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February 13, 2003

Strata Plan NW 2184
c/o Vancouver Condominium Services Ltd.
400-1281 West Georgia Street
Vancouver, B.C. V6E 3J7

Attention: Mr. Peter Chan

Dear Sir:

Re: Design Review, P/T Strand Extraction and CPE Testing
Westhampton Court
8511 Westminster Highway, Richmond, B.C. **RJC No. 38294-03**

The investigation has now been completed at Westhampton Court with respect to the P/T (P/T) system contained in the main floor slab. In writing this report, it is assumed that the reader has access to and is familiar with the previous condition evaluation report dated May 22, 2002. In that report we recommended the following:

1. **Design Review**: In view of the four tension-deficient strands identified previously, we recommended that a design review of the structural capacity of the main floor slab be conducted. The intent of the review is to determine the number of strand failures that could be tolerated before the load-carrying capacity of the structure is compromised beyond acceptable levels.

2. **Strand Extraction**: We recommended that the three tension-deficient strands identified in our field investigation be extracted for examination along their entire length to confirm whether or not the tension deficiencies are a result of corrosion. Also, full extraction of the strand that originally erupted was also recommended.

3. **Corrosion Potential Evaluation (CPE) Testing**: CPE testing involves injecting dry air into the cable sheathing at one end and measuring the humidity of the exhausting air at the other end. The humidity level is correlated with known established values that promote corrosion. The cables are then graded on their likelihood to corrode. The intent of the testing is to assess the potential for future corrosion of the P/T strands and to provide a basis for confirming the applicability of the Gas Purge (GP) drying technique to this structure.

1.0 DESIGN REVIEW

The review was performed based on the drawings available from the City of Richmond archives. No shop drawings of the P/T system were available for our use.

Our calculations focused on the ultimate capacity of the P/T slab to determine the maximum live (occupancy, landscaping etc.) load that could be supported with varying percentages of P/T strand breakage/loss. Our calculations ignored the serviceability parameters of cracking and deflection that would be considered in the design of a new floor structure. As such, strand failure rates less than the threshold established could result in permanent deflection or cracking in the affected areas.

The National Building Code of Canada prescribes minimum design live loads of 100lbs/ft², in addition to the weight of any landscaping material, for main floor slabs such as this. A load factor of 1.5 is applied to these loads, as stipulated by the Code. However, a reduction is permitted when evaluating existing structures to account for performance of the structure in the past (among other considerations).

Our review indicated the structure has little tolerance for strand failure. Where sufficient information existed on the original drawings, our review indicated that any loss of strands would begin to reduce the available live load capacity. Other areas did not provide sufficient information to accurately assess the structure's capacity. As such, any tension deficient strand should be considered for replacement at the earliest opportunity.

2.0 STRAND REMOVAL AND REPLACEMENT

2.1 Methodology

A total of five strands were removed from the slab. Our proposal indicated four tension deficient strands would be extracted and replaced (including the one that had erupted). In performing the work necessary to remove the four strands, a fifth detensioned strand was discovered.

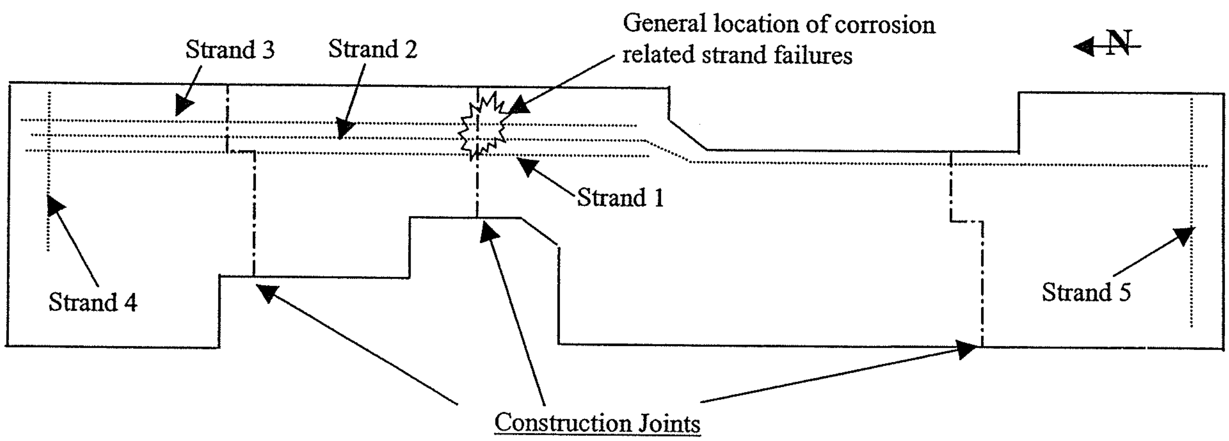
Strand extraction was performed by accessing the strands from a number of inspection recesses chipped in the underside of the concrete slab. Where accessible, strand anchors were exposed at the exterior of the structure. Strands were extracted from the slab, labeled, and made available for our inspection.

Prior to installing the new strands, the existing plastic sheathing was cleaned thoroughly to remove previous grease and any contaminants. The new strand was inserted into the existing sheathing. During replacement strand threading, new grease was applied to the strand and injected into the sheathing to fill the annular space between the strand and the sheathing.

Existing P/T anchors were reused if considered in good condition. New anchors were used to replace rusty ones and at locations where access to the existing anchors was not possible.

2.2 Strand Inspection Observations

The following observations were noted. Please refer to Appendix A for P/T field investigation logs. Also, for reference purposes, we include the following keyplan.



.1 Strand No. 1

- Inspection recess access point: #49
- Running direction of strand: North/South
- Approximate length of strand: 140'-0"
- General information: Strand forms part of banded group that runs along east column line in north part of structure.
- Visual inspection of strand length:
  - No corrosion, emulsified grease, or other evidence of moisture contamination noted.
  - No obvious cause for failure. May have slipped at time of construction, although, no grip marks noted at strand ends.

.2 Strand No. 2 (Previously Erupted)

- Original inspection recess access point: #49
- Running direction of strand: North/South
- Approximate length of strand: 208'-0"

- General information: Strand forms part of banded group that runs along east column line in north and south parts of structure.
- Visual inspection of strand length:
  - Surface rusting noted at construction joint anchor (middle joint in structure). See Photo 1.
  - Strand failed as a result of corrosion at construction joint (see keyplan).

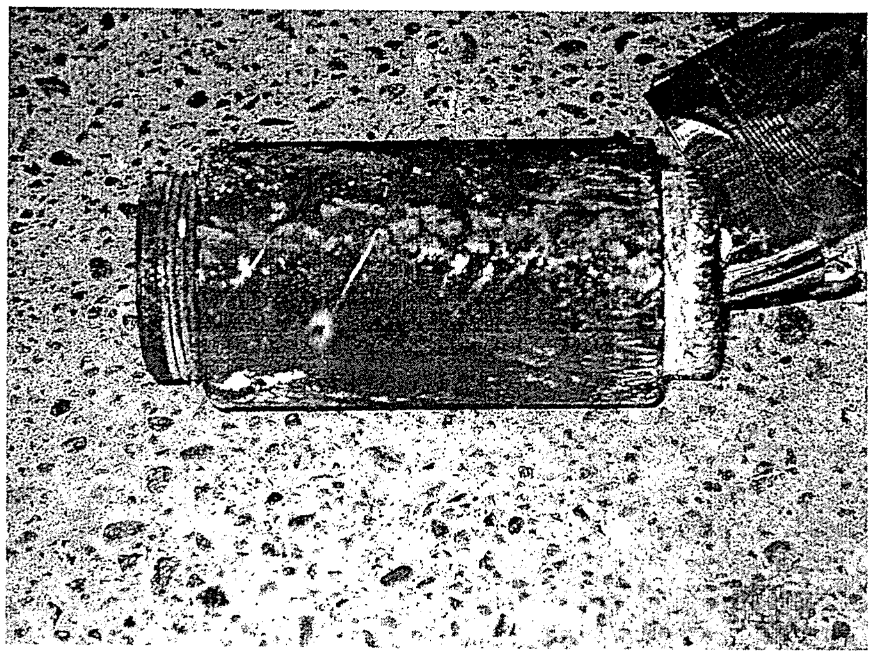


PHOTO NO. 1
CORRODED ANCHOR ALONG STRAND NO. 2

.3 Strand No. 3

- Original inspection recess access point: Not inspected originally
- Running direction of strand: North/South
- Approximate length of strand: 106'-0"
- General information:
  - Strand 3 forms part of banded group that runs along east column line in northern part of structure.
  - Strand 3 was discovered while searching for points to cut Strand 2 (i.e., it was part of the same group but outside the extent of the original inspection recesses). It was only during removal that it became apparent that it was actually another detensioned strand
- Visual inspection of strand length:
  - Heavy pitting/corrosion noted at and adjacent to failure point. Failure location at construction joint (see key plan). See Photo 2.
  - Additional corroded region noted 16'-0" north of failure point. One wire detensioned as a result of corrosion. See Photo 3.
  - Remainder of strand exhibited little evidence of moisture contact.

