^{(S2-1)}$ - Indicates - Core column 605 from splice in Tier S2 (El. 274') up to splice in 1st story.

(c) 605 $^{(1-3)}$ - Indicates - Core column 605 from 1st story splice to 3rd story splice.

5. Interior Columns (Below the 1st floor - El. 310')

Use the column number shown on the design drawing suffixed with the column tier number.

(a) 1200 $^{(S5-S3)}$ - Indicates - Column 1200 from Tier S5 (El. 242) up to splice in Tier S3 (El. 264).

6. Louver Wall Struts

Use the letter S followed by the column line number for the exterior wall column suffixed with the floor number. Example:

(a) S302 $^{(7-9)}$ - Indicates - Strut on column line 302 extending from the 7th floor to the 9th floor.

7. Vertical Bracing at Exterior Walls

Use the letters XB followed by numerals 1, 2, etc. Example:

(a) XB1 - Indicates - Exterior Wall Brace 1

(b) XB2 - Indicates - Exterior Wall Brace 2

- 3 -

Please note that no tier marks are used as a suffix here. Marks shall appear on elevations of erection drawings only.- not in plans.

8. Vertical Bracing at Core Columns

Use the letters CB followed by numerals 1, 2, etc. Example:

(a) CB1 – Indicates - Core Brace #1

(b) CB10 - Indicates - Core Brace #10

Please note that no tier marks are used as a suffix here. Marks shall appear on elevations or erection drawings only.- not in plans.

9. Interior Pipe Posts, Hangers, Etc.

Use the letter P followed by numeral 1, 2, 3 etc. and suffix with the tier mark. Example:

(a) P1 (7-8) - Indicates - Post number 1 extending from the 7th floor to the 8th floor.

(b) P1 (41-42) - Indicates - Post number 1 extending from the 41st to the 42nd floor.

10. Floor Beams

Use a numeral suffixed with the floor number. All beams within the core shall be consistently marked all the way up the tower. That is a beam framing between core columns 501 and 502 might be marked "1" on each floor of the tower, such as:

(a) 1 (S3) - Indicates - Beam 1 - At floor S3 (El. 264').

(b) 1 (10) - Indicates - Beam 1 - At floor 10

(c) 1 (11-20) - Indicates - Beam 1 exactly alike from 11 through 20 floors. This will aid the erector to locate a beam which may be used on floors 11 through 20 at assumed location between columns 501 and 502. All beams outside the core which are of a repetitious nature such as framing at the 7 and 9, 41 and 43, 75 and 77 and 108 and 110 shall also be consistently marked in numerical sequence.

- 4 -

11. Horizontal Bracing at Exterior Wall - At Beam Framed Floors

All diagonals and struts within the 10'-3" panel area adjacent to the exterior column reference line shall be prefixed with the letter H followed by a numeral and suffixed with the floor designation. Example:

$H1^{(7)}$, $H1^{(9)}$, $H10^{(41)}$, $H10^{(43)}$ would all be horizontal braces in Tower - , occuring at the 7, 9, 41 and 43rd floors.

12. Prefabricated Floor Units

All prefabricated panels shall be prefixed "F" followed by a numeral and suffixed with the floor designation. All panels to be numbered clockwise starting with "1" at the panel between core columns 501 and 502. Example:

(a) $F1^{(10)}$, $F2^{(10)}$, etc. - Indicates floor unit at 10th floor.

(b) $F1^{(15)}$, $F2^{(15)}$, etc. - Indicates floor unit at 15th floor.

With regard to components comprising prefabricated units, the following ground rules shall prevail:

A. All trusses, bridging, bracing and beams for prefabricated floor units supplied by Laclede to the assembler (Koch) shall be marked as agreed between the parties. Laclede shall furnish an assembly diagram to Koch showing components in each "F" panel.

B. All steel deck and power/telephone cells for prefabricated floor units supplied by Granco to the Assembler (Koch) shall be marked as agreed between the parties. Granco shall furnish an assembly diagram to Koch showing components of deck and P/T cells in each "F" panel.

C. The assembler (Koch) shall furnish a combined assembly diagram showing all components comprising each "F" panel.

13. Loose Deck and Loose Power/Telephone Cells for Beam-Framed Areas and Core Areas

All loose deck shall be prefixed SD followed by a numeral and floor designation such as:

$SD1^{(7)}$, $SD2^{(7)}$, etc.

Similarly all power/telephone cells shall be prefixed PT followed by a numeral and floor designation such as:

$PT1^{(9)}$, $PT2^{(9)}$, etc.

- 5 -

14. Anchor Bars and Anchor Plates (see drawing SAB-198)

Use prefix WX at exterior walls.

Use prefix WC at perimeter of core.

Examples: WX1, WX2, etc. - Indicate - Anchors at exterior wall

WC1, WC2, etc. - Indicate - Anchors at core perimeter.

Note - No tier designations are required. All anchors will be shown and located on erection plans and field welding sketches.

15. Shear Studs

Prefix "R" - followed by 3 digit numeral indicating diameter in eighths, length in inches and eighths such as:

R742 - Stud - 7/8" diameter x 4½" long, shall be painted on all kegs or containers.

16. Damping Units

Use Prefix "D" -

Example: D1, D2, D3, etc.

NOTE: No tier designations are required

16A. Grillages, Base Plates and Anchor Bolts

Use the following prefix letters:

G - Assembled Grillages

BP - Loose Base Plates

AB - Anchor Bolts

All the above prefix letters are to be preceded by the Tower letter thus:

A-G1, A-G-2, etc. (Tower A Grillages)

B-G1, B-G2, etc. (Tower B Grillages)

A-BP-1, A-BP-2, etc. (Tower A Base Plates)

B-AB-1, B-AB-2, etc. (Tower B Anchor Bolts)

MEMORANDUM

PA 30-A
5-63

TO:	James White - Skilling-Helle-Christiansen-Robertson
FROM:	David L. Brown
DATE:	July 26, 1968
SUBJECT	THE WORLD TRADE CENTER - CONTRACT WTC-230.00 - QUALITY CONTROL & SAFETY PROGRAM
REFERENCE	
COPY TO:	L.S. Feld (W/Att), R.M. Monti, F.H. Werneke; A. Guttentag (TRCC)

Please review the attached Koch Quality Control Program as soon as possible and let me have your comments on same.

DLBrown

David L. Brown
Supervising Engineer
The World Trade Center

DLB/DMD
Att.

April 25, 1968

Outline of Items to be Included in Quality Control Program by Karl Koch Erecting Company

A. Survey Control

   1. Methods and Equipment

   2. Qualification of survey personnel

   3. Establishment of monuments and reference lines

B. Control of Construction and Erection Loads

   1. Loads on work platforms and finished structure

      a. Weight of equipment

      b. Weight of stored materials

      c. Posting of load limitations

      d. Provision of planking where required

   2. Cranes and derricks

      a. Boom angle vs. weight of pick

   3. Bracing and erection sequences

      a. Column bracing in Plaza area

      b. Bracing of core columns for tower cranes

         (1) Sequence of jumping bracing

         (2) Sequence of jumping crane

         (3) General erection sequences

C. Field Welding

   1. Control of field weld details vs. Fy of material.

   2. Qualification and certification of welders

   3. Qualification and certification of welding procedure specifications for joints not pre-qualified by AWS.

4. Preparation of welding procedure specifications for welds and joint designs designated pre-qualified by AWS.
5. Control of preheat and interpass temperatures.
6. Control of welding electrodes, ~~welding~~ fluxes, ~~welding~~ shielding gases, and the like.
7. Storage of welding materials such as heating ovens for low hydrogen electrodes.

D. Bolting of Structural Steel

1. Control of type of bolts and washers used
2. Installation methods and procedures for bolted connections
3. Quality control and assurance that high tensile bolts are properly tightened.
4. Control of ASTM A307 bolts
5. Control of set-up of bolted joints
6. Cleaning of faying surfaces for bolted joints

E. Control of Stud Welding Operations

G. Erection procedures

1. Plumbing
2. Fit-up
3. Guying and bracing
4. Elimination of trapped water from box columns and similar members.
5. Allowance for temperature changes and related movements and deflections of structure.

H. Control of Workmanship

1. Flame-cutting
2. Reaming of holes
3. Drifting

I. Control of Erection Tolerances

1. Refer to tolerance diagrams included in the Specifications.
2. Surveying and other controls.

J. As-Built Drawings

1. Preparation of as-built drawings, procedures for.
2. Control and maintenance of as-built drawings and related procedures.

K. Safety Programs

1. Hoisting equipment
2. Guying materials.
3. Wind conditions
4. Provisions for bad weather

Note: KKE should relate their quality control program carefully to the provisions and requirements of the Specifications and Drawings. Possibly in some areas of the KKE quality control program, explanatory sketches should be prepared and included in the document.

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Appendix G
Supporting Documents for Chapter 8

This appendix contains the supporting documents that are referenced in Chapter 8 of this report. All of the documents contained in this appendix are reproduced with permission of The Port Authority of New York and New Jersey. Table G–1 contains a summary of supporting documents and their location within this appendix. The footnote numbers given in the table correspond to those in Chapter 8.

Table G–1. Supporting documents for Chapter 8.

Footnote Number	Document Title	Page(s)
Section 8.2 – Variances Relating to Fabrication/Erection Tolerances		
1	Letter dated December 27, 1967 from Richard Chauner of SHCR to Robert Dempsey of United States Testing Company (WTCI-499-L)	407
2	Letter dated December 22, 1967 from James White of SHCR to R. Monti of PONYA (WTCI-499-L)	412
3	Letter dated June 20, 1969 from James White of SHCR to R. Bay from Laclede Steel Company (WTCI-506-L)	415
4	Letter dated November 17, 1969 from James McGuiness of SHCR to R. Monti of PONYA (WTCI-506-L)	418
5	Letter dated October 16, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-506-L)	424
6	Letter dated October 20, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-506-L)	426
7	Letter dated June 16, 1969 from Malcolm Levy of PONYA to Carl Weber of Laclede Steel Company (WTCI-506-L)	429
Section 8.3 – Variances Relating to Defective Components		
8	Letter dated June 20, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-506-L)	434
9	Letter dated December 15, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-506-L)	437
10	Letter dated July 7, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-506-L)	440
11	Letter dated July 3, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-506-L)	442
12	Letter dated March 31, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-506-L)	445
13	Letter dated June 6, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-736-L)	449
14	Letter dated May 19, 1969 from James White of SHCR to R. Monti of PONYA (WTCI-736-L)	458
15	Letter dated May 5, 1969 from R. Monti of PONYA to H. Fish of PDM (WTCI-735-L)	462

Footnote Number	Document Title	Page(s)
16	Letter dated March 20, 1969 from James White of SHCR to R. Monti of PONYA (WTC1-738-L)	463
17	Letter dated June 6, 1969 from James White of SHCR to R. Monti of PONYA (WTC1-736-L)	464
18	Letter dated May 16, 1969 from James White of SHCR to R. Monti of PONYA (WTC1-735-L)	469
19	Letter dated June 9, 1969 from James White of SHCR to R. Monti of PONYA (WTC1-736-L)	474
20	Letter dated May 16, 1969 from James White of SHCR to R. Monti of PONYA (WTC1-735-L)	477
21	Letter dated May 16, 1969 from James White of SHCR to R. Monti of PONYA (WTC1-735-L)	478
22	Letter dated July 15, 1971 from James White of SHCR to R. Monti of PONYA (WTC1-736-L)	481
23	Letter dated August 21, 1968 from James White of SHCR to R. Monti of PONYA (WTC1-740-L)	484
24	Letter dated October 7, 1968 from James White of SHCR to R. Monti of PONYA (WTC1-738-L)	485
25	Letter dated October 18, 1968 from James White of SHCR to R. Monti of PONYA (WTC1-739-L)	489
	Section 8.4 – Variances Relating to Alternate Fabrication/Erection Procedures	
26	Letter dated September 21, 1969 from R. Monti of PONYA to W. Gibson of Stanray Pacific Corporation (WTC1-490-L)	491
27	Letter dated October 16, 1969 from R. Monti of PONYA to Robert Bay of Laclede Steel Company (WTC1-506-L)	493
28	Letter dated December 15, 1967 from James White of SHCR to R. Monti of PONYA (WTC1-748-L)	497
29	Letter dated May 26, 1969 from James White of SHCR to R. Monti of PONYA (WTC1-756-L)	498
	Section 8.5 – Variances Relating to Product Substitutions	
30	Letter dated May 2, 1969 from James White of SHCR to R. Monti of PONYA (WTC1-756-L)	500
31	Letter dated June 11, 1968 from James White of SHCR to R. Monti of PONYA (WTC1-739-L)	504
32	Letter dated December 18, 1967 from R. Monti of PONYA to H. Fish of PDM (WTC1-745-L)	505
33	Letter dated December 18, 1967 from R. Monti of PONYA to H. Fish of PDM (WTC1-745-L)	510
	Section 8.6 – Variances Relating to Inspection Practice	
34	Letter dated May 3, 1968 from James White of SHCR to R. Monti of PONYA (WTC1-742-L)	515
35	Letter dated April 18, 1968 from James White of SHCR to R. Monti of PONYA (WTC1-483-L)	517

PROJECT MEMORANDUM

FROM: SKILLING-HELLE-CHRISTIANSEN-ROBERTSON
1840 Washington Building
Seattle, Washington 98101

DATE: December 27, 1967

TO: United States Testing Company
5521 Telegraph Road
Los Angeles, California 90022

ATT'N: Robert Dempsey

SUBJECT: The World Trade Center- New York
Contract WTC 217.00 Stanray Pacific Steel Inspection

RE:

Transmitted to you on 12-21-67 was a copy of a telegram from James White, SHCR-New York concerning dimensional tolerances on the box columns. Included with this telegram was Stanray's interoffice memorandum showing their interpretations of this telegram. The following comments are to be added to these sketches.

1. This applies only to clip angles on the flange and web plates.

2. These minimum edge distances apply only away from the end of the column. Tolerances at the end shall be 1½ inches ± 5/32 inch.

3. Minimum AISC weld shall be increased by the gap dimension.

In addition to the above, other items were transmitted verbally.

1. The detail of welding certain clip angles call for fillet welds on three sides leaving the heel of the angle free for beam clearance. The AWS Code requires a return of the fillet weld on this side. This is not required... .

2. Variance of the end tolerance on column 604-9 has been approved by the supervising engineer. This permitts one flange to be offset 3/16 inch in place of 1/8 inch as specified on Page 3-04 of the contract document.

PROJECT MEMORANDUM Page 2

FROM: SKILLING-HELLE-CHRISTIANSEN-ROBERTSON
1840 Washington Building
Seattle, Washington 98101

DATE: December 27, 1967

TO:

ATT'N:

SUBJECT:

RE:

3. All hold dimensions on the detail drawings shall be ± 1/16 inch except as modified by the enclosed telegram.

4. Slotted holes shall not be hand flame cut.

5. The tolerance on the dimension between flanges of the column shall be plus 1/8 inch and minus 1/4 inch.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

Richard W. Chauner

Richard W. Chauner

cc: SHCR-New York Jim White

W. P. MARSHALL
CHAIRMAN OF THE BOARD

TELEGRAM

R. W. McFALL
PRESIDENT

NL=Night Letter
LT=International Letter Telegram

The filing time shown in the date line on domestic telegrams is LOCAL TIME at point of origin. Time of receipt is LOCAL TIME at point of destination

1137A PST DEC 20 67 LA 102
SSD189 L NA092 RX PDB NEW YORK NY 20 145P EST
J N TARKAN, STANRAY PACIFIC CORP
11633 SOUTH ALAMEDA ST LOSA
THESE RULINGS APPLY TO BOX COLUMNS FABRICATED UNDER CONTRACT WTC-217.00. ITEM ONE REFER TO DRAWING 6-AB1-41 6-AB7-2. ANGLE IRON CLIPS THESE AND EQUIVALENT DETAILS MAY HAVE ELONGATED HOLES. LONG DIMENSION PERPENDICULAR TO COLUMN FACE SHALL BE BOLT DIAMETER PLUS 1/4 INCH, SHORT DIMENSION STANDARD 1/16 INCH OVERSIZE. THIS PROVIDES 1/8 INCH PLUS OR MINUS TOLERANCE FROM KEEP DIMENSION TOLERANCE FOR ROUND HOLES SHALL BE 1/16 INCH PLUS OR MINUS KEEP DIMENSION. ITEM TWO NO WEB PLATE IN COMPLETED MEMBERS SHALL MEASURE LESS THAN ONE INCH FROM FACE OF WEB TO INSIDE CORNER OF FLANGE PLATE. THIS ALLOWS WEB PLATE TO RUN STRAIGHT END TO END OF COLUMN AND ACCOMMODATED MAXIMUM ALLOWED SWEEP OF 3/8 INCH IN THE FLANGE PLATE. ITEM THREE FOR

WESTERN UNION

CLASS OF SERVICE
This is a fast message unless its deferred character is indicated by the proper symbol.

W. P. MARSHALL
CHAIRMAN OF THE BOARD

TELEGRAM

R. W. McFALL
PRESIDENT

SYMBOLS
DL=Day Letter
NL=Night Letter
LT=International Letter Telegram

The filing time shown in the date line on domestic telegrams is LOCAL TIME at point of origin. Time of receipt is LOCAL TIME at point of destination

L NA092/2

COLUMNS FABRICATED ON OR BEFORE DECEMBER 16 1967 WHEN INSPTECTED AT MILLED ENDS. 1/16 INCH GAP AT ROOT OF LONGITUDINAL FILLET WELD PLUS 1/32 INCH FOR OUT OF SQUARE CUT WILL BE ALLOWED WHEN MEASURED AT INSIDE PLATE. ANY GAP EXCEEDING THIS ALLOWANCE SHALL RECEIVE AISC MINIMUM FILLET WELDS BEGINNING ONE INCH FROM THE MILLED COLUMN END AND PROVIDE FULL THROAT MINIMUM OF NINE INCHES IN LENGTH
JAMES WHITE

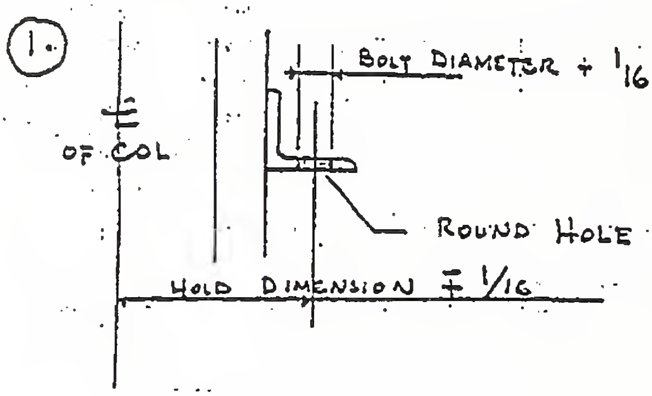
WTC-217.00 6-AB1-41 6-AB7-2 1/4 1/16 1/8 3/8 16 1967 1/16 1/32
(32).

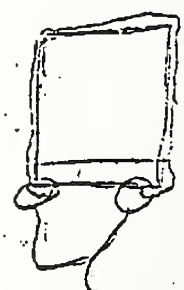
NOTE DETAIL PLATE ON FACE OF COLUMN THICKNESS CAN
VARY HOLD ±1/16

STANRAY PACIFIC CORPORATION
INTER-OFFICE MEMORANDUM

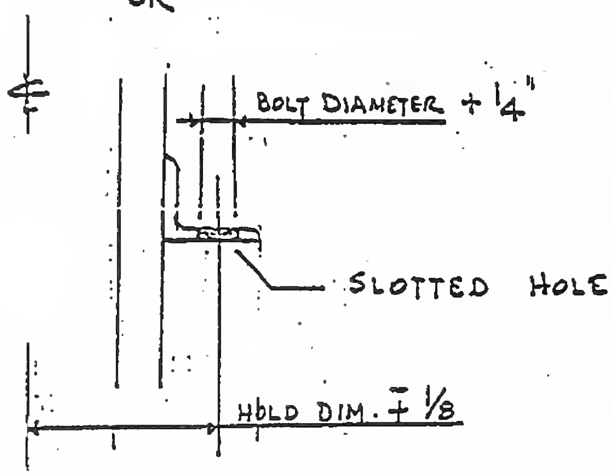
To: GENE WALTON
Date: 12-21-1967
From: JOE TARKAN
Subject: WORLD TRADE CENTER

ALL COLUMNS FABRICATED ON OR BEFORE DECEMBER 16TH SHALL BE COMPLETED WITHIN THE LIMITS OF FOLLOWING TOLARANCES





OR



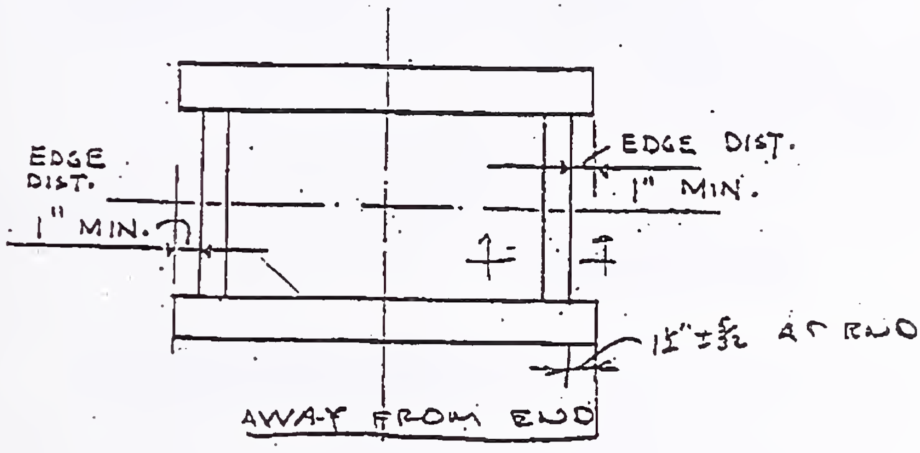
ALSO CLIP ANGLE ON FACE OF WEB.

STANRAY PACIFIC CORPORATION
INTER-OFFICE MEMORANDUM

To: Date:

From: Subject:

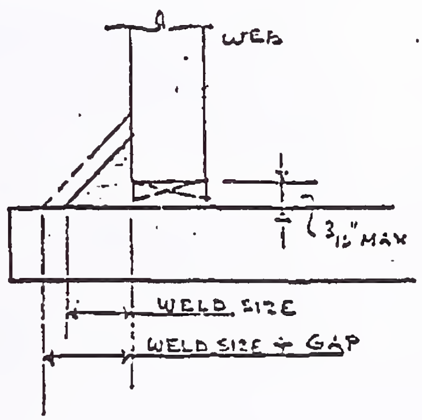
(2)



(3) THE GAP AT MIDDLE OF COLUMN SHALL NOT BE MORE THAN 3/16"

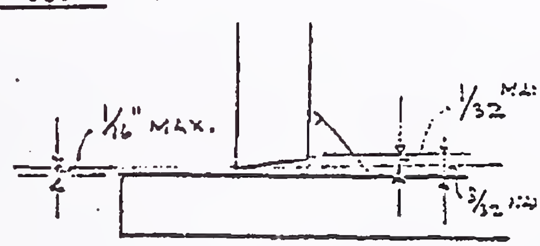
WELD SIZE AT GAP SHALL BE INCREASED ACCORDINGLY

GAPS OF 1/16" OR LESS SHALL BE IGNORED



GAPS AT THE END OF COLS SHALL BE 3/32 MAX. AS SHOWN

IF GAP IS MORE THAN THESE LIMITS PUT 9" LONG FILLET WELD AT INSIDE OF COLUMN STARTING 1" BEYOND MILLED END ACCORDING AISC MIN. WELD SCHEDULE



SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

John B. Skilling • Helge J. Helle • John V. Christiansen • Leslie E. Robertson

December 22, 1967

Consultants
Harold L. Worthington
Joseph F. Jackson

Port of New York Authority
Office of the Construction
Manager - Room 1119
30 Church Street
New York, New York 10007

Attention: Mr. R. n. Monti, Construction Manager

Reference: The World Trade Center
Contract WTC-215.00, Moshe
Tolerances for Box Beams

Gentlemen:

Enclosed please find a copy of a letter received by SHCR from Mosher Steel Company dated December 14, 1967 requesting approval of tolerances shown on the 8-1/2" x 11" sketch prepared by Mosher and attached to their letter.

