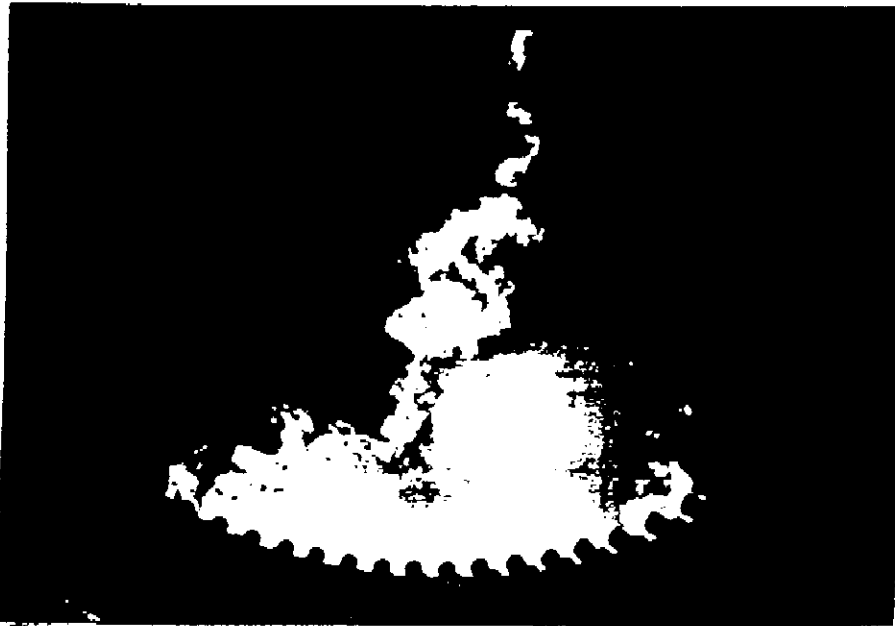


**THE STRUCTURAL STABILIZATION OF THE NEW YORK STATE PAVILION  
LOCATED IN FLUSHING MEADOW CORONA PARK, BOROUGH OF QUEENS,  
KNOWN AS CONTRACT NUMBERS Q099-1695 TO Q099-1895  
DESIGN CONTRACT NUMBER CNYG-195**



Prepared For:

**NYC DEPARTMENT OF PARKS & RECREATION**

Prepared By:

**JOHN CIARDULLO ASSOCIATES  
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NEW YORK, N.Y. 10019**

October 2, 1996

**Q-RE-99-11400 ✓**

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THE STRUCTURAL STABILIZATION OF THE NEW YORK STATE PAVILION LOCATED  
IN FLUSHING MEADOW CORONA PARK, BOROUGH OF QUEENS, KNOWN AS  
CONTRACT NUMBERS Q099-1695 TO Q099-1995  
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USTA National Tennis Center Soil Boring Logs

**SUMMARY OF THE STRUCTURAL STABILIZATION STUDY OF THE NEW YORK STATE PAVILION WHICH IS PREPARED BY JOHN CIARDULLO ASSOCIATES**

CATED  
/N AS

The New York State Pavilion in Flushing Meadows Corona Park, Queens, was constructed for the 1964-1995 Worlds Fair. The pavilion consists of three parts; the Theaterama, the Tent of Tomorrow with indoor exhibition areas and the Observation Towers. John Ciardullo Associates (JCA) has completed an investigation that includes inspections of the "Tent of Tomorrow" and the "Towers".

2, 1996

**The Tent of Tomorrow**

The compression and tension rings are structurally sound. The concrete columns and pile caps are also structurally sound. However, the untreated wood piles have continued to deteriorate since 1992 investigation by Geiger Engineers. Due to the continued rot of the supporting wood piles immediate action must be taken to secure the Tent of Tomorrow from further deterioration and collapse. JCA recommends that in the best interest of the City, and for the safety of the general public, that an emergency contract for either stabilization or demolition of the Tent of Tomorrow be issued forthwith. The cost to stabilize the foundations of the columns by pile replacement will cost between \$2,538,496.00 and \$3,654,416.00.

**The Exhibition Space**

JCA documented the deficiencies present in the perimeter structure, its mechanical systems and the promenade. These components are distressed and an overall plan for rehabilitation and reuse must be addressed. However, for the purpose of this report they discuss demolition and reconstruction of the perimeter structure. Since the roof structure is supported on grade beams on pile caps with piles of the same untreated wood, and the walls are supported on spread footings, they recommend demolition of the structure and driving of new steel piles with concrete pile caps, should the need for the existing structure be warranted.

