D. Leavitt cc
Rec'd 7/28/98
Job bid by Ward - not funded

Parking Garage Study
DPW Project No.: BI-2B-034

25 SIGOURNEY STREET PARKING GARAGE

(FORMERLY XEROX CENTER)
Hartford, Connecticut

Submitted To:

State of Connecticut
Department of Public Works
165 Capitol Avenue
Hartford, Connecticut 06106

Submitted By:

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July, 1998

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THIS IS PART OF
CAP. EX. REQUEST.
DL
9/28/98

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EXECUTIVE SUMMARY

The 25 Sigourney Street Parking Garage, located in Hartford, Connecticut, is approximately thirteen years old and should be considered in fair condition. A repair and preventative maintenance program should be developed to assure the long-term durability of the structure. While no significant structural deterioration was identified, conditions exist that indicate that problems will develop in the near future due to an increased potential for corrosion related structural deterioration. The facility's drainage characteristics and various waterproofing detailing issues are all contributing factors that will impact this facility's durability.

The garage is comprised of two types of construction. The external garage west of the tower is a cast-in-place post-tensioned concrete slab. The garage slabs located below the office tower are cast-in-place two-way reinforced concrete slabs.

Although no danger of structural failure exists, a column has cracked at one location (within the tower footprint) that requires repair. Additionally, epoxy injection of several interior support columns of the external garage is required to seal cracks in order to minimize future corrosion of their reinforcing steel.

Desman's field observations and review of laboratory testing results indicates relatively low levels of chloride (road salt) contamination in the proximity of the top reinforcing steel. Both portions of the facility (i.e., below the office tower and external portions) have extremely high levels of chloride in the top one inch of the concrete deck, particularly for a parking facility of this vintage. Portions of the parking deck will be subject to a high probability of continued (and progressive) structural deterioration unless steps are taken to eliminate areas of standing water and to protect existing concrete decks with some form of waterproofing (i.e., penetrating sealer or traffic bearing waterproofing membrane).

Desman recommends that structural repairs and modifications be made to existing deteriorated portions of the concrete deck prior to the installation of any form of waterproofing membrane (i.e., traffic bearing or protected membrane). All existing floor cracks and construction joints should be reworked with joints routed and sealed with an approved two component polyurethane sealant material. Removal of all existing sealant material from all pre-existing joints and cracks will be prerequisite to proper sealant repairs and to the application of a waterproofing membrane. Cove joints also need to be installed on the supported decks at all transitions between horizontal and vertical structural elements.

The parking garage's expansion joint seals located along column line "K" are in extremely poor condition and should be replaced with appropriate expansion joints to prevent continued water leakage and subsequent structural damage. The existing pre-molded expansion joint seals are not as durable as other joint systems available and thought should be given to replacing these joints with joints of a more durable configuration. Installation of new expansion joint seals should incorporate new concrete washes and/or aprons to direct water away from the joint locations. Water should not be allowed to collect above joints.

The guardrails along the interior column line of the exterior portion of the garage are severely corroded at many locations and require repair. It should also be noted that these guardrails are not compliant with State of Connecticut building code requirements and should be updated as part of their repair. Certain points of pedestrian egress to and from the garages also present a significant safety hazard with steps located right at the door sills creating a tripping hazard; construction of an extended curb or landing in front of individual doors will be required. Those locations that might conflict with vehicular traffic may have to have flared aprons installed in lieu of raised curbs.

Other miscellaneous repairs recommended for this facility are stair tower roof repair, dry standpipe repair, drainage repair, vertical and overhead concrete repair, miscellaneous surface preparation/painting, electrical/ mechanical improvements, along with other miscellaneous facility improvements.

Desman's estimated costs associated with the repair and preventative maintenance of the 25 Sigourney Parking Garage have been broken down into Priority I & II Repairs. This allows certain flexibility in the implementation of the required repairs should the State's anticipated construction budget be insufficient to cover the actual construction costs for all work items (i.e., the Priority I & II repairs). The outlined repair priorities have been divided logically to address repairs in a specific order understanding that a delay of the Priority II repairs for as much as twenty four months will have little impact on either continued garage operation or the costs associated with the implementation of the repairs.

<u>Priority I Repair and Improvements - (Zero to Twelve Months):</u>

I. Concrete Repair:
   A. Column Repair
   B. Partial Depth Slab Repair
   C. Concrete Wash/Apron Modifications at Expansion Joints
   D. Miscellaneous Ledger Beam Repair
   E. Miscellaneous Vertical & Overhead Concrete Repair

Epoxy Injection

III. Crack, Control/Construction Joint & Cove Joint Repair
- A. Crack Repair
- B. Control/Construction Joint Repair
- C. Cove Joint Installation

IV. Traffic Bearing Membrane Installation

V. Expansion/Isolation Joint Replacement

VI. Miscellaneous Plumbing Improvements
- A. Supplemental Drains
- B. Supplemental Drain Pipe
- C. Repair Existing Drains and Drain Piping
- D. Re-route Pipe w/ Clearance Conflict

VII. Miscellaneous Electrical Improvements
- A. Relocated and/or Replace Exit Signs
- B. Emergency Lighting Improvements

VIII. Miscellaneous Coordination Work (General & Special Conditions)

Total Priority I Repair and Improvement Costs = $1,013,630.00

<u>Priority II Repair and Improvements - (Twelve to Twenty Four Months):</u>

I. Plaza Repair:
- A. Paver Removal/Replacement for Structural Deck Repair
- B. Landscape Removal/Replacement for Structural Deck Repair
- C. Plaza Deck Repair
- D. Supplemental Plaza Drainage
- E. Plaza Waterproofing

II. Concrete Repair
- A. Door Step and Landing Improvements
- B. Miscellaneous Concrete Curb Repair

III. Crack, Control/Construction Joint & Cove Joint Repair
   A. Crack Repair
   B. Control/Construction Joint Repair
   C. Cove Joint Installation

IV. Guardrail Reconstruction

V. Miscellaneous Painting Improvements
   A. Concrete & Masonry Surfaces
   B. Doors & Door Frames
   C. Misc. Metals (i.e., guardrails, piping, ventilation ducts, etc.)

VI. Stair-tower Roof Repair

VII. Miscellaneous Plumbing & Mechanical Improvements
   A. Dry Standpipe Fire System Repair
   B. Ventilation Equipment Maintenance and Repair
   C. Install New Garage Wash-Down System

VIII. Miscellaneous Electrical Improvements
   A. Supplemental Lighting Fixture Installation
   B. Lighting control Improvements
   C. Emergency Intercom Installation

IX. Miscellaneous Coordination Work (General & Special Conditions)

Total Priority II Repair and Improvement Costs = $462,500.00

Total Priority I & II Repair and Improvement Costs = $1,476,130.00

In summary, Desman Associates would recommend that repairs be implemented soon to prevent further structural deterioration and any associated increase in repair cost. Implementing repairs will not only prevent further structural deterioration and any associated increase in repair cost, they will also correct liability hazards that exist. Delay in implementing repairs, particularly those associated with liability hazards identified is not recommended.

Desman anticipates that repairs of this facility would be implemented in such a way so that approximately 15 to 20 percent of the facility's capacity would be impacted during construction with the remainder kept operational. Further reduction in the amount of parking spaces impacted during construction might increase construction costs significantly. Certain areas of this parking facility that require repair may have to be addressed during off-hours to minimize the impact on facility traffic movements (i.e., facility entry/exit areas, etc.).

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INTRODUCTION

A. Authorization

Desman Associates was retained by Department of Public Works (DPW) to provide consulting services to conduct a condition survey/appraisal of the 25 Sigourney Parking Garage located in Hartford, Connecticut. The condition survey and assessment of the facility was performed in accordance with the requested scope of services outlined in DPW letter dated April 13, 1998 regarding project BI-2B-034.

B. Scope of Services

The basic Scope of Services are outlined in detail in the above reference proposal. In summary, the services primarily consist of the following:

1. Review of existing design documents and drawings supplied by the Owner.
2. Visual inspection of the parking facility.
3. Perform limited field tests to determine both the extent and causes of deterioration to the structural framing and supported floor slabs.
4. Review laboratory test results to verify the existing concrete's physical properties and the extent of chloride contamination.
5. From the evaluation of the data obtained (as described above) prepare a report documenting the results of our investigation along with an outline of the recommended course of action. Desman will meet with representatives from Connecticut DPW and their property manager to further review the garage restoration and repair recommendations, and discuss potential repair program phasing options should they be required.

C. Objective

The objective of the condition survey performed by Desman Associates is to document the various types of deterioration existing in the 25 Sigourney Street Parking Garage and make appropriate recommendations for prioritizing and implementing these repairs. It is important to note that repair of an existing deteriorated structure will extend the service life of the structure. However, certain types of deterioration, such as chloride contamination, are irreversible and may require additional repairs in the future.

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DESCRIPTION OF THE STRUCTURE

The 25 Sigourney Street Parking Garage, located in Hartford, Connecticut was build in 1986 and is integrated with an office tower of the same address. The facility's main function is to service the parking needs of this state office building, formerly known as the Xerox Center.

The freestanding portion of the garage is a 6 level structure with 5 supported levels and one at grade. The garage under the tower has four levels comprised of three supported levels and one at grade. The freestanding garage structure is primarily comprised of post-tensioned concrete deck supported by cast-in-place concrete columns and cantilever beams, and is separated by expansion joint from the tower building. Within the office tower foot print nine-inch thick two-way reinforced concrete decks with five-inch drop panels are support by columns spaced generally on a thirty foot column grid. Garage floor plans (see appendix C) provide addition detail regarding the configuration of the two structures and their orientation to one another.

Employee and visitor vehicle access to the facility is provided directly to and from Sigourney Street (via ticket or keycard) with additional employee access to the garage from Woodbine Street (via keycard access).

The external post-tensioned (PT) portion of the garage is constructed as a two bay system with the southern bay being ramped and the northern bay being flat (i.e., constructed with only nominal slope to storm drain locations).

Pedestrian access between parking levels and the street level is provided by elevator and stair towers within the tower building footprint and by a stair tower on the Woodbine Street side of the garage at its southwest corner.

The parking facility is illuminated by high pressure, sodium (HPS) light fixtures that appear to provide sufficient lighting, but certain areas of the garage might be improved through the installation of supplemental light fixtures to increase ambient light levels. These areas include areas of potential vehicular traffic conflict or similarly those areas with vehicular and pedestrian traffic conflict.

Desman noted that some of the exit signs over doors at the southwest stair core are too high to be viewed from a distance. Signs become obstructed by building structure or various mechanical equipment and piping and should be move to improve lines of sight.

Facility deck drainage is provided by floor drains located along the perimeter of each level and at strategic interior locations below the office tower portion of the garage. Floor drains a typically spaced at intervals of approximately fifty feet. Although most floor drains appear to functioning properly, several areas of standing water exist that need to be addressed through the installation of additional supplemental drains and drain piping.

Several drain line locations were identified as being damaged by what would be characterized as being caused by water freezing within the pipe. Water might not be draining through the individual pipes in these locations due to a lack of adequate slope (i.e., 1/8 inch per foot) or due to accumulated debris within the pipe. Unless there is an ongoing maintenance program to do so, all drains and drain lines need to be cleaned and flushed periodically. Evidence of condensation was noted on some large vertical drain lines that could be minimized by the installation of insulation. Several areas of either damaged or missing pipe insulation were identified that should be repaired.

Most levels of the garage are piped with water supplied to four locations, but this system does not supply sufficient volume or pressure for a completely successful wash-down of the parking decks. The elimination of accumulated chloride requires a significant quantity of water and the installation of a dedicated pressurized wash-down system is strongly recommended to maintain this property adequately.

The 25 Sigourney Street Parking Garage is an enclosed mixed-use facility built integrally with the tower building and requires both mechanical ventilation and automatic fire suppression equipment.

Level P1 of the exterior portion of the garage is ventilated by four propeller fans that discharge into dedicated ventilation shafts or areaways. The tower portion of Level P1 is served by a ducted exhaust system that is routed to an axial exhaust fan located in a Level 3 mechanical room. Similarly, Levels P2 and P3 are served by ducted exhaust systems that are routed to dedicated axial exhaust fans in the same location. According to maintenance staff, this mechanical equipment is maintained regularly and operates satisfactorily. Ductwork and air inlets appear to be in good condition. Fans are controlled based upon readings of carbon monoxide sensors located throughout the facility. Carbon monoxide levels are routinely measured in the garage to confirm proper system operation. No major repairs to the existing ventilation system aside from routine maintenance (i.e., cleaning of air inlets and sensors to help system performance) should be anticipated at this time.

Basic traffic flow within the garage is two-way with 90-degree parking. Some parking (approximately 20% of the total) is posted as compact with the balance being standard sized spaces.

With the exterior portion of the parking garage footprint being approximately 233' x 119', there is about 26,500sf of usable parking on each level of this section of garage. The usable parking area of the tower portion of the garage varies from level to level, a summary of the garage's usable floor area per level is provided below:

Level Designation	Tower Portion of Garage	Exterior Portion of Garage
P1	33,425 SF	26,500 SF
P2	30,025 SF	26,500 SF
P3	33,075 SF	26,500 SF
P4	33,500 SF (w/ Plaza)	26,500 SF
P5	N/A	26,500 SF
P6 (Roof)	N/A	15,000 SF
Supported Area	**96,600 SF**	**121,000 SF**
Slab-on-Grade Area	**33,425 SF**	**26,500 SF**
Total Floor Area	**130,025 SF**	**147,500 SF**

Combined Floor Area for the 25 Sigourney Street Garage

Supported Slab:
217,600 SF

Slab-on Grade:
59,925 SF

Total Floor Area:
277,525 SF

Parking Capacity:

Standard	838 spaces
Handicap	14 spaces
Handicap Van	4 spaces
Total Parking Capacity	**856 spaces**

Documents review were:

Original Structural Drawings
Original Architectural Drawings
Original Mechanical, Electrical and Plumbing Drawings

Documents not available for review were:

Shop drawings for PT reinforcing or mild reinforcing.

INVESTIGATION AND EVALUATION

Desman Associates has undertaken the investigation and evaluation of the existing conditions of the 25 Sigourney Street Parking Garage for the Department of Public Works (DPW). The purpose of this investigation and evaluation is to establish the condition of the facility for the purpose of identifying areas of deterioration and potential future deterioration for the development of a program of repairs to extend the useful service life of the facility. Safety related issues (i.e., hazardous conditions, potential liability exposures, etc.) were also addressed. The tasks associated with this evaluation include the review of all available construction records, inspection of the facility, material testing, and data evaluation.

The initial task of Desman's investigation was to gather together all available information regarding the original construction and any previous repairs to the facility that may have been performed. The review of existing construction documentation enables Desman Associates to identify the specified requirements of the existing construction and evaluate this information with respect to general practice, code requirements, observed deterioration and potential future deterioration. This review also provides valuable insight regarding the structure prior to the start of the field investigation portion of the work allowing Desman personnel to focus their attention more efficiently.

The second task associated with the performance of this condition appraisal consists of an inspection of existing conditions. The inspection efforts concentrated mainly upon the structural systems of the garage, but include various other building components and systems that were visually inspected and commented on.

The documentation and reporting of existing conditions will be presented with respect to each structural component or item, and includes a brief discussion of our field observations. The following is a summary of those items observed.

Concrete Column

In a previous walk through of the parking facility that Desman Associates performed for the State of Connecticut in 1994 a cracked column at column line N-12 level P4 (elev. 70ft) near the Sigourney Street entrance was identified.

The condition of this column observed during this most recent condition assessment has not changed significantly from previously documented conditions. Two #10 vertical corner bars are bowed out, creating vertical cracks in the concrete column. The cracking extends up to approx. 5 feet above the floor (reference photos 8,9 & 10 in Appendix "B"). Structural drawings indicate that in this vertical distance 14 -#10 bars are splicing into 16-#10 bars. This lap compression splice distance ("LCS" on the original design drawings) is designed to be 38 inches for #10 bars. At the slab level (the slab is 14 inches thick at the column) the 14-#10 bars end and the 16-#10 bar configuration is designed to carry the additional vertical loads imposed by the slab at elevation 70.

Pachometer readings (magnetic non-destructive testing used to identify embedded reinforcing steel) indicate that steel ties designed to wrap the four corners of the column at 18 inch vertical spacing exist except where the two bars, described above, are bowing. Pachometer readings indicate the steel tie at failure point is wrapped around the two interior bar splices located just north of the corner bars (i.e., steel ties do not engage the bowed steel reinforcing). A tie running north south in the center of the column does exist however that typically ties a vertical #10 bar located between the two bowing bars; observations are consistent with this center tie being in place at this area of concrete failure.

Desman Associates recommends that repairs to this failed column be implemented to tie in the existing #10 corner reinforcing bars to prevent further bowing in the steel due to continued creep (shortening) of the concrete column over time. Repairs will consist of constructing a reinforced concrete jacket around the existing column to restrain future deflection or bowing of the #10 vertical corner bars. Suggested repairs are not expected to intrude into existing drive lanes or to impede traffic movement at the P4 level of the garage. No modification of this particular column is expected to be required on any other of the parking levels or in the structure located above.

Supported Concrete Slabs:

Tower Building Garage:

The parking structure integral with the tower building with its two-way reinforced parking slabs is in fair structural condition; there is, however, extensive radial flexural cracking around column supports. Crack sealant within the majority of these cracks is failing (aging) and needs replacement. Additional cracks that have not been sealed to date need to be properly routed primed and then sealed. If left alone open cracks in a two-way flat slab will allow chloride laden moisture to infiltrate down to the level of the structures reinforcing steel. The resultant accelerated corrosion and subsequent concrete deterioration will drive an exponential cost curve regarding future repairs.

Use of two-way reinforced concrete flat slabs for garage construction is typically not recommended due to its propensity for cracking in the negative moment regions of the deck. Use of smaller diameter reinforcing steel and closer bar spacing can sometimes minimize the extent of cracking experience, but not eliminate it entirely. Current ACI recommendations for two-way reinforced flat slabs for garage construction recommends not only an increased amount of concrete cover above the reinforcing steel (2 inches minimum), but also the use of some form of waterproofing membrane system (i.e., traffic bearing or protected membrane waterproofing system.

Where office floors are located above the garage a slab heating system is provided in the slab and insulating ceiling panels (visible from within the garage) are installed to minimize heat loss. Certain areas of the insulating ceiling panels are showing signs of moisture penetration from the plaza area (northeast quadrant of tower building).

The tower building parking slab thickness is typically 9 inches thick, with and additional 5 inch thickness at 10 foot square drop panels around columns, though some drop panels may vary in overall dimension dependent upon their location. Slab thickness at the supported plaza area may also vary slightly from the garage construction, typically being around 12 inches thick. The facility's slab construction was designed with a 5,000-psi compressive strength material.

Spandrel reinforcing between columns is present in the slab, in addition to the typical two way embedded slab reinforcing. The supported slabs are designed with negative moment reinforcing around columns while providing the recommended 2 inch minimum concrete cover, but for reasons stated previously cracking in the deck's negative regions still remains a problem. Cracking observed is likely the result of flexural action due to imposed live loads as the negative moment reinforcing engages in tension tending to open cracks in the surface of the deck. The structure's own weight (dead load) may have also created open cracks in the negative moment regions of the deck.

Exterior Garage:

The post-tensioned (PT) exterior portion of the garage is constructed with two slab thicknesses of 6 inches and 8 inches. The thicker portion of the deck at the west-end of the structure, specifically the transition and/or turning area at the end of the structure between parking bays.

PT strands run east to west, transverse to supporting cast-in-place cantilever beams, and consist of ½ inch diameter 270 ksi low-relaxation strands anchored at the ends of the slab and at construction joints.