We approve the tolerances as shown on the Mosher sketch. All tolerance figures shown are 1/16 or 1/8 inch (see sketch).

We approve a maximum twist in box columns as fabricated of 1/4 inch whe measured at one end in relationship to the other end.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

James White

James White

JW:s
cc: Mr. W. C. Bradford, Mosher
Mr. L. Feld, PNYA
Mr. R. Fensch, SIS
Mr. J. Ciulo, SHCR-SE

Enclosure

WAYNE A. BREWER
P. D. A. FOSTER
FRANK HOELTERHOFF
ROBERT E. LEVIEN
V. A. PRIKAZSKY
KENT A. ROGERS
CHARLES BRADBURY
WILLIAM B. WARD
E. J. WHITE, JR.
LORENZO WIDING

SEATTLE OFFICE: 1200 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

MOSHER STEEL COMPANY

ENGINEERS – FABRICATORS – ERECTORS

POST OFFICE BOX 1579 HOUSTON, TEXAS 77001

Over 80 Years

December 14, 1967

Skilling - Helle - Christiansen - Robertson
230 Park Avenue
New York, New York 10017

Attention: Mr. James White

Reference: The World Trade Center
Contract WTC - 215.00 Mosher
S. O. 31060 & 31061

Gentlemen:

Fabrication tolerances as set forth in Specifications 304.100 and 305.100 are clear as far as built-up columns are concerned, however they are not clear as far as built-up box beams are concerned. We do not feel that it was ever intended for the box beams, which are considerably lighter than the box columns, to be fabricated according to tolerances shown on sheet 3-04 which pertains to box columns.

Therefore, we are submitting for approval our sketch which indicates the fabrication tolerances which we recommend in the fabrication of box beams. We have already started burning the flange and web plates for the box beams and would appreciate your giving this matter your earliest possible consideration.

Also, we have not received as yet written confirmation for a maximum one quarter of an inch ($\frac{1}{4}$") twist in the fabrication of the box columns.

Yours very truly,

MOSHER STEEL COMPANY

W. G. Bradford

W. G. Bradford
Works Manager

WGB/jac

cc: NEE

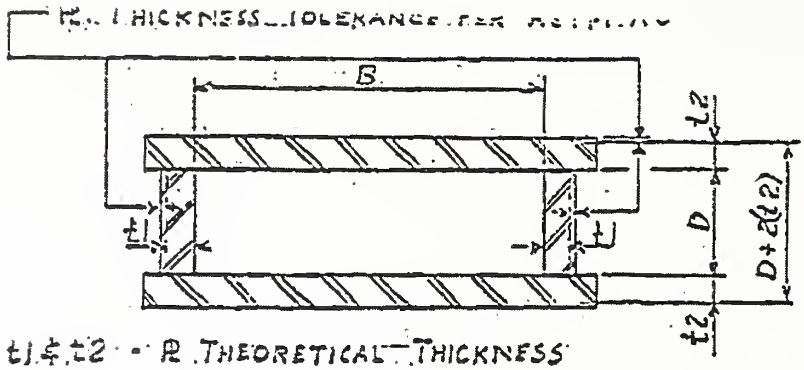
cc: RFV

cc: WLP

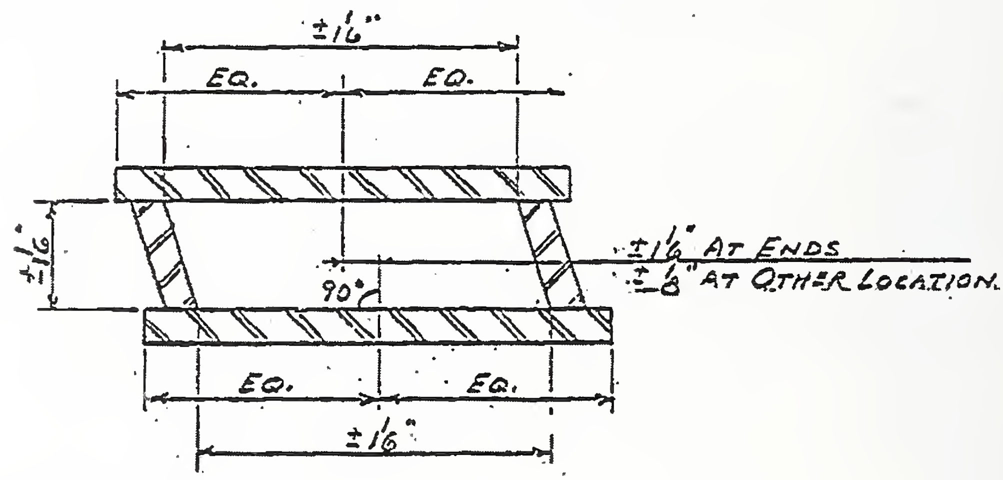
cc: VHT

cc: OWS

PLANTS AND SALES OFFICES } HOUSTON · DALLAS · TYLER · LUBBOCK · SHREVEPORT · CORPUS CHRISTI · SAN ANTONIO
SALES OFFICES } NEW YORK · LOS ANGELES
STRUCTURAL STEEL · MISCELLANEOUS · REINFORCING · MACHINE WORK · PRESSURE VESSELS · CARBON & ALLOY PLATE WORK · L.P.G. SYSTEMS



DETAILING DIMENSIONS



MAX. SWEEP & CAMBER = 1/8" x LENGTH IN FEET/10

FINISHED LENGTH OF BUILT-UP MEMBERS = ±1/16"

TWIST = 1/8" MAX.

DEPTH, WIDTH AND OUT-OF-SQUARE TOLERANCES (BEAMS)

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-5574

John B. Skilling • *Helge J. Helle* • *John V. Christiansen* • *Leslie E. Robertson*

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

June 20, 1969

Laclede Steel Company
Arcade Building
St. Louis, Missouri 63101

Attention: Mr. R. Bay

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Approval of C32T33, C32T34 and C32T35 Trusses

Gentlemen:

In confirmation of our telephone conversation today, Mr. Jackson of PTL has been instructed that he can waive the 4½" Hold Exact dimension on

8 - C32T33
8 - C32T34
4 - C32T35

provided the dimension is in no case less than 4 inches (Laclede Drawings ST233, ST234 and ST235). Mr. Jackson has also been requested to inform the writer immediately by telephone of any recurrence of the above problem on new production of the three affected truss designations.

This approval is granted on the basis of SHCR review of clearances at truss seats and your discussion with KKE in which KKE agreed to accept the subject twenty (20) trusses from Laclede for fabrication, provided Laclede would rectify all difficulties, if any, experienced by KKE due to Laclede's deviation from the approved "Hold Exact" dimension.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

James White

cc: Messrs. R. M. Monti, PNYA
L. S. Feld, PNYA
R. Piasecki, KKE
A. Guttentag, TRCC

ROBERT C. LEVIEN
PAUL B. A. FOSTER
[illegible]
KENT R. ROGERS
CHARLES A. SANDUSKY
WILLIAM D. WARD
E. J. WHITE, JR.
LORENTS L. WIDING

RICHARD CHAUNER
[illegible]
JOSTEIN NES
[illegible]
HAROLD D. FORT
RICHARD E. TAYLOR

SEATTLE OFFICE: 1960 WASHINGTON BUILDING, SEATTLE WASHINGTON 98101

Laclede Steel Company

General Offices Laclede Building

St. Louis, Missouri 63101 March 13, 1969

Mr. Wayne Brewer
Skilling-Helle-Christiansen- Robertson
230 Park Avenue
New York, New York

Dear Wayne:

Request for Acceptance of
32" Trusses not Fabricated
<u>According to Approved Drawing</u>

The purpose of this letter is to formally request approval of the twenty (20) trusses listed below that were verbally approved by Mr. Gene Chorny at our Madison Plant on March 11, 1969.

4 - C32T35
8 - C32T34
8 - C32T33

These trusses were fabricated with the "hold exact" dimension at the core end as being 4" instead of 4-1/2" as shown on the approved drawings.

Gene and I feel that this may cause a tight fit when the panel is placed in the building but the panel is adjustable enough to accommodate this variance.

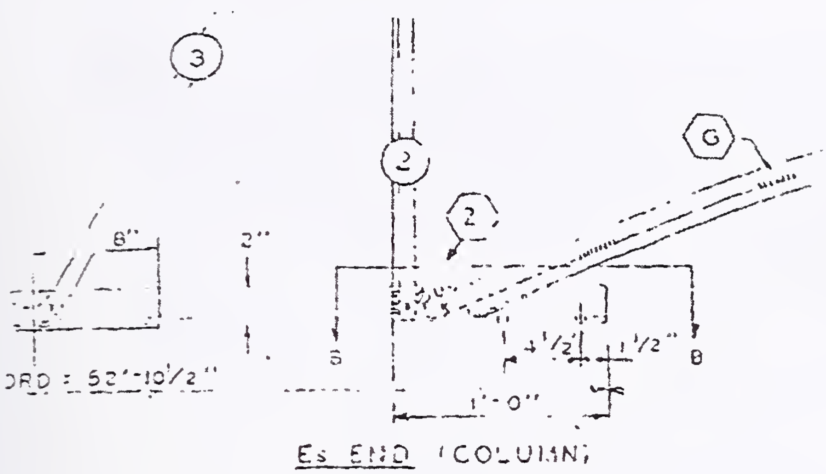
Yours very truly,

LACLEDE STEEL COMPANY

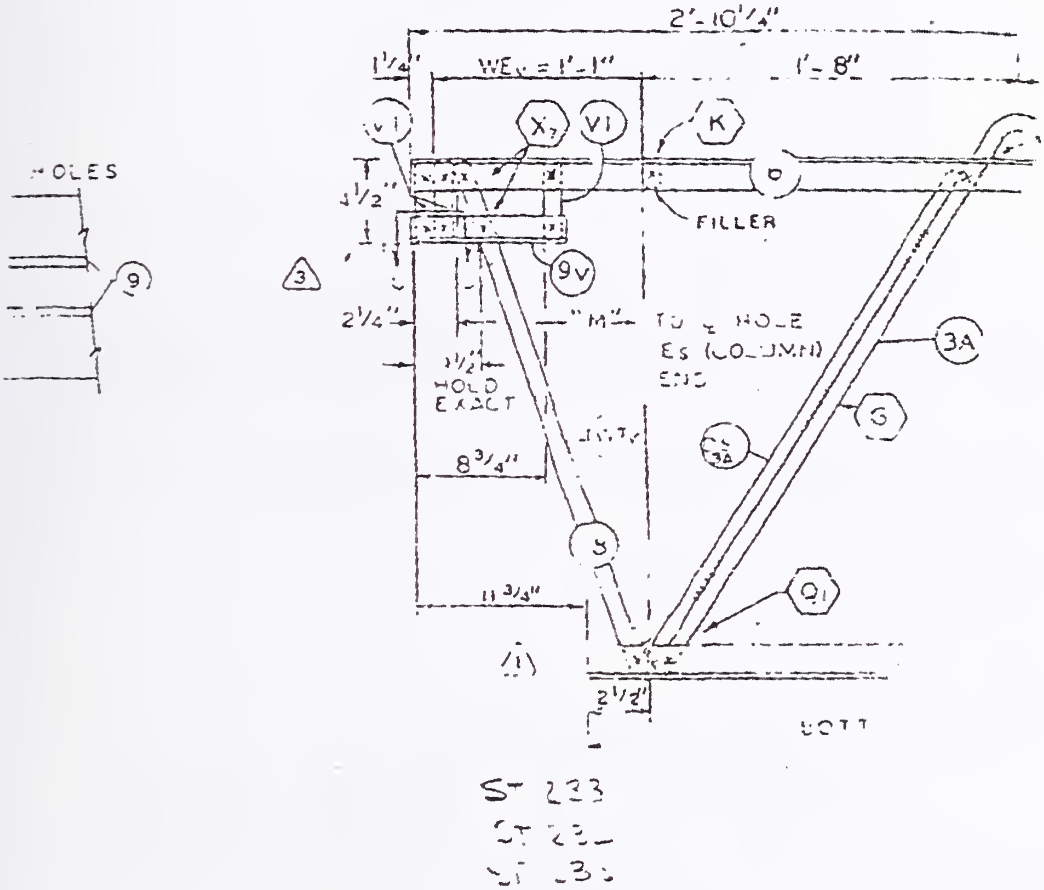
Thomas M. Chura

Thomas M. Chura, P. E.
Research Engineer
Construction Products

lp



3
2
G
8"
2"
ORD = 52'-10½"
1'-0"
B
Es END (COLUMN)



2'-10¼"
1¼"
WE = 1'-1"
1'-8"
K
FILLER
HOLES
9
9V
3A
G
HOLD EXACT
8¾"
11¾"
2¼"
2½"
"M" TO ℄ HOLE Es (COLUMN) END
Q1
ST 233

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu 9-8874

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

November 17, 1969
File: WTC-221C-WTC-223C

Port of New York Authority
Office of the Construction Manager
30 Church Street-10th Floor
New York, New York 1007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Contract WTC-223.00, KKE (Carteret)
Tolerances and Repair Procedures
Letter of November 7, 1969, KKE to TRCC

Gentlemen:

We have reviewed the KKE letter of November 7, 1969, regarding tolerances and repair procedures on C32T6 trusses. Our comments follow.

Attached please find SHCR sheet no. 1 showing the required tolerances for the members in question. We approve of Tolerance Schedule 5 on KKE Dwg. T6B (attached to KKE's November 7, 1969 letter) as the maximum allowable tolerances required to fit-up and weld details 13C and 15C as shown on Laclede shop drawings CD209 and CD 205.

Repair details 13C and 15C on KKE Dwgs. T6D and T6C, respectively, are approved, as noted (see attachments). This repair work is to be done at no cost to PNYA in all cases where the tolerances shown on SHCR sheet no. 1 are exceeded.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

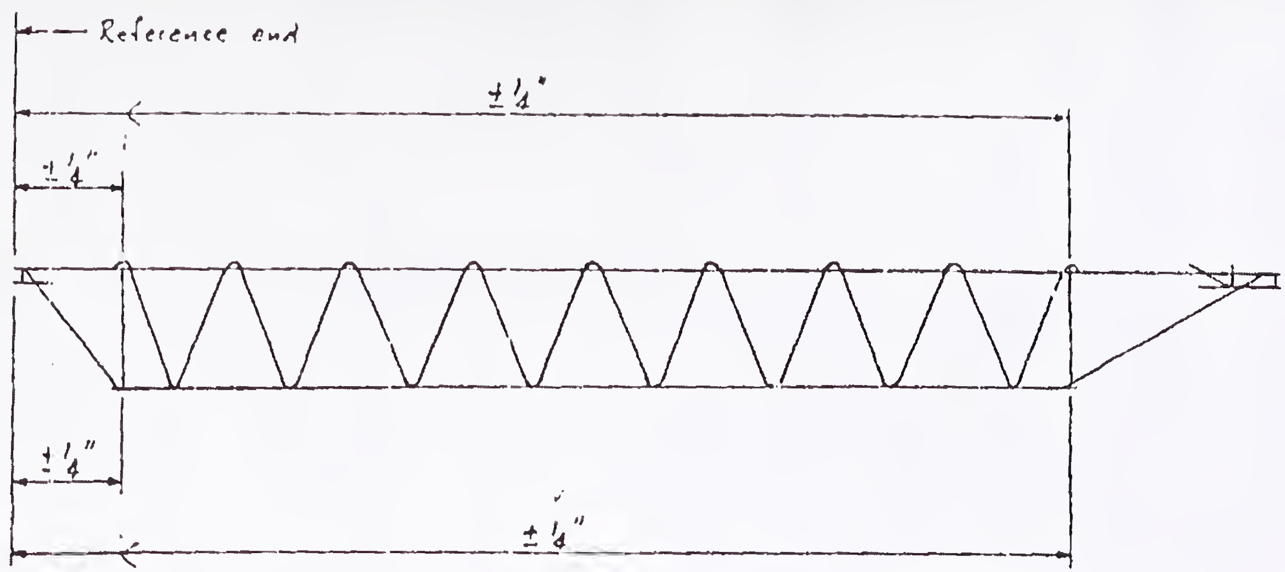
James T. McGuinness

JTM:df

cc: Messrs. U. C. Morland, PNYA (w/attachments)
R. Ray, Laclede
R. Piasecki, KKE
A. Guttentag, TRCC
EJS, LER, JRF

SEATTLE OFFICE · 1810 WASHINGTON BUILDING · SEATTLE, WASHINGTON 98101

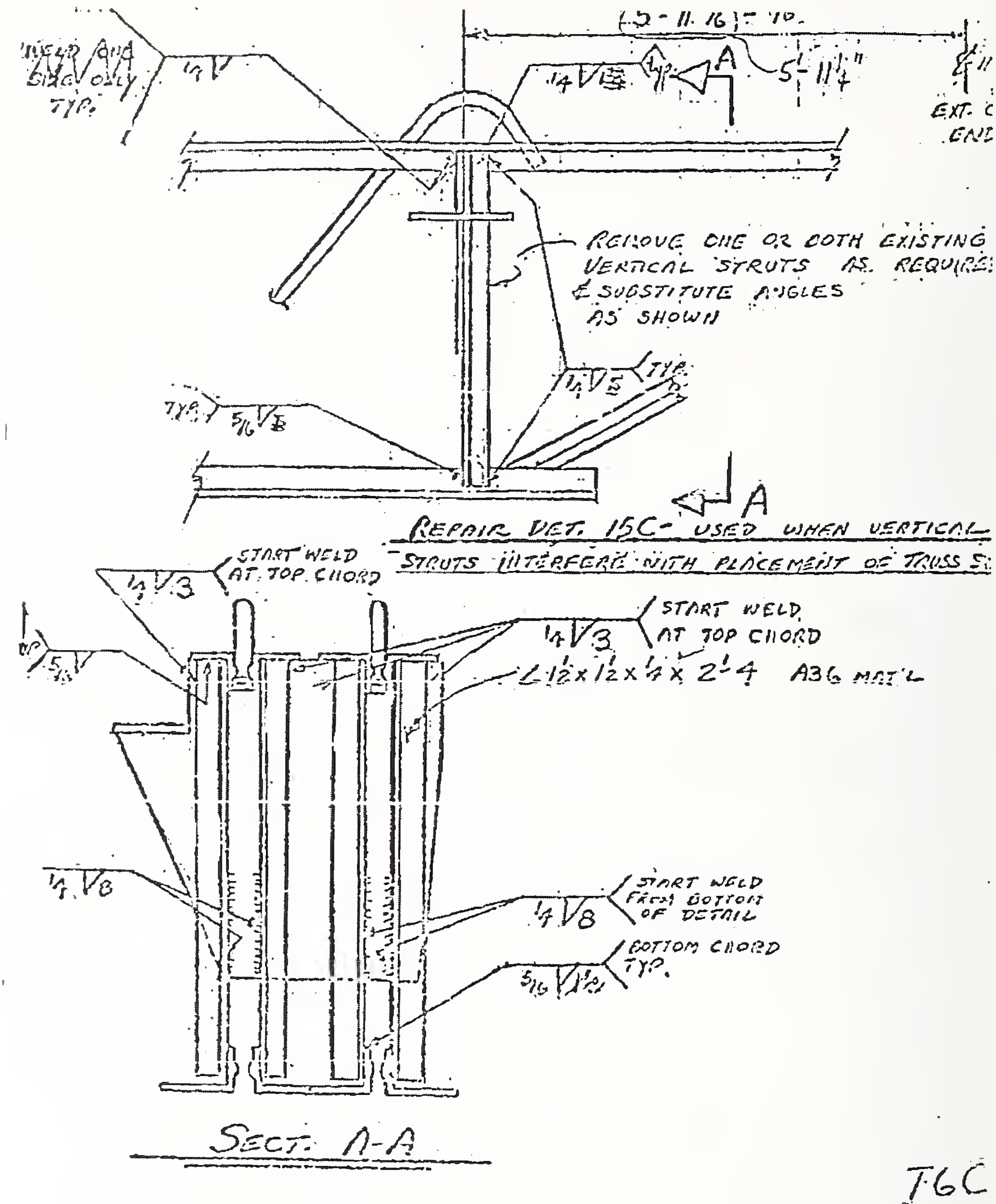
SKILLING HELLE CHRISTIANSEN ROBERTSON Structural & Civil Engineers	PROJECT World Trade Center	DATE 11-17-69	Sheet No.
	Tolerances	PREPARED BY JTM	1
		APPROVED	

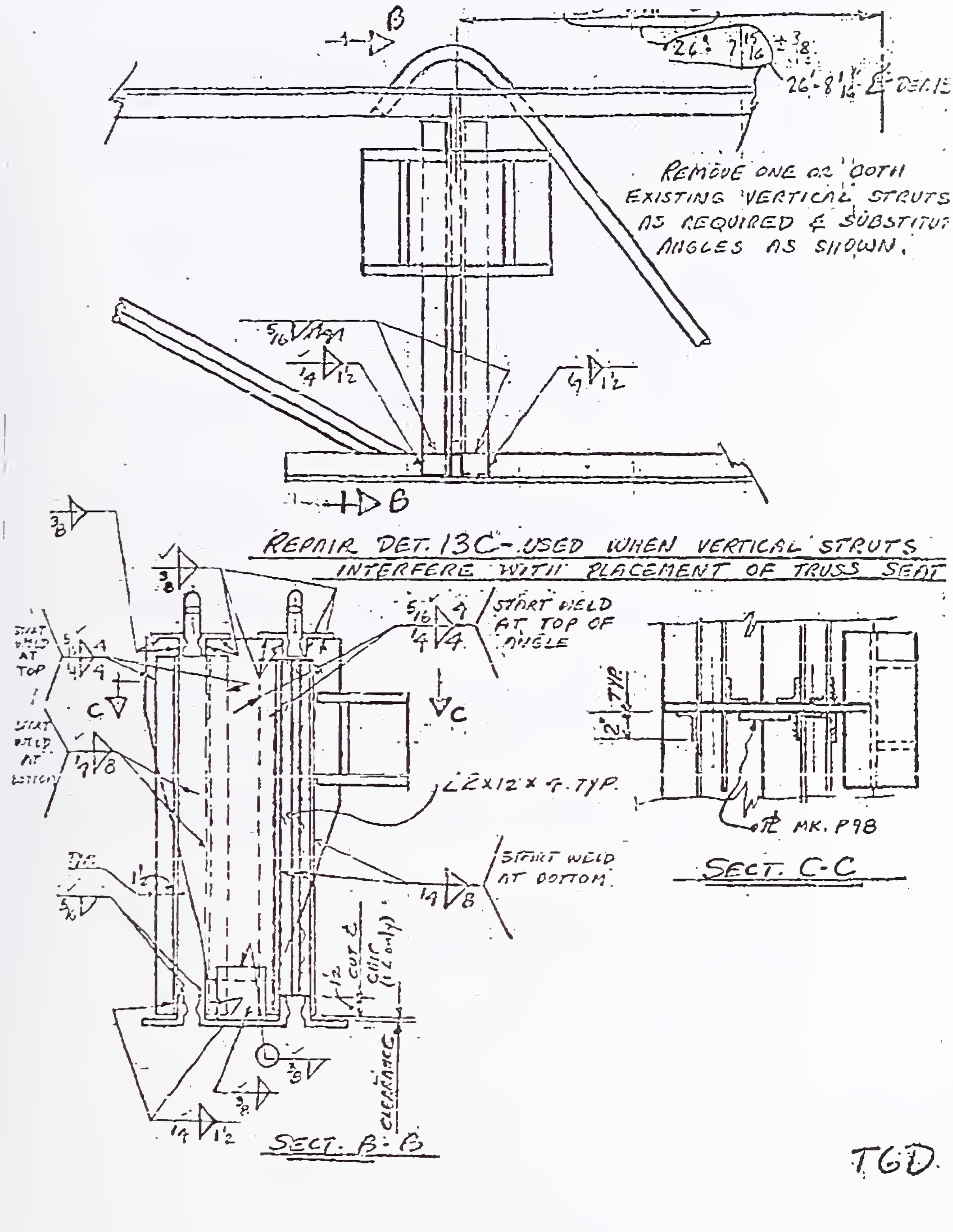


Tolerance for Longitudinal Deviation of Panel Point Along Chord

Notes:

1. Reference for tolerances: Contract WTC-221.00, para. 305.
2. Reference end shall be either end of truss but not both ends.
3. This sketch illustrates the required tolerances for the placement of the vertical web members of Truss C32T6.


