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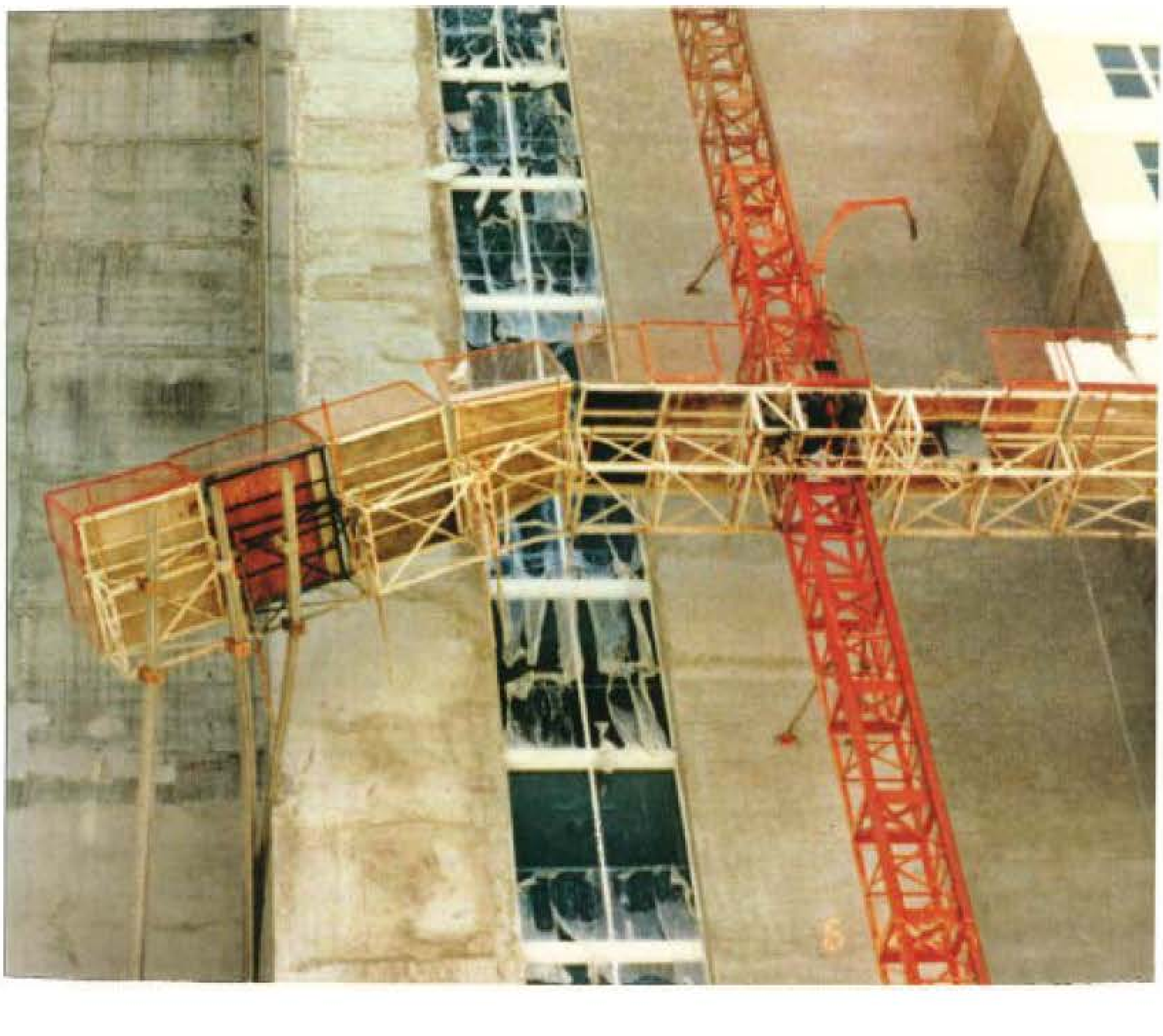
U.S. Department of Labor
Occupational Safety and Health Administration

June 1995



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U.S. Department of Labor
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June 1995

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EXECUTIVE SUMMARY

On March 4, 1995, at about 8:30 am, a mast climbing scaffold collapsed at a building construction site in Miami, Florida. As a result of the collapse three stucco contract employees were killed when they fell approximately 75 feet to grade. Two other employees sustained minor injuries. These employees were admitted to the hospital for observation and were released a short time later.

An OSHA compliance officer from the Fort Lauderdale, Florida Area Office arrived at the site within hours of the event and secured the evidence related to the failure. Part of this process included documenting, i.e. video tape and photographs, the scene.

On March 6, 1995, the Office of Construction and Engineering (OCE), OSHA National Office, Washington, DC was contacted by the OSHA Region IV Office and was asked to provide assistance in determining the cause of the failure. A Civil Engineer arrived on-site that same evening and made preliminary observations and assisted in lowering the scaffold to a secure position. The next day, March 7, 1995, a structural engineer from the OCE arrived on-site and assisted the investigation through visual observation, detailed evidence examination and providing direction for further on-site activities.

Based upon the structural analyses, lab testing, eyewitness statements and observation of the collapsed structural members, the Occupational Safety and Health administration concludes that:

1. The scaffold platform structure as it was configured and erected in the field was not designed for the loads imposed upon it.

2. The collapse occurred because several members of the scaffold platform structure including outrigger beams were subjected to forces in excess of their ultimate capacities due to the loads placed over them prior to the accident.

3. The scaffold platform structure as used and as loaded at the site did not have adequate factor of safety in accordance with OSHA standard 1926.451 (a)(7).

4. With respect to the loading of the aluminum outriggers, the owner/erector did not follow the allowable load tables provided by a contract engineer.

5. The president of the stucco company was on the scaffold and observed excessive deflection of the cantilever decking section. As a result, the president directed that additional decking material be placed to level the cantilever section for the employees to work on.

6. The owner/erector did not provide any load chart on the site for the scaffold user to determine the safe load capacity of the scaffold when it was erected in various configurations.

7. The scaffold platform did not have any plate, placarding or labeling information related to the rated capacity of the unit. This is required by industry consensus standards.

8. No approval as required by the industry consensus standards had been provided to the scaffold erection company or the users (stucco contractor) to modify the scaffold platform with the use of the cantilever decking.

9. There were no bolts in place to connect the bottom section of the platform extensions of the scaffold as per manufacturer's recommendations.

10. A competent person was not available for either the scaffold owner or the user to direct the erection, modification or alteration of the scaffold.

11. The general contractor did not inspect the scaffold when ample opportunity was afforded to determine that the scaffold was being used in an unsafe manner. In fact, the general contractor had actual employee exposure to the hazard of collapse when its employees used the same scaffold which eventually failed to inspect a wall of the building.

12. Field observations and laboratory testing indicated that the members of the scaffold platform structure had sustained loss of cross sectional area due to corrosion.

1.0 ACCIDENT DESCRIPTION

1.1 Introduction

On Saturday, March 4, 1995, at approximately 8:30 a.m., a multi-fatality construction accident occurred at a building project in Miami, Florida. Five employees of LBJ Plastering, Inc. (LBJ) were applying stucco to the walls of a building when the platform of a mast climbing work platform (scaffold) collapsed. Three of the employees were on a modified cantilever decking section which was connected to platform extensions attached to the main platform. As a result of the failure, the cantilever decking deflected and rotated which resulted in the three employees falling about 75 feet to grade where they were fatally injured. The other two employees were located on the platform extension portion of the scaffold. As this portion of the scaffold failed the other two employees were able to grab and hold on which prevented their fall. These two employees sustained minor injuries as a result of the collapse. They were admitted to the hospital and were released a short time later.

1.2 General Information

The building project under construction is a 31 story condominium complex, called the St. Louis Condominium Complex. The site location is 800 Claughton Island Drive, Miami, Florida. The general contractor at the site is JJW Construction, Inc. (JJW).

The contractual relationships between the entities involved in the incident included several companies. JJW subcontracted with SPD Contracting, Inc. (SPD) to provide plaster/stucco material to the face of the building. As part of the contract SPD was required by JJW to provide access for employees conducting plaster/stucco operations. SPD subcontracted with Access Equipment Systems, Inc. (ACCESS) to provide mast climbing work platform scaffold units at the site. This agreement also required ACCESS to erect/dismantle/move their scaffolds to specified locations along the perimeter of the building. SPD also subcontracted the actual plaster/stucco work to LBJ. It was understood that the LBJ employees would operate the scaffolds. Figure 1.1 is a flow chart depicting the relationships of the companies involved in the incident.

1.3 Overview of the Failure

At the time of the failure an ACCESS Satellite Elevating Work Platform (scaffold) was being used by LBJ to stucco an inset portion of the west face of the building. Figure 1.2 illustrates the position of the scaffold relative to the west wall of the building. The platform was located approximately 75 feet above grade when the failure occurred. Figure 1.3 depicts the location of the 5 LBJ employees just prior to the failure. Employees #1, #2, and #3 were on a modified cantilever decking section which was attached to the north platform extensions, NPE3 (North platform extension #3) and NPE4. Employee #4 was on the main platform near the middle of NPE3. Employee #5 was located on the walkway platform adjacent to NPE3.

Employees #1, #2, and #3 were fatally injured when as a result of the failure the cantilever decking rotated to the point that they fell to grade. Employees #4 and #5 were able to grab onto the platform which prevented them from falling. These two employees were admitted to the hospital and were released a short time later having sustained minor injuries.

Figures 1.4 thru 1.11 give an overview of the failed scaffold. Figure 1.4 is a photograph of the failed scaffold relative to another scaffold located north of the failed scaffold. Figure 1.5 is a photograph of the failed scaffold relative to the building. Figures 1.6 and 1.7 are photographs showing the scaffold relative to the building. This figure shows deflection of the north platform extensions relative to the main platform. Additionally, buckled structural members of the NPE1 can be seen. Figures 1.8 and 1.9 are photographs which show the deflection and rotation of the platform extensions relative to the main platform. Figures 1.10 and 1.11 are photographs which show the aluminum outriggers supporting the cantilever decking. The photos show the outriggers relative to the building inset. The 3 outriggers are connected with brackets to the bottom chords of NPE3 and NPE4.

1.4 Description of the Scaffold

The equipment that was being used by the LBJ employees at the time of the incident was a specialty type of scaffold - mast climbing work platform (scaffold). Note: OSHA's Office of Construction and Maritime Compliance Assistance has determined that these mast climbing work platforms are in fact scaffolds[1]. The type of unit utilized by ACCESS was an ACCESS Satellite Elevating Work Platform. This scaffold is a mobile platform which can be used free standing up to about 33 feet or if tied to the structure can be utilized at a working height of 328 feet[2]. The basic components of the scaffold include: 1) a mast; 2) platform consisting of a main platform where materials are temporarily staged to be used by the workers and a walkway platform where workers stand and perform operations; 3) platform extensions of various standard lengths up to 5 feet to increase the length of the platform, these extensions are connected by using 3/4" bolts through plates mounted near the top of the structural framing of each extension, additionally, plates are provided near the bottom structural framing members to connect each platform extension together for the purpose of resisting forces on the platform and platform extensions (see ACCESS Vice President Witness interview, pg. 33); and 4) an electrical control system which controls the movement of the platform up and down the mast.

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[1] Memorandum from Construction and Maritime Compliance Assistance, OSHA National Office, Washington, DC to Mast Climbing Manufacturer, date 10/14/93

[2] Operations Manual: The Access Satellite Elevating Work Platform, ACCESS Equipment Systems, Tucker, GA

The scaffold has a capacity which is a function of the magnitude of the load, type of load, i.e. uniformly distributed or concentrated loads, platform length and the eccentricity of the load. The manufacturers of these type of scaffold are required by industry standards to provide a load chart with the scaffolds indicating safe working loads of the scaffold when it is erected in various configurations. ACCESS provides a load chart in an operators manual. The safe working loads range from a maximum uniform load of 8360 lbs. for a 20 foot platform to 6100 lbs for a 50 foot platform (20 foot main platform + 3 platform extensions on each side of the mast). For eccentric loads distributed over the outside section, the maximum eccentric load ranges from 2,000 lbs. for a 20 foot platform to 750 lbs. for a 50 foot platform. Appendix A includes a load chart for the ACCESS Satellite.

At the time of the incident the platform and platform extensions were configured in such a manner that the total length of the unit was 47′6″. The platform was extended 30′ on the north side of the centerline of the mast and 17′6″ of platform on the south side of the mast. The main platform was 20′ long. The north side had four - 5′ platform extensions. The south side had 2 platform extensions, one - 5′ and the other, 2-½′.

At the time of the event ACCESS and LBJ had modified the scaffold by erecting a cantilever decking section which was attached to the platform extensions, NPE3 and NPE4. The modification was being used to reach the insets of the west face of the building (refer to Figure 1.2). The inset distance from the front face of the building was approximately 12 feet. With the standoff distance of the mast from the front face of the building, it was decided by ACCESS that 21 foot outriggers with an outboard length of 14′6″ were required to reach/work on the far (east) walls of the building insets. The cantilever decking was approximately 8′ to 9′ wide by 14′6″ long. The aluminum beams were SAFWAY Aluma Beams. Three aluma beams were connected to the bottom chords of the platform extensions using #1 Type tube clamps (8″x6″x¼″), two per outrigger. Two outriggers were attached to NPE4 and one outrigger was attached to NPE3 (refer to Figure 1.2 for the outriggers relative positions). Four 4x6 inch wood members were nailed perpendicular to the outriggers. Eight sheets of 4′x8′x¾″ plywood were overlaid and nailed to the 4x6's.

On the day before the failure, March 3, 1995, the President of LBJ after observing excessive deflection of the cantilever decking instructed his employees to build up the decking to make it level. On the morning of the incident, two LBJ scaffold operators altered the cantilever decking in an attempt to level it. The alteration included nailing tow 4x6 inch wood member along the north edge of the cantilever decking. Then 4 sheets - 4′x8′x¾″ plywood were laid perpendicular to 4x6's along the length of the cantilever decking. Figure 1.13 is an illustration of the components of the altered cantilever decking section. The LBJ personnel apparently duplicated this "leveling" procedure from the ACCESS leadman. The south side of this scaffold was originally set up to cover the south building inset. The same type deflection of the cantilever decking reportedly occurred. The ACCESS leadman altered that decking in the same manner that was described above while LBJ employees looked on.

1.5 Field Observations

The following section discusses observations of the physical evidence related to the failed scaffold (Unit #78) which was observed at the site.

Scaffold Foundation

The scaffold foundation which actually is the first section of the mast was set on top of two rows of 4x4 inch (nominal) lumber on top of the buildings concrete foundation. The first section of mast was anchored/supported with two sets of diagonal 2 inch diameter tubing. There was no evidence of any foundation failure.

MAST

The mast was continuous for the full height of the building for a total height of 328 feet. The mast was anchored to the building with a pair of two inch diameter tubing approximately every 30 feet in height. The mast appeared to be in a plumb position and exhibited no apparent distress due to the failure.

Main Platform and South Platform Extensions

The main platform and the south platform extensions appeared to be in a level condition and did not exhibit any structural problems after the event. There were two south platform extensions, south platform extension 1 (SPE1) which was 5 feet long, and SPE2 which was 2′6″ long. The south platform extensions supported 2+ bundles of styrofoam insulation sheets. The walkway outriggers were retracted indicating that no scaffold boards were in-place on the south side of the scaffold at the time of the event. This is consistent with (see witness interview #4, pg. 27) the statement which indicates that the scaffold planks on the south side of Unit #78 had been moved over to the north side which in effect double planked the walkway on the north side with a total of 6 - 2x10 inch planks. Figure 1.12 is a photograph of the south side of Unit #78 after the event.

A number (#78) was observed to be inscribed on the main platform near the mast. This was later described as the scaffold's serial number.

Except for one illegible placard on the north side of the mast/platform, the scaffold did not contain any placarding information related to the safe operation of the unit, i.e. rated load capacity for various configurations of the unit. Figures 1.17 thru 1.19 are photographs of locations on Unit #78 designed to have placarding attached. The president of ACCESS stated that the placards had been removed from this scaffold so that it could be cleaned and painted prior to bringing it to the site.

After the scaffold was brought down and secured at a safe level, the ACCESS vice president retrieved an ACCESS Satellite Operators Manual from the electrical box of Unit #78. Upon review of this manual it was determined that it did not contain a load chart. A specification section in this manual listed the maximum uniformly distributed load as ranging from 8360 lbs. for a 20 foot platform to 6,100 lbs. for a 50 foot platform. No other load charts were found on-site. LBJ employees have stated that they had not seen any load chart. The president of ACCESS contends that he provided load charts for this unit to SPD and JJW. Later in the investigation ACCESS provided OSHA with another operators manual which did contain a load chart for the unit.

North Platform Extensions

The first platform extension to the north of the main platform (NPE1) exhibited signs of failure. Two fractures occurred in the structural tubing of NPE1. The location of the fractures was in the bottom south corner of the east plane of the NPE1. The fractures occurred in the vertical and horizontal members close to the corner intersection. The following tubing members were buckled: 1) both bottom horizontal members running north-south buckled to the west; 2) bottom horizontal plane diagonal member buckled in upward direction; and 3) east face (plane) diagonal member running from top to bottom buckled in a westerly direction. Figures 1.14 and 1.15 are photographs showing the NPE1 structural tubing and its deformation. Figure 1.16 is a photograph of the two tube fractures described above.

The platform extension had deflected in a downward angle approximately 30 - 45 degrees from horizontal due to the collapse. The platform extensions appeared to have also rotated about 30 - 40 degrees toward the building.

None of the top bolted connections for the platform extensions failed due to the collapse, e.g. all top bolted connections remained in-place. All top bolts were in-place as required.

Upon inspection of the bottom chord bolt connections it was observed that none of these bolts were in-place. This was also true on the south side of Unit #78. The scaffold which was erected to the north of Unit #78 was inspected to determine if the bottom bolt connections were utilized at the site. This inspection revealed that no bottom bolts were in-place on that unit.

The connections of the outriggers to the bottom chords of NPE3 and NPE4 remained intact. The bottom chords of the platform extensions where the tubing clamps were secured exhibited no signs of distress.

Except for NPE1, no other platform extension exhibited signs of failure.

Outriggers

Prior to removing the three outriggers from their position they were marked to facilitate the determination of their outboard distances (distance from outside edge of outboard tubing clamp to the end of the cantilevered beam). The measured outboard lengths were as follows:

North side beam - 14′ 7-½″
Middle beam - 14′ 8″
Inside (south) beam - 14′ 9-½″

A visual inspection of the outriggers showed the following qualitative results:

North Side Beam - Some torsional buckling. Twisting starts about 13′ feet from outboard end.

Middle Beam - No deflection, deformation, or twisting.

Inside Beam - Lateral bending. No warping or twisting.

The beams were measured to be 21′ long. The depth of the beams was 6-½″. The top and bottom flanges measured 3″ and 4″, respectively. Figure 1.20 is a photograph of the outriggers on the ground after the event.

Labels on the beams included the following instructions: a) intended for uniformly distributed loads; b) consider deflection; and c) Do not cantilever beyond recommended limits. Figure 1.21 is a photograph of a label on one of the outrigger beams.

From visual observation it appeared from the position of the outriggers that the cantilever decking had rotated about 30 - 40 degrees during the event. It also appeared that the inside outrigger became lodged against the corner of the building and restricted further rotation of the decking.

The wood cantilever decking members were apparently moved during the rescue operation. After it was moved it was not saved. Therefore, an accounting of the wooden cantilever decking material could not be made. The construction materials and erection orientation were determined by witness interviews (see discussion related to the construction of the cantilever decking above, pg. 5).

Relationships of Contractors Involved in the Event

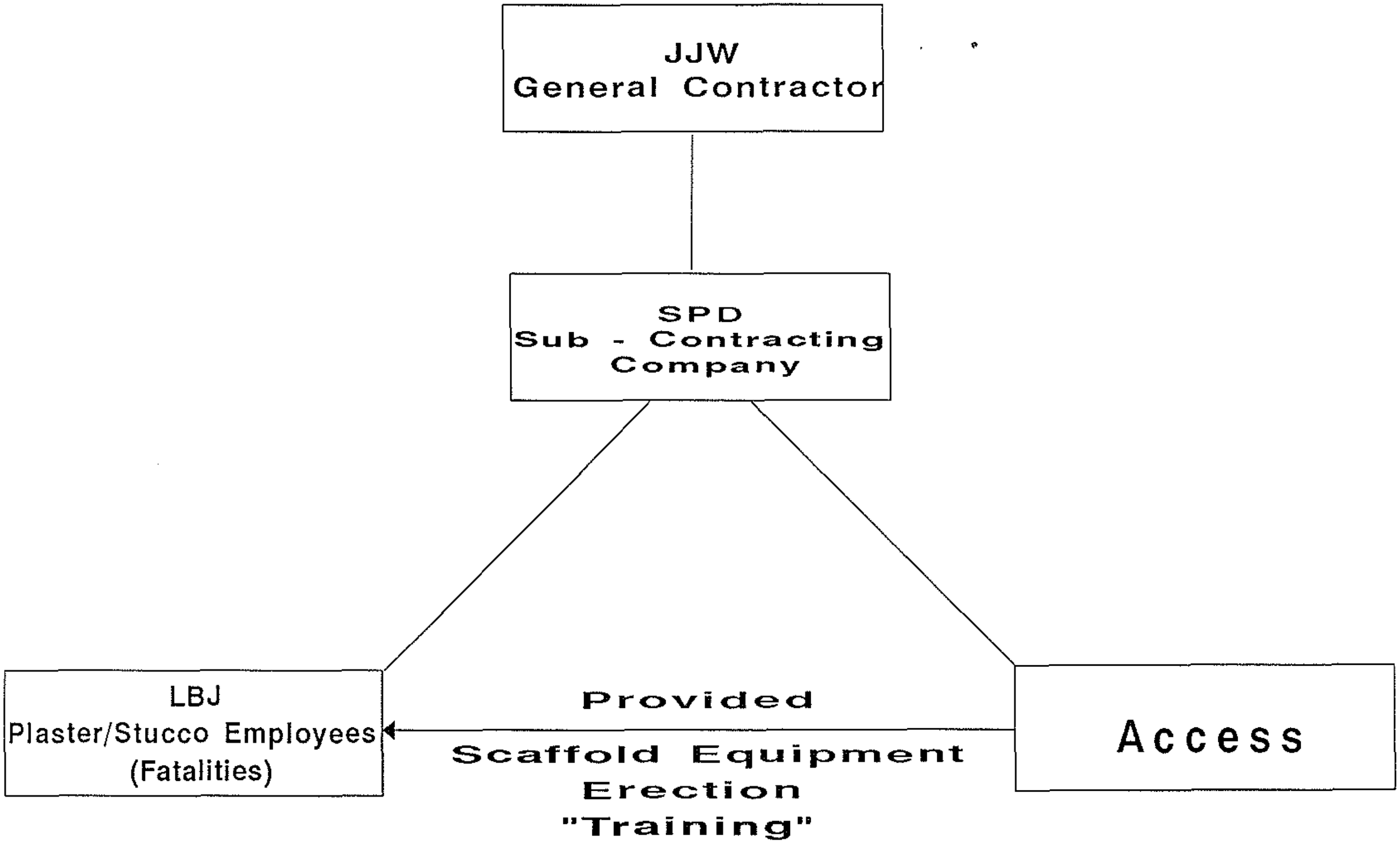
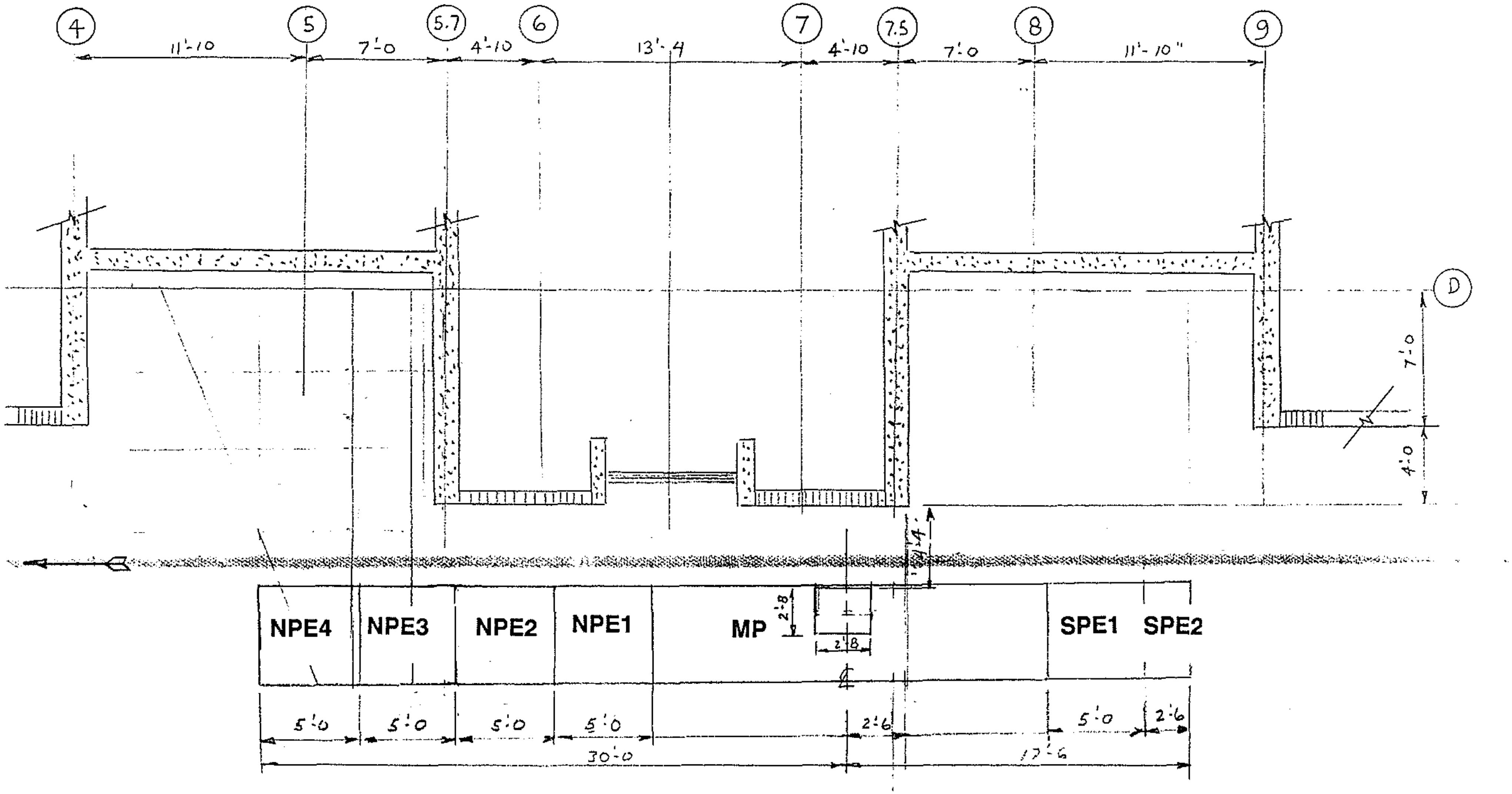