One post-tensioning strand located along column line 5 has popped (see photo). This strand should be cut back to below the floor and the floor repaired to eliminate any additional water infiltration to adjacent strand. Because of the location of this damaged PT strand, the structure is not threatened by this localized failure, however it is strongly recommend (as noted elsewhere) that a membrane be installed to help minimize or prevent further problems such as this.

Historic repair on the west-end of P4 involved placement of a thin concrete overlayment material on top of the existing slab. This unsuccessful repair was apparently meant to increase concrete cover above pre-existing PT strands or to eliminate standing water by directing water to existing drain locations. A combination of repairs shall be required to extend the useful service life of this entire facility inclusive of concrete deck repair and will include surface scaling repair, installation of supplemental drains and the installation of an approved waterproofing membrane system.

Observations of garage ceilings particularly at the west end of the facility where the slab is eight inches thick, indicates significant cracking and continuous water infiltration into and through the concrete deck as evidenced by the presence of with efflorescence on the bottom surfaces of the deck. This is the same area that Desman observed with significant standing water or ponding above and is a likely candidate for the addition of supplemental drains to tie into the pre-existing storm drainage system.

Mild embedded reinforcing that runs transverse to the cantilever support beams was constructed with too little concrete cover in a few areas. Historic repairs to these areas have involved the installation of epoxy patches (see photos) that have performed somewhat satisfactorily, but now require attention. Several new bar exposures are now observed and require repair.

The installation of a waterproofing membrane system would be advantageous for the protection of this parking deck. The post tensioned portions of this facility's supported concrete decks exhibit significant extensive cracking in the negative moment regions of the deck's cantilevered exterior bays. Additionally, the typical cracking pattern that runs parallel to the direction of the PT strand is not minimized by post-tensioning techniques, nor has the historic routing or sealing of cracks been entirely successful in eliminating continued chloride contaminated moisture intrusion into and through the deck.

While PT parking decks ordinarily have minimal cracking, the extent of cracking in this facility is a concern from a durability standpoint. Noting the age of this parking structure, its level of chloride contamination, the existence of standing water, of full depth water penetration, lack of adequate concrete cover, and the quantity of exposed reinforcing steel and PT strand, there are few options available to prolong the useful life of the facility. The most viable option will be to install some form of waterproofing membrane system.

The supported concrete decks are exhibiting three (3) basic types of deterioration mechanisms:

1. Corrosion induced concrete spalling and delamination due to elevated levels of chlorides (road salt) in close proximity of reinforcing steel.

2. Increased damage due to freeze/thaw of water collecting at the interface between sound concrete and previously damaged or repaired concrete (reference item no. 1 above).

3. Freeze/thaw induced surface scaling due to concrete carbonation and lack of sufficient concrete air-entrainment.

The current state of structural deterioration that has been experienced within this facility has not impacted the load carrying capacity of the supported decks, but conditions should be monitored periodically until repairs are implemented. The elimination of continued moisture and chloride intrusion through the use of approved materials is strongly recommended.

- **Average chloride ion contents** found at various locations of the supported deck and/or elevations within the concrete topping are generally higher than would be expected for a facility of this vintage (approximately 10 ½ years old). The average chloride content at the level of the reinforcing steel was found to be a bit lower or right at the threshold limit necessary to support active corrosion of any embedded ferrous materials (i.e., reinforcing steel, shear connectors, bearing assemblies, electrical conduit, etc.) in the concrete. Chloride levels in the top one-inch of concrete were found to be significantly higher than the threshold limit indicative of an increased potential for continued and progressive structural deterioration.

- **Petrographic** results and visual observations indicate that the overall quality of concrete should be considered as only fair to poor. Cement paste being judged as dense and hard with a poor paste to aggregate bond. Problems associated with freeze/thaw damage, continued chloride intrusion and surface abrasion due to vehicular traffic can be expected due to the concrete's lack of air entrainment, depth of surface carbonation and the large amount of bleed water void space indicative of both re-tempering of the concrete and over finishing.

- Depth of surface carbonation was determined to be up to approximately 1/4 to 7/8 inches from the concrete top surface. Surface carbonation is a progressive reaction between carbon dioxide and calcium hydroxide within the concrete matrix that weakens the concrete's surface creating a condition for increased moisture penetration and surface damage due to abrasion and cyclical freeze/thaw.

- Surface scaling and the erosion of the cement paste exposes aggregate from within the concrete matrix particularly in those areas constantly exposed to moisture (i.e., exposed roof deck, areas of standing water, areas near floor drains, etc.).

- Corrosion related concrete spalling amounts to approximately 2,000 SF or somewhat less than 1% of the total supported floor area. This amount of concrete repair does not include those areas of concrete repair that would be associated with expansion joint repair (i.e., modifications required to existing concrete blockouts to accept new expansion joint seals).

- Existing expansion joints at column line K at the separation between the exterior portion of the garage and the tower portion (see floor plans) have reached the end of their useful life or are failing prematurely due to poor installation and/or detailing during the facility's original construction. Moisture penetration has resulted in minor concrete failure, minor overhead concrete deterioration and potential damage to patron's vehicles parked within the garage.

- Limited areas of damaged or delaminated concrete need to be removed then replaced with a high quality, low water/cement, fiber reinforced, concrete. Repair areas shall be square and true both in plan and section to insure proper performance. Repairs shall be performed to limit the number of re-entrant corners (i.e., repair areas shall be square and/or rectangular in plan), with their perimeters properly routed and sealed. Control joints should also be provided above pre-existing control joints to address reflective cracking through newly repaired areas.

- Surface scaling should be repaired using appropriate polymer modified concrete repair material. Removal of damaged concrete surfaces down to sound substrate shall be required as will the provision of an adequate keyway around the repair area perimeter (thus preventing a feathered edge in the repair material). The creation of control joints above pre-existing joints is again required. Similar repair techniques might be utilized in an attempt to redirect standing water to existing floor drain locations or perhaps locations of new supplemental drains.

- Existing and/or subsequently repaired concrete topping areas should be protected through the use of traffic bearing waterproofing membrane. Use of traffic bearing waterproofing membrane is recommended in lieu of penetrating concrete sealer. Membrane is not only more effective as a chloride screen than penetrating sealers, they can bridge smaller cracks in the concrete (penetrating concrete sealers do not), and they protect joint sealants from traffic damage prolonging their useful life.

- Neoprene bearing areas (where the PT garage sits on ledger beam at column line K) should be cleaned and inspected during overhead repairs performed in this area. This is advisable to ensure continued unrestrained movement resulting from imposed loads and/or thermal movements due to temperature variation.

Miscellaneous Vertical & Overhead Concrete Deterioration

Various areas of vertical and overhead concrete deterioration exist (some mentioned previously) which need to be addressed. Additionally, some conditions exist related to the original construction where plywood forms, foam backing material and concrete over-pour were left in place. These should all be removed to prevent the potential for falling debris, and then all exposed concrete surfaces repaired as required.

Repairs described under this item should be considered as non-structural, repairs that address either liability hazards due to falling debris or cosmetic damage (i.e. minor concrete spalling). Performance of this work along with the elimination of future water intrusion (Reference Sections on Waterproofing Membranes, Penetrating Sealer, Crack Repair, Construction Joint Detailing and Expansion Joint Repair) should protect existing reinforcing steel from further corrosion and concrete deterioration and spalling.

Epoxy Injection

Cracking in various structural components may be effectively repaired and protected through the use of pressure epoxy injection. Several columns along column 5 (at upper levels of the exterior portion of the garage) have cracks requiring epoxy injection repair. Moisture penetration into and through these cracks was identified by traces of mineral deposits and efflorescence present along their length. Epoxy injection should alleviate concerns of continued chloride contaminated moisture intrusion along with problems related to freeze/thaw.

Crack & Construction/Control Joint Detailing

- A number of cracks were identified in the ceilings of both the PT garage and the two-way flat slab portion of the garage that need to be repaired through the use of properly detailed two component polyurethane joint installed in the individual slab's top surfaces. Much of this cracking through the individual slabs shows evidence of full depth water penetration and efflorescence (chloride and associated mineral deposits) all of which may be indicative of steel corrosion taking place within the slab.

- Water leakage through the deck has resulted in efflorescence, concrete deterioration, and damage to electrical conduit and lighting fixtures. Water penetrating concrete decks can pick up various minerals from within the concrete matrix that can be harmful to vehicle windows and paint finishes if left unchecked.

- Water leakage into and through concrete decks via unsealed cracks and construction joints carries chlorides down to the level of the reinforcing steel and PT strand creating an environment for increased structural deterioration and eventual loss of the deck's load carrying capacity.

- Previously routed and sealed cracks and/or construction/control joints are showing signs of progressive failure and have probably reached the limit of their useful life. All cracks and joints need to be re-worked in their entirety to remove existing sealant material then have approved two component polyurethane sealant installed.

- Detailing/profiling of construction/control joints edges of adjacent concrete placements or previous concrete repairs is required to remove jagged concrete and to provide joints of appropriate dimensions for the installation of approved two component polyurethane sealants.

- Shot-blasting of all decks and ramps prior to application of traffic bearing waterproofing membranes will be necessary in identifying all cracks and joints requiring attention.

Cove Joint Installation

- Sandblasting of the concrete and masonry surfaces prior to the installation of cove joints at the transition between all horizontal and vertical surfaces (i.e., perimeter parapet walls, stair enclosures, elevator enclosures, miscellaneous room enclosures, columns, curbs, slab penetrations, etc.) is required.

- Joints existing between the exterior parapet walls and various stair and elevator enclosures are showing signs of progressive sealant failure having likely reached the limit of their useful life.

Expansion/Isolation Joints

- All expansion and isolation joints within this facility are in various stages of failure and are not capable of performing their intended function of allowing differential thermal movements within the structure or providing a watertight seal. Existing expansion joints require total replacement with a proper watertight and traffic bearing joint. Left alone, water leakage through the existing joints will start to have an adverse impact on various structural components located below, including PT anchorage elements. Several of the existing expansion joints also present significant tripping hazards in their present condition.

- Modifications to existing concrete blockouts to accept new expansion and isolation joint seals will be required to provide sufficient concrete blockout profile or dimension to assure long term performance of any joint approved for installation. The expansion joint manufacturer of any approved replacement joint will be expected to provide written approval of concrete blockout modifications and surface preparation prior to the actual joint installation.

- Expansion and isolation joint termination details will require modification with input from a qualified engineering consultant.

Traffic Bearing Membrane Installation & Penetrating Sealer Application

The use of a protected waterproofing membrane with a bituminous concrete overlay would be a preferred method for waterproof this parking deck, but has limited application in this particular case due to the imposed dead loads that would be added to the existing structure. The only alternative for protecting both portions of the garage is the application of a thin-type traffic bearing waterproofing membrane system.

Some concerns have been voiced with the ability of various deck coatings to withstand UV degradation, but it should be noted that most manufacturers have developed their technology to the point where this is becoming less of a concern. Additionally, UV degradation even if it were to be an ongoing concern with a membrane's long term performance, it should be noted that replacement membrane is far less expensive than the costs associated with concrete deck repair if a membrane were not installed.

The efficiency and/or long term benefit of installing an approved deck membrane will necessitate comprehensive routing and sealing of all cracks and construction joints. Detailing of waterproofing is critical to its successful performance.

If traffic bearing waterproofing membrane is not used immediately, future consideration should be given to its use. It is Desman's professional opinion that installation of a waterproofing membrane will become an absolute necessity for protecting this deck in the next two to three years If delayed any longer significant and costly deck repairs will be required.

Stairs/Handrails

- The concrete stairs that service this facility are in good condition. Only minor painting is suggested as a possible improvement to the interior of the southwest stair tower.

- While the garage stair handrails are in good condition, these handrails need to be updated to meet current building code requirements at some point.

Inspection of architectural detailing on the stair-tower roof and its exterior facade indicates that consideration should be given to making repairs to the roof and the application of a penetrating masonry sealer to exterior surfaces of the stair towers. Currently moisture is entering through the masonry cladding with efflorescence (water borne mineral deposits) accumulating on interior masonry surfaces. Aesthetically, consideration should be given to cleaning off interior masonry surfaces, then painting these surfaces with appropriate coating material.

Guardrails

Many rail posts that support the exterior garage's guardrails between parking bays are in poor condition. Heavy corrosion is observed and their deck connections are likely weakened. The existing guardrails do not meet current building code or industry standard with regard to the restraint of vehicular impact. It is recommend new code compliant rail be constructed. Guardrails also do not address aspects of the code meant to prevent a child from either climbing through large openings between rails or perhaps becoming entangled between them.

Doors & Associated Hardware

- The facility's doors are in good condition, but should be reviewed periodically for missing door hardware or inoperative hydraulic door closures, miscellaneous repair is suggested as required.

- The facility access doors to various stairs, storerooms, mechanical and electrical rooms are currently in good condition. It is suggested, however, that each receive a new coat of paint along with minor work associated with making repairs to address the initial stages of paint failure.

Electrical System & Lighting

- Lighting fixtures are in good condition with only a minor number of fixtures found to be not operating. Problems with existing wiring, bad ballasts or failed lamps are the typical culprits. Repair should be implemented as required.

- Existing lighting levels in this facility are somewhat lower than currently recommended by industry standards (particularly at night) to provide a minimum light level of 5 to 7 foot-candles at the drive lanes and 2 foot candles at the front of the parking stalls. The issue of lighting at the facility turning areas (i.e., transitions between parking bays) and at pedestrian areas directly adjacent to the facility elevator core is particularly important. Desman suggests that increased lighting be provided at these locations due to limited vehicle and pedestrian sight distances. It is also suggested that additional lighting fixtures be added to increase visibility.

- This facility's emergency exit signage is in poor condition and should be replaced. New signs should be specified for exterior application, capable of withstanding severe service conditions experienced in a parking garage. New fixtures should also be vandal resistant.

- The garage is served by the building's main electrical switchgear that includes emergency distribution from the generator. Feeders serve normal and emergency lighting panel-boards that are located on two levels and appear to be in satisfactory condition.

- Most electrical conduit serving light fixtures within the garage are unfortunately routed within the concrete decks. While there are no indications of significant problems or damage with the electrical distribution system at this point. This aspect of the garage's original construction again makes the application of an appropriate traffic bearing waterproofing membrane all the more important. Some corrosion of various exposed electrical conduits was identified throughout the facility that should be repaired.

Elevators

This facility's existing elevators, which serve the full height of the tower building, were not reviewed during Desman's inspection of the property. Desman recommends having a qualified electrical/mechanical engineer and/or elevator maintenance company review the elevators and their component parts carefully. Reworking of hydraulic pumps, system controllers, pistons and/or hoistway cabling, door closers, railguides and other system components may be required either now or in the near future. Improvements to elevators should include ADA improvements to call stations, cab improvement, and other code improvements the State or Federal Governments may require.

Mechanical/Plumbing Systems

- Existing floor drainage system appears to be satisfactory with only minor pipe leakage identified. Major areas of standing water exist, however, that should be addressed with supplemental floor drains piped to the existing storm drainage system. Any drainage system within a parking deck should be flushed and tested annually to prevent debris buildup and checked for system leaks.

- A high-pressure garage wash-down system has is not been provided within this parking facility. The existing water supply, with small diameter piping and only limited pressure from the street, is insufficient to successfully flush chlorides from the parking deck. Steam systems also lack sufficient volume to flush chlorides. Any new system, if installed, should consist of a pressurized accumulator tank and jockey pump along with either schedule 40 galvanized steel pipe with victaulic fittings or type "K" copper tubing with a minimum 1¼" diameter.

  Wash-down supply lines should be placed in centralized locations with hose bibs positioned on each level or at the ends each level. New wash-down supply lines should allow drainage of system during winter months. Costs associated with the installation of such a wash-down system have not been included within Desman's engineering estimate, but can be developed should this information be required.

Wash-down System Suggested Operating Requirements:

- One Hose Operation
  20 GPM @ 100psi
- Two Hose Operation
  14 GPM @ 75psi

Miscellaneous Items

- Painting of miscellaneous metal surfaces (i.e., doors, doorframes, handrails, guardrails, ventilation ducts/grills, piping, etc.) should be scheduled to be performed at approximately five (5) year intervals, or as otherwise required to both protect and enhance their appearance.
- Re-striping of parking stalls, lane striping and directional arrows will be required after concrete repairs, shotblasting of the deck and installation of new elastomeric waterproofing membrane or penetrating sealer has been accomplished.
- While sand and debris has not been allowed to accumulate within the garage in any significant quantity, it should be noted that sand and debris holds moisture and chlorides detrimental to the longevity of a concrete deck, and often clogs storm drains. This is an important maintenance item that should never be ignored.

- Snow removal operations should be performed so that the depth of stockpiled snow never exceeds 3'-0" in depth. Minor flexural beam cracking in several areas of the exterior portion of the garage may have resulted from not attending to this requirement in the past.

MATERIAL TESTING

As a part of this investigation, a material testing program was developed and implemented to determine the existing condition of the structure and the current structural behavior with respect to any deterioration. The testing performed included both non-destructive and destructive testing. Non-destructive testing is a procedure or process that does not require the removal of a sample specimen or damage to the item under investigation. Destructive testing is a procedure or process that either removes a sample or exposes underlying conditions for inspection. It is important to note that destructive testing is performed in a manner and at locations which does not adversely affect the structure. Non-destructive testing performed on these parking facilities included the performance of a chain drag delamination survey of the supported decks and half-cell potentiometer survey of selected areas of the structural slabs. The destructive testing performed included the taking of core drilled concrete samples and concrete powder samples.

Delamination Survey

Chain drag delamination survey was performed on various areas of the structural slabs of the parking structure except for a few locations occupied by vehicles to document the extent of deterioration. The chain drag survey technique is used to locate the limits of delaminated portions of reinforced concrete slab construction. Testing of concrete for subsurface deterioration is performed by dragging a chain across a concrete surface, then noting the change audible tone the chain makes as it passes over a delaminated area.

Pachometer Survey

A pachometer survey was performed at various locations to determine the amount of concrete cover over existing reinforcing steel.

ACI 318 "Building Code Requirements for Reinforced Concrete", Chapter 7 - Details for Reinforcement recommends a minimum concrete cover of 2 inches for bars larger than No. 6 and 1½ inches for bars smaller than No. 5, and allows a placement tolerance of –3/8 inch. Therefore, the minimum concrete coverage given the placement tolerance would be 1 1/8 inches or approximately 1.13 inches.

Desman's survey results from 4 locations on the top surface of the supported deck indicates that the majority of reinforcing and PT strand was placed approximately 1 1/8" to 1½" inches below the deck's surface. Several locations exist however where poor detailing and lack of adequate concrete cover has resulted in premature corrosion of embedded ferrous materials. Reinforcing steel and PT strand are indeed showing through on the top surfaces of the deck. These areas need to be addressed individually, then protected through the installation of a thin polymer modified concrete overlay and the installation of an approved waterproofing membrane system.

<u>Concrete Powder Sampling & Testing</u>

Powder samples were taken from individual concrete core samples obtained from several locations within the parking facility. Each powder sample was taken from different elevations within each concrete core to determine the migration and extent of chloride ions into the deck. The threshold chloride ion content necessary to support active corrosion is approximately 1.3 lbs. of chloride per cubic yard of concrete. Therefore, the results of powder sample testing can be evaluated with respect to this threshold.

- Concrete powder samples obtained from various concrete core samples that were subsequently tested indicate chloride concentrations generally below the threshold limit necessary to support active corrosion at the level of the reinforcing steel. Testing of chloride ion concentrations resulted in a range of 0.4 lbs/cy of concrete to as much as 21.7 lbs/cy in sample ST-7 on Level P3 of the tower portion of the garage. Desman has discounted the 24.0 lbs/cy readings obtained in sample numbers SG-9 and ST-5 as they seem to be abnormally high and may be indicative of sample contamination from an outside source during testing.