REMOVE ONE OR BOTH EXISTING VERTICAL STRUTS AS REQUIRED & SUBSTITUTE ANGLES AS SHOWN
REPAIR DET. 15C - USED WHEN VERTICAL STRUTS INTERFERE WITH PLACEMENT OF TRUSS
START WELD AT TOP CHORD
START WELD AT TOP CHORD
START WELD FROM BOTTOM OF DETAIL
BOTTOM CHORD TYP.
A36 MAT'L
SECT. A-A
T6C


REMOVE ONE OR BOTH EXISTING VERTICAL STRUTS AS REQUIRED & SUBSTITUTE ANGLES AS SHOWN.
REPAIR DET. 13C - USED WHEN VERTICAL STRUTS INTERFERE WITH PLACEMENT OF TRUSS SEAT
START WELD AT TOP OF ANGLE
L2x12x ¼. TYP.
START WELD AT BOTTOM.
MK. P98
SECT. C-C
SECT. B-B
CLEARANCE
TGD.

KARL KOCH ERECTING CO., INC.
... AVE. CARTERET, N. J. 07008 · 201/969-1700 · CABLE ERECTING

WORLD TRADE CENTER PROJECT
130 LIBERTY ST. · NEW YORK, N.Y. 10006
TEL. 212/833-0810

November 7, 1969

Tishman Realty and Construction Co., Inc.
30 Church Street
New York, New York

Attention: Mr. Al Guttentag
Project Manager

Re: Letters from R. Piasecki to A. Guttentag dated April 11, 1969 and July 8, 1969

Dear Sirs:

As stated in the above referenced letters the assembly of truss seat details 13C and 15C on "G" type panels is still unresolved and a cause of irritation for all parties concerned. Laclede is continuing to fabricate C32T6 trusses at tolerances that disallow placement of the above truss seats in a plumb position and accurate location. As a result many "G" panels on floors 10 through 51, Tower A, have skewed, canted and mislocated truss seats despite our efforts. These discrepancies cause numerous field problems as well as criticism from inspection personnel.

Kindly refer to the enclosed sketches; drawing T6A shows the tolerances we use in the placement of truss seats. Drawing T6B shows three tolerance schedules that may be used in locating vertical struts on the C32T6 truss. Tolerance schedule A now used by Laclede obviously allows large deviations in the plumbness and location of the two vertical struts. We find that in many cases truss seats 13C and 15C simply cannot be placed at the proper longitudinal spacing due to physical interference with the struts. Where they do not interfere, the struts are usually out of plumb necessitating extra weld and material to take up the gap between the truss seat and the strut.

Tolerance schedule B is the required tolerance to set truss seats exactly as shown on Laclede drawings CD205 and CD209 without incurring any extra work. In addition the truss seats would automatically be in their proper locations when fit up flush against the vertical struts.

Tolerance schedule C could be used by Laclede to insure that no

KARL KOCH ERECTING CO., INC.
400 ROOSEVELT AVE. · CARTERET, N.J. 07008 · 201/969-1700 · Civil ERECTING

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TEL. 212/337-6010

- 2 -

strut interferes with the placement of truss seats; However the consistent use of a previously approved repair detail, referenced on the drawing, would be necessary. Of the three tolerance schedules this seems most realistic for achieving accurate placement of truss seats. We suggest that trusses be fabricated to these tolerances and the approved repair detail be made a scheduled detail, included in shop drawings, whenever gaps between the strut and the truss seat exceed 3/16 inch. All extra costs must be for the account of "others"

Presently we have 64 - C32T6 trusses in yard storage all of which exceed tolerance schedule C. The assembly of "G" panels has been halted starting with the 52nd floor. Of the 64 trusses Laclede has agreed that 38 trusses require removal of the vertical strut on the exterior column end and 32 require removal of the strut on the core end according to their own criteria. We are therefore submitting, for approval, repair details 15C and 13C on drawings T6C and T6D for those cases. Laclede has agreed to pay for the repair of only those trusses exceeding their own tolerances.

In order to resume assembly of "G" panels we urge a clarification of all tolerances and their consequences for WTC 221.00 and 223.00 as well as an approval for the enclosed repair details.

Yours truly,

KARL KOCH ERECTING CO., INC.

Richard Piasecki
Project Engineer

cc: R. Monti, PNYA
L. Feld, PNYA
D. Neptune, Laclede
J. McGuinness, SHCR

encl.

RP:hz

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-5574

John B. Skilling • Helge J. Helle • John V. Christiansen • Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

October 16, 1969
File: WTC-221C

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Fabrication Tolerance

Gentlemen:

Please refer to Laclede's letter to SHCR dated September 18, 1969. A xerox copy of the Laclede letter is attached hereto for your convenience.

We approve a tolerance for height above top chord of end stiffeners V3 and V4 of 3" (+ 1/8",-3/8").

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

James White

cc: Mr. L. Feld, PNYA
Mr. W. Borland, PNYA
Mr. R. Bay, Laclede
Mr. B. B. Jackson, PTL-St. Louis
LER WAB JTM LGJ

attachment

JW:1

CHARLES A. SANDUSKY
WILLIAM D. WARD
RICHARD E. TAYLOR

SEATTLE OFFICE, [illegible] WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

Laclede Steel Company

[illegible]

[illegible] September [illegible] 1969

Mr. Wayne Brewer
Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10017

Dear Mr. Brewer:

This letter is written to request a change in the tolerance for the heighth above the top chord of the end stiffeners (V3 and V4) that are fabricated in the ends of the trusses supplied to the World Trade Center Project.

This dimension is not critical and our fabrication process would be greatly augmented if it were changed from 3" ±1/8" to 3" +1/8" -3/8".

Yours very truly,

LACLEDE STEEL COMPANY

Robert D. Bay
Director of
Technical Services
Project Coordinator

lp

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8574

John B. Skilling • Helge J. Helle • John V. Christiansen • Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

October 20, 1969
File: WTC-221.00

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Fabrication tolerances

Gentlemen:

Please refer to the Laclede Steel Company to SHCR dated October 6, 1969. A copy of the subject letter is attached to this letter for your reference.

We approve the tolerance of ±3/8" for the 2-7/8" or 1-3/4" dimension at the top chord intersection of the inclined strut (mark 2 in the shop drawings) as requested in the Laclede letter. Please note that this tolerence applies to inclined end struts on 24T trusses only. This relaxation of tolerance cannot be allowed to extend to other cases. One example is the vertical strut member ST (members 2 and 5) for truss C32T6 on Laclede sheet number ST206. It is essential that these members be installed as accurately as possible in all cases.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Messrs. L. Feld, PNYA
W. Borland, PNYA
R. Bay, Laclede
B. Jackson, PTL @ St. Louis

JW:1

ROBERT E. LEVIEN
PAUL W. A. FOSTER
FRANK MOELTJENDORF
KENT R. ROGERS
CHARLES A. SANDUSKY
WILLIAM O. WARD
J. WHITE, JR.
LORENTZ L. WIDING

RICHARD CHAUNCEY
ERNEST T. LIU
JOSTEIN NES
V. A. FRIBAOCKY
HAROLD D. ROSS
RICHARD E. TAYLOR

SEATTLE OFFICE: 1040 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

Laclede Steel Company

General Offices Laclede Building

St. Louis, Missouri 63101 October 6, 1969

Mr. Wayne Brewer
Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10017

Dear Wayne,

This letter is written to request a tolerance of ± 3/8" for the dimension of 2-7/8" or 1-3/4" that locates the upper end of the Inclined Strut (Mark 2) which is fabricated in one or both ends of the following 24" trusses.

24T9	24T11
24T9A	24T11A
24T10	24T11B
24T10A	24T11C
24T10B	24T12
24T10C	24T13
24T10D	24T13A
24T10E	24T13C
24T10F	24T13D
24T10H	BT216A
24T10J	BT216B
24T10K	BT216C
24T10L	

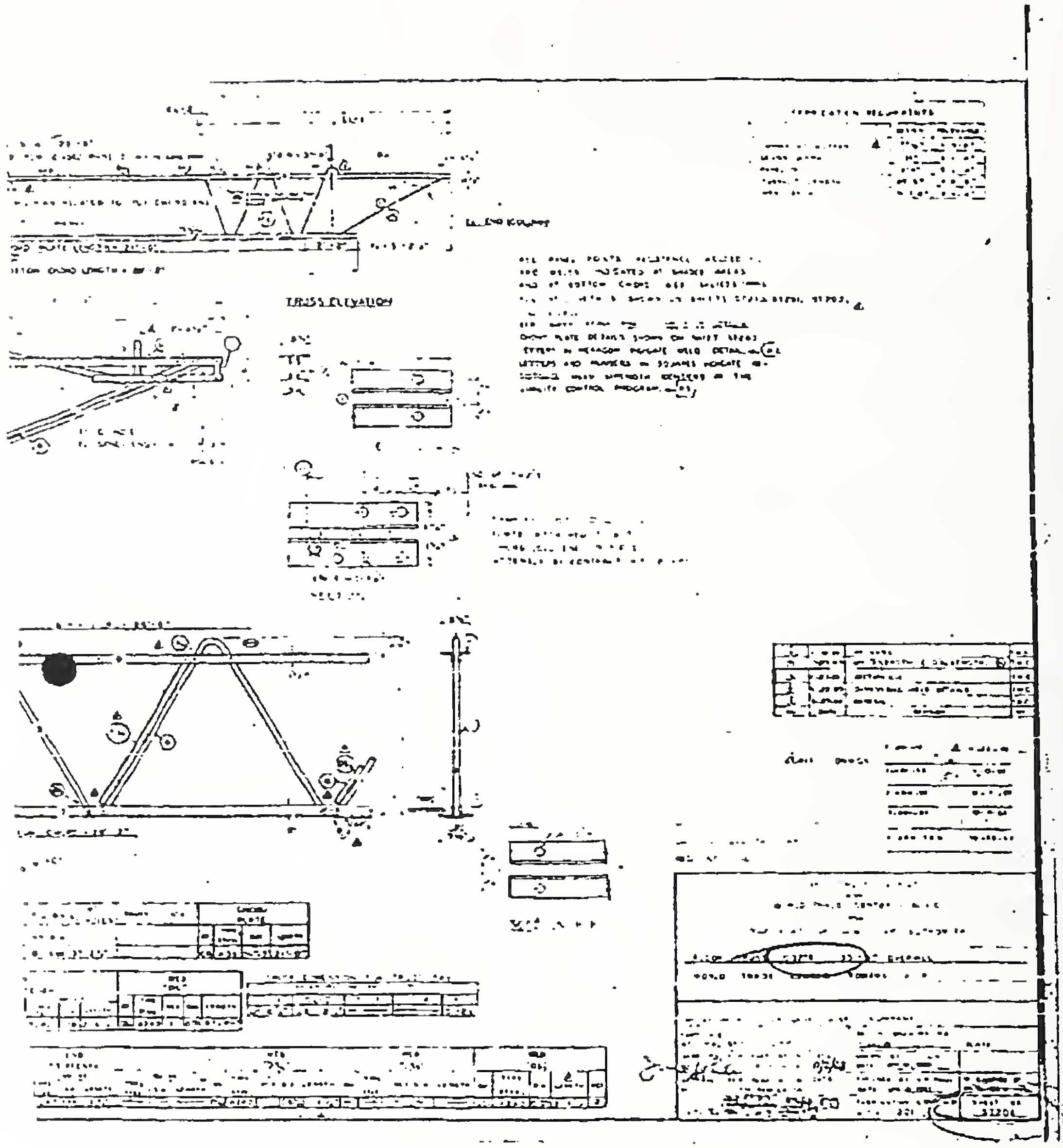
Because of the large number of these trusses that we plan to fabricate in the very near future, a prompt reply would be greatly appreciated.

Yours very truly,

LACLEDE STEEL COMPANY

Robert D. Bay
Director of Technical Services
Project Coordinator

kjj


TRUSS ELEVATION

THE PORT OF NEW YORK AUTHORITY
111 Eighth Avenue at 15th Street New York N.Y. 10011

World Trade Department
Guy F. Tozzoli Director
Richard C. Sullivan Director

June 16, 1969

Laclede Steel Company
Arcade Building
St. Louis, Missouri 63101

Attention: Mr. A. Carl Weber

Re: The World Trade Center - Contract WTC-221.00 - Field Welded Connections for Bridging Trusses and Bridging Angles at Panel Joints

Gentlemen:

A. After observing actual on-site difficulties encountered in Tower "A" (due to misalignment and accumulation of fabrication tolerances) in field welding the referenced connections, we directed the Erector to proceed as follows in order to expedite the work:

1. Use single butt plate, field welded option, shown on Drawings 7C/1, 8C/1, 9C/1, 10C/1 and 11C/1 which occur a total of 96 times on a typical floor. Butt plate thickness was determined by KKE from field measurement of actual gaps at the ends of bridging trusses in "as erected" position.

2. At connection 2C (which occurs 120 times on a typical floor) and connection 19C (which occurs 4 times on a typical floor) all field welding was eliminated by adding 4 extra #5 bars parallel to each row of bridging angles. Extra steel for a typical quadrant is shown on Drawing FP-1 (Revised 6-9-69).

3. At connections 7C thru 11C two extra #5 bars are added at all bridging truss panel joints to compensate for horizontal weld across top of top chord angles which was eliminated because of tight welding clearances.

4. Allowing 10% for laps, 7.8 tons of extra reinforcing is presently being added for floors 10-20$\pm$ per floor.

Laclede Steel Company - 2 - June 16, 1969

5. Connections 13C thru 17C remain as originally designed with no change in field welding details occurring a total of 20 times on a typical floor.

B. To mitigate costs, Laclede is directed to proceed as follows on all future deliveries:

1. At connection 2C - delete connection plate, mark P-1, as shown on Laclede Drawing CD-201.

2. At connection 7C - delete connection plates, mark P-2 and P-3, and delete connection bar, mark CB-1, all shown on Laclede Drawing CD-201.

3. At connection 8C - delete connection plate, mark P-4, delete connection bars, mark CB-1, and delete two connection bars, mark CB-4, all shown on Laclede Drawing CD-202.

4. At connection 9C - delete connection plates, mark P-2 and P-7, and delete connection bar, mark CB-1, all shown on Laclede Drawing CD-203.

5. At connection 10C - delete two connection bars, mark CB-2, shown on Laclede Drawing CD-202.

6. At connection 11C - delete connection plate, mark P-2 and delete connection bar, mark CB-1, all shown on Laclede Drawing CD-204.

7. At connections 13C thru 17C - No change

8. At connection 19C - delete connection plate, mark P-6, shown on Laclede Drawing CD-204.

9. Hold clear distance of 1" minimum, from center of panel joint to edge of web struts at both chords so as to permit the use of either field welded option in item A or field bolted option proposed in item C below.

C. Laclede is to submit separate unit price quotations on each of the following bolted alternates on a per floor basis:

1. Connection 2C - furnish, fabricate and ship 3/4" thick plates (Fy=50) and shim stock (Fy=36) shown on Drawing 2-C/2 - revised 6-13-69. Note X - all 3/4" plates to be shop welded to bridging angles by Laclede. This connection occurs 120 times per typical floor.

2. Connection 7C - furnish, fabricate and ship 3/4" thick plates (Fy=50) and shim stock (Fy=36) shown on Drawing 7-C/2 - revised 6-13-69. Note Y - all 3/4" plates to be shop welded to bridging truss chord angles by Laclede. This connection occurs 52 times per typical floor.

3. Connection 8C - furnish, fabricate and ship 3/4" thick plates (Fy=50) and shim stock (Fy=36) shown on Drawing 8-C/2 - revised 6-13-69. See Note Y above. This connection occurs 12 times per typical floor.

4. Connection 9C - furnish, fabricate and ship 3/4" thick plates (Fy=50) and shim stock (Fy=36) shown on Drawing 9-C/2 - revised 6-13-69. See Note Y above. This connection occurs 8 times per typical floor.

5. Connection 10C - furnish, fabricate and ship 3/4" thick plates (Fy=50) and shim stock (Fy=36) shown on Drawing 10-C/2 - revised 6-13-69. See Note Y above. This connection occurs 12 times per typical floor.

6. Connection 11C - furnish, fabricate and ship 3/4" thick plates (Fy=50) and shim stock (Fy=36) shown on Drawing 11-C/2 - revised 6-13-69. See Note Y above. This connection occurs 12 times per typical floor.

7. Connections 13C thru 17C - No change

8. Connection 19C - Furnish, fabricate and ship 3/4" thick plates (Fy=50) and shim stock (Fy=36) shown on Drawing 2-C/2 - revised 6-13-69. See Note Y above. This connection occurs 4 times per typical floor.

9. Tolerances for quotations C1 thru C6 and C8, out to out dimension over 3/4" butt plates (example: 19'-11-3/4" for 20'-0" panel) is to be held to a tolerance of (+ 1/8") or (- 1/4") including ASTM A6 allowance for overrun on plate thickness. Vertically, the tolerance on keep dimension of 1'-8-3/4" (connection 7C) or 1' 8-1/4" (connections 8C and 9C) is ± 1/16'.

10. All shim stock to be shipped in kegs by thickness. Furnish 2/3 of all shim sets consisting of 2-1/8" plates. Furnish remaining 1/3 of shim sets to consist of one-3/16" plate.

Laclede Steel Company - 4 - June 16, 1969

11. Bolts, nuts and washers will be furnished by others. Laclede does not furnish bolt lists.

12. Furnish alternate quote for 3/4" thick plates in Fy=36 in lieu of Fy=50 in items C1 thru C6 and C8. Your comments on availability and effect on delivery dates for Fy=36 vs. Fy=50 material are solicited.

13. In view of the fabrication greater effort required for these minimal weight butt plates we feel the formulas in the Contract Booklet on "Extra Materials" are not equitable for these items. We have therefore requested your separate quotations for those items.

14. Should the Authority accept your quotation on items C1 and C8 and/or items C2 thru C7 please advise us the lead time required from notification to convert fabrication line to these bolted alternate details.

D. With respect to deleted material in item B, please advise us as to effective floor number for deletion, tonnage deleted and credit due to the Authority as per Contract formula.

E. Time is of the essence and your prompt reply is solicited to enable us to balance extra reinforcing bar costs against bolted and welded options.

Sincerely,

Malcolm P. Levy

Attachment: As per Transmittal List 355X

cc: Messrs. R. Abrahams, W. Brewer (SHCR), M. Gerstman (TRCC), w/att.

The World Trade Center
Structural Drawings
Transmittal List 355X
June 16, 1969

Field Welded Option at Panel Joints		**Rev. Date**
FS-1 -	Floors 10 - 20 ±	6-9-69
* 2-C/1	Connection 2C	5-29-69
7-C/1	Connection 7C	5-13-69
8-C/1	Connection 8C	5-14-69
9-C/1	Connection 9C	5-20-69
• 10-C/1	Connection 10C	5-14-69
11-C/1	Connection 11C	5-14-69

Field Bolted Alternate at Panel Joints		
* 2-C/2	Connection 2C	6-13-69
7-C/2	Connection 7C	6-13-69
8-C/2	Connection 8C	6-13-69
9-C/2	Connection 9C	6-13-69
• 10-C/2	Connection 10C	6-13-69
11-C/2	Connection 11C	6-13-69

Note: * Connection 19C similar to Connection 2C
• At top chord only - bottom chord and web plate remain same as basic detail

June 20, 1969
File: WTC-221C

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Plate F91, Truss Connector 13-C, Laclede Drawing ST274

Gentlemen:

We approve the use of 32 plates P91 as fabricated by J. S. Alberici and described in the Laclede letter dated June 5, 1969 and shown in the attached Laclede sketch JS-13-91.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

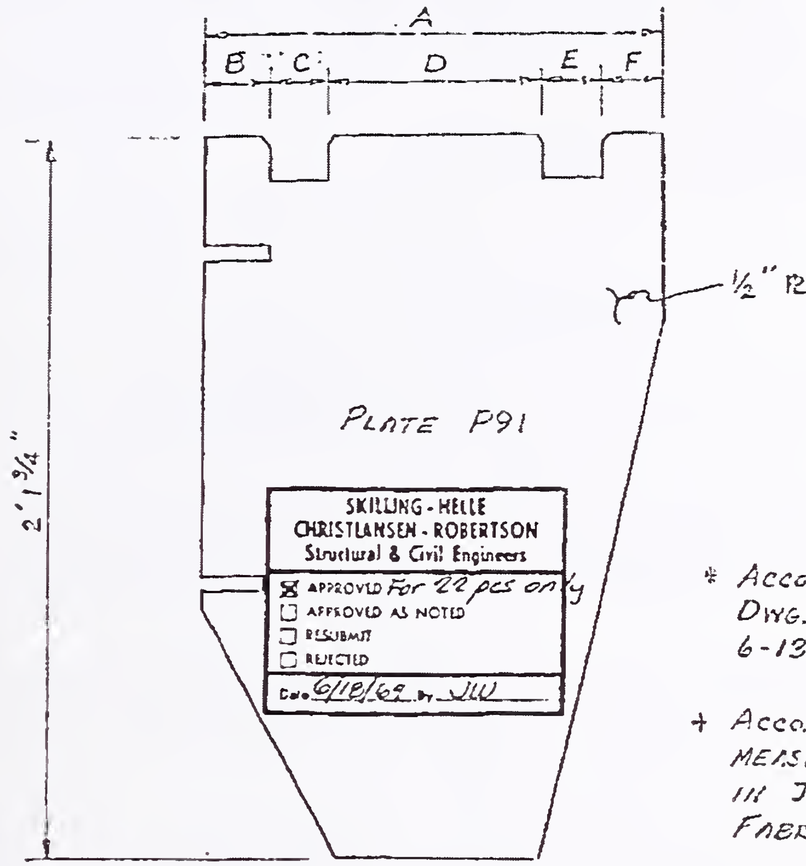
cc: Messrs. L. S. Feld, PETA
R. Day, Laclede
A. Guttentag, TRCC
B. D. Jackson, PTL, St. Louis

JW/el

DE STEEL COMPANY

DWG. NO. JS-13-91

ACTUAL LENGTH VS. SPECIFIED LENGTH OF TOP DIMENSIONS OF PLATE P91 OF TRUSS CONNECTOR 13-C



* ACCORDING TO LACLEDE DWG. ST274 DATED 6-13-68.

\+ ACCORDING TO ACTUAL MEASUREMENT OF PCS IN J.S. ALBERICI'S FABRICATING SHOP

DIMENSION	SPECIFIED LENGTH *	ACTUAL LENGTH +	DEVIATION
A	13"	12 3/4"	- 1/4"
B	1 15/16"	1 15/16"	0
C	2"	2"	0
D	5 1/8"	5 1/8"	0
E	2"	2"	0
F	1 15/16"	1 11/16"	- 1/4"

Laclede Steel Company

General Offices · Laclede Building
St. Louis, Missouri 63101

June 5, 1969

Mr. Wayne Brewer
Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10017

Dear Mr. Brewer:

Re: World Trade Center
Contract WTC 221.00
Material Supplied J. S. Alberici Co.