**The Observation Towers**

The only portion of the Observation Tower that the report investigated was the elevators. One of which appears to be in the locked position at an observation level, and the other is dismantled in its elevator pit. JCA discusses the removal of these elevators and safing off the surrounding area, and the cost is \$12,000.00. Reviewing the cost of reconstruction/stabilization and demolition, the estimates prove to be significantly more than the monies allocated for this work.

**Cost Estimate**

The cost to demolish the Tent of Tomorrow and the Exhibition Space is included in the report as \$3,654,416.00 which include the complete removal of the structure as well as the grading and seeding of the site. The cost of stabilization/Restoration the Tent of Tomorrow and the Exhibition Space is \$8,178,192.00.

## Executive Summary

JCA has completed an investigation that includes inspections of the "Tent of Tomorrow" and the "Towers" associated with the New York State Pavilion in Flushing Meadows Corona Park, with intentions of preparing the following report. The components that make up the Tent of Tomorrow includes the tension and compression rings with cables, the concrete columns, pile caps and wood piles. The exhibition space and roof promenade are constructed of non-bearing masonry walls on spread footings enclosing the one story structure, the roof deck and steel columns supported on pile caps and wood piles. The Observation Tower investigated is limited to the two elevators that once accessed three observation platforms.

### The Tent of Tomorrow

The compression and tension rings are structurally sound, requiring minor repairs and paint. The associated cables would require replacement should a roof be added. The concrete columns require minimal concrete patch, but are structurally sound. The pile caps are also structurally sound. However, the untreated wood piles have continued to deteriorate since the 1992 investigation by Geiger Engineers. The continued wood rot has reduced the solid wood diameter from 12" to 6". The reduction of the pile area due to the soft rot reduces the ability of the pile to support the existing dead load. Our calculations demonstrate that with the reduced piles' capacity, with full lateral support, it is questionable that the soft rot can laterally support the wood pile, since buckling may result in the collapse of the structure. Due to the continued rot of the supporting wood piles immediate action must be taken to secure the Tent of Tomorrow from further deterioration and collapse. Presently, the threat of collapse exists, as does damage to the Theaterama and the public. JCA recommends that in the best interest of the City, and for the safety of the general public, that an emergency contract for either stabilization or demolition of the Tent of Tomorrow be issued forthwith.

### The Exhibition Space

JCA documented the deficiencies present in the perimeter structure, its mechanical systems and the promenade. These components are distressed and an overall plan for rehabilitation and reuse must be addressed. However, for the purpose of this report we discuss demolition and reconstruction of the perimeter structure. Since the roof structure is supported on grade beams on

pile caps with piles of the same untreated wood, and the walls are supported on spread footings, we recommend demolition of the structure and driving of new steel piles with concrete pile caps. should the need for the existing structure be warranted. It is cost prohibitive to try to repair the damage that already exists and obtain a Certificate of Occupancy for the Exhibition Space, and while the condition will worsen with time, the one story structure doesn't pose the same threats that the wood piles of the ten story tent structure poses. The loading here is substantially less.

### The Observation Towers

The only portion of the Observation Towers that our report investigated was the elevators, one of which appears to be in the locked position at an observation level, and the other is dismantled in its elevator pit. JCA discusses the removal of these elevators and safing off the surrounding area.

Reviewing the costs of reconstruction/stabilization and demolition, the estimates prove to be significantly more than the monies allocated for this work. We await further direction prior to proceeding with scheduling the required meetings with the Community Boards and the Borough President, as outlined in our scope of work.

### Estimate Data

The cost to stabilize the foundations of the columns by pile replacement as indicated in this report will cost between \$2,538,496.00 and \$3,788,800.00. Contract documents for this emergency work should be prepared and a contract issued as soon as possible.

The cost to demolish the Pavilion (with the exception of the three towers) is included in this report as \$3,654,416.00. This would include the complete removal of the structure as well as the grading and seeding of the site.

The cost for the balance of the stabilization/restoration work required at the pavilion is estimated in this report to be \$4,389,392.00

All estimates exclude costs for removal of hazardous material.

## Introduction

The New York State Pavilion in Flushing Meadows Corona Park, Queens, was constructed for the 1964-1965 Worlds Fair. The Pavilion consists of three parts; the Theaterama, the Tent of Tomorrow with indoor exhibition areas and the Observation Towers. Apart from the "Theaterama," the NYS Pavilion is in a state of gross deterioration. It requires immediate stabilization to maintain its mere existence, let alone enable future use.

The scope of our contract includes investigation of the structural integrity of the Tent of Tomorrow, the Exhibition Spaces and that of the Observation Towers. We will address these components separately in terms of documentation of existing conditions. We will make recommendations for reconstruction/stabilization about an entire capital improvement project with respect to safety, the community's needs and visions for future uses.