- Average chloride ion contents at various elevations within the slabs (i.e., depth from top surface) are presented below. Chloride ion concentrations greater than 1.3 lbs/cy again being the approximate threshold amount necessary for active corrosion to take place in the presence of moisture.

Concrete Sample Depth From Slab's Top Surface (inches)	Average Chloride Content for Exterior Portion of Garage (lbs/cy)	Average Chloride Content for Tower Portion of Garage (lbs/cy)	Average Chloride Content for Both Portions of the Garage (lbs/cy)
1/4" to 1"	2.02	10.35	5.72
1" to 2"	0.88	1.92	1.46
2" to 3"	0.53	1.00	0.73

- Average chloride ion concentration within the region of the embedded reinforcing is approximately equal to the minimum threshold required too support active corrosion. The facility is an excellent candidate for the application of an approved traffic bearing waterproofing membrane system as the preferred method of deck protection.

Concrete Core Sampling & Testing:

Concrete cores were taken from several locations within the garage to determine several factors including compressive strength, and concrete composition and air entrainment. The concrete core sampling and testing is utilized as a representative index of material properties of the existing concrete with respect to strength and durability, as well as to give insight to the past behavior of the existing condition, and anticipated behavior of the reinforced concrete structure.

The concrete test reports provide a brief description of core sample size and comments observed during their petrographic examination. The results of this testing are presented in Appendix C.

Petrographic examination was performed on one core. This examination process observes a prepared sample under a microscope to determine the quality of the hardened concrete with respect to water/cement ration, air content, permeability, aggregate, and cement past characteristics.

A summary of the results of petrographic examination are as follows:

Core No. SG-3 (Level P-5 of Exterior Portion of the Garage:

- The overall quality of the concrete core was judged to be fair to poor.
- The cement paste of the core was judged to be of medium hardness with the surface partially carbonated to a depth of approximately ½ inches from concrete's top surface, and a poor paste to aggregate bond.
- Core was comprised of ½" maximum sized traprock made up of gabbro and lithic sand that was fairly well graded with uniform distribution. Fine sands were mostly sub-rounded with some sub-angular particles with fair overall distribution.
- Core had a medium estimated slump of 3 to 5 inches and a water/cement ratio of 0.45 to 0.50.
- Core did not indicate the presence of fly ash pozzolanic admixture.
- Total air contents of 3.1% was observed in core. The air void system in the core examined is inconsistent with current technology for resistance to freeze-thaw deterioration, and analysis indicates that the concrete will have a relatively high permeability. Concrete would be expected to experience minor freeze-thaw damage if not protected with a penetrating concrete sealer or traffic bearing membrane.

Core No. SG-4 (Level P-4 of the Exterior Portion of the Garage):

- The overall quality of the concrete core was judged to be fair to poor.
- The cement paste of the core was judged to be of medium hardness with partial carbonation to a depth of approximately ¼ inches from concrete's top surface, and a poor paste to aggregate bond.
- Core was comprised of ½" maximum sized traprock made up of gabbro and lithic sand that was fairly well graded with uniform distribution. Fine sands were mostly sub-rounded with some sub-angular particles with fair overall distribution.
- Core had a medium to high estimated slump of 4 to 6 inches and a water/cement ratio of 0.48 to 0.52.

- Core did not indicate the presence of fly ash pozzolanic admixture.

- Total air contents of 3.6% was observed in core. The air void system in the core examined is inconsistent with current technology for resistance to freeze-thaw deterioration, and analysis indicates that the concrete will have a relatively high permeability. Concrete would be expected to experience minor freeze-thaw damage if not protected with a penetrating concrete sealer or traffic bearing membrane.

Core No. ST-4 (Level P-4 of the Tower Portion of the Garage):

- The overall quality of the concrete core was judged to be fair to poor.

- The cement paste of the core was judged to be of medium hardness with intermittent carbonation to a depth of approximately 7/8 inches from concrete's top surface, and a poor paste to aggregate bond.

- Core was comprised of ½" maximum sized traprock made up of gabbro and lithic sand that was fairly well graded with uniform distribution. Fine sands were mostly sub-rounded with some sub-angular particles with fair overall distribution.

- Core had a medium to high estimated slump of 4 to 6 inches and a water/cement ratio of 0.48 to 0.52.

- Core did not indicate the presence of fly ash pozzolanic admixture.

- Total air contents of 3.7% was observed in core. The air void system in the core examined is inconsistent with current technology for resistance to freeze-thaw deterioration, and analysis indicates that the concrete will have a relatively high permeability. Concrete would be expected to experience minor freeze-thaw damage if not protected with a penetrating concrete sealer or traffic bearing membrane.

Several cores were subjected to compressive strength testing. This testing provides representative compressive strength capabilities of the existing concrete. Core samples are subjected to compressive loading until failure, and this failure load is divided by the core's cross sectional area to provide the compressive strength per unit area. The values obtained are then compared with the concrete compressive strengths specified. The concrete tested had variable compressive strengths, but results are indicative of concrete strength sufficient for its intended purpose.

Sample Number	Compressive Strength	Average Compressive Strength
SG-1	6,970 psi	
SG-5	7,760 psi	**7,470 psi**
SG-8	7,680 psi	
ST-2	6,680 psi	
ST-6	7,260 psi	**7,690 psi**
ST-9	9,130 psi	

RECOMMENDATIONS

25 Sigourney Parking Garage is in fair structural condition; the development and implementation of a prioritized repair program could offer significant cost savings in the long term. To effectively extend the service life of any parking structure, the most important consideration is how to reduce or eliminate the intrusion of chloride contaminated moisture into the concrete down to the level of the reinforcing steel. Therefore, the majority of repairs Desman currently recommends concentrate on stabilizing the rate of moisture intrusion into the structure, reducing the extent of continued structural deterioration as well as reducing those costs associated with implementing future repairs.

Desman recommends that repairs be instituted soon to address existing problems and reduce the potential for further structural deterioration.

Repairs are divided into three prioritized repair categories (Priority I through III) and have been placed in order of their importance. Desman has indicated the work as taking place over the next thirty-six month period, but this is only suggested phasing and could be compressed or extended depending upon budgetary constraints.

Priority I Repair and Improvements - (Zero to Twelve Months):

I.	Concrete Repair:				
	A.	Concrete Column Repair			
			500 SF @ $44.00/SF	=	$22,000.00
	B.	Partial Depth Concrete Slab Repair			
			2,000 SF @ $27.00/SF	=	$54,000.00
	C.	Concrete Apron Modifications at Expansion Joints			
			Lump Sum	=	$28,000.00
	D.	Miscellaneous Ledger Beam Repair			
			250 SF @ $70.00/SF	=	$17,500.00
	E.	Miscellaneous Overhead & Vertical Concrete Repair			
			400 SF @ $70.00/SF	=	$28,000.00
II.	Epoxy Injection				
			Lump Sum	=	$12,000.00

III.	Crack Repair and Joint Detailing:			
	A. Crack Repair			
		30,000 LF @ $3.00/LF	=	$90,000.00
	B. Control/Construction Joint Repair			
		7,000 LF @ $3.00/LF	=	$21,000.00
	C. Cove Joint Installation			
		10,000 LF @ $3.00/LF	=	$30,000.00
IV.	Traffic Bearing Waterproofing Membrane Installation			
		206,600 SF @ $2.55/SF	=	$526,830.00
V.	Expansion/Isolation Joint Replacement			
		600 LF @ $160.00/LF	=	$96,000.00
VI.	Miscellaneous Plumbing Improvements			
	A. Supplemental Drains			
		15 Drains @ $1,000.00/Each	=	$15,000.00
	B. Supplemental Drain Pipe			
		500 LF @ $33.00/LF	=	$16,500.00
	C. Repair Existing Drains & Drain Piping			
		Lump Sum	=	$8,500.00
	D. Re-route Sprinkler Pipe w/ Clearance Conflict			
		Lump Sum	=	$2,500.00
VII.	Miscellaneous Electrical Improvements			
	A. Miscellaneous Electrical Coordination			
		Lump Sum	=	$10,000.00
	B. Relocate and/or Replace Miscellaneous Exit Signs			
		Lump Sum	=	$12,000.00

VIII.	Miscellaneous Coordination Work			
	A. Lane & Parking Stall Striping			
		Lump Sum	=	$3,800.00
	B. General & Special Conditions			
		Lump Sum	=	$20,000.00

Total Priority I Repair and Improvement Costs = $1,013,630.00

Priority II Repair and Improvements - (Twelve to Twenty Four Months):

I.	Entry Plaza Repair:			
	A. Paver Removal/Replacement to Allow Structural Deck Repair			
		Lump Sum	=	$30,000.00
	B. Landscape Removal/Replacement to Allow Structural Deck Repair			
		Lump Sum	=	$18,000.00
	C. Plaza Deck Repair			
		600 SF @ $75.00/SF	=	$45,000.00
	D. Plaza Waterproofing			
		1000 SF @ $4.00/SF	=	$4,000.00
	E. Supplemental Plaza Deck Drainage (Drains & Drain Piping)			
		Lump Sum	=	$15,000.00
II.	Concrete Repair:			
	A. Door Step & Landing Improvements			
		Lump Sum	=	$10,000.00
	B. Miscellaneous Concrete Curb & Sidewalk Repair			
		100 SF @ $35.00/SF	=	$3,500.00
III.	Crack Repair and Joint Detailing:			
	A. Crack Repair			
		3,000 LF @ $3.00/LF	=	$9,000.00
	B. Control/Construction Joint Repair			
		500 LF @ $3.00/LF	=	$1,500.00
	C. Cove Joint Installation			
		500 LF @ $3.00/LF	=	$1,500.00
IV.	Guardrail Reconstruction			
		2,400 LF @ $65.00/LF	=	$156,000.00

V.	Garage Stair Handrail Update		
	Lump Sum	=	$7,500.00
VI.	Miscellaneous Painting Improvements:		
	A. Miscellaneous Interior Concrete & Masonry Surfaces		
	Lump Sum	=	$8,000.00
	B. Miscellaneous Metal Doors & Door Frames		
	Lump Sum	=	$4,500.00
	C. Miscellaneous Metal Surfaces (i.e., guardrails, piping, ventilation ducts etc.)		
	Lump Sum	=	$5,500.00
VII.	Stair Tower Roof & Flashing Repair		
	Lump Sum	=	$8,500.00
VIII.	Miscellaneous Plumbing & Mechanical Improvements		
	A. Dry Fire Standpipe Repair		
	Lump Sum	=	$5,000.00
	B. Ventilation Equipment Maintenance & Repair		
	Lump Sum	=	$5,000.00
	C. Install New Garage Wash-Down System		
	Lump Sum	=	$55,000.00
IX.	Miscellaneous Electrical Improvements		
	A. Supplemental lighting Fixture Installation		
	Lump Sum	=	$10,000.00
	B. Lighting Control Improvements		
	Lump Sum	=	$10,000.00
	C. Emergency Intercom Installation		
	Lump Sum	=	$50,000.00
X.	Miscellaneous Coordination Work (General & Special Conditions)		
	Lump Sum	=	$15,000.00

Total Priority II Repair and Improvement Costs = $462,500.00

Appendix A

Laboratory Testing Reports

AMERICAN
PETROGRAPHIC
SERVICES, INC.

REPORT OF CONCRETE TESTING

PROJECT:

25 SIGOURNEY STREET
PARKING GARAGE
HARTFORD, CT

REPORTED TO:

DESMAN ASSOCIATES
433 S. MAIN STREET, SUITE 327
WEST HARTFORD, CT 06110

ATTN: NED GLOVER

APS JOB NO: 10-00143

DATE: JUNE 12, 1998

INTRODUCTION

This report presents the results of laboratory work performed by our firm on 18 concrete core samples submitted to us by Mr. Ned Glover on Desman Associates on May 21, 1998. We understand the concrete cores were obtained from an exterior concrete parking structure currently under evaluation. The scope of our work was limited to 1) performing petrographic analysis testing on cores SG-3, SG-4, and ST-4, 2) documenting the water soluble chloride-ion content at various levels in eleven cores, and 3) documenting the compressive strength of six cores.

CONCLUSIONS

Based on our observations, test results, and past experience, our conclusions are as follows:

1. The overall quality of the concrete was fair to poor. The cement paste was moderately dense and hard with carbonation up to 7/8". The crushed gabbroic aggregate was hard, sound, and durable. The concrete exhibited evidence of retempering and was placed with a moderate slump.

2. The concrete has poor durability. The concrete appears to have been purposefully air entrained but does not contain an air void system that is consistent with current technology for resistance to freeze-thaw deterioration. We expect scaling to occur if the concrete becomes frozen when saturated.

3. Corrosion conditions are developed in seven of the cores tested. We measured water soluble chloride-ion content levels ranging from 110 to >6000 ppm.

4. The concrete tested was strong with an average compressive strength of 7580 psi.

SAMPLE IDENTIFICATION

Sample Number	Original Dimension
SG-1	2-3/4" diameter by 4-1/4"long
SG-2	2-3/4" diameter by 4"long
SG-3	2-3/4" diameter by 4-1/4"long
SG-4	2-3/4" diameter by 2-15/16"long
SG-5	2-3/4" diameter by 4-1/4"long
SG-6	2-3/4" diameter by 3-3/4"long
SG-7	2-3/4" diameter by 4-1/4"long
SG-8	2-3/4" diameter by 4-1/8"long
SG-9	2-3/4" diameter by 3-1/2"long
ST-1	2-3/4" diameter by 4-1/4"long
ST-2	2-3/4" diameter by 4-1/2"long
ST-3	2-3/4" diameter by 3-1/8"long
ST-4	2-3/4" diameter by 4-1/4"long
ST-5	2-3/4" diameter by 4-1/2"long
ST-6	2-3/4" diameter by 4"long
ST-7	2-3/4" diameter by 4-1/4"long
ST-8	2-3/4" diameter by 4-1/4"long
ST-9	2-3/4" diameter by 4-1/2"long

TEST RESULTS

Our complete petrographic analysis test results appear on the attached sheets entitled 00 LAB 001 "Petrographic Examination of Hardened Concrete, ASTM:C856." A brief summary of these results is as follows:

a. The coarse aggregate in the cores was comprised of 1/2" maximum sized crushed gabbro that was fairly well graded with fair to good overall distribution.

b. Fly ash pozzolanic admixtures were not observed in the concrete samples.

c. The paste color of the cores was light reddish tan with the slump estimated to be medium to high (3" - 6").

d. The paste hardness of the cores was judged to be medium with the paste/aggregate bond considered poor.

e. The depth of carbonation ranged from 1/4" up to 7/8".

f. The water/cement ratio of the cores was estimated at between 0.45 to 0.52 with approximately 8-11% unhydrated cement particles.

Air Content Testing

Sample Identification:	SG-3	SG-4	ST-4
Total Air Analysis -			
Air Void Content, %	4.0	4.5	5.2
Spacing Factor, in	0.012	0.011	0.011
Entrapped Air (%)	0.9	0.9	1.5
Entrained Air (%)	3.1	3.6	3.7

Water Soluble Chloride-ion Content Testing

Sample No., Depth	ppm	Cl^- lbs/yd^3**
SG-2 (1/4" - 1")	1420	5.5
SG-2 (1" - 2")	159	0.6
SG-2 (2" - 3")	144	0.6
SG-3 (1/4" - 1")	144	0.6
SG-4 (1/4" - 1")	291	1.1
SG-6 (1/4" - 1")	628	2.4
SG-6 (1" - 2")	179	0.7
SG-6 (2" - 3")	141	0.5
SG-7 (1/4" - 1")	134	0.5
SG-7 (1" - 2")	110	0.4
SG-7 (2" - 3")	123	0.5
SG-9 (1/4" - 1")	>6000	>24.0
SG-9 (1/4" - 1")	450	1.8
SG-9 (1" - 2")	121	0.5
ST-1 (1/4" - 1")	223	0.9
ST-1 (1" - 2")	134	0.5
ST-1 (2" - 3")	152	0.6
ST-3 (1/4" - 1")	3572	14.3
ST-3 (1" - 2")	1011	4.0
ST-3 (2" - 3")	310	1.2
ST-5 (1/4" - 1")	>6000	>24.0
ST-5 (1" - 2")	815	3.3
ST-5 (2" - 3")	296	1.2
ST-7 (1/4" - 1")	5421	21.7
ST-7 (1" - 2")	298	1.2
ST-8 (1/4" - 1")	1113	4.5
ST-8 (1" - 2")	154	0.6

**Calculations based on a 3890 and 4000 lb. mix

Our experience has been that chloride-ion levels in excess of 300 to 400 ppm will cause problems with corrosion of embedded steel reinforcement and significantly increase the number of freeze-thaw cycles.

Compressive Strength Testing

Sample Number	Compressive Strength, psi
SG-1	6970
SG-5	7760
SG-8	7680
ST-2	6680
ST-6	7260
ST-9	9130
Average	7580

TEST PROCEDURES

Laboratory testing was performed on May 21, 1998 and subsequent dates. Our procedures were as follows:

Petrographic Analysis

A petrographic analysis was performed in accordance with APS Standard Operating Procedure 00 LAB 001, "Petrographic Examination of Hardened Concrete," ASTM:C856-latest revision. The petrographic analysis consisted of reviewing cement paste and aggregate qualities on a whole basis as well as on a cut/polished section. The depth of carbonation was documented using a phenolphthalein indicator solution applied on a freshly cut and polished surface of the concrete samples. Further, our analysis included a review for the presence of deleterious substances. The water/cement ratio of the concrete was estimated by viewing a thin section of the concrete under an Olympus BH-2 polarizing microscope at magnification up to 1000x.

Air Content Testing

Air content testing was performed using APS Standard Operating Procedure 00 LAB 003, "Microscopical Determination of Air Void Content and Parameters of the Air Void System in Hardened Concrete," ASTM:C457-latest revision (linear traverse method). The concrete cores were cut perpendicular with respect to the horizontal plane of the concrete as placed and then polished prior to testing.

Water Soluble Chloride-ion Content

We obtained a 3-gram pulverized portion of each sample either by crushing a dry saw-cut piece or by use of an impact drill. We then mix the powder with 20 ml of digestion solution for a total of 3 minutes and then add 80 ml of stabilizing solution. We then immersed a calibrated electrode coupled to an Orion Model 720 ph/ISE meter in the solution and recorded the chloride-ion concentration. This method is consistent with APS Standard Operating Procedure 00 LAB 017 (AASHTO-T260 Procedure C).

By testing six pulverized concrete QA samples of known chloride content, we were able to determine the standard deviation for this chloride test. Each QA sample was tested five times and the following standard deviation ranges were calculated. Samples with chloride levels from 80-200 ppm have a STD of 32 ppm, 201-450 ppm STD = 38 ppm, 451-950 ppm STD=48 ppm, 951-2000 ppm STD=119 ppm, 2001-4000 ppm STD=207 ppm and 4001-6000 ppm STD=609 ppm. Results that are <80 ppm or >6000 ppm are reported as such due to the high magnitude of the standard deviation in both cases.

Compressive Strength Testing

Compressive strength testing was performed in accordance with American Engineering Testing, Inc. Standard Operating Procedure 4-52, ASTM:D42 procedures.

REMARKS

The test samples will be retained for a period of thirty days from the date of this report. Unless further instructions are received by that time, the samples will be discarded.

