Investigation of the July 22, 2004, Collapse of a Building, “Tranquility at Hobe Sound”, Hobe Sound, FL

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

December 2004

REPORT

Investigation of the July 22, 2004 Collapse of a Building, "Tranquility at Hobe Sound", Hobe Sound, FL

Report Prepared by
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REPORT

The Incident:

The project consisted of ten three-story buildings to construct 82 townhouses. There were eight buildings with nine townhouses each, and two buildings with five units each. Initially, the contracts were awarded to complete the "building shell". The project was known as "Tranquility at Hobe Sound" located at 12503 Flora Avenue, Hobe Sound, FL 33455. The incident occurred in building No. 9 while concrete was being placed on the third floor of the southern part of the building. The building was approximately 53' wide and 150' long. The following were the primary members of the project:

Owner:	Harbor Communities LLC and PM Development Inc. 3300 PGA Boulevard, Palm Beach Gardens, FL 33410
Construction Manager:	Allied Capital and Development LLC Address the same as the owner's
Concrete Contractor:	Macs Construction 1000 Lake Ida Road, Delray Beach, FL 33477
Architect:	Theodore E. Davis & Associates 1851 W. Indiantown Road, #101, Jupiter, FL 33458
Structural Engineer:	Stephen R. Walsh, PE P.O. Box # 933, Boca Raton, FL 33429

It must be noted here that though Allied was the construction manager of the project, it is believed that it also assumed the role of a general contractor. The structural engineer, Walsh, was brought onto the team at the beginning of the construction phase and was not the original structural engineer of record. However, when tunnel forms were selected by the construction team (Allied, Macs, Walsh, etc.) for casting concrete on the floors and in the walls, Mr. Walsh redesigned the structure and became the new structural engineer of record.

The incident occurred during the placement of concrete on the elevated floors of Building No. 9 on July 22, 2004. Days earlier, placement of concrete on the second and third floors of a similar Building No. 2 was completed. Similar to Building No. 2, Building No. 9 was also divided into two parts, the south and the north for the purpose of casting concrete. There were not enough tunnel forms available at the site to cast concrete on the entire second or third floor at one time.

Construction of Building No. 9 using tunnel forms began on July 20, 2004. Tunnel forms were first placed on the south part of Building No. 9. Work started in the early morning and by the late afternoon, about 3:00 pm, the tunnel forms were placed in their final location to begin

casting concrete over the second floor and in the walls between the first and second floor (Fig. 1 & 2). Concrete began to be placed on the forms at about 4:00 pm and was completed by about 8:00 pm. Allied retained a geotechnical and material testing company, PEICO of Jupiter, FL, to perform concrete sampling and testing. PEICO took two specimens of concrete on July 20, 2004 for testing. The test results of the cylinders will be discussed later.

The next day, (July 21), at about 8:00 am the tunnel forms were loosened so that they could be removed from the south part and placed in the north part of the building. The tunnel forms were rolled out of the south part and placed in the north part by about 3:00 pm. Concrete began to be placed on the second floor and the walls by 4:00 pm. Concreting was completed by 8:00 pm. Again, PEICO took specimens for testing the concrete.

The following day, the day of the incident, a similar routine was followed to cast the third floor (Fig. 3) and the wall between the second and third floors. At about 8:00 am, tunnel forms at the north part were loosened and were rolled out and placed on the south part on the second floor. Tunnel forms were placed in their final location by about 3:00 pm and concreting by bucket began at about that time. Macs had placed all the concrete except the last two cubic yards over the third floor and in the walls between the second and the third floors when the rear of the entire Building No.9 suddenly collapsed. The entire rear of the building, including the freshly placed concrete on the third floor of the southern part of the building and the second floors of the northern and southern parts collapsed (Fig. 8). There were five workers on the third floor and three workers on the first floor. Two workers were killed and three were injured, one critically.

Discussion:

In early 2004, Macs suggested that Allied use tunnel forming in the construction of the townhouse buildings. Macs had successfully used tunnel forms in prior projects similar to the current one. Anticipated savings in the construction cost led Allied to support the idea and accept the suggestion. Macs had worked with a structural engineer, Stephen R. Walsh, PE, of Boca Raton, FL, in prior projects to perform structural design of the buildings facilitating the use of tunnel forms. The tunnel forms are manufactured by Outinord Universal, Inc., (Outinord) of Miami, FL. Following the decision to accommodate the tunnel forms, Steve Walsh was assigned the responsibility, by Macs and Allied, to re-design the structural framing of the building to suit the tunnel forms. For example, block walls were to be changed to concrete walls and the design had to be streamlined for the repeated use of tunnel forms. In the beginning, Steve Walsh directly worked for Macs, but later, Allied proposed that Walsh work for Allied instead. On April 27, 2004, Allied expressed its intent to retain Walsh for the structural engineering, and asked him to submit a proposal. Walsh never submitted the proposal, but he continued to work on the project based on verbal orders only. In fact, Walsh did not have any written contract with either Allied or Macs up to the time of the incident. Despite the lack of any written contract, Walsh assumed full responsibility for his work. Allied dismissed Walsh from the project a few days after the incident.

Walsh submitted the structural drawings dated March 31, 2004 based upon his re-design for the Martin County building permit. Later, two revisions were made on June 2, 2004 and July 14, 2004. The original drawings submitted for the building permit were embossed with the PE's seal. Other copies of the structural drawings neither contained Walsh's signature nor his stamp.