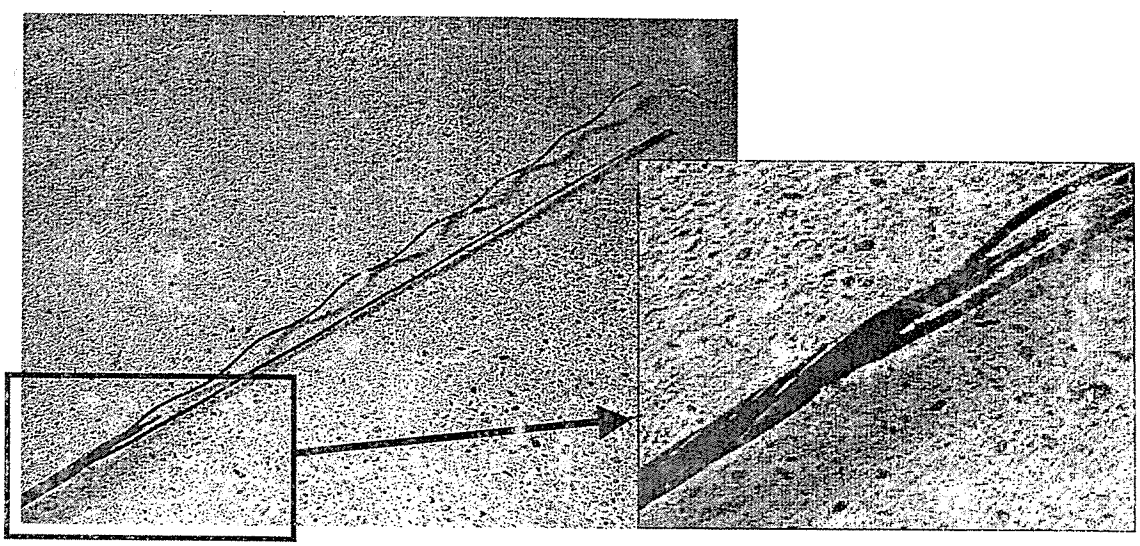


PHOTO 2
CORROSION FAILURE OF P/T STRAND NO. 3

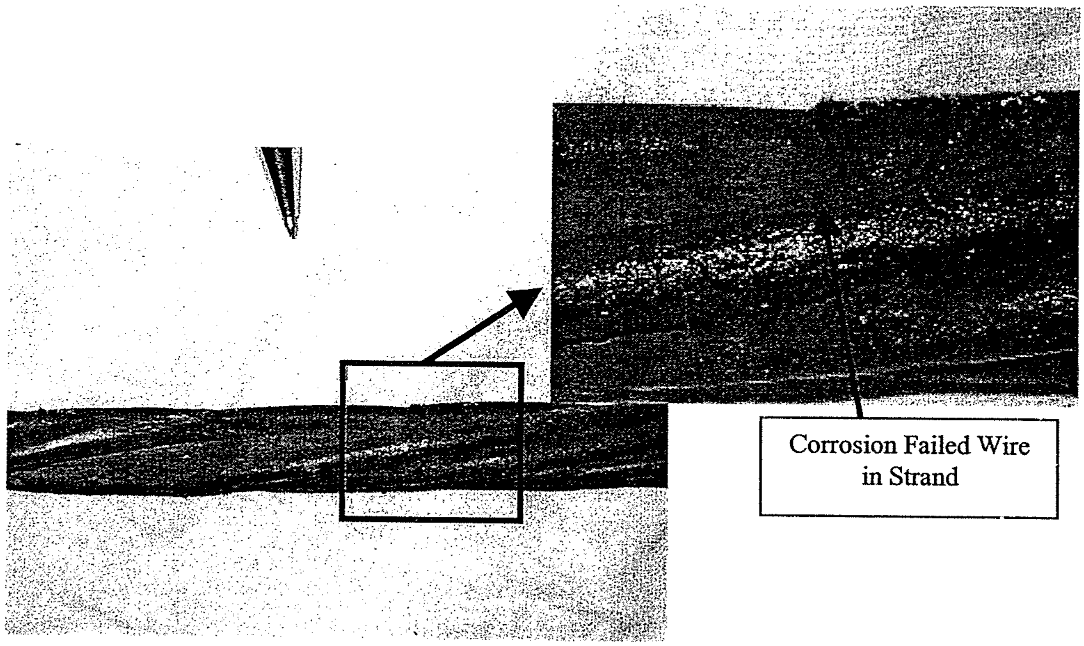


PHOTO 3
SINGLE WIRE FAILURE AND CORROSION OF P/T STRAND NO. 3
(Location Approximately 16'-0" North of Failure Shown in Photo 2)

.4 <u>Strand No. 4</u>

- Original inspection recess access point: #12
- Running direction of strand: East/West
- Approximate length of strand: 48'-0"
- General information:
  - Strand is a distributed strand located near the north end of the building.
  - No anchor wedges noted at live end anchorage.
  - Dead end of strand was located approximately 12" from buried dead end anchor.
- Visual inspection of strand length:
  - No evidence of moisture contact.
  - Lack of anchor wedges and distance separating strand end from dead end anchor suggests strand likely failed during initial stressing. We suspect repair of this strand at the time of construction was deemed unnecessary and as such, wedges would likely have never been installed.

.5 Strand No. 5

- Original inspection recess access point: #32
- Running direction of strand: East/West
- Approximate length of strand: 144'-0"
- General information:
  - Strand is a distributed strand located near the south end of the building.
  - No anchor wedges noted at live end anchorage.
  - No evidence of anchor slippage.
- Visual inspection of strand length:
  - Minor rusting was noted a distance of 3'-0" along the strand from the west end. No significant pitting observed.
  - We suspect this strand was also not tensioned at the time of original construction.

2.3 Discussion

Four tension-deficient strands were extracted from the slab for inspection and replaced. In the process, a fifth tension-deficient strand was found. A portion of this fifth strand was removed to confirm the source of failure.

Three of the five strands inspected revealed no significant evidence of corrosion. It is our opinion that the lack of tension in these three strands was a result of problems encountered during initial construction.

The other two strands had failed as a result of corrosion. Strand 3 exhibited wire failures in two locations. Both strands demonstrated significant corrosion and failure in the vicinity of a construction joint in the slab beneath interior, occupied living space. We suspect this location was left vulnerable during construction, likely permitting water to enter the P/T system at this location.

3.0 CORROSION POTENTIAL EVALUATION (CPE) TESTING

3.1 CPE Testing Results

CPE is a proprietary technique developed by Post-Tech Construction Technologies Inc. This testing involves injecting dry gas into the strand sheathing. The gas forces the air within the sheathing to be exhausted out the end anchors (or installed ports where the anchors are not accessible). The humidity of the exhausting air is measured as an indicator of the presence of moisture somewhere along the strand length. The potential for corrosion of individual strands is graded as low, moderate, high or very high (Post-Tech's summary report of the CPE test results is included with this letter). The following summarizes the findings.

In presenting the findings, please note one item of nomenclature. First, the reader will note the use of the term "cable" by Post-Tech vs. our use of the term "strand". For the purposes of this report, the reader should consider these terms interchangeable.

Also, Post-Tech categorizes the strands (or cables) investigated as "beam" or "dist". In general in this P/T slab, the strands spanning east-west are regularly distributed across the slab area (i.e. "Dist."). The north-south strands are grouped together, or banded in a relatively narrow width over the column lines. These banded strands tend to act like a beam, even though no distinguishable beam is observed in the structure. As such, Post-Tech uses the "beam" designation in their reporting. For the sake of consistency, we shall also present the results using this convention.

TABLE 1 – SUMMARY OF CPE TEST RESULTS

Area	No. of Strands Tested (excluding "No Flows")	CPE Grade 4 & 5 "HIGH" Potential for Corrosion (No. of Strands)	Percentage of "WET" strands in sample tested (CPE Grade 5)
Beam Strands	15	4	26.7%
Distributed Strands	15	3	20.0%
Total	**30**	**7**	**23.3%**

Testing results have been categorized in terms of the potential for corrosion. For this structure, strands with a CPE Grade of 4 or higher are characterized as being "wet" with a high potential for corrosion. Any strands with a grade of 3 or lower would be characterized as being "dry".

Of the 30 strands that were CPE tested, seven strands were classified as having a high potential for corrosion. We comment as follows:

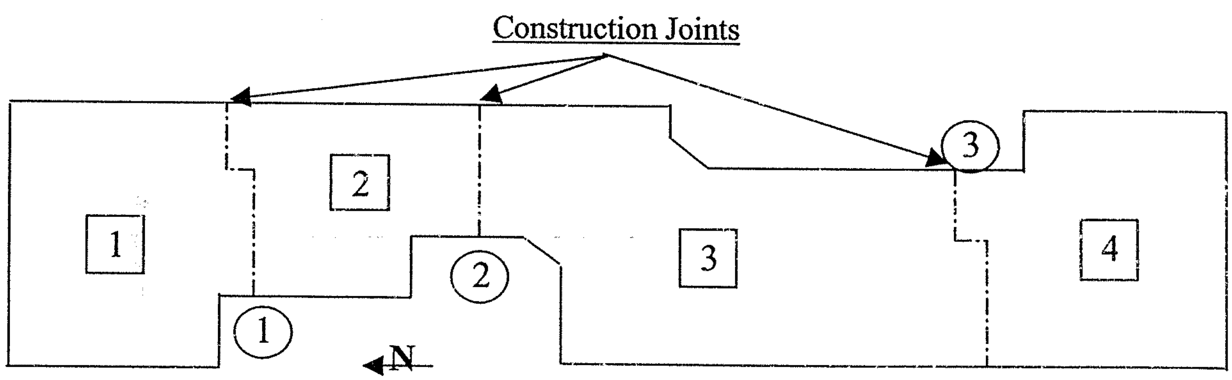
- A similar proportion of wet strands were identified in both the "beam" and "distributed" is roughly equal.

- Five of the seven wet strands are located north of the northernmost construction joint.
- One wet strand was located beneath the patio area in the southern part of the building.

4.0 GENERAL DISCUSSION

In analyzing the information obtained, we draw attention to the following:

- The slab is segmented in four sections by three construction joints that traverse the slab from east to west. The keyplan reproduced below assigns numbers to each of the sections and joints to lend clarity. (Section numbers have been designated in boxes while circles designate construction joints.)



- Corrosion failure of two strands was noted at or near Construction Joint 2. We suspect water entry at this location likely occurred during construction. This vulnerability may have also been a source of moisture infiltration at the other two construction joints as well.

- The design review revealed little tolerance for strand failure before a reduction of structural capacity is realized. While a number of strands would likely have to fail before an unsafe condition is created, it is prudent to ensure failed strands are replaced in a timely fashion so as to preserve the capacity.

- **Section 1:** Five of 14 strands (or 36%) CPE tested contained sufficient moisture to be categorized WET. No evidence of moisture was detected when inspecting strands at inspection recesses.

- **Section 2**: One of five strands (20%) CPE tested were classified as WET. Evidence of moisture was also detected at four of 20 (25%) strands inspected previously in this section.

- **Section 3**: One of 11 strands (9%) CPE tested were classified as WET. Evidence of moisture was detected at eight of 46 (17%) strands inspected previously. Seven of those strands, as well as the one wet strand detected in the CPE testing extend beneath the landscaped region above.

- **Section 4**: No strands tested WET during CPE testing. Five of 19 strands (26%) inspected had visible evidence of moisture.

Moisture has been permitted to gain entry into the P/T system. We believe this may have occurred both during construction and since construction while the building has been in service. Construction Joint 2 is located beneath living space and, as such, is not a likely location for ongoing ingress of moisture. Section 3 supports a significant amount of landscaping beneath which a notable number of strands display moisture evidence.

Of equal concern is that sufficient corrosion has occurred to result in failure of P/T strands, some of which did not erupt and as such, were not known to have failed prior to this investigation.

Given the above, we present the following discussion for consideration.

.1 Strand Drying Measures

One method to proactively address the moisture contained within the P/T system is to dry the strands. The strand drying process involves installing ports in the same fashion as was done for the CPE testing. Once installed, dry air is passed continuously through the strands until the moisture is removed. In structures where the CPE pilot program reveals significant numbers of wet strands, we would recommend proceeding to the drying program without any further testing. However, in this instance, the number of wet strands detected in the test sample may be small enough that there could be a cost benefit to drying only those strands that are identified as wet.

Use of this technique has been limited to date and the long-term track record of this preventative maintenance approach has not been established. Also, the fact that some strands have already failed as a result of moisture contained within the system, the success of strand drying may further be reduced. However, it is the only proactive system we are aware of to date to mitigate corrosion of strands once water has entered the sheath.

.2 Monitoring For Strand Breakage

Given that corrosion failures have occurred, the Strata may wish to pursue a more reactive approach involving monitoring of the P/T system. This can generally be approached in one of two ways.

.1 Additional Inspection Recesses

Additional inspection recesses could be chipped in the slab soffit and monitored on a regular basis. The frequency of monitoring would be recommended initially at one-year intervals, possibly increasing if additional failures are detected. When failed strands are detected, replacement could be made in a timely fashion.

The location of additional recesses would focus on the areas we know have been vulnerable in the past. Sufficient numbers of recesses located either side of the construction joints, as well as beneath any landscaped areas, would serve to detect any past or future strand failures. We would also recommend increasing the number of recesses throughout the remainder of the structure so that, should corrosion related failures begin to increase evidence of this trend would be detected permitting a refined examination to determine the extent of any localized problems.

Installing additional inspection recesses would have some drawbacks. There would be some short-term inconvenience as the recesses are installed. In the long term, inspections would be carried out periodically providing only a glimpse into the overall performance of the system. Should situations prevail that permit failures to occur and possibly accelerate shortly after an inspection is completed, significant loss of capacity could occur before the next inspection is undertaken. Again, while unlikely to create a safety issue, it could create a situation where funds are needed to address a larger more urgent problem rather than replacing strands in an organized manner.

Also, should additional recesses be chipped, an allowance should be made for replacement of isolated areas of thermal insulation on the slab soffit. The extent of replacement would only be known for certain once the recesses were installed.

.2 Acoustic Monitoring

An acoustic monitoring system has been developed to detect failures of strands within existing structures. The "Soundprint" monitoring system consists of a network of sensors installed on the soffit of the P/T slab. These sensors are connected to a data monitoring and recording system. When a strand fails, it emits a unique sound that is detected by the sensors and through triangulation, the system is able to locate the failure event. This system is monitored continuously via proprietary software.

