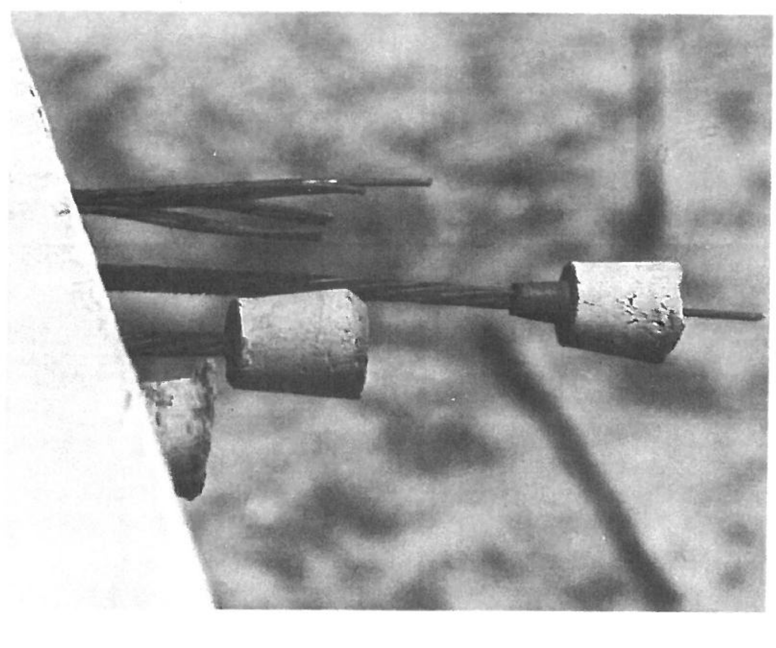
CONTROLLED DEMOLITION OF AN UNBONDED POST-TENSIONED CONCRETE SLAB

BY FLORIAN G. BARTH
AND BIJAN O. AALAMI



POST-TENSIONING INSTITUTE

CONTROLLED DEMOLITION OF AN UNBONDED POST-TENSIONED CONCRETE SLAB

By Florian G. Barth[1] and Bijan O. Aalami[2]

Synopsis: This report describes the controlled demolition of 100,000 square feet of post-tensioned slab, which was necessitated by suspicion of damage due to fire. The saw cutting procedure was used to neutralize over 900 post-tensioned tendons. The neutralization of the tendons was programmed to reveal information on response of live and in-place tendons to saw cutting. Observations made are described and tabulated. Steps taken to integrate the retained portions of the building with new construction are described. The work illustrates that, if required, slabs constructed with unbonded post-tensioned tendons can safely and readily be dismantled. The report concludes with recommendations for demolition of similar projects.

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[1]Florian G. Barth is President of Bijan, Florian Associates, Inc. (BFL), a structural consulting firm in Mountain View, California, specializing in design of post-tensioned structures. He serves on the Technical Advisory Board of PTI and is a member of ACI Committee 224, "Control of Cracking in Concrete Structures." He holds a master's degree in structural engineering and is a registered engineer.

[2]Bijan O. Aalami, PhD, SE, is the principal consultant to Bijan, Florian & Associates, Inc. Dr. Aalami also serves as professor of Civil Engineering at San Francisco State University. He is the author of the internationally acclaimed **ADAPT** Post-Tensioning Software System, chairperson of the joint ACI/ASCE Committee 421 on "Design of Reinforced Concrete Slabs," and member of Committee 423, "Recommendations for Concrete Members Prestressed with Unbonded Tendons."

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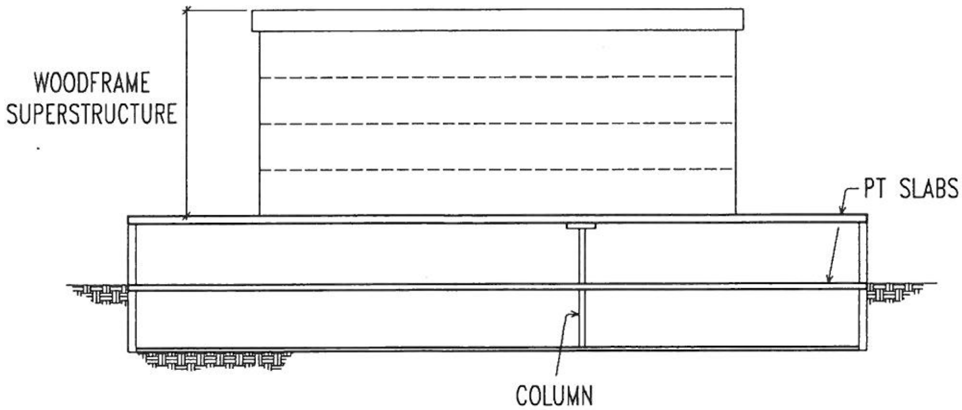
INTRODUCTION

Several references are available which describe the demolition of bonded post-tensioned concrete structures (Felstead et al, 1981, Buchner et al, 1985). The National Association of Demolition Contractors (NADC, 1981) has issued a demolition safety manual for special structures including post-tensioned members. The Federation International Precontrainte (FIP, 1982) has compiled a comprehensive summary of demolition methods for prestressed structures. Additional information is given in references listed at the end of this report.

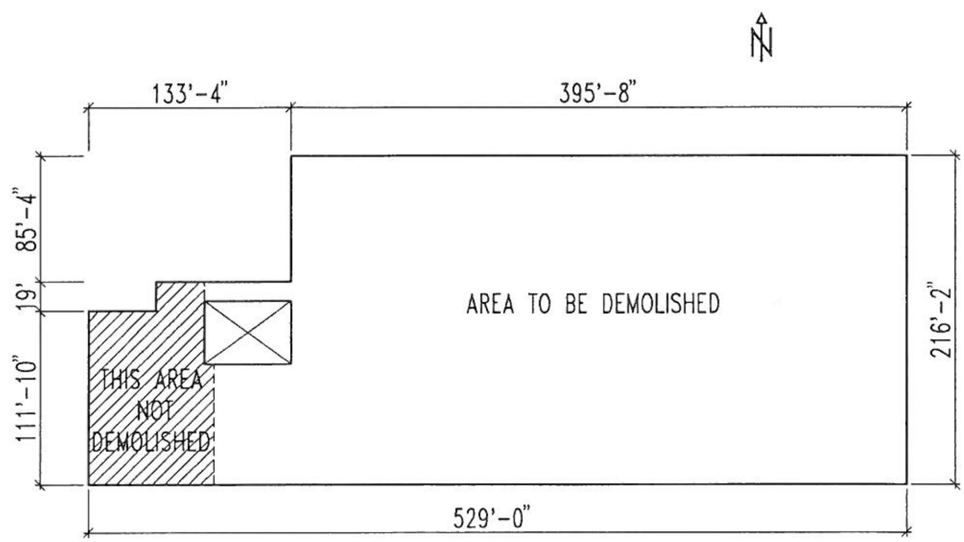
The published information available today for the controlled demolition of unbonded post-tensioned structures is meager. In view of the fact that, during the last two decades most of the elevated concrete slabs in the United States are post-tensioned using unbonded tendons, and that changes in function or occupancy may require partial or entire removal of a slab, controlled demolition of unbonded post-tensioned slabs is of particular importance.

The purpose of this report is to document a specific controlled demolition procedure of an unbonded post-tensioned concrete slab, which was executed successfully on a large project. During the demolition process the response of the tendons being neutralized was monitored and documented. The observations made are categorized and presented. The report concludes with a summary and recommendations.



SIMPLIFIED BUILDING SECTION

FIGURE 1



OVERALL DIMENSIONS OF THE DEMOLISHED SLAB (PLAN VIEW)

FIGURE 2

GENERAL DESCRIPTION OF PROJECT

A fire on June 10th, 1988, partially destroyed the Bristol House apartment complex in Santa Ana, California. The six story building comprised of a four level wood frame constructed over two levels of elevated post-tensioned concrete garage slabs (see Figures 1 and 2). At the time of the fire, the concrete slabs were supported by a combination of cast-in-place concrete columns and walls, and concrete masonry walls. The concrete frame was laterally supported by the walls. The second elevated post-tensioned deck acted as a podium supporting the four level wood frame. It also furnished the required fire separation between the garage and the residential occupancy.

After the completion of the concrete structure and during the erection of the wood frame superstructure, but prior to the placement of the exterior sidings, the fire destroyed the entire wood frame. The podium slab appeared to have been damaged on account of the observed excessive concrete spalling at its top surface.

The slab to be removed had overall plan dimensions of 529 x 216 feet covering an area of approximately 100,000 square feet. The eight to nine inch thick slab was post-tensioned with over 1000 unbonded 1/2" diameter 270 ksi strands, providing an average of 210 psi biaxial precompression. The seven wire strands used were greased and wrapped in a 0.04 inch polyethylene sheath and heat-sealed.

The podium slab was designed as a two-way flat slab using the predominant banded distribution method (refer to Figure 3). Due to the presence of unbonded post-tensioning, which appeared to have essentially remained intact, it was considered necessary to engineer the demolition with great care.

VISUAL OBSERVATIONS:

After the remains of the burnt wood frame superstructure were cleared, the podium slab was inspected visually for surface conditions.

It was observed that spalling and disintegration of concrete over the top of slab was concentrated in patches. It was most severe at midspans and away from the column or wall supports. At these locations there were few, or no reinforcement at the top of slab, and the slab surface was in compression. Over the columns and the walls the concrete appeared to retain its integrity. The locations of columns and wall supports marked on the slab surface confirmed this observation (refer to Pictures 1, 2 and 3).