Figure 1.1

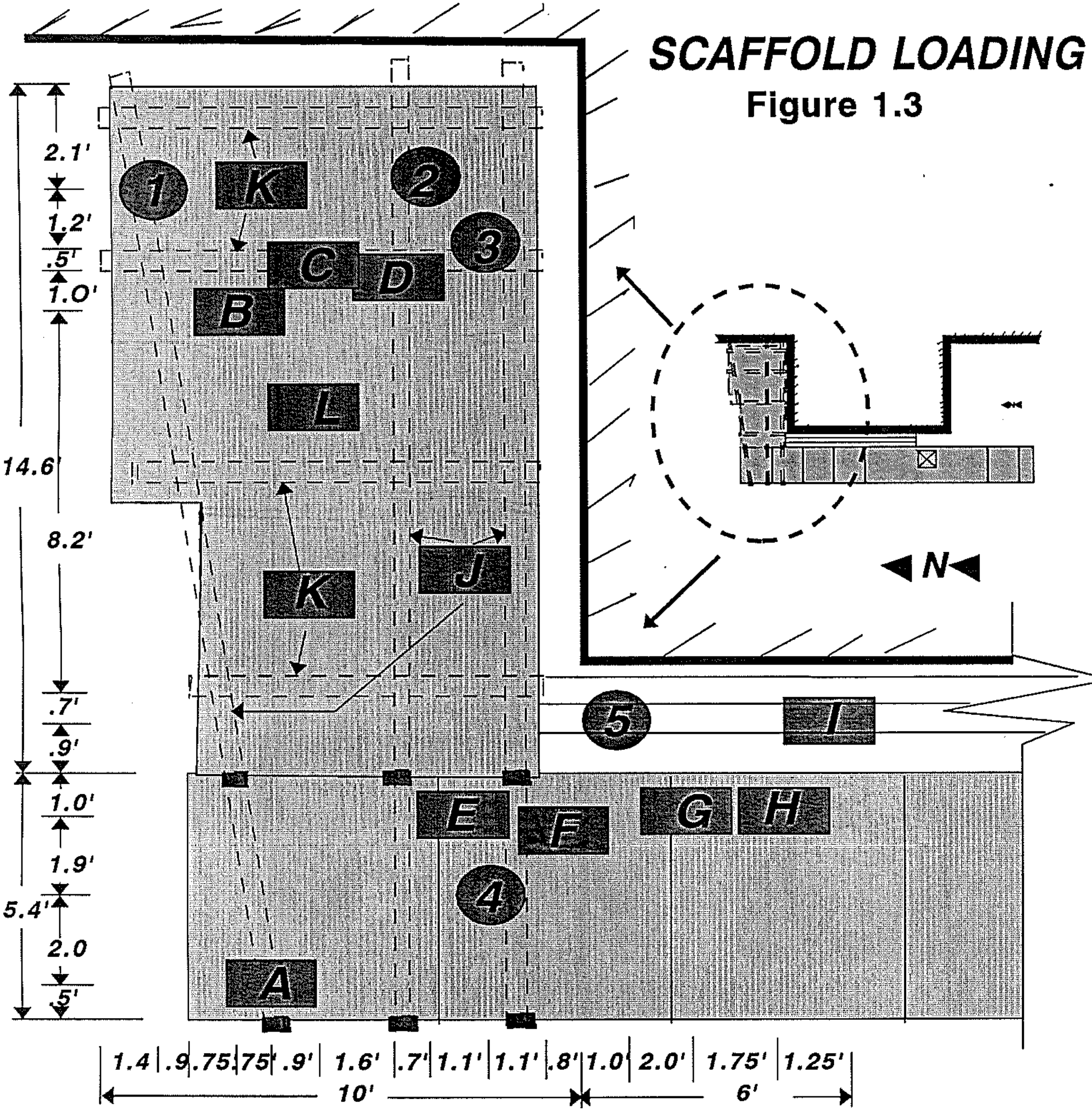


Scaffold Platform in Relation to West Face of Building

Figure 1.2

SCAFFOLD LOADING PRIOR TO EVENT

Figure 1.3



LOADING

1. Employee - 250 lbs.
2. Employee - 180 lbs.
3. Employee - 160 lbs.
4. Employee - 190 lbs.
5. Employee - 150 lbs.

A. 2 small coolers - 20 lbs. & Tool Bag

B. 5 Gallon Bucket - 1/2 full of Stucco

C. Mud Board w/1 Bucket Stucco

D. Same as B.

E. Mud Board w/1 Bucket Stucco

F. Same as B.

G. Same as B.

H. Same as B.

I. 8 - 16' (2"x10") Scaffold Planks

J. 3 - 21' Aluma Beams

K. 6 - 4x6 Wood Timbers

L. 12 - (4'x8'x3/4") plywood sheets

Two Mast Climbing Elevated Work Platforms on West Face of Building
Arrow shows the Failed Scaffold (Looking East)

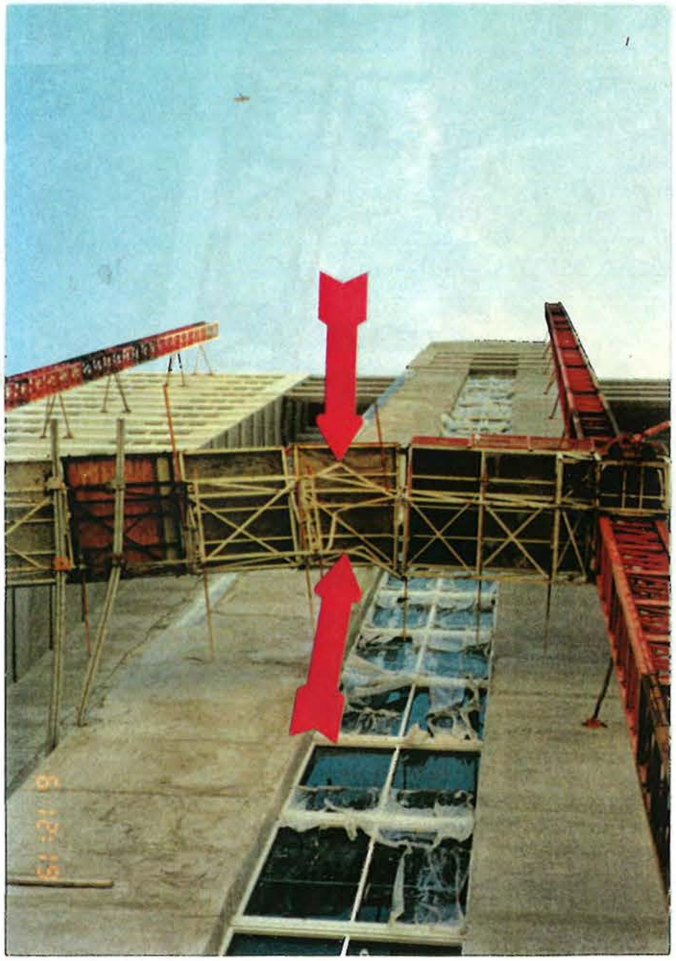
Figure 1.4

Failed ACCESS Satellite Scaffold - Unit #78 (Looking East)

Figure 1.5

Failed Platform Relative to the Building (Looking East-Northeast)
Arrow Shows Deflection of Platform Extensions Starting at NPE1

Figure 1.6

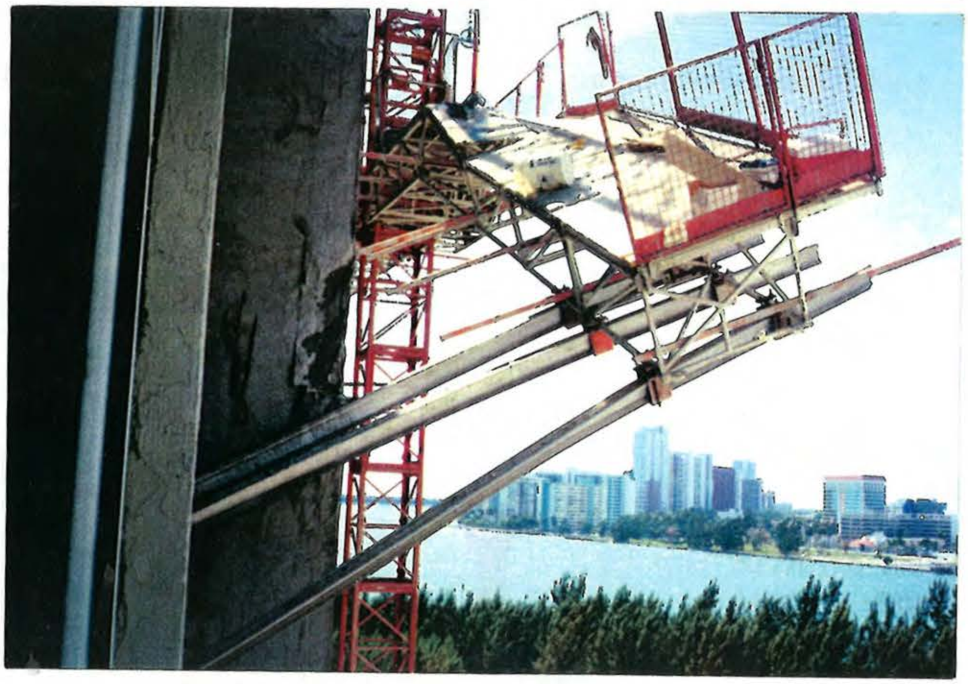


Failed Platform Extensions Relative to the Main Platform (Looking Up)
Arrow shows Buckled structural Members of NPE1

Figure 1.7

Deflection of the Platform Extensions and Cantilever Decking Relative to the Main Platform (Looking South)

Figure 1.8



Rotation of the Platform Extension Relative to the Main Platform
(Looking South-southwest)

Figure 1.9

Aluminum Outriggers Relative to the Platform and Building (Looking South)

Figure 1.10

Outriggers Attached to Bottom Chords of NPE3 and NPE4 (Looking Up)
Arrow shows Buckled structural Members of NPE1

Figure 1.11

South Side of Unit #78 After the Event (Looking Northwest)
Arrows Show the Retracted Outriggers Which Support the Scaffold Plank Walkway

Figure 1.12

ELEVATION VIEW OF OUTRIGGER SECTION OF PLATFORM PRIOR TO COLLAPSE

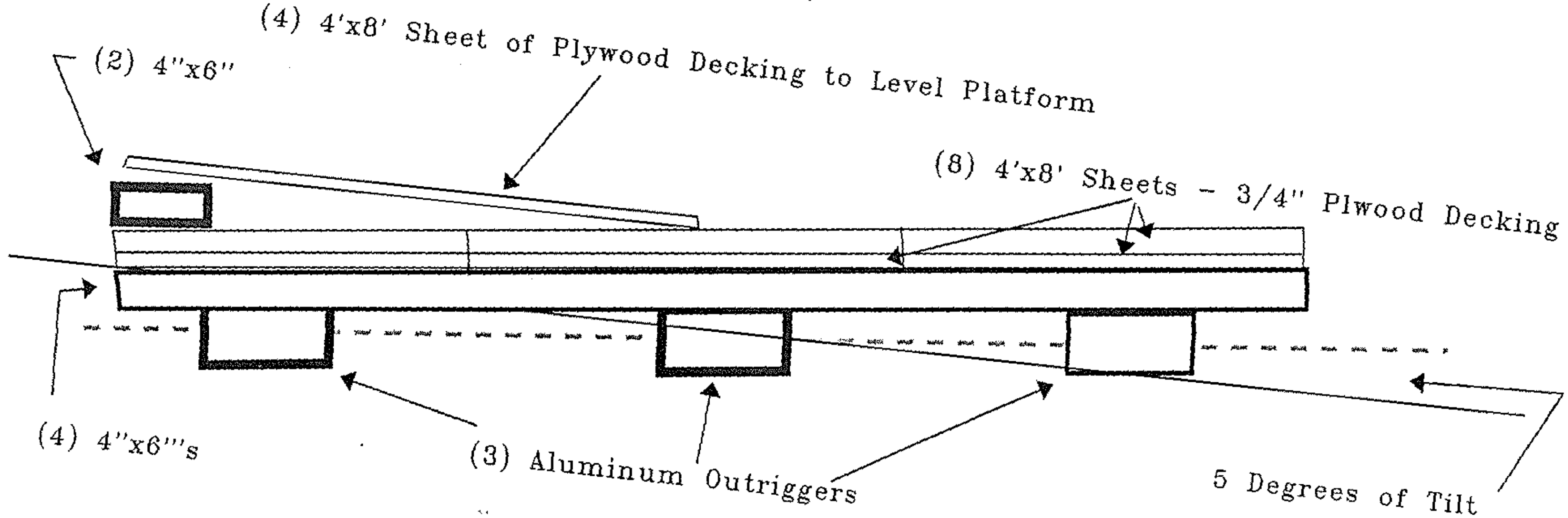
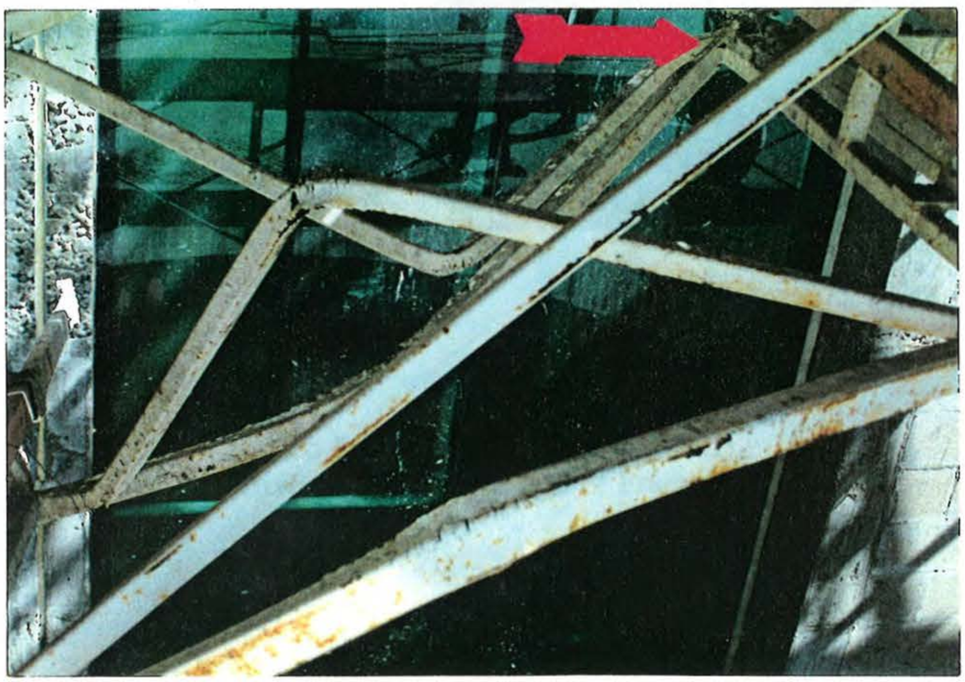


Figure 1.13

Note: Not to scale

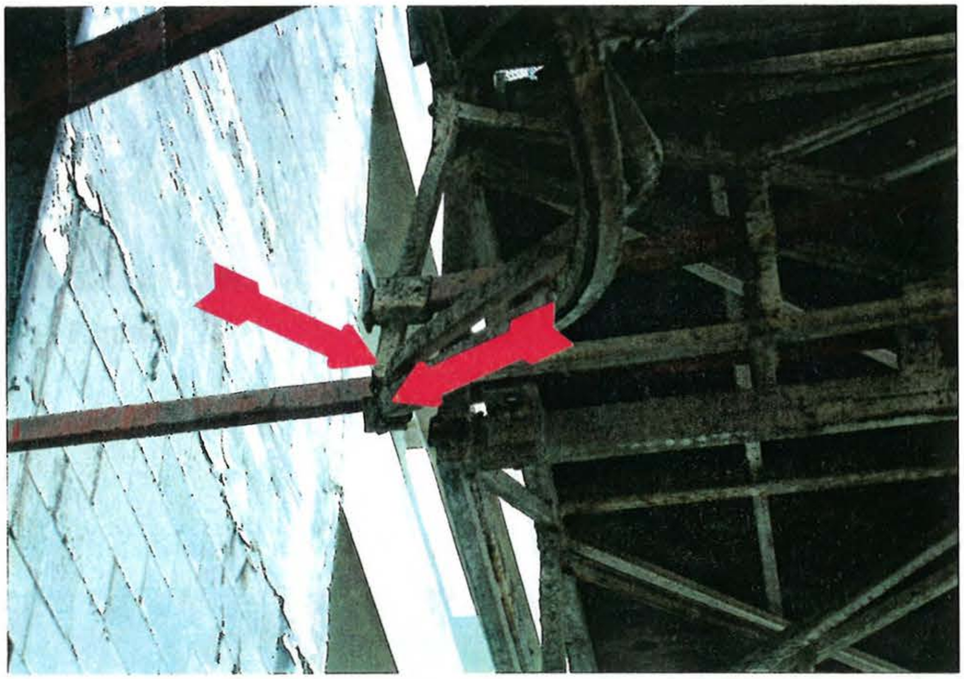
Buckled Tubing Members on Bottom Side of North Platform Extension 1 (NPE1)

Figure 1.14



Deformed Members of NPE1
Arrow Shows Location of Fractured Members

Figure 1.15



Two Fractured Members of NPE1
Arrows Depict Location of Fractures

Figure 1.16

Figure 1.17

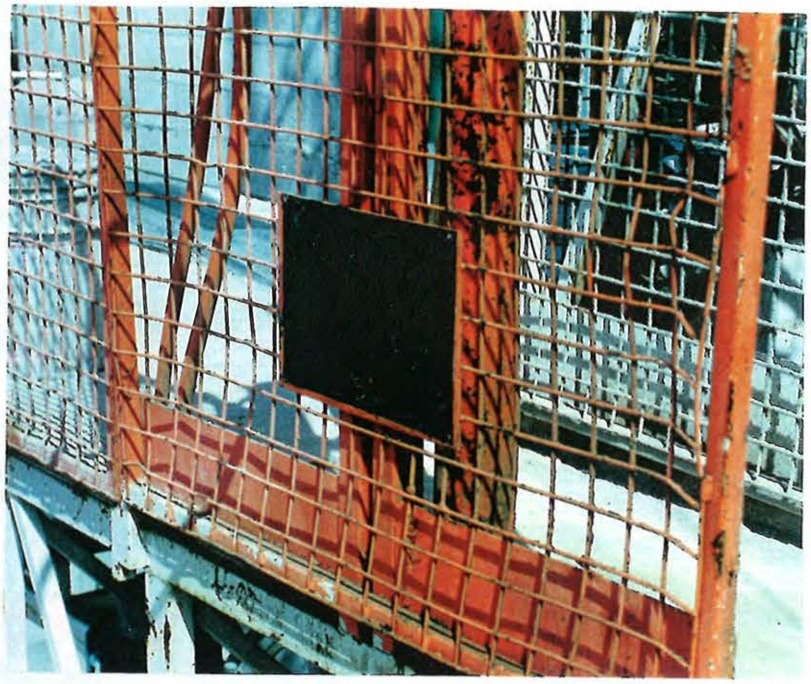
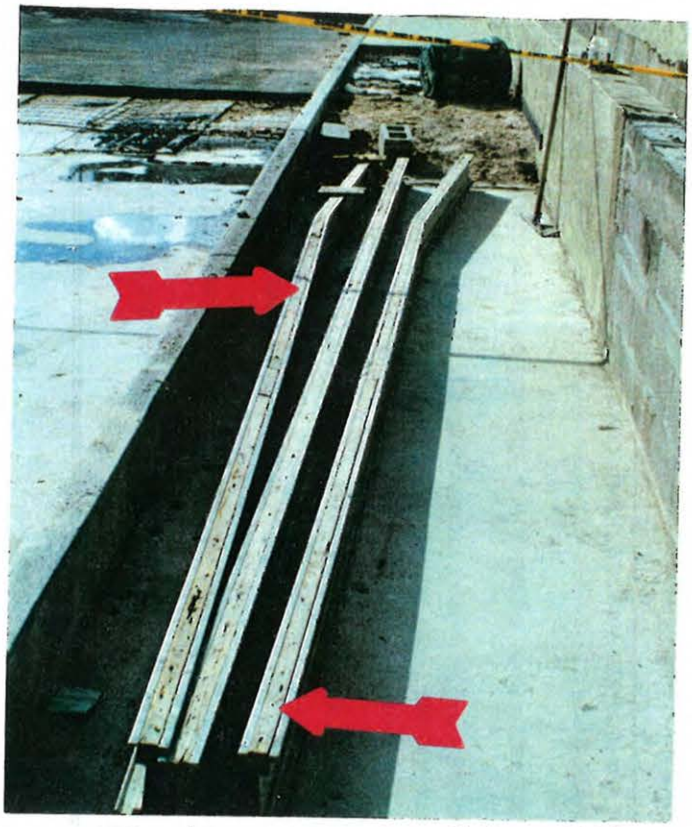


Figure 1.18

Missing Placarding From Designated Locations

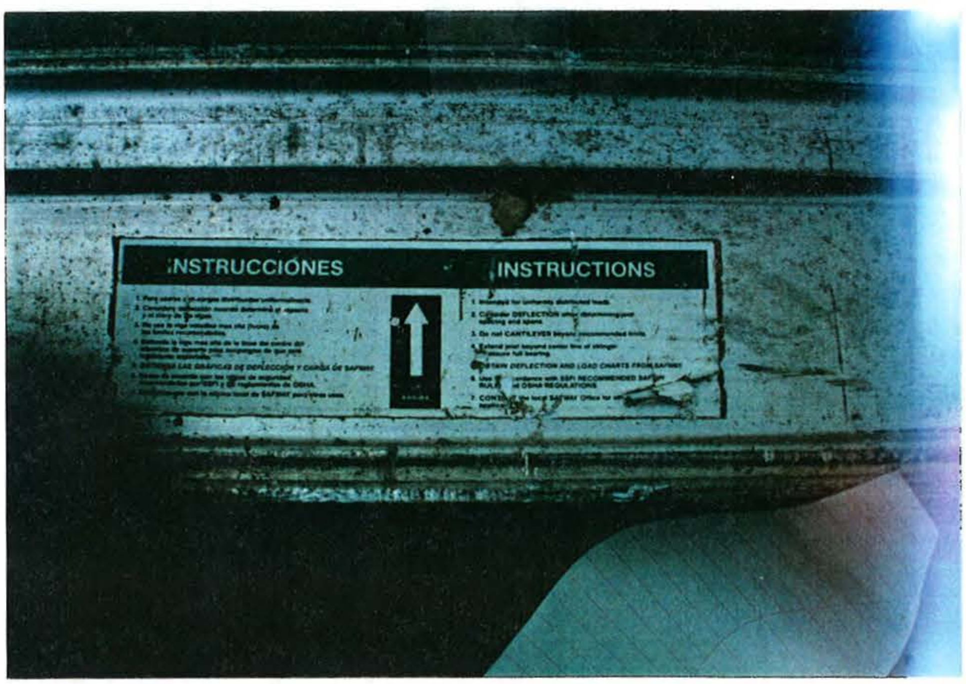
Illegible Placard on North Side of Mast Unit #78

Figure 1.19



3 Outriggers From the Failed Scaffold
Near Arrow Shows South Outrigger, Far Arrow Shows North Outrigger

Figure 1.20



Label/Instructions on 1 of Outrigger Beams

Figure 1.21

2.0 HIGHLIGHTS OF WITNESS STATEMENTS

The following section presents the highlights of the witness statements which were conducted related to this incident. Witness statements include: eyewitnesses, e.g. were at the site and observed or have information related to the actual failure; and other witnesses, who are not eyewitnesses to the event, but have pertinent information which is related to the incident.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#1 **East Coast Electric** Electrician/Mechanic 3/8/95	o Having lunch day before incident at ≈ 1:00 pm and observed scaffolding on west face of building. o Location - on tailgate of truck on east side of company work trailers ≈ 200 yards from the west face of the building (side where scaffold units were erected). o Observed 2 scaffold units on west face of building. He observed the north scaffold unit platform as being straight (level). o The west scaffold unit platform (unit involved in collapse) was tilted down on the north end. o Observed a cantilever decking section erected on the east side of the north end of the platform on the west unit. o Observed the cantilever decking tilting (out of level). o Spoke to another electrician that he was having lunch with about the tilting platform and cantilever decking. o Was not on site on day of event.
#2 **East Coast Electric** Electrician/Mechanic 3/???/95	o Having lunch day before incident at ≈ 1:00 pm with Interviewee #1 and observed scaffolding on west face of building. o Location - on tailgate of truck on east side of company work trailers ≈ 200 yards from the west face of the building (side where scaffold units were erected). o Saw the left (north) end of the platform unit (failed scaffold) appeared to be tipped down. This end of the platform did not appear to tilt like this before. o The right end (south side of the failed platform) appeared straight (level). o Saturday morning (day of incident), observed the north end of the platform was still tipped downward.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#3 LBJ Plasterer	o Was on the unit at the time of failure. o Did not work on failed unit on Friday (day before accident). o There were 3 employees on unit on Friday afternoon. o Had worked on unit when south end of the platform was configured to work on southside inset of the west face of the building. o Saturday (day of event) was first day he worked on the north side of the unit. o Platform was level when he was on it. o Access to the failed unit was provided by using the north scaffold unit. The north unit was brought level with the failed unit and employees stepped across an opening from one unit to the other. o Scaffold plank was provided on the north side of the unit to provide a working platform for employees to stand while applying stucco. Doesn't believe there were scaffold planks on the south end of the unit. o Provided location of employees, equipment, and materials on the unit at the time of failure: - He was on the scaffold plank work platform on the north end platform adjacent to the corner intersection of the west face of the building and the south wall inset applying stucco. - Interviewee #4 was located on the north end of the platform near the middle of the 4th platform extension. He was on the material platform portion of the unit providing stucco to the plasters. - The 3 fatally injured employees were located on the cantilever decking plastering the building's south and east inset walls. o The platform was not being raised or lowered at the time of the event. o Short time (minutes) before event heard Interviewee #4 say he didn't like noise he had heard from the traction hoist. o At the inception of the failure heard a noise , "crack", he believes was similar to one earlier described by Interviewee #4. o Noise may have come from below platform. o Never has used pendant controls (operated the unit).