### I. Existing Documentation

The materials available to us for documenting the Tent of Tomorrow and the Observation Tower included the following:

- Partial Sets of Architectural Drawings
- Partial Sets of Mechanical Drawings
- Partial Sets of Electrical Drawings
- 1992 Structural Report prepared by Geiger Engineers.

### II. Method of Investigation

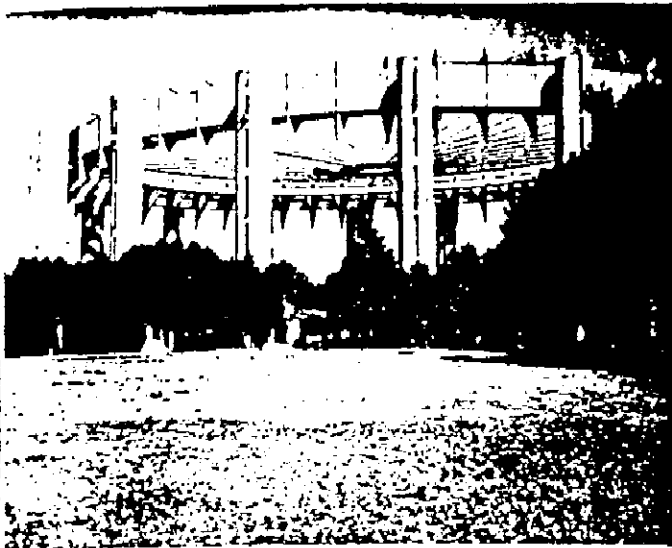
Due to the limited resources available from DPR, we sought and obtained the following:

#### A. Structural Drawings (obtained from Lev Zetlin Associates, the Engineer of Record)

- Pile Cap and grade beams drawings supporting the Promenade Level
- Cable Drawing for Tent
- Conversations with LZA indicated that steel piles were used to supplement the bearing capacity of the wood piles.

#### B. Soil boring logs were obtained from the USTA construction documentation

- Boring logs confirmed a bearing layer at 75'-80' below



grade.

- Boring logs confirmed a good bearing strata at 150' below grade.

C. Based on the above documentation, JCA conducted several on site field investigations. Two concrete columns (Column 'C' and Column 'K') were designated as representative of the structure on the site. At each column location, excavation was performed and the existing conditions were documented with respect to the condition of the surface material of the individual piles in the cluster, the pile cap and the surrounding water and soil conditions.

- Inspection pits were constructed.
- Visual inspections were substantiated with site photographs.
- Timber piles were exposed at representative locations and the piles were probed for depth of deterioration.
- Soil conditions were documented by means of visual inspection.

D. The Cables of the Compression and Tension Ring of the suspended structure were inspected in the field by JCA using a two person, 120' boom.

- All of the Tension Ring cable connections were visually inspected, and photographed.
- At the Compression Ring five cable connections were visually inspected and photographed.
- All of the typical steel sections of the Tension and Compression Rings were measured, and documented for use in calculations for actual dead loads.
- The bearing plates at two columns were inspected and documented.
- The cables were visually inspected, measured and photographed.

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### III. Pavilion components

#### A. The Tent of Tomorrow:

This is a large oval structure with an overhead cable suspension structure that supported a plexiglass roof during its use in the World's Fair. The circular space beneath the suspension structure was at one time covered with an oversized terrazzo map of New York State, which is deteriorated and beyond repair. This space was used for outdoor performances and roller skating after the World's Fair. Our report will investigate the following components of the Tent of Tomorrow:

1. Pile foundations Supporting Tent Columns
  - a) Existing Conditions of pile caps and piles
  - b) Load bearing Capacity
  - c) Longevity
  - d) Recommendations/Stabilization methods
  - e) Cost estimate to stabilize pile caps and piles
2. Roof Cables and Perimeter Ring Steel Structure
  - a) Existing Conditions
  - b) Stabilization/Reconstruction
  - c) Cost estimate to stabilize cable structure
3. Exhibition Space

The Exhibition Space consists of concrete masonry walls making up the perimeter structure wherein individual areas are sectioned off and toilet facilities exist. Above the actual structure a Roof Promenade comprises the upper level, which is accessed via stairways which are in a state of deterioration and currently pose a safety hazard.