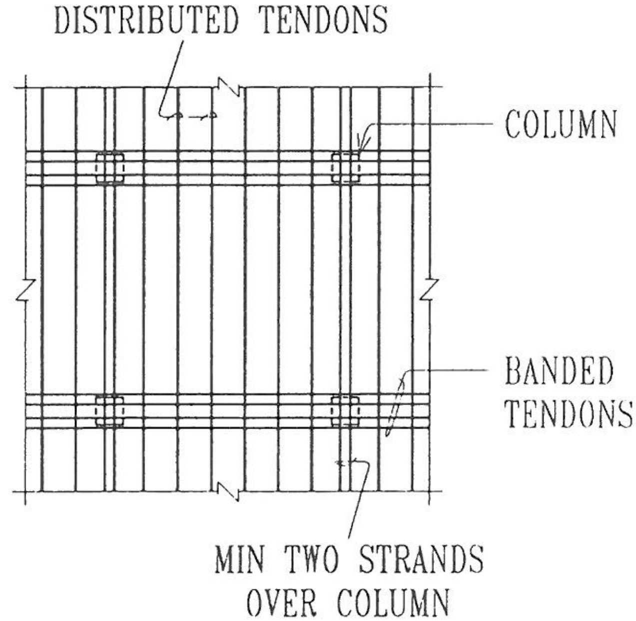
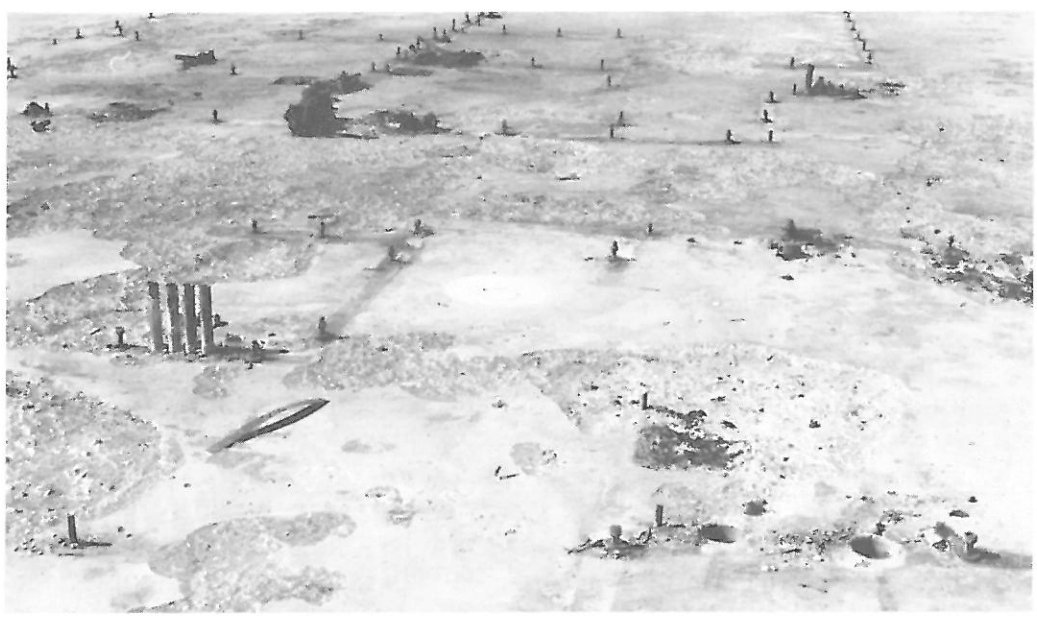


ILLUSTRATION OF BANDED TENDON LAYOUT USED IN THE PROJECT

FIGURE 3



PICTURE 1: CONCRETE SPALLING IS MORE PRONOUNCED AT MIDSPANS AWAY FROM COLUMNS AND WALL SUPPORTS.

PICTURE 2: COLUMN LOCATIONS ARE MARKED ON SLAB SURFACE. CONCRETE DETERIORATION IS MINIMUM OVER COLUMN SUPPORTS.

PICTURE 3: REMAINS OF ANCHOR BOLTS AT LINE SUPPORTS. OBSERVE CONCRETE SPALLING AWAY FROM THE SUPPORT LINE.

At locations the depth of spalled concrete reached three inches. (See Pictures 4 and 5).

A search over the slab surface and along the exposed slab edges indicated that approximately 3% of the tendons were ruptured. These either protruded from the top of slab, or had their tails dislodged at the slab edge. It appeared that the failed tendons were limited to the distributed strands, and that the failure occurred at the high point of the tendon where the cover was least. (See Pictures 6 and 7).

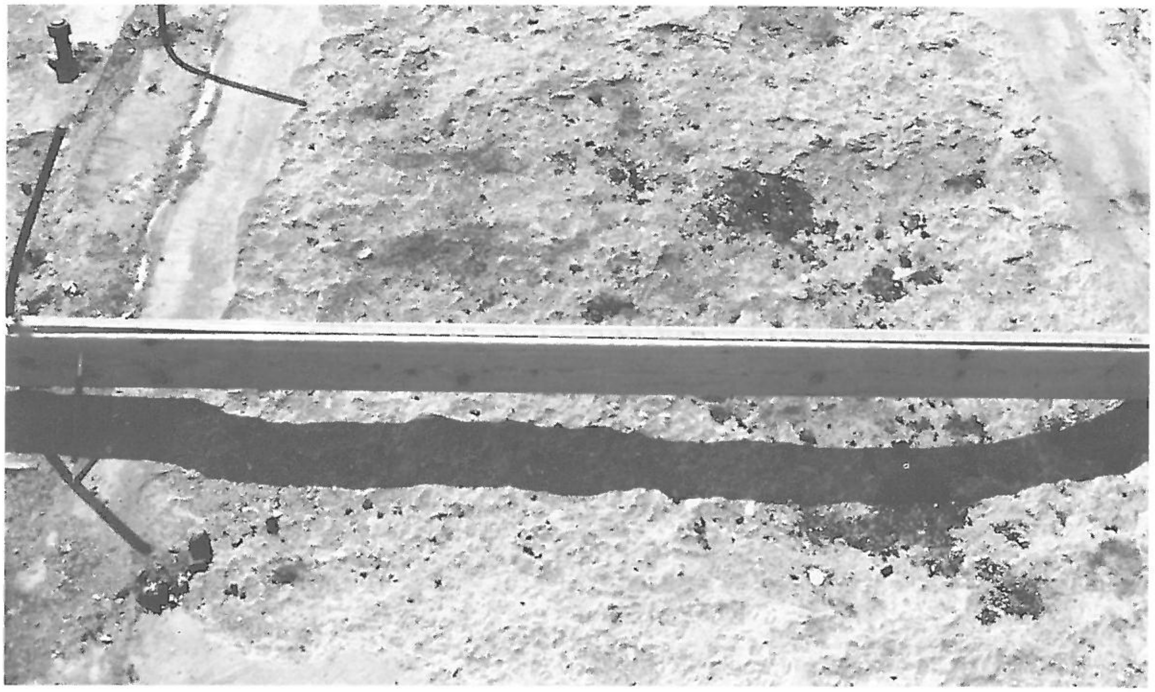
Very few mild reinforcement bars were exposed due to fire over the entire 100,000 square feet surveyed. The concrete disintegration was primarily at locations with no reinforcement.

A close examination of slab soffit showed no apparent distress of the slab. There were no cracks or deflection which could be attributed to the fire. The slab soffit remained in good condition, although the entire four-level wood frame above it was burnt down to the slab surface. Occasionally the metal connections used to anchor the superstructure to the slab were melted down. The slab edges at the perimeter of the structure and at penetration/openings suffered concrete spalling.

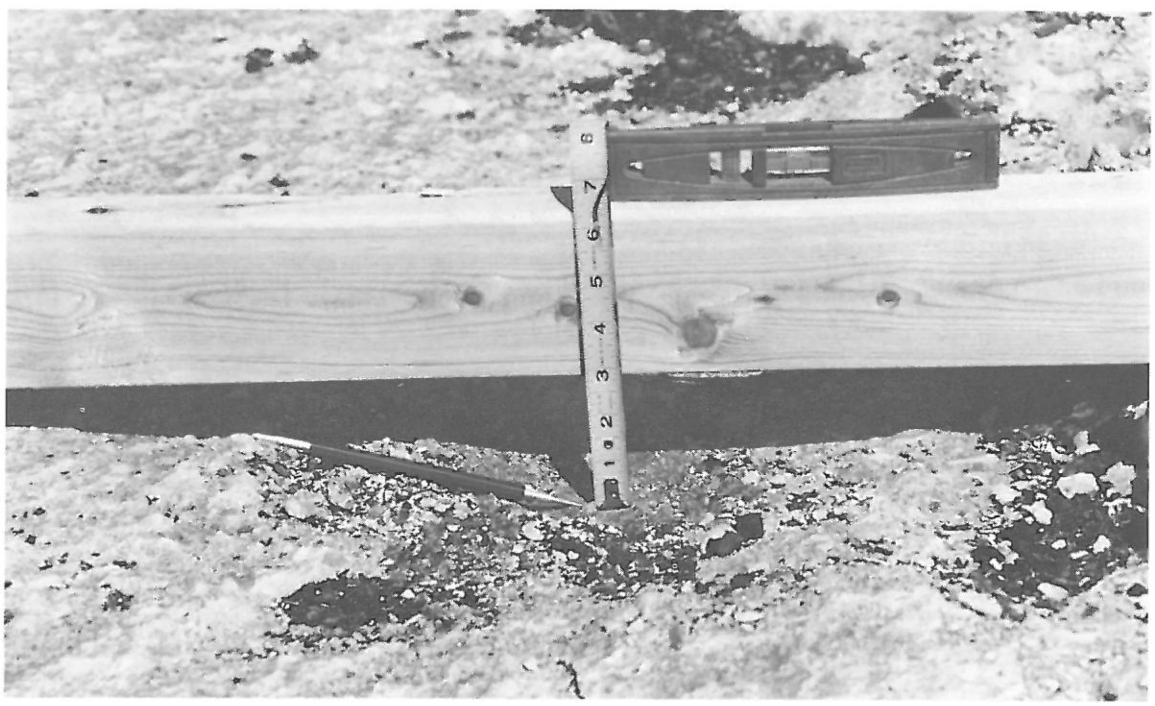
EXTENT OF DEMOLITION:

