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WHC-SD-WM-DA-177 Rev. 0 Structural Integrity Analysis of the 224U Elevator Mothballing		ECN No. N/A

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Document Number: WHC-SD-WM-DA-177, REV.0

Document Title: Structural Integrity Analysis of the 224U Elevator Mothballing

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**This document was reviewed following the
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APPROVED FOR PUBLIC RELEASE

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SUPPORTING DOCUMENT		1. Total Pages 12
2. Title Structural Integrity Analysis of the 224U Elevator Mothballing		3. Number WHC-SD-WM-DA-177
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5. Key Words 224U, ELEVATOR, MOTHBALL 11/18/94		6. Author Name: William M Boehnke Signature Organization/Charge Code W17140/KP43A
7. Abstract This document provides an analysis of the structural integrity of all structural components associated with mothballing the 224U elevator. This analysis was prompted by the need to mothball the elevator so that it may be used by the D & D group after 10 to 25 years. This document shows that the structural components as specified by this SD have the required structural capacity to safely support the elevator and its components.		
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WHC-SD-WM-DA-177

Rev. 0

Structural Integrity Analysis of the 224U Elevator Mothballing

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William M Boehnke

PUREX/VO₃ Design Engineering

October 31, 1994

MASTER

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ANALYTICAL CALCULATIONS

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Subject WHC-SD-WM-DA-177 Rev. 0 - 224U Elevator Mothballing

Originator William M. Boehnke *W.M. Boehnke*

Date 11/3/94

Checker Kurt A. Lenkersdorfer *K.A. Lenkersdorfer*

Date 11/3/94

BACKGROUND

As part of the preparation of Building 224U for turnover to D&D, it is necessary to place the elevator in a mothballed condition so that it can be reactivated for use after 10 to 25 years. This mothballing is going to be accomplished by landing the counterweight on wooden timbers and suspending the elevator cab with wire rope or chain slings. This will take the load off the cables and make it relatively easy to reactivate. See Figure 1, for the normal configuration of the elevator.

OBJECTIVE

The objective of this Supporting Document is to verify the structural integrity of all of the load bearing components involved in mothballing the 224U Building elevator.

CITED REFERENCES

1. AISC - Manual of Steel Construction, Allowable Stress Design; American Institute of Steel Construction, 9th edition, 1989.
2. Shigley and Mischke - Mechanical Engineering Design; McGraw-Hill, Inc., 5th edition, 1989.
3. Marks' Standard Handbook for Mechanical Engineers; McGraw-Hill, 9th edition, 1987.

DESIGN ALLOWABLES

Minimum Yield Strength, $F_y = 36$ ksi (ASTM A-36)

Allowable Shear Stress, $F_v = (0.40)F_y = 14.4$ ksi (Ref 1, 5-49)

Allowable Tensile Stress, $F_t = (0.60)F_y = 21.6$ ksi (Ref 1, 5-40)

Allowable Bending Stress, $F_b = (0.66)F_y = 23.8$ ksi (Ref 1, 5-45)

ANALYTICAL CALCULATIONS

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Date 11/3/94

Figure 1 - Normal Configuration of Elevator

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Figure 2 - Elevator Car and Counterweight Supported

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Date 11/3/94

ANALYSIS

Consider the Stresses in the Elevator Shaft Roof Beams:

Since these beams were designed to support the total load of the elevator, penthouse, and equipment in the penthouse, it is given that they are adequate for the original loading. This analysis will be limited to the loads induced by the elevator cab supports to be installed for mothballing.