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#4 **LBJ** Plasterer Scaffold Operator 3/9/95	o Been operating scaffold units 5 days/wk at site since ≈ October 1994. o Has not seen an operators manual for the mast climbing unit. In fact wrongly identified an ANSI mast climbing standard as "probably" the operating manual. o Has not seen a load chart for the mast climbing unit. o Identified some type of placard on the mast but condition rendered it unreadable. o States was trained by another LBJ operator, extent of training was to show how the pendant controls raised and lowered the unit. o Had not been told how to conduct a safety inspection of the unit. o Could not identify the ACCESS Equipment, <u>Equipment Erection Checklist</u>. o Could not identify the ACCESS Equipment, <u>Certificate of Competence</u>, to operate the units. Additionally, doesn't recall ever signing the document. o Never knew the maximum capacity of the unit in any configuration. o After the event heard the unit could hold a load of 8000 lbs. o Built cantilever decking on north end of unit about 1 to 2 days before incident. o The cantilever decking was constructed using (3) - aluminum I-beams, (4) - 4x6 wood cross members and (8) - 4'x8'x3/4" sheets of plywood. All components were nailed together. o Friday (day before incident) morning worked with another employee on the unit repairing on corner intersection of the west face of the building and the south wall inset between floors 7 to 28. o After lunch began stuccoing the building inset with 3 other employees. o There were 4 people maximum on the platform, platform extensions and cantilever decking on Friday afternoon. There was a maximum of 3 employees on the cantilever decking. When 3 people were on the cantilever decking it was of short duration because the 3rd employee was running "mud" to the other two plasters on the cantilever decking. The 3rd employee was only ever on the cantilever decking for a brief period of time. o The cantilever decking "dropped a little" on Friday afternoon. o LBJ president would come on the platform to check on the job. On Friday afternoon the LBJ president was on the unit and observed the cantilever decking tilting and ordered the employees to make it level.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#4 (Continued) **LBJ** Plasterer Scaffold Operator 3/9/95	o On Saturday morning he and another LBJ employee altered the cantilever decking with (3) - 4x6 wood members nailed to the north end of the cantilever decking. (4) sheets of 4'x8'x¾" were placed lengthwise (perpendicular to the longitudinal axis of the outrigger) to "level" the north side of the cantilever decking. o He was standing near the middle of the 4th platform extension facing the mast when he first detected the cantilever decking going down. o Then the platform he was standing on began to collapse. o Doesn't remember hearing any noise immediately preceding the failure. o After they moved the platform approximately 15 minutes before the event he heard a new noise as he brought the platform to a stop. Mentioned noise to Interviewee #3. He did not hear that noise again. o Provided location of employees, equipment, and materials on the unit at the time of failure which were somewhat consistent with the loadings related by Interviewee #3. o There were no scaffold boards on the work platform portion of the unit at the time of the event. All the scaffold planks were on the north side of the platform.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#5 **ACCESS** Erector/Leadman 3/8/95	o Has erected this model of mast climber in the past. o At startup of job at site 3 ACCESS employees erected/moved units. o 2 employees (himself included) erected the unit #78 (failed unit) in the position it was at the time of the incident. o No certification is required for an erector. o No certification of training is required for the users/operators of the mast climbing units. o Load chart should have been in the electrical box on Unit #78. o Load charts are shown in the (operators) manual. o He is not a certified trainer. He feels he can conduct quality training for users of the units. o ACCESS Vice President was on-site functioning as a salesman/coordinator. o He does the inspection checklist (ACCESS Equipment, <u>Equipment Erection Checklist</u>) with the customer. o He has the customer sign-off on the Bill of Competence (ACCESS Equipment, <u>Certificate of Competence</u>). o Went over inspection checklist with LBJ president and LBJ operator (Interviewee #6) including operation, planking of the unit and the electrical breaker in the power system. o Does not remember if he addressed the load rating of the unit with LBJ personnel. o Does not remember if he discussed the load chart with LBJ personnel. o He gave operation manual to LBJ personnel, the same one that was found on the unit after the incident. o Maximum allowable length of the platform is 55′. o Believes the platform on the failed unit was centered on the mast, e.g. same distance from north and south end of platform to centerline. o Used cantilever decking configurations on corners of east face of building. o Used cantilever decking configuration on 1st set up on the west face of the building (near south corner). o With Unit #78 positioned in the spot it failed it was configured such that the north end of the platform consisted of 4 platform extension. The inset of the building in that location was being worked utilizing a cantilever decking configuration supported by 3 outriggers 14′6″ long.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#5 (Continued) **ACCESS** Erector/Leadman 3/8/95	o Does not know the weight of the cantilever decking materials. Thinks a sheet of plywood weighs 65 lbs. o Only does cantilever decking when instructed by ACCESS Vice President or others. Believes customer is responsible for constructing cantilever decking. o Has erected cantilever decking with an LBJ employee (Interviewee #6) including the failed cantilever decking. o Maximum load rating of a platform with 4 platform extensions is (load placed at end): a) without cantilever decking - 800 lbs. b) with cantilever decking - 500 lbs. o Feels 800 lbs. is maximum working load not the safe load of the scaffold. o Doesn't know how he knows what he believes is the maximum rated load of the unit with 4 platform extensions and a cantilever decking section, only knows that information by word of mouth. o The (ACCESS) inspection sheets and operating manual do not address the cantilever decking. o It is his responsibility to train users of the scaffold. o The rated load information related to the various platform configurations is not transferred to the users via any documentation. This type information is transferred via verbal communication. o He issued ACCESS Equipment, <u>Certificates of Competence</u> to the LBJ president and Interviewee #6. o Certificates of Competence are supposed to show that the user is competent to operate the scaffold in all configurations. o The erection and inspection checklists is done every time a scaffold is moved. o There should be an erection checklist for both the south and north configurations of Unit #78 when it was in the position that it failed. o The erection checklist would require bolts be in place for both the top and bottom cords of the platform extensions, o Sometimes the bottom chord bolts don't get installed when the unit's bottom plates do not align properly. He stated Unit #78 didn't have bottom bolts because of this reason. o Believes the cantilever decking is a modification to the unit.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#5 (Continued) ACCESS Erector/Leadman 3/8/95	o Load chart does not address platform modifications. o I-beam (cantilever decking outriggers) information comes from engineering drawings which he does not have possession of. o ACCESS Corporate was supposed to send the user, in this case SPD/LBJ information on modifying the platform and the related allowable loading. o Was able to visually identify an old version of the ACCESS Satellite Operators Manual. o Was able to visually identify the load chart in the operators manual. o Knew that if the platform length was eccentric it would affect the allowable loading to some degree. o Didn't know how a user could determine a rated load capacity of a platform configuration which was different than those listed in the load chart. o The Certificates of Competence for the LBJ personnel were not on-site, they were given to ACCESS Corporate Office. o His equipment inspection does not include a check to determine if the placard for rated load capacities is in-place.
#6 LBJ Laborer Scaffold Operator 3/9/95	o Assisted Interviewee #5 with erecting Unit #78 and other units at the site. o Followed Interviewee #5 instructions when erecting units. o Friday, day before incident, assisted Interviewee #5 in erecting cantilever decking on the north end of Unit #78. o Believes he received no training on operating units. However, admits Interviewee #5 showed him how to use the up/down buttons on the unit's pendant control. o Has not seen or signed a ACCESS Equipment, <u>Certificate of Competence</u>, which would certify him as receiving training equivalent to a competent operator of the unit. o Has signed a form he identified as an ACCESS work order form. o From a position underneath Unit #78 near mast he observed the north end of the platform had an approximate 10 to 20 degree tilt (downward). o On Friday he observed 5 employees on the platform. o Observed a maximum of 2 employees of the cantilever decking on both Friday and Saturday. o He was on the platform on Friday acting as a laborer and operator. o Unit #78 was "squealing" just prior to the failure. o Saw a bar on the bottom side of the platform bending before he saw the cantilever decking fail. He was located just to the south of the mast near the "mud mule" when he observed this sequence. o He has not seen a load chart. o Has never been told by anyone, including Interviewee #5, about the rated load capacity of the mast climber units. o Interviewee #5 told him that the mast climbing units were safer than working from two point suspension scaffolds. o Didn't know there was an operators manual located in the electrical box on Unit #78.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#7 LBJ President XX/XX/95	o Prior to this job had never used a mast climbing unit. o Had a small LBJ crew assist ACCESS in erecting mast climbers at the site. o SPD requested that he provide the laborers to ACCESS to assist in the scaffold erection. o Interviewee #5 was the leadman for ACCESS that erected the scaffolds. o At the time of the event Unit #78 platform with extensions was 50′ long. o Interviewee #5 put cantilever decking on Unit #78 during the initial setup. o ACCESS made the decision to use the cantilever decking sections. o Interviewee told him to get longer outriggers because they would be needed for the insets on the west face of the building. o SPD rented the aluminum outriggers and ACCESS provided the other wood materials for the cantilever decking. o Interviewee #5 did not discuss with him what the rated load limits of the mast climber are. o Interviewee #5 showed him how to use the up/down buttons on the pendant controls. o He did not ask ACCESS about the load limits of the unit because the sales brochure related to the unit said it had a capacity of 8000 lbs. o Interviewee #5 erected cantilever decking on the south side of Unit #78 to cover the south inset on the west face of the building. The cantilever decking consisted of 5 or 6 outrigger beams. o ACCESS did not inform him of how many people could safely be on the cantilever decking. o The use of the mast climbers to span the building insets was discussed several times with the ACCESS Vice President. o It would have been a problem to set the mast of the unit inside the building insets. This would have eliminated the need to use cantilever decking. o In the end it was ACCESS's decision to use the cantilever decking. o Interviewee #5 added the last 2 platform extensions on the north end of Unit #78 and added the 3 aluminum outriggers to those extensions. o After adding the 4th platform extension Interviewee #5 did not inform him of any weight limitations for the platform.
#7 (Continued) LBJ President XX/XX/95	o He did not ask about any load limits because they had successfully used their decking platform (with cantilever decking) with 3 employees on the east face of the building. o The platform was tilted downward (Unit #78 - north side). It was also tilted down on the southside. o On Friday, day before event, Interviewee #6 put a couple of 2x4's and plywood down to straighten (level) the platform (cantilever decking). o Interviewee #6 copied what Interviewee #5 did when the same problem (cantilever decking was deflecting in a downward manner) arose on the southside of Unit #78. o He did not ask for a load chart because he did not know one existed. Consequently, no LBJ employee received training in the use of the load chart.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#8 SPD President 4/10/95	o First job he has used any type of scaffold that was different than tubular welded frame scaffolds. o Most company projects (residential and commercial) have a maximum height of 3 or 4 stories. This project has the highest building height this company has ever worked on. o Got bids from a couple of different mast climbing companies before awarding contract to ACCESS. o A reason for contracting with ACCESS is because he was assured by ACCESS Vice President, Interviewee #11, that the ACCESS Satellite could hold up to 8000 lbs. o He was never told by Interviewee #11 that by adding platform extensions that the capacity of the unit would decrease. o Stated that units were erected by ACCESS employees under the direction of Interviewee #5. o He was told by Interviewee #5 that longer aluminum outriggers would be needed for the cantilever decking. So he contracted with SAFEWAY Scaffold to obtain the outriggers which were required. On other sections of the building 8 to 10 foot outrigger lengths were used. o He was never told by Interviewee #11 that 3 people could not be on the platform. o ACCESS Vice President, Interviewee #11 told him the reason they (ACCESS) get so much business is because they have the ability to use the cantilever decking sections on their units. o He had no knowledge of an operators manual or load chart prior to the event. o Since he was told by the ACCESS representative that the capacity of the unit was 8000 lbs. it would be safe for the men to work on it.
#9 SPD Vice President 4/10/95	o Prior to SPD contracting with ACCESS, Interviewee #11 came to the site and made an inspection. o He gave Interviewee #11 a set of building plans and discussed the unique configuration of the building, i.e. building face insets. He was assured the ACCESS units could be configured to cover more distance and could cover the "holes" (building insets) with no problems. o He told Interviewee #11 that the platform length would be required to be 55' at the "hole". Interviewee #11 told him that configuration would not be a problem for ACCESS's units. o Interviewee #11 told him their units have the capacity for the cantilever decking sections and that is a reason they receive so much business. o He wanted to use 16 foot platforms inside the building insets, in lieu of using the longer platforms with the cantilever decking, however, there was a problem with getting past some structural members of the building which were already in-place. o Interviewee #11 told him the capacity of the mast climbers was 8300 lbs. o After the machine (Unit #78) was set with the cantilever decking he, Interviewee #11, and Interviewee #6 (operator) rode the unit to the top of the building. o He did not ask about loading for various platform configurations or a load chart because Interviewee #11 assured him of the 8300 lbs. capacity so he didn't feel he would ever overload the unit.

WITNESS NUMBER COMPANY OCCUPATION INTERVIEW DATE	HIGHLIGHTS OF WITNESS STATEMENTS
#10 **ACCESS** President 3/10/95	o Prior to Unit #78 being brought to the site it was cleaned and painted. At this time the load chart and placards were left off the unit. o Interviewee #5 was the leadman in erecting the platforms at the site. o Stated Interviewee #5 is qualified to erect the units no matter their height or configuration. o Interviewee #5 is qualified and responsible for instructing the customer in the operation of the units and the load capacities for various configurations of the unit. o Interviewee #5 is also familiar with the load capacities associated with the cantilever decking sections. o ACCESS does not have any records certifying erection capabilities and knowledge of the use of the unit load chart for Interviewee #5, or any of its employees. o He provided a load chart to SPD and the superintendent for JJW at his request.
#11 **ACCESS** Vice President 4/10/95	o Had a conversation with Interviewees #6, #7, #8 and #9 about problems associated with setting up a mast climber in the "hole" (building insets). This was a very big issue. o Interviewee #7, President LBJ was very strong on using the cantilever decking because of the work schedule. Interviewees #8 and #9, SPD left the final decision up to Interviewee #7. o Stated that when cantilever decking is used bolts should be used in the platform extension bottom chord to resist twisting (of the platform) and to give it more stability. o 3 platform extensions are the most which can be used when the cantilever decking it utilized. Otherwise the platform (and extensions) will not have the capacity to support the cantilever decking. o Has used this (one utilized at the time of the event) configuration at other sites, but used shorter outriggers.
#12 **JJW** Site Superintendent 3/8/95	o Unit #78 was positioned same spot as at time of failure. The south end of the platform was configured such that the cantilever decking (with 14.5′ outriggers) spanned the entire width (≈ 18′) of the inset of the building. o There was 7 people on the southside of the platform inspecting the walls. These people were employed by JJW, SPD and LBJ. o Observed 5 people on the cantilever decking at one time.

3.0 CHRONOLOGY OF SIGNIFICANT EVENTS

The following section presents a chronology of significant events which are related to the incident.

Chronology of Significant Events

Date/Time	Description of Significant Events
1990	An ACCESS Satellite scaffold owned and erected by ACCESS catastrophically fails at a construction site in Atlanta, GA. As a result, one employee fell from the unit approximately 170' to his death. The configuration of the scaffold at the time of the collapse and the cause of the event are similar to those in the subject incident.
9/28/90	Calculations conducted by contract engineer showing the allowable loads on cantilevered aluminum outrigger beams. These calculations were provided to OSHA by ACCESS on-site on 3/7/95.
Prior to 10/94	ACCESS Vice President (VP) came to the site and made an inspection prior to bidding on job. SPD VP reportedly told ACCESS VP that a platform length of 55' would be required to cover the "hole" (south inset on the west face of building). ACCESS VP reportedly said that a 55' platform with the required cantilever decking would be no problem. He added that their scaffolds (ACCESS Satellite models) have the capacity for the cantilever decking section and that is why they receive so much business.
Prior to 10/94	Reported conversation between ACCESS VP, LBJ President and operator/laborer, and SPD President and VP related to problems with setting up a mast climbing scaffold in the building insets. If a scaffold could/would have been erected in the inset, no cantilever decking section would have been required.
Prior to 10/94	Unit #78 was cleaned and painted prior to bringing it to the site. Apparently, it is at this time the placards for the unit are taken off the machine and are not returned when the unit is delivered to the site.
10/94	3 mast climbing units, including #78 brought to site and erection/work begins.
10/9/94	ACCESS work order for Unit #78 signed. Includes description of the erected scaffold with the outriggers and their connection plates. Additionally, states that, "informed and showed" SPD "on running units".

Date/Time	Description of Significant Events
≈ 2 - 4 wks. before 3/4/95	Unit #78 spotted in location it was in at time of event. The south side of the platform was configured to cover the entire south inset. This required ≈ a 15′ wide cantilever decking modification with 14.5′ outriggers. ACCESS leadman erected the unit including the cantilever decking. In response to excessive deflection of the cantilever decking the leadman altered the decking by adding more materials to build up the deck. This was an attempt to "level" the decking.
≈ 2 - 4 wks. before 3/4/95	Reportedly 7 people rode on #78 to inspect the south inset wall. Personnel from JJW, SPD and LBJ were on the unit. Apparently, 5 individuals were on the cantilever decking at one time.
Friday, a.m. 3/3/95	ACCESS leadsman and LBJ personnel erect cantilever decking section on north end of Unit #78.
Friday, a.m. 3/3/95	2 employees worked on Unit #78 repairing corner of north inset of building between floors #7 and #28.
. Friday, ≈ 1:00 pm 3/3/95	2 electricians report north end of platform and the cantilever decking of Unit #78 are visibly deflecting from there vantage point ≈ 200′ away.
Friday, p.m. 3/3/95	3 - 5 employees were reported on the north end of platform and cantilever decking applying stucco to the inset.
Friday, p.m. 3/3/95	The north end of the platform (Unit #78) and the cantilever decking were reported to be tilting in a downward direction. The President of LBJ was on the scaffold, observed the cantilever decking deflection and instructed his employees to "level" it. LBJ employees alter cantilever decking by adding timers and plywood decking to north side of decking (Note: there is a contradictory statement on this item that indicates the alteration may have occurred on Saturday morning, 3/4/95).
Saturday morning 3/4/95	An electrician still observed the north end of Unit #78 deflected in a downward manner. The north end of the platform was configured with 4 - 5′ platform extension, with a cantilever decking ≈ 8′ - 9′ wide x 14.5′ long. The cantilever decking was supported by 3 aluminum outriggers connected to the 2 north platform extensions.
Saturday 8:00 am to 8:29 am 3/4/95	The platform was raised for the last time (possibly 15 minutes before the failure) before the incident, e.g. it was not moved immediately before the failure. As the operator was bringing the platform to a stop he heard a new noise he had not heard before from the scaffold. The operator is reported to have said he didn't like the noise he heard from the hoist.

Date/Time	Description of Significant Events
Saturday ≈ 8:30 am (inception of failure)	It is reported that a "crack" noise was heard at the on set of the failure. This noise was apparently similar to the noise which was reported above, e.g. new noise. The noise may have been generated somewhere below the main platform. Another noise reported as a "squealing" sound was heard immediately before failure. It is reported that a bar on the bottom side of the platform was reported to bend before the cantilever decking section began failing. 3 employees were on the cantilever decking when the scaffold began to collapse.
3/4/95 ≈ 8:30 am	Scaffold collapses. 3 of 5 LBJ employees on scaffold system at the time of failure fall about 75' to grade and incur fatal injuries.

4.0 STRUCTURAL ANALYSIS and DISCUSSION

The purpose of the structural analysis was to determine the internal stresses in the members of the scaffold platform structure including the aluminum outrigger beams due to the loads imposed upon them at the time of the accident. The actual stresses in the members were then compared with their limit state values to examine if any failure was imminent. Several loading conditions were examined during the analysis whose results are discussed later.

A three dimensional space frame computer model was used for the analysis to compute the forces in the members of the structure. The computer model represented the structure as it existed immediately prior to the accident. The model consisted of four 5-ft. platform extensions on the north side of the main fixed platform, five steel tubing members overhanging 40" from the platform extensions on the east side, three aluminum outrigger beams cantilevering approximately 14.7 ft eastward from the third and fourth platform extensions, the 4x6 timber members placed over the aluminum beams, and the platform-extensions' top and bottom members (connecting links of the platform frames). This computer model had 144 joints and 247 members, see Figure 4.1.

As the tower's mast and the center fixed portion of the scaffold framing did not sustain any damage, see previous chapters, and the mast structure remained plumb after the accident, the mast and fixed platform portion of the scaffold structure was not included in the analysis. The support of the platform-extension to the main platform was assumed fixed at the top connecting links. In regard to the support conditions of the bottom connecting links, analyses were done on two assumption. First, it was assumed to transfer axial compressive force only and second, it was considered to transfer axial compressive force and shear forces.

Special consideration was given to the top and bottom connecting links between the platform-extension frames during the computer modelling. The top connecting link was modelled as two short members rigidly connected to the platform at one end and pinned to each other to closely resemble the actual bolted connection of the two top plates as observed in the field, see Fig. 4.2. To evaluate the effects of the bottom connection and determine whether the failure could have been prevented if the bottom adjoining member were bolted at the time of the accident, the bottom connecting links were analyzed for two conditions. First, the bottom connecting link was modelled to resist axial compressive load only to reflect the actual as-built condition where the link was simply bearing against the frame with no positive connection. Second, it was modelled as pinned condition at the ends and had the capability of resisting both the axial and shear forces.

The physical dimensions of the structure and the member sizes were taken from the actual field measurement. The platform-extension frame's member sizes were then compared with sizes shown on a fabrication drawing obtained by the OCE and were found to be close. All members were assumed to have their full thicknesses for all the load cases considered in this report, even though it was observed in the field that several frame members had sustained corrosive damage to a varying degree. The laboratory report, see Appendix D, has indicated substantial corrosion loss of the metal of the sample tested. The dead load of the structure was considered by the computer program as uniformly applied loads for all members. Other loads such as plywood decking, scaffold planks, stucco material, and tools etc. were hand computed and applied at the appropriate structural member as uniform load or concentrated loads. For discussion of the magnitude and location of loads, see previous chapters and Fig. 1.3. Live loads of the five workers were also calculated based on their actual weight and applied to the appropriate members, see Fig. 4.3 for the locations. The weather, at the time of the accident, was reported to be without any appreciable wind. Wind loads were, therefore, not considered in the analysis.

To evaluate the internal member forces of the platform-extension and its outrigger cantilever structure under various loading conditions and under different assumptions of the end conditions of the bottom connecting links, several different cases were studied. Result of the structural analysis for each of the cases is discussed below.

Case 1. In this case, loads at the completion of the erection of four platform-extensions with the east overhang, three aluminum outrigger beams and the 4x6 timber members were considered. Plywood decking and scaffold planks were not included. Bottom connecting links were assumed to bear against the frame. The structure was subjected to its selfweight only. The analysis indicated that all members of the structure were stressed well within their allowable values. The maximum deflection at the northeast corner of the cantilever outrigger beam was approximately 1.9 inches.

Case 2. In this case, a four platform-extension was sheathed with one layer of 3/4" plywood decking. The 40" wide work platform overhang to the east of the platform-extensions was supporting 2"x10" scaffold planks, and the cantilever outrigger platform was sheathed with 8 sheets of 3/4" thick plywood. These loading conditions represented the dead loads as they existed a day earlier, i.e., prior to the placement of the last layer of plywood on the outrigger platform. The bottom connecting links members of the platform-extensions were considered bearing against the frames to resist axial compressive forces only. It was determined that with no live load on the platform, the northeast corner of the outrigger aluminum beam was subjected to a 5.8" downward deflection. A maximum axial compressive force of 7,180 lbs occurred in the first platform-extension east vertical diagonal member- member 214 of Fig 4.4. This force was exceeding the allowable value of the member as per the Allowable Stress Design, however, it was below the critical load, see Table 1.

Case 3. An additional layer of plywood decking was placed on the outrigger cantilever platform bounded by the north and center aluminum beams as a mean to "level" the platform as reported by the workers, see Fig. 4.4

These loads of the decking materials were added to the Load Case 2 representing total dead loads on the platform in the morning of the accident. Without any other load, i.e. loads of workers or materials, it was determined that an additional downward deflection of about 1.7" occurred at the North-East corner and the force in the member 214 increased to 8,350 lbs. (same member as Case 2) which was still below the critical load of the member.

Case 4. This case dealt with condition at the time immediately prior to the collapse. As per the eyewitnesses, five workers and several buckets of stucco were on the platform at various locations as shown in Fig.4.3. representing the live load condition at the time of the accident. Bottom connecting links of the platform-extensions were assumed bearing against the frames to resist axial compressive forces only. When the platform structure was subjected to the live loads discussed above, in addition to the dead loads of Case 3, the northeast corner of the outrigger platform was subjected to a total downward deflection of 14 inches and the compressive force in the same member 214 (east diagonal member of the first platform extension) increased to about 14,330 lbs, exceeding the critical buckling strength of the member, see Table 1. The buckling strength of the members, the significance of the high compressive force in member 214, and its effect on the stability of the structure will be discussed further.

Case 5. This case considered the same loading condition as the above case (Case 4), except that the bottom connecting links of the frames were assumed bolted together, i.e., they had the ability to resist axial and shear forces. Under these assumption, member 214 was subjected to a compressive force of approximately 14,000 lbs which was about 2.5% lower than the Case 4, but was still higher than the critical strength of the member. The northeast corner experienced a deflection of 13.5 inches. In case 4 above, this corner was subjected to a total deflection of 14".

Case 6. This case was considered to examine the results if the last four sheets of plywood decking were not placed to "level" the outrigger platform. With the platform subject to the same live loads of Case 4 and the bottom connecting links bearing against the frame, as in the Case 4 above, member 214 was subjected to a force of 13,160 lbs which was still higher than the buckling strength. The same northeast corner would deflect downward approximately 12.4 inches.

Two steel tube specimen were taken from the failed platform and tested for their yield and ultimate tensile strengths by an independent laboratory after the accident. The tests concluded that the small size tube (1.2"x1.2"x0.1") had a yield stress and ultimate tensile strength of

72,378 psi whereas the large size tube (1.5"x1.5"x0.128") had 61,032 psi and 67,135 psi of yield and ultimate strength respectively. See Appendix D, Metallurgical Testing Report.

Manual computations were performed to compute the failure load of the members in accordance with the Load Resistance Factor Design (LRFD) of the American Institute Of Steel Construction (AISC), Dec. 1, 1993's edition and the allowable load of the members in accordance with the Allowable Stress Design (ASD) of AISC, ninth edition. In the LRFD computations, the load and resisting factors were considered as 1.0 to arrive at the limit state values. Emphasis was given to the first platform-extension frame's east side diagonal member(member 214) because of its high member force, see Fig. 4.5.

The east vertical side diagonal member of the first platform-extension from the main fixed was subjected to a high compressive forces in all cases discussed above. The member consisted of a tube of 1.2"x1.2" size. The wall thickness as per the measurement was about 0.1" (fabrication drawing indicated this member to be 30mmx30mmx2.6mm in size). To determine the limit state value of this member as per LRFD and ASD Specifications, considerable thought was given to arrive at a reasonable and justifiable value of the slenderness ratio because the failure load of a compression member significantly depends upon the effective length (kl) of the member.

From the above computer analyses, it was determined that the member 214 was primarily a compression member with some flexural moments at each end. From the ratio of the two end bending moments, it was computed that the point of the inflection was about 46" from the top end (Member 214 was approximately 60" long), see Fig. 4.5 and 4.6 . It was then considered that an effective length kl = 46" be used (k value of 0.77) for computing the maximum compressive strength as per the AISC's LRFD and ASD requirements. It is commonly recognized that instability would occur when the actual member load exceeds the critical load. Based on an effective length of 46" and a yield strength of 72,378 psi, the critical load of this diagonal as per AISC's LRFD was approximate 9,450 lbs. The maximum allowable load of the diagonal as per ASD specification was 5,700 lbs.