- a) Concrete Masonry Walls (Perimeter Structure)
  - 1) Existing Conditions
  - 2) Stabilization/Reconstruction Options
- b) Roof Promenade of Perimeter Concrete Structure
  - 1) Existing Conditions
  - 2) Stabilization/Reconstruction Options

- c) **Stairways to Promenade**
  - 1) Existing Conditions
  - 2) Removal Implications
  - 3) Stabilization/Reconstruction Options
  
- d) **Central Court Pavement**
  - 1) Existing Conditions
  - 2) Stabilization/Reconstruction Options
  
- e) **Utilities/Building Systems**
  - 1) Existing Conditions
  - 2) Reconstruction/Upgrade Recommendations
  
- f) **Cost of Stabilization of Exhibition Space**

#### B. The Observation Towers Elevators

The Towers consist of three observation platforms that were accessed by two elevators, as well as stairs and platforms. The towers and the elevators have been unused for at least 20 years. The extent of this investigation will only include the elevators, with respect to removing and/or securing them to insure the public's safety, and with consideration for future use.

- 1. Towers
  - 1) Existing Conditions
  
- 2. Elevators
  - a) Existing Conditions
  - b) Recommendations
  - c) Cost Estimate to Remove Elevators

#### IV. Cost Estimates

- A. Costs of the Stabilization/Restoration of the New York State Pavilion
  
- B. Demolition of the New York State Pavilion

## A. The Tent of Tomorrow

### 1. Pile Foundations Supporting Tent Columns

#### Description

The Tent of Tomorrow is composed of 16 concrete columns arranged in an oval plan. Each column is a 12" thick cylindrical wall with an outside diameter of 12'-0", and is supported by a rectangular 4'-0" deep concrete pile cap. Each pile cap is supported by a cluster of wood piles. From the contract documents we have determined that a minimum of 26 piles make up each of the pile clusters. In addition, it was reported by Charles Thornton of the Structural Engineering firm of Lev Zetlin Associates. Thornton Tomasetti located at 641 6th Avenue, New York, New York 10011 that in addition to the 26 wood piles, up to four steel H piles were installed at each pile cap location to supplement the wood piles, some of which failed to reach the expected bearing capacity when driven to full length. Only one of these steel piles was discovered during the pile investigation and their impact on the adequacy of the existing pile cap foundations was ignored for the purpose of this study due to the fact that their exact locations are unknown and there may be pile cap pile clusters that do not contain any steel piles.

#### a) Existing Conditions of Pile Caps and Piles

- 1) Column C is supported by a pile cap on a pile cluster. The investigation pit excavated here exposed three untreated timber piles, A, B and C, and one "H" pile, D. At the location of our test pit, the bottom of the pile cap was 18" below grade, at the point of connection to pile cap.

- The concrete pile cap was visually inspected and showed no signs of distress.
- Piles A, B and C had a butt diameter of 13" below the pile cut off, with a 12-1/2" butt diameter at the water level. All piles were surrounded by soil containing tree roots (some of which penetrated the timber piles) and cinder materials.



1. View of test pit @ column C



2. Looking down test pit

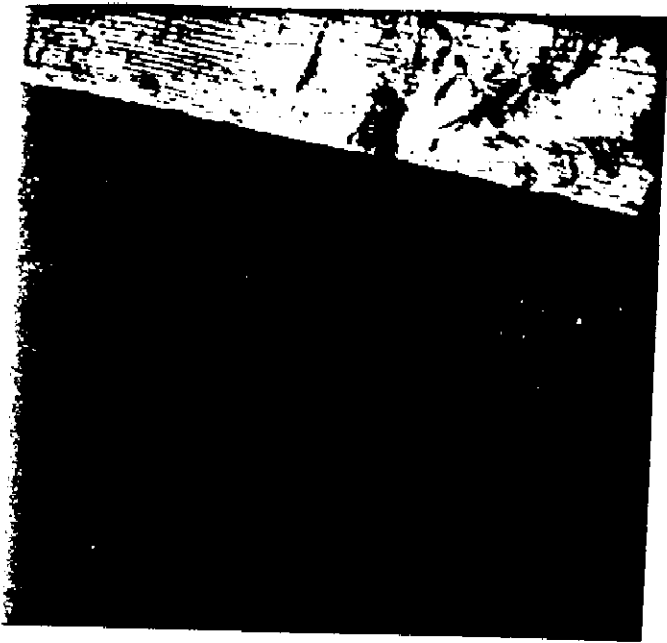


Probing @ deteriorated wood pile.



Probing @ deteriorated wood pile

- Pile A was exposed at a depth 3'-0" from the bottom of the pile cap. The pile was probed to a depth of 1-1/2" before a firm surface material was reached. The probed material was soft and rotten. This same pile was probed at a depth of 18'-0" below grade, which was 1'-6" below the water level. Here a probe pushed 1/2" into the pile, of which the probed material was continuously firm.
- Pile B was exposed 3'-0" below from the bottom of the pile cap. This pile was easily probed to a depth of 2-1/2", and with difficulty an additional 3/4" was probed. The surface material was soft and rotten.