Beam Fixed at Both Ends - Concentrated Load at Center (Ref 1, 2-301)

Max Shear,
$$V = R = \frac{P}{2} = \frac{2600 \text{ lb}}{2} = 1300 \text{ lb}$$

Max Moment,
$$M = \frac{PL}{8} = \frac{(2600 \text{ lb})(124 \text{ in})}{8} = 40,300 \text{ lb}\cdot\text{in}$$

Properties of W 12x26 (conservative estimate for a W 12x28, Ref 1, 1-28):

$A = 7.65 \text{ in}^2$ Flange Thickness, $T_f = 0.380 \text{ in}$
 $S = 33.4 \text{ in}^2$ Web Thickness, $t_w = .230 \text{ in}$

(Ref 2, 44 & 52):

Actual Bending Stress,

$$\sigma = \frac{M \cdot C}{I} = \frac{M}{S} = \frac{40,300 \text{ lb}\cdot\text{in}}{33.4 \text{ in}^3} = 1,207 \text{ psi} < F_b \quad F.S. = 19.7$$

Actual Shear Stress,

$$\tau = \frac{V}{A} = \frac{1300 \text{ lb}}{7.65 \text{ in}} = 170 \text{ psi} < F_v \quad F.S. = 84.7$$

Therefore, the two roof beams will adequately hold the load supported in the center.

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Checker Kurt A. Lenkersdorfer *K. A. Lenkersdorfer*

Date 11/3/94

ANALYSIS - CONTINUED

Consider the Wire Rope/Chain Supports:

As shown in Figure 2, the support ropes/chains will be at a slight angle. What will be the actual load due to the resulting angle?

$$\Sigma F_y = 0 = F_{Ay} + F_{By} = 5200$$

$$\Sigma F_x = 0 = F_{Ax} = F_{Bx}$$

$$F_A = F_B \text{ (By Inspection)}$$

$$F_{Ay} = F_{By}$$

$$\therefore F_y + F_y = 5200$$

$$2F_y = 5200$$

$$F_y = 2600$$

$$\tan \frac{\alpha}{2} = \frac{15}{93} = 0.161290$$

$$\frac{\alpha}{2} = 9.162^\circ$$

$$F_y = F \cdot \cos \frac{\alpha}{2} = 2600$$

$$F = \frac{2600}{\cos \frac{\alpha}{2}}$$

$$F = 2633.6 \text{ lb}$$

Therefore, for each support to be able to carry twice the load, each must have a minimum working capacity of:

$$2F = \underline{5268 \text{ lb}}$$

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ANALYSIS - CONTINUED

Consider The Crosshead Channels:

The crosshead channels are two C10x15.3 Channels back-to-back spaced 8-5/8" apart with the sheaves in between. They are welded to the rest of the cab frame on both ends. They have several spacers and supports which eliminate the possibility of them being crushed together horizontally. Therefore, this analysis only considers the vertical stresses.

As before,

$$V_{MAX} = \frac{P}{2} = \frac{2600 \text{ lb}}{2} = 1300 \text{ lb}$$

$$M_{MAX} = \frac{P \cdot L}{8} = \frac{(2600 \text{ lb}) \cdot (86 \text{ in})}{8} = 27,950 \text{ lb} \cdot \text{in}$$

Properties of C 10x15.3 (Ref 1, 1-40):

$$A = 4.49 \text{ in}^2$$

$$S = 13.5 \text{ in}^3$$

$$\sigma = \frac{M}{S} = \frac{27950 \text{ lb} \cdot \text{in}}{13.5 \text{ in}^3} = 2,070 \text{ psi} \quad F.S. = 11.5$$

$$\tau = \frac{V}{A} = \frac{1300 \text{ lb}}{4.49 \text{ in}^2} = 290 \text{ psi} \quad F.S. = 50$$

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Date 11/3/94

ANALYSIS - CONTINUED

Consider The Beam Clamps:

As with the support chain/rope, each beam clamp shall have a minimum working capacity of 5268 lb.

The proposed beam clamp is the model B-1, 3 ton, 3 - 6-1/2" flange width range manufactured by JC Renfroe & Sons, Inc.