Report Prepared By:

Scott F. Wolter, P.G.
President
MN License No. 30024

Richard D. Stehly, P.E.
MN Reg. No. 12856

00 LAB 001 Petrographic Examination of Hardened Concrete
ASTM: C-856

Job #:	10-00143	Date:	6-5-98/6-10-98
Sample Identification:	SG-3	Performed by:	S. Veglahn/G. Moulzolf

I. General Observations

1. Sample Dimensions: Our analysis was performed on both sides of a 4-1/4" x 2-3/4" x 5/8" thick polished section that was cut from the original 2-3/4" diameter x 4-1/4" long core.

2. Surface Conditions:

   Top: Rough, broomed surface with minor traffic wear
   Bottom: Rough, irregular, fractured surface

3. Reinforcement: None observed.

4. General Physical Conditions: The top 3/8" of the sample is characterized by a somewhat darker colored paste. A large amount of sinuous bleedwater void space was observed between 1/4 and 2-1/4" depth in the sample. Darker colored, denser areas of paste observed in several concave coarse aggregate notches suggest the concrete was retempered. Fair to good overall condition.

II. Aggregate

1. Coarse: 1/2" maximum sized traprock made up of gabbro. Fairly well graded with fair overall distribution.

2. Fine: Natural lithic sand with many quartz particles that was fairly well graded. The grains were mostly sub-rounded with some sub-angular particles. Good overall uniform distribution.

III. Cementitious Properties

1. Air Content:	4.0% total, 0.9% entrapped, 3.1% entrained
2. Depth of carbonation:	Negligible, partially carbonated up to 1/2"
3. Pozzolan presence:	None observed
4. Paste/aggregate bond:	Poor
5. Paste color:	Light reddish tan
6. Paste hardness:	Medium
7. Paste proportions:	26% to 28%
8. Microcracking:	Numerous subvertical plastic shrinkage microcracks were observed in the top 1/16" of the sample.
9. Secondary deposits:	None observed
10. Slump:	Estimated, medium (3-5")
11. Water/cementitious ratio:	Estimated at between 0.45 to 0.50 with approximately 9-11% unhydrated portland cement clinker particles.
12. Degree of hydration:	Well

IV. Conclusions

The general overall quality of the concrete was fair to poor.

00 LAB 001 Petrographic Examination of Hardened Concrete
ASTM: C-856

Job #:	10-00143	Date:	6-4-98/6-10-98
Sample Identification:	SG-4	Performed by:	S. Veglahn/G. Moulzolf

I. General Observations

1. Sample Dimensions: Our analysis was performed on both sides of a 2-15/16" x 2-11/16" x 7/8" thick and a 2-3/4" x 2-3/4" x 1-1/2" thick polished section that was cut from the original 2-3/4" diameter x 2-15/16" long core.

2. Surface Conditions:

   Top: Rough, broomed surface with minor traffic wear
   Bottom: Rough, irregular, fractured surface

3. Reinforcement: None observed.

4. General Physical Conditions: The top approximately 1/16" is characterized by a darker colored, denser paste. Several subvertical plastic shrinkage microcracks were observed proceeding up to 1/8" depth from the top surface. Numerous bleedwater void spaces were observed in the top 7/8" of the sample. Fair to good overall condition.

II. Aggregate

1. Coarse: 1/2" maximum sized traprock made up of gabbro. Fairly well graded with fair overall distribution.

2. Fine: Natural lithic sand with many quartz particles that was fairly well graded. The grains were mostly sub-rounded with some sub-angular particles. Good overall uniform distribution.

III. Cementitious Properties

1. Air Content:	4.5% total, 0.9% entrapped, 3.6% entrained
2. Depth of carbonation:	Negligible, partially carbonated up to 1/4"
3. Pozzolan presence:	None observed
4. Paste/aggregate bond:	Poor
5. Paste color:	Light reddish tan
6. Paste hardness:	Medium
7. Paste proportions:	24% to 26%
8. Microcracking:	Several subvertical plastic shrinkage microcracks were observed proceeding up to 1/8" depth from the top surface.
9. Secondary deposits:	None observed
10. Slump:	Estimated, medium to high (4-6")
11. Water/cementitious ratio:	Estimated at between 0.48 to 0.52 with approximately 8-10% unhydrated portland cement clinker particles.
12. Degree of hydration:	Well

IV. Conclusions

The general overall quality of the concrete was fair to poor.

00 LAB 001 Petrographic Examination of Hardened Concrete
ASTM: C-856

Job #:	10-00143	Date:	6-5-98/6-10-98
Sample Identification:	ST-4	Performed by:	S. Veglahn/G. Moulzolf

I. General Observations

1. Sample Dimensions: Our analysis was performed on both sides of a 4-1/8" x 2-3/4" x 3/4" thick and a 4-1/4" x 2-3/4" x 1-1/4" thick polished section that was cut from the original 2-3/4" diameter x 4-1/4" long core.

2. Surface Conditions:

   Top: Rough, broomed surface with minor traffic wear
   Bottom: Rough, irregular, fractured surface

3. Reinforcement: None observed.

4. General Physical Conditions: A subvertical drying shrinkage microcrack proceeds up to 3-3/8" depth from the top surface. Intermittent carbonation proceeds up to 7/8" depth, along the microcrack. Numerous bleedwater void spaces were observed concentrated in the top 1" of the sample. Fair to good overall condition.

II. Aggregate

1. Coarse: 1/2" maximum sized traprock made up of gabbro. Fairly well graded with fair to good overall distribution.

2. Fine: Natural lithic sand with many quartz particles that was fairly well graded. The grains were mostly sub-rounded with some sub-angular particles. Good overall uniform distribution.

III. Cementitious Properties

1. Air Content:	5.2% total, 1.5% entrapped, 3.7% entrained
2. Depth of carbonation:	Intermittent up to 7/8"
3. Pozzolan presence:	None observed
4. Paste/aggregate bond:	Poor
5. Paste color:	Light reddish tan
6. Paste hardness:	Medium
7. Paste proportions:	24% to 26%
8. Microcracking:	A subvertical microcrack proceeds up to 3-3/8" depth from the top surface.
9. Secondary deposits:	None observed
10. Slump:	Estimated, medium (3-5")
11. Water/cementitious ratio:	Estimated at between 0.47 to 0.51 with approximately 8-10% unhydrated portland cement clinker particles.
12. Degree of hydration:	Well

IV. Conclusions

The general overall quality of the concrete was fair to poor.

AMERICAN
PETROGRAPHIC
SERVICES, INC.

REPORT OF AIR VOID ANALYSIS

PROJECT:

25 SIGOURNEY STREET
PARKING GARAGE
HARTFORD, CT

REPORTED TO:

DESMAN ASSOCIATES
433 S. MAIN STREET, SUITE 327
WEST HARTFORD, CT 06110

ATTN: NED GLOVER

APS JOB NO: 10-00143

DATE: JUNE 12, 1998

Sample No:	SG-3	SG-4	ST-4
Conformance:	The samples contain an air void system which is not consistent with current technology for freeze-thaw resistance.		
Sample Data:			
Description:	Hardened Concrete Core		
Dimensions:	2-3/4" diam by 4-1/4" long	2-3/4" diam by 2-15/16" long	2-3/4" diam x 4-1/4" long
Test Data ASTM:C457 Linear Traverse Method, APS Standard Operating Procedure 00 LAB 003			
Air Void Content, %	4.0	4.5	5.2
Entrained, % ≤ 0.040"	3.1	3.6	3.7
Entrapped, % > 0.040"	0.9	0.9	1.5
Air Voids/inch	4.41	4.88	5.56
Specific Surface, in^2/in^3	440	430	430
Spacing Factor, inches	0.012	0.011	0.011
Paste Content, %	26.0	26.0	26.0
Magnification	50x	50x	50x
Traverse Length, inches	80"	80"	81"
Test Date	6/5/98	6/5/98	6/5/98

Remarks: The test samples will be retained for 30 days. We will discard the samples unless we receive other instructions.

AMERICAN PETROGRAPHIC SERVICES, INC.

TEST OF CONCRETE CORES

PROJECT:

25 SIGOURNEY STREET
PARKING GARAGE
HARTFORD, CT

REPORTED TO:

DESMAN ASSOCIATES
433 S. MAIN STREET, SUITE 327
WEST HARTFORD, CT 06110

ATTN: NED GLOVER

APS JOB NO: 10-00143

DATE: JUNE 12, 1998

ASTM:C42

Sample No.	SG-1	SG-5	SG-8
Original Length, in.	4.0	4.2	4.1
Capped Length, in. (.1)	4.3	4.4	4.2
Cut Length, in. (.1)	4.0	4.0	3.9
Diameter, in. (.01)	2.76	2.76	2.76
Date Tested	6/4/98	6/4/98	6/4/98
Moisture Condition	as received	as received	as received
Load at Failure, lbs.	43,720	48,600	48,330
Area Tested, sq. in.	5.98	5.98	5.98
Compressive Strength, psi	7,310	8,130	8,080
L/D Ratio	1.45	1.45	1.41
Correction Factor	.954	.954	.950
Corrected Compressive Strength, psi	6,970	7,760	7,680

The samples have been tested perpendicular in respect to the horizontal plane of the concrete.

AMERICAN
PETROGRAPHIC
SERVICES, INC.

TEST OF CONCRETE CORES

PROJECT:

25 SIGOURNEY STREET
PARKING GARAGE
HARTFORD, CT

REPORTED TO:

DESMAN ASSOCIATES
433 S. MAIN STREET, SUITE 327
WEST HARTFORD, CT 06110

ATTN: NED GLOVER

APS JOB NO: 10-00143

DATE: JUNE 12, 1998

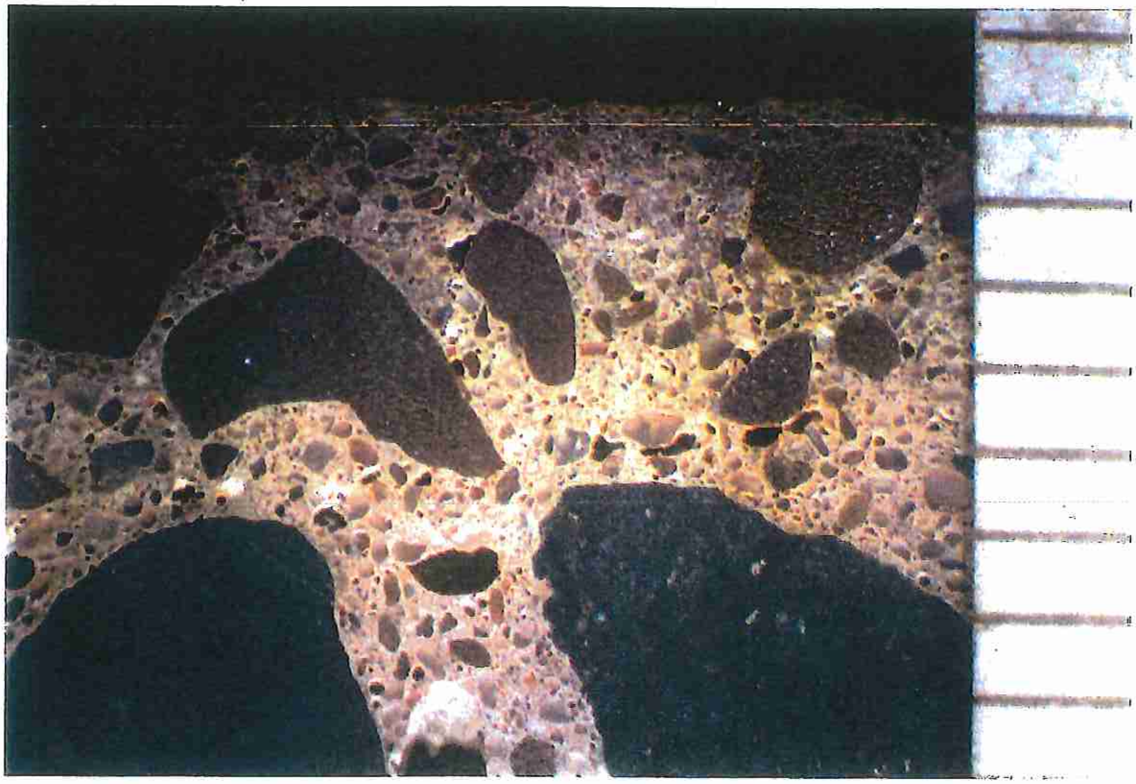
ASTM:C42

Sample No.	ST-2	ST-6	ST-9
Original Length, in.	4.3	4.1	4.2
Capped Length, in. (.1)	4.3	4.1	4.4
Cut Length, in. (.1)	4.0	3.8	4.2
Diameter, in. (.01)	2.76	2.76	2.76
Date Tested	6/4/98	6/4/98	6/4/98
Moisture Condition	as received	as received	as received
Load at Failure, lbs.	41,860	45,920	56,760
Area Tested, sq. in.	5.98	5.98	5.98
Compressive Strength, psi	7,000	7,680	9,490
L/D Ratio	1.45	1.38	1.52
Correction Factor	.954	.945	.962
Corrected Compressive Strength, psi	6,680	7,260	9,130

The samples have been tested perpendicular in respect to the horizontal plane of the concrete.

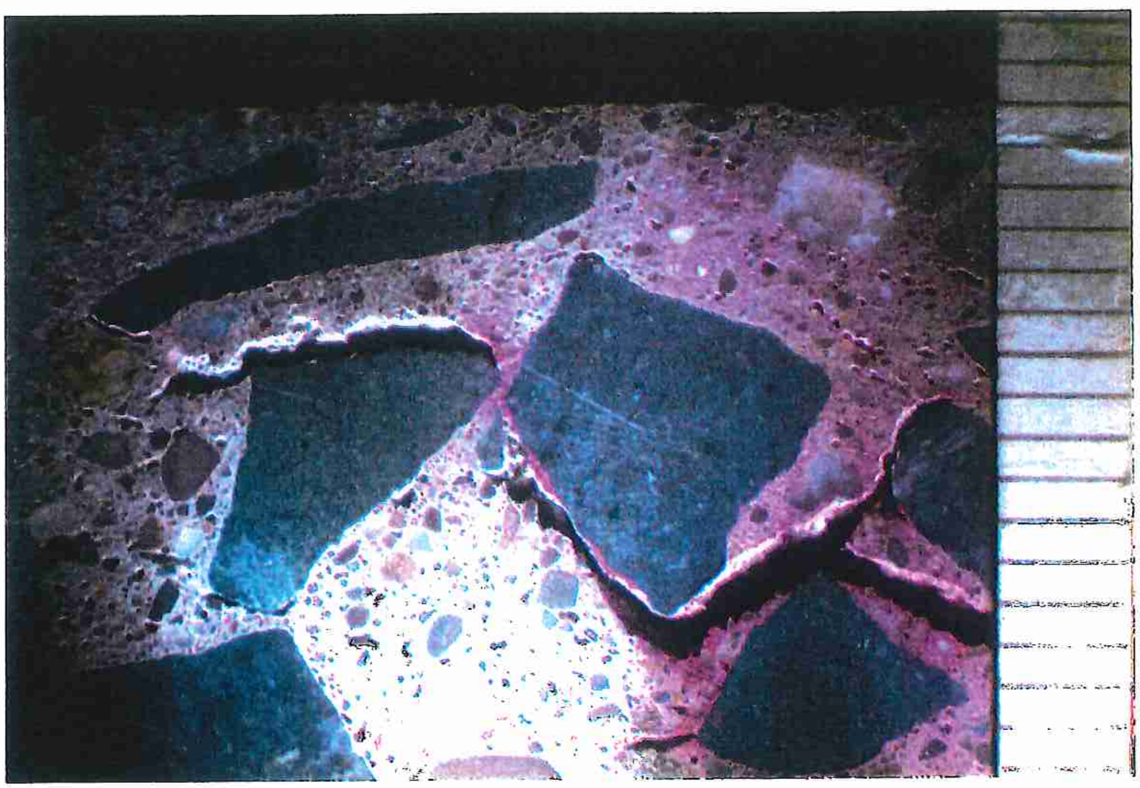
APS# 10-00143 DATE: 6-12-98

PROJECT: 25 SIGOURNEY STREET PARKING GARAGE, HARTFORD, CT



SAMPLE IDENTIFICATION: SG-4
MAGNIFICATION: 7.5x

SAMPLE DESCRIPTION: Darker, grayer, denser paste layer at the top surface.

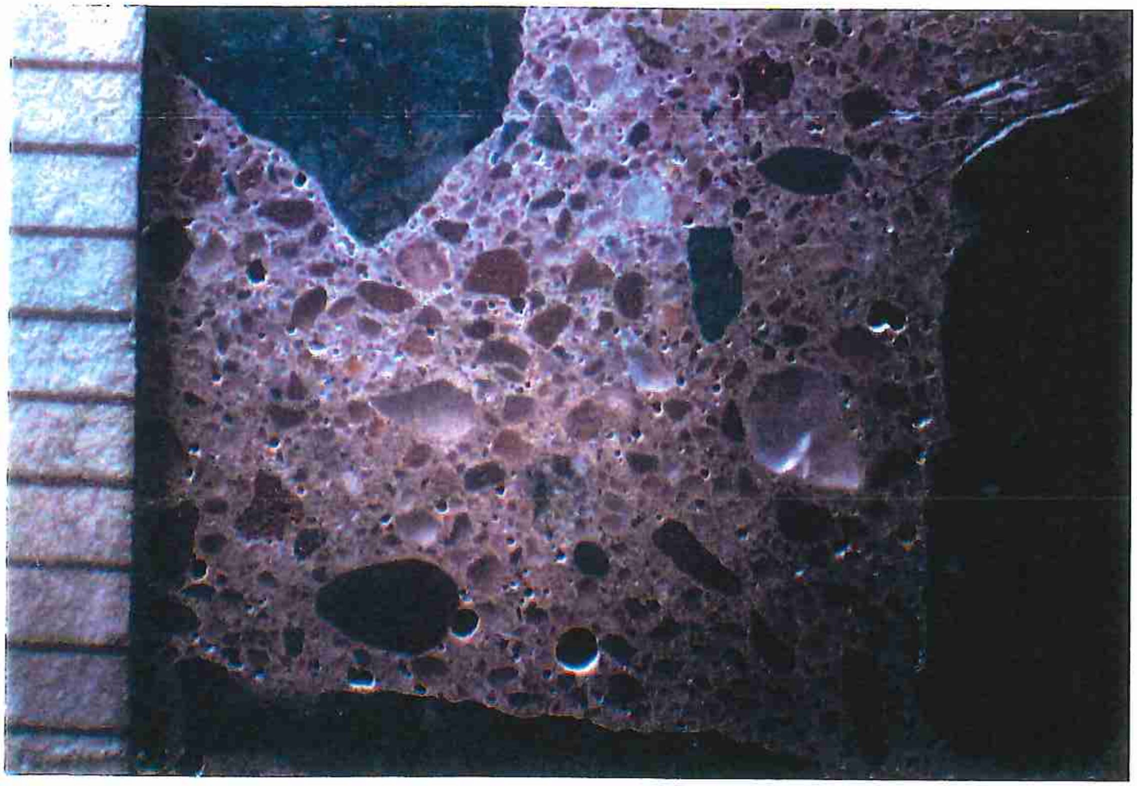


SAMPLE IDENTIFICATION: SG-3
MAGNIFICATION: 3.75x

SAMPLE DESCRIPTION: Subhorizontal bleedwater void space in the top 1/2".