The structure was visually inspected by the City Building Department, engineer of record and the insurance carrier. Gravity and lateral supporting elements of the upper deck, such as concrete columns and walls appeared undamaged. These were considered not to have been affected significantly by the fire. It was decided to salvage the columns and use them in reconstruction of the building. It was collectively agreed among the Building Official, the engineer of record and the insurance carrier to limit the demolition to the upper (podium) PT-slab and its wall supports, without inflicting damage to the remainder of structural elements.

Special care was to be exercised during the removal of the upper slab/walls in order to retain adequate reinforcing steel for the structural integration of the remaining members to the new construction.



PICTURE 4: LOCAL CONCRETE SLAB SURFACE CONDITIONS AFTER REMOVAL OF WOOD REMAINS.



PICTURE 5: SLAB SURFACE SHOWED LOCAL DISINTEGRATION OF CONCRETE UP TO THREE (3) INCHES.

PICTURE 6

PICTURE 7

VISUAL INSPECTION INDICATED THAT 3% OF STRANDS WERE DAMAGED DUE TO FIRE. THE OBSERVED DAMAGED STRANDS WERE ALL DISTRIBUTED TENDONS.

The Building Department requested that a program for the controlled demolition of the PT-slab with detailed description of each step be submitted for City's approval. The program should describe the shoring, detensioning and removal sequences with shop drawings prepared by a qualified professional engineer in collaboration with a demolition contractor. Bijan, Florian and Associates, Inc., of Mountain View, California, were retained by the demolition contractor to engineer the controlled demolition process.

METHOD OF DEMOLITION:

The method used for demolition is greatly governed by the structural elements which require removal. There are many methods for demolishing concrete structures safely and cost effectively. Some of these methods are the "Ball and Crane Method," "Diamond Saws and Drills," "Hand Operated Percussion Tools," and "Machine Mounted Pneumatic and Hydraulic Breakers." However, site constraints, environmental conditions and/or project requirements may govern the type of method selected.

Based on the project type, condition and extent of demolition, considerations led to the selection of the diamond saw-cut method. This offered the controlled removal of concrete elements cut to a size which is governed by the removal equipment.

Other methods were ruled out since no additional loading on or damage to the lower parking level was acceptable due to uncontrolled concrete removal.

DEMOLITION PROCEDURE:

With 962 stressed monostrand tendons in position in the area designated for demolition, the project provided a unique opportunity to monitor the detensioning of strands with the objective to observe their behavior in releasing the strain energy stored. Impressions from a close visual inspection of the slab for the assessment of damage due to tendon force release, as well as findings regarding the selective detensioning of tendons were compiled and presented in this report.

The demolition procedure consisted of four major steps, which were carried out successfully. The following is a detailed account of each.

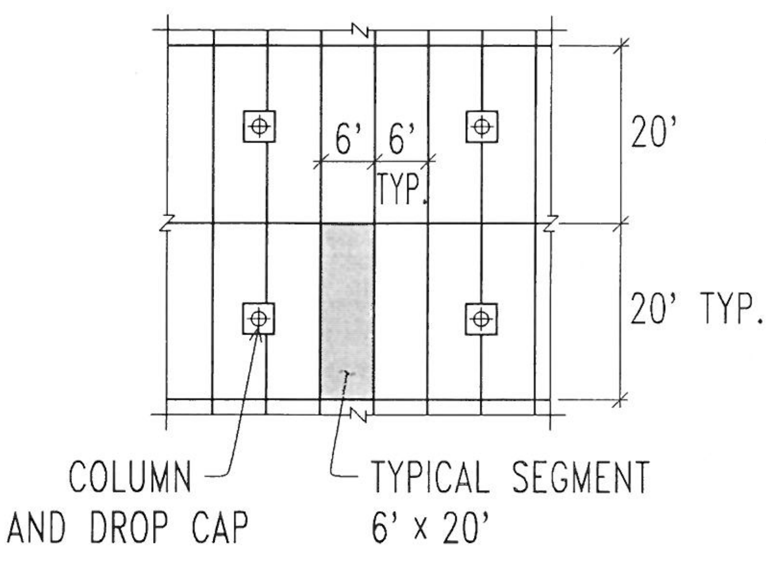
1. SHORING AND SUBDIVISION OF SLAB

Both elevated concrete slabs were fully shored to the ground by tiers which were aligned over one another across two levels. At locations where the lower shoring frames could not align with the upper slab shoring, additional shore posts and secondary members were installed, such that the entire weight of the upper slab was transferred directly to the slab on ground and footings through the shoring elements.

Prior to tier installation, complete shoring shop drawings were prepared and submitted for both levels. The shop drawings indicated the capacity of each shoring frame and its top/base plate size of the extension legs. The upper level shoring called for lateral bracing of each individual frame. The shoring design included a 25% load increase due to impact loading.

After the installation of all form work, the podium slab surface was marked-up into typical rectangular segments of approximately 6 by 20 feet (refer to Figure 4 and Picture 8). The sizing of the segments was determined by the capacity of the removal equipment.

The panels were individually marked and numbered to reflect the removal sequence.



TYPICAL LAYOUT OF SEGMENTS FOR CUTTING AND REMOVAL

FIGURE 4

PICTURE 8: VIEW OF THE PODIUM SLAB AFTER CLEARING THE REMAINS OF THE BURNT WOOD FRAME AND MARKING THE SEGMENTS FOR DEMOLITION.

PICTURE 9: EQUIPMENT USED TO SAW CUT SLAB.

2. NEUTRALIZATION OF PRESTRESSING AND CUTTING OF SLAB SEGMENTS

By continuous saw cuts through the entire thickness of the slab the tendons were encountered and cut one by one along with the remainder of reinforcement.

Uniformly distributed tendons were cut first, followed by the bands. The distributed tendons were cut along the segment boundary lines which did not interfere with the layout of banded tendons. Further, as a precautionary measure, the cut lines were selected at locations where the live strands were approximately at mid-depth of the slab thickness, thus minimizing the likelihood of local blowouts of concrete.

The slab was cut in two runs. First, a continuous six inch deep slot cut was cut through the slab along the demarcation lines using an 18-inch diameter diamond radial saw. Second, a 22-inch diameter saw was used to complete the separation of slab segments. Picture 9 shows the equipment used to saw cut the slab.

Figure 5 illustrates the building plan view showing the simplified layout of distributed and banded tendons. All slab cuts were sequenced as shown in Figure 6. The one hundred and twenty one distributed tendons designated as D1 were broken into four groups. Each group was cut at a different length from the free slab edge. The cuts ranged from 54 to 165 feet. The objective of different cut lengths was to observe and document the behavior of tendons for cuts made at different lengths from the free end. The longer the tendon length, the more is the energy released in the cut length. At the same time, the longer the length the greater is the friction the cut length strand must overcome to slide along its duct. Detailed results are noted in Table 2.

The banded tendons B1 and B3 were cut six feet away from the stressing end at the free edge of slab. This was aimed at providing information on very short lengths (six feet) and very long lengths (over 200 feet), since these tendons were over 200 feet in length and stressed at both ends. It was interesting to note that from a total of over 300 such tendons, thirty percent (30%) of the strands cut dislodged the grout pocket at the short end (6 feet), while only 0.5% showed sign of movement at the far end (over 200 feet).