The following are the internal member forces of member 214 under various loading cases versus its critical strength as per LRFD with the load factor = 1.0 and the Resistant Factor = 1.0, and the Maximum Allowable Load as per ASD requirements.

TABLE 1

Loading Case	Critical Load per LRFD,(lbs)	Allowable Load per ASD (lbs)	Actual Force Mem. 214 (lbs)
Load Case 1	9,450	5,700	2,500
Load Case 2	9,450	5,700	7,170
Load Case 3	9,450	5,700	8,350
Load Case 4	9,450	5,700	14,330
Load Case 5	9,450	5,700	14,000
Load Case 6	9,450	5,700	13,160

Load Case 4 represented the conditions as it existed at the time of the accident. Result of this analysis indicated that member 214 was subjected to an internal compressive force of 14,330 lbs, which was substantially higher than the ultimate capacity of 9,450 lbs as per LRFD of AISC. It is believed that as the live loads were placed on the platform, the failure was imminent due to the buckling of the diagonal member.

To evaluate the condition of the structure after the member 214 become ineffective, the structure was analyzed by eliminating this diagonal member See Fig 4.7. Two cases were examined:

Case 7. All loads were placed as in the case of Case 4, except that member 214 was deleted from the structure. The bottom connecting links were assumed to transfer axial compressive force only.

Case 8. Same as above except that the bottom connecting links were considered pinned.

In both cases, e.g. Case 7 and 8, the results were similar, i.e., differences in the member forces were insignificant. When the member 214 became ineffective and all loads remained on the platform as in Case 4, several members of the first platform-extension frame were determined to be stressed beyond their limit state values. Members 124 and 128 (bottom and top chords diagonals) were subjected to compressive stresses of 61,000 psi and 59,800 psi; member 198 (southwest vertical member) had a compressive stress of 60,000 psi; and member 178 (southeast vertical member) had a tensile stress of 89,600 psi. See Fig. 4.8. It is believed that after the failure of member 214, the southeast vertical member fractured at the joint, see Fig. 4.9. because its tensile stress was well above the tube's ultimate tensile strength of 72,378 psi, see Lab report. The fracture of this member and the failure of several other members led to the ultimate collapse of the scaffold platform.

The outrigger aluminum beams, manufactured by Safway Steel Products, were also manually analyzed to determine the safe carrying capacity of the beams due to their long unbraced lengths of the compression flanges. It was determined the stresses due to the loads imposed upon them at the time of the accident exceeded the allowable stresses and also their ultimate strengths. It may be noted here that the loads placed on them far exceeded the loads recommended by a consulting engineer contracted by the owner/erector for a different project in the past.

1 MN/ELEM

STRUCTURE DATA

TYPE = SPACE

NJ = 144

NM = 247

NE = 0

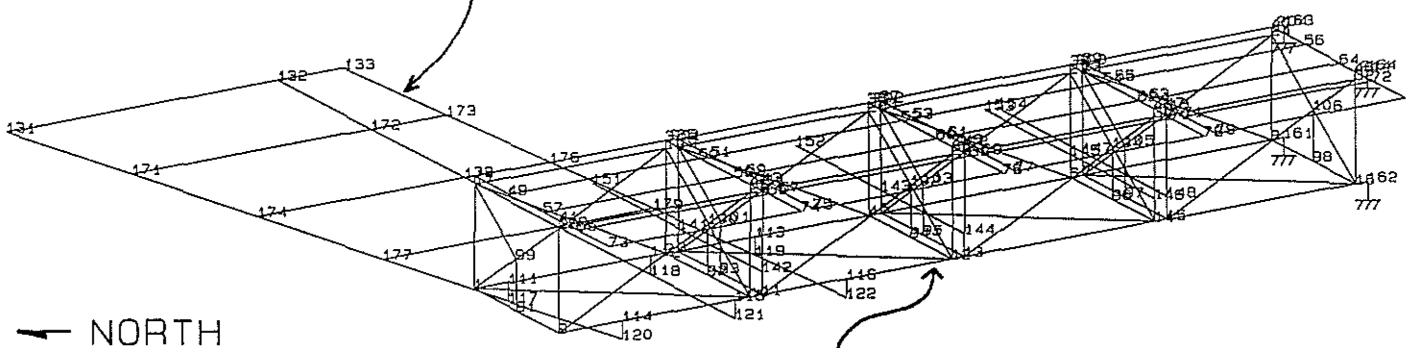
NS = 4

NL = 4

XMAX= 21.8

YMAX= 2.6

ZMAX= 19.8



COMPUTER MODLE OF THE PLATFORM STRUCTURE

FIGURE 4.1

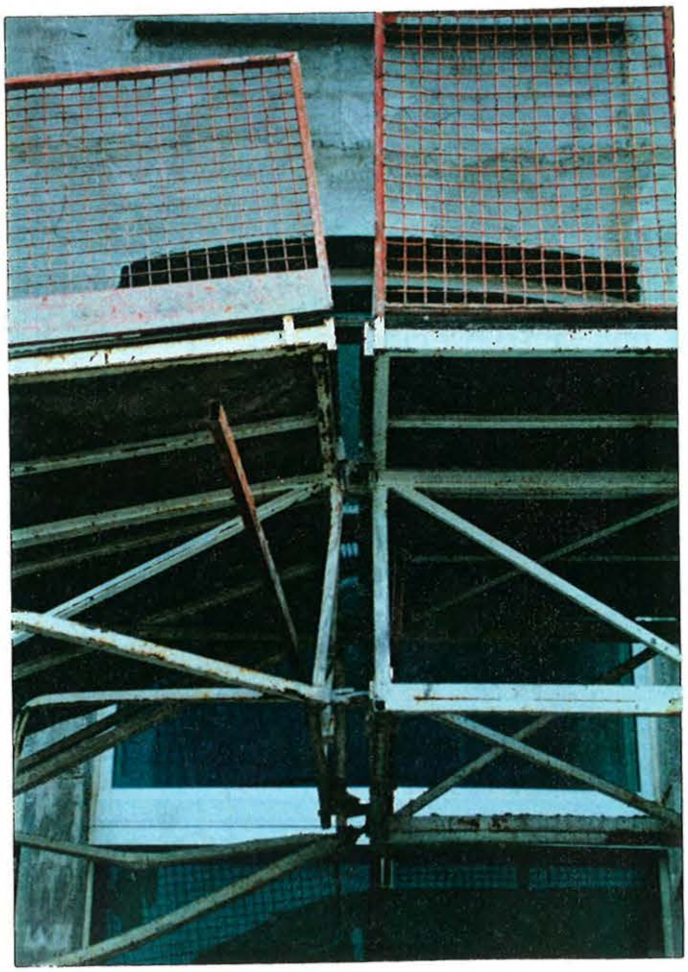
J=144, M=247 UNIT FEE POU

USER ID: US DEPARTMENT OF LABOR

S T A A D P O S T - P L O T (REV: 20.0)

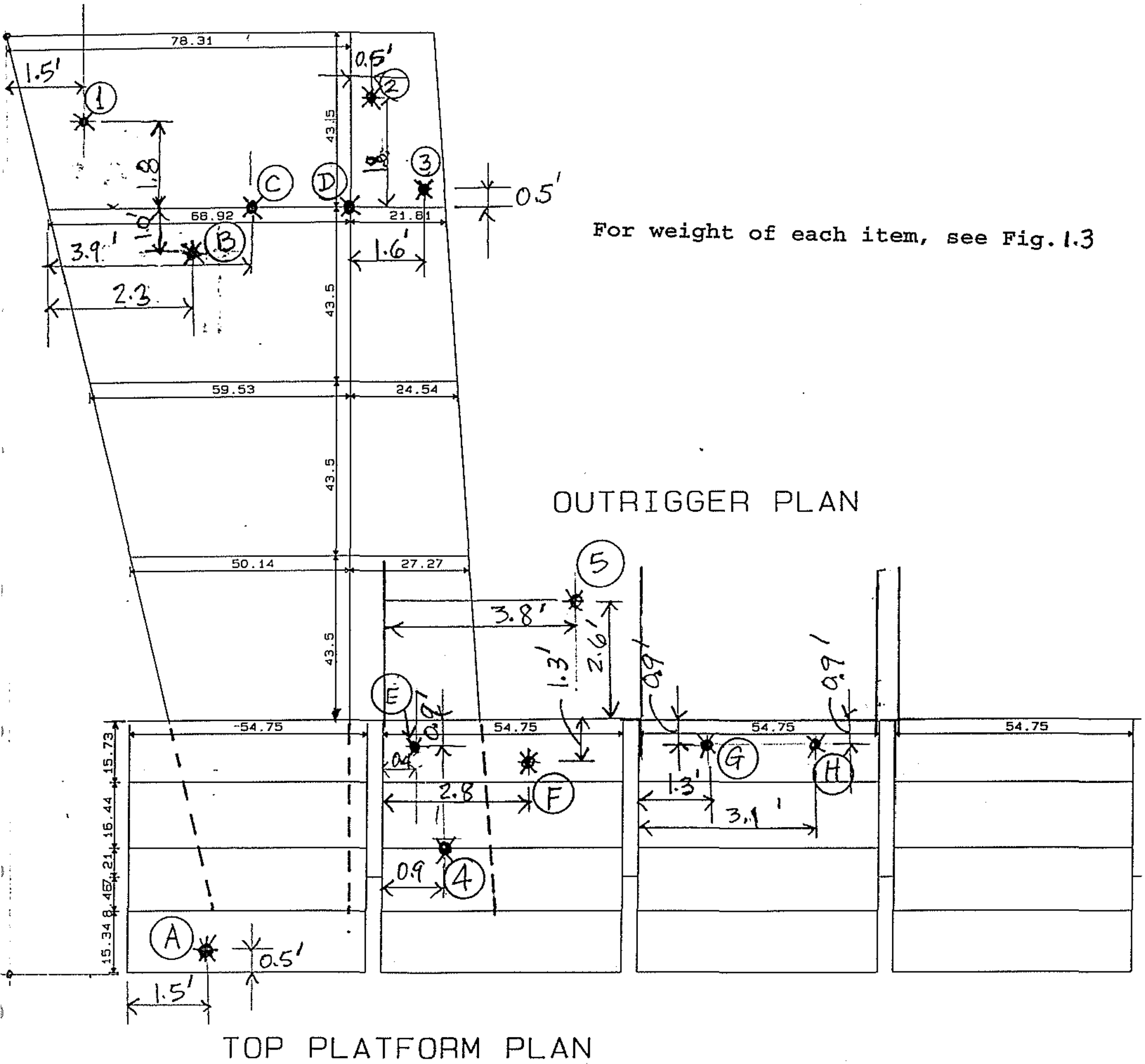
TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI14)

DATE: JUN 21, 1995



Platform-Extension Connection Details

Fig.4.2



For weight of each item, see Fig. 1.3

Locations of live loads as per the witness

Fig. 4.3

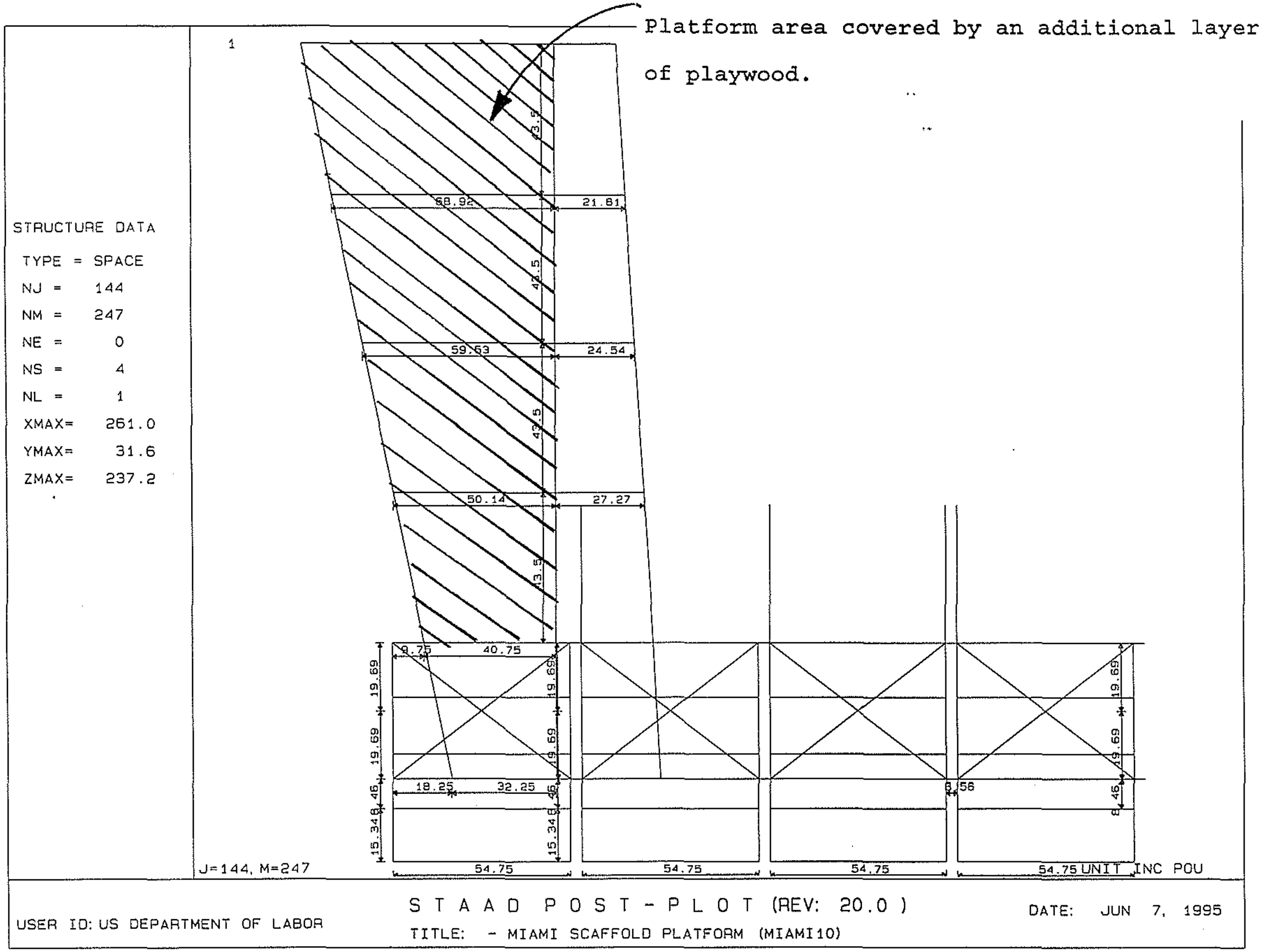

Platform area covered by an additional layer of playwood.
STRUCTURE DATA
TYPE = SPACE
NJ = 144
NM = 247
NE = 0
NS = 4
NL = 1
XMAX= 261.0
YMAX= 31.6
ZMAX= 237.2
J=144, M=247
58.92
21.81
59.63
24.54
50.14
27.27
43.5
40.75
19.69
18.25
32.25
15.34
54.75
54.75 UNIT INC POU
USER ID: US DEPARTMENT OF LABOR
S T A A D P O S T - P L O T (REV: 20.0)
TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI10)
DATE: JUN 7, 1995

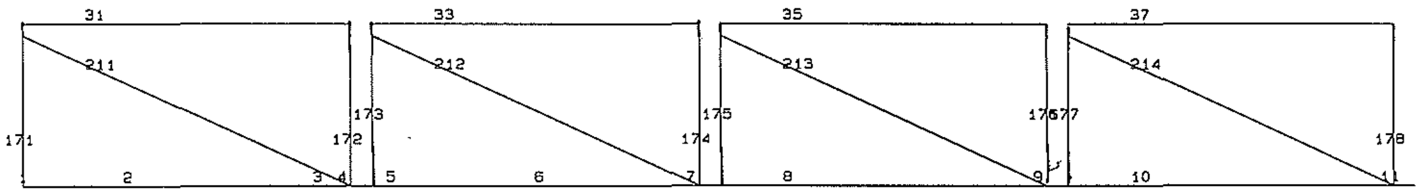
Fig. 4.4

1

MN/ELEM

STRUCTURE DATA

TYPE = SPACE
NJ = 144
NM = 247
NE = 0
NS = 4
NL = 4
XMAX= 261.0
YMAX= 31.6
ZMAX= 237.2



EAST ELEVATION - MEMBER NUNBERS

J=144, M=247

UNIT INC POU

S T A A D P O S T - P L O T (REV: 20.0)

TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI14)

USER ID: US DEPARTMENT OF LABOR

DATE: JUN 14, 1995

Fig. 4.5

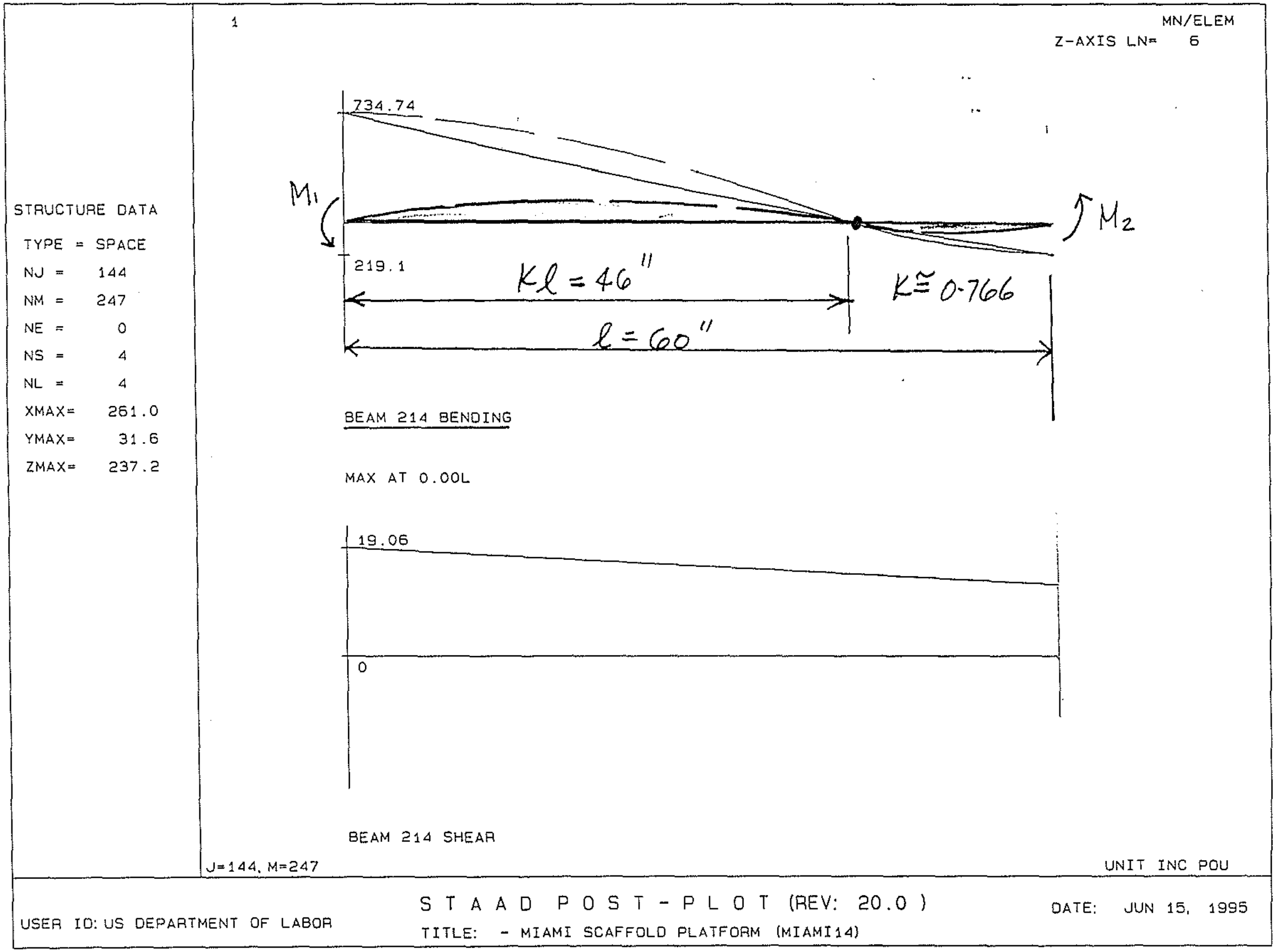

1
MN/ELEM
Z-AXIS LN= 6
STRUCTURE DATA
TYPE = SPACE
NJ = 144
NM = 247
NE = 0
NS = 4
NL = 4
XMAX= 261.0
YMAX= 31.6
ZMAX= 237.2
734.74
M1
M2
219.1
Kl = 46"
K ≅ 0.766
l = 60"
BEAM 214 BENDING
MAX AT 0.00L
19.06
0
BEAM 214 SHEAR
J=144, M=247
UNIT INC POU
S T A A D P O S T - P L O T (REV: 20.0)
DATE: JUN 15, 1995
USER ID: US DEPARTMENT OF LABOR
TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI14)

Fig. 4.6

1 MN/ELEM

STRUCTURE DATA

TYPE = SPACE

NJ = 144

NM = 247

NE = 0

NS = 4

NL = 4

XMAX= 21.8

YMAX= 2.6

ZMAX= 19.8

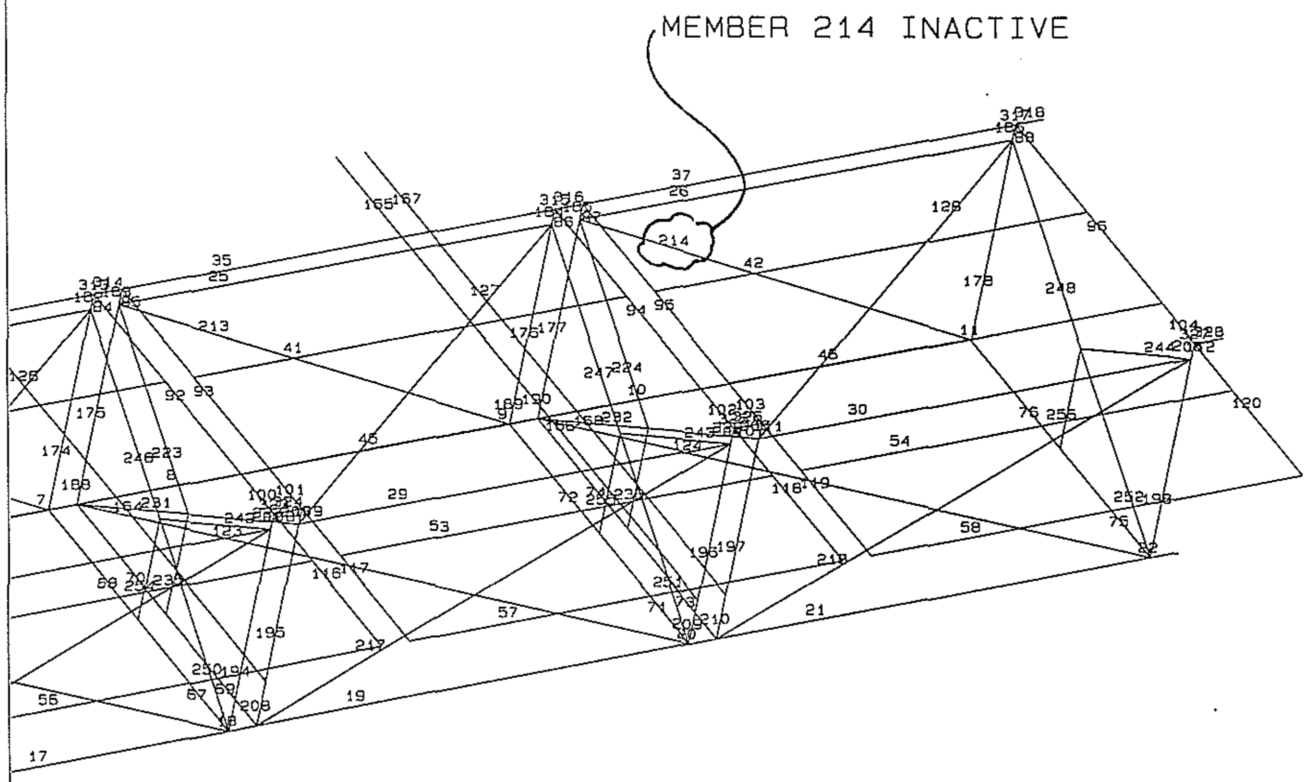


FIG. 4.7

J=144, M=247 UNIT FEE POU

USER ID: US DEPARTMENT OF LABOR

S T A A D P O S T - P L O T (REV: 20.0)

TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI15)