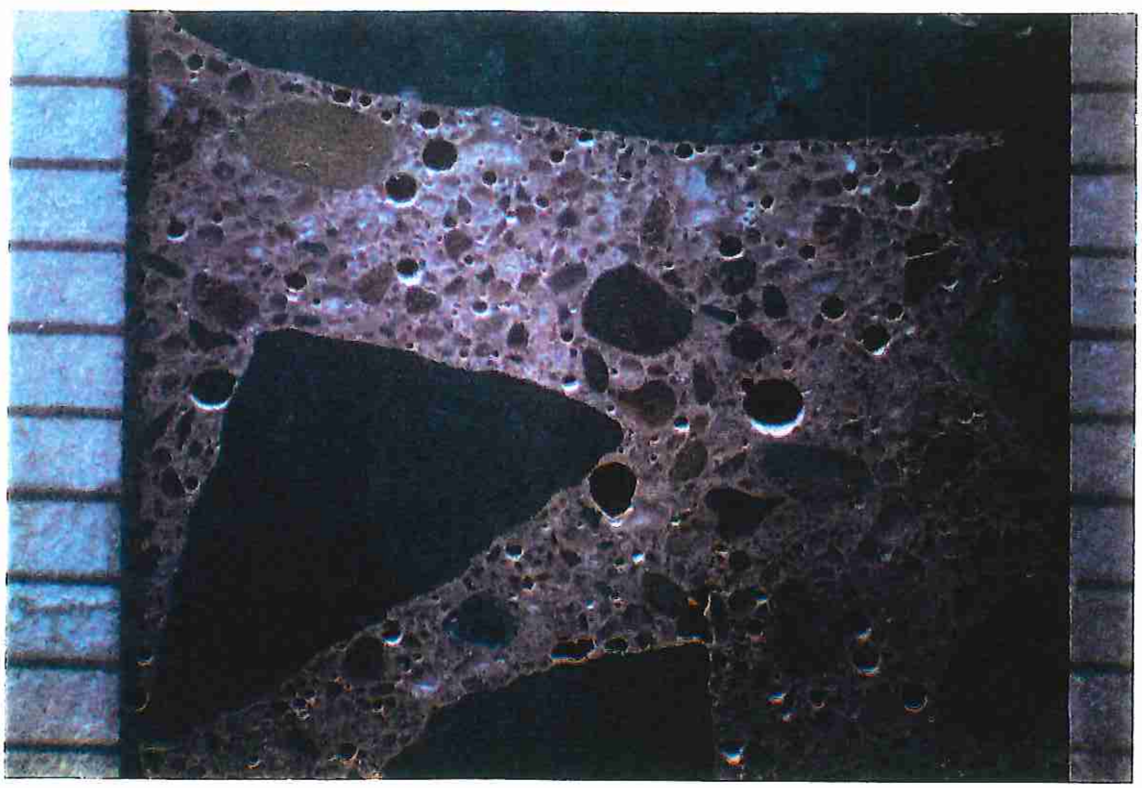
APS# 10-00143 DATE: 6-12-98

PROJECT: 25 SIGOURNEY STREET PARKING GARAGE, HARTFORD, CT



SAMPLE IDENTIFICATION: SG-3
MAGNIFICATION: 7.5x

SAMPLE DESCRIPTION: Overall view of the entrained air void system (4.0% total).

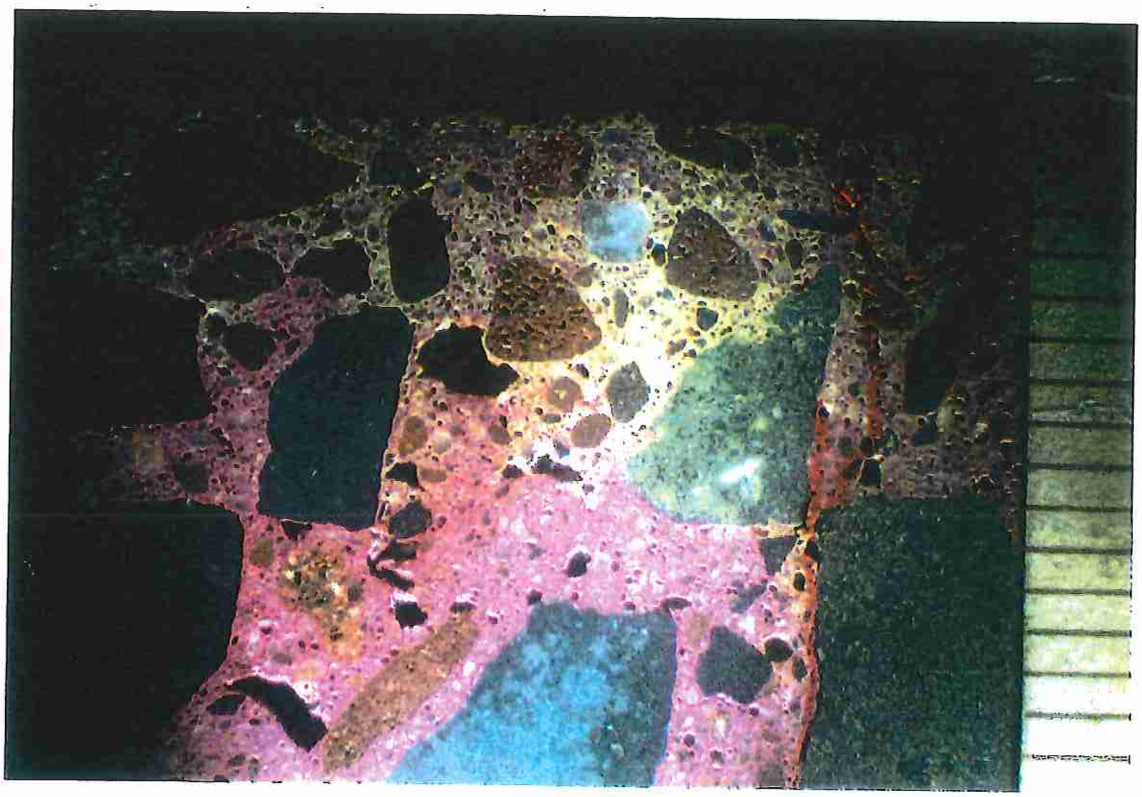


SAMPLE IDENTIFICATION: SG-4
MAGNIFICATION: 7.5x

SAMPLE DESCRIPTION: Overall view of the entrained air void system (4.5% total).

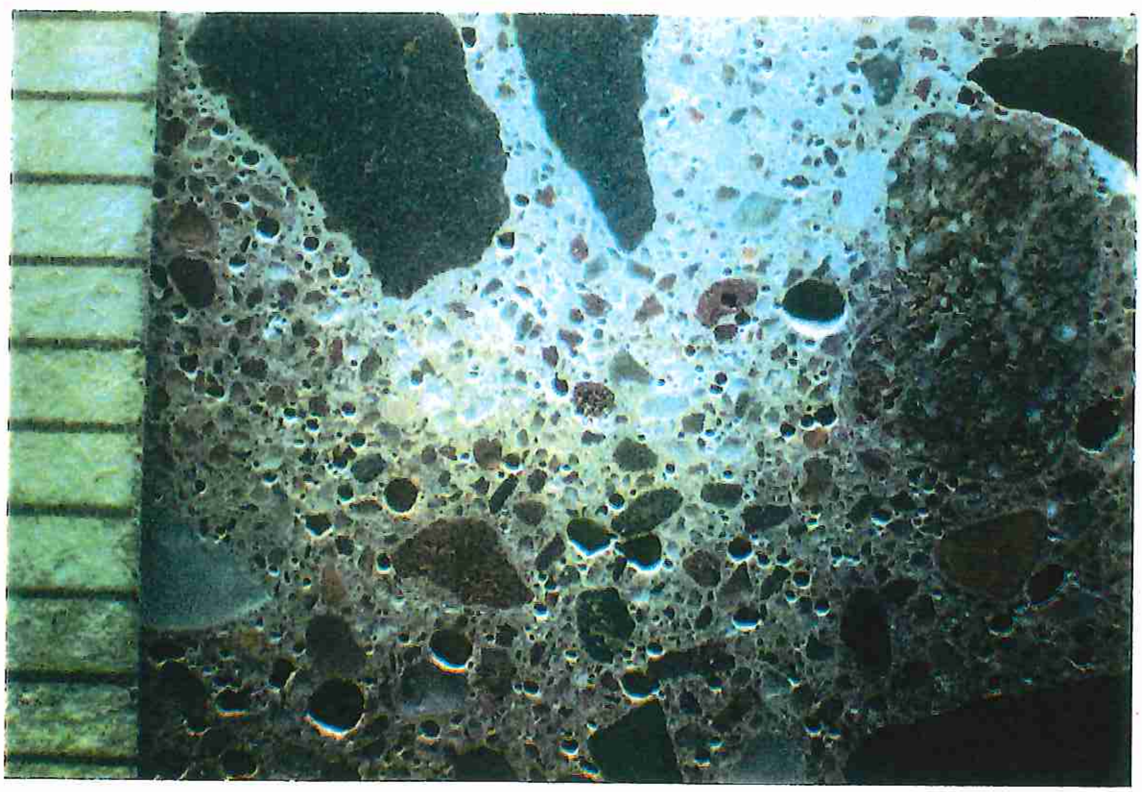
APS# , 10-00143 DATE: 6-12-98

PROJECT: 25 SIGOURNEY STREET PARKING GARAGE, HARTFORD, CT



SAMPLE IDENTIFICATION: ST-4
MAGNIFICATION: 3.75x

SAMPLE DESCRIPTION: White, up to 3/4" deep carbonation.

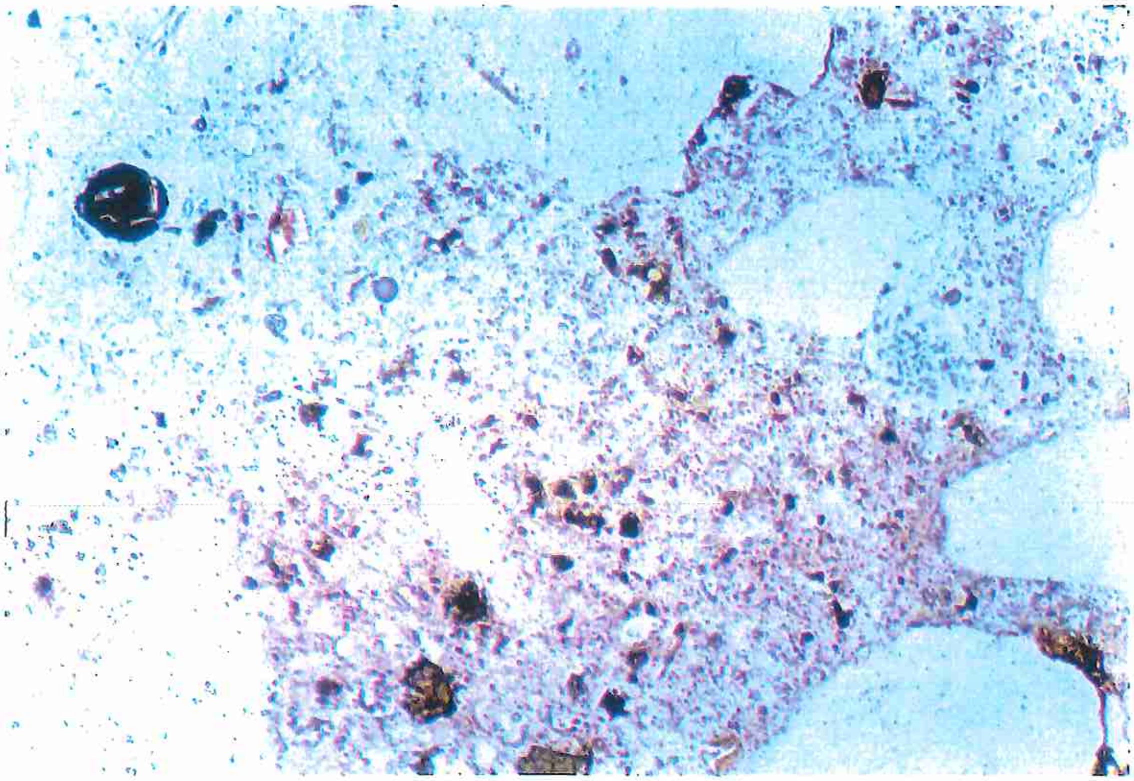


SAMPLE IDENTIFICATION: ST-4
MAGNIFICATION: 7.5x

SAMPLE DESCRIPTION: Overall view of the entrained air void system (5.2% total).

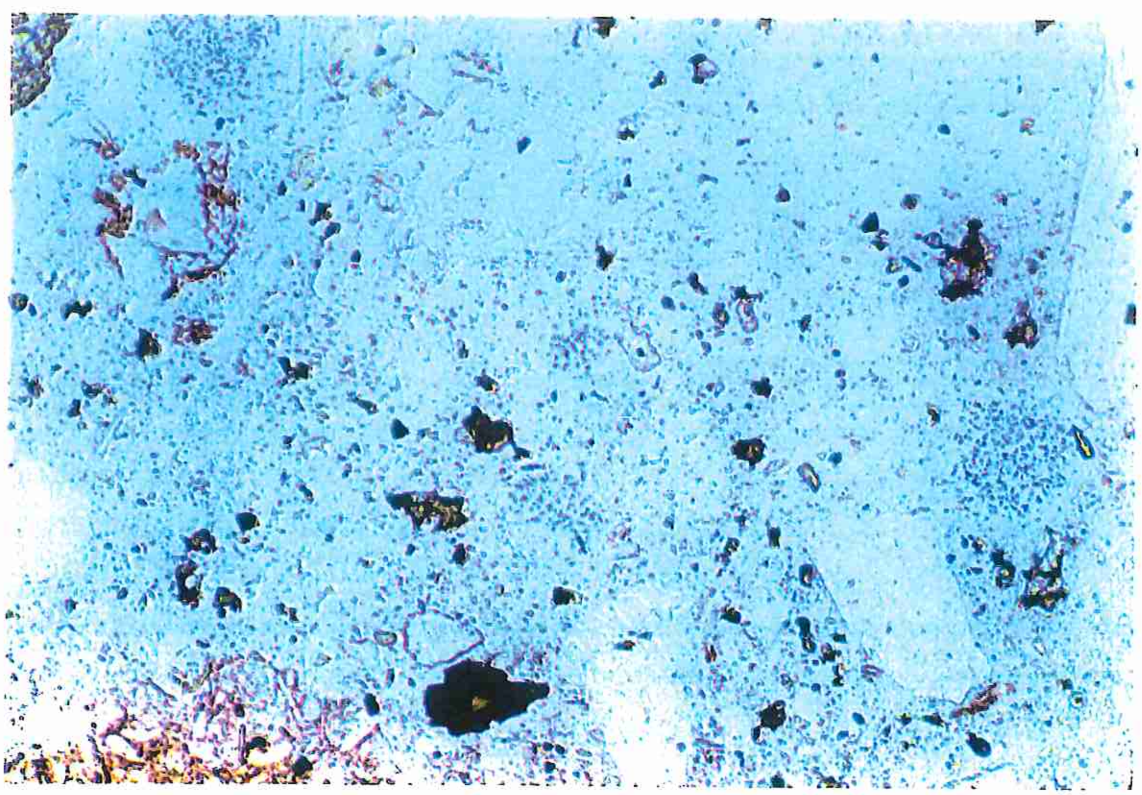
APS# 10-00143 DATE: 6-12-98

PROJECT: 25 SIGOURNEY STREET PARKING GARAGE, HARTFORD, CT



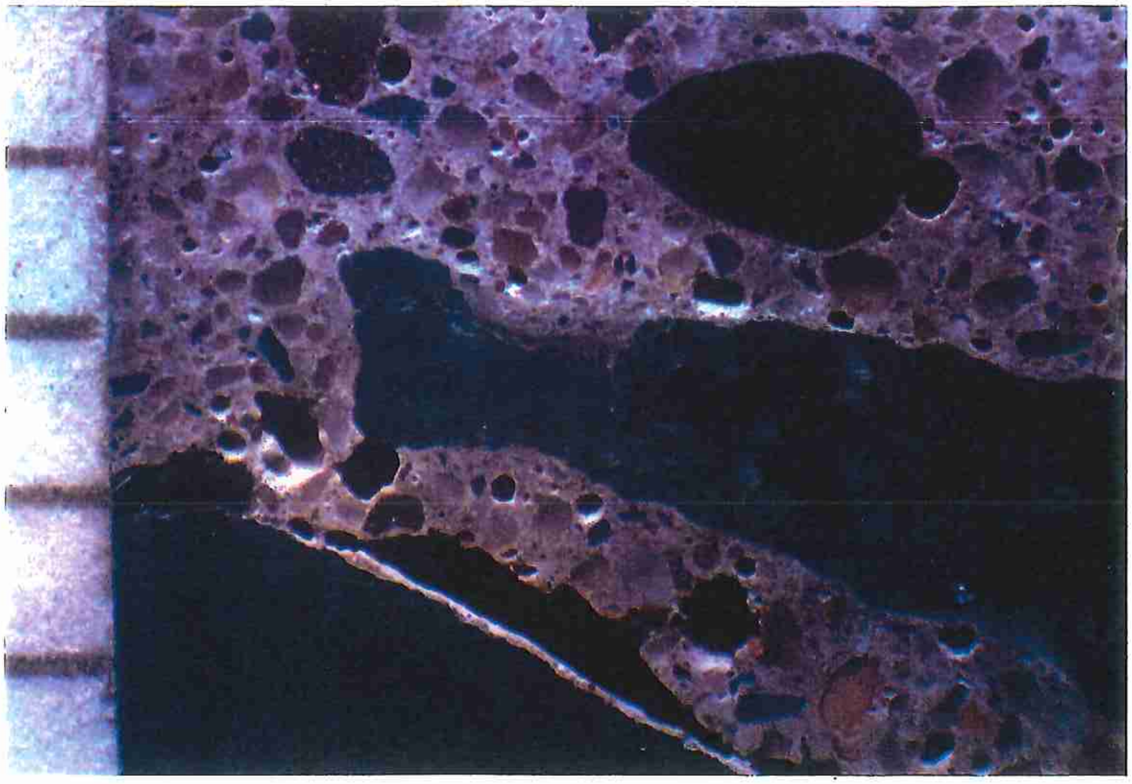
SAMPLE IDENTIFICATION: SG-3
MAGNIFICATION: 100x

SAMPLE DESCRIPTION: Dark, amber colored unhydrated cement particles (9-11%) under plane polarized light.



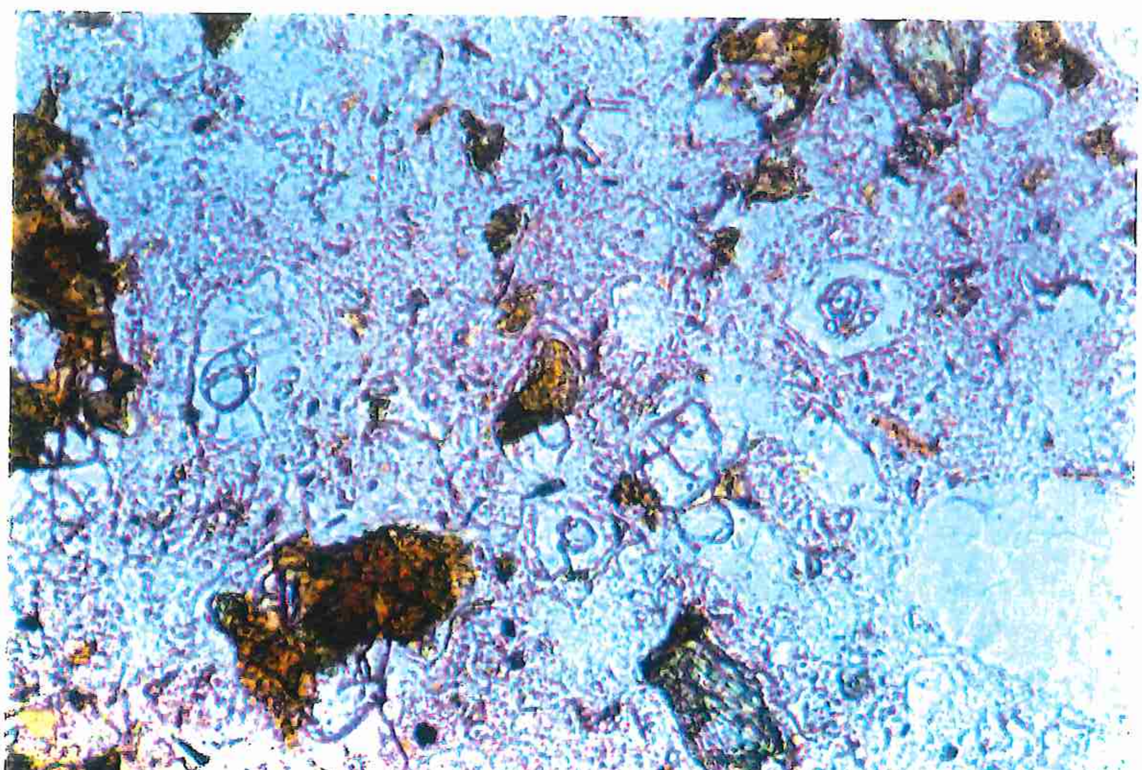
SAMPLE IDENTIFICATION: SG-4
MAGNIFICATION: 100x

SAMPLE DESCRIPTION: Dark, amber colored unhydrated cement particles (8-10%) under plane polarized light.