The advantage of this monitoring system is that it provides information regarding strand breakage throughout the structure, rather than monitoring strand breakage through tension testing of a limited number of strands at inspection recesses. However, the Soundprint system provides no information regarding strand failures that occurred prior to the monitoring system installation. If the monitoring system identifies a strand failure, inspection recesses are typically chipped to check the tension of strands adjacent to the detected strand failure. This is intended to confirm if there were any additional strand failures in the vicinity prior to the system installation, and safeguard against any significant strand breakage remaining undetected.

Please note that if an acoustic monitoring system were to be installed, there would be no immediate need for additional inspection recesses to be chipped into the slab soffit.

.3 <u>Waterproofing</u>

We have discussed that entry of water into the system has likely occurred for a number of reasons. Two areas we believe to be vulnerable in an ongoing sense are the landscaped regions and the slab edges.

The landscaped regions were likely waterproofed at the time of original construction. We are not aware if any replacement of that waterproofing has occurred. Results of the CPE testing suggest water is entering the P/T system beneath these areas so we believe some breaches in the integrity of the membrane have occurred.

The slab edges were discussed in our previous report. These regions should be waterproofed.

.4 Eruption Plates

We also discussed previously that eruption plates should be installed along the slab edges. Where live end anchorages are located, there is a risk that a failing strand could erupt out the edge of the slab where the original grout pocket was installed following stressing of the strands.

5.0 RECOMMENDATIONS AND OPINIONS OF PROBABLE COST

Significant moisture was detected during our investigation. Corrosion failures of strands, including the strand that erupted from the slab were also noted. In our opinion, these conditions combined do not make this structure a good candidate for a strand drying program. It is likely there are other strands that have corroded to a sufficient extent the drying program would not be capable of improving their condition.

In developing this opinion, we also reviewed the potential costs of a drying program. In this building, we anticipate costs in the order of $180 to $200 per strand for drying. If all strands were dried (approximately 1265), we would expect costs as high as $250,000. With the benefits the program would yield in question. we do not believe there is a cost advantage to the Strata to implement a drying program.

Given the above, we believe the appropriate course of action for this structure is monitoring of the structure. As discussed, this can be done in one of two ways:

1. Installation of additional inspection recesses and periodic testing.

2. Installation of an electronic, acoustic monitoring system that would permit continuous monitoring of the system.

Monitoring, regardless of which approach, will give the Strata the ability to replaced failed strands as needed, creating a manageable approach to maintaining the P/T system If monitored regularly, we suggest this approach would also eliminate the likelihood that significant numbers of strand failures could progress undetected, resulting in the need for costly repair schemes such as structural subframing.

We present our opinion of probable cost for both monitoring options following.

5.1 Monitoring

.1 By Inspection Recess (Alternative I)

The monitoring would include reinspection of strands at the existing recesses and addition of more recesses. We envision needing to add approximately 250 inspection recesses.

Probable Cost:

Initial Expenditure for Additional Recesses and Inspection (Including Contractor Allowance and Engineering)	$ 50,000.00

Annual Monitoring:

Engineering Cost to Reinspect all Recesses and Report	$ 7,500.00

.2 By Acoustic Monitoring (Alternative II)

The cost of the Acoustic Monitoring system varies depending upon the type of structure, the size of the inst llation, etc. Budget prices have been obtained for Westhampton Court based on an approximate main floor slab areas of 60,000 ft^2.

Another factor that will significantly influence cost is the type of wiring needed to connect the system. Typically, we would expect wiring in this type of installation to be nonfire-rated, taking into account that the ceiling over the parking does not constitute a supply or return air space. However, experience has shown that this can vary from authority to authority and, as such, we would confirm requirements for this with the City of Richmond Planning Department if the Strata opts to take this approach. In the meantime, we will provide the range of costs using both fire-rated and nonfire-rated wiring.

Probable Cost:

Initial Expenditures for Supply and Installation:

- NonFire-Rated Wiring — $ 120,000.00

OR

- Fire-Rated Wiring — $ 180,000.00

Annual Monitoring: $ 5,000.00

The following should be highlighted as well:

- Monitoring by inspection recesses provides a **periodic** glimpse into the performance of strands located at particularly vulnerable locations as well as a statistical representation throughout other areas.
- Electronic Acoustic monitoring provides **continuous** information as to how **all** the strands are performing.
- In both instances, should additional strand failures be detected, the cost to repair said strands has not been included in the above opinions of probable cost.

5.2 Mitigation of Moisture Ingress

.1 Moisture Protection and Structural Repairs

We suspect the main floor waterproofing in the landscaped area is nearing the end of its intended services life. The Strata should be considering replacement in the short term (i.e., next five years).

The slabs should be protected as best as possible to prevent further moisture ingress into the P/T strands. At present, there are no strands identified for replacement in this area. As such, any leakage that does occur into the P/T system is likely contaminating strands that were already wet. As time passes and replacement strands need to be installed, these new strands would also be susceptible to moisture if the membranes were not waterproof. As such, we suggest considering maintenance to these membranes before strand replacement is needed in these regions.

Should there be any structural deterioration discovered beneath the existing membrane at that time of replacement, structural repairs would be appropriate. We estimate the cost of removing and reinstating existing landscaping, and installing a new waterproofing membrane on the patio areas to be as follows:

Probable Cost (Including Contractor Allowance for Removal/Replacement and Engineering): $ 230,000.00

.2 Strand Anchor Pocket Protection

We recommend that the parging be removed and a waterproof elastomeric coating be applied over the strand anchor grout pockets around the building perimeter to eliminate a potential source of moisture ingress into the P/T system.

Probable Cost: $ 10,000.00

At the same time that the waterproofing elastomeric coating is applied, we suggest that eruption restraint plates be installed over all exposed live end anchors at the main floor slab edge.

Probable Cost: $ 35,000.00

Please note that all probable costs presented do not include GST. Contractor pricing would have to be confirmed prior to commencing with any work. Engineering fees have been included.

6.0 CLOSING

Preliminary testing has revealed evidence of water at a number of locations in the main floor slab. Two detensioned strands extracted from the structure, including the one that erupted previously, have been confirmed to have failed as a result of corrosion.

Recommendations have been made to monitor the strands for future failure. A number of methods for doing this have been outlined. A proactive approach involving drying the strands has been presented for discussion. We do not believe the cost benefit to the strata warrants implementation of a drying system, given the extent of moisture and corrosion observed.

We have also restated our recommendations regarding the waterproofing in the landscaped areas, ensuring it is fully functional and protecting the structure, and that the slab edges are also protected.

If you require any clarifications regarding the contents of this report, please do not hesitate to contact us. We are available to meet as required to review our findings and recommendations.

Yours truly,

READ JONES CHRISTOFFERSEN LTD.

Roger Steers, M.Eng., P.Eng.
Principal

RS/lp

cc: *John Harder, RJC Calgary*
Doug Clark, RJC Vancouver

Encl.

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POST-TENSIONING SYSTEM CONDITION EVALUATION

For

WESTHAMPTON COURT
8511 Westminster Highway
Richmond, B.C.

Prepared For:

STRATA PLAN NW 2184
c/o Vancouver Condominium Services Ltd.
400-1281 West Georgia Street
Vancouver, B.C.
V6E 3J7

Prepared By:

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May 22, 2002

RJC Reference No. 38294-02

TABLE OF CONTENTS

1.0 INTRODUCTION

At the request of Mr. Cory Pettersen of Vancouver Condominium Services Ltd. (VCS), acting on behalf of Strata Plan NW2184, Read Jones Christoffersen Ltd. (RJC) performed a condition evaluation of the post-tensioning (P/T) system in the main floor slabs of the Westhampton Court residential complex, located at 8511 Westminster Highway, Richmond, B.C.

Our initial involvement with the P/T system at Westhampton Court began in late November 2001 when RJC was requested by Cory Pettersen of VCS to investigate the eruption of a main floor P/T cable located in the north wing of the complex. We had determined that the cable failure had been caused by corrosion due to moisture ingress. The strand failure had occurred approximately 2 feet north of the first interior column support, and approximately 35' from the cable anchor. Evidence of rust staining and intermittent pitting was observed along a length of approximately 2 feet extending from the failure point. The results of our field investigation are summarized in our report dated February 6, 2002.

The intent of the current evaluation work was to develop an opinion of the condition of the main floor P/T system as per recommendations outlined in our report dated February 6, 2002 and our proposal dated March 4, 2002.

2.0 DESCRIPTION OF STRUCTURE

Situated on a flat and level site, the Westhampton Court residential complex is bounded by Ackroyd Street to the north and Westminster Highway to the south. The building complex, constructed in the early 1980's, consists of two wings connected by a central lobby area. The north wing fronts on Ackroyd Street, while the south wing fronts on Westminster Highway.

The north and south wings are three-storey buildings with one level of on-grade parking. The main floor is constructed of concrete slabs reinforced with unbonded P/T cables. The type of post-tensioning system employed at Westhampton Court is commonly referred to as the 'pushed-in' or 'stuffed' system. A brief description of the 'stuffed' system is found in Appendix A. The main floor slab is supported on perimeter concrete walls and interior concrete columns. The underside of the main floor slab is insulated with sprayed-on thermal insulation in areas immediately below living areas.

Grout pockets for cable anchors at the main floor slab perimeter appeared to be covered with only a thin concrete parging.

There are exposed patio areas on the east side of the south wing, and on the west side of the north wing.

The upper floors and roof are constructed of wood framing. The floor of the parking level consists of a concrete slab-on-grade. Exterior wall finishes consist primarily of cedar siding along the east and west elevations, and brick veneer cladding on the north and south street elevations.

An incomplete set of structural drawings, S1 to S5, was provided for our use.

3.0 POST-TENSIONING SYSTEM EVALUATION

A total of 48 inspection recesses were chipped by Post-Tech Construction Technologies Inc. to expose short lengths of cables in locations designated by RJC. A total of 116 main floor P/T cables were exposed and tested: 60 cables in the north wing, and 56 cables in the south wing.

It is noted that 8 of the 60 inspected cables in the north wing were located near the cable eruption previously reported on February 6, 2002. At the time of the inspection, these eight cables were found to be without any concrete cover, protected only by an application of sprayed-on thermal insulation.

The cable sheathing was cut to expose the cables in the inspection recesses. The visual condition of the cable and grease, as well as the presence of any free water in the sheathing was recorded. Our investigation also involved testing each of the exposed cables for tension using a penetration test. In this test, the tip of a flathead screwdriver is placed between adjacent wires of the exposed cable. Using a hammer, the screwdriver handle is firmly struck with a number of repeated blows. If the screwdriver tip displaces the wires, the cable is deemed to be tension deficient. This process is repeated for each pair of the six exterior wires in the cable and the results are documented on RJC's standard log sheets.

Table 1 summarizes our observations and test results for all 117 P/T cables inspected to date, which include the single failed cable documented in February 2002, and the 116 cables tested in our current investigation. We estimate that there are approximately 1,625 cables in the main floor P/T system at Westhampton Court.