DATE: JUN 21, 1995

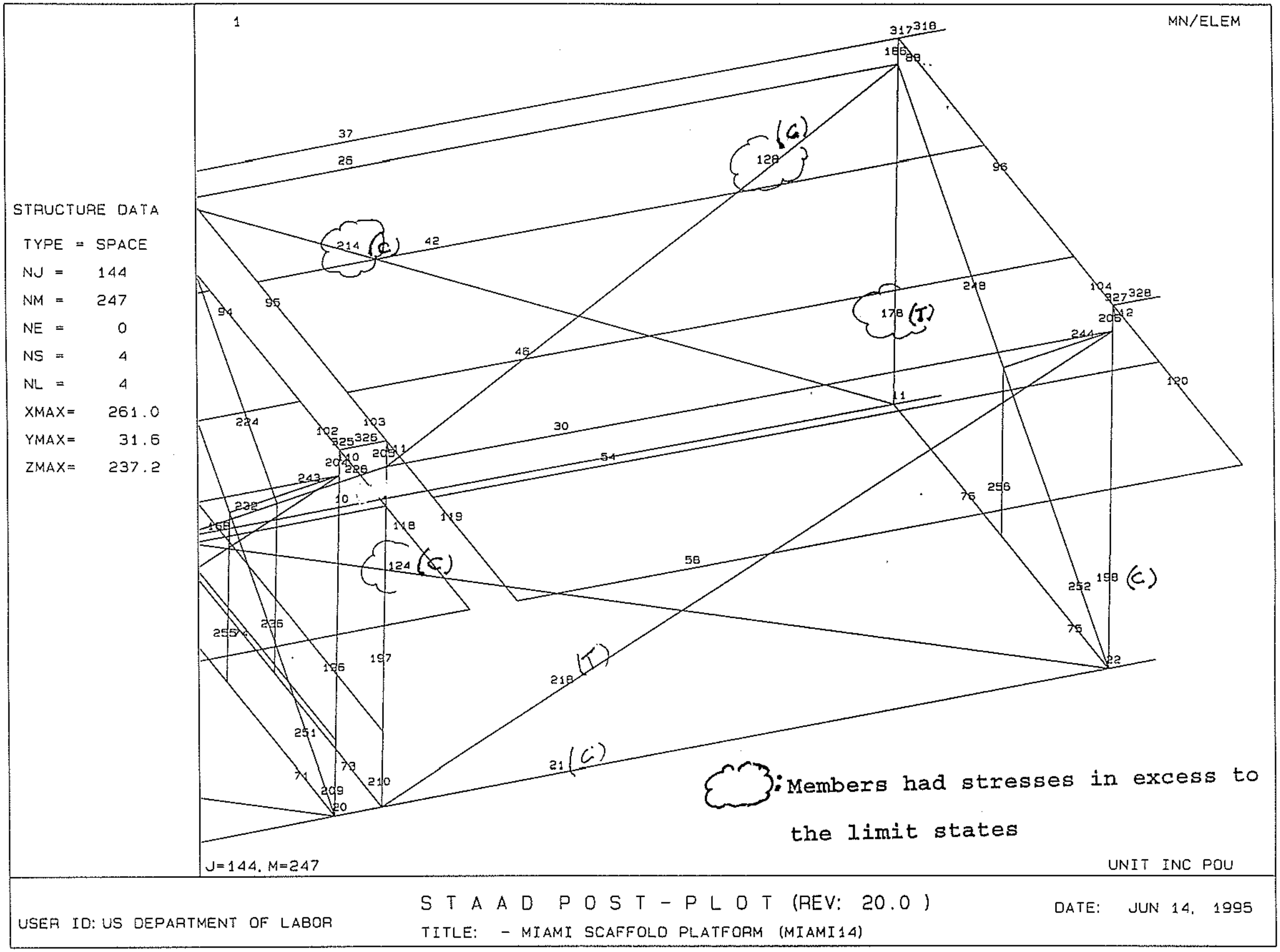
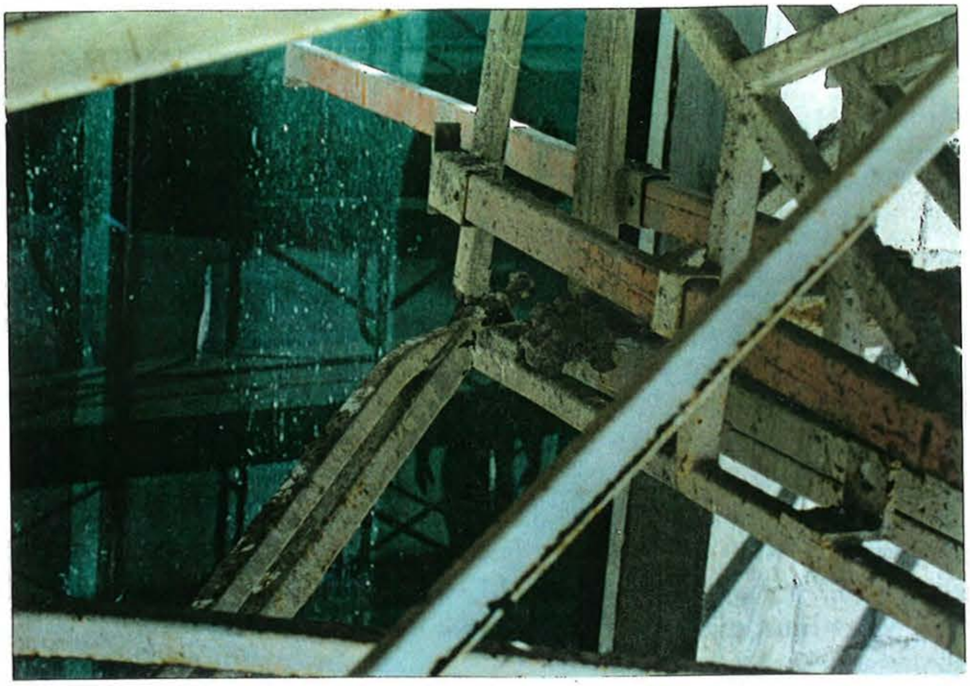

MN/ELEM
STRUCTURE DATA
TYPE = SPACE
NJ = 144
NM = 247
NE = 0
NS = 4
NL = 4
XMAX= 261.0
YMAX= 31.6
ZMAX= 237.2
: Members had stresses in excess to the limit states
J=144, M=247
UNIT INC POU
USER ID: US DEPARTMENT OF LABOR
S T A A D P O S T - P L O T (REV: 20.0)
TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI14)
DATE: JUN 14, 1995

Fig. 4.8



The South-East vertical member fractured at the connection.

The buckled members at the first platform-extension
Fig. 4.9

5.0 OTHER INFORMATION

During the course of the investigation other pertinent information related to the safe use of the scaffold was identified. Those areas of other information are listed below.

5.1 Load Charts

The load chart for the ACCESS Satellite units lists a maximum eccentric load (point load) of 750 lbs. for a 50 foot platform which is symmetrical in length to the mast, e.g. 25′ on each side. The cantilever decking materials (outriggers, 4x6's and plywood sheets) weighed approximately 1600 lbs. by themselves. The weight of the plywood (1150 lbs.) was greater than the eccentric load capacity for a 50′ platform (750 lbs.). Note: the configuration of the platform relative to the mast was eccentric with 30′ of platform on the north side of the mast. The weight of the live load (people + materials) on this north end was approximately 1200 lbs. Therefore, the total eccentric load (DL + LL) was approximately 2,800 lbs. near the end of the NPE4. This represents a 370% overload with respect to the listed value in the load chart for a 50′ foot symmetrical platform.

No load charts were on-site at the time of the incident.

The mast-climbing scaffold industry requires each configuration of the scaffold to have an alternative configuration statement. In other words, the scaffold should not be used in a configuration other than those listed in the operators manual or load chart. The configuration which was being used at the time of the event is not listed in the load chart.

5.2 Operators Manual

The operators manual for the subject scaffold has a section on loading which emphasizes the importance of proper loading on the unit. The following statements are taken from the operators manual:

> ***"It is of extreme importance that the recommended loads are not exceeded as this could result in platform failure and personal injury"***
>
> ***"The attached load chart shows both uniform loading, and eccentric loading, (point loading on one side only). Extreme care should be taken when working from the platform which is eccentrically loaded,..."***
>
> ***"IF IN DOUBT CONTACT YOUR LOCAL DISTRIBUTOR OR ACCESS ENGINEERING USA, INC...."***

The operators manual also contains information related to training and certifying operators of the scaffold. A further discussion of this subject is addressed below in the section related to Certificate of Competence.

5.3 Contract Engineering Calculations

On March 8, 1995 ACCESS provided OSHA with calculations related to the capacity of aluminum beams used in a cantilever fashion. The calculations were done by a contract engineer[3].

The results of these calculations indicated that the maximum allowable load on a single 14' cantilevered aluminum beam is 323 lbs or the maximum allowable concentrated load located at the end of the cantilever is 130 lbs. In other words, if any one of the 5 LBJ employees were located on the end of the cantilever decking over one of the aluminum beams, the allowable maximum concentrated load would have been exceeded. Appendix C contains a copy of this allowable loading table.

Another item on this calculation is a note which alerts the user that the tabulated loads represent only the capacity of the aluminum beams. Continuing, the effect of the loading of the outriggers on the scaffold must be evaluated for each application before use. In other words, the loading on the outriggers will transfer to the platform and the capacity of the platform must be checked to insure it is not overloaded.

5.4 Type of Scaffold Used

According to a witness statement (see Interviews #9 and #11) there was substantial discussion between management members of ACCESS, SPD and LBJ about the best way to access the building insets on the west face of the building. There was an obstruction problem created by concrete beams that span the face of the insets at about the 50 foot level. Figures 5.1 and 5.2 are photographs of the concrete beams on the face of the building inset. The concrete beams made it infeasible to set up a unit inside the inset. Additionally, the width of the inset was too narrow for a standard size mast climbing scaffold. According to SPD management they did not have a lot of experience in using suspension scaffolds. Additionally, SPD management stated (see Interviews #8 and #9) they decided to use mast climbing units because they were assured by ACCESS management personnel that their scaffolds had the capacity to work in the insets from a cantilever decking.

ACCESS management reportedly said (see Interview #11) that the LBJ president made the final decision to use the mast climber scaffold. It was stated that the LBJ president was strong on using the mast climber units because of the schedule (the inference is that these type units can increase production).

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[3] Aluminum Outrigger Beams Allowable Loads, 9/28/90, C.A. Pretzer Associates, Inc., Cranston, RI.

5.5 Cantilever Decking Used in Other Locations

The cantilever decking modification has been used by ACCESS on other jobs and at least 4 different set ups on the building under construction. At this building, cantilever decking was used on the two east face corners. The platform length on one side of the mast was less than 20′ and the outrigger length was 8 to 10 feet. A similar configuration was used to work the southwest corner of the building.

The fourth set up was the position Unit #78 was in at the time of the event. The west face, south building inset had been worked using a cantilever decking modification. The entire building inset was covered with a cantilever decking section connected to the south side platform of Unit #78. Five - 14′6″ aluminum outriggers (see Interview #7) were used to support the decking material and live load. From Figure 1.2 the cantilever decking would have had to be 15′ to 16′ wide to cover this inset. To accommodate this configuration of cantilever decking, two additional 5 foot platform extensions would have been required. This would have made the south side platform length 20′. According to the JJW site superintendent (see Interview #12) there was a total of 7 people on the south portion of the scaffold at one time inspecting the wall of the inset. He stated there were 5 individuals on the cantilever decking at one time. The individuals on the scaffold include employees from JJW, SPD and LBJ. Again, the loading of the cantilever decking caused it to deflect in a downward manner. As a result the ACCESS Leadman altered the cantilever decking by building up the deck with additional lumber and sheets of plywood to make it "level".

The maximum allowable platform eccentric load for a 40′ platform (20′ on each side of the mast is 850 lbs. That rated load would not be sufficient to safely support the dead load of the cantilever decking materials which would have weighed about 1500 lbs. The live load weight of 7 persons would have increased that load (dead load) by about 1400 lbs. This loading would have substantially overloaded the platform beyond its safe working capacity.

The difference between the configuration of the scaffold that failed and all other configurations, including the one in the previous paragraph is that there has not been a documented case where the combination of 30′ of platform and 14+′ of cantilever decking was used with loading similar in magnitude to that which the scaffold experienced when it failed. Even though the south platform configuration had a somewhat higher loading and used the same length of cantilever decking, it had a platform length that was 10′ shorter than that used on the north (failed) side.

5.6 General Contractor's Role

The general contractor, JJW, failed to inspect the job site in an adequate manner. The mast climbing scaffold was unique to the site and therefore presented at a minimum, a responsibility for JJW to determine any limitations of the equipment or any special hazards it presented to the job site and its employees. ACCESS management (see Interview #10) states that a load chart was provided to JJW at their request. JJW denies this claim and states they had not seen a load chart for a mast climbing machine until after the incident. In any event, JJW was on site and was in a position to observe the use of the mast climbing scaffolds on-site. If they did not have a load chart, they could not adequately inspect the scaffolds. JJW personnel's limited exposure to these units did not afford for an experience base which was developed to a point where visual determination of safe working capacities could be made.

JJW had actual exposure to its own employees when Unit #78 was used to inspect the south inset walls on the west face of the building. See discussion above. Had JJW exercised its responsibility to protect its own employees, a safe load capacity of that particular configuration of the scaffold would have been determined. Had that determination been made, it would have been clear that the scaffold was grossly overloaded. The use of the modified cantilever decking with 14′ outriggers would have been prohibited in the building insets. Consequently, this incident would not have occurred.

5.7 Modifications

The addition of the cantilever decking to the mast climbing scaffolds is considered by the industry[4] to be a modification. The ANSI standard prohibits a dealer, owner, user, lessor, or lessee from making modifications to a subject scaffold. Modifications are only allowed if prior written permission is given by the manufacturer or an equivalent entity if the manufacturer is no longer in business (Rule 5.10). A practice in the industry has an authorized dealer of a manufacturer making modifications without written permission from the manufacturer. However, in this case, engineering calculations related to the modification and its particular application are completed prior to the modification being approved. ANSI defines a modification as, "***To make a change(s) to a Mast Climbing Work Platform which affects the operation, stability, safety factors, or rated load of the Mast Climbing Work Platform in any way.***".

ACCESS acts in the capacity of a dealer/owner/lessor of the subject scaffold. ACCESS did not produce any written approval from the manufacturer for the cantilever decking modification. The manufacturer of this equipment was originally from England and went out-of-business in the 1980's. Since then ACCESS has not evaluated the cantilever decking modification. Even though ACCESS is a dealer and a practice in the industry is to grant a dealer "equivalent entity" status, they have not done an engineering evaluation of the modification.

ACCESS had in its possession the calculation done by the contract engineer to determine the capacity of the aluminum outriggers. However, this calculation cannot be construed as a full system evaluation because it analyzed only one component of the modification.

LBJ also modified/altered the system when they "leveled" the cantilever decking on the north side of the platform of Unit #78.

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[4] ANSI/SIA A92.9-1993 for Mast-Climbing Work Platforms, 1/13/94, American National Standards Institute, New York, NY

In conclusion, no written approval for the modification was given by the manufacturer or equivalent entity and no evaluation of the modifications affect on the scaffold system was conducted.

5.8 Certificate of Competence

The industry requires that each individual that is to operate a scaffold must be trained and a record of that training must be kept by the owner of the scaffold for at least 3 years. ACCESS has a form[5] which certifies the training of individuals that will operate their scaffolds. Appendix B contains a copy of this certification document. The certificate states that once trained by the owner, the operator is competent in the instructions and technical requirements to safely operate the scaffold. Additionally, it states that the individual has read and understood the operation manual and understands the precautions which should be used to safely operate the platform.

ACCESS stated that these certificates were issued to the LBJ president and one other employee. Upon request, neither ACCESS or LBJ could produce copies of the certifications for individuals that operated the scaffolds at the site..

Additionally, ACCESS could not produce these certificates for their own employees, including the leadman that was in-charge of the erection of the scaffolds at the site. ACCESS employees are required to operate these platforms during pre-delivery inspections and for other inspections.

The ACCESS operators manual (see excerpt in Appendix A) states the following related to training scaffold operators:

> ***"After a platform has been tested and a certificate issued, the test foreman will train and certify such persons as the contractor or his agent may nominate, in the correct use and operation of an Access Satellite Work Platform.***
>
> ***The certificate of competence will be displayed in the site office. A copy will be retained by the test foreman.***
>
> ***At this time the test foreman will hand over the platform to the contractor or his agent."***
>
> ***"It is incumbent upon the contractor...that recommended loads are never exceeded..."***
>
> ***"In the event of a certificated operator deeming the platform unsuitable for use due to structural,....defect he will bring the platform to the position of maximum safety."***

5 Certificate of Competence, ACCESS Equipment Systems, Lithonia, GA

Given the following facts in aggregate, it is concluded that the LBJ operators and the ACCESS leadman were not competent to erect, modify, alter or operate this type of scaffold under OSHA[6], industry (ANSI A92.9-1993), or ACCESS (see above) criteria:

1. LBJ personnel did not know of the existence of a ACCESS scaffold operators manual or load chart.

2. The scaffold was grossly overloaded at the time of failure and a previous time when the cantilever decking was configured on the south end of Unit #78. Neither ACCESS or LBJ personnel recognized or acted to correct the hazard of the overload.

3. When Unit #78 exhibited signs of excessive deflection of the platform and cantilever decking on two separate occasions, there was no action taken by either party to correct the problem. In fact, both parties exacerbated the problem by adding more weight to the cantilever decking in an attempt to "level" that section.

4. LBJ personnel were under the impression that this scaffold had a safe capacity of at least 8000 lbs. no matter what configuration it was used.

5. Even after the event, the ACCESS leadman did not know how the addition of the cantilever decking affected the capacity of the scaffold system.

6. The ACCESS Leadman had the responsibility to train the LBJ operators. Apparently, the only instruction given was to show them how the pendant control buttons actuated movement of the scaffold. No instruction related to other aspects of safe operation were given such as loading alternative configurations, inspections, maintenance procedures, clearance from obstructions, etc. No Certificates of Competence were produced to document training had been provided.

5.9 Erection and Inspection Checklist

ACCESS has an erection[7] and equipment[8] checklist that they are supposed to utilize when erecting and inspecting their scaffolds at the site. The ACCESS Leadman stated (see Interview #5) that for each time a scaffold is erected or reconfigured an erection checklist should be completed. He also stated that there should have been an erection checklist generated for both the south and north configuration of Unit #78 for the position it was in at the time of the incident.

---

[6] 29 CFR 1926.32(f), U.S. Dept. of Labor - OSHA, Washington, DC

[7] Equipment Erection Checklist, ACCESS Equipment Systems, Inc., Lithonia, GA

[8] Equipment Inspection Checklist, ACCESS Equipment Systems, Inc., Lithonia, GA

No erection checklists have been provided by ACCESS to OSHA in response to OSHA's request for production of any erection checklists which were completed for the job site.

Part of the erection checklist states that all platform extension bolts be properly installed and secured (see checklist in Appendix B). Two units at the site, including Unit #78 were examined after the event and it was found that no bottom chord platform bolts were installed on either machine. A primary function of these bolts is to prevent torsional forces on the platform.

The ACCESS leadman stated that when the bottom bolt holes do not properly align, the platform extensions are not connected at these locations. This statement was questioned because first the platform extensions are fitted with bolts near the bottom chord which serve two functions. The one function is to act as a compression/bearing member to keep the platform extensions evenly spaced or plumb with respect to their vertical members. Another function is the screw bolts have threads which facilitates the platform extension movement relative to the long axis of the platform. This movement allows the bottom bolt holes to align themselves so the 3/4 inch bolts can be inserted.

The second reason to question the alignment problem stated by the ACCESS leadman is that an inspection of the two units revealed that bolts could have been inserted in a large majority of the bottom bolt holes which were observed. Eleven of twelve bolt hole alignments observed had ample clearance for a 3/4 inch bolt to be inserted. The only connection that could not have been made was on the north unit. One of the bolt plates was missing from a platform extension rendering the connection ineffective. Four of the connections on the north unit could not be determined because plaster obscured the visual observation.

In conclusion of the bottom bolt issue, the bolts were not installed as required by the ACCESS Erection Checklist[9].The inspection checklist is for the purpose of conducting an inspection of the scaffold prior to delivering it to the user.

ACCESS was asked to provided the inspection checklists which were generated from work at the site. None of these checklists were provided for the job site, however, one report was provided for an inspection which was conducted in the company shop (see Appendix B for a copy of this report).

[9] Equipment Erection Checklist, ACCESS Equipment Systems, Inc., Lithonia, GA.

5.10 Work Orders

An ACCESS work order form is utilized to show work activities that are ordered or completed by the company. ACCESS provided OSHA with one work order[10] related to Unit #78 (see Appendix C). The work order included the following information: 1) customer was listed as SPD; 2) Jobsite - St. Louis Condominiums; 3) Make - ACCESS Work Platform; 4) serial number - 78; 5) work performed - erected 50′ x 310′ tall unit with all screens, added 10 I-beam brackets & 5 I-beams; 6) SPD was informed & showed running units; 7)customer - signed by Interviewee #6 (LBJ); and 8) signed for ACCESS - Leadman. It is interesting to note that this document dated October of 1994 states that some form of training (***"informed & showed"***) was provided to SPD (LBJ) personnel.

5.11 Previous Fatal Incident with Mast Climbing Scaffold

ACCESS had previously experienced a fatal incident involving one of their mast climbing scaffolds. The incident occurred in Atlanta, GA in 1990. The configuration of the scaffold in Atlanta was reportedly similar to the one in Miami, both utilized cantilever decking. The scaffold collapsed in Atlanta caused one worker to fall 170 feet to his death. OSHA cited the company for exceeding 4 times the maximum intended load of the scaffold. The president of ACCESS at the time of that event is the same individual that heads the company today.

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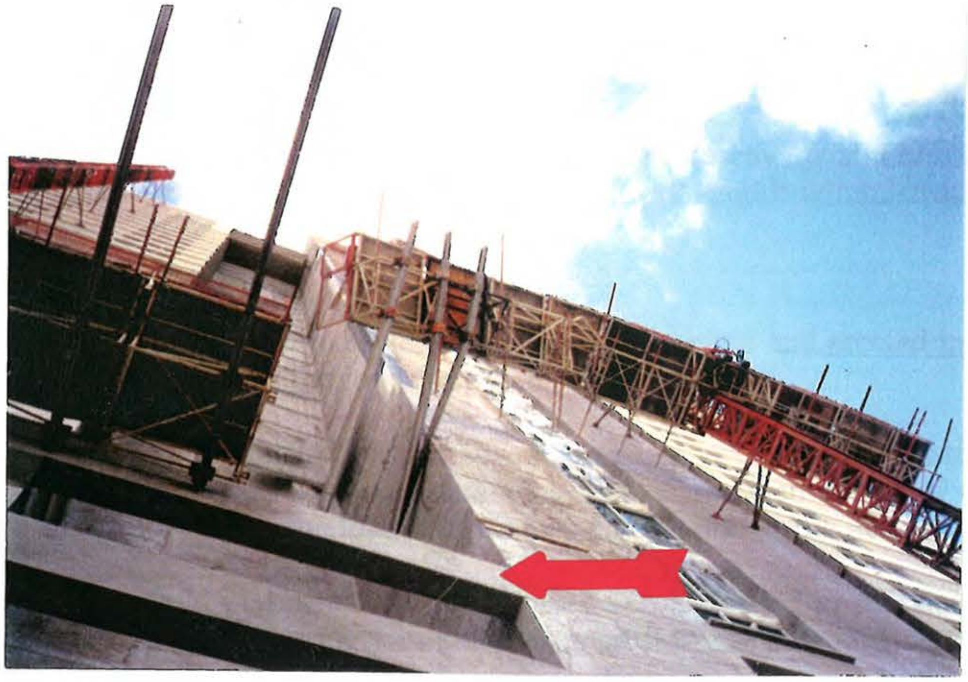
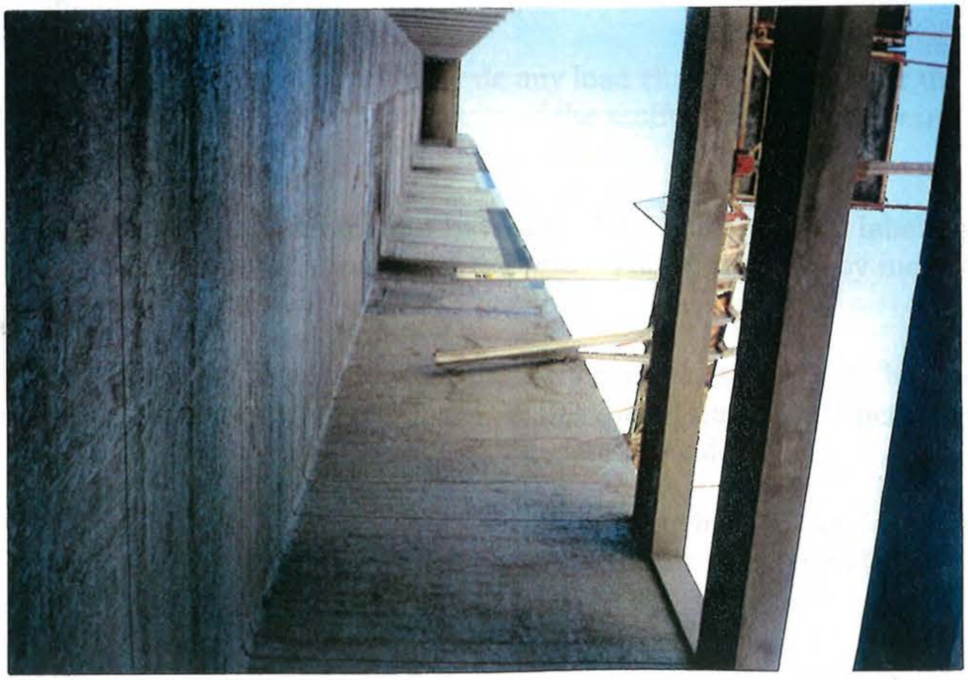
[10] Work Order #2932, 10/7/94, Access Equipment Systems, Inc., Lithonia, GA



North Inset on the West Face of Building (Looking Up)
Arrows Show Concrete Beams Which are on Face of Building

Figure 5.1



Concrete Beams Which Prohibit Setting Mast Climber Directly in Inset

Figure 5.2

6.0 CONCLUSIONS

Based upon the structural analyses, lab testing, eyewitness statements and observation of the collapsed structural members, the Occupational Safety and Health administration concludes that:

1. The scaffold platform structure as it was configured and erected in the field was not designed for the loads imposed upon them.

2. The collapse occurred because several members of the scaffold platform structure including outrigger beams were subjected to forces in excess of their ultimate capacities due to the loads placed over them prior to the accident.

3. The scaffold platform structure as used and as loaded at the site did not have adequate factor of safety in accordance with OSHA standard 1926.451 (a)(7).

4. With respect to the loading of the aluminum outriggers, the owner/erector did not follow the allowable load tables provided by a contract engineer.

5. The president of the stucco company was on the scaffold and observed excessive deflection of the cantilever decking section. As a result, the president directed that additional decking material be placed to level the cantilever section for the employees to work on.

6. The owner/erector did not provide any load chart on the site for the scaffold user to determine the safe load capacity of the scaffold when it was erected in various configurations.

7. The scaffold platform did not have any plate, placarding or labeling information related to the rated capacity of the unit. This is required by industry consensus standards.

8. No approval as required by the industry consensus standards had been provided to the scaffold erection company or the users (stucco contractor) to modify the scaffold platform with the use of the cantilever decking.

9. There were no bolts in place to connect the bottom section of the platform extensions of the scaffold as per manufacturer's recommendations.

10. A competent person was not available for either the scaffold owner or the user to direct the erection, modification or alteration of the scaffold.

11. The general contractor did not inspect the scaffold when ample opportunity was afforded to determine that the scaffold was being used in an unsafe manner. In fact, the general contractor had actual employee exposure to the hazard of collapse when its employees used the same scaffold which eventually failed to inspect a wall of the building.

12. Field observations and laboratory testing indicated that the members of the scaffold platform structure had sustained loss of cross sectional area due to corrosion.

APPENDIX A

Excerpts From ACCESS Satellite Operators Manual

- Load Chart (Provided post event from off-site)
- Copy (excerpts) of Operators Manual Found on Unit #78 in Electrical Box
    - o Specifications
    - o Warning Statements

OPERATIONS MANUAL

The Access Satellite
Elevating Work Platform

Patent # U.K. **8225960** | **U.S. Patent** **4,498,556**

ACCESS
ENGINEERING U.S.A. INC.
Manufacturers of:
The Access Satellite Single Mast Working Platform.