To safeguard against possible hazards in the event that the strand, wedges or grout plug pieces exit while the strands are cut and the stored energy is released, a backed plywood was held about 4 to 8 feet against the projected line of each strand being neutralized. The shield was held away from the slab edge in order to observe and monitor the free projection of anchorage

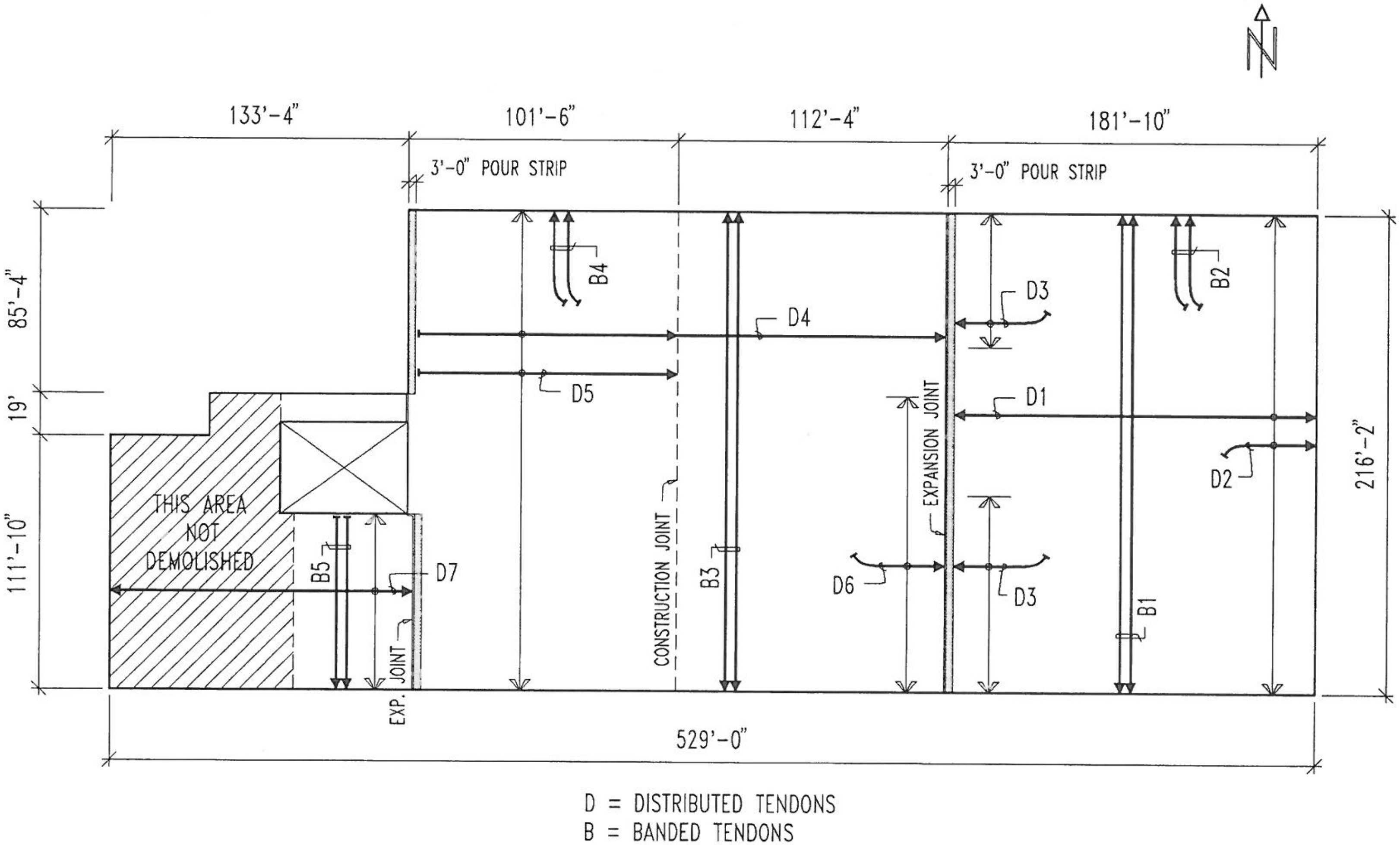


FIGURE 5 - **TENDON LAYOUT**

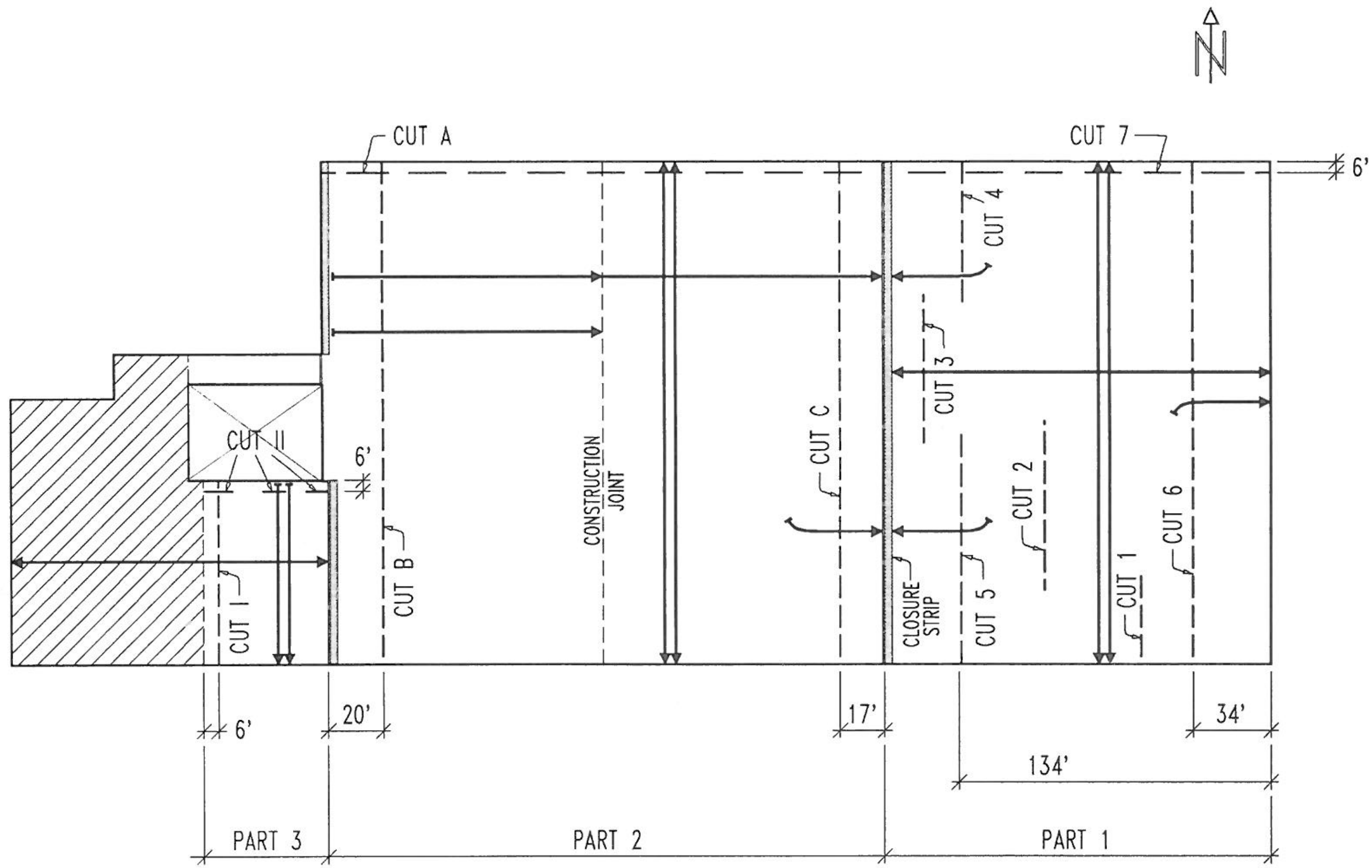
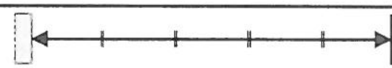
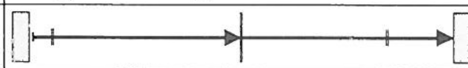
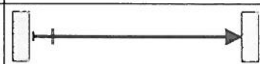
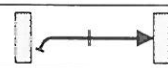
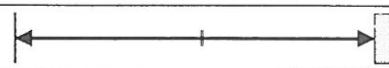


FIGURE 6 - **LOCATIONS OF CUTS**

TABLE 1

<table>
<tr><th rowspan="2">TENDON DESIGNATION</th><th rowspan="2">NUMBER OF TENDONS</th><th rowspan="2">TENDON LENGTH</th><th rowspan="2">TENDON END CONDITION AND LOCATION OF CUT</th><th colspan="12">SEE LEGEND BELOW</th><th colspan="8">TENDON EXIT LENGTH</th></tr>
<tr><th colspan="2">1</th><th>2</th><th>3</th><th colspan="2">4</th><th colspan="2">5</th><th colspan="2">6</th><th colspan="2">7</th><th colspan="2">UP TO 3"</th><th colspan="2">3" TO 6"</th><th colspan="2">6" TO 12"</th><th colspan="2">12" TO 18"</th></tr>
<tr><td>DIST D1</td><td>121</td><td>178'</td><td></td><td colspan="2">51</td><td>2</td><td>3</td><td colspan="2">7</td><td colspan="2">44</td><td colspan="2">6</td><td colspan="2">42</td><td colspan="2">14</td><td colspan="2">30</td><td colspan="2">5</td><td colspan="2">2</td></tr>
<tr><td>DIST D2</td><td>107</td><td>52'</td><td></td><td colspan="2">18</td><td>0</td><td>0</td><td colspan="2">3</td><td colspan="2">15</td><td colspan="2">2</td><td colspan="2">9</td><td colspan="2">12</td><td colspan="2">5</td><td colspan="2">1</td><td colspan="2">0</td></tr>
<tr><td>DIST D3</td><td>62</td><td>58'</td><td></td><td colspan="2">—</td><td>0</td><td>1</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td></tr>
<tr><td>DIST D4</td><td>132</td><td>211'</td><td></td><td colspan="2">—</td><td>2</td><td>3</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td></tr>
<tr><td>DIST D5</td><td>60</td><td>99'</td><td></td><td colspan="2">—</td><td>0</td><td>0</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td></tr>
<tr><td>DIST D6</td><td>32</td><td>26'</td><td></td><td colspan="2">—</td><td>0</td><td>0</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td><td colspan="2">—</td></tr>
<tr><td>DIST D7</td><td>50</td><td>135'</td><td></td><td colspan="2">14</td><td>0</td><td>0</td><td colspan="2">6</td><td colspan="2">8</td><td colspan="2">6</td><td colspan="2">6</td><td colspan="2">2</td><td colspan="2">4</td><td colspan="2">7</td><td colspan="2">1</td></tr>
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<tr><td>BAND B1</td><td>149</td><td>216'</td><td></td><td rowspan="2">46</td><td>0</td><td>0</td><td>1</td><td rowspan="2">2</td><td>0</td><td rowspan="2">44</td><td>0</td><td rowspan="2">2</td><td>0</td><td rowspan="2">16</td><td>0</td><td rowspan="2">46</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
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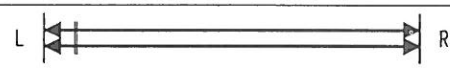
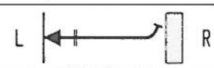
<tr><td>BAND B3</td><td>177</td><td>216'</td><td></td><td rowspan="2">56</td><td>2</td><td>0</td><td>2</td><td rowspan="2">0</td><td>0</td><td rowspan="2">56</td><td>2</td><td rowspan="2">0</td><td>0</td><td rowspan="2">28</td><td>2</td><td rowspan="2">56</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>BAND B4</td><td>8</td><td>48'</td><td></td><td>—</td><td>0</td><td>0</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>0</td><td>—</td><td>0</td><td>—</td><td>0</td><td>—</td></tr>
<tr><td>BAND B5</td><td>48</td><td>80'</td><td></td><td colspan="2">16</td><td>0</td><td>0</td><td colspan="2">6</td><td colspan="2">10</td><td colspan="2">6</td><td colspan="2">8</td><td colspan="2">2</td><td colspan="2">5</td><td colspan="2">9</td><td colspan="2">0</td></tr>
</table>