TABLE 1 **SUMMARY OF CONDITION OF CABLES EXPOSED AT INSPECTION RECESSES**				
	north wing (February 2002)	**north wing (April 2002)**	**south wing (April 2002)**	**Total**
Cables with detected tension deficiencies	1 (100%)	2 (3.3%)	1 (1.8%)	**4 (3.4%)**
Cables displaying free water, emulsified grease, or corrosion, but no detected tension deficiencies	0 (0%)	7 * (11.7%)	11** (19.6%)	**18 (15.4%)**
Cables with no observed problems at inspection location	0 (0%)	51 (85%)	44 (78.6%)	**95 (81.2%)**
Total Number of cables inspected and tested	**1**	**60**	**56**	**117**

* 2 of 7 contaminated cables exhibited free water
** 8 of 11 contaminated cables exhibited free water

It is emphasized that the information in Table 1 reflects the specific cable conditions at the recess locations, and that conditions a few centimetres away along the same cable can vary from those observed at the inspection locations. For instance, where selected cables have been removed for a full-length evaluation on other RJC projects, moisture contact has typically been observed at various locations along the cable length. As such, reported findings observed at inspection recesses, in general would tend to underestimate the extent and amount of contamination and deterioration of the P/T system. The reader is reminded of the limitations associated with investigations of this nature.

There were four tension-deficient cables identified in total: three tension-deficient cables (including the February 2002 erupted cable) in the north wing, and one in the south wing. All four failed cables were fully tension deficient (i.e. loose).

Of the eighteen contaminated cables observed, ten cables (i.e. two in the North Wing, and eight in the South Wing) exhibited moisture at the time of inspection. There is a high likelihood of future corrosion and cable failures in the moisture-laden cables.

Seventeen cables were identified as having oily or runny grease. Grease that has become oily and runny over time is not necessarily an indication that moisture is present in the cable sheathing. However, when grease loses its viscosity, it will tend to flow more readily to the low points in the cable, leaving the high points of the cable more susceptible to corrosion if moisture migrates into the cable sheathing.

4.0 GENERAL OBSERVATIONS AND COMMENTS

4.1 Outdoor Patios

The Westhampton Court residential complex is flanked by two outdoor landscaped patios on the suspended main floor level: one located on the west side of the north wing, the other on the east side of the south wing. The landscaped patios consist of a paving stone pathway, turf and some planters. During our inspection, we did not remove any turf or paving stones to evaluate the condition of the waterproofing membrane.

Based on our field observations, we have evidence to suggest that the waterproofing membrane is not performing as originally intended. Of the 18 cables that were observed to be contaminated by moisture (i.e. free water, emulsified grease or cable corrosion) but not tension deficient, 13 cables (73%) extended beneath the outdoor patios where there was high exposure to the elements. We note that for two of the cables that extend beneath the south wing patio, water was dripping past the cover plates that were installed to cover the recesses. Also, in the north wing, one leak was observed at the main floor slab construction joint near Parking Stall 126.

4.2 Cable Anchor Grout Pockets

Based on our experience with other buildings constructed with an un-encapsulated P/T system similar to that of Westhampton Court, it is our opinion that grout pockets at live end cable anchorages are considered to be a common source of moisture ingress.

The P/T anchors grout pockets of Westhampton Court main floor slabs are at a greater risk to moisture ingress because they are not protected by cladding or sheltered from the elements by adjacent buildings. The P/T anchor grout pockets are only covered by a thin concrete parging which, in general, offers minimal protection from moisture ingress.

We noted several slab edge locations throughout the building complex where the thin concrete parging has delaminated, exposing the P/T cable anchor grout pockets.

If moisture was to enter the P/T cable sheathing from the slab edge grout pocket, a likely location where the water would collect is at the first low point of the cable profile, (i.e. at the first interior span from the perimeter).

Given the field evidence presented above, we suspect that the moisture has been entering the cable sheathing from the cable anchor grout pockets.

5.0 RECOMMENDATIONS AND DISCUSSION

5.1 Post-Tensioning Recommendations

.1 Design Review

In view of the four tension-deficient cables identified in our investigation, we recommend that a design review of the structural capacity of the main floor slab be conducted. The intent of the review is to determine the number of cable failures that could be tolerated before the load-carrying capacity of the structure is compromised beyond acceptable levels. We suggest an engineering fee of $3,000 to conduct the design review.

The results of the design review will also determine whether further P/T testing (i.e. more recesses) will be warranted immediately. For example, if the design review indicates that the main floor slab has no reserve capacity, the ability of the floor slab to carry the code-specified design loads would be sensitive to any cable failures. We would then recommend that a larger sample of cables be tested to achieve a more accurate diagnosis of the condition of the P/T cables. The construction budget and engineering fees associated with chipping additional recesses, if required, would be confirmed once the scope of the testing is established based on the results of the design review.

.2 Cable Extraction and Inspection

We recommend that the three tension-deficient cables identified in our field investigation be extracted for examination along their entire length to confirm whether or not the tension deficiencies are a result of corrosion. We also suggest that the extracted cables (including the erupted cable previously extracted in February 2002 be replaced with new fully-tensioned cables. We suggest a budget of $9,500, which includes contractor's costs (cable extraction and replacement) and engineering fees.

.3 Corrosion Potential Evaluation (CPE) Testing

The investigation of the P/T system, to date, has revealed evidence of moisture contamination, and free water. Based on these observations, we believe it is highly likely that there is significant moisture ingress into the main floor P/T system.

If, however, the Owners would like to obtain further evidence to demonstrate that moisture has indeed penetrated the P/T system, we would then suggest that the Corrosion Potential Evaluation (CPE) be conducted on an additional 30 to 50 cables.

CPE testing consists of injecting a constant flow of gas into the sheathing of selected cables, and measuring changes in the moisture content of the gas between points of entry and exit as the gas absorbs moisture as it passes along the cable length. CPE testing of 30 to 50 cables would give the Owners additional information regarding the extent of moisture ingress into the P/T system.

We estimate the budget for this work, if required by the Owner, as follows:

Contractor Allowance	\$4,100 to \$6,800
Engineering Fees	\$1,000

.4 Survey of Concrete Cover Over P/T Cables

During our February 2002 investigation of the erupted cable we discovered that there was no concrete cover over the P/T cables in the inspected areas. Typically, the building codes require a minimum of ¾" of concrete cover over the P/T cables for fire protection and eruption restraint. We recommend an investigation be carried out to identify other locations of inadequate concrete cover. For this evaluation, we suggest a budget of \$3,500 which includes engineering fees and the labour costs to determine the concrete cover.

5.2 Remediation of Post-tensioning System

The selection of suitable techniques for the remediation of the Post-tension system at Westhampton Court will depend largely on the results of the design review, and cable extraction and inspection. As an overview, we present the following rehabilitation strategies along with descriptions of their suitability for different field conditions. Please note that the following are presented for discussion purposes only, and should not be construed as being necessary remedial actions until such time that they are justified by further P/T testing.

.1 Gas Purge

Gas Purge is a relatively new procedure and consists of injecting cable sheathing with a constant flow of dry gas. The gas absorbs moisture as it passes along the cable length and exhausts at end anchors. Gas Purge has the effect of drying the cables, thus reducing the risk of future corrosion. Although the long-term effectiveness of the Gas Purge procedure has yet to be established, it is the only proactive means of rehabilitating existing cables.

Based on results to date on buildings we are monitoring which have undergone Gas Purge, we have observed that the approach is beneficial in reducing corrosion rates. For cables that exhibited advanced stages of corrosion at the time of cable drying, Gas Purge remains an unproven method of arresting corrosion and mitigating future failures. For this reason, we would suggest that an annual contingency be set aside to replace corroded cables that may fail over time.

We estimate the costs associated with the Gas Purge to be as follows, assuming all cables to be dried:

Gas Purge (1265 cables@$200 per cable)	$ 253,000
Cable replacement (over 10 years) 10% of 1265 cables@$2,500 each	$ 317,000

.2 Cable Replacement

If the design review demonstrates that there is reserve capacity in the main floor slab and that the number of tension-deficient cables is within the cable breakage tolerance, it might be economically viable to replace the cables as they break based on the regular monitoring of the P/T system. We estimate the engineering fees to be $3,000 for annual monitoring of the P/T system. The replacement of the cables typically costs in the order of $2500 per cable, depending upon the length, accessibility, etc.

It is not possible to definitively establish the total number of cables that may contain moisture and present a future risk of corrosion-induced breakage. If significant future cable breakage were to necessitate replacement of all cables at one time, the costs are estimated to be in the order of $1.9M. However, if this scenario should be realized we would expect alternate means of supporting the slab may be more economically viable. Please see the following section for discussion on alternate options for dealing with extensive cable failures.

.3 Structural Steel Sub frame

In the event that the amount of cable failure becomes significant, alternative means of structural support may be considered. Typically, we have found this approach to cost in the order of $20/ft^2 when needed. If alternate structural support is needed extensively at Westhampton Court, the costs associated with installing a structural sub frame over the entire footprint of the main floor slab is estimated to be approximately $1.2 million.

The structural steel sub frame could also be installed on an as-required basis in localized areas where sufficient P/T cable failure has compromised load-carrying capacity of the main floor slab. Combined with a program of annual monitoring of the P/T system to identify cable breakage, the costs associated with the installation of structural sub frames on an as-required basis could be amortized over an estimated period of time during which cable breakage might be expected. For comparison purposes, if the $1.2 million for sub-framing the entire main floor slab were amortized over, say, ten years, the discounted present value of the $1.2 million sub frame would be approximately $800,000 (assuming an interest rate of 4%).

5.3 Mitigation of Moisture Ingress

In addition to the various methods of rehabilitating the P/T system presented earlier in Sections 5.1 and 5.2, we recommend that proactive steps be taken to mitigate the ingress of moisture into the P/T system.

.1 Moisture Protection and Structural Repairs

As discussed earlier, we suspect that the waterproofing membrane over the main floor slab at the landscaped patio is nearing the end of its service life, given the age of the structure. As such, we suggest that the existing waterproofing membrane system be examined and replaced, if required. Should there be any structural deterioration discovered beneath the existing membrane at that time, structural repairs would be appropriate. We estimate the cost of removing and reinstating existing landscaping, and installing a new waterproofing membrane on the patio areas to be as follows:

Contractor Allowance:	$ 210,000
Engineering Fees	$ 20,000

.2 Cable Anchor Pocket Protection

We recommend that the parging be removed and a waterproof elastomeric coating be applied over the cable anchor grout pockets around the building perimeter to eliminate a potential source of moisture ingress into the P/T system. We estimate the cost of applying a waterproofing elastomeric coating to be $10,000.

At the same time that the waterproofing elastomeric coating is applied, we suggest that eruption restraint plates be installed over all exposed live end anchors at the main floor slab edge. We estimate the cost of installing eruption restraint cover plates to be approximately $35,000.

5.4 Installation of Eruption Cover Plates at Underside of Main Floor Slab

During our inspections, we noted three groups of banded P/T cables near the site of the February 2002 cable eruption where there was no concrete cover to provide fire protection or to contain the cables in the event of future eruptions. We recommend that steel cover plates with intumescent paint be installed in these areas. The estimated costs for this work is approximately $1,000.

5.5 Contingencies

We recommend that a 10% contingency be added to the probable cost to cover any unforeseen costs. The probable costs do not include GST. Unless specifically noted, engineering fees are not included in the cost estimates. The above costs were also based on the assumption that the Contractor would have a reasonable number of parking stalls closed off, in order to carry out their work.

6.0 CLOSING

In light of our experience on other similar P/T evaluation projects, our field observations and test results for Westhampton Court provide sufficient evidence to suggest that significant portions of the main floor P/T cables have been exposed to moisture ingress. Further CPE testing could be conducted on 30 to 50 cables to provide a higher level of confidence in regards to the extent of moisture ingress.

We recommend that a design review be conducted to determine the sensitivity of the P/T system to other cable failures. If there is little or no reserve capacity in the main floor slab, we suggest that additional recesses be excavated to test other P/T cables to confirm whether sufficient intact cables are present in each bay to carry the design loads.

We recommend that the three tension-deficient cables be extracted to determine the cause of failure.