Outinord designed the tunnel formwork for the project but did not design the shoring or re-shoring that were needed after the tunnel forms were rolled out. This was in accordance with their usual practice. The standard industry practice was for the concrete contractor to design shoring and re-shoring for the project and prepare a shoring plan, readily available to the job site. It is not clear whether Macs ever asked Walsh to design and prepare a plan for shoring and re-shoring. There is no written record supporting this contention. However, there is a record of Allied repeatedly asking Walsh to submit a shoring plan. Walsh's response to Allied was that it was the concrete contractor's responsibility and not his. Walsh reminded Allied that the structural drawings required Macs to submit shoring plans to Walsh for his approval. When Macs was asked about the shoring plan after the incident, Macs produced handwritten instructions signed by Walsh. The instructions were dated June 28, 2004 (Fig. 7). The instruction was addressed by Walsh to the "Tranquility at Hobe Sound" project. The instructions did not specify any building number to which the instructions were applicable. The instructions also did not specify the size and strength of the single post shores to be used. They did not contain any sketch to illustrate the location of the shores. The note from Walsh also did not address the size, location and spacing of shores under the walls which began from the second floor and up. Also, the instructions did not specify the required concrete strength at which time the tunnel forms could be removed. The instructions, at best, were deficient and lacked clarity.

Walsh, during OSHA's discussions at the site after the incident, did not say that his instructions of June 28, 2004, were meant to be used only for a certain building. He confirmed that these were his instructions to be followed at the site. Walsh further said that he had verbally instructed the contractor to place single post shores every two feet on centers under the wall. Four months later, however, Walsh told OSHA that the instructions were prepared only for five-unit buildings and not for nine-unit buildings. He further said that he did not advise the contractor regarding the spacing of the shores under the wall. Three days after the incident, Walsh prepared computations to demonstrate that if single post shores (Safway 350 DB) were used at two feet on centers under the wall, they would have been able to support the load. It is not known why Walsh assumed that Safway posts were used at the site because in fact Macs had been using a different post, GB-2 (also called N350 by the supplier) manufactured by another company. GB-2 posts have a lower capacity than the Safway 350 DB posts.

Macs told OSHA at the site following the incident, that the tunnel forms were removed when the concrete attained 30% of the required strength, on the advice of Walsh. Walsh admits that he verbally provided the instructions to Macs, although his written instructions of June 28, 2004 did not contain any such requirements. Walsh specified concrete to be of 3,000 psi strength at 28 days. So, at 900 psi, the tunnel forms could be rolled out. However, lab test results indicated that on the second floor on the south side, the average strength of the two breaks at one day was only 833 psi. One cylinder broke at 979 psi and the other at 687 psi. It must be noted here that the tunnel forms were rolled out after only about 17-18 hours, even before the completion of one day. The lower strength of the concrete contributed to the collapse.

Analysis:

Before demolition of building No.9, Allied retained Capri Engineering to survey the failed structure in its collapsed form and preserve the retrieved tunnel forms and single post shores for later examination. OSHA's interest, among other things, was two-fold. First, to determine whether or not the tunnel forms were placed according to the manufacturer's instructions, in particular whether the wall jacks were screwed down to the concrete slabs. Initial observations of the failed building had indicated that some of the wall jacks were not down. Second, it was crucial to determine the size, strength and spacing of the single post shores supporting the concrete walls above the second floor.

Outinord sold the tunnel forms to Macs and provided a technical advisor, Jimmy Smith, to Macs. He spent about two weeks at the site supervising and training Mac employees on how to properly install the tunnel forms. Macs had used the system in the past for at least three years, as per Outinord. Outinord designed the tunnel forms for the dead and construction loads and prepared detailed shop drawings that were provided to Macs for their use at the site. The tunnel form comes in 10' segments and comes in an L shape (Fig. 4). Two L-segments are inverted to form a tunnel (Fig. 5 & 6). The tunnel segments are assembled on the ground and placed by a crane. Each tunnel form is provided with two outer and two inner jacks located at the ends. The outer jacks transfer the load of the wet concrete and construction, and it must be screwed down to the load carrying member. The inner jack does not transfer the loads and must be raised up while placing wet concrete on the tunnel forms. The inner jacks are lowered prior to rolling out the tunnel forms. If the clear span between the concrete walls exceeds the width of the tunnel forms, then additional forms are used known as table forms. In building no. 9, tunnel forms were used with and without table forms. In bays without tables, the load is transferred through the outer jacks only. Where tables are required, the loads are transferred through the outer jacks and two rows of shores supporting the table. Walsh's instructions of June 28, 2004, (Fig. 7) directed that the tunnel forms without tables be provided with one row of back shores and that those with tables be provided with two rows of back shores. The back shores must be shored to the first floor.

Our observations indicate that a number of outer jacks were not lowered to the slab, thus altering the load path. This could have significantly overloaded those jacks which were lowered, thus compromising the integrity of the one-day-old structure. Our observations are supported by the post-incident survey. The survey confirmed that approximately 50% of of the jacks were not screwed down in the area of the building that failed.

Of significance to this analysis was the spacing of the single post shores placed under the walls which started from the second floor to the third floor. It was determined that the posts would be subjected to a load of about 4,000 pounds per foot of the length of the wall. If the posts were placed at 2' or 4' on centers, each post would bear a load of 8,000 or 16,000 pounds, respectively. Walsh's instructions of June 28, 2004 do not address the issue of shoring the walls. However, Walsh, according to Macs, advised Macs on the telephone that the posts be placed at

2’ on centers under the wall. Macs’s foreman, however, said that he placed the posts at 4’ on centers. If GB-2 posts were used, the allowable capacity of the posts for a height of 10’-6” is approximately 4,600 pounds with a factor of safety of 3. The ultimate capacity of the shores is, therefore, 13,800 pounds. If the shores were used at spacing greater than 3’-6”, the posts would buckle and fail. A post-incident survey indicated that posts were placed at spacing greater than 3’-6” on centers. The survey indicated that the number of shores recovered along grid line 2 thru 7 (Fig. 1) was 3, 5, 3, 1, 4 and 3 respectively, indicating that the spacing of the posts under the wall was generally 5’-3”. In one case, the spacing was far greater.