ACCESS ENGINEERING U.S.A., INC.
5301 Nations Ford Road
Charlotte, North Carolina 28210

Telephone 800-438-3656
704-523-7014

Telex 856812
Answerback Access Engineering Charlotte

ases the use of a crane will be unnecessary as the
ill perform many functions of a hoist as the hydraulic
designed to handle the mast sections.

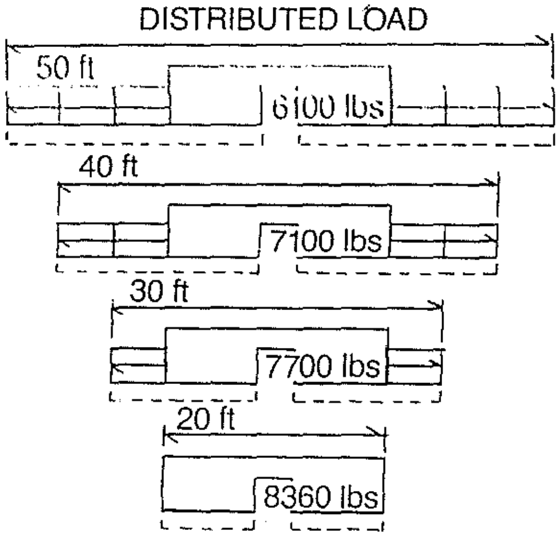
hown in the diagram below the platform really comes into
fficiency when it is loaded with the required materials.
Evenly spread over a 20 foot platform you can have up to 8360
of personnel and materials and travel at 24 feet per minute up
a height of 328 feet. This allows more than enough space and
aterials for a team of workers.

Eccentric loads can be placed at the end of the platform to
nform with the manufacturers load chart and you will still
operative.

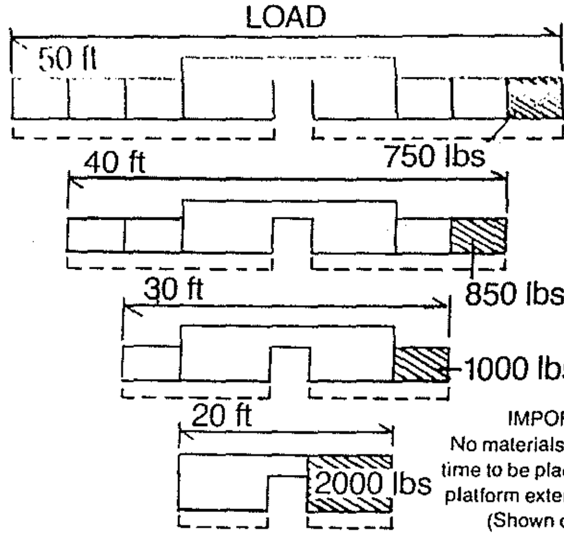
Each Access Satellite is fitted with an automatic audio-visual
ning device and underneath the machine there is a manual
fety trip wire.

Your Access representative will assist you in the training of your
ff, giving demonstrations, video shows and staff certificates to
sure that each platform is erected safely and easily time
er time.

MAXIMUM PLATFORM LOADINGS
UNIFORMLY
DISTRIBUTED LOAD



MAXIMUM PLATFORM LOADINGS
ECCENTRIC
LOAD



IMPORTANT
No materials at any
time to be placed on
platform extensions
(Shown dotted)

access
EQUIPMENT SYSTEMS, INC.
Authorized Access "Satellite" Distributor
2196B Stephens St. Tucker, GA 30084 (404) 493-4500 FAX (404) 493-6263

OPERATIONS MANUAL

The Access Satellite Elevating Work Platform

Patent # U.K.	U.S. Patent
8225960	4,498,556

Atlanta
(404) 482-2200
Orlando
(407) 649-7848

ACCESS ENGINEERING U.S.A., INC.
5301 Nations Ford Road
Charlotte, North Carolina 28210

Telephone 800-438-3656
704-523-7014

Telex 856812
Answerback Access Engineering Charlotte

SPECIFICATIONS

CAPACITY
Uniformly distributed load: 8,360 lbs. on 20' platform with a 4:1 safety factor decreasing to 7,100 lbs. on a 40' platform. 6,100 lbs. on a 50' platform. Consult authorized dealer for lengths over 50 feet.

WORKING HEIGHT
Free standing: 32'10"
Tied to structure: 328'0"
Maximum tie spacing: 35 ft.
Platform is 6' below working height.

PLATFORM DIMENSIONS
Main platform: 5'7" x 19'6" min.
5'7" x 49'6" maximum
Walk way: 20" by length of platform. 48" by length of platform available by request.

WEIGHT
Minimum for towing: 7,590 lbs.
5' tower sections: 390 lbs. each
5' platform extensions: 250 lbs. each
Tongue weight minimum: 750 lbs.

TRAVEL SPEED
Up or down, under power: 24' per minute.
Down, no power: 27' per minute.

GUARD RAIL
42" high steel frame and wire mesh at each end and along the total length of platform. 52" high at each end of each walk way. 60" high around tower.

RUNNING GEAR
Chassis is U.S. certified steel, all welded construction mounted on independent suspension axles. Hitch is standard 1 7/8" ball. Tires are 650 x 16-10 ply rating. Minimum O.A. length is 22'10".

ELECTRICAL
230 Volt 3 PH. 60 Cycle
Starting Load 100 Amp
Running Load 25 Amp max.
2 each 4 HP gear motors 105:1 reduction, electro magnetic brakes and centrifugal brakes for each motor. 2 110 volt SL, PH outlet on the platform. 110V AC pendant control for raising, lowering and operating the hydraulic erection hoist. Circuit breaker protected.

ACCESS
ENGINEERING U.S.A. INC.

RECOMMENDED WORKING ROUTINE

After a platform has been tested and a certificate issued, the test foreman will train and certify such persons as the contractor or his agent may nominate, in the correct use and operation of an Access Satellite Work Platform.

This certificate of competence will be displayed in the site office. A copy will be retained by the test foreman.

At this time the test foreman will hand over the platform to the contractor or his agent.

It is incumbent upon the contractor or his agent to institute a permission to work routine which ensures that an elevated platform carries at least one certificated person, that recommended loads are never exceeded and that where loads alter during a working period they are repositioned as necessary so that the allowable eccentricity of load specified by the manufacturers and displayed in the site cabin is not exceeded.

In the event of a certificated operator deeming the conditions unsuitable to work he will immediately bring the platform to the position of maximum safety, isolate the platform and suspend operations until conditions improve.

In the event of a certificated operator deeming the platform unsuitable for use due to structural, mechanical or electrical defect he will bring the platform to the position of maximum safety. The contractor or his agent will then withdraw the permission to work and hand the machine back to the manufacturer or his agent who will in turn remove the three main fuse links so that the platform cannot be operated until such work deemed necessary carried out.

WARNING

Replace all fencing after loading prior to operation.

*LOADING

It is of extreme importance that the recommended loads are not exceeded as this could result in platform failure and personal injury.

The attached load chart shows both uniform loading, (along the entire length of the platform), and eccentric loading, (point loading on one side only). Extreme care should be taken when working from the platform which is eccentrically loaded, as this loading changes as the consumables, (bricks, etc.), are used during operation.

IF IN DOUBT CONTACT YOUR LOCAL DISTRIBUTOR OR ACCESS ENGINEERING U.S.A., INC. IN CHARLOTTE, NORTH CAROLINA, AT 800-438-3656.

**LOWERING PLATFORM IN EVENT OF POWER FAILURE

In the event of power failure while the platform is raised from the ground, the motor brakes are designed to allow release of the power brakes and controlled descent using the built-in centrifugal brake. To release the power brakes, follow this procedure:

a) Examine platform to ensure it is clear of any protrusions.
b) Remove wooden flooring above motors, (at rear of mast, beside crane jib).
c) Stand on motors with feet against the vertical levers fitted to each motor.
d) Press levers away from platform, this will release brake and platform will descend at a controlled speed of 27 feet per minute. Releasing pressure on these brake levers will cause the platform to stop.
e) Descend to ground and inform supervisor of power failure.

APPENDIX B

Certification, Inspection Forms, and Work Order

ACCESS EQUIPMENT SYSTEMS, INC.

397 Chapman R... ...ithonia, Georgia 30058 • (404) 482-2200 • FAX (404) 482-1800

CERTIFICATE OF COMPETENCE

THIS IS TO CERTIFY THAT Date of Issue ______________

NAME ________________________________

ADRESS ________________________________

COMPANY to which EMPLOYED ________________________________

JOBSITE NAME ________________________________

JOBSITE ADDRESS ________________________________

LESSEE NAME ________________________________

Has received the necessary instructions and technical training in the safe operation of the ACCESS and MALMQVIST work platforms. He is fully competent in carrying out this type of work. The above person is also fully qualified in the instruction of the safe use of these platforms.

Signature of Instructor ________________________________
Access Equipment Systems, Inc.

I have undergone the above training, read and understand the OPERATION MANUAL on the above platforms, and understand the precaution that should be used during the safe operation of the above referenced plat... .

Signature of person r... ...ing Certification ______________

397 CHAPMAN ROAD
LITHONIA, GA 30058

ACCESS EQUIPMENT SYSTEMS, INC.

ATLANTA 404 482-2200
FAX 404 482-1800
ORLANDO 407 649-7848

EQUIPMENT ERECTION CHECK LIST

CUSTOMER		JOBSITE
ADDRESS		
CITY & STATE		CONTACT
MAKE	MODEL	S/N

- ☐ 1. FRONT OUTRIGGERS (adjacent to structure) ARE SWUNG AS FAR FORWARD TOWARD STRUCTURE AS POSSIBLE.
- ☐ 2. REAR OUTRIGGERS ARE AS CLOSE TO RIGHT ANGLES TO CHASSIS AS POSSIBLE.
- ☐ 3. MATS UNDER SCREW JACKS ARE SUFFICIENT FOR CONDITIONS. AND ARE STABLE UNDER LOAD.
- ☐ 4. THE TWO MAIN (CENTER) JACKS BELOW THE MAST ARE SCREWED DOWN ON SUFFICIENT CRIBBING.
- ☐ 5. LEVEL MACHINE AT TOP OF BASE MAST SECTION.
- ☐ 6. CONNECT MAIN POWER SUPPLY TO APPLICABLE MACHINE CONNECTION ENSURE THAT ROTATION IS PROPER
- ☐ 7. ENSURE THAT ALL TOWER BOLTS ARE PROPERLY INSTALLED AND SECURE.
- ☐ 8. ENSURE THAT ALL PLATFORM EXT. BOLTS ARE PROPERLY INSTALLED AND SECURE.
- ☐ 9. ENSURE THAT ALL TIE-SYSTEMS ARE PROPERLY INSTALLED AND SECURE.
- ☐ 10. ENSURE THAT ALL GUARD RAILS ARE PROPERLY INSTALLED AND SECURE.
- ☐ 11. ENSURE THAT ALL LIMIT SWITCHES (UPPER & LOWER) OPERATE PROPERLY.
- ☐ 12. ENSURE THAT ALL PENDANT CONTROL FUNCTIONS OPERATE PROPERLY.
- ☐ 13. ENSURE THAT EMERGENCY BRAKE RELEASE LEVERS OPERATE PROPERLY.
- ☐ 14. ENSURE THAT THE PLATFORM CANNOT GET CAUGHT ON ANY PROTRUDING OBJECTS (CABLES. WIRES. BALCONIES ETC.)
- ☐ 15. ENSURE THAT WHEN DRIVING A SELF-PROPELLED MACHINE THAT ALL OUTRIGGERS ARE FULLY EXTENDED AND PINNED (IF THIS IS NOT POSSIBLE CONSULT YOUR LOCAL DEALER BEFORE PROCEEDING

ERECTED BY	CUSTOMER	DATE

397 CHAPMAN ROAD
LITHONIA, GA 30058

ACCESS EQUIPMENT SYSTEMS, INC.

ATLANTA 404 482-2200
FAX 404 482-1800
ORLANDO 407 649-7848

EQUIPMENT INSPECTION CHECKLIST

CUSTOMER	JOBSITE
ADDRESS	
CITY & STATE	CONTACT

MAKE	MODEL	S/N

ELECTRICAL

☐ PENDANT CONTROL ☐ MOTOR CONTROL ☐ MOTOR(S) ☐ LIMIT SWITCHES ☐ POWER CORD ☐ MISC.

STRUCTURAL

☐ MAIN PLATFORM ☐ PLATFORM EXTENSIONS ☐ TIE ASSEMBLY ☐ TOWER ☐ BASE ☐ MISC.

SCREENS & RAILS

☐ MAIN PLATFORM ☐ PLATFORM EXTENSIONS ☐ TOWER ☐ WALKBOARD ☐ CANTILEVER ☐ MISC

MISCELLANEOUS

INSPECTED BY	CUSTOMER	DATE

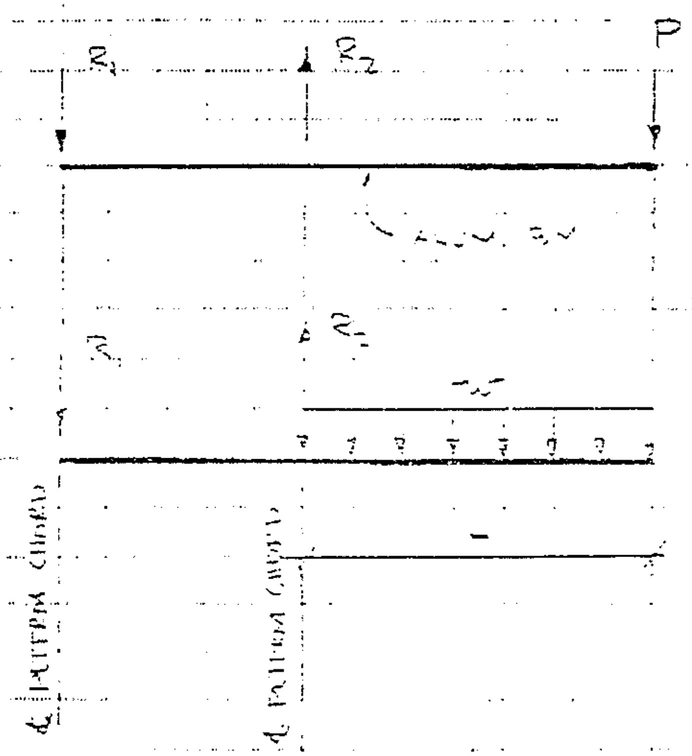
APPENDIX C

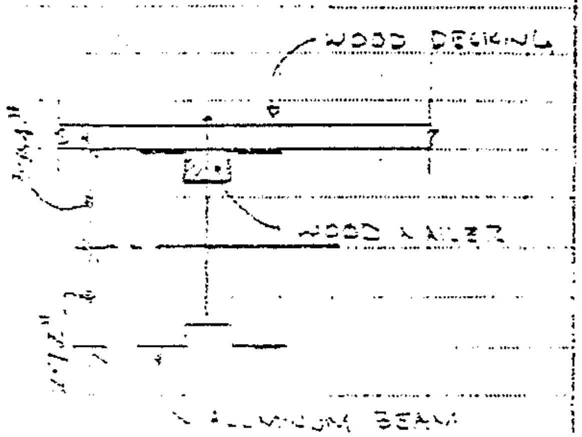
Contract Engineer's Allowable Aluminum Outrigger Loading Table

C. A. Pretzer Associates, Inc.
Engineers
191 Frances Avenue
CRANSTON, RHODE ISLAND 02910
(401) 785-2690 FAX: (401) 461-9360

JOB ALUMINUM BEAMS
SHEET NO 1 OF 3
CALCULATED BY TNM DATE 28 SEP 90
CHECKED BY MJG DATE 28 SEP 90
SCALE

ALUMINUM OUTRIGGER BEAMS - ALLOWABLE LOADS





$S_{min} = 4.43\ in^3$
$S_{max} = 6.23\ in^3$
$F_b = 19$ ksi

→ W = w×L

L (FT)	*P (LB)	*w (LB/FT)	*W (LB)
4	1107	646	2584
6	573	229	1374
8	352	107	856
10	238	59	590
12	172	35	420
14	130	23	322

*NOTE: THE CONCENTRATED LOAD (P) AND THE UNIFORMLY DISTRIBUTED LOAD (w, W) DO NOT ACT CONCURRENTLY

NOTE: THE ABOVE LISTED LOADS REPRESENT THE CAPACITY OF THE ALUMINUM BEAM, THE EFFECT OF THE OUTRIGGERS ON THE ELEVATING WORK PLATFORM MUST BE EVALUATED FOR EACH APPLICATION BEFORE USE.

APPENDIX D

Metallurgical Testing Report

ENGINEERING REPORT
SCAFFOLD COLLAPSE OF 3/4/95
800 CLAUGHTON ISLAND DRIVE
MIAMI, FLORIDA

SUBMITTED TO
OSHA, DEPT. OF LABOR

ENGINEERING AND INSPECTIONS
UNLIMITED, INC.

ENGINEERING REPORT
SCAFFOLD COLLAPSE OF 3/4/95
800 CLAUGHTON ISLAND DRIVE
MIAMI, FLORIDA

SUBMITTED TO
OSHA, DEPT. OF LABOR

E&I
ENGINEERING & INSPECTIONS
UNLIMITED, INC.

June 19, 1995

Mr. Mohammed Ayub
Department of Labor, OSHA
2000 Constitution Avenue N.W.
Washington, D.C. 20210

RE: Scaffold Collapse of March 4, 1995 at 800 Claughton Island Drive, Miami, Florida.

Dear Mr. Ayub:

Enclosed are the findings of our various tests that were performed on the test samples collected from the above referenced collapsed scaffold.

The tests included

* Chemical analysis of the steels,
* Hardness Test
* Tensile Strength Test (Stress-Strain Curve), and
* Fractography.

Of the two fracture locations, only one (where complete fracture had occurred) was analyzed (both fracture surfaces) using Scanning Electron Microscopy (SEM). The sample for the second location was not suitable for placement in the SEM without involving destructive specimen preparation. Further, the advanced corrosion and general weathering of the specimens prohibited clear view of the fracture surfaces in spite of very careful cleaning. Yet some general conclusions could be drawn and are presented in the accompanying report. The fractured pieces are preserved for future use, if required.

If you have any further questions, please call us at (407) 241-0303.

Sincerely,
ENGINEERING & INSPECTION UNLIMITED, INC.

S. S. Rajpathak, P.E.
Vice President.

ENGINEERING & INSPECTIONS UNLIMITED, INC.

5455 NORTH FEDERAL HIGHWAY • SUITE I • BOCA RATON, FLORIDA 33487 • (407) 241-0303 • FAX (407) 241-0349

HARDNESS TEST

a. Samples:

Samples for the hardness test were cut from two square tube members of the scaffold, which were also used for the tensile strength test and the chemical composition analysis. The two tube differed in cross sectional size.

b. Sample Preparation:

Approximately 1/2 square inch of sample piece from each tube member was cut out and mechanically cleaned to remove external corrosion and other debris. The two pieces were identified as small and large according to the size (cross sectional) of the individual tubes.

c. Test Results:

The samples were tested for Rockwell Hardness on "B" scale. The diameter of the indenter ball was 1/16" and the load used was 100 Kg. Ten readings (five on each face) were taken for each sample and averaged to calculate the resultant hardness number. Table I shows the readings for each sample, their average and the standard deviation.

TABLE - I

HARDNESS TEST (ROCKWELL "B" SCALE)

READING NO.	MEMBER "A"	MEMBER "B"
1	78.0	81.2
2	80.5	82.5
3	80.9	82.3
4	77.6	83.1
5	79.5	83.2
6	81.6	82.5
7	80.4	81.9
8	81.0	82.0
9	80.5	81.5
10	78.6	81.8
AVERAGE	**79.9**	**82.2**
STANDARD DEVIATION	**1.366**	**0.648**

MEMBER "A" : SMALL SIZE PIPE
MEMBER "B" : LARGE SIZE PIPE

CHEMICAL COMPOSITION

a. Samples:

Samples for the Chemical Composition were the same as that for the Hardness Test. The Hardness Test samples, after performing the hardness test, were shipped to Applied Technical Services, Inc. in Atlanta, Georgia for chemical analysis.

b. Test Results:

The results of the chemical analysis, as received from the ATS, Inc. are presented in Table II. Both the samples showed similar chemical composition, with in the % range of each constituent element, for the AISI 1016 Carbon Steel.

TABLE - II

APPLIED TECHNICAL SERVICES, INCORPORATED

1190 Atlanta Industrial Drive, Marietta, Georgia 30066 • (404)423-1400

CHEMICAL TEST REPORT

Ref. C53272 Date June 15, 1995 Page 1 of 1

Customer: Engineering & Inspection Unlimited, Inc., 5455 N. Federal Highway, Suite 1, Boca Raton, Florida 33487 Attention: S. S. Rajpathak

Purchase Order #: Verbal Part #/Name: Steel Carbon

Material Designation: SAE/AISI 1016 Carbon Steel

Special Requirement: N/A

Lab Comment: Analyzed by spectrographic techniques.

Test Results

Composition: Weight %

Identification	C	Mn	Si	Ni	Cr	Mo	P	S		
Alloy or Spec. Req. (1)	0.12 0.18	0.60 0.90	0.10 Max.	--	--	--	0.040 Max.	0.050 Max.		
Large	0.13	0.79	<0.029	<0.026	0.02	<0.005	0.016	0.016		
Small	0.14	0.65	<0.029	<0.026	0.02	<0.005	0.012	0.009		
			****LAST ITEM****							

(1) Metals Handbook, Vol. 1, 10th Edition.

Prepared by J. A. Mothershed, Chemist

Approved by P. E. Rogers, Manager

Notary Public, Cobb County, Georgia
My Commission Expires August 29, 1998

TENSILE STRENGTH TEST

a. Samples:

Samples for the Tensile Test were cut from two square tube members of the scaffold, which were also used for the Hardness Test and the Chemical Composition Analysis, as mentioned before.

b. Sample Preparation and Test:

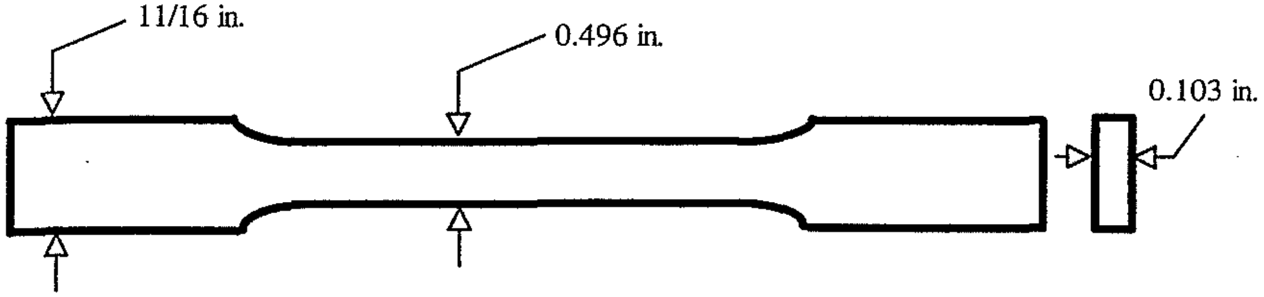
Standard ASTM specimens, one from each sample, were cut and machined. A strain gage was mounted on each of the specimen to measure the strain. The cross sectional dimensions of the reduced section were carefully measured. Then the specimens were tested according to ASTM recommended procedures in a Tensile Test machine at Florida Atlantic University, Boca Raton, Florida. For various values of the loads, the strain readings were noted. The specimens were allowed to break to record the ultimate strength value.

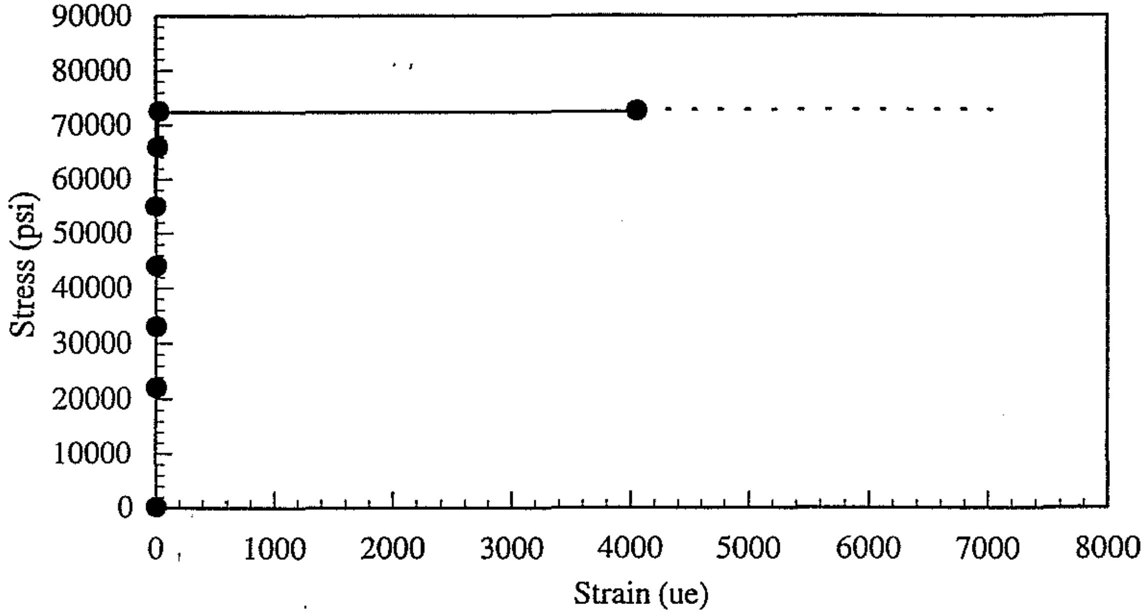
c. Test Results:

The test results for each specimen are presented in Figures 1 and 2 in the form of a stress-strain curve, along with the specimen dimensions. Both the steels showed comparable tensile strength and high level of plasticity.