The Gas Purge procedure was presented as a means of reducing the rate of corrosion in the P/T cables. The Gas Purge procedure, however, is ineffective in arresting advanced stages of corrosion evident in any cable at the time that the cables are dried. Therefore, annual monitoring would be required to identify and replace those cables that break as a result of corrosion. The reader is reminded that because the Gas Purge is a relatively new procedure, long-term track record of its effectiveness in reducing the rate of corrosion has yet to be established.

Combined with a regular monitoring program, we suggested replacing the cables only as they failed as means of amortizing the repair costs over time. If, however, the monitoring program reveals an extensive pattern of cable breakage at any time, we have considered the installation of a structural sub-frame (where and as required) as an alternate to replacing cables. The decision to install a sub frame or to replace failed cables will depend on the number and locations of cable failures.

To inhibit the future ingress of moisture into the P/T system, we recommend the replacement of the waterproofing membrane over the patio slabs, and the application of a waterproof elastomeric coating over the cable anchor grout pockets at the slab edges.

Based on our field observations, we suspect that the concrete cover over the P/T cables is inadequate for fire protection purposes and eruption restraint. We suggest that an investigation be conducted to determine the concrete cover. At the slab edges around the perimeter of the building, it is recommended that cover plates be installed over the cable live end anchors to contain any future cable eruptions.

We trust that this meets your current requirements. Please contact the undersigned should you have any questions regarding the contents of this report.

Yours truly,

READ JONES CHRISTOFFERSEN LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. CHAO
May 23/02

James Chao, P.Eng.
Design Engineer

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA R.M. STEERS
05/23/02

Roger Steers, P.Eng.
Principal

JC/lp

cc: *John Harder, RJC Calgary*

APPENDIX A

DESCRIPTION OF UNBONDED POST-TENSIONING SYSTEMS AND DURABILITY

DESCRIPTION OF POST-TENSIONING SYSTEM AND DURABILITY

Construction of Post-Tensioned Slabs

The type of post-tensioning system in this structure is commonly referred to as the "pushed-in" or "stuffed" system (as opposed to the more recently developed "extruded" system). This system was employed by most post-tensioning companies who were active in Canada between the late 1960's and the early 1980's.

Please refer to Figures 1 and 2 which show typical details of the post-tensioning system.

In the fabricating shop, the cables were coated in grease and inserted into plastic sheaths (or ducts). The dead end anchors were then attached. The completed assembly of grease, cable, sheathing, and anchors is referred to as a "tendon".

The tendons were transported to the jobsite and were placed in draped profiles on the formwork. The live end anchors were attached and the concrete was then cast. The cables were tensioned at the live anchors using hydraulic jacks. The ends of the cable were trimmed and concrete grout was placed in the recess which had allowed access for the jack.

At the time this project was designed and constructed, this type of structural system was considered to be durable. It was believed that the cables were protected from corrosion by the grease, the grout plugs and the plastic sheathing. The extent of vulnerability of post-tensioning tendons of the "pushed-in" type was not generally understood in Canada until the mid 1980's. And even now, it appears that some structural engineers are only just becoming aware of the durability issue.

Susceptibility to Entry of Water

It is now becoming generally known that post-tensioning systems, especially those of the "pushed-in" type, are vulnerable to the entry of water. In addition, the steel used in post-tensioned structures is very high strength cold drawn material and hence is vulnerable to corrosion.

Figure 2 shows a typical cross-section of a post-tensioning tendon. In the case of the "pushed-in" system, the annular space inside the sheath can act as a reservoir and a passageway for any water which enters such a system. In addition, the spaces between the individual wires can act as capillaries for water movement.

Investigations, which our office has conducted on approximately 200 post-tensioned structures, have confirmed that water can apparently enter the tendons at various locations, both during and after construction, as described on Figure 1.

1. Before and during construction, water can enter at the tendon ends or at perforations in the sheath. This can happen while the tendons are being stored or transported, or when they are lying on the formwork.

2. Until the grout plugs are completed water can enter at the anchorages into the ends of the cables.

3. After the grout plugs are installed, the grout typically shrinks. Water can enter the tendons through porosity or cracks in the grout and through cracks at the interface between the grout and the concrete. This is not only significant in below-grade situations, but can also occur at permanently exposed slab edges (such as balconies) and at other slab edges during the period preceding enclosure of the building.

4. Although post-tensioned slabs will sometimes have fewer cracks than nonpost-tensioned slabs, they are typically not entirely crack free. Water can therefore enter the tendons via slab cracks and then through perforations which may exist in the sheaths. The location of perforations apparently does not need to coincide with crack location, as it appears that water can travel along the tendons by capillary actions in the space between the concrete and the sheath until it reaches a perforation.

5. Where tendons are exposed at the top of a slab, water can enter directly at any perforation in this sheath.

Corrosion Mechanism

Once water enters a cable, the progression which we have observed in various investigations is as follows:

- Emulsification of grease.
- Pitting due to corrosion.
- Formation of microscopic cracks (stress corrosion cracking)
- Brittle fracture of one or more wires in the cable.
- Fracture of all wires in the cable.

Photographs 1 to 5 inclusive are RJC's "Standard Reference Photos" and are not from your project. These photos are presented merely to show the various stages of deterioration and to define the stages of deterioration referenced throughout this report.

The rate at which corrosion will progress appears to be highly variable from one structure to another. Factors such as the amount of water, quality of grease, amount of grease, and the chemical composition and heat treatment history of the steel would have a significant effect to the corrosion rate.

Consequences of Cable Breakage

The consequences of cable breakage are two-fold:

1. If a sufficient number of cables were to break as a result of continuing corrosion, the slab would lose its load-carrying capacity.

2. When an individual cable breaks, it can erupt from the structure. Eruption can occur at an anchorage, in which case cables have been known to project several metres out of the structure. In other cases, eruption can occur at either the top or bottom surface of a slab, where cables have been observed to erupt in a loop configuration which can project up to one metre from the surface of the slab.

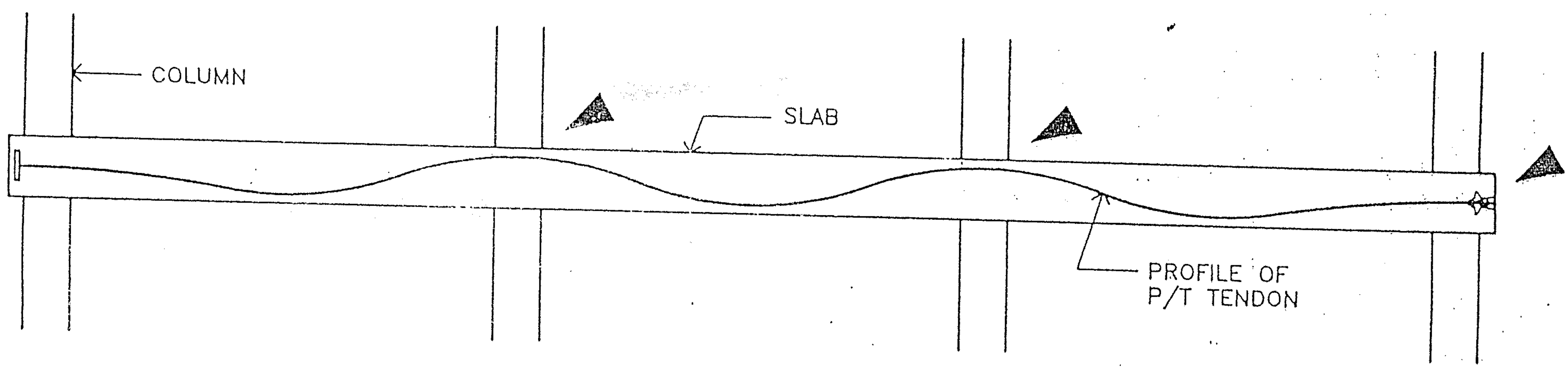


FIGURE 1

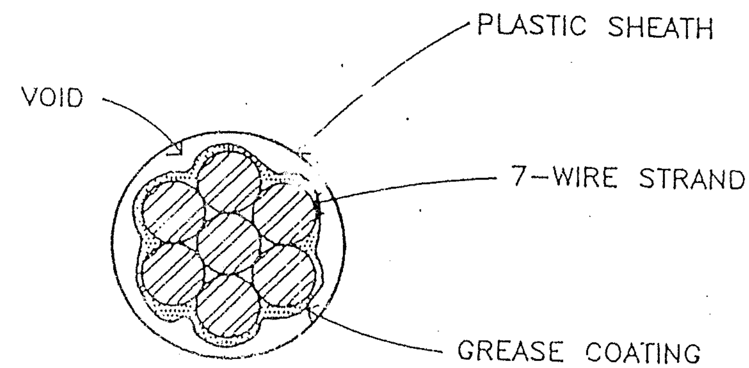
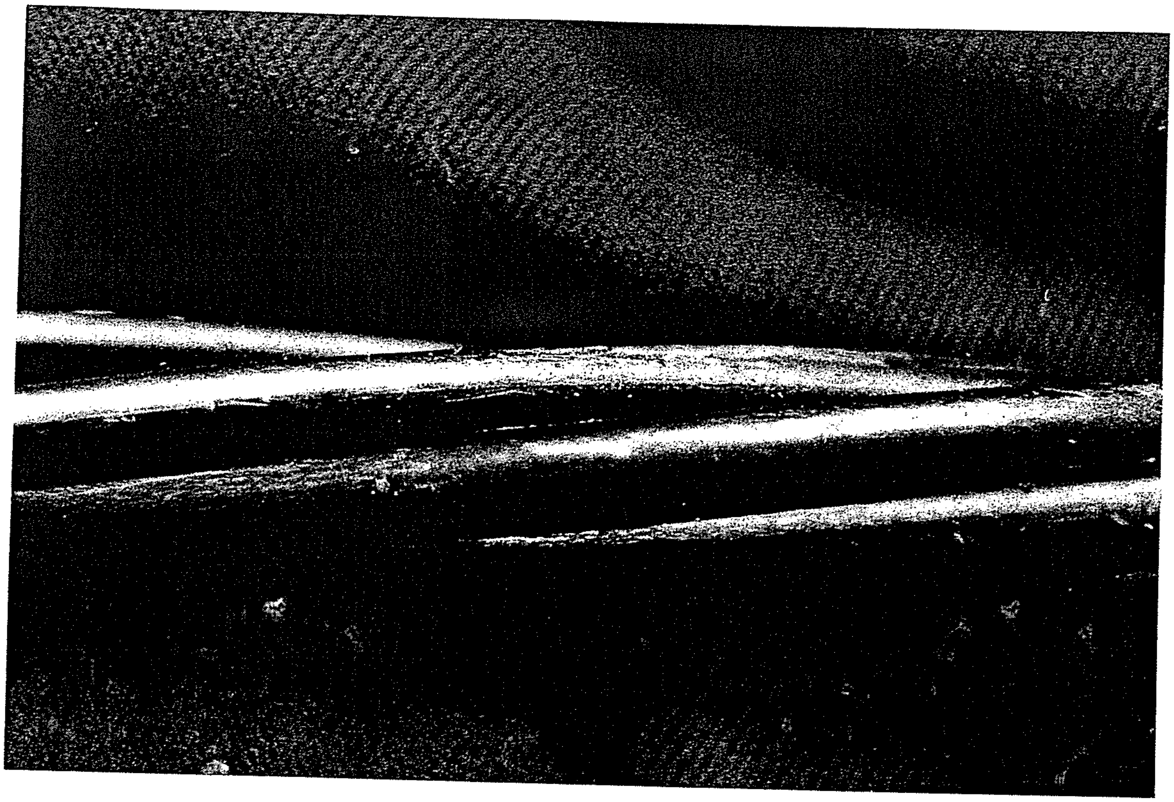