4. Wood pile at water level



3. Steel "H" pile

- Pile C was exposed at a depth of 3'-0" from the bottom of the pile cap. The pile was easily probed to a depth of 3" before firm material was reached. The surface material was soft and rotten. At the water level, 18'-0" below grade, a probe was pushed 1/2" into firm material.
- Pile D, a steel pile, was exposed 3'-0" below the bottom of the pile cap and again at the water level, 18'-0" below grade. At both locations, the steel pile exhibits surface rust but is not deteriorated. Pile D is an uncoated A36 steel HP14 x 73 in soil that contains tree roots and cinder materials.

2) Column K is supported by a pile cap on a cluster of piles. The investigation pit excavated here exposed seven untreated timber piles. The pile cap had two horizontal cracks across the full face of the pit (4'-0" wide); these cracks were not recent and showed no sign of slippage or distress.

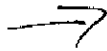
- Piles E, F, G, H, J, L all had a butt diameter of 12" at both the pile cut-off and at the water level. All piles were exposed at a depth of 3'-0" below the bottom of the pile cap and probed easily to a depth between 2-1/2" - 3-1/4" before firm surface was reached. The surface material is soft and rotten. At the water level, 8'-6" below the pile cap, the piles were probed to a depth of 1/2". The material is firm throughout. The soil material at this column had an odor of acetone. The soil contains roots and cinder material.

→ b) Load Bearing Capacity

1) Piles

- Background  
It is assumed that the Theater and the Tent of Tomorrow, which were constructed at the same time are supported by the same type of wood piles. Based on the information available from the Construction Documents for the Queens Theater, the allowable wood pile capacity was 20 tons. During a previous examination, the deterioration of the piles was discussed in reports of an investigation of the Theater performed in 1989, and the 1992 investigation of the Tent of Tomorrow contained an Engineering Report prepared by Geiger Engineers.
- Field Investigation  
Our field findings are consistent with the assumptions of Geiger Engineers that predict further deterioration of the wood piles. The

the ground water level. At the water level, however, the wood piles were found to be more stable, and showed a consistent 1/2" surface deterioration at the water level. This deterioration at the water level and below has not increased in 4 years, and is compatible with the normal conditions of wood piles intact and under water. The basic friction capacity of the submerged section of pile is stable. However, the area of concern occurs at the pile section between the pile cap and water level. Here a loss of 3" of bearing surface around the wood piles was indicated. This 3" circumferential rot reduces the 12" diameter (113 SF) of the deteriorated pile bearing area to 6" diameter (28 SF) capacity. Thus the 12" diameter wood pile is reduced to a 6" diameter wood pile, with a 76% decrease in bearing capacity.



• **Calculations**

Using the allowable compression stress parallel to the grain of 1200psi (average for western and southern pine), we determined the reduced capacity of each wood pile to be:

$$1.2 \times \frac{3.14 \times 6 \times 6}{4} = 33.9 \text{ kips/pile}$$
$$= 16.96 \text{ tons/pile.}$$

The capacity is based on lateral bracing from the soil to prevent lateral buckling under the axial load. The length of the wood pile that has rotted is approximately 12'-6", the entire length being surrounded by soft rot and cinder contaminated soil. The total area of the wood pile does give some lateral support, however, it is highly questionable that a wood pile with 3" circumferential rot, with only 6" diameter of solid wood, could develop the capacity of 16.96 tons. Our field investigation also found some steel piles in what appears to be random locations beneath the pile caps. In conversations with the design engineers, they stated that at 70 feet there was soil with sufficient capacity to develop 20 ton wood piles. They also stated that some steel piles were also driven. The reason for this was that some wood piles did not fetch up (developing 20 ton capacity) at the maximum length of the wood piles (90 feet). Since the steel piles are longer they were used to replace the wood piles. The steel piles are structurally sound. However, since an exact number of these piles is unknown, and their bearing capacity and locations beneath the pile cap can not be determined for each column, they cannot be included in this report.