Presently the J. S. Alberici Construction Company which fabricates the truss connectors we supply for the World Trade Center has 22 pieces of our material which is 1/4" under the required width. These pieces are 12-3/4" x .500" x 2'1-3/4"; they should be 13" x .500" x 2'1-3/4". Alberici has already cut this material and notched it as shown in the accompanying drawing (JS-13-91). These pieces which are to be used for truss connector mark 13-C have dimensions which correspond to those shown on Laclede Drawing ST-274 dated 6-13-68 with the exception of dimensions "A" and "F" which are 1/4" shorter than the corresponding dimensions shown in ST-274.

The only problem involved with using this short material would be that the length of weld between truss connector 13-C and the horizontal bridging angle at their connection point (see attached SCHR drawing 7-AB4-13) would be reduced by 1/4" top and bottom. As far as fitting the truss connector there will be no problem since all critical dimensions have been held.

The writer requests your approval of Alberici using the above mentioned 22 pieces in truss connector 13-C. If you do not approve of using these pieces we will have to supply new material to Alberici which they will have to cut and notch. This will require a considerable amount of extra work on their part.

Yours very truly,

LACLEDE STEEL COMPANY

David B. Neptune

David B. Neptune
Product Development Engineer
Construction Products

CC: Mr. Lester Feld, Planning Engineer
The Port of New York Authority
111 Eighth Avenue
New York, New York 10011

Mr. Al Guttentag, Project Engineer
Tishman Realty & Construction Co., Inc.
30 Church Street - 11th Floor
New York, New York 10007

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · MU 9-8874

John B Skilling · Helge J Helle · John V Christiansen · Leslie E Robertson

Manager
Wayne A Brown

Consultants
Harold L Worthington
Joseph F Jackson

December 15, 1969
File: WTC-221C

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Out-of-Tolerance Fillers

Gentlemen:

Attached to this letter please find a xerox copy of the Laclede letter to SHCR dated December 8, 1969. We approve on a one time basis only the deviations in filler positions described by Laclede for 160-C32T11 trusses. Mr. Bay was advised by the writer by telephone on Thursday afternoon, December 11, 1969 of the above approval.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Messrs. L. Feld, PNYA
W. Borland, PNYA
R. Bay, Laclede
S. Jackson, PTL
LER, WAB, ~~JFM~~

JW/is

Laclede Steel Company

General Offices Arcade Building

St. Louis, Missouri 63101

December 8, 1969

Wayne Brewer
Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10017

Dear Wayne,

160-C3CT11 trusses were fabricated this week as shown on the attached print. Note that the three fillers on the core end were located approximately 1" more to the center of the truss than is shown on our drawings. Three trusses have the third filler 2" more than shown on the drawing. All these trusses were inspected and accepted by PTL with the provision that we obtain approval from you for the location of the fillers.

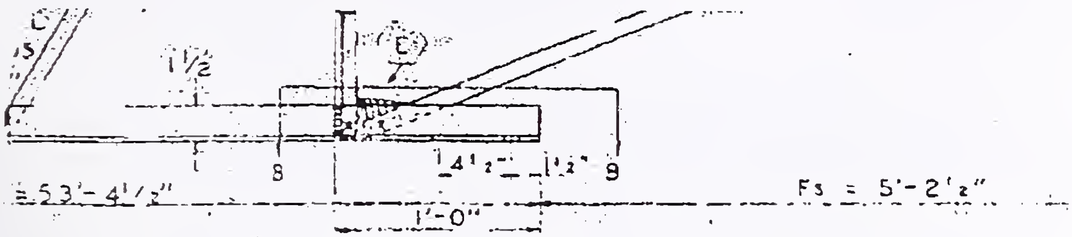
We therefore, request that these trusses be accepted as fabricated. Please answer by letter or telephone by Tuesday, December 9, 1969, so that we may continue with our present production schedule.

Yours very truly,

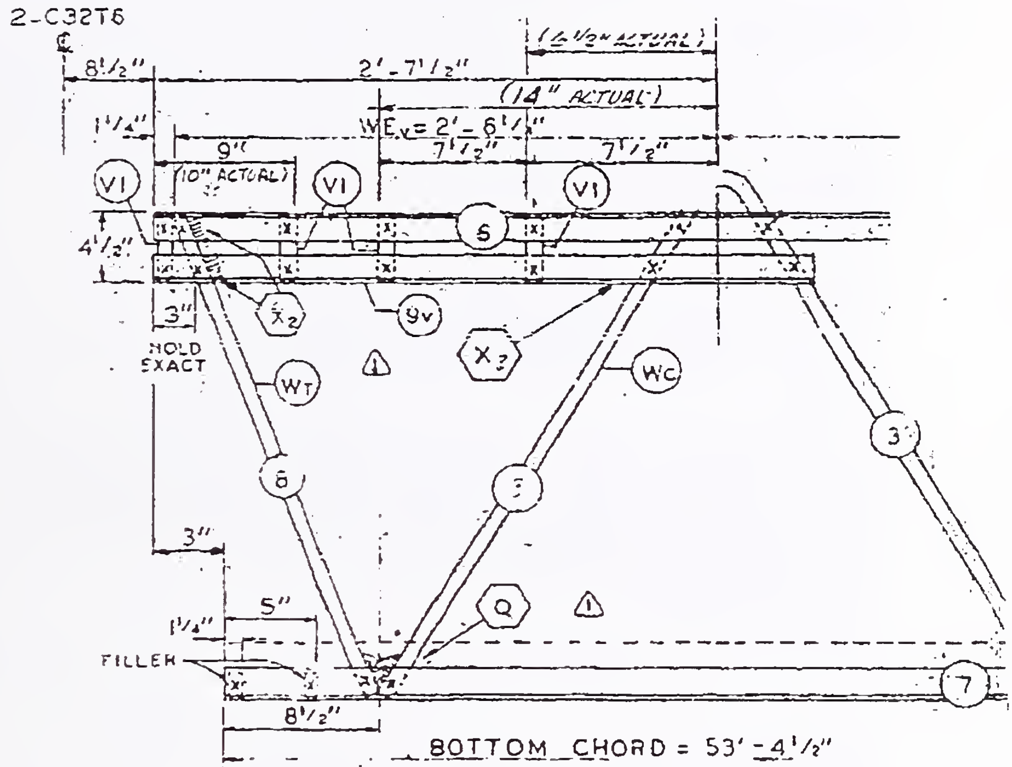
LACLEDE STEEL COMPANY

Robert D. Bay
Director Technical Services
Project Coordinator

kjj



Es END (COLUMN)



EL END (CORE)

BOTTOM CHORD TWO ANGLES				MAIN WEB W					FILLER	
MK	TYPE STEEL	CHORD SIZE	LENGTH	MK	TYPE STEEL	DIA	LENGTH	NO. OF K SEE NOTE #1	NO	DIA
7	A242	2"x 1½"x.25	53-4½"	3	A242	92	[illegible]	15 @ 3'-4' = [illegible]	12	.92

SKILLING HELLE CHRISTIANSEN ROBERTSON

July 7, 1969
File: WTC-221C

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Repair Procedure for Vertical Struts

Gentlemen

Please refer to the Laclede letter to SHCR dated June 5, 1969 transmitting the Laclede document titled "Repair Procedure for Vertical Struts on 32" Trusses" dated June 5, 1969. We approve the above repair procedure and the attached Laclede drawing W-VS-1 dated June 3, 1969. We attach hereto one xerox copy each of the Laclede procedure and drawing stamped "approved" by SHCR and initialed by the writer.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc Messrs. S. Feld, PNYA
W. Day, Laclede
B. B. Jackson, PTL

JW/sl

Laclede Steel Company

[illegible]

St. Louis, Missouri [illegible] June 5, 1969

Mr. James White
Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10017

Dear Mr. White:

Please find attached "Repair Procedure for Vertical Struts on 32" Trusses" and drawing W-VS-1 dated 3 June 1969. With the submission of this procedure, formal request is made for approval to repair as necessary the vertical struts on trusses furnished under WTC-221.00.

If there are any questions, please contact me at once as we are anxious to obtain formal approval for this work.

Yours very truly,

LACLEDE STEEL COMPANY

Robert D. Bay
Director of
Technical Services

lp

CC: Mr. Lester Feld, PONYA
Mr. R. M. Monti, PONYA
Mr. Al Guttentag

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N.Y. [illegible] · [illegible]

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold J. Worthington
Joseph F. Jackson

July 3, 1969
File: WTC 221C

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract 221.00, Laclede
Repair Procedure, Truss Bearing Ends

Gentlemen:

Please refer to the Laclede letter to SHCR dated June 3, 1969, transmitting the Laclede document titled "Repair Procedure, Truss Bearing Ends" dated June 3, 1969. We approve the above repair procedure and the attached Laclede drawing W-BE-1 dated June 2, 1969. We attach hereto one xerox copy each of the above procedure and drawing stamped "approved" by SHCR and initialed by the writer.

This approval does not apply to double diagonals, which must be welded all around as shown in the attached SHCR sketch dated July 2, 1969.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

James White

cc: Messrs. L. S. Feld, PNYA
R. Bay, Laclede
B. B. Jackson, PTL

JW/sl

Seattle Office · [illegible] Washington Building · Seattle, Washington [illegible]

June 3, 1969

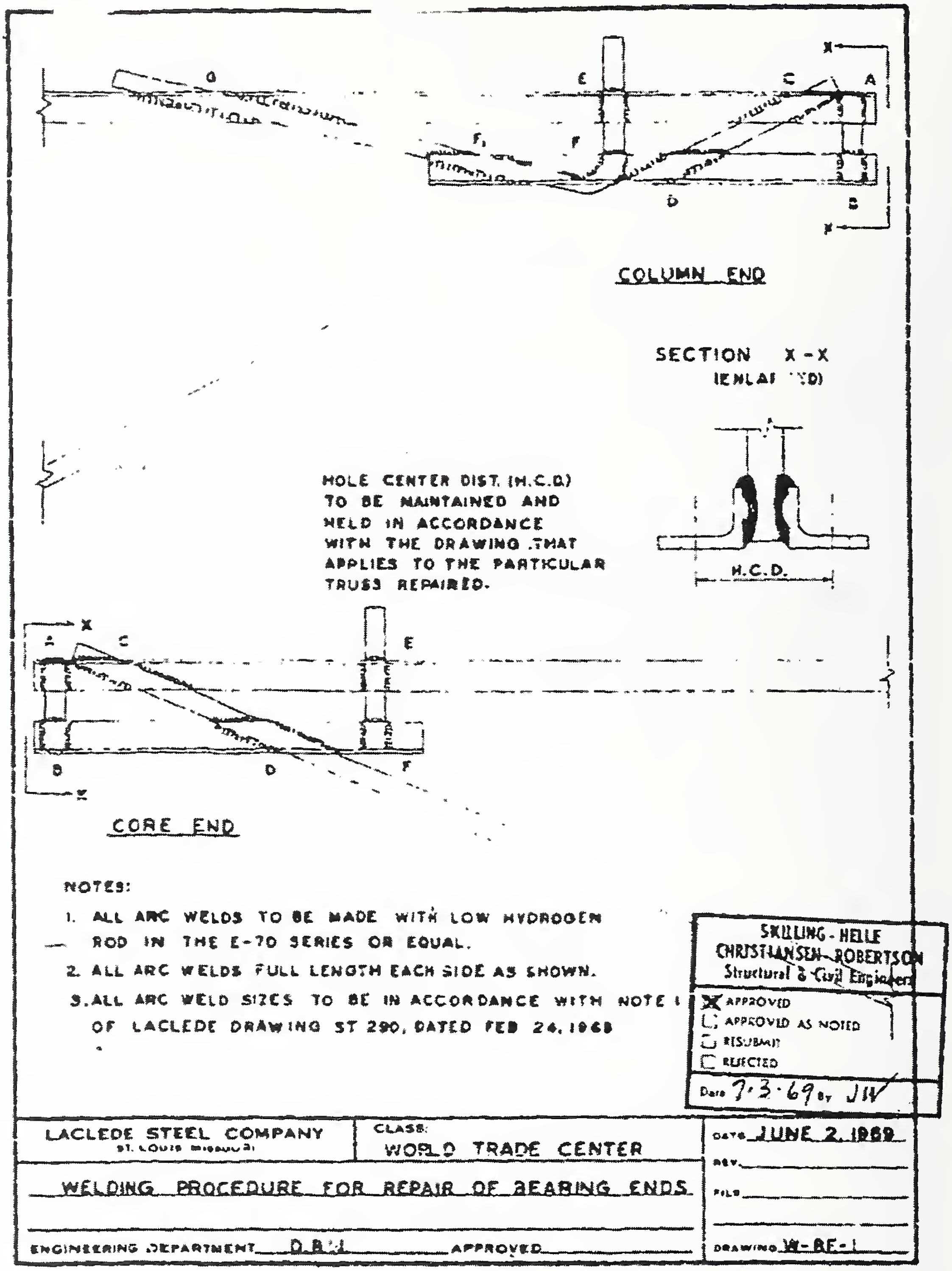
REPAIR PROCEDURE
<u>TRUSS BEARING ENDS</u>

The following procedure is written to cover the repair of bearing ends on trusses provided for the World Trade Center Project under Contract WTC-221.00. Such repairs that may be necessary from time to time will normally be made at the Madison Plant of Laclede Steel Company and may involve one or more of the lettered welds on drawing W-BE-1 dated June 2, 1969 which is attached and a part of this procedure. Primarily the repair welds will be made to adjust the bearing depth of the seats which have a tolerance of ± 1/8".

Under the supervision of the Certified Arc Welder Foreman, a Certified Arc Welder will perform the necessary repairs. The lettered joint to be repaired will be burned apart with a torch. All weld splatter from the previous resistance weld will be removed from the surface to be rewelded so that there is a clean surface of base metal. (If the weld is already separated, burning would not be required but removal of the weld splatter material must be accomplished.)

With reference to the drawing W-BE-1 of the particular lettered joint to be welded, the members will be accurately positioned and the welding of the joint will be completed in accordance with the existing procedures for arc welding which have been previously approved. The dimensions of the welds which are full-length shall be in accordance with the table on drawing ST290 dated February 26, 19[illegible].

The repaired trusses and welds will be inspected and tested following the quality control procedures which are stated in Section 105 Quality Control and Inspection, World Trade Center 221.00.


COLUMN END
SECTION X-X
(ENLARGED)
H.C.D.
HOLE CENTER DIST. (H.C.D.) TO BE MAINTAINED AND HELD IN ACCORDANCE WITH THE DRAWING THAT APPLIES TO THE PARTICULAR TRUSS REPAIRED.
CORE END
NOTES:
1. ALL ARC WELDS TO BE MADE WITH LOW HYDROGEN ROD IN THE E-70 SERIES OR EQUAL.
2. ALL ARC WELDS FULL LENGTH EACH SIDE AS SHOWN.
3. ALL ARC WELD SIZES TO BE IN ACCORDANCE WITH NOTE 1 OF LACLEDE DRAWING ST 290, DATED FEB 24, 1968
SKILLING - HELLE CHRISTIANSEN - ROBERTSON
Structural & Civil Engineers
APPROVED
APPROVED AS NOTED
RESUBMIT
REJECTED
Date 7-3-69 By JW
LACLEDE STEEL COMPANY
ST. LOUIS MISSOURI
CLASS: WORLD TRADE CENTER
DATE JUNE 2, 1969
REV.
FILE
WELDING PROCEDURE FOR REPAIR OF BEARING ENDS
ENGINEERING DEPARTMENT
APPROVED
DRAWING W-RF-1

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · [illegible]

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

[illegible]

Consultants

[illegible]

March 31, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street, Room 1030
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Rework of C32T1A Trusses

Gentlemen:

Please refer to the Laclede letter dated March 18, 1969, requesting approval for the repair of twenty-four C32T1A trusses. We approve repair of the subject trusses by double-strutting with an additional 0.75" ⌀ bar as shown in the Laclede repair drawing dated March 27, 1969, a copy of which was attached to the Laclede letter. One copy each of the Laclede letter and the attached sketch are included with this letter for your ready reference.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

JW:s
Enclosure

cc: Messrs. R. Bay, Laclede
L. Feld, PNYA
L. Thielmeier, PTL

Seattle Office · [illegible] Washington Building · Seattle, Washington [illegible]

THE PORT OF NEW YORK AUTHORITY

May 8, 1969

Laclede Steel Company
Arcade Building
St. Louis, Missouri 63101

Attention: Mr. Robert D. Bay

RE: The World Trade Center
Contract WTC-221.0[illegible] Laclede
Rework of C32TIA Trusses

Gentlemen:

We approve the repair of twenty four (24) C 32 TIA Trusses by double-strutting with an additional 0.75"Ø bar as shown on your sketch dated March 17, 1959 accompanying your request letter dated March 17, 1969.

Very truly yours,

H. C. Borland
Engineer of Materials
The World Trade Center

CC: Messrs: R.M. Monti
J. W[illegible] (S[illegible]R)

Laclede Steel Company

General Offices Laclede Building
St. Louis, Missouri 63101 March 18, 1969

Mr. Wayne Brewer
Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10011

Dear Wayne:

Request for Approval of
Reworked C32T1A Trusses

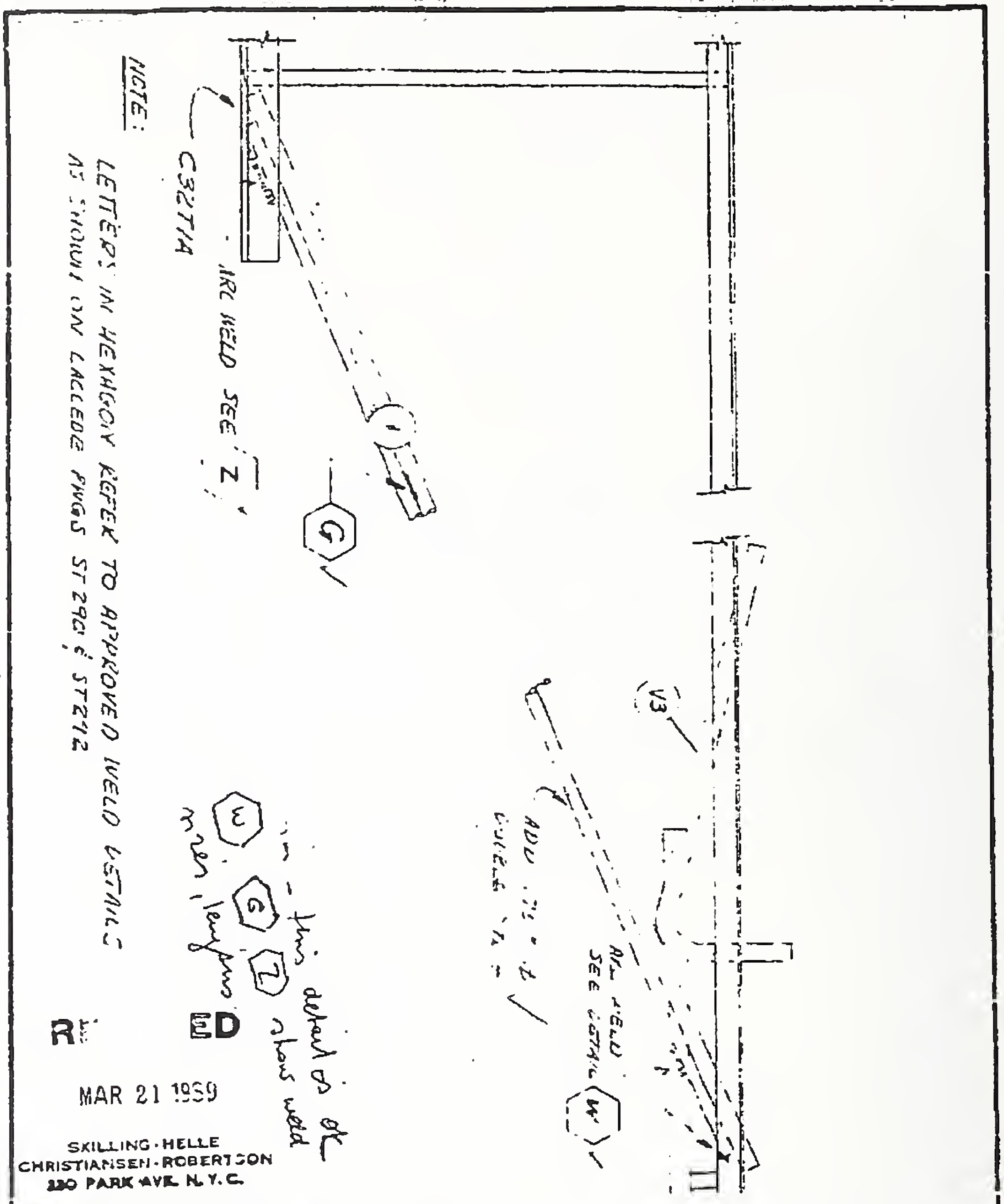
The 24 C32T1A Trusses have been fabricated at our Madison Plant with the V3 and diagonal strut on the column end with 1.09" web stock instead of 1.14" as shown on the approved drawing.

We request that the trusses be approved after repairing them by double strutting the diagonal strut with a .75 bar as shown on the attached drawing.

Yours very truly,

LACLEDE STEEL COMPANY

Robert D. Bay
Director of
Technical Service



LACLEDE STEEL COMPANY ST. LOUIS, MISSOURI	CLASS:	DATE March 17, 1969 REV. FILE DRAWING
Weld Detail for Repair of C32T1A's with 1.09" Diagonal Strut. ENGINEERING DEPARTMENT TMC APPROVED		

June 6, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair of Plate "d", Panel 2308

Gentlemen:

Please refer to the PDM letter to PNYA dated May 23, 1969. NDT report sheets 3 and 4 complete our records on the referenced repair. We, therefore, approve Panel 2308 as repaired.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Messrs. L. Feld, PNYA
H. Fish, PDM
D. Caffery, SIB-Houston

JW/lo

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N.Y. 10017 · MU 9-8874

John B. Skilling Helge J. Helle John V. Christiansen Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold E. Worthington
Joseph F. Jackson

May 16, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. G. H. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM:
Repair of Plate 'd', Panel 230B

Gentlemen:

Please refer to the PDM letter to PNYA dated May 1, 1969. We approve the repairs described contingent upon receipt from PDM of confirming [illegible] reports.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Mr. L. Feld, PNYA
Mr. R. Fish, PDM
Mr. [illegible]. Caffery, SIB (Houston)

JW:tc

SEATTLE OFFICE · 1800 WASHINGTON BUILDING · SEATTLE · WASHINGTON 98101

PDM

ENGINEERS · FABRICATORS · CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

May 1, 1969

The Port of New York Authority
30 Church Street
New York New York 10007

Attention: Mr. R M. Monti

Reference: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17133

Gentlemen:

We are sending you for your record and approval one (1) copy of our repair procedure sheets No. 1 and 2 showing the repairs of laminations we found in Plate "d" Panel 230B.

These repairs were made in accordance with the "Investigation and Repair of Lamination and Other Discontinuities" dated March 19 1969. They were witnessed by your inspector Mr. Dave Caffory of Southern Inspection

Please send us a letter of approval for our record

Very truly yours

PITTSBURGH DES MOINES STEEL COMPANY

H. M Fish
Project Manager

HMF:ksh
Enc

cc: Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10007

Attention: Mr. James White
Plus one copy

Tishman Realty and Constr Co
11th Floor 30 Church St.
New York New York 10007

Attention: Mr. M. Gerstman

75 TH ANNIVERSARY

PDM

ENGINEERS · FABRICATORS · CONSTRUCTORS

CABLE PITTDESMOIN
TELEX [illegible]

PITTSBURGH-DES MOINES STEEL COMPANY

[illegible]

May 23, 1969

The Port of New York Authority
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138
Repair of Plate "d", Panel-230B.

Gentlemen:

Reference to SHCR letter of May 16, 1969, to Mr. R. M. Monti approving our repair procedure to plate "d" Panel 230B contingent upon receipt of our NDT reports.

We are enclosing for your records one (1) copy of our NDT reports Sheets No. 3 and No. 4.

Unless we hear from you we will assume that this subject matter is finalized.