SAMPLE IDENTIFICATION: SG-3
MAGNIFICATION: 15x

SAMPLE DESCRIPTION: Darker gray paste area in coarse aggregate notch is consistent with retempering.



SAMPLE IDENTIFICATION: SG-3
MAGNIFICATION: 400x

SAMPLE DESCRIPTION: Well developed reaction rims around alite particles under plane polarized light.

APS #10-00143 DATE: 6/3/98

PROJECT: 25 Signourney Street Parking Garage, Hartford, CT

SAMPLE DESCRIPTION: Core Samples as received

Appendix B

Photographs

Photo 1: Exit (on left) and entrance (on right) on the east elevation. Garage extends under circular plaza area.

Photo 2: Entrance surface of brick, stone and concrete is deteriorating. Moisture and chlorides are penetrating through to structural elements as shown in photos to follow .

Photo 3: Previous repairs at entrance. Area needs reconstruction to protect structure below.

Photo4: Garage extends under the plaza area up to this crack (garage is to the right of the line).

Photo 5: Result of moisture penetration from entrance above; chloride deposits and ongoing corrosion.

Photo 6: Moisture affects 12" plaza slab, ceiling elements below (P3 level soffit shown here) and any embedded mechanical systems (including slab heating grid)

Photo 7: More evidence of soffit deterioration.

Photo 8: Column near entrance at Column Line intersection "N-12". Two vertical bars (at corners) are bowing out approx. two feet above floor. See photo #10.

Photo 9: Drawings indicate this area is transitioning from 14 vertical bars to 16 bars; the 16 bars extend up from the floor below to provide a lap splice with 14 bars coming down from above.

Photo 10 - Bar bowing. Indications are that the rectangular horizontal tie at this one elevation does not wrap outer two corner bars.

Photo 11 - Typical cracking around columns east of column line "K" in two-way slab negative moment region. Crack seals need repair.

Photo 12 Another example of two-way slab cracking at tower building garage. Note new cracks that need routing and sealing to protect tension reinforcing below.

Photo 13 - Expansion joint at roof looking north along column line "K". Joint is damaged and is leaking along entire length. Joints at all levels should be replaced.

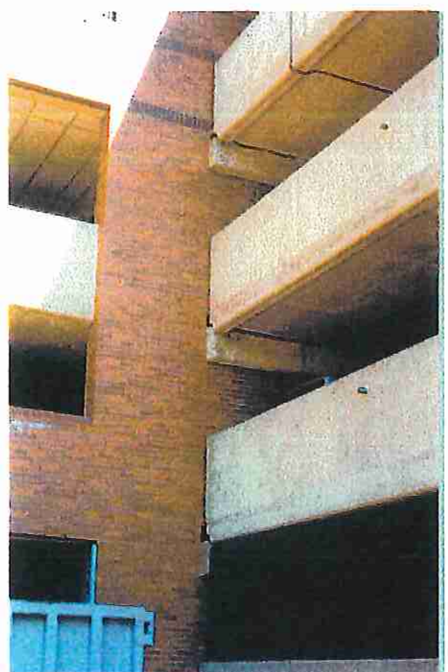


Photo 14 - Expansion movements and leaking joints have caused cracking at support ledge at "K-8". Neoprene bearings on ledge absorb expansions.

Photo 15 Close-up of typical damage at locations observed in photo 14. Bottom corner of parapet (above fence post) should be chipped back where it is touching ledge support. Note black neoprene bearing disappearing behind this parapet lip.

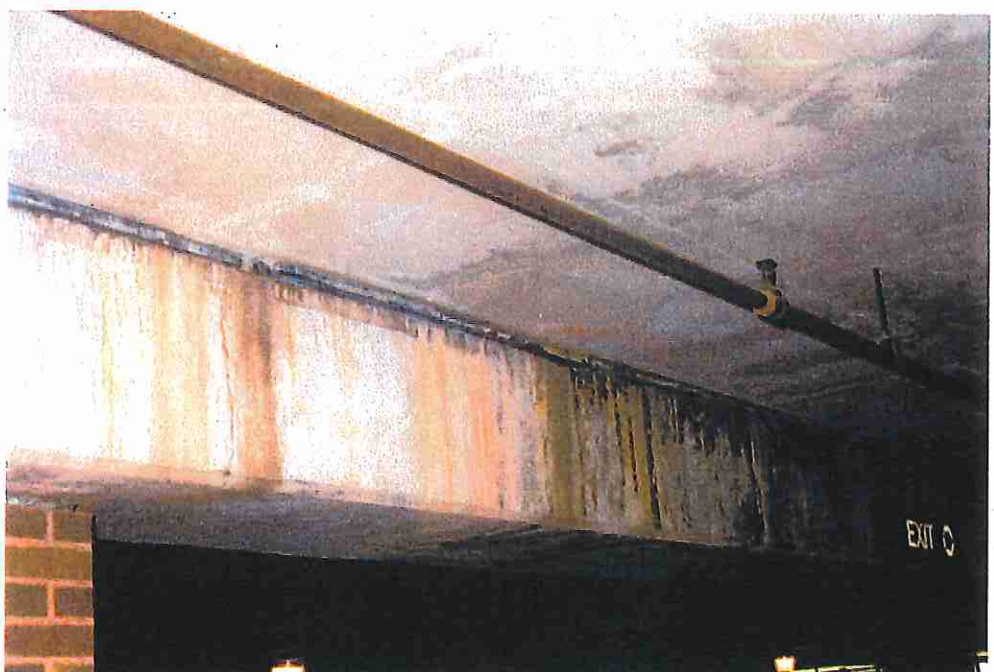


Photo 16 Moisture penetrating down past neoprene due to leaking joints (along column line "K"). Joints must be replaced.

Photo17 - Cracks with white sealant at roof slab run tranverse to axis of cantilever beams (cantilevered section is under cars). PT running in the direction of the cracks cannot prevent them. Tension in this negative moment region tends to open these cracks as the slab acts compositelv with the cast-in-place cantilever beams.

Photo 18 -Again at roof but over cantilevered section of beam. (parapet is in background)

Photo 19 Previous epoxy type repairs in roof deck and exposed embedded rebar in forground needing similar repair

Photo 20 Crack sealant is aging and failing. Note no cove joint at parapet; should install new cove joints.

Photo 21: Spalling over column bars has occurred in several places at the floor level. Minimum cover was not provided; repair required.

Photo 22: Looking west through cantilevered and post tensioned garage structure.

Photo 23: Soffit of external garage showing chloride deposits. Occurs more on the west end at the bottom of ramps.

Photo 24: At column line 5, where ramping bay beams connect to columns some cracking is occuring. Note evidence of heavy moisture and that column is loaded assymetrically at two different elevations (sloping ramp configuration)

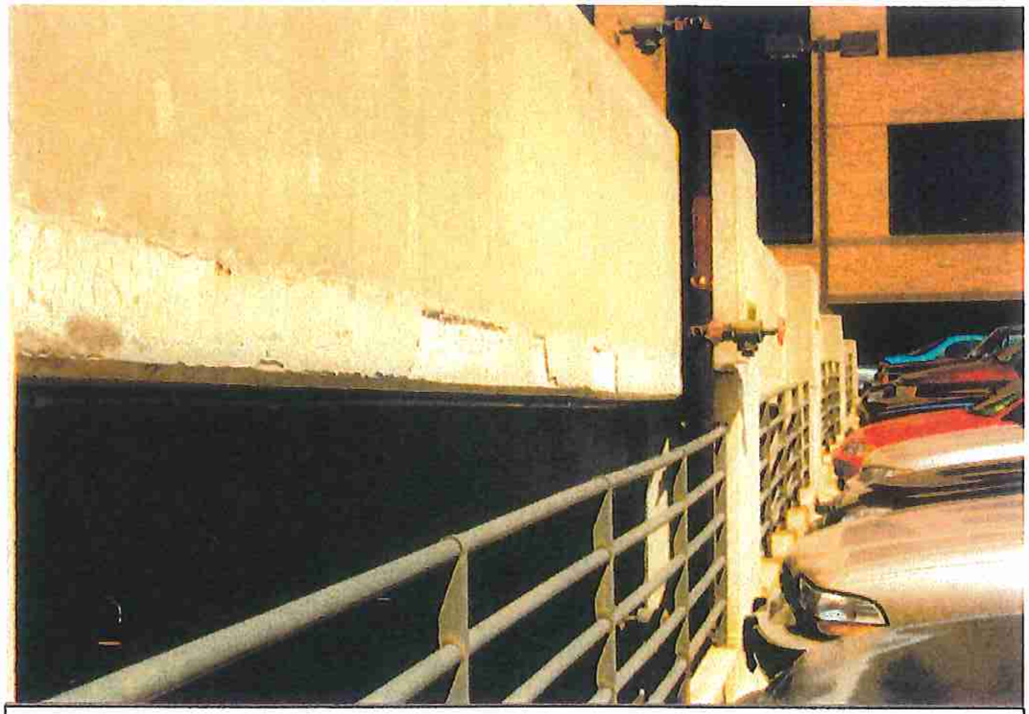


Photo 25 Parapet repairs required at roof and in several other areas.

Photo 26 Temporary repairs made to southwest stair core. Needs proper reconstruction

Photo 27 Efflorescence on inside wall of staircore.

Photo 28 In some areas the sight lines to exit signs are obstructed.

Photo 29 One post-tensioned strand was found "popped". Due to the location this is not a concern. It is an example, however, of what could happen if proper repair and maintenance is not preformed.

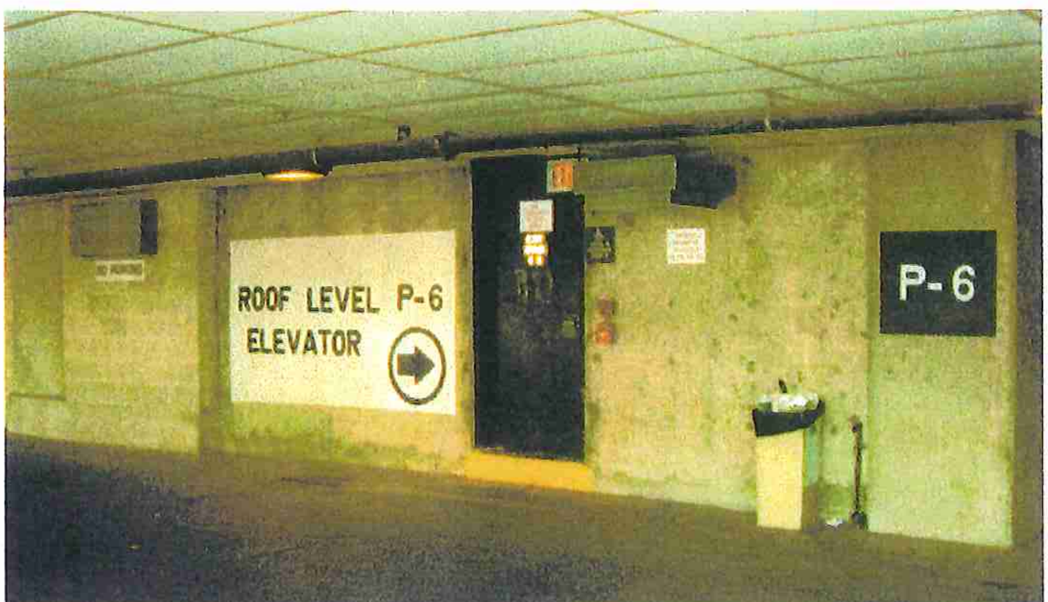
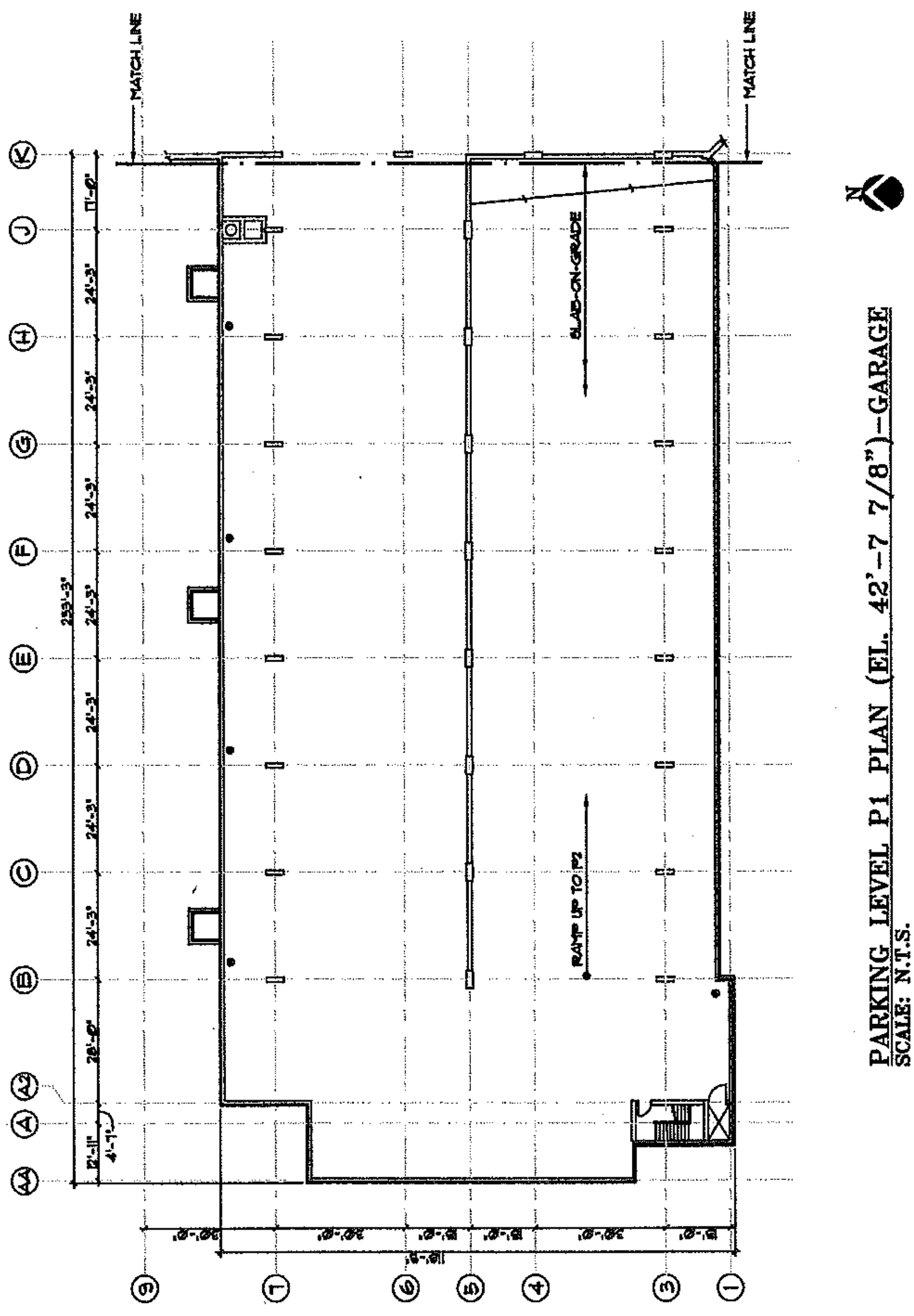


Photo 30 Step at door can catch pedestrian un-aware. Modification required.