← STRESSING END

⊢ DEAD END

| EXTERIOR FREE SLAB EDGE

▯ INTERIOR SLAB CONDITION SUCH AS POUR STRIP, EXPANSION JOINT, CONSTRUCTION JOINT OR DEAD END

|| LOCATION OF CUT

① NUMBER OF TENDONS WHICH WERE DISLODGED AT FREE SLAB EDGE DUE TO CUTTING

② NUMBER OF BLOWOUTS THROUGH SLAB SOFFIT DURING CUTTING

③ NUMBER OF BLOWOUTS AT TOP OF SLAB DURING CUTTING

④ DISINTEGRATED GROUT PLUG

⑤ GROUT PLUG EXITED BUT REMAINED INTACT

⑥ KERN WIRE EXTENSION WITHOUT GROUT PLUG

⑦ KERN WIRE EXTENSION WITH GROUT PLUG

TABLE 2

TENDON DESIGNATION	CUT DESIGNATION	CUT DISTANCE FROM FREE SLAB EDGE	NUMBER OF TENDONS	SEE LEGEND BELOW							TENDON EXIT LENGTH			
				1	2	3	4	5	6	7	UP TO 3"	3" TO 6"	6" TO 12"	12" TO 18"
DIST D1	CUT 1	54'	23	6	0	1	1	5	1	5	1	5	0	0
	CUT 2	94'	34	20	1	1	4	16	3	16	7	7	4	1
	CUT 3	165'	29	12	1	1	1	11	1	10	4	7	0	1
	CUT 4	134'	35	13	0	0	1	12	1	11	2	11	1	0
TOTALS			121	51	2	3	7	44	6	42	14	30	5	2

① NUMBER OF TENDONS WHICH WERE DISLODGED AT FREE SLAB EDGE DUE TO CUTTING

② NUMBER OF BLOWOUTS THROUGH SLAB SOFFIT DURING CUTTING

③ NUMBER OF BLOWOUTS AT TOP OF SLAB DURING CUTTING

④ DISINTEGRATED GROUT PLUG

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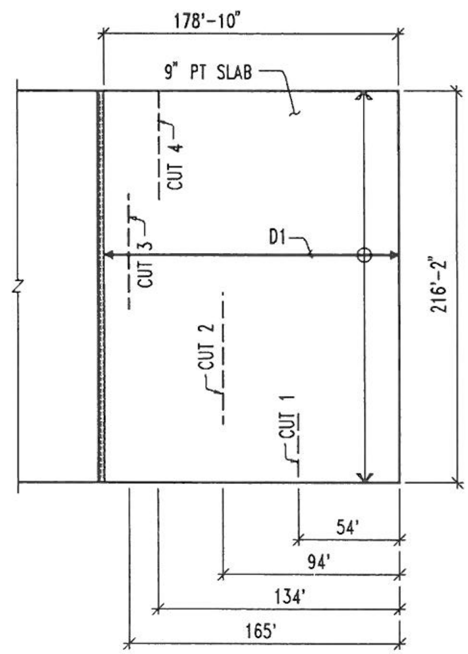


PLAN VIEW SHOWING DISTANCES, FROM THE FREE SLAB EDGE, AT WHICH THE DISTRIBUTED TENDONS D1 WERE CUT

PICTURE 10: PLYWOOD SHIELD RAISED WITH A FORKLIFT TRUCK AND HELD IN LINE OF THE STRANDS BEING CUT.

pieces which became loose (see Picture 10). Recommendations called for sandbags at interior openings, such as stair or elevator shaft, placed at slab edge over the tendon stressing end.

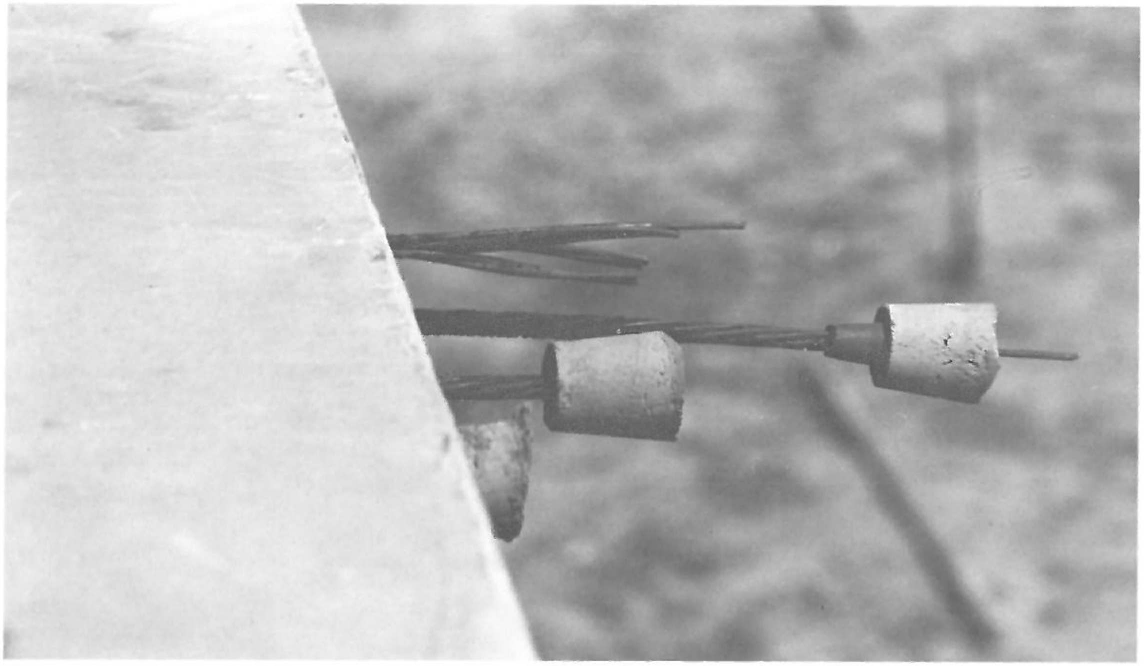
During the demolition of this project 962 tendons were cut with 1002 stressing ends at free slab edges. Only at 203 locations did the tendon tail/grout plug exit the slab edge at the stressing ends. No tendon tail/grout plug exited the slab edge more than 18 inches. In almost all cases the anchorage assembly remained intact. In only 12 percent of the tendons which exited at the slab edge, the bond between the grout plug of the recess block and the strand tail broke. In such cases, the pieces fell off about 3 feet from the slab edge. In no case did a wire or strand become detached from its duct to fall off the slab. Pictures 11, 12, 13 and 14 illustrate the slab edge where tendons dislodged after cutting the tendons.

The local Building Department expressed concern, that the slurry formed by the diamond saw sprayed with water could precipitate a hardened layer on the lower floor. Plan check comments requested the use of a bond breaker over the lower parking slab. However, due to the high water ratio, the slurry did not solidify into a hard compound. It dried into a powdery substance and was easily removed.

PICTURE 11: SLAB EDGE CONDITION AT LOCATIONS OF DISLODGED TENDONS.

PICTURE 12: NOTE THE GROUT PLUG PUNCHED THROUGH BY THE KERN WIRE.