Very truly yours,

PITTSBURGH DES MOINES STEEL COMPANY

M. H. Fish
Project Manager

MHF:kch
Enc.

CC: Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10007
Attention: Mr. James White
Plus one copy

Tishman Realty & Constr.
11th Floor, 30 Church St.
New York, New York 1000[illegible]
Attn: Mr. M. Gerstman

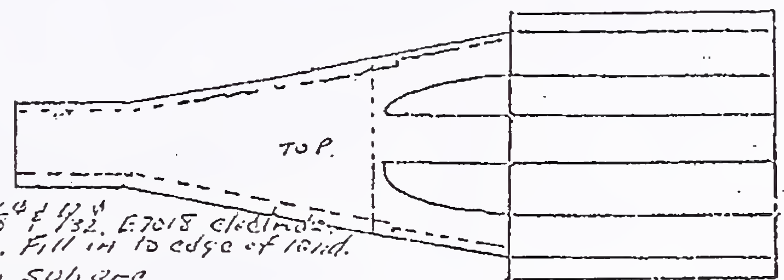
75TH ANNIVERSARY

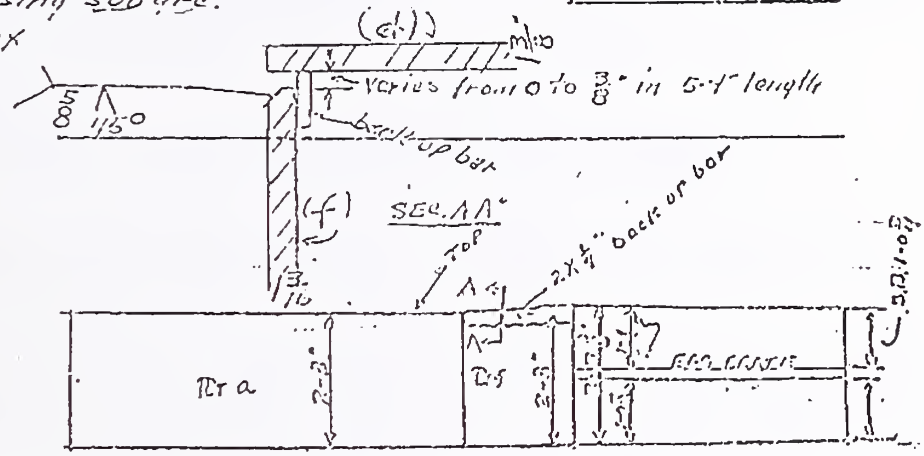
REV. 4/16/69

1753B
Col. 230B

4/11/69
OK TO WELD AS 1ST
W.W.

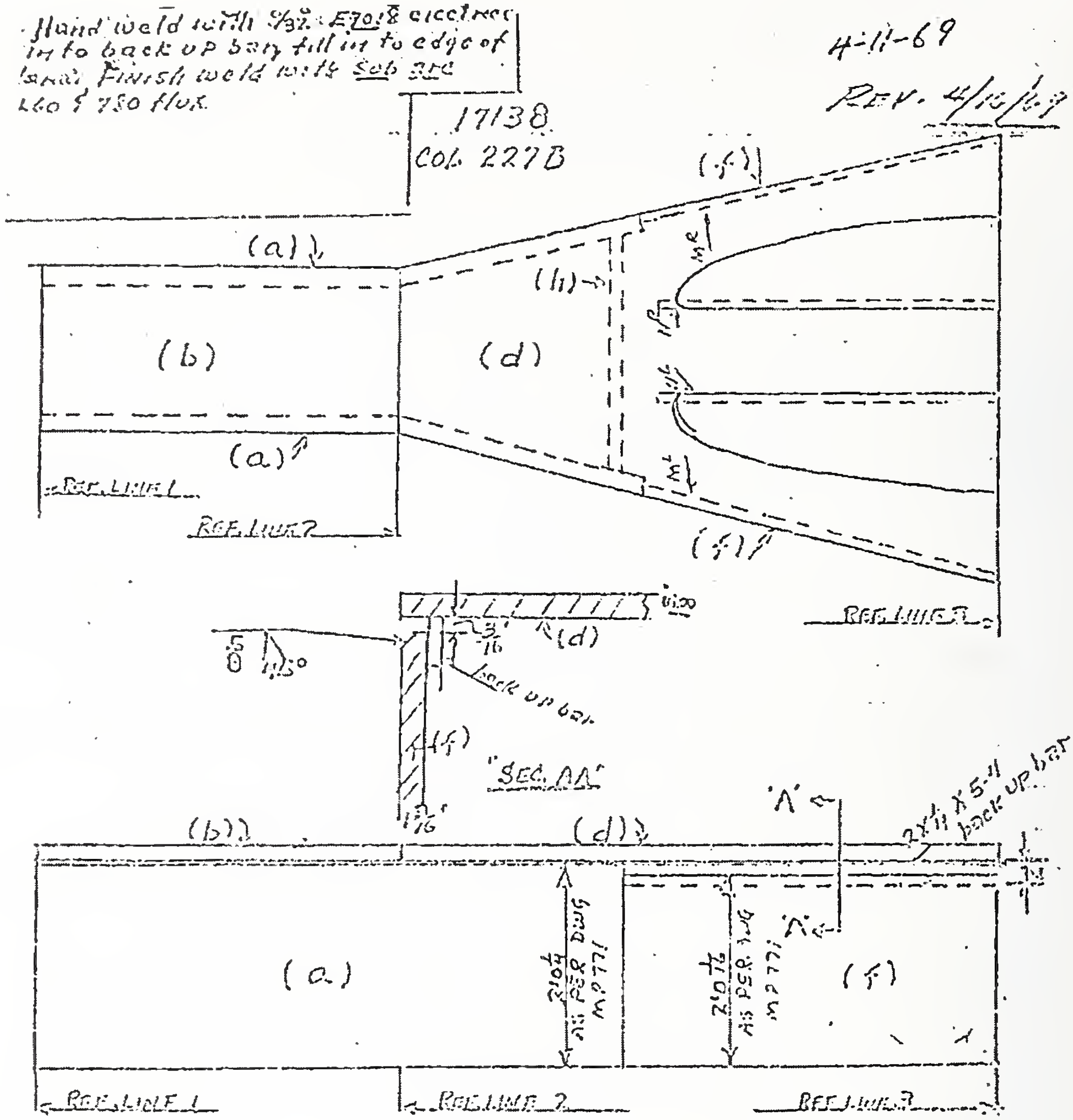
SEC. AA'
Weld procedure
Hand weld with 1/8" & 5/32" E7018 electrode in to back up bar. Fill in to edge of land. Comp. weld using sub arc.
L60 & 780 flux





Egg crate fabricated 3/8" too wide on one corner, in fitting (f) Pl. to egg crate, on bottom side was held flush, leaving 3/8" between top of egg crate and top of Pl f. Request permission to use back up bar, to fill void, between f and cover plate d.

R. Swank Q.C.



Verbal approval recieved from H. Fish 11-10-69 to make up difference in width of Plates f & a by using 2x1/4" back up bars, tacked to f Plate. Written approval to follow.
R. Swank Q.C.

PDM

CABLE PITTDESMOIN
TELEX 086 754

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

May 1, 1969

.ne Port of New York Authority
... ...eet
... York New York 10007

Attention: Mr. R M. Monti

Reference: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138

Gentlemen:

We are sending you for your record and approval one (1) copy of our repair procedure sheets No. 1 and 2 showing the repairs of laminations we found in Plate "d" Panel 2303.

These repairs were made in accordance with the "Investigation and Repair of Lamination and Other Discontinuities" dated March 19 1969. They were witnessed by your inspector Mr. Dave Caffory of Southern Inspection

Please send us a letter of approval for our record

Very truly yours.

PITTSBURGH DES MOINES STEEL COMPANY

R. H. Fish
Project Manager

BHF:ksh
Enc

cc: Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York. New York 10007

Attention: Mr. James White
Plus one copy

Tishman Realty and Constr.Co.
11th Floor 30 Church St.
New York. New York 10007

Attention: Mr. M. Gerstman

75TH ANNIVERSARY

Pittsburgh-Des Moines Steel Company

ULTRASONIC REPORT FORM

ULR

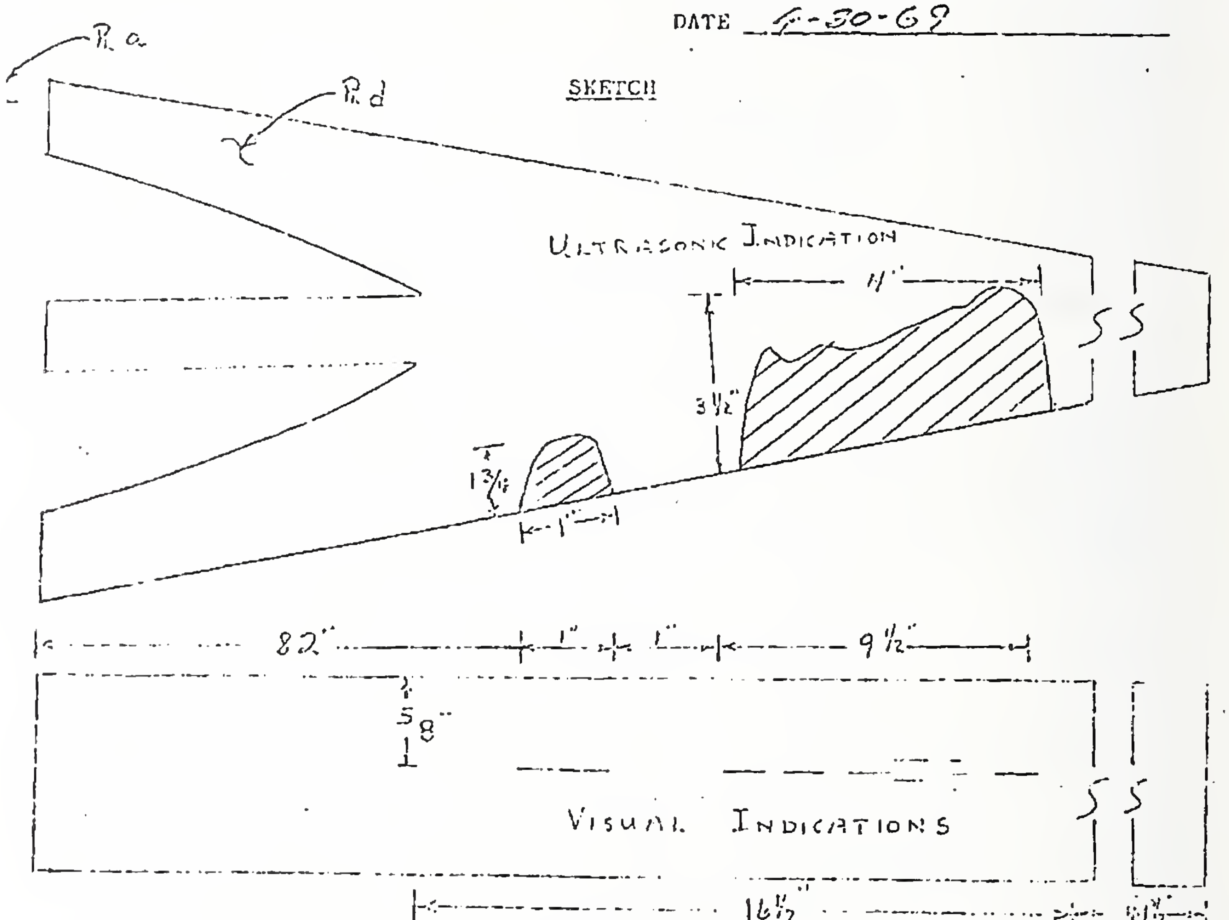
Sheet 1-1

CONTRACT 17138   230B
MATERIAL FY55   HT & A391B-66
THICKNESS 13/8"
DRAWING MD775
SURFACE FINISH Smooth
PIECE MARK D
ULTRASONIC PROCEDURE USED ASTM -435
METHOD USED Contact
TECHNIQUE USED Pulse Echo
PERSONNEL QUALIFICATIONS

EQUIPMENT USK 5M
SEARCH UNIT Straight Beam
FREQUENCY - SIZE 2.25 MHz - 1"Ø
CALIBRATION BLOCK Sound Area of P
COUPLANT Cellulose
BASIC SENSITIVITY B.R.

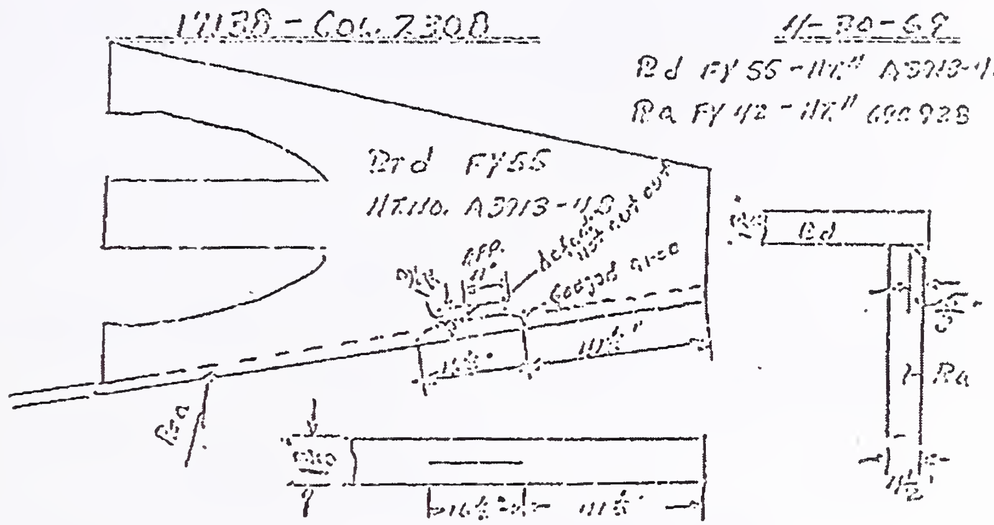
WITNESSED BY $ D Caffrey
OPERATOR C. Vigne
DATE 6-30-69

SKETCH



Area Gouged Exceeded
Above Visual Indications
Gouged To 1 3/4" Depth

Sheet 2



Area to be repaired after gouging and discing = 16½" long x 1 3/8" wide x 1½" dp. (Varies)

Repair Procedure

Preheat 225° – Arc air gouge out defected area. Disc grind and M.T. check gouged out area to insure removal of defect. (One area app. 4" lg. x 1 3/4" dp. not removed) Preheat 225°, weld one pass of weld, using E7018 electrode, disc grind and M.T. check to insure sound metal. Finish repair using E7018 electrode – M.T. check each 1/4" of weld. Slow cool – grind and M.T. check – also U.T. check repaired area.

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu 9-8874

John B. Skilling • Helge J. Helle • John V. Christiansen • Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold J. Worthington
Joseph E. Jackson

May 19, 1969

Port of New York Authority
Office of Construction Manager
30 Church Street
New York, New York

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair of Plate "b", Panel 300B

Gentlemen:

Please refer to the PDM letter dated May 8, 1969 transmitting 8½ x 11 sheets 1 through 8 inclusive describing repair procedures and including reports of non-destructive test results for repair work on plate "b", Panel 300B.

The repair of plate "b" is approved as well as the final repaired weld, plate "ab" to "b", as documented by UT test on May 8, 1969.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Messrs. L. S. Feld, PNYA
R. M. Kleh, PDM
D. Caffery, SIS (Houston)

JW/ld

PDM

CABLE PITTDEMOIN
TELEX 000 734

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

NEVILLE ISLAND • PITTSBURGH PENNSYLVANIA • PHONE

May 8, 1969

The Port of New York Authority
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138

Gentlemen:

We are sending you for your record and approval one (1) copy of sheets 1 to 8 inclusive covering the repair procedure for repairing a crack that developed in Plate "b" Panel-300B.

This repair was made in accordance with the Investigation and Repair of Laminations and other Discontinuities dated on March 19, 1969. The repairs were witnessed by your inspector Mr. Dave Caffery.

Please send us a letter of approval for our records.

Very truly yours,

PITTSBURGH DES MOINES STEEL COMPANY

H. M. Fish
Project Manager

HMF:kah
Enclosure

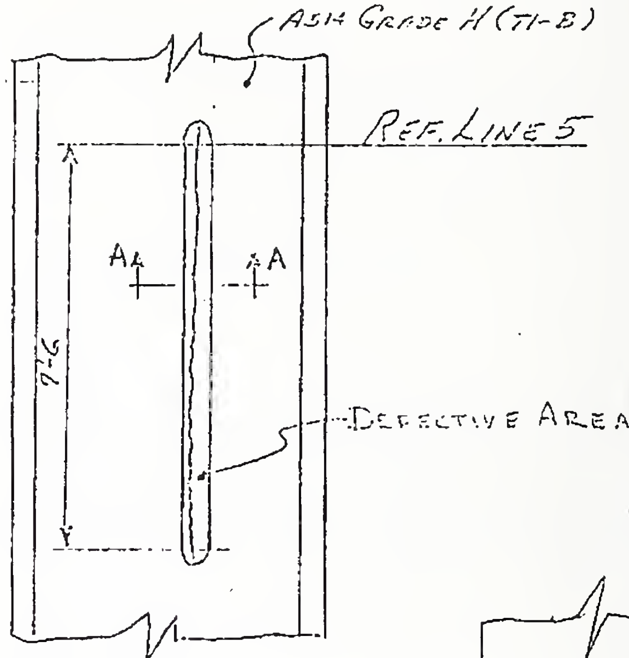
75th ANNIVERSARY

Skilling-Helle-Christiansen-Robertson
Attention: Mr. James White
Plus one (1) Copy

Tishman Realty and Constr. Co.
Attention: Mr. M. Gerstman

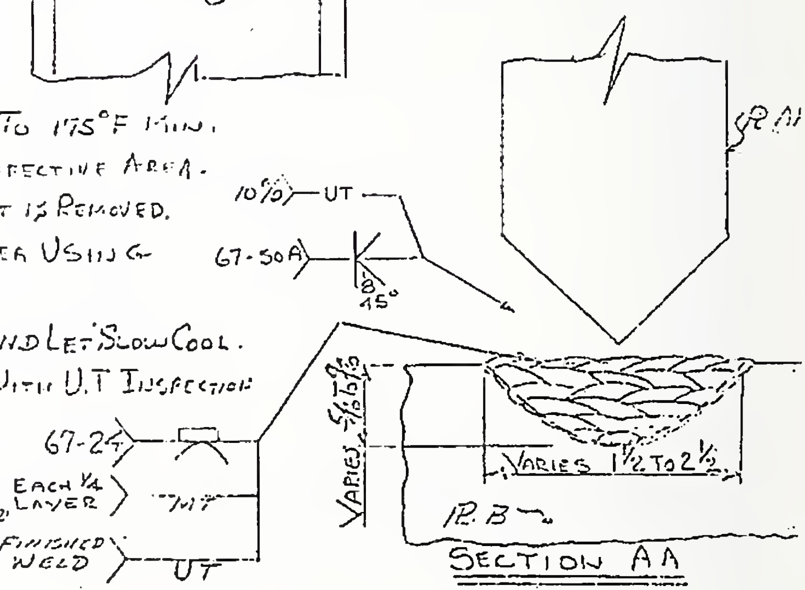
Sheet-1

Cont. 17138 Corner Column No. 300B – MP 817 5-2-69



Procedure

(1) Preheat Defective Area To 175°F Min.
(2) Gouge And Disc Out Defective Area.
(3) MT To Make Sure Defect Is Removed.
(4) Weld The Gouged Out Area Using E11018M 3/16" Electrode.
(5) After Welding Cover And Let Slow Cool.
(6) Check Completed Weld With U.T Inspection
(7) Preheat To 175°F
(8) Fit And Weld R. AH
(9) All Operations To Be Witnessed By Southern Inspection Agency And To Be Documented.



PITTSBURGH-DES MOINES STEEL COMPANY Sheet 1 - 2

ULTRASONIC REPORT FORM U-9
WORLD TRADE CENTER

Contract No. - [redacted]-17130
Material FY 42 - T1
Thickness 1 1/2"
Joint Design 67-50A
Drawing MP 818

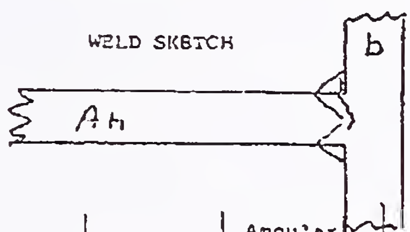
Equipment - USK5J
Transducer Angle [redacted] - 70°
Frequency 2.25 MHZ
Calibration Block Basic + IIW
Couplant: Cellulose - [redacted]

Date - 5-1-69

Inspector - C.V. - [redacted].

Witnessed By - [redacted] $ D Caffery

WELD SKETCH



Pc. Mk	Transducer Angle	DB Rating	Length	Angular Distance	Depth	Remarks
Ah-b	70°	4	7'-6"	2.2"	3/4"	⊗ CRACK TOTAL LENGTH OF WELD VISUAL AT SURFACE

THE PORT OF NEW YORK AUTHORITY

World Trade Department

May 5, 1969

Pittsburgh-Des Moines Steel Company
Neville Island
Pittsburgh, Pennsylvania 15225

Attention: Mr. B. M. Fish

Re: The World Trade Center - Contract [illegible] - [illegible]
as fabricated Condition of Column 3, Panel 200B

Gentlemen:

Further to your letter dated February 4, 1969, the sub-assembly for Column 3, Panel 200B, is acceptable as fabricated and may be incorporated into Panel 200B.

Please note that approval is given only for this particular sub-assembly. In the event of any similar instance, approval will be given, if warranted, on a unit by unit basis, after submission of complete data for such individual cases.

Very truly yours,

[illegible]. M. Monti
Construction Manager
The World Trade Center

JAC:gw

cc: W. Borland, J. White (SHCR)

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue New York, N. Y. 10017 · Mu. 9-8874

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

March 20, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street, Room 1030
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair of Plates "b", Panel 339D

Gentlemen:

Please refer to the PDM letter dated March 12, 1969 requesting approval of plates "b" for panel 339D. Based upon our telephone review of this matter with Mr. L. Colarossi of PDM, we approve the subject plates as repaired contingent upon PDM furnishing PNYA and SHCR with revised copies of the [illegible] test reports, specifically stating the time, location and purpose of each test.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Messrs. L. S. Feld, PNYA
G. M. Fish, PDM
D. Caffery, SIS

JW/jeb

[illegible]

SEATTLE OFFICE: [illegible] WASHINGTON BUILDING SEATTLE WASHINGTON [illegible]

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers

June 6, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. E. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair of Misfits, Panels 227B and 230B

Gentlemen:

Please refer to the PDM letter to PNYA dated May 23, 1969 and attaching revised repair sketches. We approve repairs to Panels 227B and 230B as shown in the PDM sketches dated 4-11-69 and revised 4-16-69 to show complete repair details.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Mr. L. Feld, PNYA
Mr. H. Fish, PDM
Mr. D. Caffery, SIS HOUSTON

JW:l

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · [illegible]

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
[illegible]

Consultants
Harold L. Worthington
Joseph E. Jackson

May 16, 1969

Port of New York Authority
Office of the Construction Manager
[illegible] Church Street
New York, New York

Attention: Mr. [illegible] Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair of Misfits, Panels 227B and 230B

Gentlemen:

Please refer to the PDM letter to PNYA dated April 15, 1969. While we are confident that the repairs described in the two (2) attached PDM repair procedure sheets (one undated and one dated 4-11-69) are completely satisfactory, we will require diagrams of the actual weld joints and all other pertinent data before we can issue formal approval of the subject repairs.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Mr. [illegible], PNYA
Mr. [illegible], PDM
Mr. [illegible] Cafferty, SIS(Houston)

JW:lc

[illegible]

SEATTLE OFFICE · [illegible] WASHINGTON BUILDING · SEATTLE · WASHINGTON [illegible]

CABLE PITTDESMOIN
TELEX 866 734

Pittsburgh-Des Moines Steel Company

Engineers
Fabricators
Constructors

NEVILLE ISLAND · PITTSBURGH PENNSYLVANIA 15225 · AREA CODE 412
PHONE 331-3000

April 15, 1969

Mr. R. M. Monti
Construction Manager
Room - 1119
The Port of New York Authority
30 Church Street
New York, New York 10007

Re: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138

Gentlemen:

We are sending you for your record and approval one (1) copy of our repair procedure for misfits on panels 227B and 230B.