During the construction of building No.2, it was reported that there were several single post shores that buckled under the loads. Macs placed additional shores next to the failed ones but did not investigate why the failures were occurring. Macs did not consult the structural engineer to determine the cause of the failures. Failures of posts are signs of either inadequate strength or improper spacing of posts. In fact, Macs’s foreman reported that the posts appeared to be too “thin”.

Findings:

Based on the above, we conclude that:

1. The concrete contractor did not provide an adequate number of single post shores on the first floor to support the weights of the walls of the 2nd and 3rd floors and the weight of the 2nd and 3rd floor slabs. The posts buckled under the load and precipitated the failure of the building. The contractor failed to prepare a shoring plan to support the vertical loads that could be expected. Thus, OSHA standard 1926.703(a)(1) was violated.

2. Shoring plans were not available at the job site. Thus, OSHA standard 1926.703(a)(2) was violated.

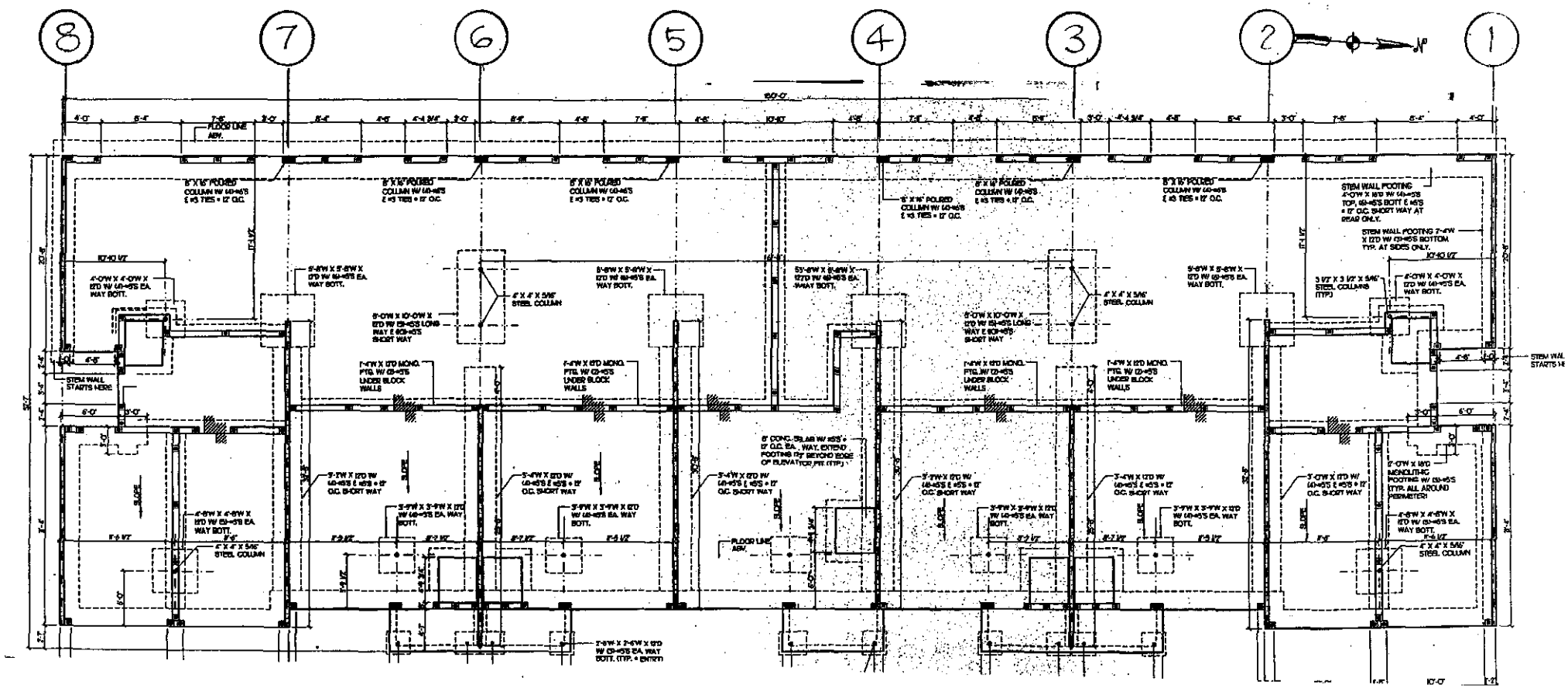
3. A number of tunnel formworks were not properly placed because their leveling jacks were not turned down to the floor slab to properly transfer the loads. Proper inspections were not done prior to and during the concrete placement. OSHA standard 1926.703(b)(3) was violated.

4. The concrete contractor removed the tunnel forms before concrete could attain the required strength as required by the structural engineer. Thirty percent of the 28 days strength was required by the structural engineer. On the south side of Building No. 9, concrete forms were removed before the concrete could attain 30% of the required strength. Thus, OSHA standard 1926.703(e)(1) was violated.

5. At locations near the front of building No. 9, single post shores were placed on loose cinder blocks without firm supports. Thus, OSHA standard 1926.703(b)(5) was violated.