J.C. RENFROE & SONS, INC.
JACKSONVILLE, FLORIDA 32206

MODEL B-1 3 TON (3 - 6 1/2) FLANGE WIDTH *10-12-94*

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Checker Kurt A. Lenkersdorfer *K.A.L.* Date 11/3/94

ANALYSIS - CONTINUED

Consider the Stresses in the Beam Due to the Beam Clamps:

Due to the geometry of the beam clamp, the beam flange will be totally in shear, and the beam web will be totally in tension. Furthermore, this conservatively only considers the portion of the beam in contact with the width of the clamp:

Properties of this section:

$$A_{FLANGE} = c \cdot d = (2.25 \text{ in}) \cdot (.380 \text{ in}) = 0.855 \text{ in}^2$$

$$A_{WEB} = t_w \cdot c = (.230 \text{ in}) \cdot (2.25 \text{ in}) = 0.5175 \text{ in}^2$$

Shear Stresses:

$$V = P = 1316.8 \text{ lb}$$

$$\tau = \frac{V}{A_{FLANGE}} = \frac{1316.8 \text{ lb}}{0.855 \text{ in}^2} = 1540 \text{ psi} \quad F.S. = 9.4$$

Tensile Stresses:

$$V = P = 2633.6$$

$$\sigma = \frac{V}{A_{WEB}} = \frac{2633.6 \text{ lb}}{0.5175 \text{ in}^2} = 5,089 \text{ psi} \quad F.S. = 4.2$$

Therefore, considering only one support carrying the entire load, and conservatively neglecting the contribution of the rest of the beam, it still has a Factor of Safety of 4.2.

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ANALYSIS - CONTINUED

Consider the Supports for the Counterweight:

Consider using two 6x6 wooden timbers, $F_c = 1,000$ psi

NOTE: This is the lowest (No. 1) commercial grade timber based on the West Coast Lumber Inspection Bureau (Ref 3, 6-128).

Properties (Ref 3, 6-128, 12-25):

Actual Dimensions: 5.5 in x 5.5 in

$A = 30.25 \text{ in}^2$

$I = bd^3/12 = 76.2552 \text{ in}^4$

$E = 1,600,000 \text{ psi}$

Conservatively model as a Long Column with One End Fixed and One End Free (Ref 2, 121-122)

Critical Load,

$$P_{cr} = \frac{\pi^2 \cdot E \cdot I}{(2 \cdot L)^2} = \frac{\pi^2 \cdot (1,600,000 \text{ psi}) \cdot (76.2552 \text{ in}^4)}{[(2) \cdot (36 \text{ in})]^2}$$

$$P_{cr} = 232,287 \text{ lb} \quad (\text{at } L = 36 \text{ in})$$

Worst case scenario is for L to be 72 in.

$$P_{cr} = 58,071 \text{ lb} \quad (\text{at } L = 72 \text{ in})$$

Consider it to be an intermediate column (Ref 2, 124):

$$\frac{P_{cr}}{A} = S_y - \left(\frac{S_y}{2\pi} \cdot \frac{1}{k} \right)^2 \cdot \frac{1}{CE} = 1000 - \left(\frac{1000}{2\pi} \cdot \frac{36}{2.521} \right)^2 \cdot \frac{1}{(.25) \cdot (1,600,000)}$$

$$P_{cr} = 29,859 \text{ lb} \quad (\text{at } L = 36 \text{ in})$$

$$P_{cr} = 28,683 \text{ lb} \quad (\text{at } L = 72 \text{ in})$$

Therefore, even if the timber supports need to be 6 feet tall, there still is a Factor of Safety of:

$$F.S. = \frac{\text{CRITICAL LOAD}}{\text{ACTUAL LOAD}} = \frac{28,683}{8900} = 3.2 \quad (\text{ONLY CONSIDERING ONE TIMBER})$$

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SUMMARY AND CONCLUSIONS

The 224U Elevator can be safely and securely mothballed as shown in Figure 2, page 2. The following components, at a minimum, shall be used to achieve this:

<u>QTY</u>	<u>DESCRIPTION</u>
2	6x6 Wooden Timbers, minimum allowable compressive stress parallel to grain, $F_c \geq 1,000$ psi
4	Beam Clamps - JC Renfro & Sons, Inc., model B-1, 3 ton, 3 - 6-1/2" flange width)
40 ft	Wire Rope or Chain with a minimum working capacity of at least 5268 lb. NOTE: If wire rope is used, it must be protected from the corners of the Channels by using an appropriate overlay.