Appendix C

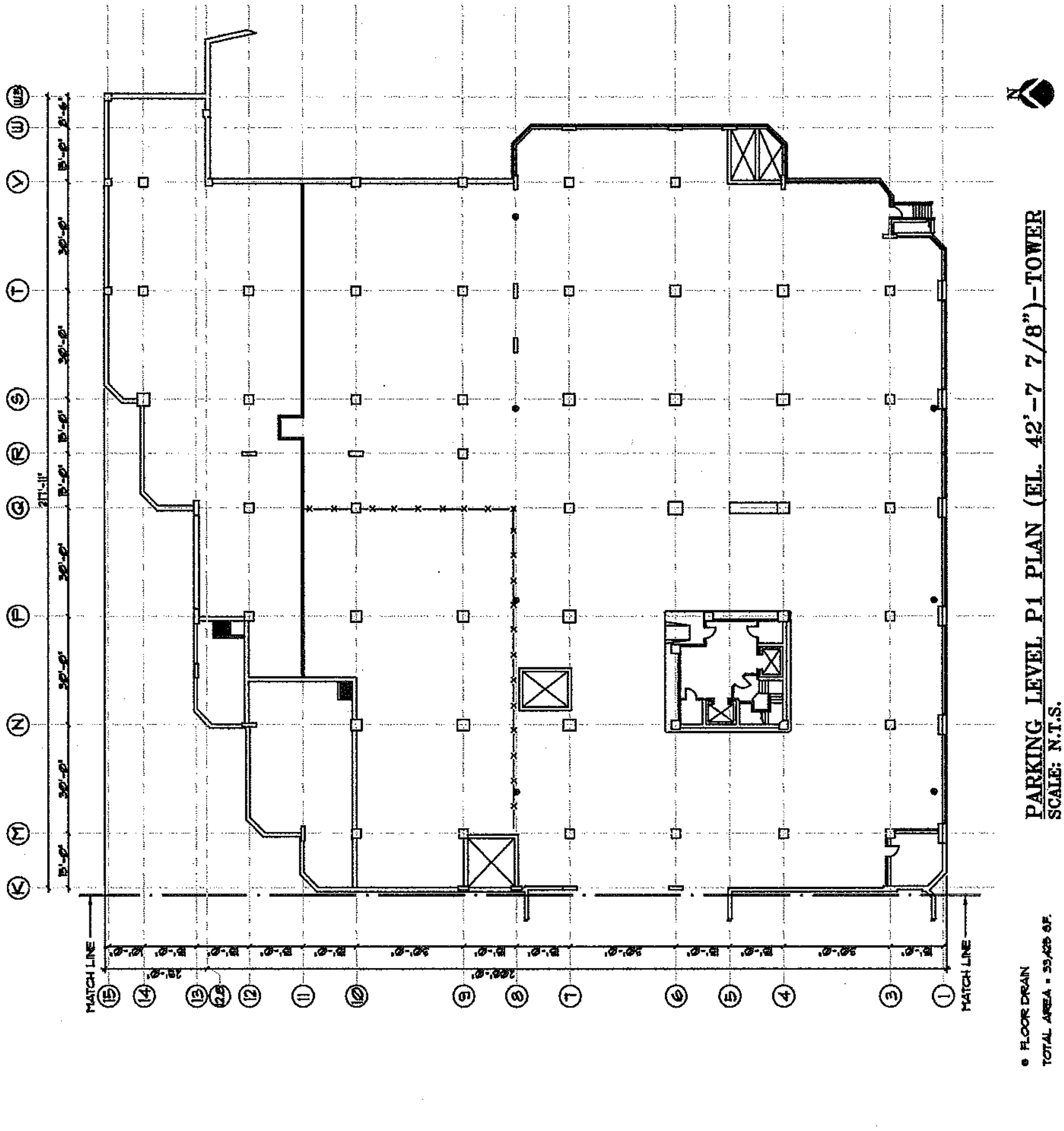
Garage Floor Plans



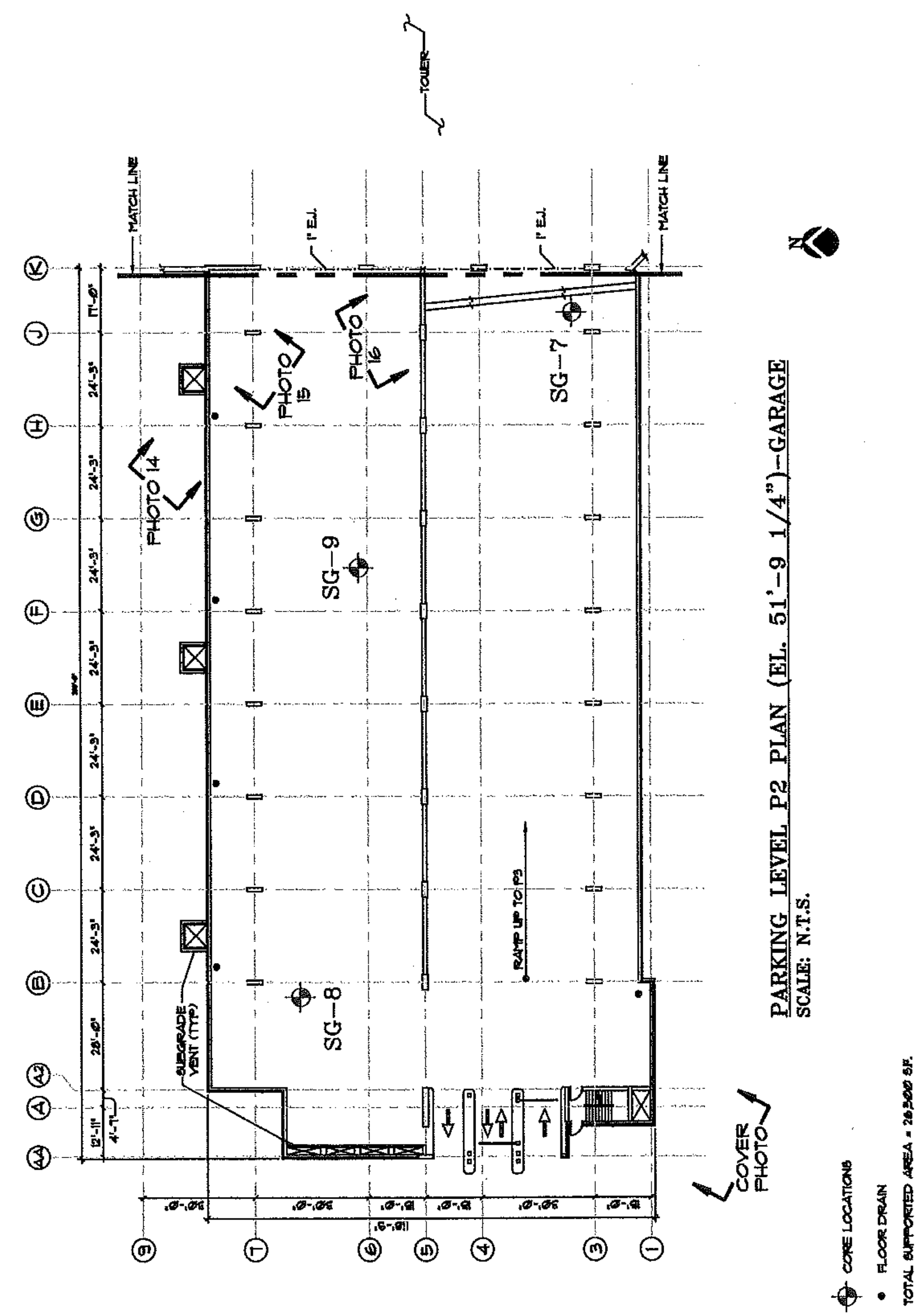
PARKING LEVEL P1 PLAN (EL. 42'-7 7/8")-GARAGE
SCALE: N.T.S.

• FLOOR DRAIN
TOTAL AREA = 26,300 S.F.

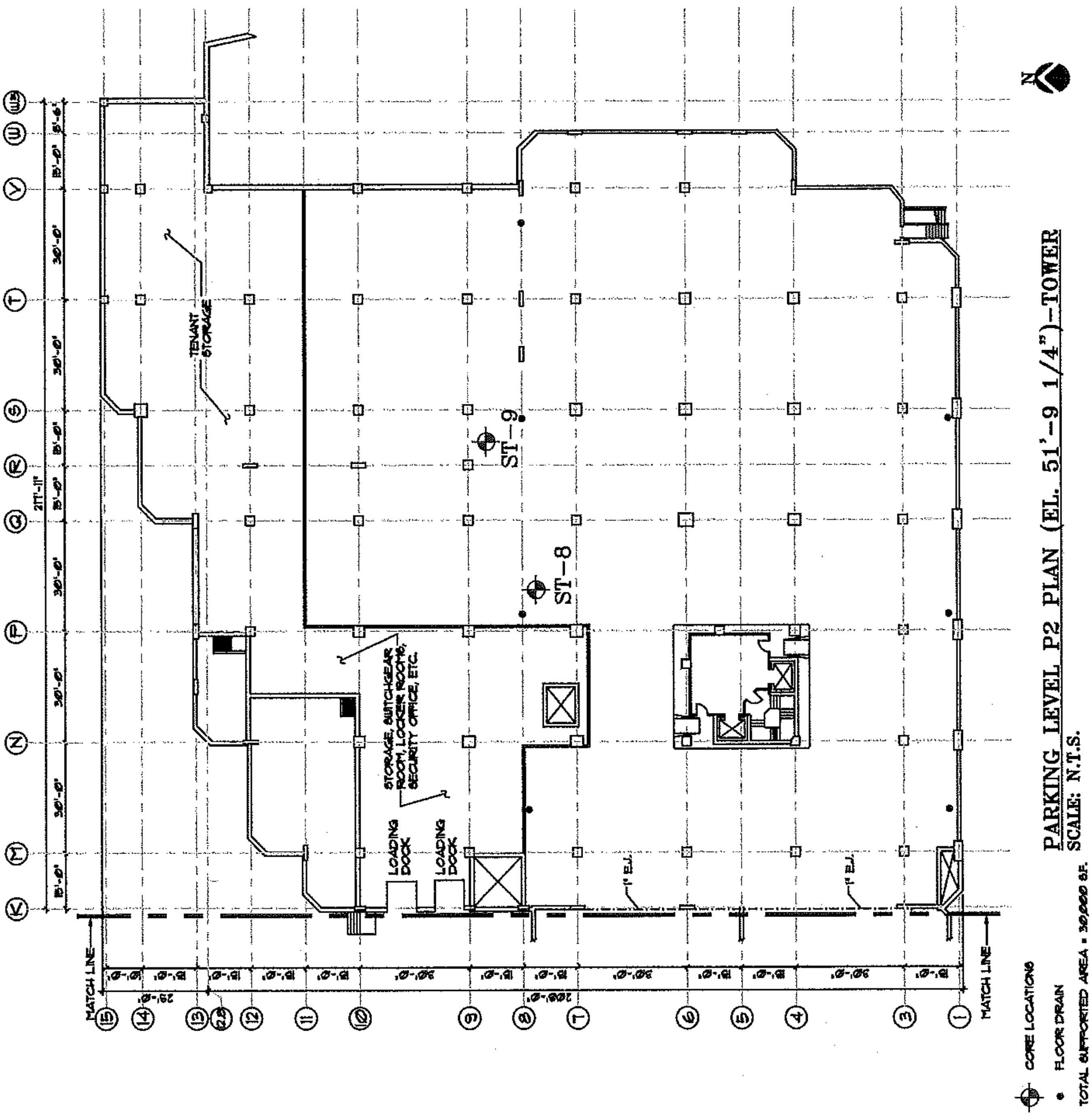
SK-1	CORE AND PLAN SURVEY FOR THE 25 SIGOURNEY STREET PARKING GARAGE HARTFORD, CONNECTICUT	DESMAN ASSOCIATES 433 SOUTH MAIN STREET, SUITE 327 WEST HARTFORD, CT 06110 (860) 313-0660 FAX:(860) 313-0661



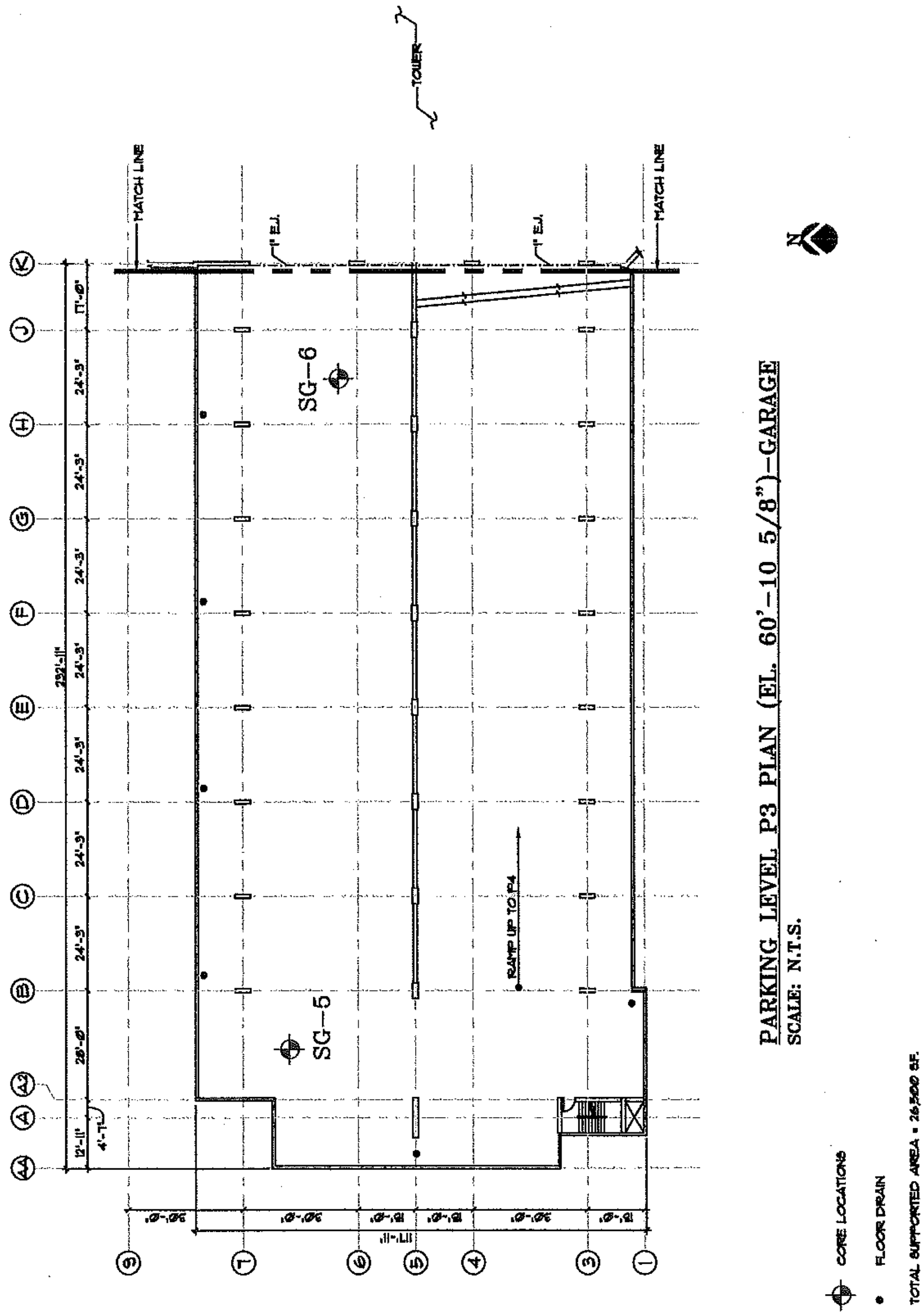
SK-2	CORE AND PLAN SURVEY FOR THE 25 SIGOURNEY STREET PARKING GARAGE HARTFORD, CONNECTICUT	DESMAN ASSOCIATES 433 SOUTH MAIN STREET, SUITE 327 WEST HARTFORD, CT 06110 (860) 313-0860 FAX:(860) 313-0861



SK-3	CORE AND SURVEY PLAN FOR THE 25 SIGOURNEY STREET PARKING GARAGE HARTFORD, CONNECTICUT	DESMAN ASSOCIATES 433 SOUTH MAIN STREET, SUITE 327 WEST HARTFORD, CT 06110 (860) 313-0860 FAX:(860) 313-0861



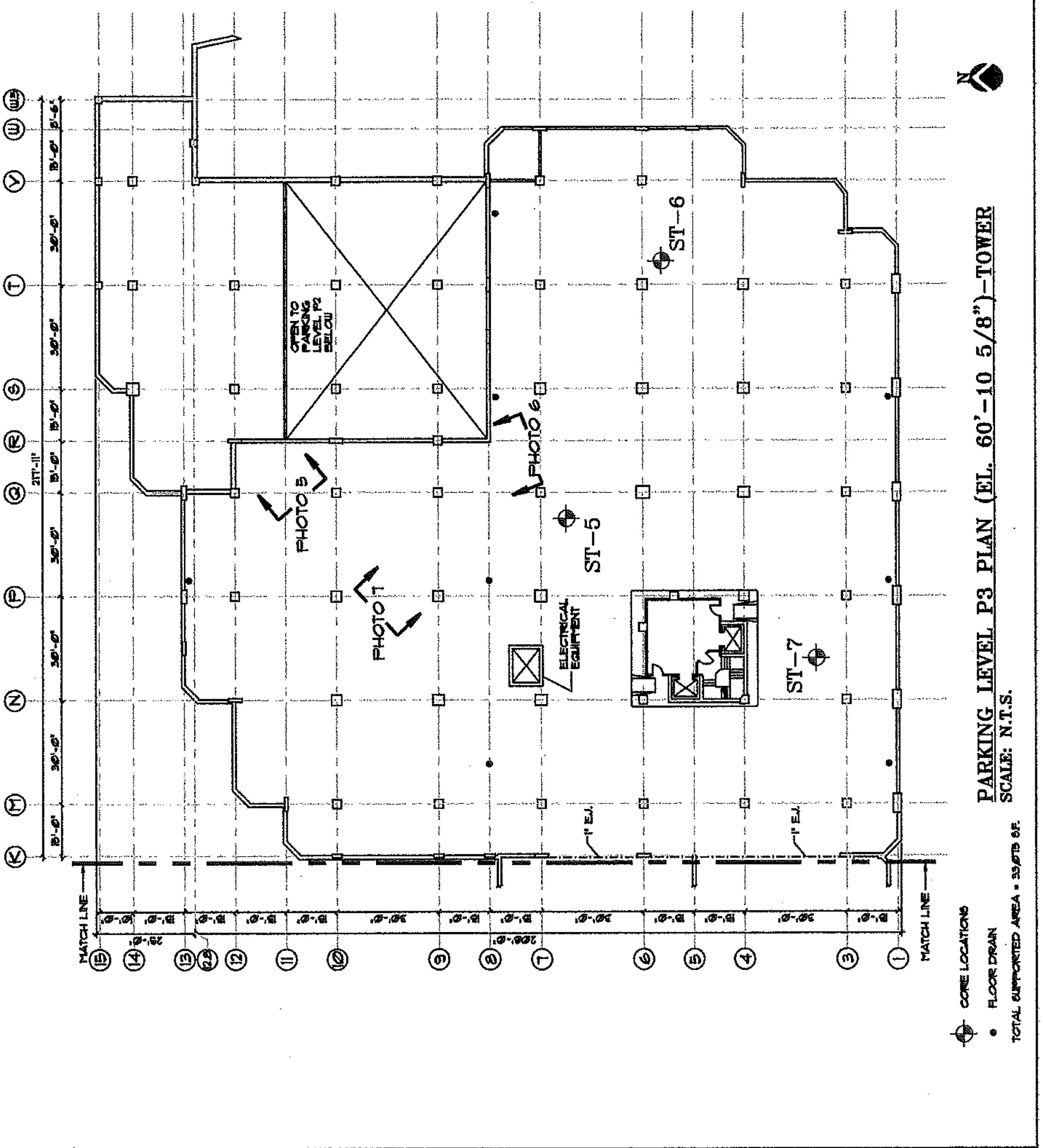
SK-4	CORE AND SURVEY PLAN FOR THE 25 SIGOURNEY STREET PARKING GARAGE HARTFORD, CONNECTICUT	DESMAN ASSOCIATES 433 SOUTH MAIN STREET, SUITE 327 WEST HARTFORD, CT 06110 (860) 313-0860 FAX:(860) 313-0861



PARKING LEVEL P3 PLAN (EL. 60'-10 5/8")-GARAGE

SCALE: N.T.S.