FIGURE 2 – TYPICAL STRAND

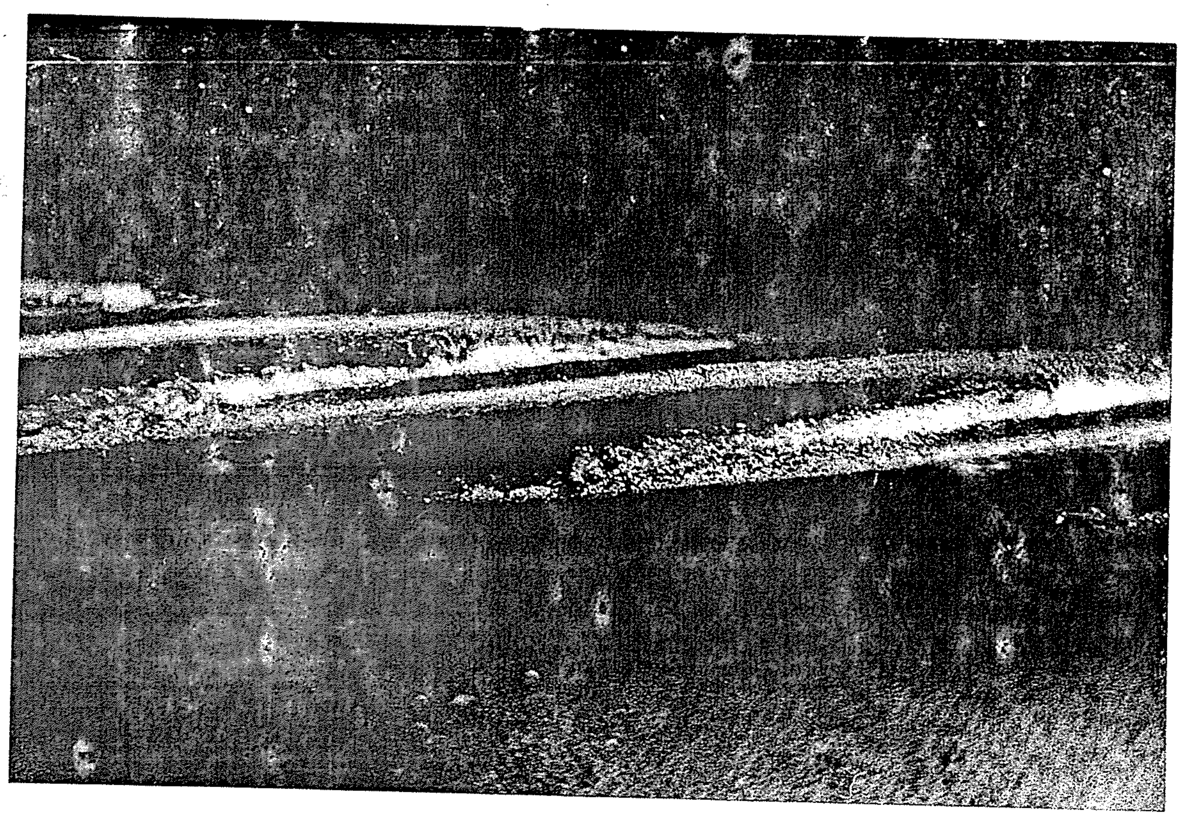
READ JONES CHRISTOFFERSEN LTD. Consulting Engineers & Parking Planners	PROJECT TITLE: POST-TENSIONING INVESTIGATION	SHEET TITLE: FIGURE 1 & FIGURE 2	FILE: JOB NO.: SHEET NO.: SK-1

APPENDIX B

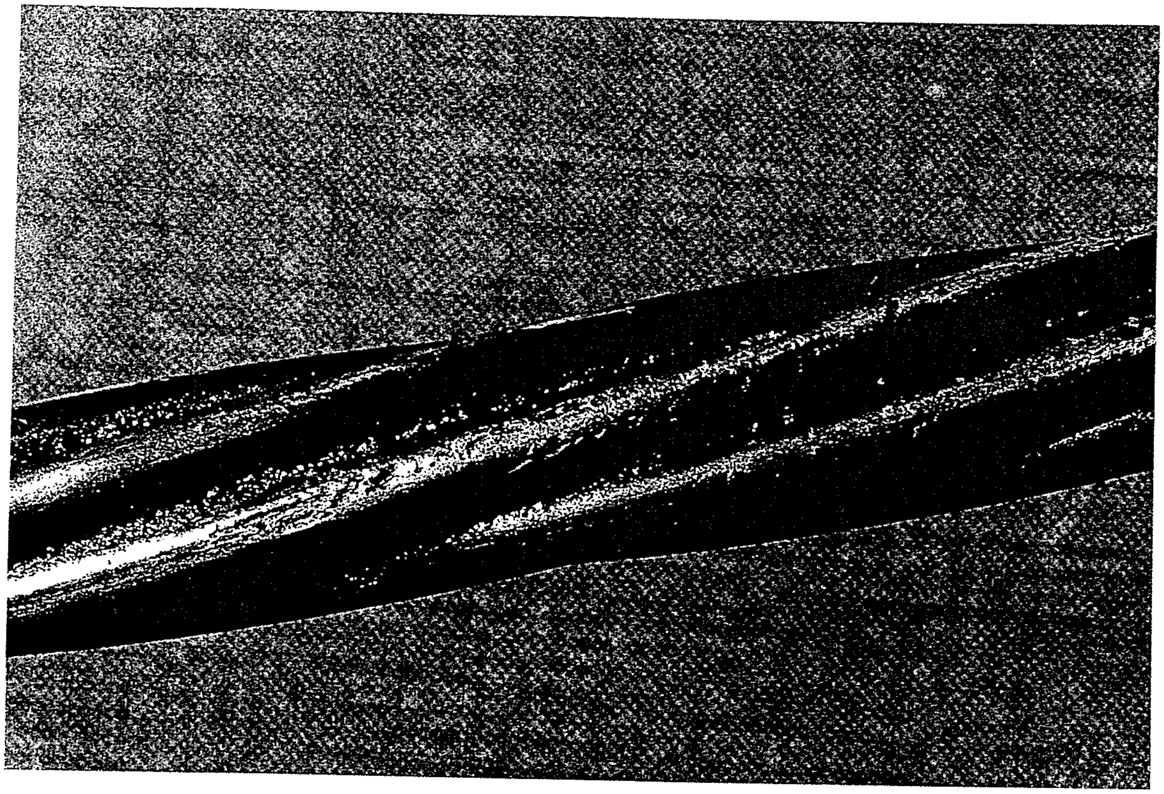
STANDARD INFORMATION PHOTOGRAPHS



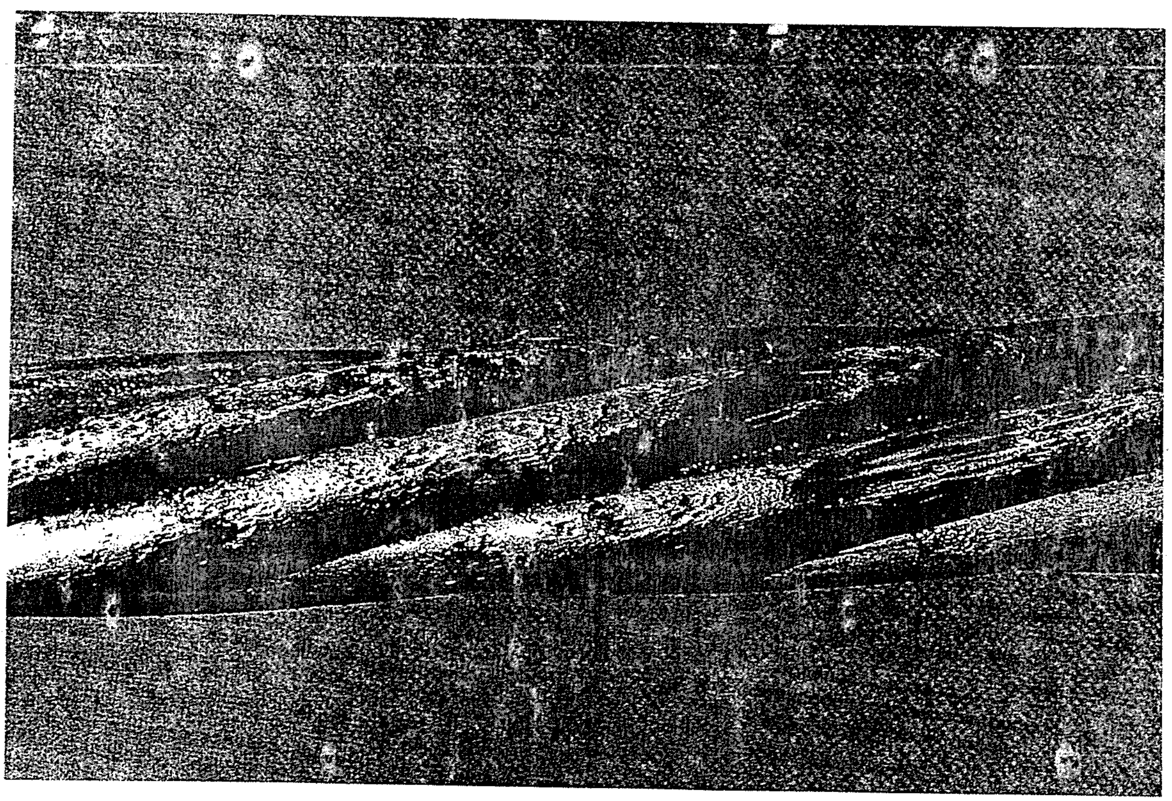
PHOTOGRAPH NO. 1
RJC STANDARD REFERENCE PHOTO
UNCORRODED STRAND



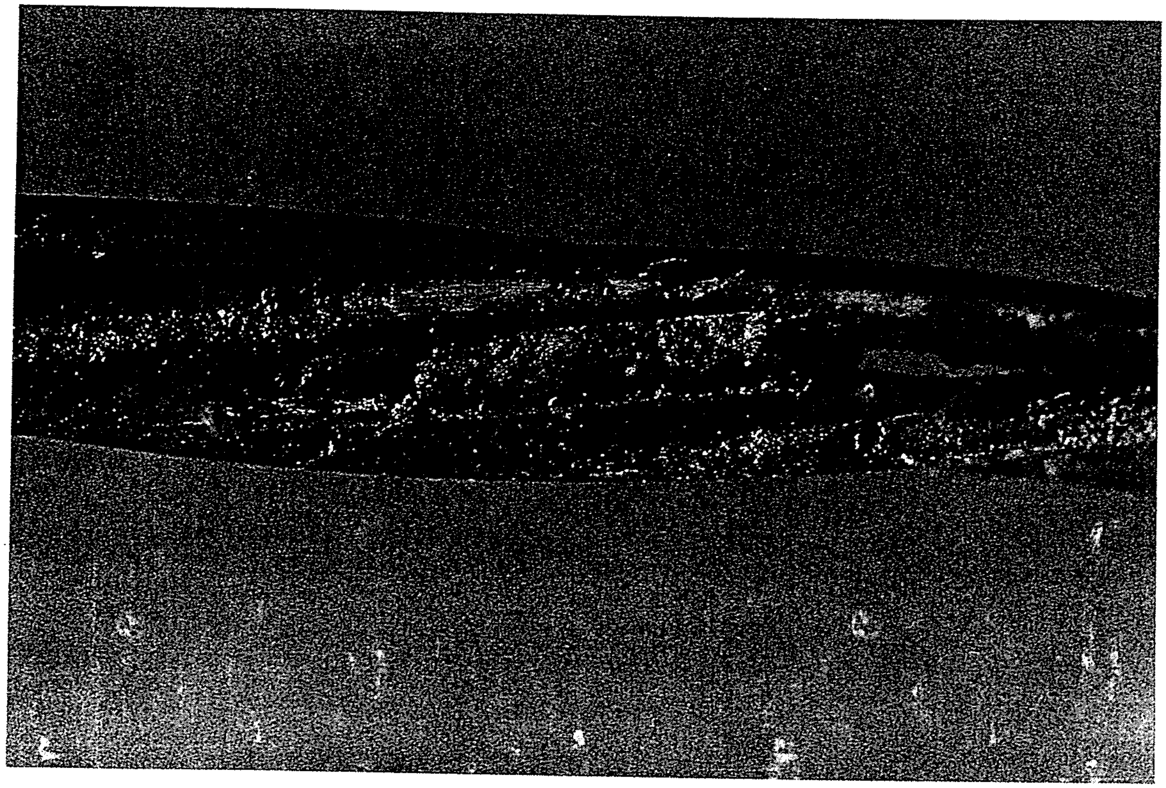
PHOTOGRAPH NO. 2
RJC STANDARD REFERENCE PHOTO
EMULSIFIED GREASE



PHOTOGRAPH NO. 3
RJC STANDARD REFERENCE PHOTO
STRAND WITH INTERMITTENT PITTING



PHOTOGRAPH NO. 4
RJC STANDARD REFERENCE PHOTO
STRAND WITH HEAVY PITTING



PHOTOGRAPH NO. 5
RJC STANDARD REFERENCE PHOTO
STRAND BREAKAGE
(NOTE THAT PITTING IS NOT DEEP)