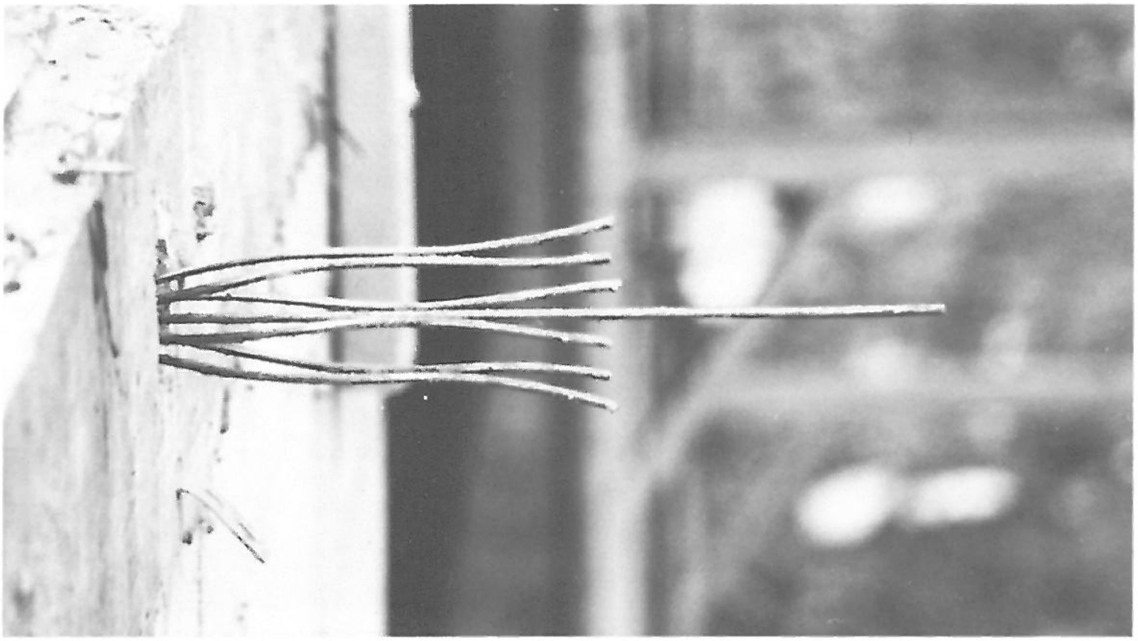
From the 21% of the tendons which were dislodged at the slab edge, the majority exited two (2) to six (6) inches. In no event the tendons ejected more than 18 inches.



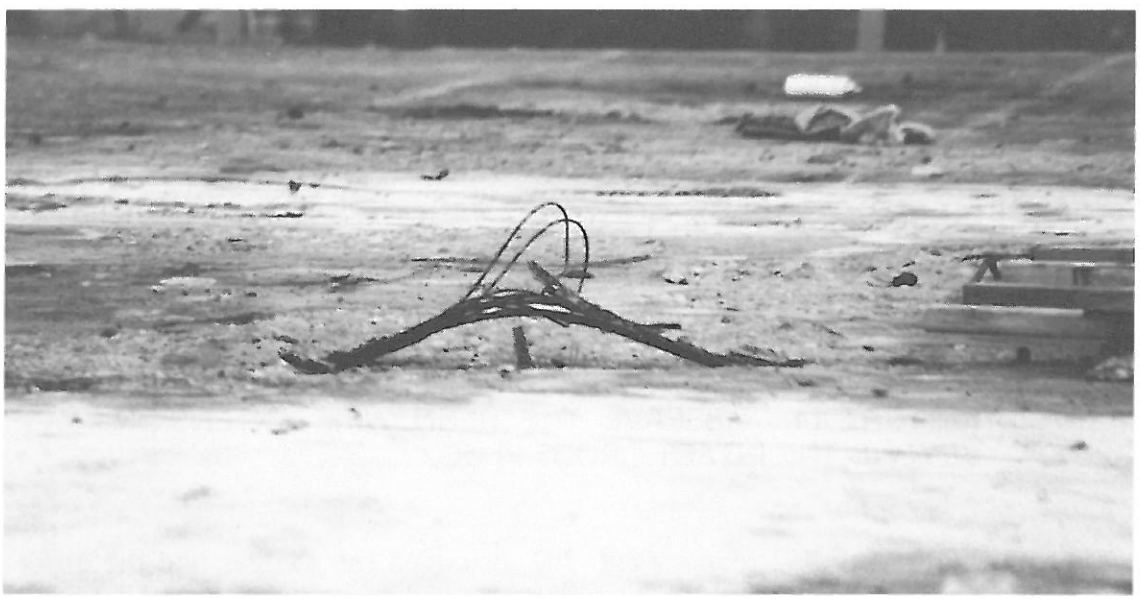
PICTURE 13: NOTE THE WEDGE INTACT BEHIND ONE OF THE GROUT PLUGS.

PICTURE 14: OBSERVE THE KERN WIRE EXTENSION BEYOND THE INTACT GROUT PLUG.

From the total of 962 tendons cut, 203 dislodged the wedges and the grout plug. From there, only 12% broke the bond between the strand and the grout plug, and in no event any strand ejected out of the slab edge more than 18 inches.



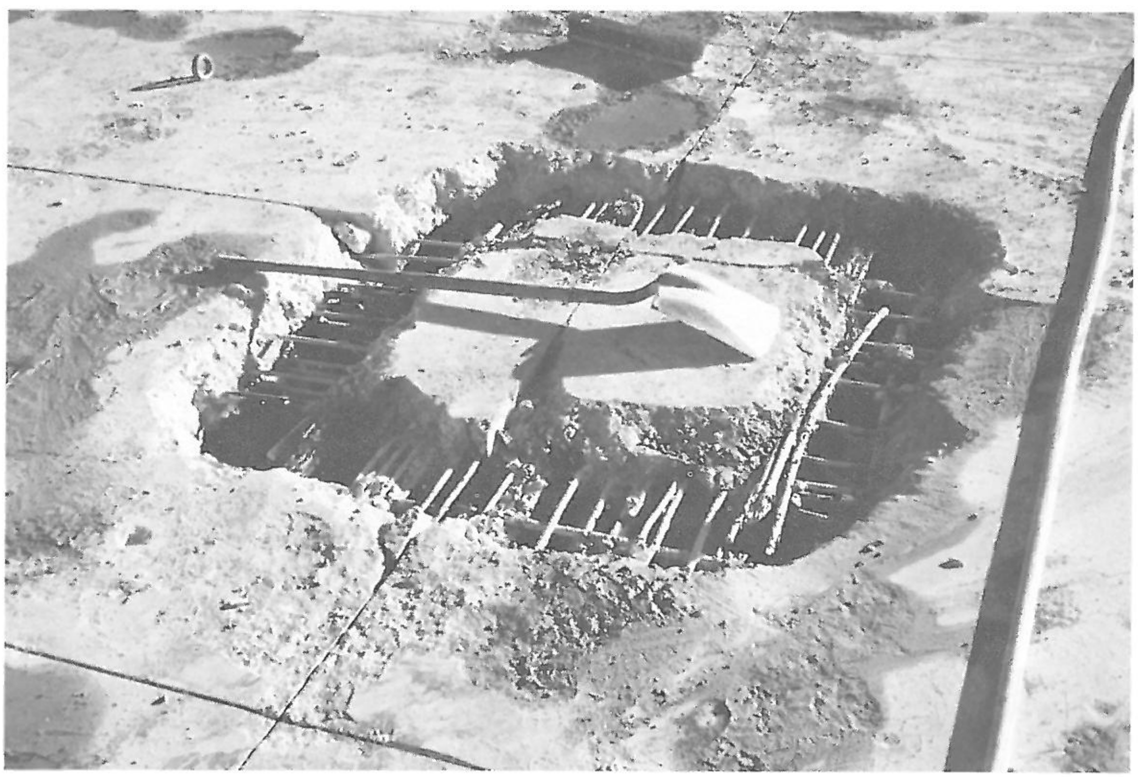
PICTURE 15: VIEW OF AN UNRAVELED STRAND AT SLAB EDGE.



PICTURE 16: BLOWOUT OF STRAND FROM TOP OF SLAB.

At column locations, the concentration of mild reinforcement and post-tensioning strands caused excessive wear and made it uneconomical to use diamond saw discs. Hence, the method used for separating column caps from slab segments was altered to concrete chipping with pneumatic tools. After a gap of about three inches was chipped open, the strands and reinforcement across the gap were flame cut. Refer to Pictures 17 and 18. The tops of walls were chipped down approximately four (4) inches to create a separation between slab soffits and walls for flame cutting the reinforcing steel (refer to Picture 19).

To avoid instability during a lateral force application, not more than ten segments were fully separated after the precut for lifting and removal.



PICTURE 17: THE COLUMN CAPITALS WERE CLEARED FROM THE SLAB USING PNEUMATIC TOOLS.

PICTURE 18: THE REBAR AND STRAND ACROSS THE OPENED GAP WERE FLAME CUT.

PICTURE 19: THE WALL CONNECTION TO THE SLAB WAS CHIPPED OUT.