## 2) Pile Caps

### Background

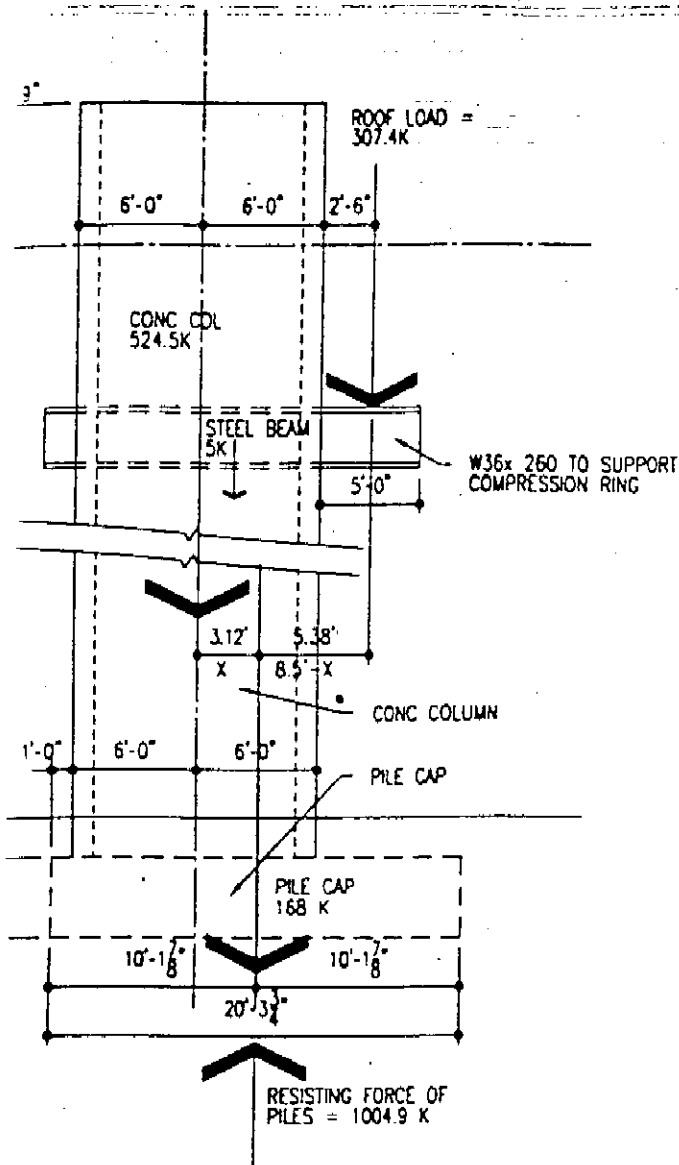
There were no structural drawings for us to research the configuration of the pile cap, or to determine the size and spacing of the piles.

- Working from the roof level down, based upon field measurements for the roof structural members and sizes and the weight of steel, the roof dead loads were calculated. The roof live loads were calculated based upon the building code and snow loading for the area. These were combined and total of the roof dead loads and the live loads were calculated. The total roof load was then distributed to the 16 columns for transfer to the pile caps. The weight of the concrete columns was calculated from the volume of concrete each column contains. The pile caps were likewise measured and calculated and their weight added to the roof and column loads.
- Assuming the minimum number of piles, each acting to resist their design loading, the number of wood piles necessary to support the combined loading was calculated.
- Based upon the calculated load from the roof, the weight of the column and the distance measured between them, the centroid of the pile cap was calculated.

- The actual bearing capacity of the wood piles in their noted condition was calculated based upon the deterioration noted during the field investigation.
- Wood pile capacities are based upon the assumption that they are continuously braced along their length by the soil around them. The existing piles no longer qualify for this assumption since the outer 3 inches of the piles have become spongy and this layer is easily compressed. With a slenderness ratio for a 6" column and an unbraced height of 12'-6", it can no longer be assumed that the piles will continue to support the imposed loading without buckling.
- By this method it was determined that replacement of the existing wood piles with steel piles is necessary to sustain the original design load.

#### Investigations

- The roof structure, which includes the compression and tension rings and cable structures, was measured and drawn to scale.
- The steel support beams and wide flange members were measured and their locations were documented as forces applied relative to the concrete column.
- Excavation was performed at the pile cap on three of its four sides, and at a portion of some of the existing piles. Using this information we determined the size and weight of the concrete pile cap.



### Calculations

In order to determine the number of piles required to support the original design load, the first step was to determine the total dead and live loads.

### Loading

#### Dead loads

- 1) Roof weight
  - Tension Ring ..... 120.26kips
  - Compression Ring:
    - Outer ..... 1,163.12kips
    - Inner ..... 730.61kips
    - Web ..... capes
    - Misc plates ..... 72.20kips
  - Total compression ring ..... 2,247.6 kips
  - Cables & Anchors ..... 129.92kips
  - Plexiglass roof (5psf @ 53,784) ..... 268.92kips
  - 2,766.7kips**

$$\text{Total} = \frac{2,766.6 \text{ kips}}{16 \text{ columns}} = 172.9 \text{ kips/col}$$