READ
JONES
CHRISTOFFERSEN
LTD.
3rd Floor • 1285 West Broadway, Vancouver, B.C., V6H 3X8
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Web site: rjc.ca • e-mail: rjcvan@rjc.ca

FEB 0 6 2002

CP

February 6, 2002

Strata Plan NW 2184
c/o Vancouver Condominium Services
400-1281 West Georgia Street
Vancouver, B.C. V6E 3J7

Attention: Mr. Cory Pettersen

Dear Sir:

Re: Post-Tensioning Strand Eruption
Strata Corporation NW 2184 - Westhampton Court, Richmond, B.C.
RJC Reference No. 38294-01

We visited the above-referenced site on January 24, 2002 and have completed our field investigation of the Post-tensioning (P/T) strand that had erupted from the Main Floor slab. As per our November 27, 2001 proposal, the purpose of this field visit was to determine the cause of the strand failure. We were assisted by Post-Tech Construction Technologies Incorporated in the extraction of the failed strand.

The erupted strand was located near the south end of the Ackroyd Street Wing of Westhampton Court. The subject strand forms part of a group of strands (or banded strands) running in a north-south direction along a column line.

A piece of strand approximately 14' in length was extracted from the slab. The following observations were made:

- The strand failure had occurred approximately 2' north of a column support.
- Strand failure had been caused by corrosion.

Evidence of rust staining and intermittent pitting was observed along a length of approximately 2' extending from the failure point. No other evidence of moisture contact along the extracted portion was noted. The corroded portion was cut from the extracted cable and retained from future reference.

Moisture ingress into P/T systems can occur for a number of reasons. In this instance, the failure appeared to be located beneath interior residential space making it seem less likely that the moisture infiltrated after construction of the building. (For information purposes, we have included a brief discussion on durability of P/T systems and reasons for moisture ingress in the attachment to this letter.)

In light of our field observations, we recommend that an investigation of the P/T system be performed to evaluate the condition of the system in general. Given the susceptibility of this vintage of P/T system to moisture ingress, it is possible other strands may have failed without erupting or have not corroded sufficiently to fail yet.

In order to assess the present condition of the P/T system and identify any additional strand breakage that may have affected the structural capacity, evaluation of a representative number of strands would be required. This involves chipping of inspection recesses at the underside of the floor slab to expose short lengths of the embedded P/T strands. Evidence of strand corrosion or moisture present within the sheathing would be recorded and the strand tension would be checked to identify any strand failures in the test sample.

Also, we recommend that a brief design review be performed to establish the structure's capacity to tolerate strand failures. It has been our experience that many P/T structures have some inherent reserve capacity and can thus tolerate a certain level of failure before cables actually need to be replaced.

In order to perform the design review and to better perform the field investigation, structural drawings of the building would be needed. If these are not available on site, they may be available at the City of Richmond Archives. The availability of these drawings would have to be established before we could provide a fee estimate to perform the recommended services. (i.e., without the drawings, the amount of time and cost related to the investigation will increase.)

Please review the enclosed information. Should questions arise, we would be pleased to address them as necessary. Also, we have found in the past that clients who are unfamiliar with P/T system can benefit from a brief meeting during which concerns and questions can be fielded by our staff. We remain available as required to this regard.

In the interim, we remain available to provide any clarifications.

Yours truly,

READ JONES CHRISTOFFERSEN LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA J. CHAO

Feb 6/02

James Chao, P.Eng.,
Structural Engineer

Roger Steers, M.Eng., P.Eng.
Principal

cc: RJC Vancouver, Doug Clark, P.Eng.,
RJC Calgary, John Harder, P.Eng., Principal,

Encl.

DESCRIPTION OF POST-TENSIONING SYSTEM AND DURABILITY

Construction of Post-Tensioned Slabs

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At the time this project was designed and constructed, this type of structural system was considered to be durable. It was believed that the strands were protected from corrosion by the grease, the grout plugs and the plastic sheathing. The extent of vulnerability of post-tensioning tendons of the "pushed-in" type was not generally understood in Canada until the mid 1980's. And even now, it appears that some structural engineers are only just becoming aware of the durability issue.

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The consequences of strand breakage are two-fold:

1. If a sufficient number of strands were to break as a result of continuing corrosion, the slab would lose its load-carrying capacity.

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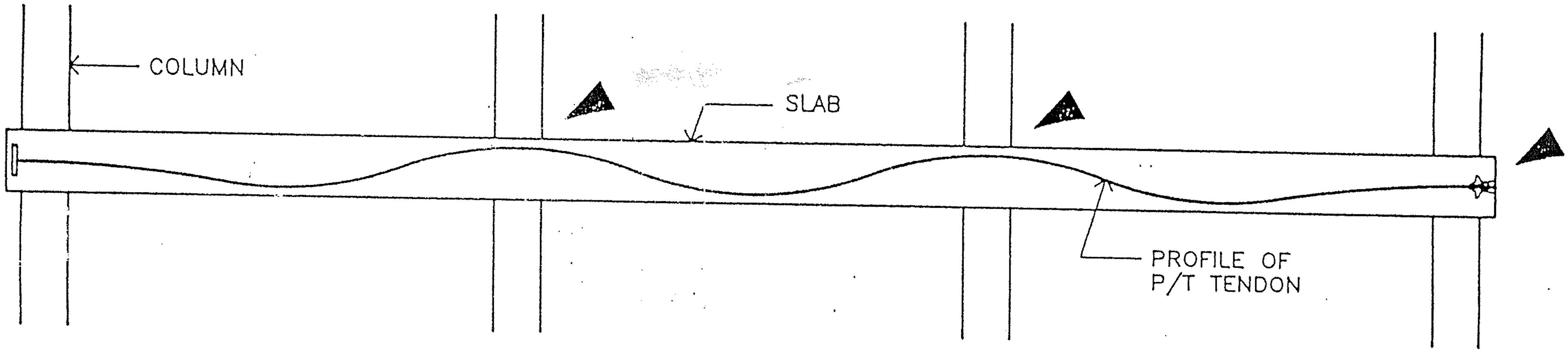


FIGURE 1

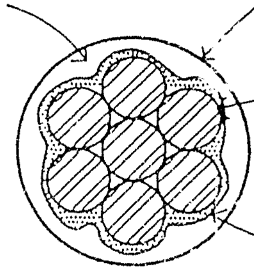
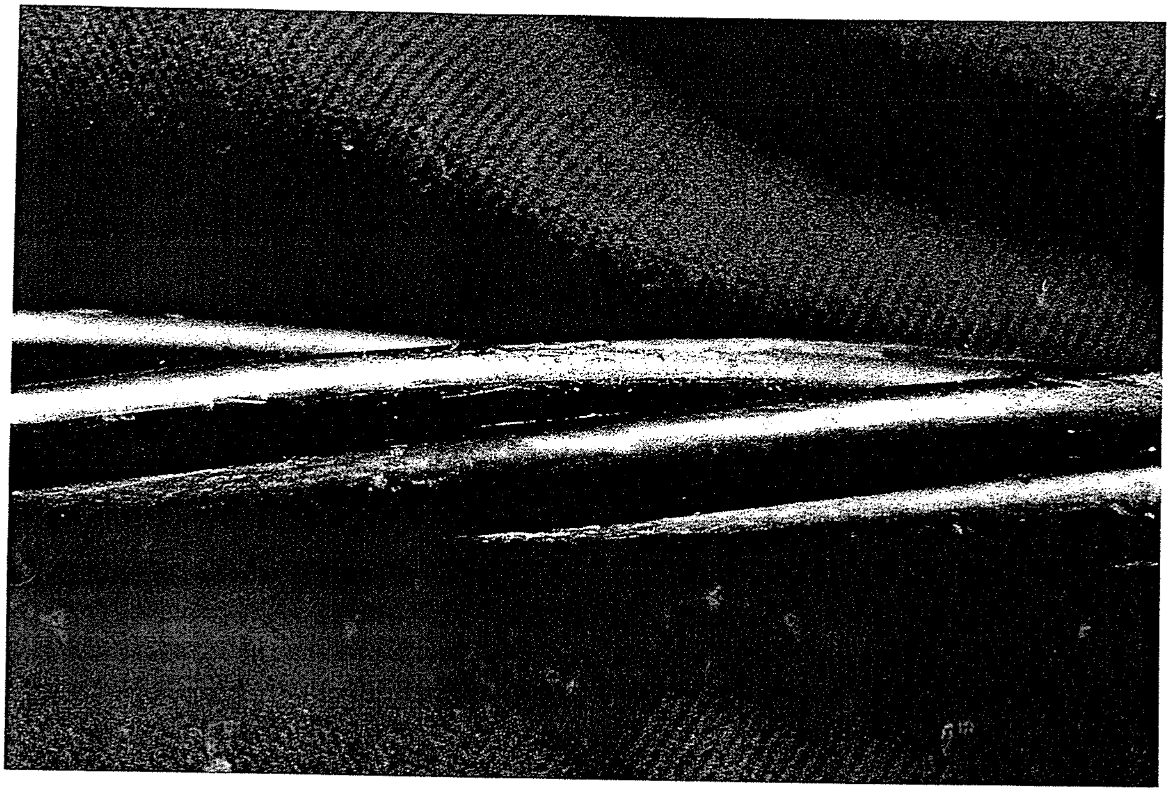
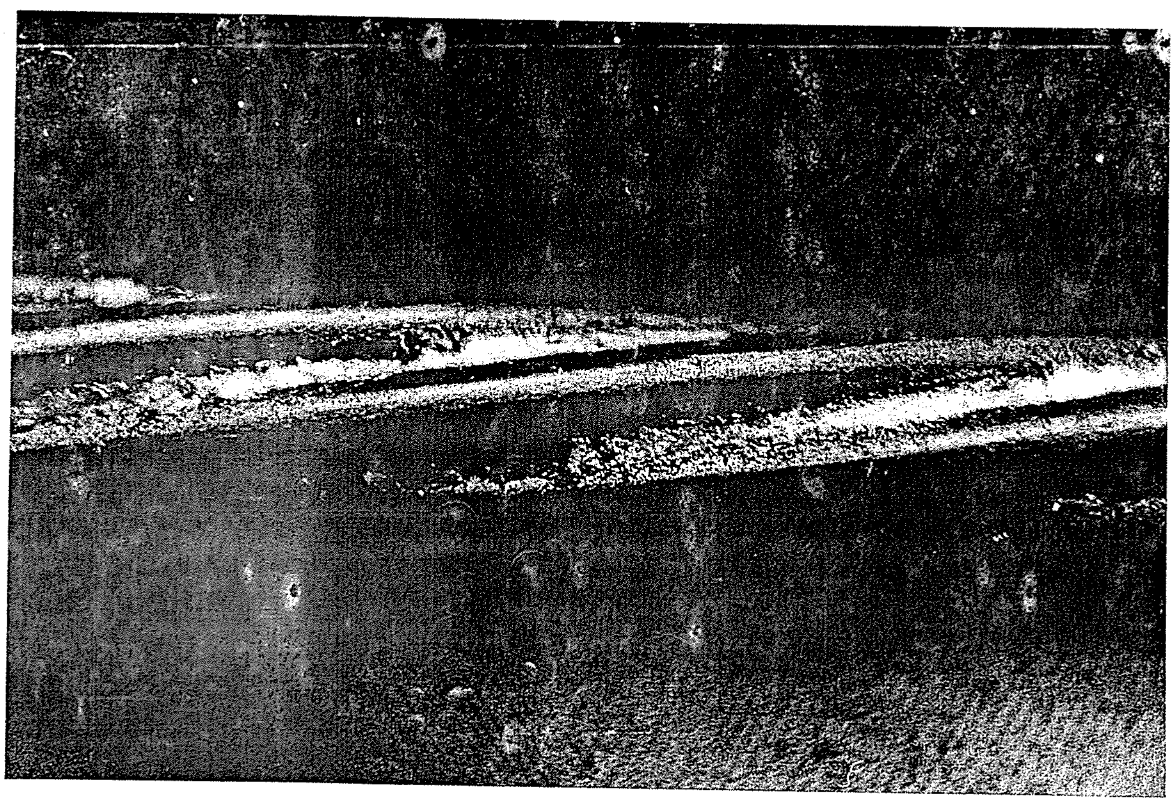