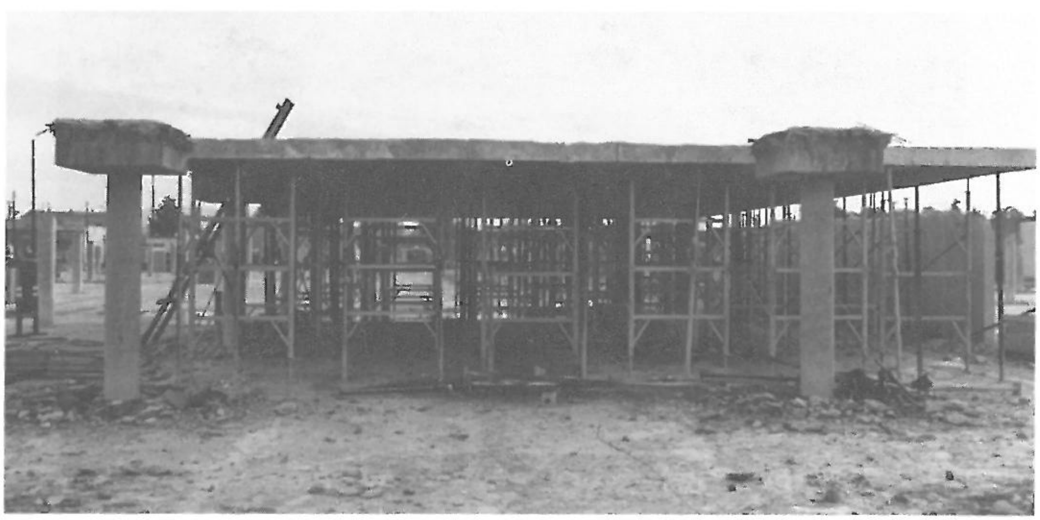
3. LIFTING AND REMOVAL:

Prior to the engagement of a crane for lifting and removal of the cut segments, a site plan was prepared for the Building Department. The plan showed the proposed locations of the crane and the range of its boom, with due consideration to avoid interference with the existing overhead power lines. Further, the crane locations were specified a minimum of 12 feet away from the exterior walls, in order to avoid additional surcharge to lower walls caused by the equipment.

The typical separated slab segments were lifted and removed using a C-hook and boom crane. Non-typical slab segments next to column caps or at slab edges were first drilled through at four corners. An all-thread eyebolt was installed at each corner with a six by six inch steel plate secured at the soffit. The crane then lifted the segments for removal. Each segment was individually inspected prior to hoisting to confirm actual separation on all four sides. Sudden pick-up or horizontal offset was avoided by the crane operator at all times.

PICTURE 20: THE C-HOOK IS BEING LOWERED TO PICK UP A SEGMENT WHICH IS CUT AWAY.

PICTURE 21: THE LIFTED SEGMENT IS BEING REMOVED.



PICTURE 22: MOST OF THE SLAB IS REMOVED. NOTE THE REMAINDER OF SLAB ON SHORING AWAITING REMOVAL.

PICTURE 23: EXPOSED COLUMN CAPITAL AFTER REMOVAL OF SLAB.

PICTURE 24: PNEUMATIC TOOLS WERE USED TO CHIP OFF THE COLUMN CAPS TO THE TOP OF THE COLUMN.

Up to 64 segments were lifted per day. The well known high Santa Ana winds and the balancing of the boom crane posed a more frequent interruption and thrill in the progress of the work than the neutralization of prestressing.

4. COLUMN DROP CAPS AND WALL REMOVAL

The final removal of the column caps proceeded significantly slower than expected, due to the concentration of reinforcement over the supports. The column caps were reached and worked on using a remotely operated pneumatic chipping tool (see Pictures 23 and 24). Great caution was taken to recover the column vertical reinforcement undamaged for use in reconstruction.

Inspection of the concrete columns after the column drop cap removal revealed no significant cracking of concrete.

Interior and exterior cast-in-place walls were chipped down to within four feet of the lower slab. The remaining four feet high walls were carefully removed to recover the lower wall dowels for reconstruction.

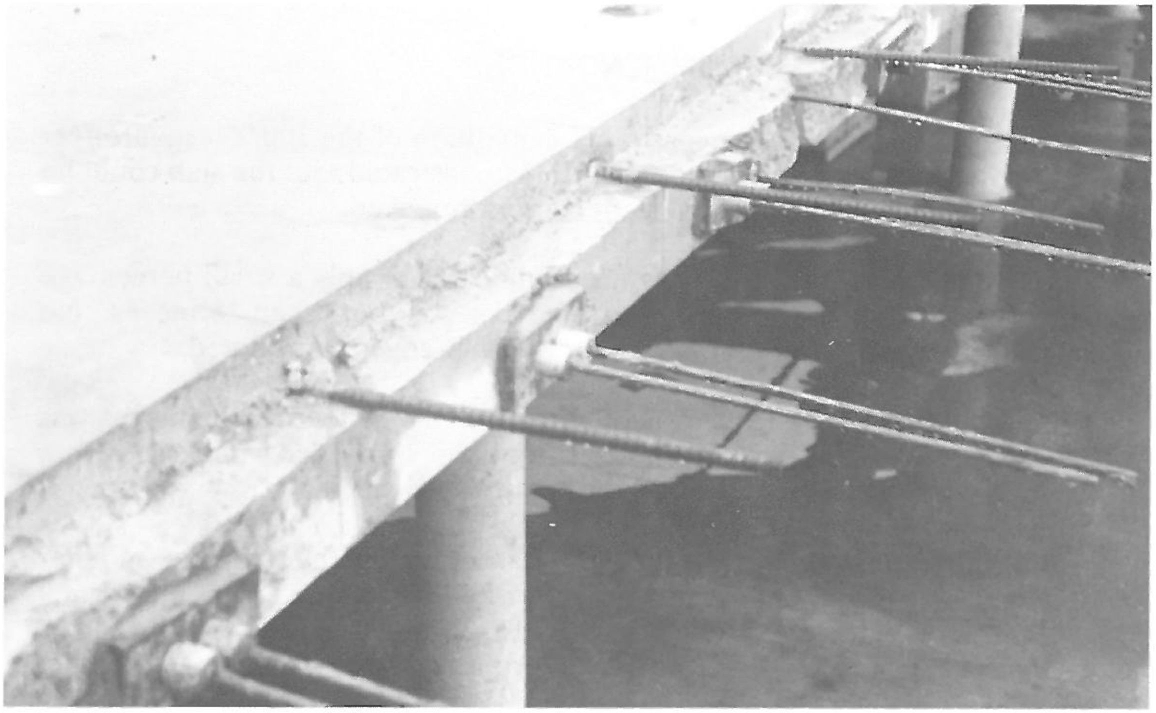
PICTURE 25: VIEW OF THE STRUCTURE AFTER COMPLETE REMOVAL OF THE UPPER POST-TENSIONED SLAB.

PREPARATION FOR RECONSTRUCTION

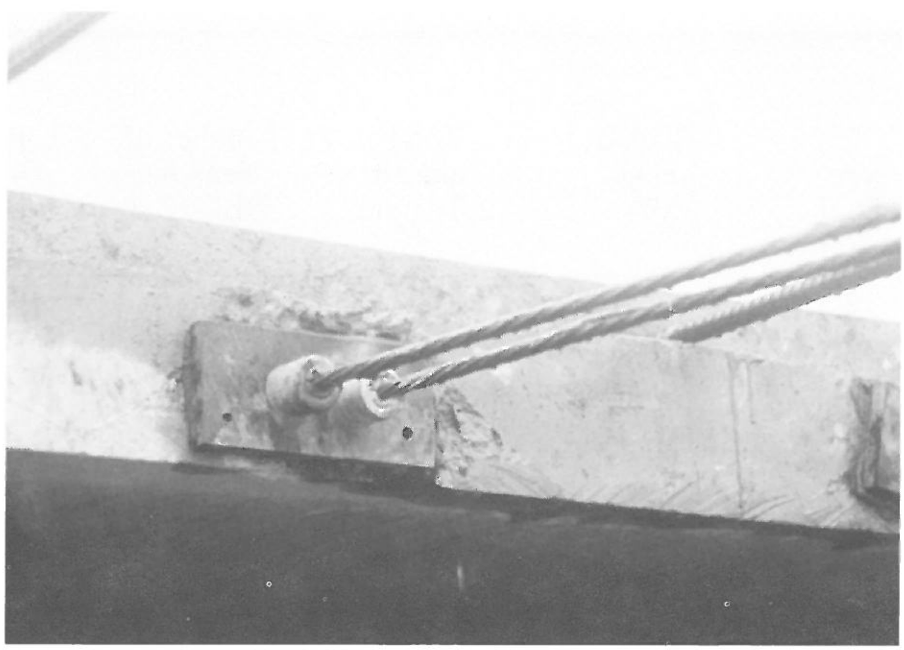
An area assigned for tennis courts over the podium slab escaped damage, since it was not covered by the woodframe superstructure. This slab area was shored during the demolition and tendon neutralization. The distributed tendons of this slab area extended into the region which was slated for demolition. It was required to detension these tendons, cut them along the interface with the demolished slab and retension them, in order to restore the structural integrity of the tennis court area. The concrete was cut within six (6) feet of the future reconstruction joint which was selected at one-quarter of the span away from the last tennis court column support. A ledger support was saw cut at the cantilevered extension of slab along the interface slab edge (refer to Pictures 26 and 27). Special anchorage bearing plates resting on high strength epoxy were installed for restressing of the undamaged area (see Pictures 28 and 29).

PICTURE 26: A SUPPORT LEDGER IS CUT OUT OF THE SLAB EDGE.

PICTURE 27: PREPARATION OF THE SLAB EDGE OF THE RETAINED SLAB PORTION FOR RECOVERY OF ITS POST-TENSIONING.



PICTURE 28: SLAB EDGE CONDITION PREPARED FOR RECONSTRUCTION.



PICTURE 29: STRANDS OF THE UNDAMAGED AREA ARE RESTRESSED AND ANCHORED.

CONCLUSIONS AND RECOMMENDATIONS

The procedure used for the controlled demolition of the 100,000 square feet prestressed slab with unbonded tendons, demonstrated that the slab could be safely and economically neutralized, cut and removed.