Both of these repairs required the addition of 2 x 1/4 bar up bars and additional welding as explained in detail on the attached sketches.

Please favor us with your written approval of those repair procedures.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

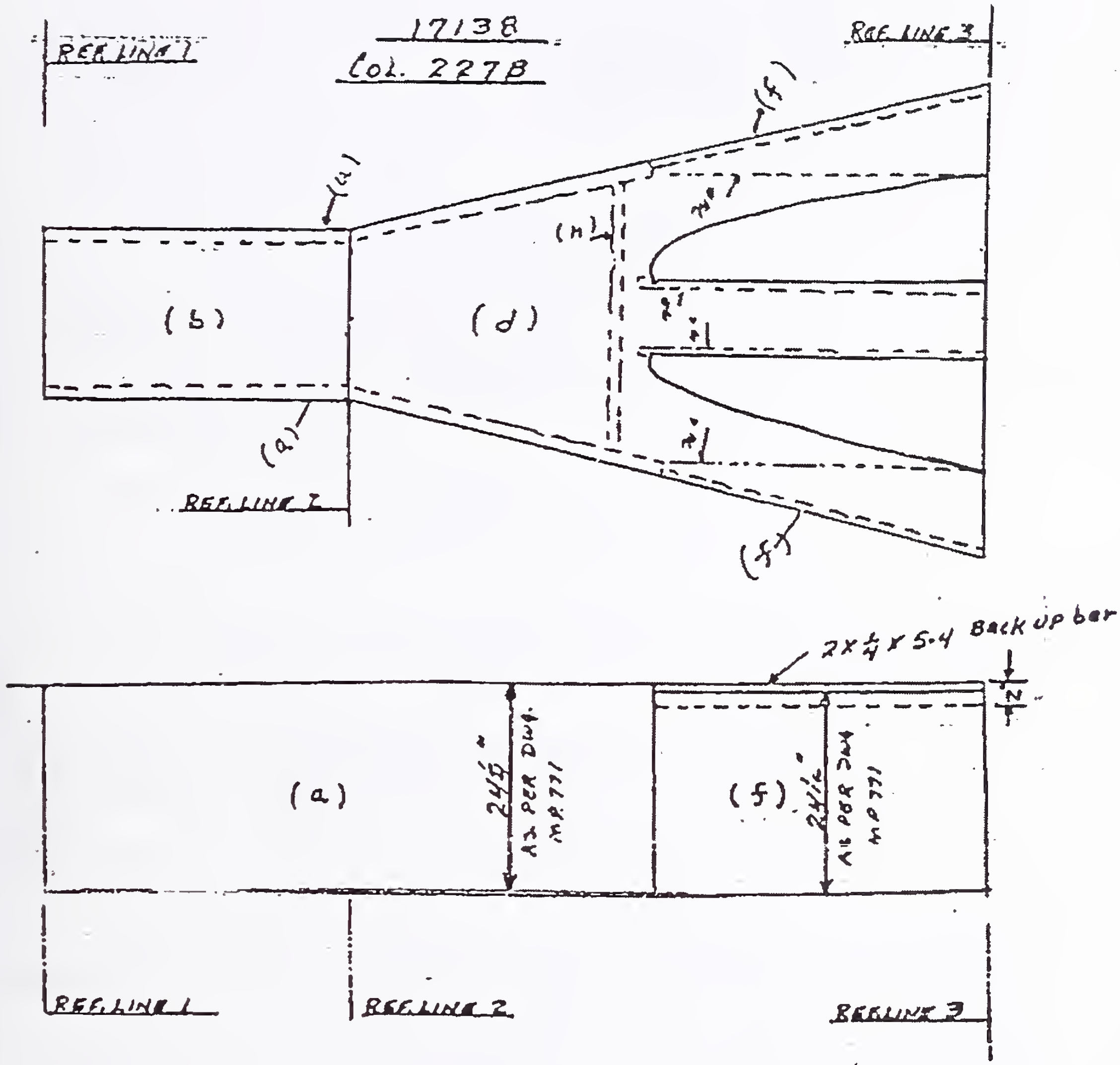
H. M. Fish
Project Manager

HMF:gjb
Enc.

Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10007
Attn: Mr. James White

Tishman Realty & Constr. Company
11th Floor, 30 Church Street
New York, New York 10007
Attn: Mr. M. Gerstman

HAMMOND PRODUCTS

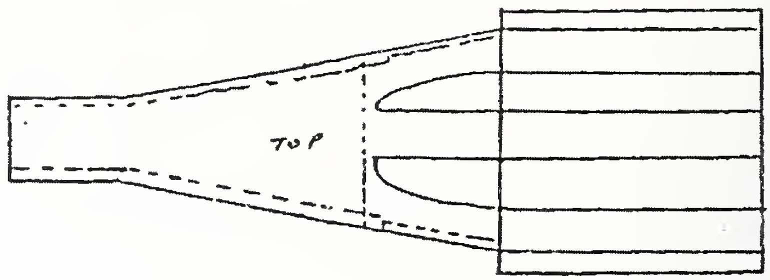


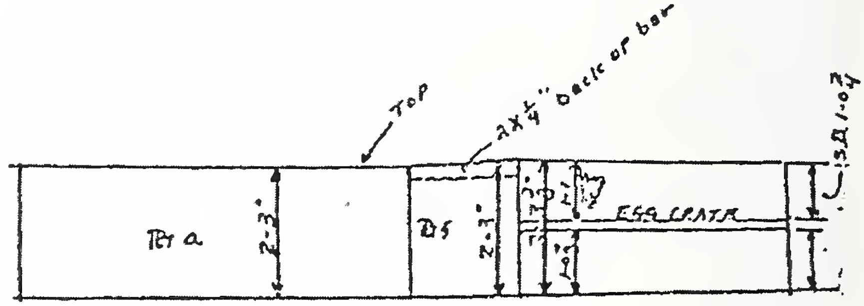
Verbal approval recieved from Mr. H. Fish 4-10-69, to make up difference in width of plates a & f, by using 2x¼" back up bars, tacked to f plate. Written approval to follow.

R. Swank Q.C.

17138
Col. 230B

4/11/69
(OK TO WELD AS IS; WBM)





Egg crate fabricated 3/8" too wide on one corner.
In fitting 'f' Pl. to egg crate, bottom side was field flush.
leaving 3/8" between top of egg crate and top of Pl. 'f'.
Request permission to use back up bar, to fill void, between 'f' and cover plate 'd'.

R. Swank Q.C.

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N.Y. 10017 · Mu [illegible]

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold E. Worthington
Joseph L. Jackson

May 16, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. S. M. Ponti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair to Plate "vR", Panel 224B

Gentlemen:

Please refer to the PDM letter to PNYA dated April 30, 1969. We approve the repair of plate "vR", Panel 224B, as described and documented in sheets 1 through 5 inclusive attached to the PDM letter.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

[illegible]

cc: Mr. L. Veld, PNYA
Mr. N. Fink, PDM
Mr. [illegible] Cafferty, SIS (Houston)

[illegible]

SEATTLE OFFICE · 1800 WASHINGTON BUILDING · SEATTLE · WASHINGTON 98101

PDM

ENGINEERS · FABRICATORS · CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

April 30, 1969

The Port of New York Authority
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Subject: The World Trade Center
Contract WTC-313.00
PDM Contract 17072 & 17130
Repairs to plate V^{R} Panel 224B

Gentlemen:

We are sending you for your record and approval one (1) copy of sheets 1 to 5 inclusive covering the repair procedure for repairing a crack that developed in Plate V^{H} Panel 224B.

This repair was made in accordance with the "Investigation and Repair of Laminations and Other Discontinuities" dated March 19, 1969. They were witnessed by your inspector Mr. Dave Caffery.

Please send us a letter of approval for our records.

Very truly yours,

PITTSBURGH DES MOINES STEEL COMPANY

H. M. Fish
Project Manager

HMF:ksh

Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10007

Attention: Mr. James White
Plus one copy of procedure

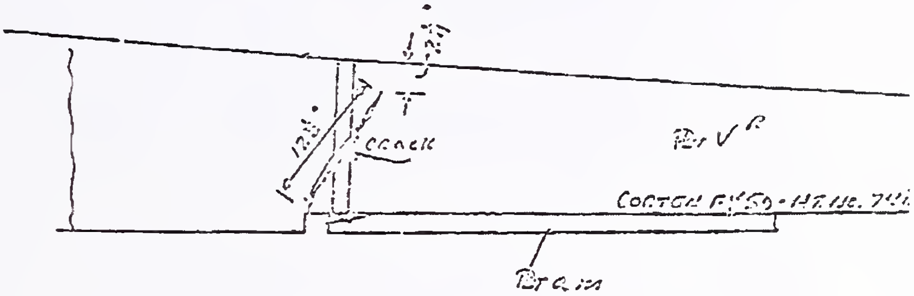
Tishman Realty & Constr. Co.
11th Floor, 30 Church St.
New York, New York 10007

Attn: Mr. M. Gerstman

75TH ANNIVERSARY

17138

COL. 224B



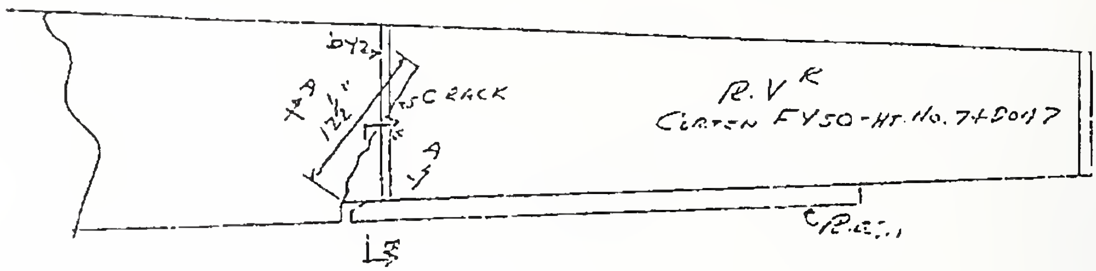
PL. V 27 X 2 3/16 X 27'-8 1/2

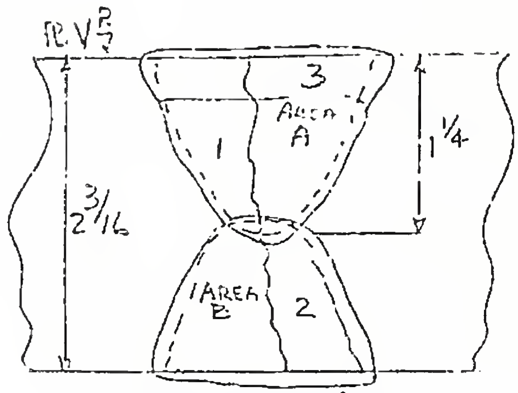
Pgs. 150766 - 769

Sheet-2

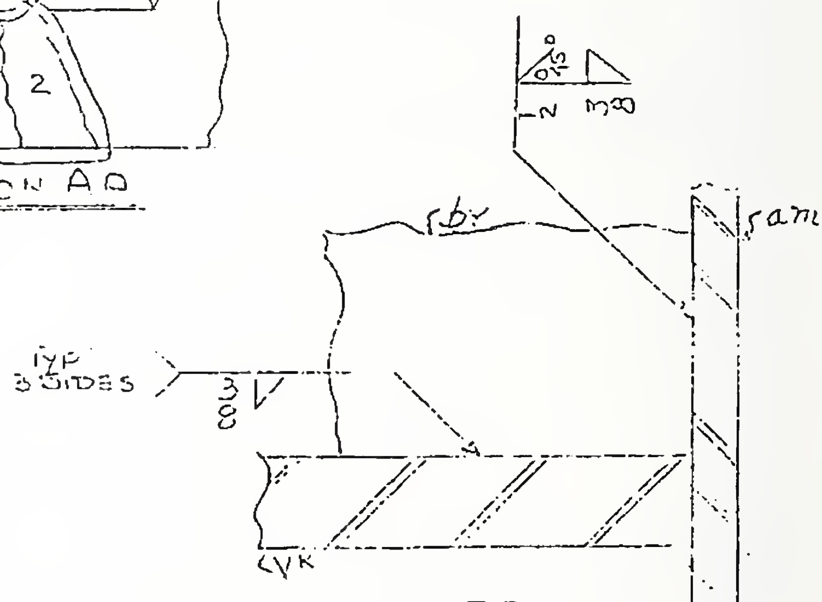
CONT. 17138 COL. 224B SKETCH X1

APRIL 25, 1969





SECTION AA



SECTION BB

Sheet - 3

Contract 1713S Col. 224B ℙ. VR. 4-25-69

Procedure to Repair Crack on ℙ. VR. FY 50 Corten B HT #74D047

(1) Remove ℙ "by" (either by burning or arc air gouge) grind any remaining weld from this area.

(2) Preheat area at least 6" on either side of crack to 200°F. Check with tempil stick.

(3) Gouge Area "A" to 1 1/4" depth, MT sides to make certain that there are no defects.

(4) Weld approx. 1" of area "A" using E8016-C1 (67-49) or Arcos 72 (67-48)

(5) Turn section over and gouge area "B", MT to make certain no defects are present.

(6) Complete welding in area "B".

(7) Turn section and complete Area "A".

(8) Cover with asbestos and let slow cool

(9) Check completed weld with ultrasonic inspection.

(10) Fit new ℙ replacement for "by"

(11) Reweld ℙ "by" as previously welded except as shown on Section B.B.

IMPORTANT

(1) Maintain preheat and interpass.

(2) M. T. every 1/4" layer of weld in areas "A" and "B".

(3) All operations to be witnessed by Southern Inspector Agency Inspector and to be documented.

June 9, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair of Plates C^{R}_{L}, Panel 130B; V^{L} Panel 139B

Gentlemen:

Please refer to the PDM letter to PNYA dated May 23, 1969. The UT reports attached to the PDM letter are sufficient to allow us to approve the referenced repairs.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Messrs. L. Feld, PNYA
U. Fish, PDM
D. Caffery, SIS-Houston

JW/sl

PDM

ENGINEERS · FABRICATORS · CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

May 23, 1969

The Port of New York Authority
30 Church Street
New York, New York   10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138
Repair of Plate U^R_L Panel - 130B
Repair of Plate V^L Panel - 139B

Gentlemen:

Reference to SHCR letter of May 16, 1969 to Mr. R. M. Monti approving our repair procedure to plates U^R_L, Panel 130B and Plate V^L Panel - 139B contigent upon receipt of our NDT reports.

We are enclosing for your record one (1) copy of our NDT reports sheets Nos. T-1 and T-2.

Unless we hear from you we will assume that this subject matter is finalized.

Very truly yours,

PITTSBURGH DES MOINES STEEL COMPANY

H. M. Fish
Project Manager

HMF:ksh
Enc.

cc: Mr. James White/plus one (1) copy
Mr. M. Gerstman

75TH ANNIVERSARY

Pittsburgh-Des Moines Steel Company

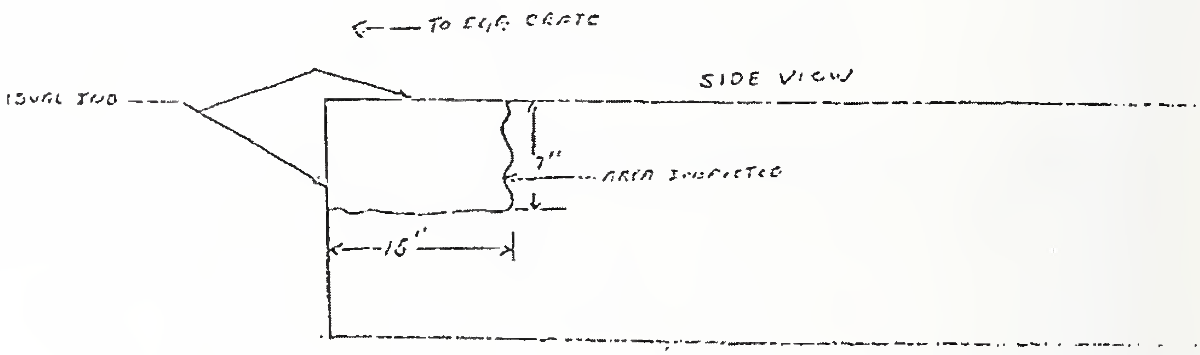
ULTRASONIC REPORT FORM

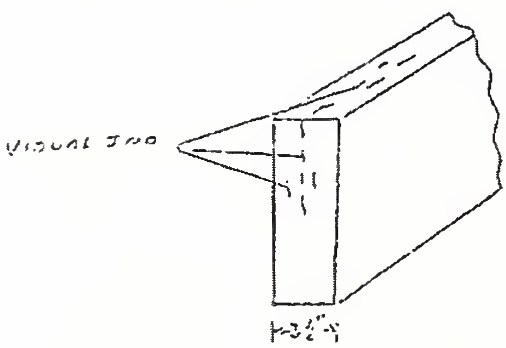
Sh. T-1

ULR

CONTRACT 17138 130 B	EQUIPMENT [illegible]
MATERIAL 45	SEARCH UNIT [illegible]
THICKNESS 3 1/2	FREQUENCY - SIZE [illegible]
DRAWING MP 716	CALIBRATION BLOCK [illegible]
SURFACE FINISH SMOOTH	COUPLANT [illegible]
PIECE MARK 1/2	BASIC SENSITIVITY [illegible]
ULTRASONIC PROCEDURE USED ASTM A 435	
METHOD USED CONTACT	
TECHNIQUE USED PULSE ECHO	WITNESSED BY D CAFFERY
PERSONNEL QUALIFICATIONS [illegible]	OPERATOR R.S. [illegible]
	DATE 4-7-63

SKETCH





J. D. Caffery

AREA ABOVE INSPECTED AND ACCEPTED UNDER [illegible]

A 435

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N.Y. 10017 · MU 9-8874

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer
Consultants
Harold L. Worthington
Joseph E. Jackson

May 16, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair of Plate "af^{L}", Panel 412B

Gentlemen:

We approve the repair of plate "af^{L}" as documented by the PDM procedure sheet dated 3-28-69 and UT test report dated 3-28-69, both attached to the PDM letter to PNYA dated March 31, 1969. While no UT report is furnished to document the UT check mentioned in the PDM repair procedure, none is required for laminations not exceeding 1½ inches in depth, per the PDM approved procedure "Investigations and Repair of Laminations and other Discontinuities" dated March 19, 1969.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Mr. [illegible], PNYA
Mr. H. Fish, PDM
Mr. D. Caffery, SIS (Houston)

JW:lc

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON
Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · MU 9-8874

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold F. Worthington
Joseph F. Jackson

May 16, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Repair of Plate "b", Panel 3393

Gentlemen:

Please refer to the PDM letter to PNYA dated April 21, 1969. The PDM UT report revised 3-19-69 reporting results of UT tests on repairs to plate "b", Panel 3393, is sufficient to allow us to approve the repairs to the subject plate.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Mr. L. Feld, PNYA
Mr. E. Fish, PDM
Mr. D. Caffery, SIS (Houston)

JW:lc

CABLE: PITTDSMOIN
TELEX: 000-734

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

NEVILLE ISLAND • PITTSBURGH, PENNSYLVANIA 15225 • PHONE (412) 331-3000

April 21, 1969

The Port of New York Authority
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Subject: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138
Repair of Plate "b" Panel-3398

Gentlemen:

In compliance with your request, in your letter of March 20, 1969, that we submit revised copies of NDT reports we are sending you for your record and approval one (1) copy of Sketch-SK-4 Sheet 5 revised March 19, 1969.

The purpose of this report was to show that areas in question were satisfactorily U.T. inspected after repairs were made and witnessed by your inspector Dave Caffery

Please advise us by letter of your approval.

Very truly yours,

PITTSBURGH DES MOINES STEEL COMPANY

H. M. Fish
H. M. Fish
Project Manager

JW approval 5/16/69

HMF:ksh

Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10007

Attn: Mr. James White

Tishman Realty & Constr. Co.
11th Floor, 30 Church ST.
New York, New York 10007

Attn: Mr. M. Gerstman

Pittsburgh-Des Moines Steel Company

ULTRASONIC REPORT FORM

(5)

ULR

CONTRACT	17138 339B	EQUIPMENT	USK5-M
MATERIAL	FY 42	SEARCH UNIT	Compression
THICKNESS	3"	FREQUENCY - SIZE	2.25 MHZ - 1" Diam.
DRAWING	MP633 and 632	CALIBRATION BLOCK	IIW
SURFACE FINISH	Smooth	COUPLANT	Cellulose
PIECE MARK	B Plate - 339B	BASIC SENSITIVITY	Back Ref. 80%
ULTRASONIC PROCEDURE USED	ASTM 435		
METHOD USED	Contact		
TECHNIQUE USED	Pulse Echo	WITNESSED BY	D. Caffrey
PERSONNEL QUALIFICATIONS	SNT Level 2	OPERATOR	R. S. Cammarata
		DATE	3-4-69

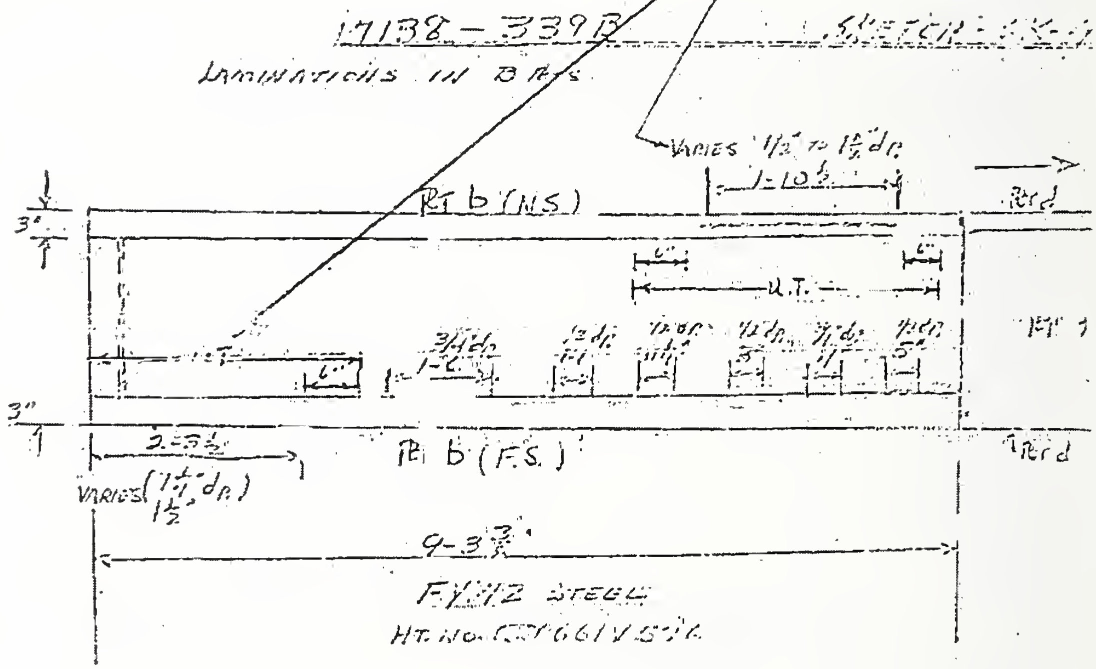
Revised Report: 3-19-69 C. Vigne

SKETCH

b Plates N.S. & F. S. U.T. Inspected as noted on sketch SK-4 shown below.

No indications seen on the machine at above procedure level.