SK-5	CORE AND SURVEY PLAN FOR THE 25 SIGOURNEY STREET PARKING GARAGE HARTFORD, CONNECTICUT	DESMAN ASSOCIATES 433 SOUTH MAIN STREET, SUITE 327 WEST HARTFORD, CT 06110 (860) 313-0860 FAX:(860) 313-0861



SK-6

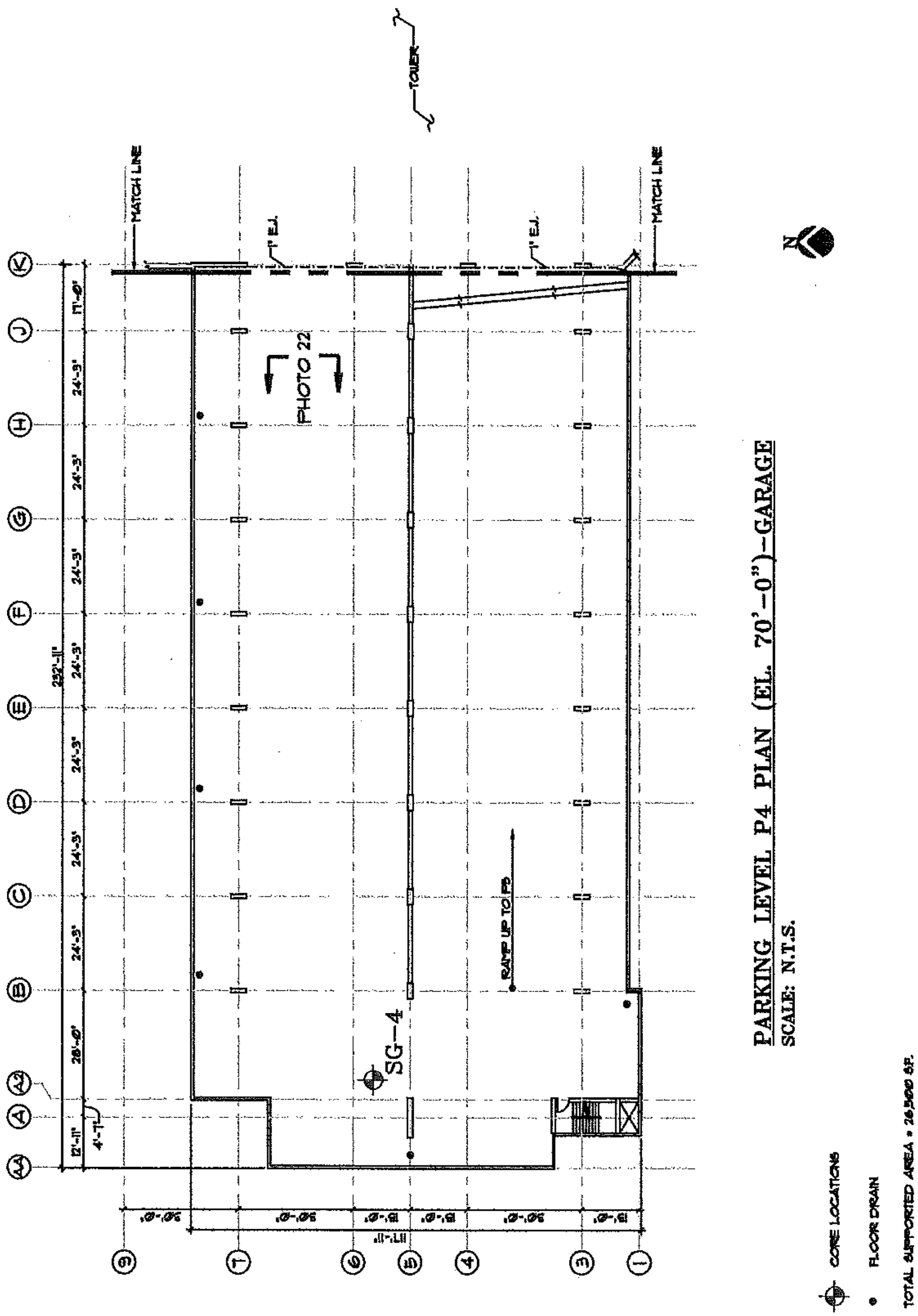
CORE AND SURVEY PLAN

FOR THE

25 SIGOURNEY STREET PARKING GARAGE

HARTFORD, CONNECTICUT

DESMAN
ASSOCIATES
433 SOUTH MAIN STREET, SUITE 327
WEST HARTFORD, CT 06110
(860) 313-0880 FAX:(860) 313-0881



PARKING LEVEL P4 PLAN (EL. 70'-0")-GARAGE

SCALE: N.T.S.

SK-7

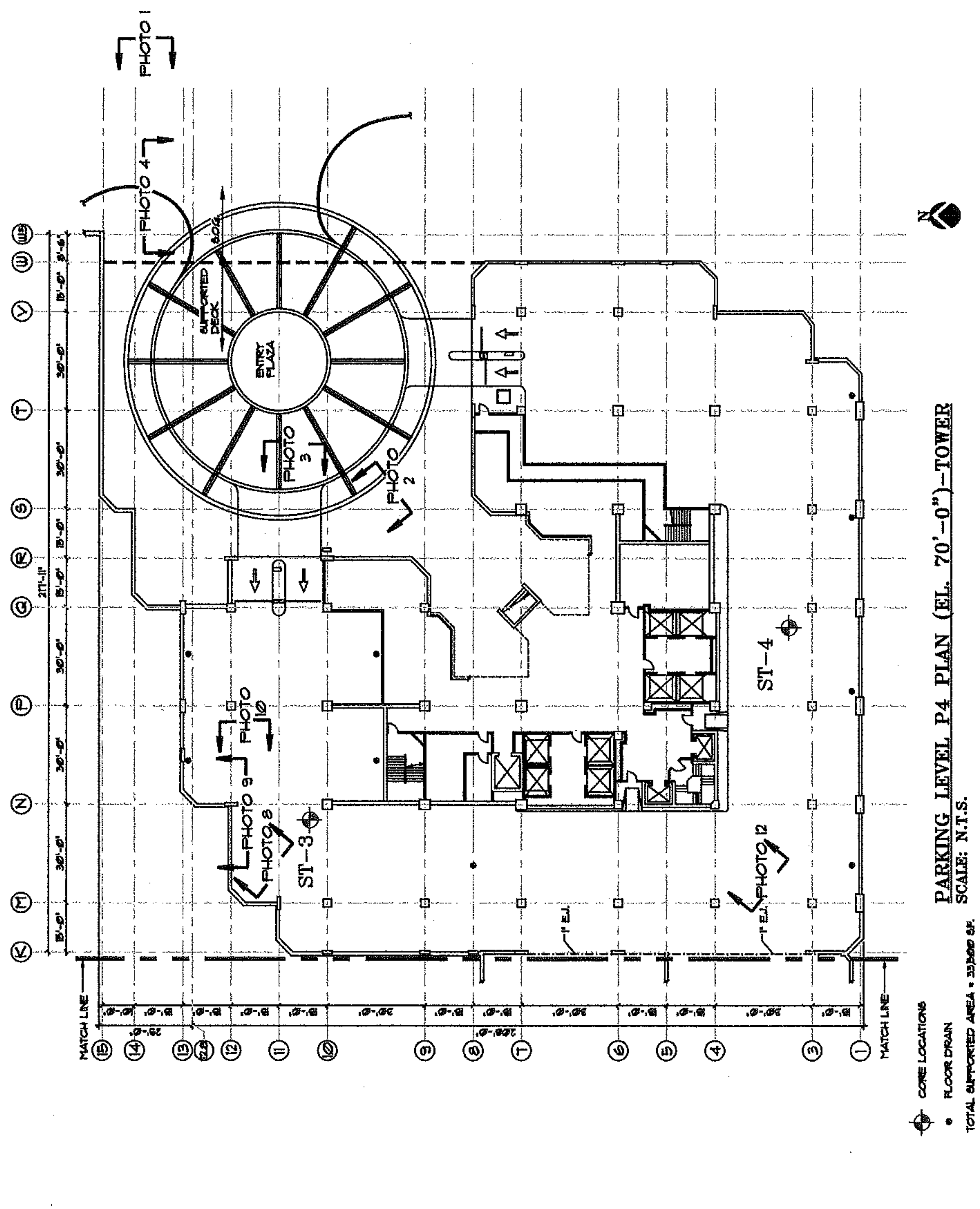
CORE AND SURVEY PLAN

FOR THE

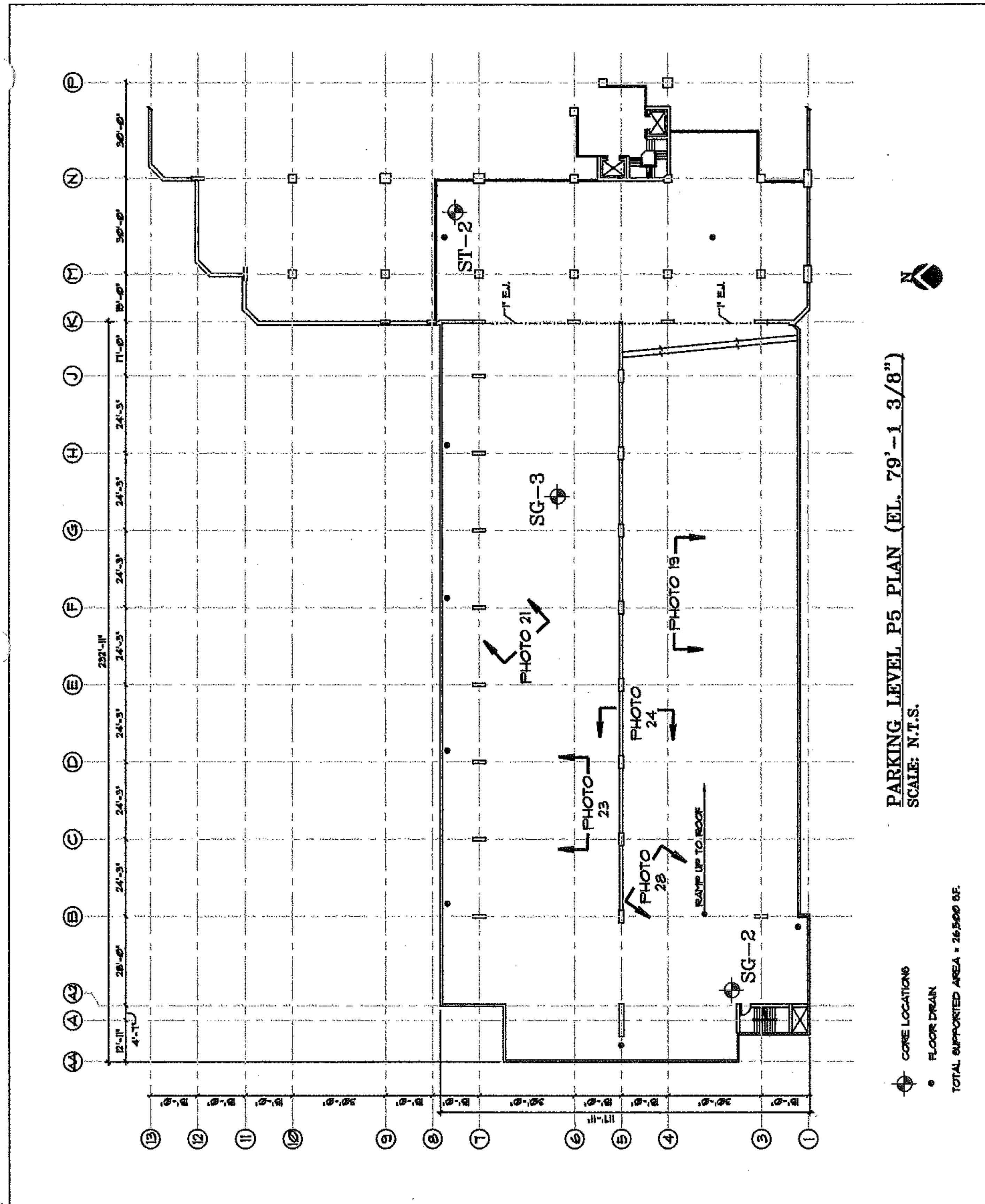
25 SIGOURNEY STREET PARKING GARAGE

HARTFORD, CONNECTICUT

DESMAN
ASSOCIATES
433 SOUTH MAIN STREET, SUITE 327
WEST HARTFORD, CT 06110
(860) 313-0860 FAX:(860) 313-0861



SK-8	CORE AND SURVEY PLAN FOR THE 25 SIGOURNEY STREET PARKING GARAGE HARTFORD, CONNECTICUT	DESMAN ASSOCIATES 433 SOUTH MAIN STREET, SUITE 327 WEST HARTFORD, CT 06110 (860) 313-0860 FAX:(860) 313-0861



SK-9

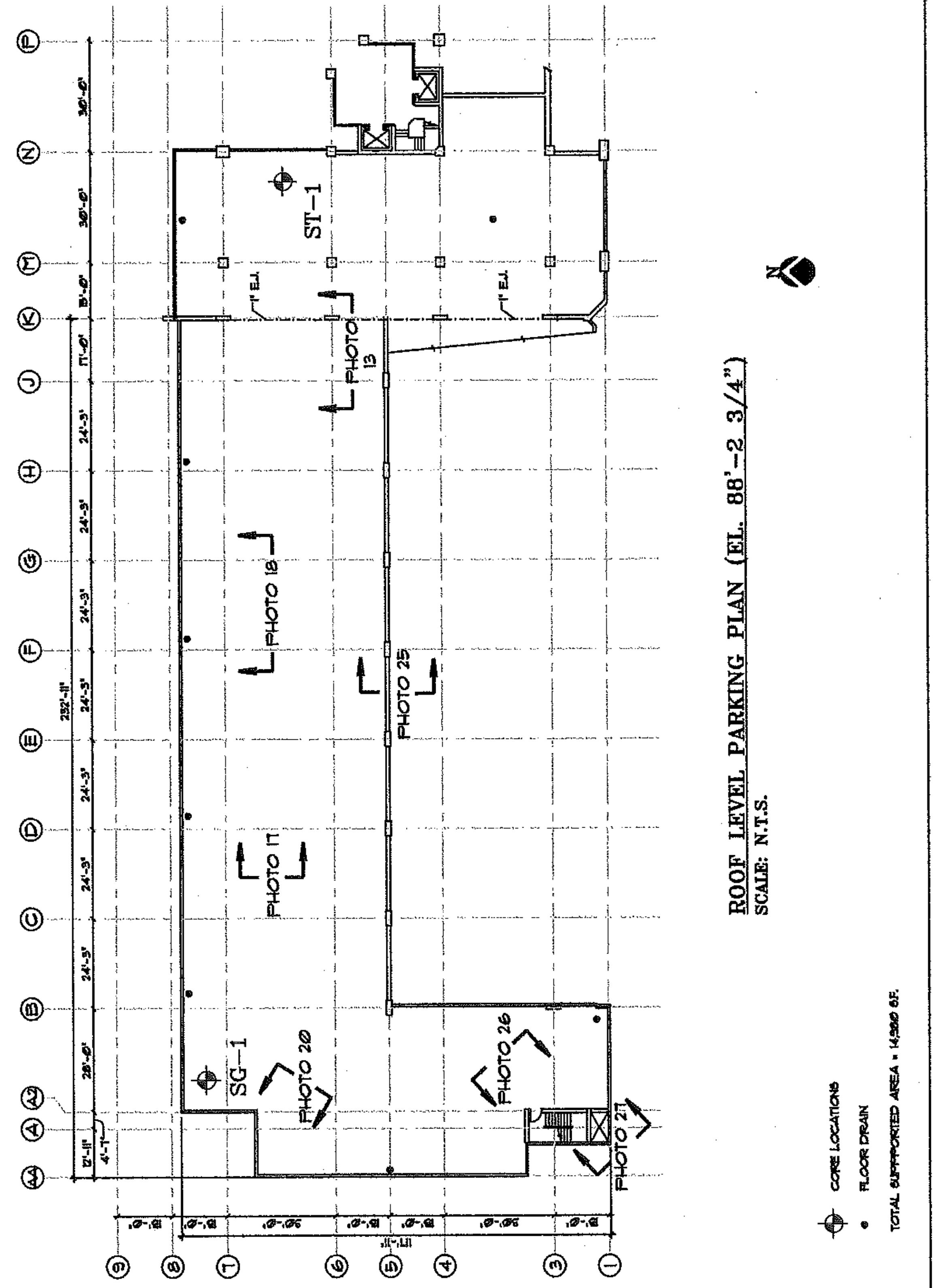
CORE AND PLAN SURVEY

FOR THE

25 SIGOURNEY STREET PARKING GARAGE

HARTFORD, CONNECTICUT

DESMAN
ASSOCIATES
433 SOUTH MAIN STREET, SUITE 327
WEST HARTFORD, CT 06110
(860) 313-0880 FAX:(860) 313-0861



SK-10

CORE AND PLAN SURVEY

FOR THE

25 SIGOURNEY STREET PARKING GARAGE

HARTFORD, CONNECTICUT

DESMAN
ASSOCIATES
433 SOUTH MAIN STREET, SUITE 327
WEST HARTFORD, CT 06110
(860) 313-0860 FAX:(860) 313-0861

Appendix D

Deterioration Mechanisms

DETERIORATION MECHANISMS

Reinforced concrete deterioration is typically caused by one or more factors or deterioration mechanisms including; corrosion of reinforcement, water penetration, freeze-thaw cycling, volume change, or chemical attack. Any one or combination of these deterioration mechanisms can adversely impact the behavior/performance of a reinforced concrete structure. These adverse impacts include corrosion induced distress, loss of reinforcing cross section, scaling, leaking, cracking, and delamination of concrete. The following is a brief discussion of each of the mechanisms noted above, and their effect on reinforced concrete structures.

Water Penetration

The primary cause of the majority of reinforced concrete deterioration within parking structures is directly related to the penetration of water into the concrete. Reinforcing corrosion, scaling, leaking, leaching, and often delamination are all caused partially by water penetration.

Concrete is a porous material, susceptible to water penetration and resulting deterioration. Reinforcing corrosion is an electrochemical process accelerated by the presence of water acting as an electrolyte. In addition, water penetrating into concrete can carry water-soluble chlorides (de-icing salts) to the reinforcing. The combination of chlorides and water further accelerates this corrosion process.

Scaling is also directly related to water penetration into concrete. Scaling is a surface deterioration resulting from pressures by freeze-thaw cycling of saturated concrete. These pressures within the pore structure cause progressive failure of the cement/sand paste. This progressive failure begins with degradation of the exposed surface, advances to the exposure of coarse aggregate, and in severe cases causes paste failure surrounding the coarse aggregate destroying the paste/aggregate bond.

Water penetration through a concrete section, cracked or uncracked, can cause leaking and often leaching. Leaking exposes underlying members to water and potentially chlorides, if present, resulting in deterioration of these members. Leaching is the result of frequent water penetration carrying water-soluble products within the concrete to the surface below. Continued leaching will adversely effect the concrete over time.

Water penetration can also cause delamination of concrete along subsurface fractures through pressures generated during freeze-thaw cycling.

Corrosion of Reinforcement

Corrosion of reinforcing steel or other embedded ferrous items such as electrical conduit is a second major factor contributing to deterioration of reinforced concrete. This corrosion process is an electrochemical process that produces by-products (rust). These by-products occupy a minimum of 250% of the volume of the parent metal. This increase in volume produces tensile stresses within the surrounding concrete. As concrete has poor tensile strength properties, cracking occurs allowing additional moisture and chlorides to reach the reinforcing causing acceleration of the corrosion process. The deterioration caused by this corrosion includes the reduction of cross sectional area of the reinforcing, and the delamination of concrete surrounding the reinforcement.

Freeze-Thaw Damage

Concrete deterioration caused by freeze-thaw cycles is a third major deterioration mechanism. The mechanism occurs within saturated concrete subjected to freezing and thawing due to the pressures generated within the pores of the concrete paste resulting from the volume changes of water during the freeze/thawing process. These pressures are even greater in the presence of de-icers/chlorides as these chemicals reduce the freezing point and indirectly increase the pore pressures. As previously mentioned, these pressures can cause progressive failure of the cement paste and result in scaling of the concrete, and delamination of concrete along subsurface fracture planes.

Volume Changes

Volume changes are a fourth major contributing factor of deterioration of reinforced concrete structures. These volume changes occur in both plastic and cured concrete. These volume changes can cause various types of cracking within the concrete member. These cracks allow access for water and contaminants to the concrete and reinforcing, resulting accelerated deterioration to occur. The cracking most often associated with plastic concrete is shrinkage cracking produced by the reduction in volume of the concrete during curing. Improper detailing, proportioning, placement, or curing of the concrete can effect the extent of this cracking, but the primary cause is the volume change that occurs during curing.

Volume changes due to thermal movement, shrinkage, creep, and loading can also contribute to the deterioration of reinforced concrete. These volumes changes will produce stress in restrained members, often resulting in cracking of the member. These cracks also provide access to water and other deterioration mechanisms to attack the member.

Chemical Attack

Chemical attack is a fifth major deterioration mechanism affecting the performance of reinforced concrete. The effect of de-icers/chlorides upon reinforcing steel and scaling is one example of chemically influenced deterioration. In addition to this type of chemical attack, severe exposure to other chemicals, notably sulfates and acids, can cause deterioration of cement paste, cement paste/aggregate bond, and reinforcing steel. In addition to these types of attack, chemical properties occurring within certain types of aggregates can cause an adverse reaction with the cement paste. The resulting volume changes can cause cracking of the concrete.