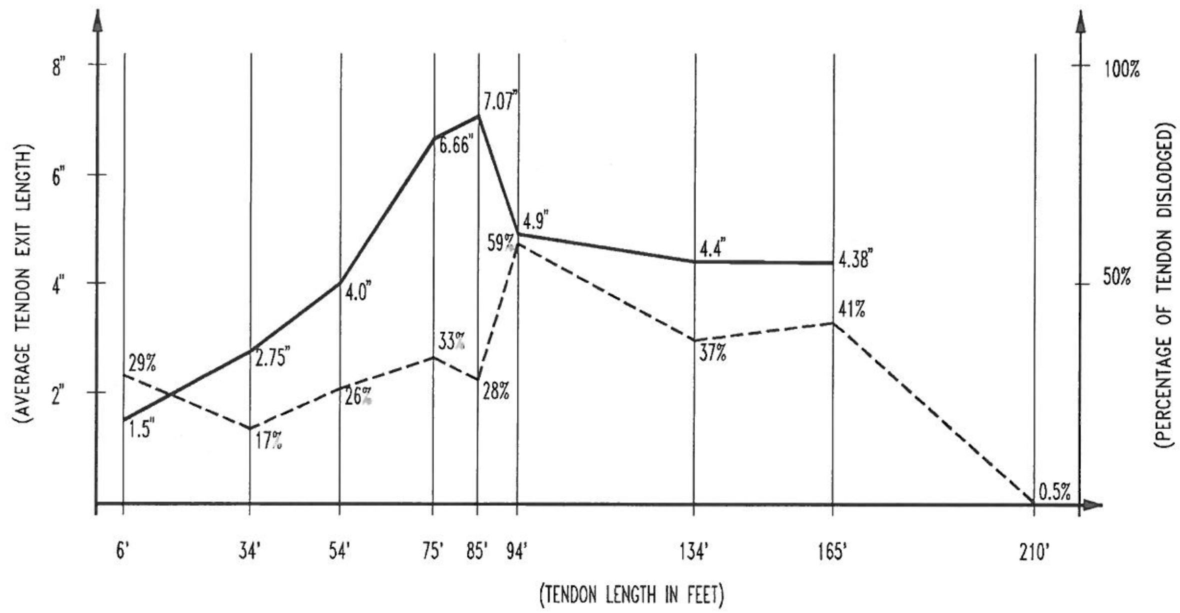
From over 900 stressed post-tensioned tendons cut, only a small percentage exited the slab edge, and in no event the exit was more than 18 inches. No dramatic ejection of tendon tails from the slab edges were noted.

The plywood shield which was held along the line of tendons being cut was hit several times by wedges ejecting from the slab edge. No significant indentation marks were observed on the plywood shield.

The distances of the cut from the free slab edge together with the number of strands dislodged at the edges are presented in Table 3. For cuts six feet away from the free slab edge about 30% of the tendon tails dislodged, whereas for lengths over 200 feet away from the slab edge only 0.5% were affected.

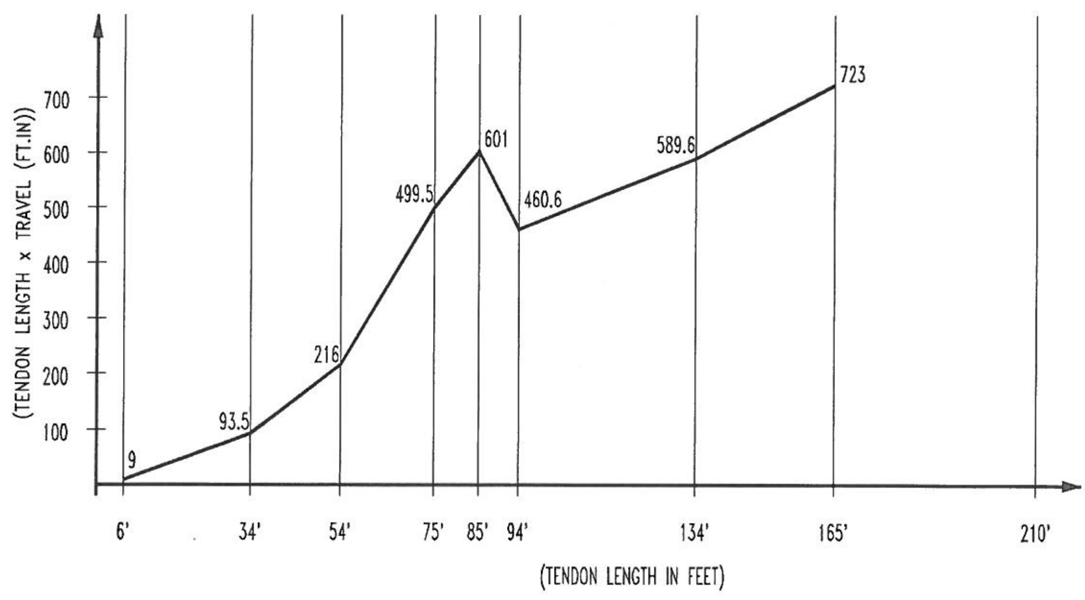
TABLE 3

Tendon I.D.	Tendon Length (ft)	Total Number of Tendons	Number of Tendons Dislodged	Percent Dislodged (%)
B1 → B4	6	350	102	29
D2	34	107	18	17
D1	54	23	6	26
B5	75	48	16	33
D7	85	50	14	28
D1	94	34	20	59
D1	134	35	13	37
D1	165	29	12	41
B1, B3	210	326	2	0.5



AVERAGE TENDON EXIT VERSUS TENDON LENGTH & PERCENTAGE OF TENDONS DISLODGED

FIG. 7



TENDON LENGTH TIMES TRAVEL VERSUS TENDON LENGTH

FIG. 8

The percentage of tendons which were dislodged, and the distance such tendons exited the slab edge are plotted as a function of their respective free lengths in Figure 7. The free length is the distance between the cut made in the tendon and the stressing pocket at the slab edge. Observe that tendons with a length between 75 to 95 ft. from the slab edge dislodged more often and exited farthest.

Since at the cut, the force in the tendon vanishes, the pull out effort of the tendon from the slab edge may be related, among other parameters such as drape, to tendon's length. Tendon length times distance a tendon exits the slab edge, can then be regarded as a measure of energy expended by the slab and the grout pocket to resist the cut tendon. Figure 8 shows the variation of this energy measure with the free length of tendon. The Figure implies that in the event of a cut in the tendon, tendons with cuts further away from slab edge are likely to release more energy to the restraining environment.

The preceding statements are based on plots representing averaged tendon behavior. They do not relate to a specific tendon. Also, it is emphasized that the tendons on this project were fabricated by the extrusion process.

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PROFESSIONALS AND CONTRACTORS DIRECTLY INVOLVED IN THE CONTROLLED DEMOLITION

Demolition Engineers

Bijan, Florian & Associates, Inc.
1601 W. El Camino Real
Mountain View, CA 94040

Engineer of Record
(Original Design)

Jitu Mehta and Associates
17750 Sherman Way
Reseda, CA 91335

General Contractor

Pacific Construction & Interiors
17751 Mitchell
Irvine, CA 92714

Demolition Contractor

Covi-Mitchell Enterprises, Inc.
17362 Gothard
Huntington Beach, CA 92647

Local Building Department

City of Santa Ana
Building Safety Department M-19
206 W. Fourth Street
P.O. Box 1988
Santa Ana, CA 92702

PTI COMPANY MEMBERS

Amsysco, Inc.
740 Racquet Club Drive
Addison, IL 60101
(708) 628-6969
FAX: (708) 628-6309

Cable Concrete Structures, Inc.
2825 Breckinridge Blvd., Ste. 125
Duluth, GA 30136
(404) 921-5500
FAX: (404) 923-1431

Canadian BBR (1980), Inc.
P.O. Box 37
3450 Midland Avenue
Agincourt, Ontario MIS 3B4
CANADA
(416) 291-1618
FAX: (416) 291-9960

Concrete Construction Systems, Inc.
3265 Orchard Lake Road
Keego Harbor, MI 48320
(313) 681-0181
FAX: (313) 681-0182

Canwest Rebar and Post Tensioning Services
11566 Eburne Way
Richmond, B.C. V6V 2G7
CANADA
(604) 324-4442
FAX: (604) 324-4333

Continental Concrete Structures, Inc.
P.O. Box 734
1400 Union Hill Road, S.W.
Alpharetta, GA 30201
(404) 475-1700
FAX: (404) 475-2293

Dywidag Systems International USA, Inc. & Canada, Ltd.
Corporate Office
301 Marmon Drive
Lemont, IL 60439
(708) 739-1100
FAX: (708) 972-9604

Florida Steel Corporation
1919 Tennessee Avenue
Knoxville, TN 37921
(615) 546-5472
FAX: (615) 546-5472

Freyssinet International & Cie
52-54 Rue de la Belle Feuille
92100 Boulogne - Billancourt
France
011-33-146-84-3945
FAX: 011-33-146-84-0467

Post-Tension Services of Texas, Inc.
6526 Lake June Road
Dallas, TX 75217
(214) 398-8465
FAX: (214) 398-8460

PTE Strand Co., Inc.
8435 N.W. 68th St.
Miami, FL 33166
(305) 593-5069
FAX: (305) 599-4132

PTSI
540 West 83rd Street
Hialeah, FL 33014
(305) 822-6316
FAX: (305) 558-3381

VSL Canada Ltd.
318 Arvin Avenue
Stoney Creek, Ontario L8E 2M2
CANADA
(416) 561-5611
FAX: (416) 561-7326

VSL Corporation
Corporate Office
1671 Dell Ave.
Campbell, CA 95008
(408) 866-6777
FAX: (408) 374-4113