REMARKS:- ULTRASONIC TEST MADE 6" ON ALL SIDES OF REPAIRED AREAS SHOWN BELOW



SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu. 9-8874

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

July 15, 1971
File: WTC-230C
WTC-213C
30C

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti, Construction Manager

Reference: The World Trade Center
Contract WTC-230.00, KKE
Contract WTC-213.00, PDM
Repair of Column 327B
Reference No. 1, SHCR Drawing 2AB2-15, Detail 26
Reference No. 2, PDM Shop Drawings MP610, MP611

Gentlemen:

Please refer to SHCR's May 21 and July 15, 1971 letters to PNYA transmitting repair procedure information for Column 327B. UT evaluation of the repair work required in the SHCR document "Repair Procedure, Column 327B, Elev. 372'-6"(+)" is reported in G&H UT report sheets 1 through 6 of 6 dated 7/6/71. G&H report is enclosed with this letter. G&H sheets 1 and 2 show that the 6'(+) length of repair weld between plates "a" and "d" is acceptable. Sheets 3 and 4 show the extent of a crack which could not be completely removed at Elevation 372'-6"(±) during the repair to the edge of plate "d" and the fractured partial penetration weld. Sheets 5 and 6 show the extent (1½ inches long; 2 to 2½ inches deep) of a defect found in the horizontal repair weld to plate "d" at Elevation 378'-6"(±).

Subsequent to the above UT testing, the south 2/3 width of the CP weld between plates "d" and "b" (E2 to F2) was repaired as follows:

1. Provide preheat temperature of 200-250°F by use of radiant heaters at repair line.
2. Arcair gouge defective metal within central 1/3 width of column. (Discussion with workmen revealed that surface to one inch deep was sound, that one inch deep to backup bar was extremely porous with cracks running from defective weld metal into the base metal vertically for various short lengths).

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Port of New York Authority
Attn: Mr. R. M. Monti - 2 - July 15, 1971

3. Allow column to cool at end of work day using asbestos blanket wrapping for slow cool.
4. Elevate temperature at beginning of work day.
5. Perform central 1/3 column width repair weld using E7018 electrodes.
6. Slow cool column at end of work day.
7. Upon completion of work at central 1/3 width, repeat repair sequence of steps 1 through 6 above for south 1/3 length.
8. Upon completion of repair of entire 23 inches of defective weld, Elevation 372'-6"(±), UT entire width of plate "b" and "d" in repair area.

It should be noted that the repair excavation was of the order of two (2) inches wide at the root, extending above the shop backup bar and roughly 1/2 inch maximum into the 1-3/4 inch diaphragm plate CP weld. The workmen reported minimum fusion to the backup bar, very spongy weld metal, and numerous cracks in the base metal running vertical in the plate (normal to the axis of the horizontal CP weld). The shop weld was made in accord with PDM procedure 67-48, a xerox copy of which is attached to this letter.

Also attached to this letter, please find the G&H UT report (one sheet) dated 7/15/71. This report shows that the defect reported at Elevation 378'-6"(±) in the G&H 7/6/71 report (Repair 1 in the 7/15/71 report) has been removed and the repair weld is UT acceptable. The 7/15/71 G&H report also shows that the repair to the defective shop weld at Elevation 372'-6"(±) is acceptable as welded.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Messrs. M. P. Levy, PNYA
L. S. Feld, PNYA

Attachment #1 G&H UT report dated 7/6/71, pages 1-6
Attachment #2 PDM Weld Procedure 67-48 dated April 6, 1968
Attachment #3 G&H UT report dated 7/15/71

EJW/is

LER

GURLICH-HENDERSON LABORATORIES, INC. P.O. BOX #550, [illegible], NEW YORK Zip - 11352

ULTRASONIC TEST REPORT

DATE: 7-1-77

Branson 301 - Wedge Angle 70°, 60°, 45°, MHZ 2.25

INSP. [illegible]

Couplant (Glycerine) ______

Calibration Blocks ______ Simulated I.I.W.

Welding Contractor: ______

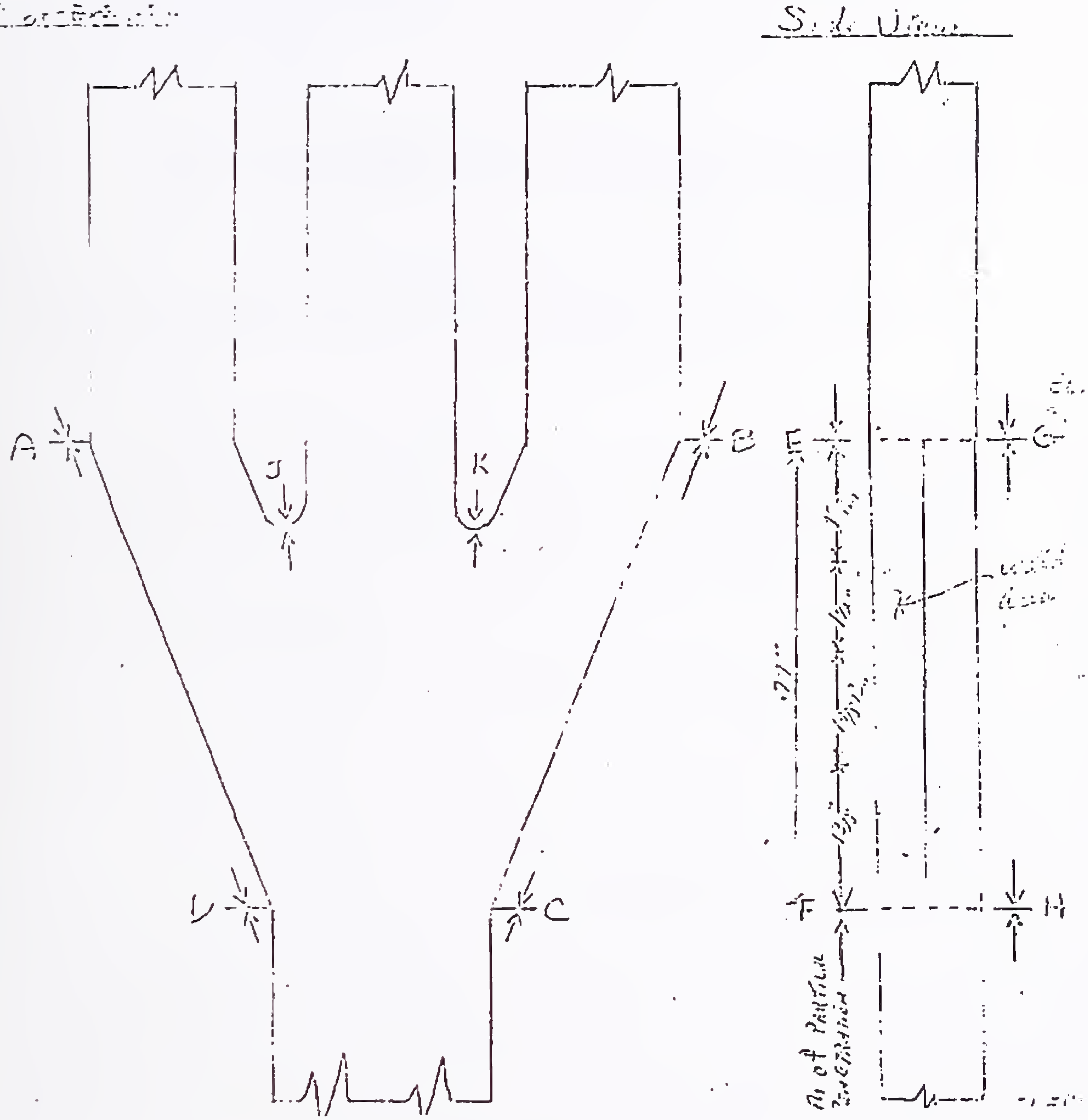
Project: [illegible]

Base Material Thickness ______ I ______ II ______ Length of Weld: 77

Elev. [illegible] 77'3"

[illegible]

[illegible]



SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Consulting Structural and Civil Engineers · *230 Park Avenue, New York, N. Y. 10017* · *Mu. 9 5574*

John B. Skilling · *Helge J. Helle* · *John V. Christiansen* · *Leslie E. Robertson*

Consultants
Harold L. Worthington
Joseph F. Jackson

August 21, 1968

Port of New York Authority
Office of the Construction Manager
30 Church Street Room 1135
New York, New York 10007

Attention [illegible] Monti

Reference The World Trade Center
Contract WTC-213.00
Laminated plates "d" Drawing MP506

Gentlemen:

Please refer to the PDM letter dated June 11, 1968 referring to laminated plates "d" shown on shop drawing MP506. The repair procedure stated in the attachment to the letter and shown in the PDM sketch dated June 10, 1968 is approved. These laminations were discovered after the plates were welded into a complete column panel assembly.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

[illegible]

[illegible]:pc

cc: Messrs. L. F. Feld - PNYA
[illegible] - PDM

WAYNE A. BREWER
[illegible]
[illegible]
[illegible]
[illegible]
KENT A. ROGERS
CHARLES SANDUSKY
WILLIAM D. WARD
E. J. WHITE JR.
[illegible]

SEATTLE OFFICE: 1040 WASHINGTON BUILDING SEATTLE WASHINGTON 98101

October 7, 1968

Port of New York Authority
Office of the Construction Manager
30 Church Street - Room 1119
New York, New York 10007

Attention: Mr. E. H. Monti

Reference: The World Trade Center
Contract WTC-213.00, Pittsburgh-Des Moines
Repair of Plate for Panel 209A

Gentlemen:

Please refer to the PDM letter dated September 30, 1968, referring to weld repair procedure for plate V^L for panel 209A. We have reviewed this procedure by telephone with Mr. H. M. Fish of PDM, and approve the PDM repair procedure.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

JW:o
cc: Messrs. L. S. Feld, PNYA
H. M. Fish, PDM

PDM

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

NEVILLE ISLAND • PITTSBURGH, PENNSYLVANIA [illegible] • PHONE [illegible]

October 4, 1968

Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10007

Attention: Mr. James White

Reference: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138

Dear Mr. White:

Enclosed is one (1) copy of the Weld Procedure that was inadvertently not sent to you.

Please notefy us by letter of your approval of this repair procedure.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

H M Fish

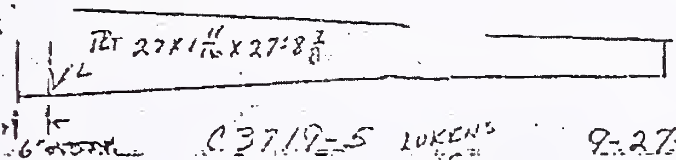
H. M. Fish
Project Manager

HMF:ksh
Enclosure

75TH ANNIVERSARY

WELD SEAM

X RAYS
U690
U691

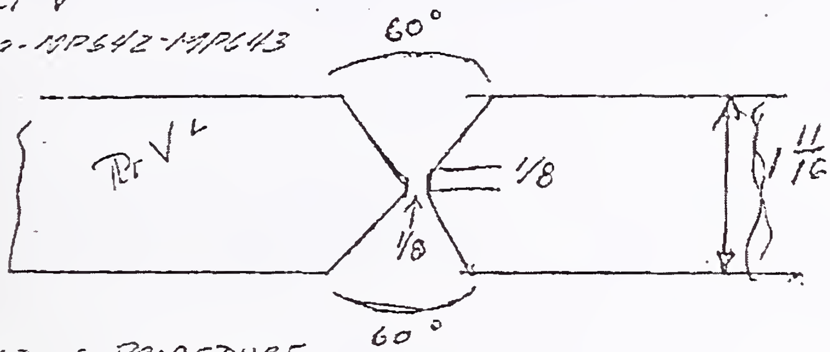


17028
COL. 3C9A
PLT V L
DWG - MP642 - MP643

C3719-5
MN 10-6

LUKENS
45

9-27-68



WELDING PROCEDURE

1ST - 2 PASS'S IN ROOT 5/32 7018 WIRE - (1ST SIDE

PASS'S - #3 TO #7 INCLUSIVE 3/16 - E7018 WIRE

TURN OVER PLT ARC-AIR GOUGE OUT ROOT

1ST - 1 PASS ON GOUGED SIDE 5/32 7018 ROD

PASS #8 TO #12 ON 2ND SIDE 3/16 7018 ROD

TURN OVER PLT

PASS #13 TO #16 ON FIRST SIDE 3/16 - 7018

TURN OVER PLT

PASS #17 TO #20 - 2ND SIDE 3/16 - 7018

PRE-HEAT USED [illegible]

ABOVE PLATE WAS BURNED ON WRONG LINE IN SHOP. AFTER ERROR WAS DISCOVERED, THE PLATE PART THAT WAS BURNED OFF WAS PREPARED, AND WELDED BACK ON TO MAIN PLATE, USING ABOVE PROCEDURE. PLATE WAS THEN X RAYED TO INSURE SOUND WELD. X RAYED AFTER RE-BURNING TO CORRECT LENGTH.

ENGINEERS • FABRICATORS • CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

September 30, 1968

Mr. R. M. Monti
Construction Manager
Room 1119
The Port of New York Authority
30 Church Street
New York, New York 10007

Re: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17158

Gentlemen:

We are submitting for approval two (2) copies of our weld procedure for repairing plate V L on panel 205A which was inadvertently cut 6 inches short. This panel is detailed on drawings MF642 and MF643.

Please have the engineer notify us by letter of his approval of this repair procedure.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

H. M. Fish
Project Manager

HMF:ksh
Enclosure

cc: Skilling-Helle-Christiansen-Robertson
Tishman Realty and Construction Company

75TH ANNIVERSARY

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

John B. Skilling • Helge J. Helle • John V. Christiansen • Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

October 16, 1968

Port of New York Authority
Office of the Construction Manager
Room 1119, 30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213, Pittsburgh-Des Moines Steel Company
Welding of Corner Panels 100A, 300A, 400A

Gentlemen:

We have reviewed the PDM letter dated October 15, 1968 to which is attached an outline of repairs PDM proposes to perform, and stating the actual weld metal placed in corner panels 100A, 200A, 300A and 400A for Tower "A". These are outlined in four (4) three page letters, one for each corner panel. The letters are dated October 10, 1968, signed by Mr. Weisner, PDM Chief of Quality Control, and are addressed to Mr. Fish, PDM Project Manager. Butt welds in eighteen separate locations require repair, and amount to a total length of weld slightly in excess of 22 feet.

Also attached to the PDM letter is a PDM procedural drawing showing, step by step, all details of the required repair work.

SHCR approves in entirety the proposed methods and specific locations of repairs submitted in the PDM letter.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Messrs. M. P. Levy, PNYA
W. C. Morland, PNYA
L. S. Feld, PNYA
R. M. Fish, PDM
Holton & Caffrey, SIS

JW/acb

Frank Hoeltershoff
Robert E. Levien
Bent R. Boeter
Charles Banchukh
William O. Ward
Lorentz L. Wiging

Richard Chaumer
P. G. A. Foster
Ernest T. Liu
Jostein Nes
V. A. Pribadsky
Richard E. Taylor
B. J. White, Jr.

SEATTLE OFFICE: 1048 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

ENGINEERS / FABRICATORS / CONSTRUCTORS

PITTSBURGH-DES MOINES STEEL COMPANY

October 15, 1968

The Port of New York Authority
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00
PDM Contract 17075 & 17136

Gentlemen:

We are sending you for approval two (2) copies of certified weld report pertaining to Panels 100A, 200A, 300A and 400A. All of these panels with the exception of 300A had some of the welds made using the wrong electrode which will require repairing.

We have reviewed these sheets with Mr. James White in our office October 14, 1968 and have noted on the left hand side of the sheets the repair action which will be required.

We are also including two (2) reproducible copies of Page 1 showing the weld procedure for repairing these panels.

Please advise us by letter of your acceptance of this repair procedure.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

H. M. Fish
Project Manager

HMF:kah

Enclosure

75TH ANNIVERSARY

cc: Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10007
Attention: Mr. James White
plus one copy of weld report and Page 1

Tishman Realty & Constr. Co.
11th Floor, 30 Church Street
New York, New York 10007
Attention: Mr. M. Gerstman

THE PORT OF NEW YORK AUTHORITY
111 Eighth Avenue at 15th Street, New York, N.Y. 10011

World Trade Department
Guy F. Tozzoli, Director
Richard C. Sullivan, Director, The World Trade Center

Malcolm P. Levy, Chief, Planning & Construction Division
R. M. Monti, Construction Manager   Telephone (212) 620-7910

September 21, 1967

Stanray Pacific Corporation
11633 South Alameda Street
Los Angeles, California 90002

Attention: Mr. W. E. Gibson

Re: THE WORLD TRADE CENTER - Contract WTC-217.00 -
Inspection Requirements for Steel in Scotland

Gentlemen:

Reference is made to your letter to Mr. M.P. Levy, dated September 5, 1967 regarding subject steel requirements.

Your statement that Stanray "did not and will not accept as a general rule length multiples other than ordered", appears to be a matter between you and your steel supplier. Superintendents, Inc., in their inspection will, of course, advise us of any variations, not only from your orders, but from the required specifications. I believe the maximum number of shop splices, that is, at every floor three (3) feet above floor line, is covered by Clause No. 303.200 of the spec. Your previous request to splice every eighteen (18) feet was approved contingent on your submission of details on handling weld interference with connection detail material.

Your letter states on edge conditions, that blowouts exceeding 1/8" in depth where asterisked on your purchase orders, will be repaired by welding and grinding and that on all other plate blowouts exceeding 1/4" in depth, will be repaired by welding and grinding. Please be advised as follows:

1. I have no definite knowledge of your purpose or ground rules used in establishing these asterisked items in your purchase orders.

2. Clause No. 303.201 of spec requires all blowouts exceeding 1/8 to be repaired by welding and grinding.

3. Therefore, it appears that you are increasing the allowable tolerance required by the specifications, which I cannot permit without further detailed explanation from you.

-2-

Pending receipt of further information from you, Cargo Superintendents, Inc., will continue to be governed by present contract specifications.

Sincerely,

R. M. Monti
Construction Manager
The World Trade Center

cc: Messrs. J. Endler (TRSC), W. Cosinuke, J. White (SHCR)
w/att. w/att.

THE PORT OF NEW YORK AUTHORITY

October 16, 1969

Laclede Steel Company
Arcade Building
St. Louis, Missouri 63101

Attention: Mr. Robert D. Bay

Re: The World Trade Center - Contract WTC-221.00 - Laclede Automatic CO2 Welding

Gentlemen:

Please refer to the Laclede letter to SHCR, dated September 8, 1969, and the SHCR letter to PONYA, dated October 6, 1969, on which you were copied.

Your request to use the Hobart automatic CO2 welding equipment and welding procedure submitted in your letter of September 8, 1969, is granted provided that production welding on Contract WTC-221.00 performed by use of this equipment meets the requirements of the contract documents and there will be no additional cost to the Authority.

If at any time welding performed by this equipment should fail to satisfy the contract requirements, this permission will be withdrawn and the cost of any repair work will be to Laclede's account.

Very truly yours,

R. M. Monti
Construction Manager
The World Trade Center

JKC:RD

Copy to: Messrs. W.C. Borland
J. White (SHCR) W/Att.

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu. 9-8874

John B. Skilling · *Helge J. Helle* · *John V. Christiansen* · *Leslie E. Robertson*

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph F. Jackson

October 6, 1969
File: WTC-221C

Port of New York Authority
Office of Construction Manager
30 Church Street
New York, New York

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-221.00, Laclede
Automatic CO2 welding

Gentlemen:

Please refer to the Laclede letter to SHCR dated September 8, 1969. We recommend PNYA approve the use of this automatic equipment. While the tests were not standard AWS tests, and the test samples were run at Troy, Ohio by Hobart Bros. instead of by Laclede, the test values clearly exceed 2/3 of the minimum specified tensile strength of the base metal for longitudinal shear and 7/8 of the minimum specified tensile strength of the base metal for transverse shear.

On Friday, September 26, 1969, Laclede was in the process of performing test runs and final adjustment to the equipment. Upon completion of trial operations by Laclede, SHCR and PTL will maintain continual day to day surveillance of the quality of production welds performed by use of the Hobart automatic CO2 welding equipment.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

James White

JW:ans

cc: Mr. L. S. Feld
R. Bay, Laclede

[illegible]
William D. Ward
E. J. White Jr.
[illegible]

[illegible]
Richard E. Taylor

SEATTLE OFFICES 1440 WASHINGTON BUILDING SEATTLE WASHINGTON 98101

Laclede Steel Company

General Offices Arcade Building

St. Louis, Missouri 63101 September 8, 1969

Mr. James White
Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10017

Dear Mr. White:

Approval - Automatic Arc Welding

In accordance with Paragraph 405.300, World Trade Center Contract WTC 421.00, formal request is herewith made for the use of CO_2 Automatic Gas Metal Wire Feed - Arc Welding Equipment for use in making continuous 3/16 inch and larger fillet welds on chord plates. The chord plates are on the bottom chord of trusses and on the top and bottom chords of bridging trusses required for the project. The equipment uses Hobart #RC-750, 750 Amp Constant Voltage, 100 Per Cent Duty Cycle Power Source with Hobart #AO-23 Automatic Panels having a Wire Feed Motor, Head and #377225 Guns. Hobart #CMS-9A Electronic Seam Trackers will be used and Hobart #377450 Nozzels.

Attached herewith is Welding Procedure numbered C-4713-A prepared by the Hobart Brothers Company and dated 8/26/69 pertaining to the equipment. Also attached are proof tests on samples of the Laclede material which was sent to Hobart and welded with the equipment at Troy, Ohio. The material was returned to Laclede Steel Company and tests were made at the St. Louis Testing Laboratory, St. Louis, Missouri. The test samples are available for inspection at the St. Louis Office. Personnel which will use this equipment have already been certified for Automatic Gas Metal, Wire Feed - Arc Welding.

Since the new equipment is to be installed this next week, we respectfully request an early approval so that we may proceed

- 1 -

Skilling-Helle-Christiansen-Robertson . . . . Page 2

with the plan to utilize this new equipment to reduce the large backlog of arc welding which is now at our shop. If there are any questions, please contact the writer.

Yours very truly,

LACLEDE STEEL COMPANY

Robert D. Bay
Director of
Technical Services
Project Coordinator

lp

CC: Mr. Wayne C. Brewer, SHCR
Mr. Lester Feld, PONYA
Mr. Al Guttentag, Tishman

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu 9-5574

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

December 15, 1967

Consultants
[illegible]
[illegible]

Port of New York Authority
Office of the Construction
Manager - Room 1119
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti, Construction Manager

Reference: The World Trade Center
Contract WTC-214.00, Pacific Car & Foundry
Diaphragm Plates, Welds Ø5 and Ø7

Gentlemen:

Pacific Car & Foundry has requested, and SHCR has approved, the elimination of the clipped corners on stiffener plates as shown in Sections b-b and d-d, Sheet 4-A22-32, Drawing Book 4, and equivalent conditions. PCF intends to install these plates in the "ladder" assembly prior to assembly with the "bed sheet." Where weld Ø5 is interrupted by a stiffener plate, it shall be thoroughly fused into both sides of the subject stiffener plate. Should weld Ø7 be interrupted by a stiffener plate, the same requirement applies. Where the Drawings show a 3/8 inch fillet weld between the stiffener plate and spandrel plate t4, this weld shall be 7 inches long as shown in the Drawings. Where a full penetration weld is required in the Drawings, or where PCF elects to use a full penetration weld, the plate shall be beveled and the weld shall extend full length along the spandrel between the two [illegible] plates.