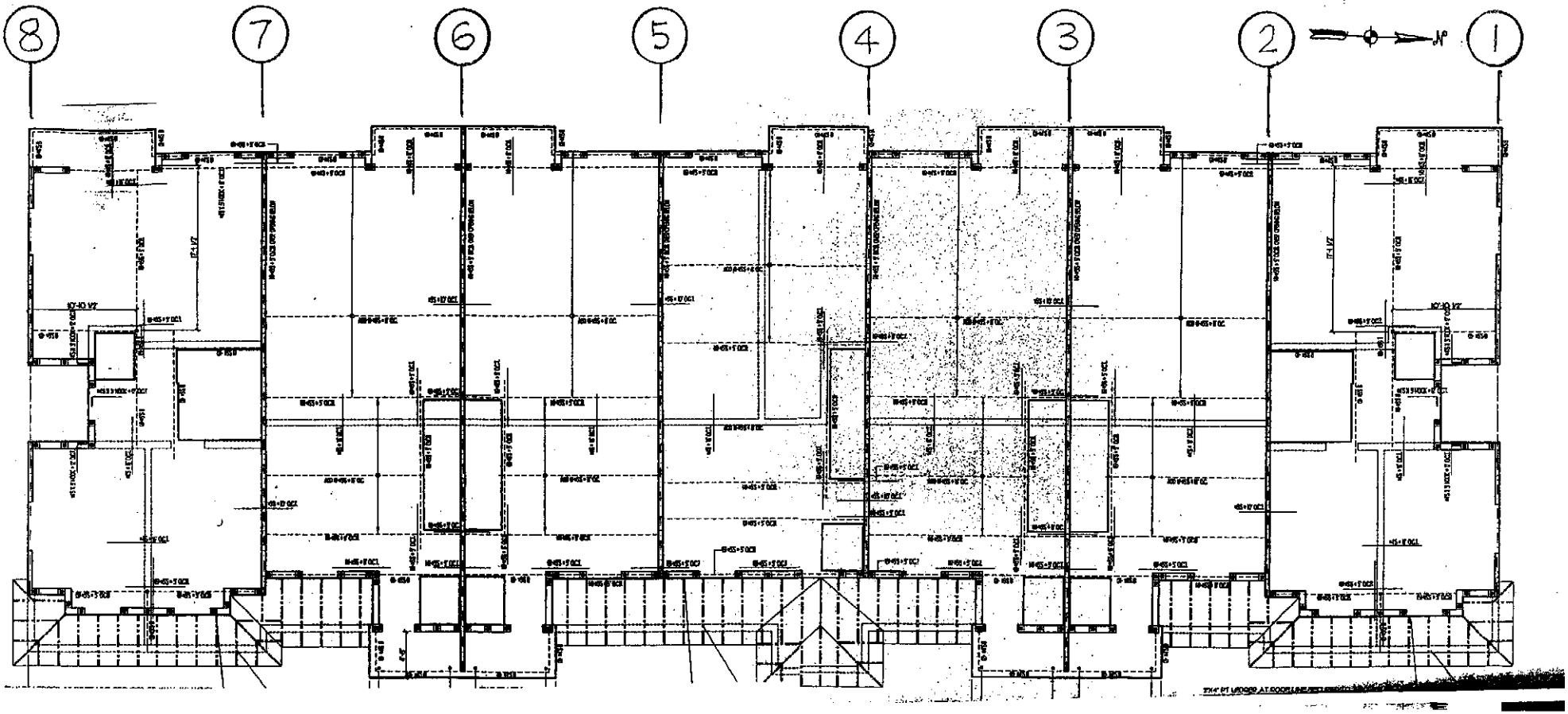
6. The structural engineer prepared a one-page instruction entitled “Tranquility at Hobe Sound Shoring” on June 28, 2004. The instructions were deficient because:

    a. They did not specify the size and strength of single post shores to be used.
    b. They did not specify the spacing of the shores under the walls.
    c. They did not contain any sketch or schematic drawing to illustrate how the shores were to be placed.
    d. They did not specify if the instructions were meant for one particular building or all of the buildings.



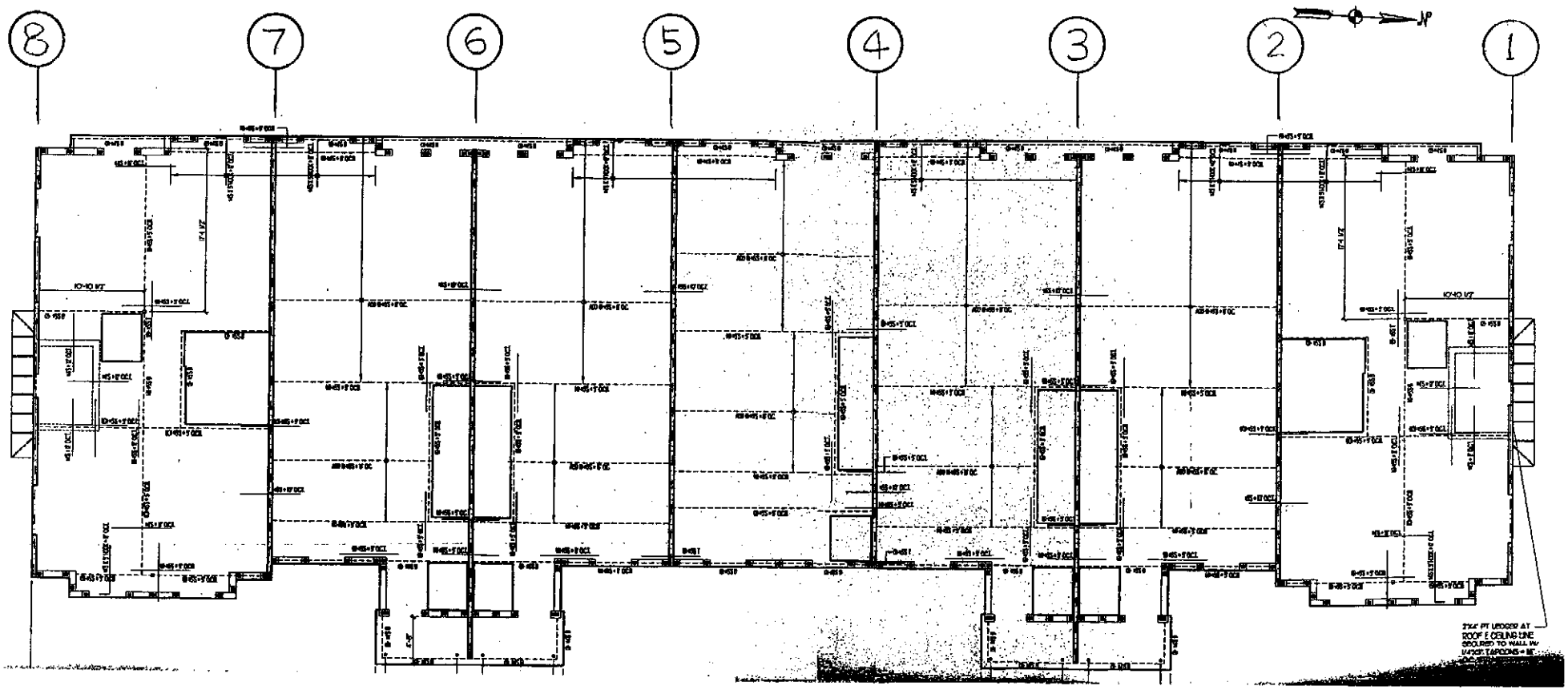
FOUNDATION PLAN (FIRST FLOOR PLAN)