FIGURE 1

Test specimen #1



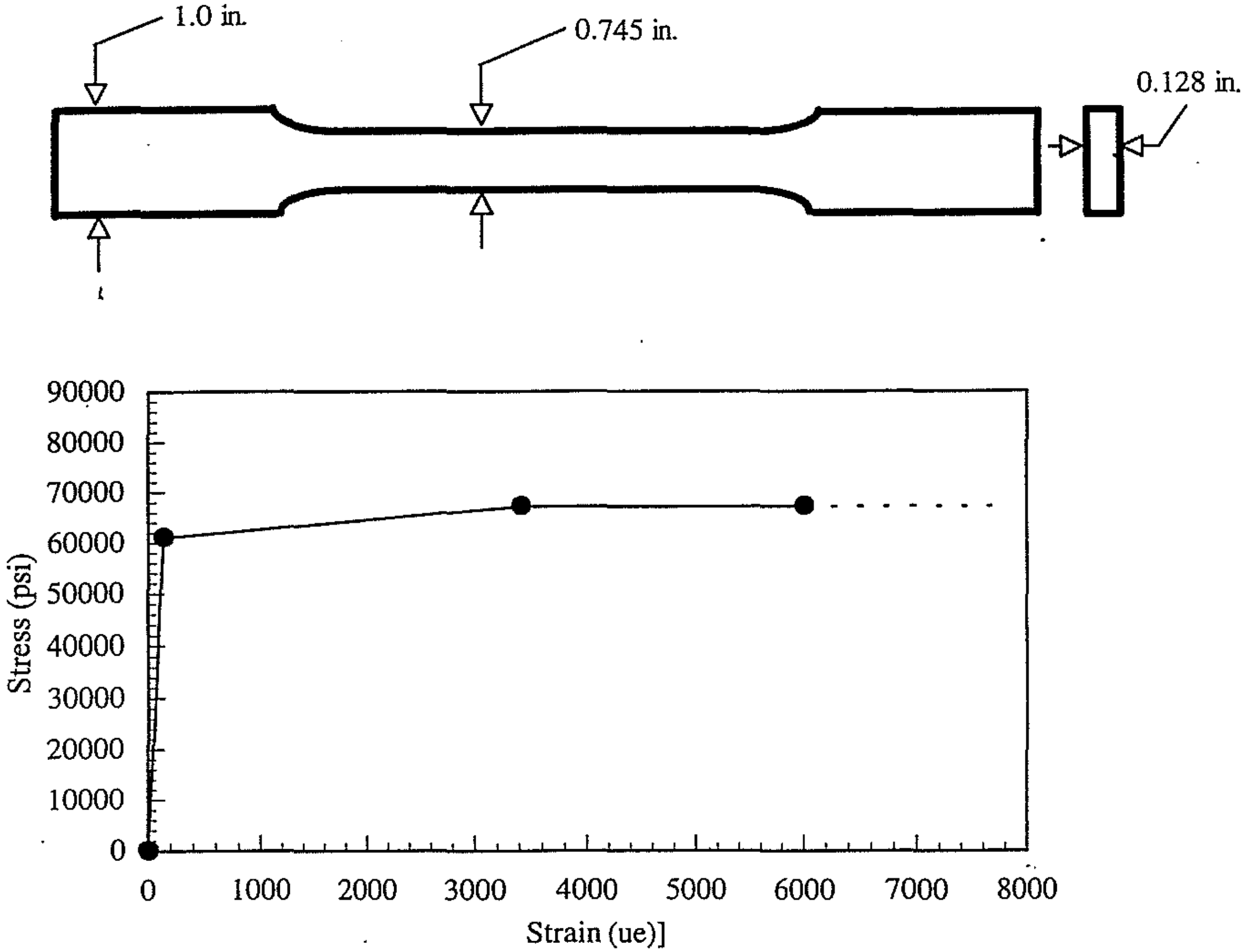


Stress at yield = 72,378 psi
Strain at yield = 73 ue
Ultimate strength = 72,378 psi

Comments: No strain hardening was observed after first yield
Significant plastic deformation was noticed after yield

FIGURE 2

Test specimen #2



Stress at yield = 61,032 psi
Strain at yield = 133 ue
Ultimate strength = 67,135 psi

Comments: Significant plastic deformation was noticed after yield

FRACTOGRAPHY

a. Fracture Specimens:

Three fracture specimens related to two fracture locations were cut from the collapsed scaffold. Photo 1 shows the one location where complete fracture had occurred resulting in two fracture surfaces. The member containing this fracture location was oriented horizontally, perpendicular to the building wall and was immediately next to the lower scaffold-tower (which allowed vertical movement of the scaffold) attachment plate. Photo 2 shows the second fracture location, close to the first one, but in the vertical member, parallel to the building wall. Both the fractures were close to the bottom, wall side corner of the scaffold unit. All the members meeting at this corner were welded. Photos 3 and 4 present the two halves of the complete fracture.

b. Specimen Preparation:

The fracture specimens, as cut from the scaffold, were too large for electron microscopy purposes. Also, after visual examination, the incomplete fracture specimen was determined to be non suitable for preparation without damaging the partially fractured surface. However, it was cleaned for future use (if needed) in the same way as the other specimens.

The two halves of the complete fracture are shown side-by-side in Figure 3 along with their actual orientation on the scaffold. All discussions about the fractography are referred to the relative locations mentioned in this figure.

The fracture specimens were first cleaned of any loose debris, such as flaking paint and the hardened concrete. Then the individual pieces were cleaned using water based detergent, Alconox, in ultrasonic cleaner preheated to 95°C. The pieces were cleaned for about 30 minutes.

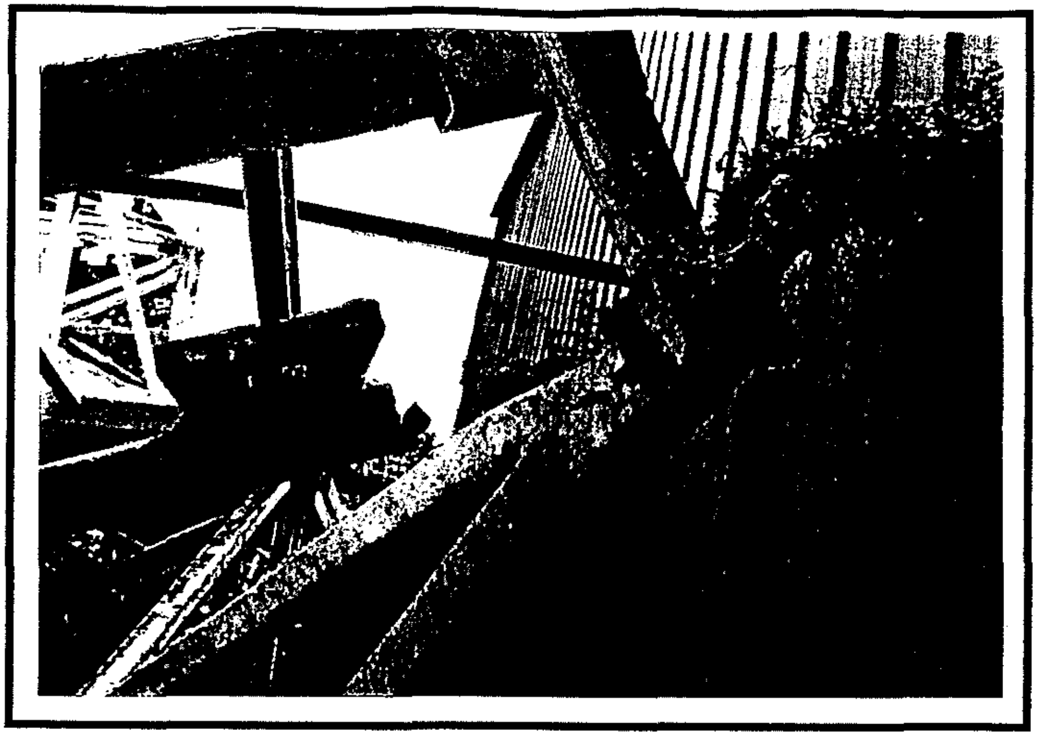


PHOTO 1 : SCAFFOLD MEMBER WITH COMPLETE FRACTURE

PHOTO 2 : VERTICAL MEMBER WITH INCOMPLETE FRACTURE

PHOTO 3 : WALL SIDE HALF OF COMPLETE FRACTURE SURFACE

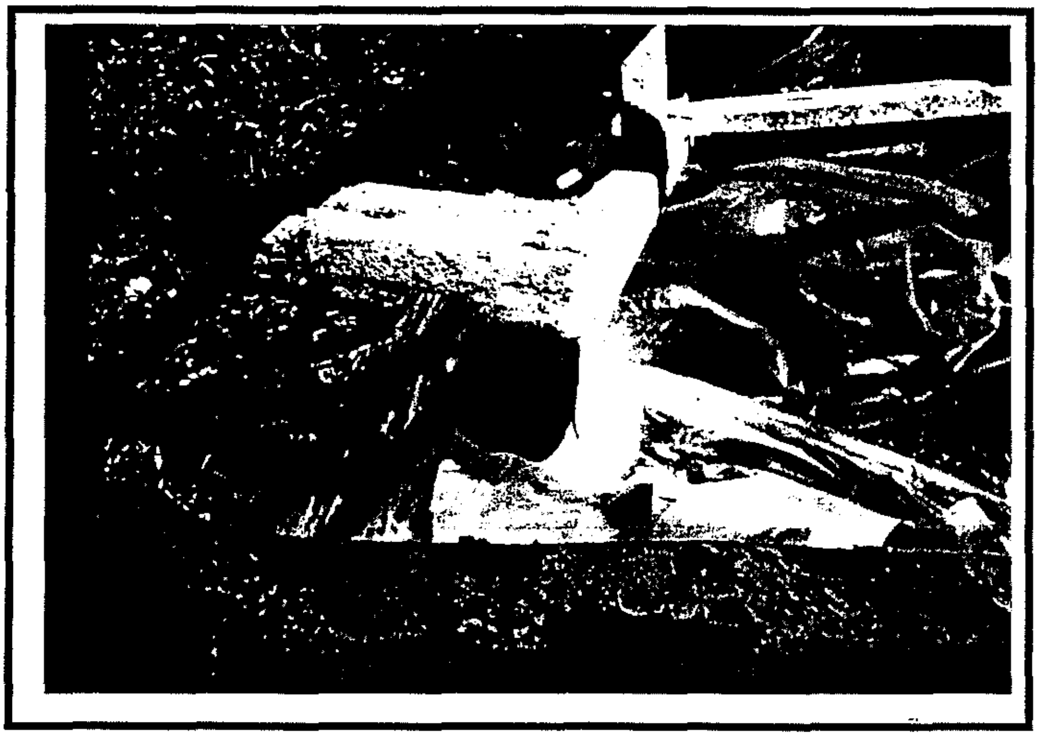
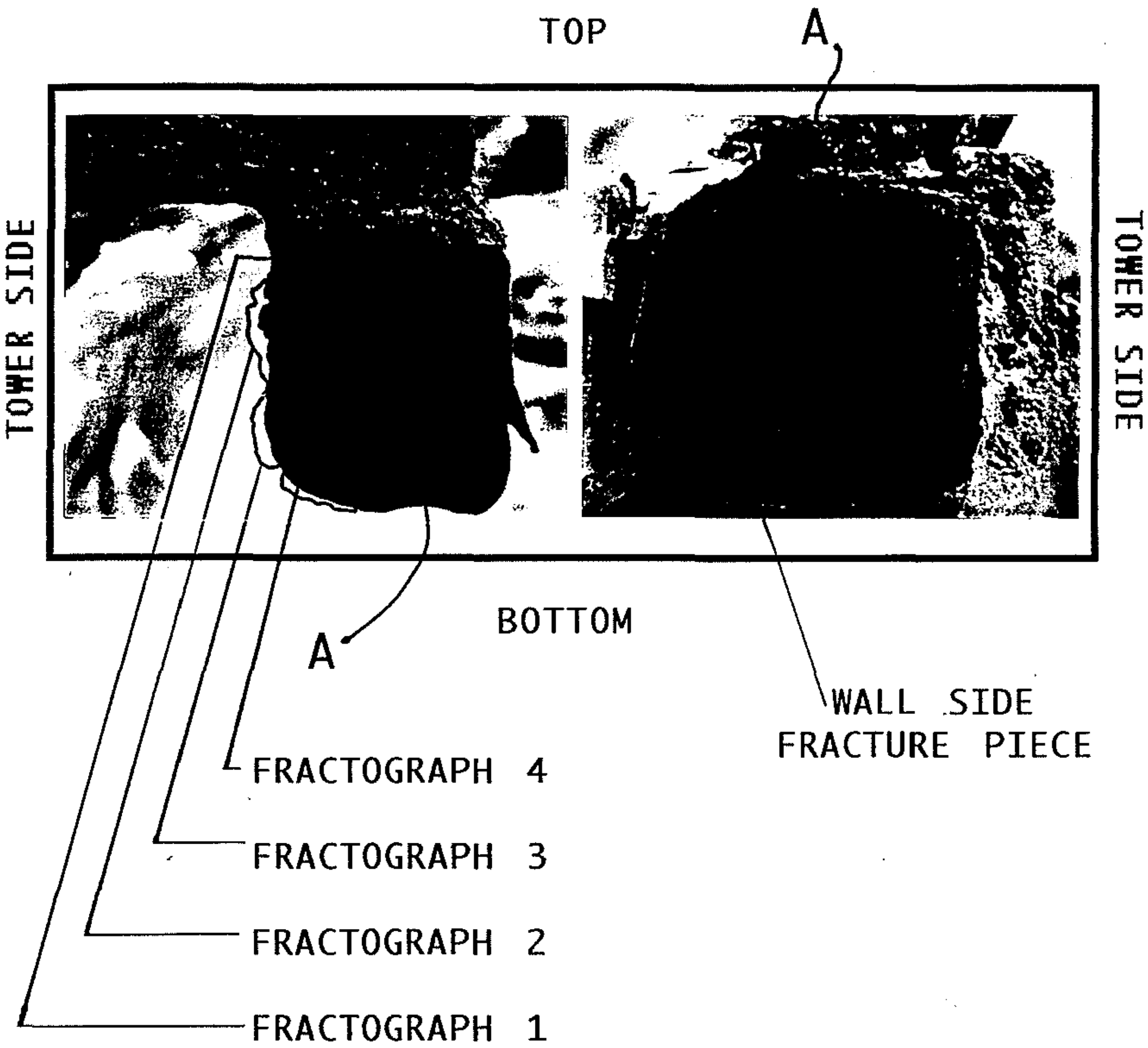


PHOTO 4 : OTHER HALF OF COMPLETE FRACTURE SURFACE



TOP
A
TOWER SIDE
TOWER SIDE
BOTTOM
A
WALL SIDE
FRACTURE PIECE
FRACTOGRAPH 4
FRACTOGRAPH 3
FRACTOGRAPH 2
FRACTOGRAPH 1

FIGURE 3

A low magnification light-microscope was then used to view the effect of the cleaning. One of the pieces, the wall side half, needed more cleaning. It was cleaned for additional fifteen minutes in Alconox. The specimens were washed with alcohol and air dried.

The fracture surfaces were still not suitable for electron microscopy and were further cleaned using cathodic cleaning technique. The cathodic cleaning utilized 5% H_2SO_4 Solution, inhibited with an organic inhibitor and about 250 mA of DC current. Cathodic cleaning was performed for about 1 to 3 minutes and specimens were optically checked for the results. 3 cycles of cleaning were performed, specimens rinsed with alcohol, air dried and stored under vacuum.

> ***Note:*** *In spite of the above cleaning processes, the specimens were still not very ideal for electron microscopy. However, it is our opinion that the fracture surfaces had already corroded beyond further cleaning. Yet, the microscopy provide some general ideas about the fracture.*

c. Microscopy:

Each fracture piece was first observed in the Scanning Electron Microscope (SEM) for best possible positioning, working distance requirements and need for any additional cleaning.

Both pieces were then individually examined for fracture characteristics, identification of initiation sites and the role of fatigue (if any). Although both the pieces were examined, the one further from the wall (the left hand side pieces in Figure 3) showed better results. The photographs of the areas of interest were taken with a Polaroid camera and then assembled for presentation purposes.

Since substantial general corrosion was noticed over the entire scaffold, particularly, under the peeled paint areas, a representative view of surface corrosion from one of the Tensile Test Specimen Tubes is also presented in Figure 4.

d. Conclusions & Discussions:

A visual examination of the two fractured pieces indicates that the two locations marked as "A" in Figure 3 were the last to separate. Also, in that case, the two halves must have rotated more than 90° counter clock wise relative to each other. Since the locations marked as "A" are away from the tower side, the fracture most probably originated on the tower side. A careful examination of the micrographs (SEM Photographs), indeed, shows a possible fracture origination site as seen in Fractograph 2 (lower left) & Fractograph 3 (top left). Further, the tube wall thickness in this region is close to 60 mils, too thin even allowing for necking during yielding. A careful examination of the towerside face of the specimens showed severe pitting and fracture line along the weld toe.

A very little visible evidence of fatigue was present in any of the micrographs, hence, presence of any pre cracks at the fracture locations is discounted. However, presence of severe pitting on the surface, and close to the weld toe, does not preclude the possibility of multiple fracture origination sites. Figure 4 shows a representative view of the pitting found under the loose paint, found elsewhere on the scaffold. The pitting could have probably reduced the member wall thickness to half the original thickness.

Also, the weld appears to be very poor and larger in size compared to the tube wall thickness. This must have substantially affected the material properties (both macroscopic and microscopic).

The scaffold members had probably 1/8" thick original walls. However, the wall thickness of fracture specimens, away from the fracture, ranged form 79 mils to 103 mils. This indicates that there had been substantial corrosion loss of the metal prior to the failure.

Since the Tensile Strength Test of steels showed substantial plasticity before failure, and very little evidence of fatigue, it is our opinion that the fracture was caused by overloading. And, the joint conditions at the fracture location (poor large size weld, severe pitting) probably helped the fracture initiation.

REFERENCES

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2. "The Corrosion Handbook", - Chapter on Preparation and Cleaning of the Specimens, John Wiley and Sons. 1948.

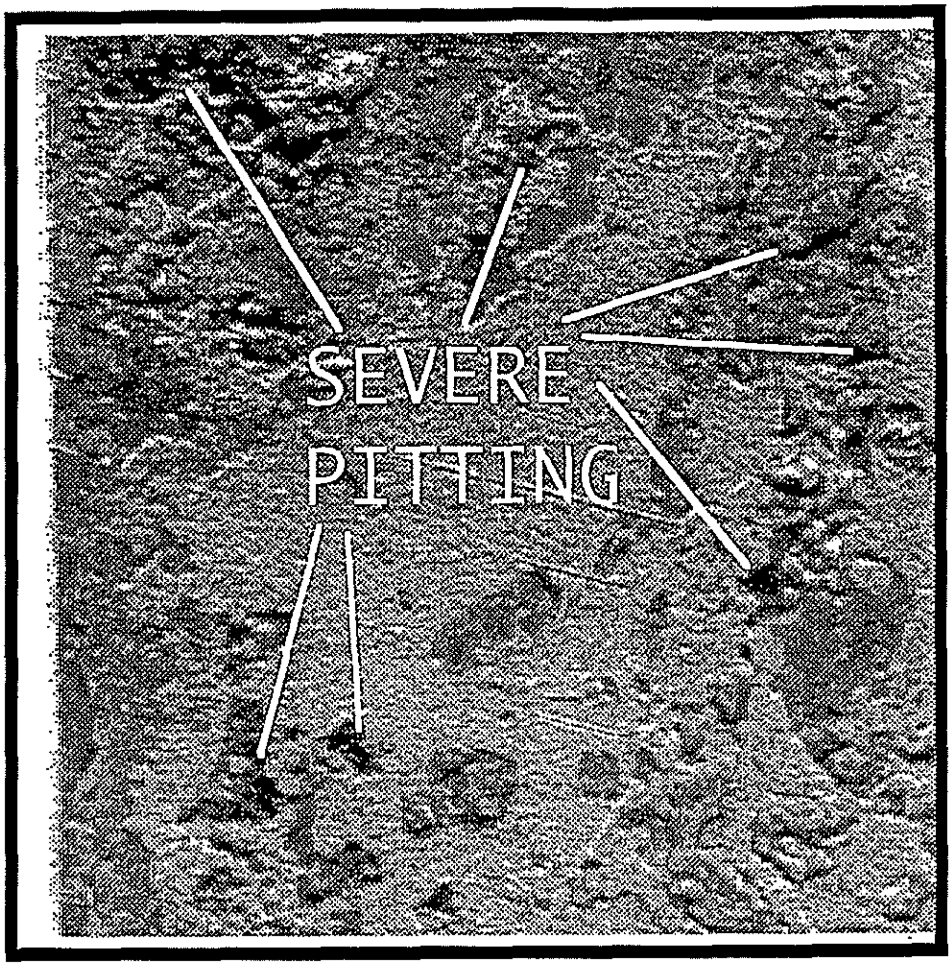
3. "Corrosion", Metals Handbook, Vol.13, Ninth Edition. ASM International. 1987.

4. "Materials Science and Metallurgy", Herman W. Pollack, Reston Publishing Company, Inc. 1973.

5. "Deformation and Fracture Mechanics of Engineering Materials, 2nd Edition", Richard W. Hertzberg, John Wiley & Sons. 1983.

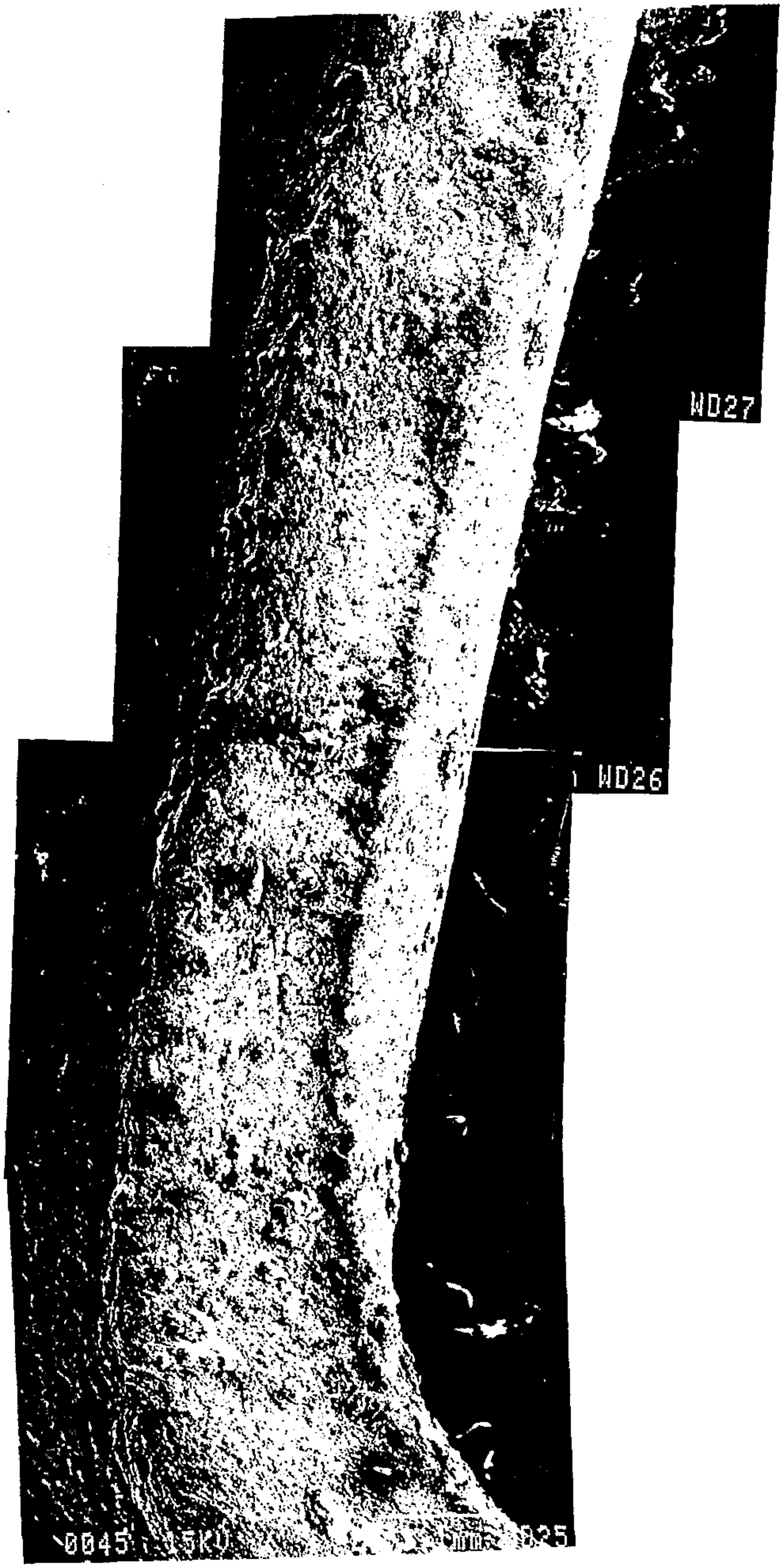
6. "Fracture and Fatigue Control in Structures, 2nd Edition", J.M. Barsom & S.T. Rolfe, Prentice-Hall, Inc. 1987.