- 2) Column weight

Area of concrete column =

$$\frac{3.14(12 \times 12) - (10 \times 10)}{4}$$

$$\frac{3.14(44)}{4} = 34.54 \text{ sf}$$

Volume of concrete column =  
 $34.54 \times 101.25 = 3,497.2 \text{ cf}$

Weight of column =  $3,497.2 \times 150 = 524.5 \text{ kips/col}$

- 3) Weight of roof support beam

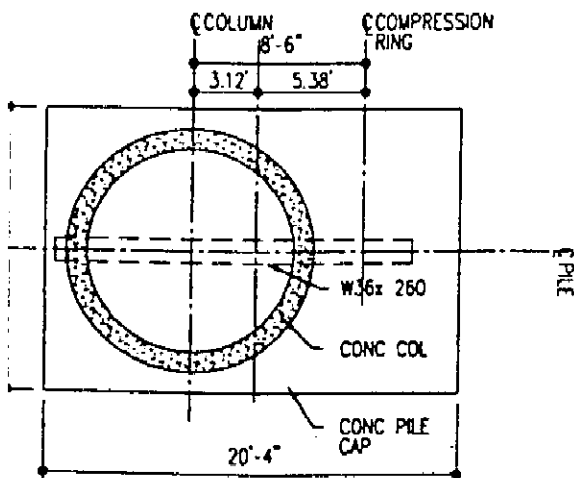
(W36x260) = ..... 5.0kips/col

Weight of pile cap

$14' \times 20' \times 4' \times .150$  ..... 168kips/col

Total dead load/column =

**870.4kips/col**



**Live loads**

53.784sf x snow load @ 40psf=

$\frac{2151.36 \text{ kips}}{16 \text{ columns}} = 134.5 \text{ kips/col}$

Total load on pile cluster

Live load(870.4)+dead load(134.5)=  
1004.9kips/col

1004.9kips/col= 502.45tons/col

Determining the centroid of the pile cluster, relative to the column since the roof load is applied eccentrically to the column (2'-6" from the face of the concrete column)

Resisting force of pile cluster=  
1004.9kips/col=502tons/col

We calculated the location of centroid of the pile cluster from the centerline of the concrete column. Taking the moments about the centroid of the pile cluster, which is x feet from the centerline of the concrete column, we can calculate its location.

Moments @ centroid = 0 = 307.4(8.5-x) - (524.5+5)x  
0 = 2612.9 - 307.4x - 529.5x  
x =  $\frac{2612.9}{836.9} = 3.12 \text{ feet}$

**Required Number of Piles**

We calculated the number of 20 ton wood piles required to support the original design load.

Number of wood piles =  $\frac{502.45 \text{ tons}}{20 \text{ tons/pile}} = 25.12 \text{ piles}$

**26 piles are required.**

**Capacity of Deteriorated Piles to Support Existing Structure.**

We calculated the required capacity of the 26 existing deteriorated wood piles to support the dead load of the structure, excluding the plexiglass roof.

**Total dead load-plexiglass roof**

$\frac{870.4 - 268.92}{16 \text{ col}} = 853.6 \text{ kips/col} = 426.8 \text{ tons/column}$

The capacity of the existing piles with full lateral support;

26 x 16.96tons = 440.96tons/col > 426.8tons/col

Therefore, the reduced wood pile, laterally supported, will presently support the structure. However, the lateral support or +/- 3" soft rotted wood is highly questionable when the length of the pile which is rotted is 12'-6". These factors put the pile in danger of buckling.

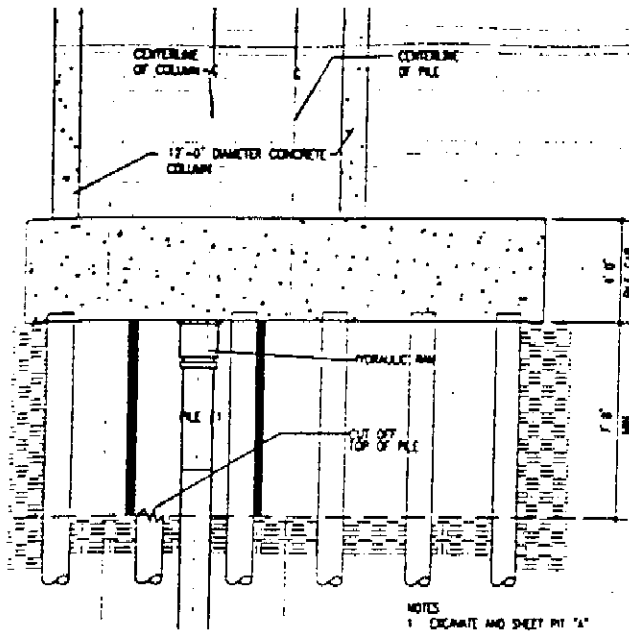
**c) Longevity**

Based upon our investigations, we propose a stabilization procedure that will result in the maximum long term use and stability, without repeated yearly investigations and monitoring for further deterioration or decay. In other words, we are proposing a permanent solution to revitalize the salvageable components of a once temporary, now historic structure. In order to do this, our calculations are based on the following derived evidence:

- 1) Documented continued deterioration of the piles' bearing capacity.
- 2) The unknown number of the actual piles.
- 3) Our calculations that the existing pile cluster can barely withstand the dead load of the structure.