FIGURE 1



SECOND FLOOR PLAN

FIGURE 2



THIRD FLOOR PLAN

FIGURE 3

TMPH half tunnel

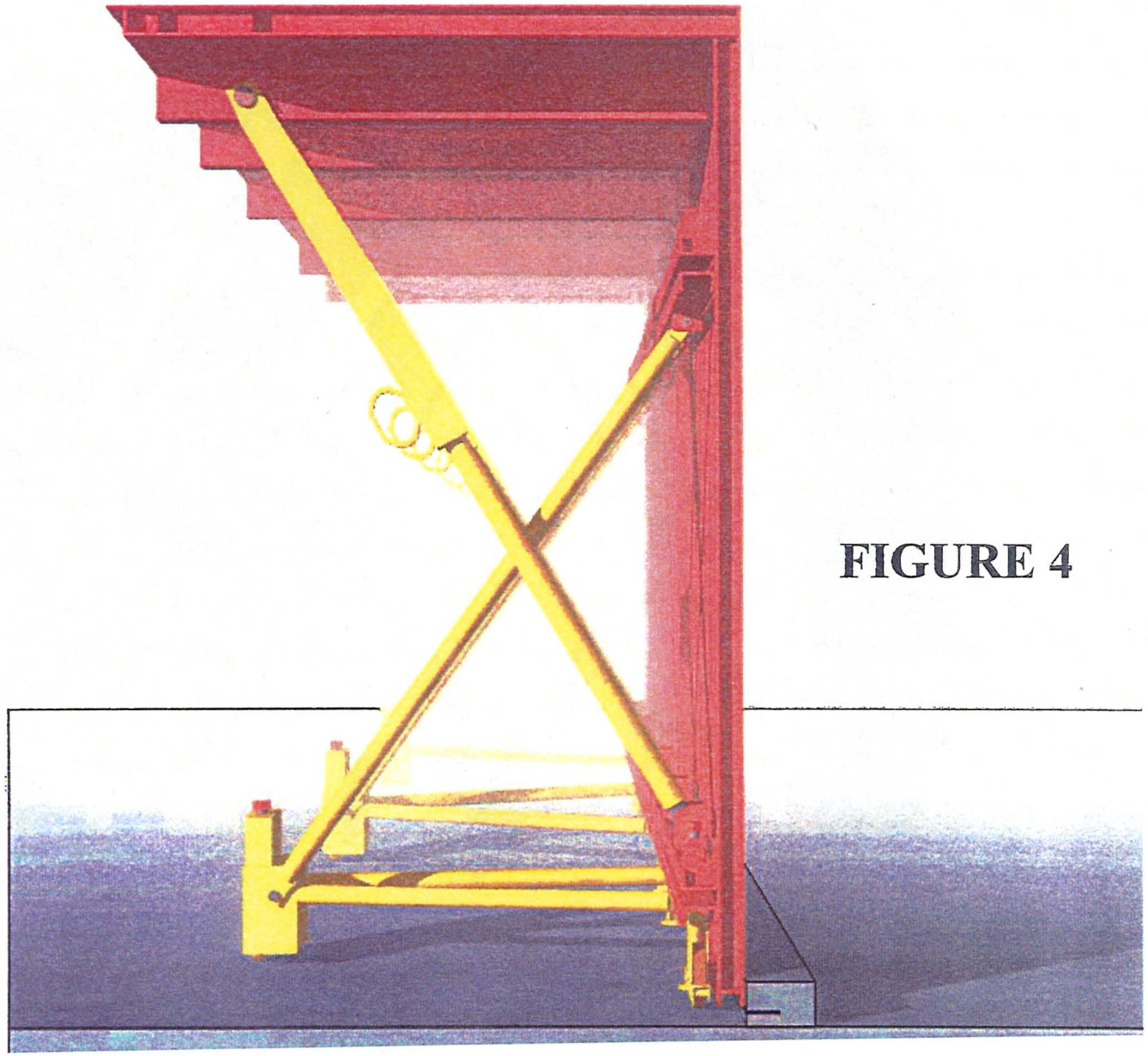


FIGURE 4

TMPH tunnel assembly

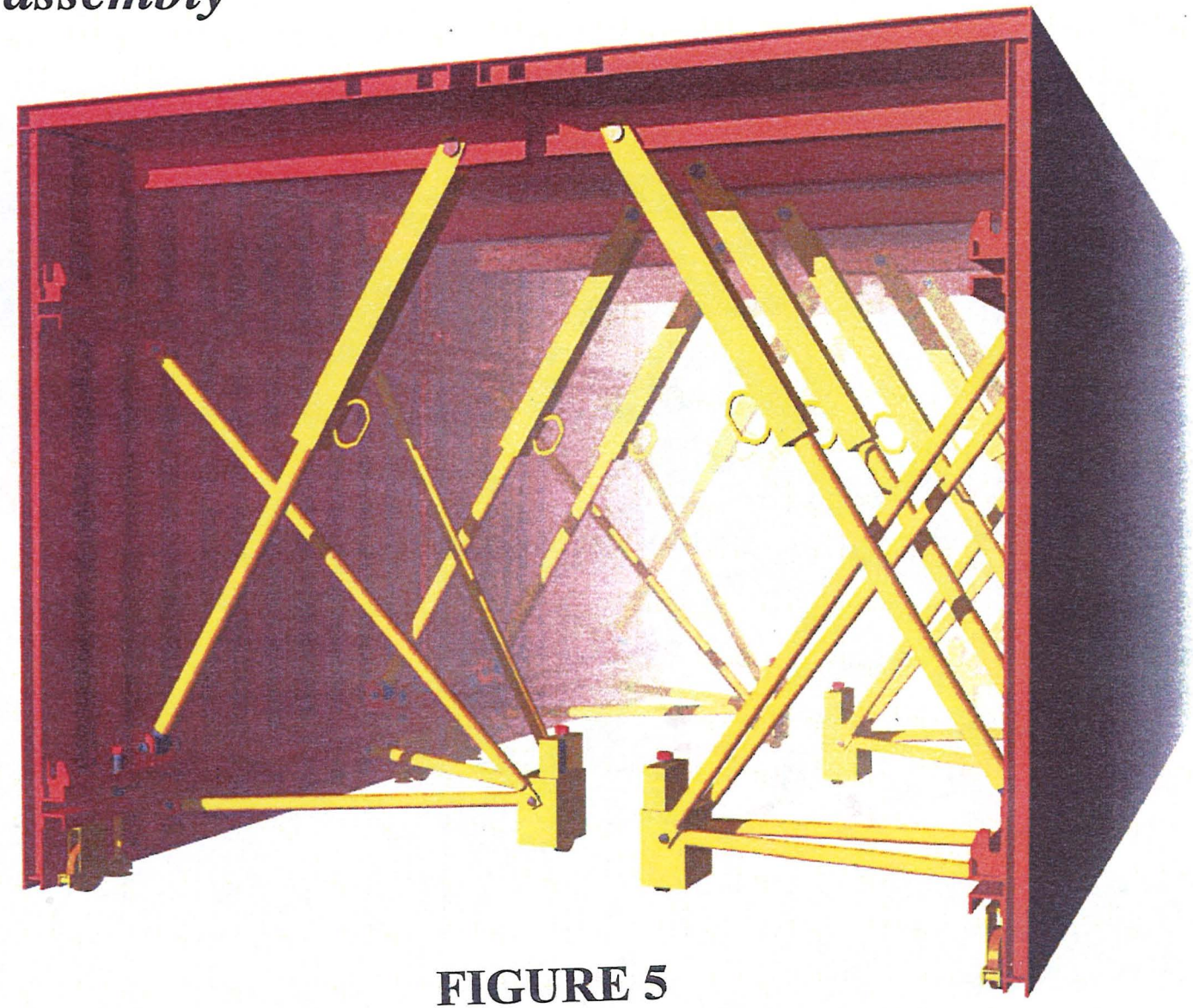


FIGURE 5

Second pour

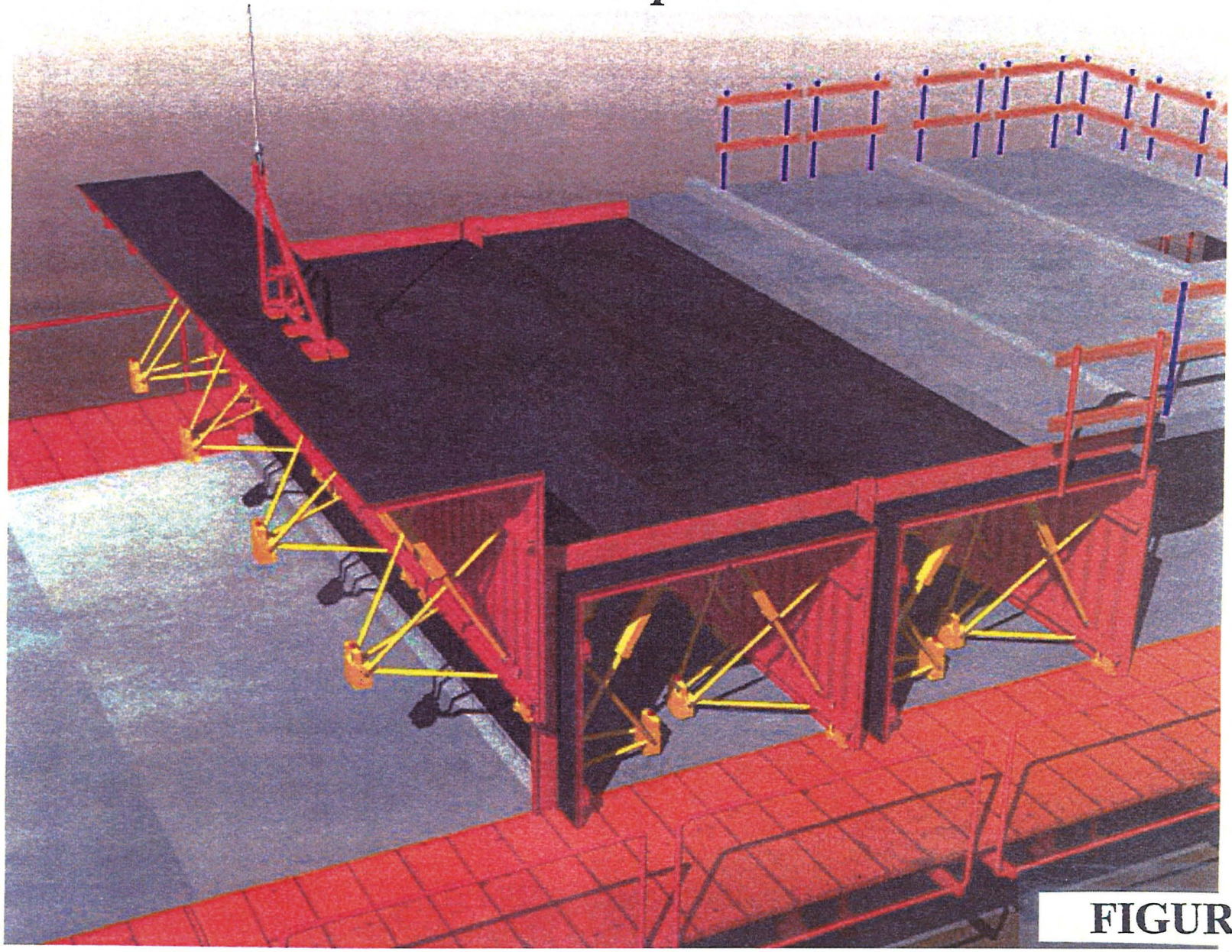


FIGURE 6