FIGURE 2 – TYPICAL STRAND

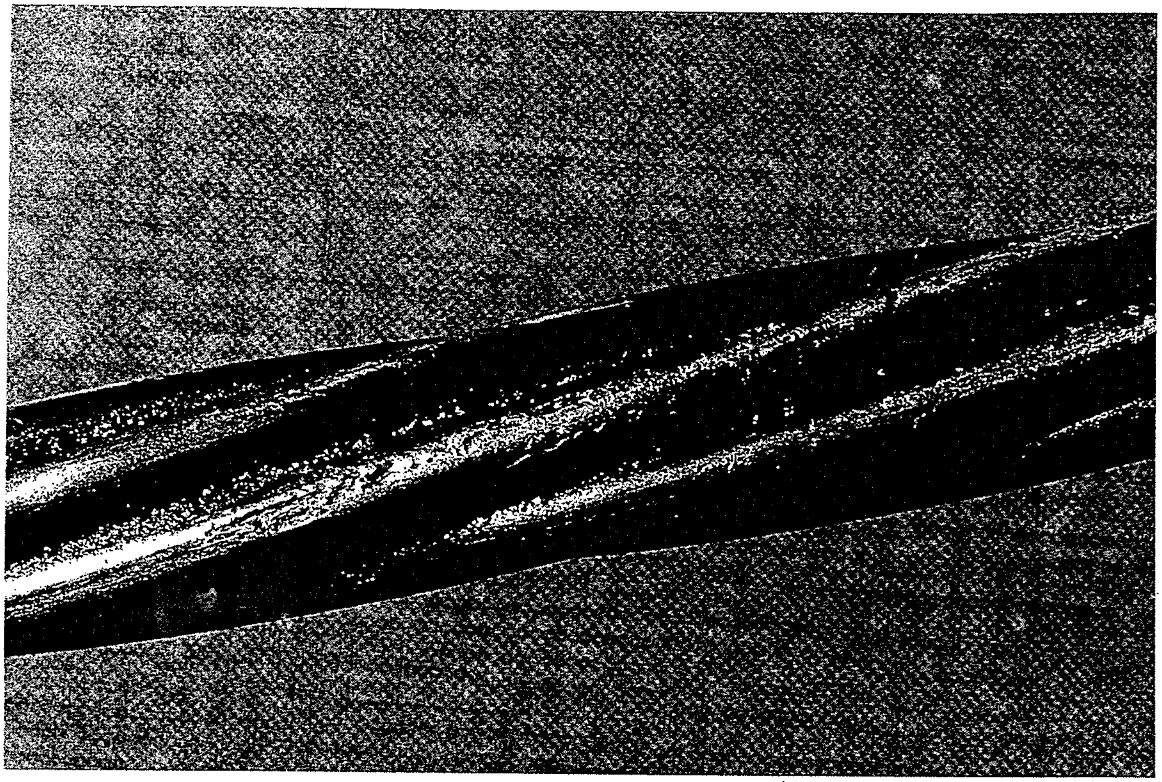
READ JONES CHRISTOFFERSEN LTD. Consulting Engineers & Parking Planners	PROJECT TITLE: POST–TENSIONING INVESTIGATION	SHEET TITLE: FIGURE 1 & FIGURE 2	DATE: JOB NO.: SHEET NO.: SK–1



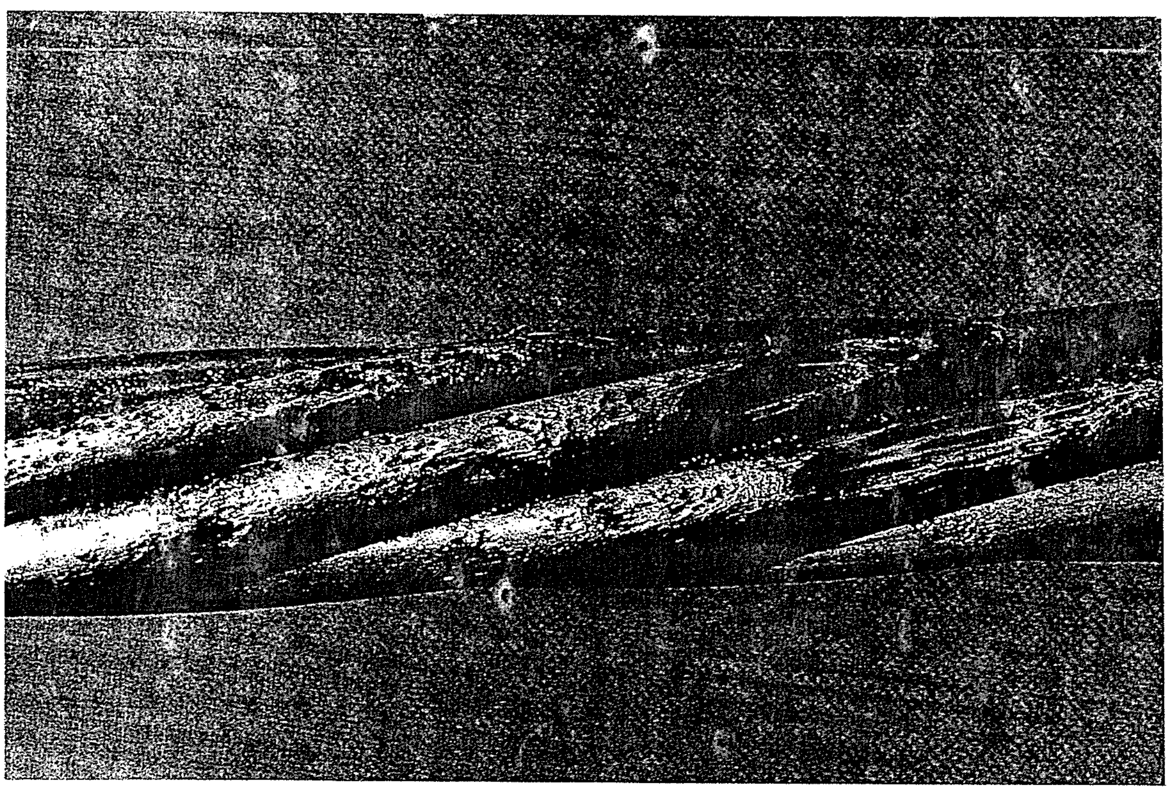
PHOTOGRAPH NO. 1
RJC STANDARD REFERENCE PHOTO
UNCORRODED STRAND



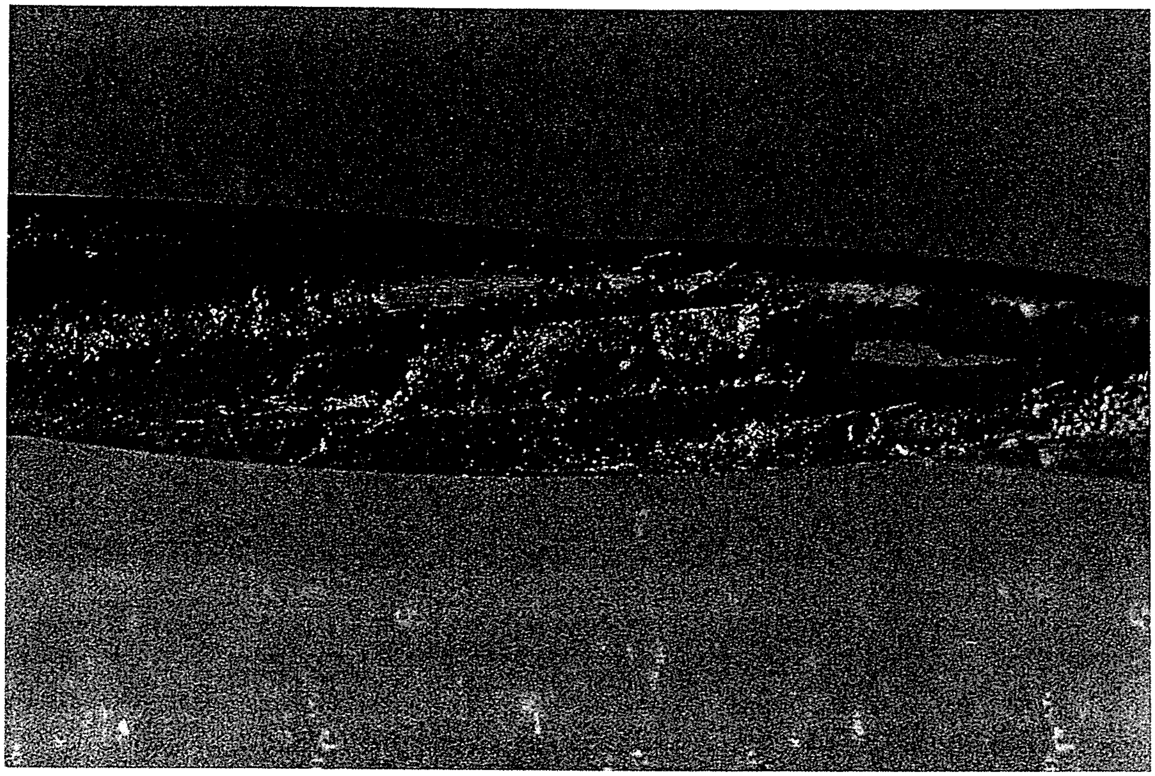
PHOTOGRAPH NO. 2
RJC STANDARD REFERENCE PHOTO
EMULSIFIED GREASE



PHOTOGRAPH NO. 3
RJC STANDARD REFERENCE PHOTO
STRAND WITH INTERMITTENT PITTING



PHOTOGRAPH NO. 4
RJC STANDARD REFERENCE PHOTO
STRAND WITH HEAVY PITTING



PHOTOGRAPH NO. 5
RJC STANDARD REFERENCE PHOTO
STRAND BREAKAGE
(NOTE THAT PITTING IS NOT DEEP)