7. "ASTM A 370-94", Annual Book of ASTM Standards, Vol. 1.04. 1995

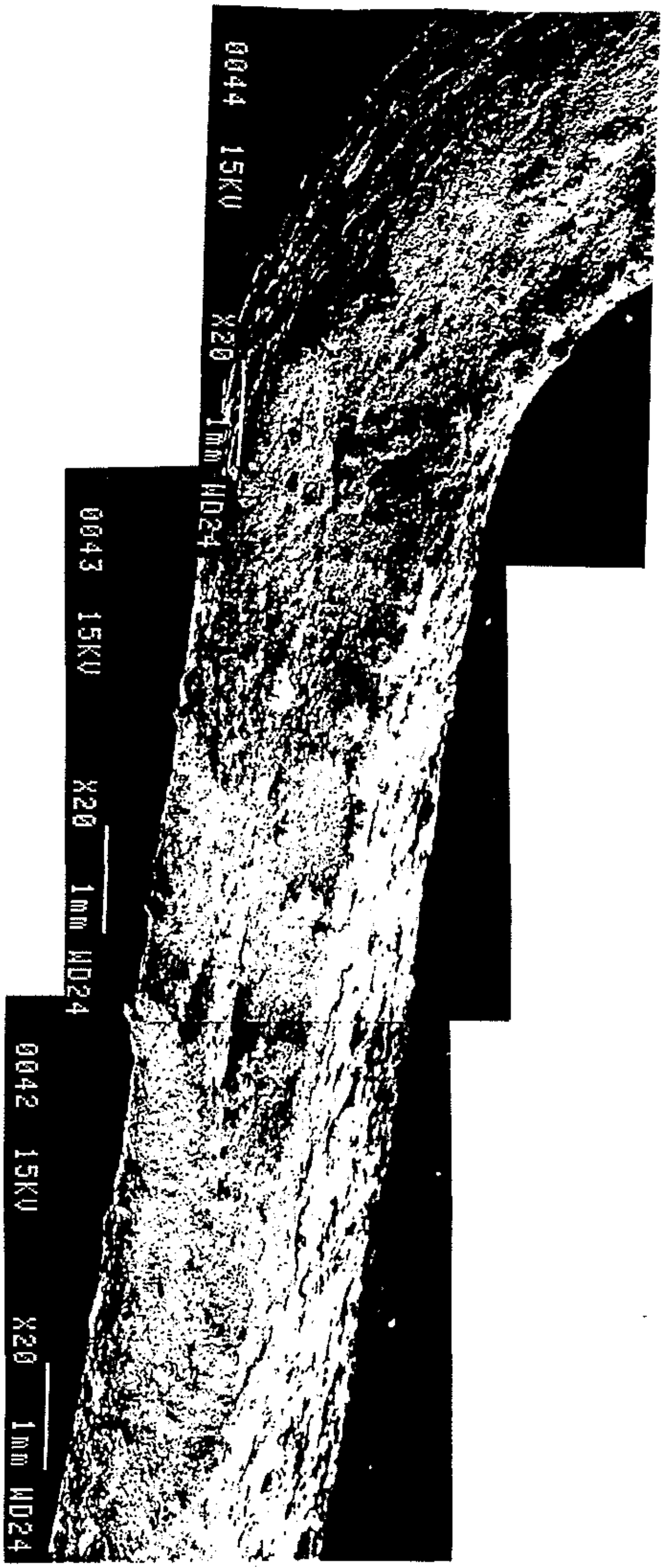


SURFACE CORROSION & PITTING

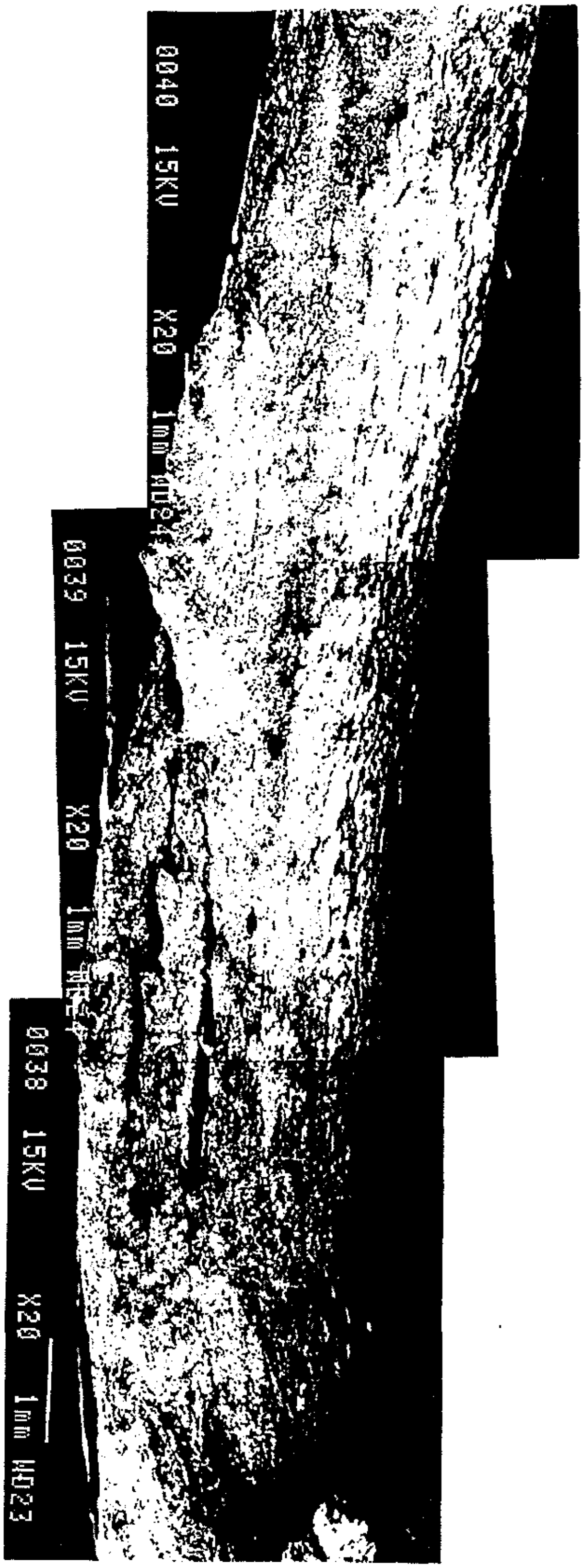
FIGURE 4



FRACTOGRAPH 1



FRACTOGRAPH 2



FRACTOGRAPH 3

FRACTOGRAPH 4

APPENDIX E

Computations

1

MN/ELEM

STRUCTURE DATA

TYPE = SPACE

NJ = 144

NM = 247

NE = 0

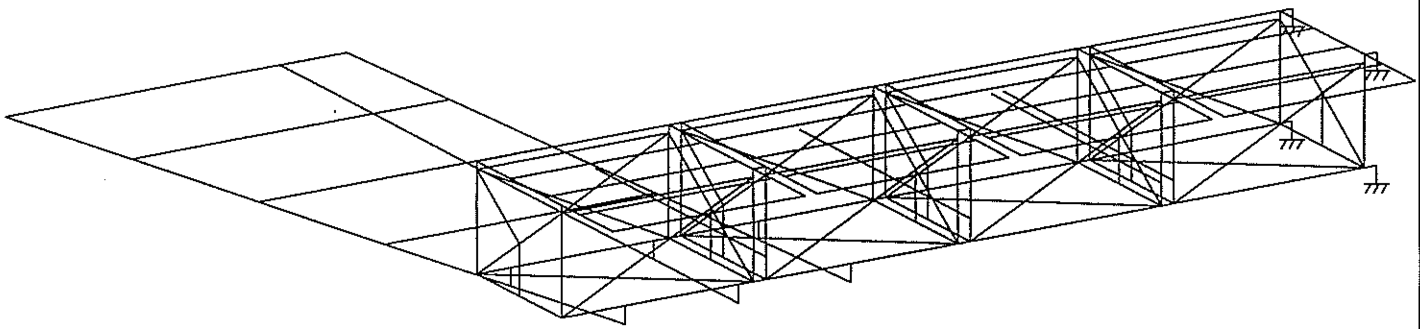
NS = 4

NL = 4

XMAX= 21.8

YMAX= 2.6

ZMAX= 19.8



COMPUTER MODEL OF THE SCAFFOLD FRAME

J=144, M=247

UNIT FEE POU

USER ID: US DEPARTMENT OF LABOR

S T A A D P O S T - P L O T (REV: 20.0)

TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI14)

DATE: JUN 22, 1995

1

MN/ELEM

STRUCTURE DATA

TYPE = SPACE

NJ = 144

NM = 247

NE = 0

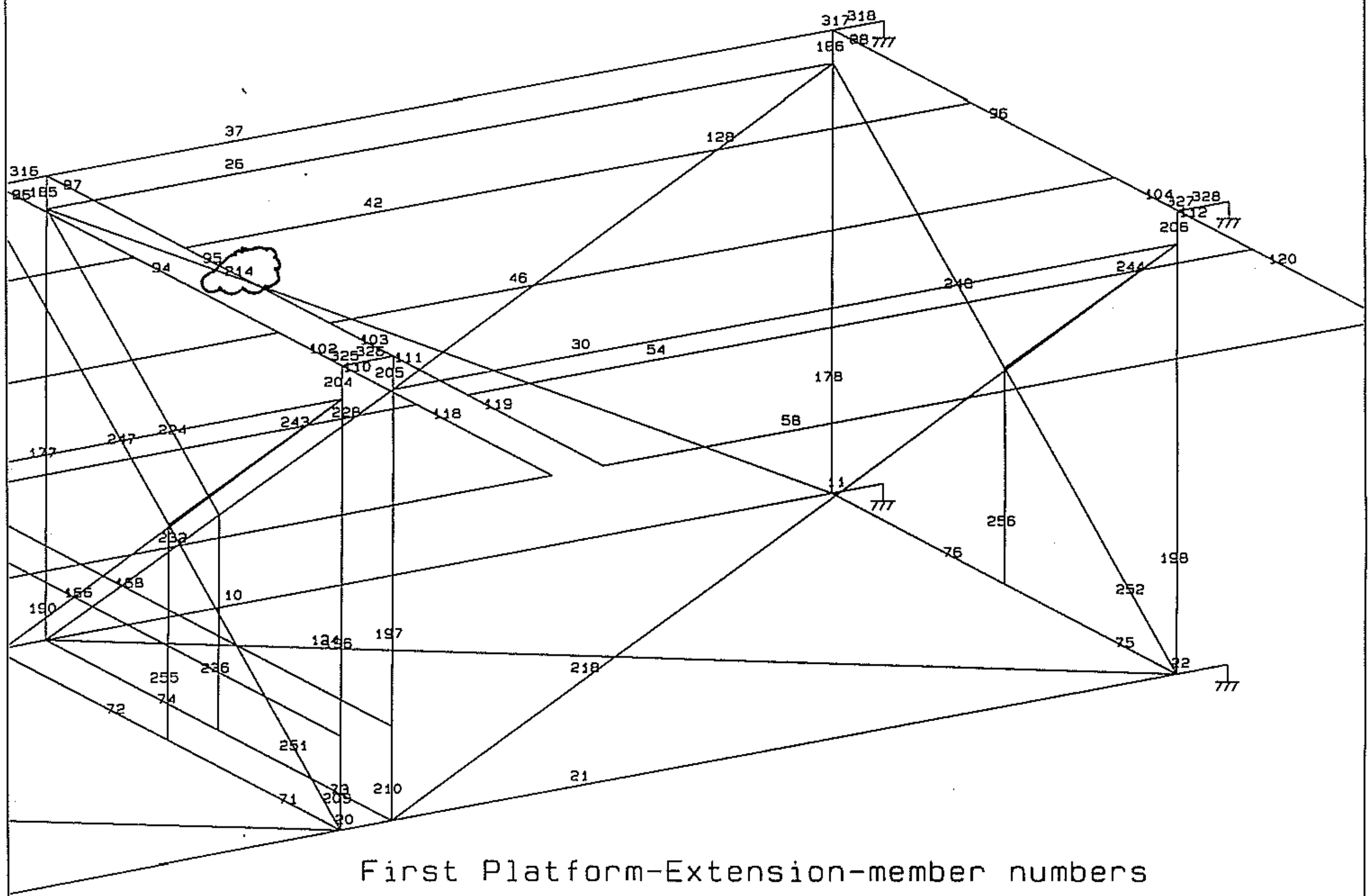
NS = 4

NL = 4

XMAX= 21.8

YMAX= 2.6

ZMAX= 19.8



First Platform-Extension-member numbers

J=144, M=247

UNIT FEE POU

S T A A D P O S T - P L O T (REV: 20.0)

USER ID: US DEPARTMENT OF LABOR

TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI14)

DATE: JUN 22, 1995

2

MEMBER END FORCES STRUCTURE TYPE = SPACE

ALL UNITS ARE -- POUN INCH

MEMB	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
178	6	8	-6079.69	55.09	-0.24	128.07	98.47	992.76
		24	6082.65	-55.09	0.24	-128.07	-92.38	391.18
198	6	16	2416.20	-116.07	-9.91	137.39	180.03	-818.17
		32	-2413.24	116.07	9.91	-137.39	68.84	-2097.43
214	6	23	14329.91	19.06	-2.66	-139.00	-8.78	734.76
		8	-14332.87	-12.61	2.66	139.00	169.04	219.03
218	6	15	4851.77	-15.63	0.32	-155.76	119.64	-316.65
		32	-4848.81	22.09	-0.32	155.76	-139.17	-819.39

************** END OF LATEST ANALYSIS RESULT **************

181. PRINT MEMBER FORCE LIST 144 149 154

MEMBER END FORCES STRUCTURE TYPE = SPACE

ALL UNITS ARE -- POUN INCH

MEMB	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
144	6	177	46.32	-629.37	-214.78	-0.03	2954.69	51274.98
		117	-46.32	641.83	214.78	0.03	6603.59	-79560.34
149	6	178	0.01	-752.30	255.08	0.00	-3265.29	57440.09
		118	-0.01	764.48	-255.08	0.00	-7830.86	-90430.16
154	6	179	2.22	-324.72	-35.29	0.00	310.64	25501.12
		119	-2.22	336.92	35.29	0.00	1227.33	-39920.12

************** END OF LATEST ANALYSIS RESULT **************

182. PRINT MEMBER STRESS LIST 311 TO 318 321 TO 328 4 7 9 11 15 18 20 22 -
183. 10 21 75 76 124 26 30 128 178 198 214 218

JOINT DISPLACEMENT (INCH RADIANS) STRUCTURE TYPE = SPACE

JOINT	LOAD	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	6	0.00413	-1.43727	0.43833	-0.03781	0.00098	-0.01018
9	6	-0.00411	-0.24641	0.43901	-0.03235	-0.00225	0.01896
131	6	0.18182	-14.04989	0.60445	-0.08135	-0.00081	-0.00212
132	6	0.18181	-11.99514	0.56352	-0.07129	-0.00094	0.01841
133	6	0.18181	-9.52040	0.49432	-0.05139	-0.00086	0.00468

************** END OF LATEST ANALYSIS RESULT **************

186. FINISH

*************** END OF STAAD-III ***************

**** DATE= JUN 22,1995 TIME= 14:19:17 ****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**********************************************************
*       For questions on STAAD-III/ISDS, contact:        *
*             RESEARCH ENGINEERS, Inc at                 *
*       Ph: (714) 974-2500    Fax: (714) 921-2543        *
**********************************************************
```

STRUCTURE DATA

TYPE = SPACE

NJ = 144

NM = 247

NE = 0

NS = 4

NL = 4

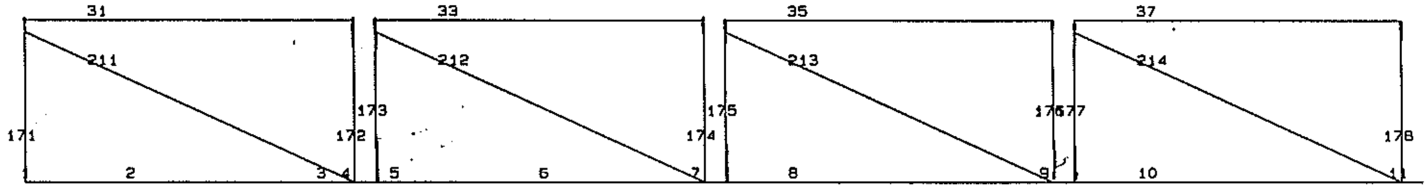
XMAX= 261.0

YMAX= 31.6

ZMAX= 237.2

1

MN/ELEM



EAST ELEVATION - MEMBER NUNBERS

J=144, M=247

UNIT INC POU

S T A A D P O S T - P L O T (REV: 20.0)

TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI14)

USER ID: US DEPARTMENT OF LABOR

DATE: JUN 14, 1995

STRUCTURE DATA

TYPE = SPACE

NJ = 144

NM = 247

NE = 0

NS = 4

NL = 4

XMAX= 261.0

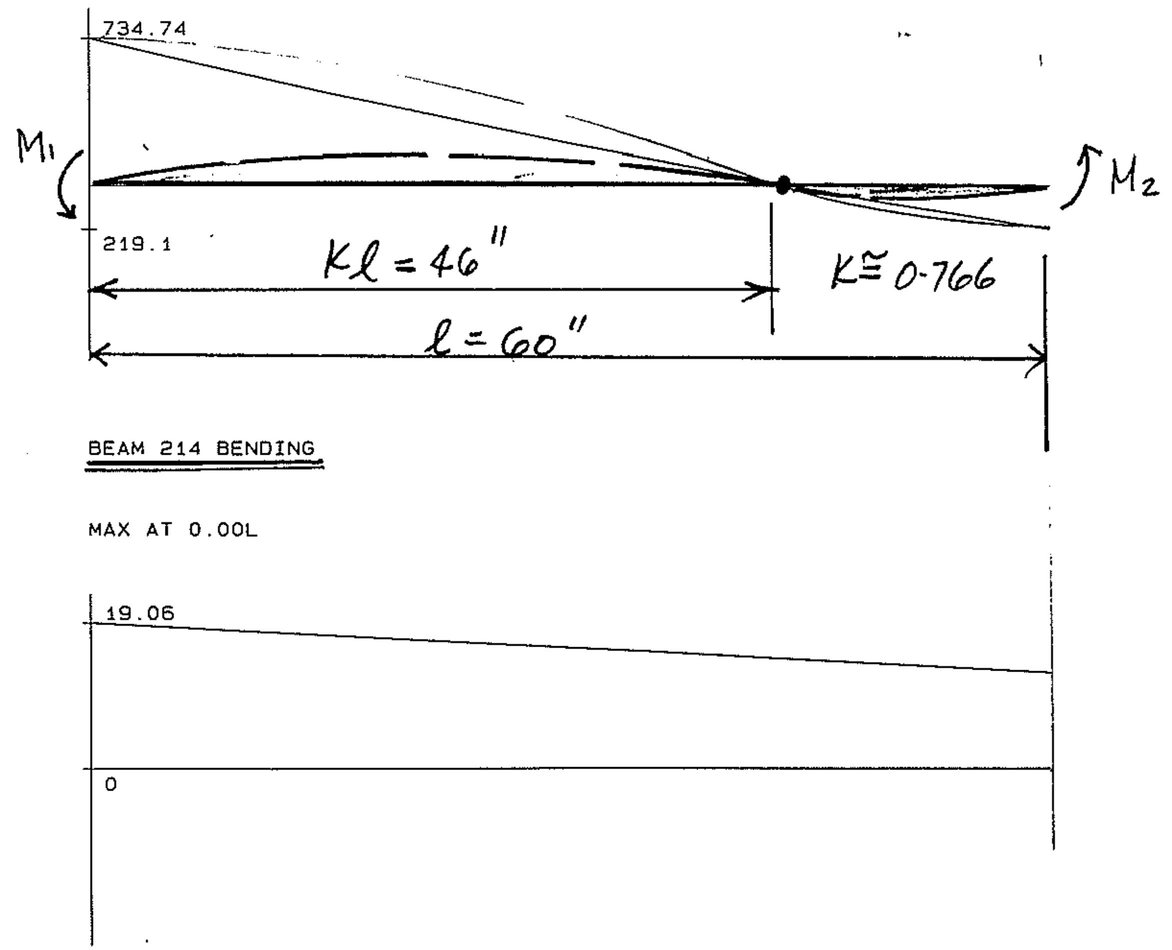
YMAX= 31.6

ZMAX= 237.2

1

MN/ELEM

Z-AXIS LN= 6



BEAM 214 SHEAR

J=144, M=247

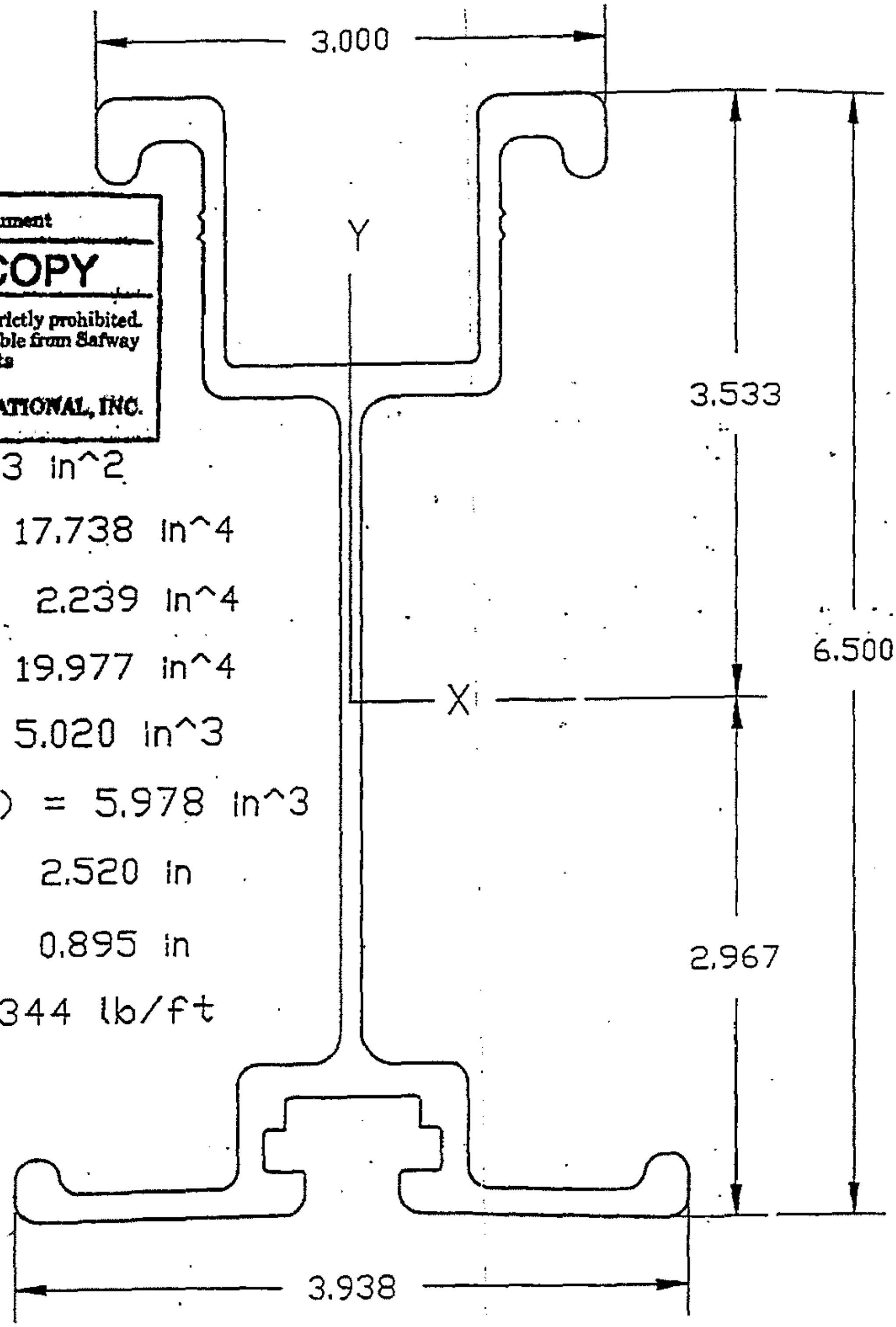
UNIT INC POU

USER ID: US DEPARTMENT OF LABOR

S T A A D P O S T - P L O T (REV: 20.0)

TITLE: - MIAMI SCAFFOLD PLATFORM (MIAMI14)

DATE: JUN 15, 1995



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Area = 2.793 in^2

Ixx = 17.738 in^4

Iyy = 2.239 in^4

Jz = 19.977 in^4

Sx (top) = 5.020 in^3

Sx (bottom) = 5.978 in^3

rxx = 2.520 in

ryy = 0.895 in

weight = 3.344 lb/ft

ALLOW ± TOLERANCE ON ALL FRACTIONAL DIMENSIONS UNLESS NOTED

SAFWAY STEEL PRODUCTS
MILWAUKEE WISCONSIN

6.5" ALUMINUM JOIST ALJ--
PROPERTIES

DR WEC	SCALE FULL	JOB NO	DRWG NO SPC-89001
CK	DATE 04-24-89		

NO	REVISION	DATE

* Member stresses of 1st Platform - Extension Frame. after member 24 became ineffective.

MEMBER STRESSES

ALL UNITS ARE POUN/SQ INCH

MEMB	LD	SECT	AXIAL	BEND-Y	BEND-Z	COMBINED	SHEAR-Y	SHEAR-Z
7	6	.0	15579.8 C	0.0	19.1	15598.9	1.7	0.0
		1.00	15579.8 C	0.0	0.0	15579.8	0.0	0.0
9	6	.0	38143.4 C	0.0	19.1	38162.5	1.7	0.0
		1.00	38143.4 C	0.0	0.0	38143.4	0.0	0.0
11	6	.0	4896.8 C	0.0	19.1	4915.9	1.7	0.0
		1.00	4896.8 C	0.0	0.0	4896.8	0.0	0.0
15	6	.0	2764.4 C	0.0	19.0	2783.4	1.7	0.0
		1.00	2764.4 C	0.0	0.0	2764.4	0.0	0.0
18	6	.0	2713.9 C	0.0	19.1	2733.0	1.7	0.0
		1.00	2713.9 C	0.0	0.0	2713.9	0.0	0.0
20	6	.0	2876.8 T	0.0	19.1	2895.9	1.7	0.0
		1.00	2876.8 T	0.0	0.0	2876.8	0.0	0.0
22	6	.0	50055.3 C	0.1	19.2	50074.4	1.7	0.0
		1.00	50055.3 C	0.1	0.0	50055.4	0.0	0.0
10	6	.0	1768.5 C	942.6	34611.1	37322.2	1037.2	36.4
		1.00	1768.5 C	1766.2	33517.0	37051.8	1068.2	36.4
21	6	.0	7736.1 C	5951.2	2001.9	15689.2	103.9	164.7
		1.00	7736.1 C	6301.3	3721.8	17759.2	72.9	164.7
75	6	.0	1016.3 T	6772.6	11215.5	19004.4	506.4	251.5
		1.00	1016.3 T	2250.8	4732.8	7999.8	517.6	251.5
76	6	.0	6.3 T	8044.5	16085.2	24135.9	1114.2	243.3
		1.00	6.3 T	687.7	18796.4	19490.3	1125.4	243.3
124	6	.0	49344.8 C	509.0	2996.9	52850.7	111.2	2.5
		1.00	49344.8 C	820.2	10904.8	61069.8	149.4	2.5
26	6	.0	12749.6 T	4263.9	2360.5	19373.9	10.7	105.7
		1.00	12749.6 T	3595.9	2671.6	19017.0	20.3	105.7
30	6	.0	14048.7 T	5625.7	20300.0	39974.4	814.8	151.4
		1.00	14048.7 T	5632.6	33433.5	53114.9	845.8	151.4
128	6	.0	48211.9 C	451.0	4406.6	53069.4	77.3	11.5
		1.00	48211.9 C	963.4	10614.5	59789.8	39.1	11.5
178	6	.0	1491.6 T	910.5	71654.5	74056.6	3958.7	74.0
		1.00	1498.7 T	2478.7	85667.0	89644.5	3958.7	74.0
198	6	.0	18326.2 C	7605.1	8075.7	34007.0	1128.0	275.1

1.00	18319.1	C	4988.0	36752.7	60059.7	1128.0	275.1

MEMBER STRESSES

ALL UNITS ARE POUN/SQ INCH

MEMB	LD	SECT	AXIAL	BEND-Y	BEND-Z	COMBINED	SHEAR-Y	SHEAR-Z
218	6	.0	18289.1 T	4571.0	9409.9	32270.0	297.9	5.3
		1.00	18296.2 T	3992.2	20460.5	42748.9	328.9	5.3

************** END OF LATEST ANALYSIS RESULT **************

185. PRINT MEMBER STRESS LIST 144 149 154

MEMBER STRESSES

ALL UNITS ARE POUN/SQ INCH

MEMB	LD	SECT	AXIAL	BEND-Y	BEND-Z	COMBINED	SHEAR-Y	SHEAR-Z
144	6	.0	16.4 C	1957.8	8690.7	10664.9	224.8	75.9
		1.00	16.4 C	4379.2	13484.8	17880.4	229.2	75.9
149	6	.0	0.0 C	2197.1	9735.6	11932.7	268.7	91.5
		1.00	0.0 C	5262.6	15327.2	20589.8	273.0	91.5
154	6	.0	0.9 C	239.3	4322.2	4562.4	116.0	13.7
		1.00	0.9 C	883.3	6766.2	7650.3	120.3	13.7

************** END OF LATEST ANALYSIS RESULT **************

186. PRINT DISPLACEMENT LIST 1 9 131 132 133