STEPHEN R. WALSH P.E.
P.O. BOX 933, BOCA RATON, FL 33429
(561) 362-0237 362-7414 (FAX)

6/28/4

TOZAN QUALITY AT HOBE SOUND

SHORING:

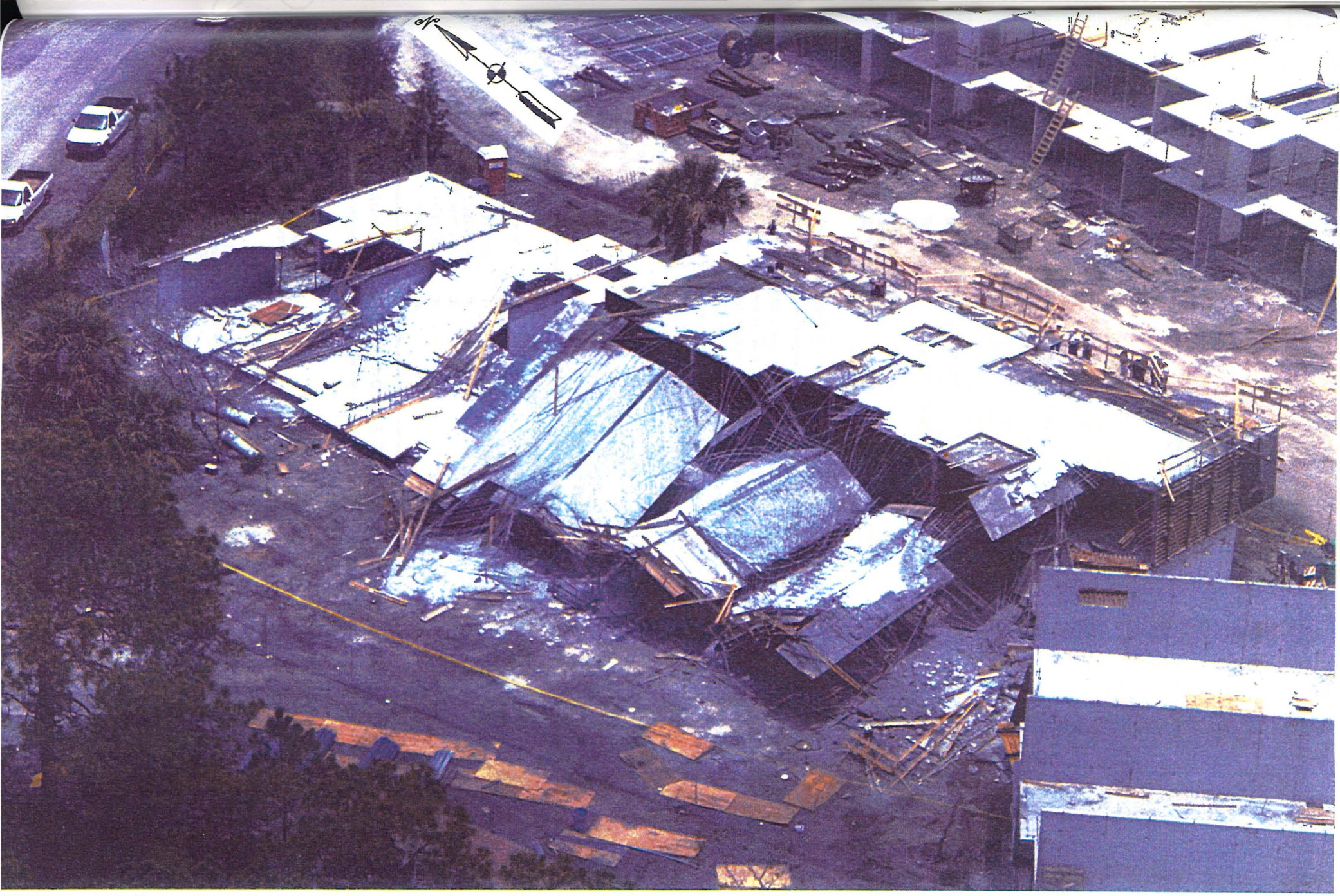
WHEN TABLES & TUNNELS ARE REMOVED FROM THE ABOVE BUILDING SHORING MAY BE PLACED ON AN 8'x 8' GRID - OR - AS EACH TUNEL IS REMOVED USE 1 ROW OF POST SHORES AT 6'OC EACH SIDE OF THE TABLE IN THE WIDE BAYS (2 ROWS TOTAL) AND USE 1 ROW OF POST SHORES @ 6'OC AS THE FIRST TUNNEL IS REMOVED IN THE NARROW BAYS. ONLY 1 ROW OF SHORES IS REQUIRED IN THE BAYS WITHOUT TABLES. TABLES MUST BE RESHORED TO THE GROUND.