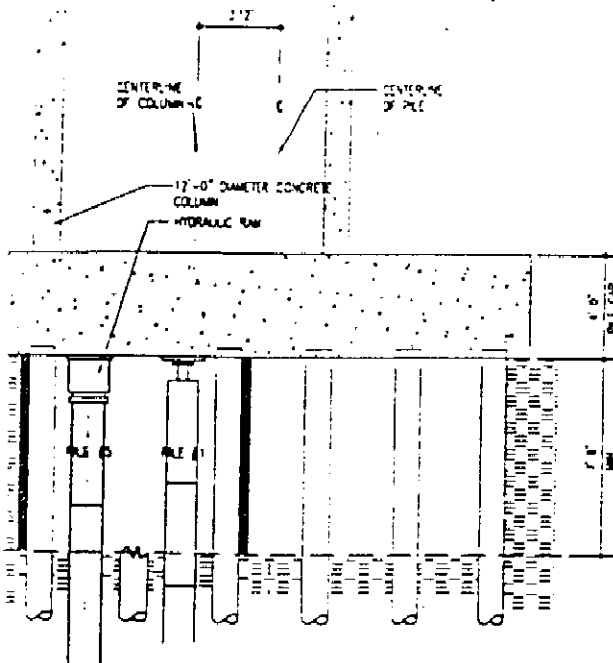
**d) Recommendations/Stabilization Methods**

We propose the use of steel piles to be installed by hydraulic jacking methods that use the pile caps, columns and steel roof support system as reactions. Replacement steel piles @65 tons jacking in 6' to 8' lengths from bottom of pile cap. We calculated the number of steel piles required to replace the wood piles, and to support the original design load



SECTION THROUGH PILE CAP  
FIRST PILE IN QUADRANT  
"A" PIT

- NOTES
1. EXCAVATE AND SHEET PIT "A"
  2. JACK PILE TO BEARING STRATUM  
CLEAN/PULL PILE
  3. JACK AND TEST TO 150% DESIGN LOAD  
HOLD 1 HOUR
  4. TRENCH POUR BUILD UP PILE TO  
WITHIN 8" TO 12" OF UNDERSIDE  
OF JACK PLATE
  5. INSERT 10.75" (Ø) x 0.365" (WALL THICKNESS)  
CONCRETE FILLED PIPE POST AND WEDGE OUT  
TO JACK PLATE (SHIM WEDGES-NO LOAD TRANSFER)
  6. PROCEED TO JACK PILE #2, THEN #3, AND #4  
AS PER NOTES #1, #2, #3, #4 & #5
  7. EXCAVATE AND SHEET PIT "B"  
JACK PILE #5, THEN #6, #7, AND #8



SECTION THROUGH PILE CAP  
SECOND PILE IN QUADRANT  
"B" PIT

on the column.

Number of piles =  $\frac{502.45 \text{ tons/col}}{65 \text{ tons}} = 7.3$  steel piles

We use (8) 65 ton steel piles/column.

Eight new piles, each having a capacity of 65 tons, are to be installed under each of the 16 pile caps. We do not currently have specific soils data for the site and have based our design on information furnished to us that indicates there is a lens of generally granular soil at a depth of about 80 feet below the existing pile caps. This would produce suitable bearing for a closed-end steel pipe pile having an outside diameter of no more than 16 inches. Unless the original borings made for this structure are obtained, it will be necessary to have new borings (one boring at alternate columns, 8 in total) made to clearly identify the soil conditions at the site.

The sketches detail the sequence of operations. Due to the conditions of the existing wood piles, we recommend that only one pile be installed at a time, and that the work progresses from quadrant to quadrant as detailed in design sketches. This procedure will limit, to the maximum extent possible under the circumstances, the exposure to over stressing the remaining wood piles in the cluster. Control measures will be necessary to monitor column settlement during all of this work. To expedite progress we would conduct operations under eight columns concurrently. The time required for the installation would be approximately eight months.

- Alternate Solution Investigated

JCA has investigated several alternate schemes to resolve the instability of the piles. In addition to the underpinning/pile jacking solution previously presented, There is another option that is typically used in similar circumstances which could not be safely employed on this project. This solution involves exposing the existing wood piles.