All the above changes shall be clearly illustrated in the shop drawings. Since the above procedures have been approved at PCF's request, it is understood that the adoption of these procedures will not result in additional cost to PNYA.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

James White

JW:s
cc: Mr. L. Feld, PNYA
Mr. R. Symes, PCF
Mr. A. Berkshire, SHCR-SE

Seattle Office: [illegible] Washington Building Seattle Washington 98101

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON
Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu. 9-8874
John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Manager
Wayne A. Brewer

Consultants
Harold E. Worthington
Joseph L. Jackson

May 26, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-214.00, PCF
Material Substitutions - Beam Seat Angles

Gentlemen:

Please refer to PCF letter 68-14 dated May 19, 1969. We approve the use of 8X6X1 inch angles in lieu of 8X6X7/8 inch angles for beam seat types 7440 through 7494. PCF must verify that no additional bolt length will be required, or provide revised bolt lists if necessary, at no cost to PNYA.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White
cc: Mr. L. Feld, PNYA
Mr. E. Symes, PCF

bcc: Mr. A. Barkshire-SHCR-SEATTLE
JW:l

[illegible]

SEATTLE OFFICE · 1640 WASHINGTON BUILDING · SEATTLE, WASHINGTON [illegible]

STRUCTURAL STEEL DIVISION

Pacific Car and Foundry Company

G SOUTH HUDSON · SEATTLE WASHINGTON 98134 · RO 2-7440

May 19, 1969 D-666 PCF #S-14

Skilling Helle Christiansen Robertson
Consulting Structural and Civil Engineers.
230 Park Avenue
New York, New York 10017

Attention: Mr. James White

Reference: World Trade Center
Contract WTC 214.00
PCF Project D-666

Subject: Material Substitutions

Gentlemen:

On beam seat types 7440 through 7494, the 8" x 6" x 7/8" angles specified on design drawings are not immediately available. We are therefore, using 8" x 6" x 1" angles for these beam seat types on tier 40-43 A and B, 43-50 A, 74-77 A and B, and 77-80 A. No other dimensions or engineering details are being changed.

Please give us your approval to this substitution.

Yours very truly,

R. C. Symes
Project Manager

RCS:ca
cc: R. Monti (PONYA)
M. Gerstman (TRCC)
A. Barkshire (SHCR)
J. Davis (PCF)

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu. 9-8574

John B. Skilling · *Helge J. Helle* · *John V. Christiansen* · *Leslie E. Robertson*

Manager
Wayne A. Brewer

Consultants
Harold L. Worthington
Joseph L. Jackson

May 2, 1969

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-214.00, PCF
Material Substitution

Gentlemen:

Please refer to PCF letter #P-102 dated April 4, 1969 attaching sheets 1 and 2 of 2 titled "Material Substitutions".

All material substitutions shown on the two (2) sheets prepared by PCF are approved by SHCR.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

cc: Mr. L. Feld, PNYA
Mr. E. Symes, PCF

JW:lc

bcc: Mr. A. Barkshire

[illegible]

Seattle Office · 1840 Washington Building · Seattle, Washington 98101

STRUCTURAL STEEL DIVISION

Pacific Car and Foundry Company

80 SOUTH HUDSON·SEATTLE, WASHINGTON 98134·RO 2-7440

April 4, 1969 D-666 PCF ØP-202

The Port of New York Authority
111 Eighth Avenue - Room 300
New York, New York 10011

Attention: Mr. R. M. Monti

Reference: World Trade Center
Contract WTC 214.00
PCF Project D-6

Subject: Material Subst

Gentlemen:

We have so far received ov arrived at
the point in fabrication w to suit
the materials on hand.

43

IN placing the original o , we had to
make allowances for cutti e obviously
attempted to hold these a ection of
material wastes that we u e yield and
thickness and insufficien itute mater-
ials having yield and/or n drawings,
we will be able to use th and control
problems which could be ll as holding
as close as possible to

The attached list shows e to make.
Most of these changes ar Revision 1,
approved by Messrs. Skilling Helle Christiansen ...... er 25, 1968.
Since all substitutions slightly increase either the thickness or the physical properties specified on design drawings, we do not anticipate any problem and are proceeding immediately on this basis. The only exceptions are mechanical floor unit Ø11, which we downgraded 5 k.s.i. The mill test report for this material, heat #L8799 (copy attached) gives physical properties above design requirements.

If you have any comments, please advise us as soon as possible.

Yours very truly,

R.C.Symes, Project Manager

RCS:ca
Attachments
cc: J. White (SHCR)
M. Gerstman (TRCC)

PACIFIC CAR AND FOUNDRY COMPANY
Attachment to letter PCF #P-202
Sheet 1 of 2

MATERIAL SUBSTITUTIONS

	Prod. Unit No.	Eng. Panel No.	Material Location	Material Specified on Design Drawings	Sub
Side	1156	A 457-53-50	PL 2 Col 1 and 2	FY 100 x 1/4"	FY
	1157	A 206-52-49	PL 2 Col 1, 2 and 3	FY 100 x 1/4"	FY
	1172	A 212-56-53	PL 2 Col 1	FY 100 x 1/4"	FY
	1325	A 333-54-51	PL 1 Col 3	FY 55 x 1 5/8"	FY
	1437	B 357-13-10	PL 1 Col 1	FY 55 x 2 1/8"	FY
	1446	B 303-13-10	PL 1 Col 3	FY 55 x 2 1/8"	FY
	1471	B 157-16-13	PL 1 Col 1	FY 50 x 2 1/16"	FY
	1472	B 103-16-13	PL 1 Col 3	FY 50 x 2 1/16"	FY
	1515	B 239-13-10	PL 1 Col 1 and 2	FY 50 x 1 15/16"	FY
	1539	B 127-17-14	PL 1 Col 1	FY 50 x 2 11/16"	FY
	1590	B 109-14-11	PL 1 Col 1	FY 45 x 2 5/8"	FY
	1611	B 318-17-14	PL 1 Col 1	FY 45 x 2 11/16"	FY
	1611	B 138-17-14	PL 1 Col 1	FY 45 x 2 11/16"	FY
	1617	B 321-13-10	PL 1 Col 2	FY 45 x 2 7/8"	FY
	1627	B 321-13-10	PL 1 Col 1	FY 42 x 2 7/8"	FY
	1625	B 409-11-9	PL 1 Col 3	FY 65 x 1 7/16 x 24'1	FY F[illegible] u[illegible]
	92	A 100-50-52	PL 1 Col 2	FY 100x 1 1/8"	F
	95	A 300-58-60	PL 1 Col 1	FY 80 x 13/16"	F

Material Substitutions
Attachment to PCF letter JP-202
Sheet 2 of 2

	Prod. Unit No.	Eng. Panel No.	Material Location	Material Specified on Design Drawings	S
crner	98	A 300-50-52	PL 1 Col 2	FY 80 x 1 1/8"	F
	116	B 200-18-16	PL 1 Col 1	FY 65 x 2 1/16"	F
	120	B 100-23-21	PL 1 Col 1	FY 60 x 1 5/8"	F
	121	B 100-21-19	PL 1 Col 1	FY 60 x 1 11/16"	F
Mech.	11	A 406-43-40	PL 2 Col 2	FY 80 16 3/8 x 3/8"	F
	21	A 248-43-40	PL 1 Col 1	FY 65 x 1 5/16"	F

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-5574

John B. Skilling • Helge J. Helle • John. V. Christiansen • Leslie E. Robertson

Consultants
Harold L. Worthington
Joseph F. Jackson

June 11, 1968

Port of New York Authority
Office of the Construction Manager
30 Church Street Room 1119
New York, New York 10007
Att: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, Pittsburgh-Des Moines
Panels 154B, 157B, Plate TD7

Gentlemen:

Mr. Fish of PDM has contacted SHCR by telephone May 28, 1968 requesting permission to use Plates TD7 of 3/4 inch thickness in lieu of 5/8 and 1/2 inch plates presently shown in the Drawings. This request is approved by SHCR. Plates TD7 occur at the top of spandrels at reference level D (7th Floor level).

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

James White

cc. Lester Feld – PNYA
H. M. Fish – PDM
William Thomas – PTL

WAYNE A. BREWER
P. B. A. FOSTER
FRANK HOELTERHOFF
ROBERT E. LEVIEN
V. A. PRISADSKY
KENT A. ROGERS
CHARLES SANDURKY
WILLIAM O. WARD
E. J. WHITE, JR.
LORENZO L. WIDING

SEATTLE OFFICE: 1840 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

THE PORT OF NEW YORK AUTHORITY

World Trade Department
Guy F. Tozzoli, Director

Malcolm P. Levy, Chief, Planning & Construction Division
R. M. Monti, Construction Manager Telephone (212) 267-7000 Office of the Construction Manager 30 Church St., New York, N.Y. 10007

December 18, 1967

Pittsburgh-Des Moines Steel Company
Neville Island
Pittsburgh, Pennsylvania 15225

Attention: Mr. H.M. Fish

Subject: The World Trade Center - Contract WTC 213.00 - Approval of Thickness Substitutions on E-1 Plates

Gentlemen:

My letter of September 29, 1967 granted approval to increase the thickness of certain E-1 plates in accordance with the Pittsburgh-Des Moines sketch No. QT-1 subject to the clarification of several items. Your disposition of these items as outlined in the Pittsburgh-Des Moines letter of October 17, 1967 has been reviewed and found to be satisfactory.

This will confirm that this change is approved subject to the understanding that there will be no additional cost to the Authority from Pittsburgh-Des Moines and that the Authority will not backcharge Pittsburgh-Des Moines for the additional design costs incurred in reviewing this request.

Very truly yours,

R.M. Monti
Construction Manager
The World Trade Center

CC: J. Endler (TRCC), L. Robertson (SCHR), H. Tessler

THE PORT OF NEW YORK AUTHORITY
111 Eighth Avenue at 15th Street, New York, N.Y. 10011

World Trade Department
Guy F. Tozzoli, Director
Richard C. Sullivan, Director, The World Trade Center

Malcolm P. Levy, Chief, Planning & Construction Division
R. M. Monti, Construction Manager   Telephone (212) 620-7978

October 26, 1967

Skilling-Helle-Christiansen-Robertson
230 Park Avenue
New York, New York 10017

Attention: Mr. Leslie E. Robertson

Gentlemen:

Ref: DBM Letter of 6/30/67, SHCR letter dated 9/25/67, R. M. Monti's letter dated 9/23/67

Attached is an October 17, 1967 letter from the fabricator in which he comments on the conditions for approval of substitution of materials contained in my letter dated September 29, 1967. Kindly review these comments and advise the undersigned as to what information or action is now required from the fabricator in order that final approval can be given to this request for substitution. Also, advise as to the time and cost of design for this change.

Very truly yours,

THE PORT OF NEW YORK AUTHORITY

R. M. Monti
Construction Manager
The World Trade Center

RMM:rw

cc: Brown, Endler (TRAC), Feld, Tessler

R.C.C.

Pittsburgh-Des Moines Steel Company

Engineers
Fabricators
Constructors

NEVILLE ISLAND · PITTSBURGH, PENNSYLVANIA 15225 · AREA CODE 412
PHONE 331-3000

October 17, 1967

Mr. R. M. Monti
Construction Manager
Room 1119
The Port of New York Authority
30 Church Street
New York, New York 10007

Re: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138

Gentlemen:

We wish to thank you for reviewing our letter of August 30, 1967 and granting us permission to increase the thickness of plates E1 as outlined on attached sheet, No. QT-1, for eleven specified columns. We understand that this permission is contingent upon our compliance with certain provisions as outlined in your letter of September 29, 1967, and submit the following comments:

1. Material Specifications:
Proposed plates E1 will have the same thickness and yield strength as the adjacent plates F-1, now called for, and therefore will comply with the same material specifications now included in section 203 of the specification.

2. Welding Procedure:
Welds for proposed plates E1 will be made under the same conditions as welds now called for on plates F-1 and welding procedures with provision for preheat and interpass temperatures will be submitted for both E1 and F-1 plates at an early date.

Pittsburgh-Des Moines Steel Company

-2-

Mr. R. M. Monti
PDM Contract 17078 & 17138

October 17, 1967

We recognize that this proposed change in E1 plates for eleven columns is at our request and no additional cost to the Authority will be made by Pittsburgh-Des Moines Steel Company for this change. We also recognize that this proposed change in plates E1 will require redesign work by Skilling-Helle-Christiansen-Robertson structural engineers and revision of design drawings effected by the change. If there will be charge to us or appreciable delays due to this redesign work, we request that we be advised prior to final approval of this change.

Very truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

H M Fish

H. M. Fish, Project Manager

rw

Enclosure

cc: Mr. H. A. Tessler
Manager, Project Planning
The Port of N.Y. Authority
Room 300
111 Eighth Avenue
New York, New York 10011
w/one copy of QT-1

Mr. J. Endler, Asst. V.P.
Tishman Realty & Construction Co.
11th Floor, 30 Church Street
New York, New York 10007
w/one copy of QT-1

PITTSBURGH-DES MOINES STEEL CO.

PDM 717078

CONT. NO. 17138 SUBJECT WORLD TRADE CENTER PAGE NO. 9

MADE BY JCD DATE 8-30-67 CHECKED BY DATE

WELDING BY DATE

P.O.N.Y.A. CONTRACT WTC 213.00

PROPOSED CHANGE: (TREE PANELS) PLATES E1 - DECREASE YIELD STRENGTH (FY) AND INCREASE THICKNESS (t) SO THAT PLATES E1 ARE THE SAME AS PLATES F1, IN THE FOLLOWING CASES:

PANELS No.	PRESENT DESIGN FY KIPS	t INCHES	PROPOSED DESIGN FY KIPS	t INCHES
142B, 145B	50	5	42	6
230B, 233B	55	3 3/8	42	4 1/2
* 245B	60	3 1/4	45	4 1/4 *
251B	65	2 3/8	45	3 5/8
315B, 318B	50	5	42	6
409B	55	2 3/8	42	3 5/8
427B, 430B	60	3 3/8	45	4 1/2

* NOTE: IN PANEL 245B, YIELD AND THICKNESS OF PROPOSED PLATE E1 GIVE SLIGHTLY LESS TOTAL STRENGTH THAN YIELD AND THICKNESS OF PRESENT DESIGN. IF THE DIFFERENCE CANNOT BE ABSORBED BY DESIGN SAFETY MARGIN, FURTHER CONSIDERATION MAY BE REQUIRED IN THIS PANEL.

THE PORT OF NEW YORK AUTHORITY

World Trade Department
Guy F. Tozzoli, Director

Malcolm P. Levy, Chief, Planning & Construction Division

R. M. Monti, Construction Manager Telephone (212) 267-7680 Office of the Construction Manager 30 Church St., New York, N.Y. 10007

December 18, 1967

Pittsburgh-Des Moines Steel Company
Neville Island
Pittsburgh, Pennsylvania 15225

Attention: Mr. H.M. Fish

Subject: The World Trade Center - Contract 213.00 - Approval of Lukens' ASTM-A441-Modified

Gentlemen:

Your November 24, 1967 letter which transmitted a Lukens Steel Company letter dated November 20th with accompanying Lukens specification for ASTM-A441-Modified Steel revised November 16, 1967, has been reviewed and approval of this steel is hereby granted provided it does not result in additional costs to the Authority.

Sincerely,

R.M. Monti
Construction Manager
The World Trade Center

CC: Messrs. L. Robertson (SHCR), W.R. Pressler (PTL) - with attach.

CABLE: PITTDEMOIN
TELEX 086-734

PDM Pittsburgh-Des Moines Steel Company

Engineers
Fabricators
Constructors

NEVILLE ISLAND • PITTSBURGH, PENNSYLVANIA 15225 • AREA CODE 412
PHONE 331-3000

November 24, 1967

Mr. R. M. Monti
Construction Manager
Room 1119
The Port of New York Authority
30 Church Street
New York, New York 10007

Re: The World Trade Center
Contract WTC-213.00
PDM Contract 17078 & 17138

Gentlemen:

As requested in your letter of October 27, 1967 we are enclosing one (1) copy of Lukens Steel Company's specification for ASTM-A441-Modified.

With the receipt of this specification we trust you will give us final approval for the thirty-six E2 plates requested in our letter of August 31, 1967. If possible we will appreciate a phone call so we can release Lukens Steel Company and your formal letter to follow.

Very ;truly yours,

PITTSBURGH-DES MOINES STEEL COMPANY

H. M. Fish

H. M. Fish, Project Manager

cc: Mr. H. A. Tessler

Mr. Al Guttentag

HAMMOND PRODUCTS

THE PORT OF NEW YORK AUTHORITY

111 Eighth Avenue at 15th Street, New York, N.Y. 10011

Construction Manager's Office
30 Church Street - Room 1119
New York, New York 10007

World Trade Department

Guy F. Tozzoli, Director

Richard C. Sullivan

Malcolm P. Levy, Chief, Planning & Construction Division

R. M. Monti, Construction Manager

October 27, 1967

Pittsburgh-Des Moines Steel Co.
Neville Island
Pittsburgh, Pennsylvania 15225

Attention: Mr. H. M. Fish

Re: The World Trade Center - Contract WTC-213.00 - <u>Approval of Lukens A-441 Steel</u>

Gentlemen:

Approval for the use of the Lukens Steel Company's specification for A441-66 steel was granted in my letter of October 13th, subject to conformance with six items. Please be advised that Item No. 5 - Table II - Tensile Requirements of ASTM A441-66 shall be deleted and replaced as follows:

<u>TABLE II - TENSILE REQUIREMENTS</u>

	<u>Plate only</u>	
	Up to 1½" inclusive	Over 1½" to 3" max.
Tensile strength, min, ksi	75	75
Yield point, min, ksi	60	55
Elongation in 8", min, per cent	18(a)	--
Elongation in 2", min, per cent	--	24(b)

(a) Refer to paragraph 5(c)
(b) Refer to paragraph 5(d)

This change is a result of direct discussions between the Authority's Consultant, Skilling-Helle-Christiansen-Robertson, and the Lukens Steel Co. Kindly obtain from the Lukens Steel Company, a specification for this material which incorporates all of the modifications and forward it to the undersigned for the purpose of confirming these modifications.

Sincerely,

R. M. Monti
Construction Manager
The World Trade Center

Copy to: Messrs. J. R. Endler (TRCC)

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

Consulting Structural and Civil Engineers · 230 Park Avenue, New York, N. Y. 10017 · Mu. 9-8874

John B. Skilling · Helge J. Helle · John V. Christiansen · Leslie E. Robertson

Consultants
Harold L. Worthington
Joseph F. Jackson

October 17, 1967

Port of New York Authority
Office of the Construction Manager
30 Church Street
New York, New York

Attention: Mr. R. Monti

Reference: The World Trade Center
Contract WTC-213.00, PDM
Steel Plate Substitutions (ASTM A441 Mod.)

Gentlemen:

Please refer to our letter of October 11, 1967, discussing the above captioned subject. Item 5, Table II, shown on page 2 of our letter shall be replaced with the following:

5. Table II - Tensile Requirements of ASTM A441-66 shall be replaced as follows:

TABLE II - TENSILE REQUIREMENTS

	Plate only	
	Up to 1½" inclusive	Over 1½" to 3" max.
Tensile strength, min, ksi	75	75
Yield point, min, ksi	60	55
Elongation in 8", min, per cent	18(a)	--
Elongation in 2", min, per cent	-	24(b)

(a) Refer to paragraph 5(c)
(b) Refer to paragraph 5(d)

WAYNE A. BREWER
[illegible]
FRANK HOLLENBECK
ROBERT E. [illegible]
[illegible]
KENT W. ROGERS
CHARLES SANDBURG
WILLIAM D. [illegible]
E. J. WHITE, JR.
LORENTZ L. WIDING

SEATTLE OFFICE · 1840 WASHINGTON BUILDING · SEATTLE, WASHINGTON [illegible]

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

M. Monti - 2 - October 17, 1967

This revision is in accordance with final data received from Lukens Steel Company by telephone on Monday, October 16, 1967.

PDM should ask Lukens to furnish a final copy of Lukens' specification of this material confirming the data in this letter and our letter of October 11, 1967.

Very truly yours,

SKILLING-HELLE-CHRISTIANSEN-ROBERTSON

James White

JW:e
cc: Mr. L. Feld, PNYA
Mr. R. Fich, PDM
cc: RE

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON
Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-5574
John B. Skilling • Helge J. Helle • John. V. Christiansen • Leslie E. Robertson

Consultants
Harold L. Worthington
Joseph F. Jackson

May 3, 1968

Port of New York Authority
Office of the Construction
Manager - Room 1119
30 Church Street
New York, New York 10007

Attention: Mr. R. M. Monti

Reference: The World Trade Center
Contract WTC-213.00, Pittsburgh-Des Moines
Radiographic Inspection

Gentlemen:

Mr. Fish of PDM has asked permission to revise the radiographic inspection provisions presently included in the PDM quality control program as they relate to the full-penetration butt weld joining spandrel plate D4 (shown on the shop drawings as plate "c") and plate E3 (shown on the shop drawings as plate "k"). SHCR has reviewed this request, and suggest that the following program be followed.

1. The first 16 column trees in Tower A shall have one radiograph taken at each end of the subject full-penetration weld.

2. Should no defective weld be found, one radiograph at one end of the subject weld will be required for each remaining column tree.

3. For each defective length of weld found, one additional column tree shall be subjected to one radiograph at each end of the subject weld.

WAYNE A. BREWER
P. S. A. PORTER
FRANK HOELTERHOFF
ROBERT E. LEVIEN
V. A. PRIBADENT
KENT R. ROGERS
CHARLES SANDUSKY
WILLIAM E. WARD
E. J. WHITE, JR.
LORENTZ L. WIDING

SEATTLE OFFICE, 1940 WASHINGTON BUILDING, SEATTLE, WASHINGTON 98101

SKILLING - HELLE - CHRISTIANSEN - ROBERTSON

PNYA 2 May 3, 1968

4. Where a radiograph shows a length of defective weld, the adjacent length of weld (approximately 16") shall be radiographed. If no additional defects are indicated, the subject weld will require no additional length to be radiographed.

5. All defects found by radiography shall be repaired and shall be subjected to re-inspection by radiography.

This program will concentrate radiographic testing performed by PDM on the ends of the full-penetration weld along Reference Line No. 2 (approximately 98-3/4" long), thereby concentrating on the most critical lengths of the subject weld. The additional benefit of the above program is that the amount of radiography reqired for a given panel is greatly reduced in comparison to the 100 percent reqirement stated in the PDM quality control program. The overall percentage of weld inspected in the program outlined above is comparable to that originally required in the PDM quality control program. We suggest that 16 radiographic tests be allocated by PDM to random assignment by the PTL inspector at locations selected by the PTL inspector after the start of fabrication of column-tree panels for Tower B.

In order to make absolutely sure that there is no confusion in identifying the weld referred to in this letter, the weld under discussion is the full-penetration weld shown in detail 19, sheet 2-AB2-11, Drawing Book 2.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White LTK

James White

JW:m

cc: Mr. L. S. Feld, PNYA
Mr. H. M. Fish, PDM

SKILLING – HELLE – CHRISTIANSEN – ROBERTSON

Consulting Structural and Civil Engineers • 230 Park Avenue, New York, N. Y. 10017 • Mu. 9-8874

John B. Skilling • Helge J. Helle • John. V. Christiansen • Leslie E. Robertson

April 18, 1968

Consultants
Harold L. Worthington
Joseph F. Jackson

Port of New York Authority
Office of the Construction
Manager – Room 1119
30 Church Street
New York, New York 10007

Attention: Mr. R.M. Monti, Construction Manager

Reference: The World Trade Center
Contract WTC 217.00, Stanray
Magnetic particle testing

Gentlemen:

We have reviewed the Stanray letter dated March 26, 1968, requesting permission to inspect a minimum of ten percent of the linear footage of welds on one flange of one member out of each two fabricated members at such times that the rejection rate of welds allows the minimum inspection rate. We approve this change to the Stanray Pacific quality control program.

Very truly yours,

SKILLING, HELLE, CHRISTIANSEN, ROBERTSON

James White

JW:bc

cc: Mr. Lester Feld, PNYA
Mr. Robert Morris, STANRAY

bcc: Mr. Richard Chauner, SHCR, SE.

WAYNE A. [illegible]
P. [illegible]
FRANK [illegible]
ROBERT [illegible]
V. A. [illegible]
[illegible]
CHARLES [illegible]
WILLIAM D. [illegible]
E. J. WHITE [illegible]
[illegible]

SEATTLE OFFICE · [illegible] WASHINGTON BUILDING, SEATTLE, WASHINGTON [illegible]

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