SHORING MUST REMAIN IN PLACE UNTIL ALL STEEL COLUMNS & BLOCK WALLS ARE IN PLACE & THE FILLED CELLS ARE POURED. REMOVE SHORES FROM THE TOP DOWN.

6/28/4

STRUCTURAL ENGINEER, P.E. #33915 - SPECIAL INSPECTOR, S.I. #0290

FIGURE 7



Allied Capital & Development, LLC

Tranquility

FIGURE 8

Print #40726230
Date:07/26/04

PETCO
U.S. LABS

Report of Compressive Strength Test

Project:	75154 - Tranquility - Materials Testing	Order #:	35141
Client:	Allied Capital & Development, LLC	Set #:	1 of 2
Contractor:	Allied Capital & Development, LLC	Permit #:	2004050051 - 12570,12574,12578,12582,12586,12590,12594,12598,12602 SE Old Cypress Drive
Project Location:	Hobe Sound, Florida	Lot/Block/Bldg #:	N/A /N/A /Building 9
Location of Pour:	Bldg. 9, 2nd floor deck, east section, southeast corner		

Field Information

Date Sampled:	7/20/2004
Sampled By:	Joe Jesteadt
Supplier:	CSR Rinker
Truck #:	1985
Ticket #:	91481907
Batch Time:	3:21
Time Sampled:	4:15
Load Size:	10
Field Remarks:	

Field Test Data

Design Mix #:	1163506
Specified Compressive Strength:	3000
Air Temperature:	93
Concrete Temperature	89
Water Added on Site:	
Slump:	5
Air (%):	
Unit Wt:	
Condition of Cylinder:	

Laboratory Test Data

Specimen Size: 6 x 12

Test #	Date of Test	Age (days)	Failure Load	Measured Area (in^2)	Compression Strength (psi)	Type of Fracture	Status
1	7/21/2004	1	27670	28.26	979	N/A	N/A
2	7/27/2004	7	94670	28.27	3350	N/A	N/A
3	8/17/2004	28				N/A	
4	8/17/2004	28				N/A	
5	8/17/2004	28				N/A	

Fracture Types: A-Cone, B-Cone & Split, C-Cone & Shear, D-Shear, E-Columnar

Respectfully Submitted,
Professional Engineering
& Inspection Company, Inc.

Distribution Copy:

No one is on this list

Steven E. Black, P.E.
Regional Vice President
STATE OF FLORIDA:
Registered Professional Engineer Number: 0039810

"Accredited Concrete Testing Laboratory"

FIGURE 9

PTICO U.S. LABS

Report of Compressive Strength Test

Project:	75154 - Tranquility - Materials Testing	Order #:	35141
Client:	Allied Capital & Development, LLC	Set #:	2 of 2
Contractor:	Allied Capital & Development, LLC	Permit #:	2004060081 - 12570,12574,12578,12582,12586,12590,12594,12598,12602 SE Old Cypress Drive
Project Location:	Hobe Sound, Florida	Lot/Block/Bldg #:	N/A /N/A /Building 9
Location of Pour:	Bldg. 9, 2nd floor deck, east section, center of deck		

Field Information

Date Sampled:	7/20/2004
Sampled By:	Joe Jostosdt
Supplier:	CSR Rinker
Truck #:	2116
Ticket #:	91481965
Batch Time:	3:55
Time Sampled:	5:20
Load Size:	10
Field Remarks:	

Field Test Data

Design Mix #:	1163506
Specified Compressive Strength:	3000
Air Temperature:	90
Concrete Temperature	87
Water Added on Site:	10gal
Slump:	7
Air (%):	
Unit Wt:	
Condition of Cylinder:	

Laboratory Test Data

Specimen Size: 6 x 12

Test #	Date of Test	Age (days)	Failure Load	Measured Area (in^2)	Compression Strength (psi)	Type of Fracture	Status
1	7/21/2004	1	19410	28.26	687	N/A	N/A
2	7/27/2004	7	84040	28.26	2974	N/A	N/A
3	8/17/2004	28				N/A	
4	8/17/2004	28				N/A	
5	8/17/2004	28				N/A	

Fracture Types: A-Cone, B-Cone & Split, C-Cone & Shear, D-Shear, E-Columnar

Respectfully Submitted,
Professional Engineering
& Inspection Company, Inc.

Distribution Copy:

No one is on this list

Steven E. Black, P.E.
Regional Vice President
STATE OF FLORIDA:
Registered Professional Engineer Number: 0038810

FIGURE 10

"Accredited Concrete Testing Laboratory"