Appendix 5.08
2012 FFA Facility Study

FFA
Architecture
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PARKING STRUCTURE ONE ASSESSMENT

FOR

PORTLAND STATE UNIVERSITY

March 22, 2012

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EXECUTIVE SUMMARY

In March of 2011, Portland State University contracted FFA Architecture and Interiors and their consultant team to provide a 'Parking Facilities Condition Assessment' of nine garages currently owned and operated by PSU.

FFA and consultants, International Parking Design (IDP) and Glumac Engineers performed this assessment over next several months. Each garage was investigated for: Overall Condition, Operation, Life / Safety, Structural, Mechanical, Plumbing and Electrical system condition. Supplemental Attachment #1: Parking Structure One Executive Summary is attached.

As noted in the assessment, Parking Structure One (PS-1) showed signs of significant deterioration of the outer 12' +/- of the building. FFA recommended that additional evaluation should be made of Parking Structure One.

> "This deterioration overshadows all other issues related to this garage. Extensive structural evaluation and forensic testing should be completed to determine the extent of deterioration and potential repairs."

On November 3, 2011 Portland State University extended FFA's contract to provide the recommended evaluation and testing of the existing conditions at Parking Structure One and to develop a strategy to extend the useful life of Parking Structure One for at least another twenty years.

FFA and their consultants, KPFF Consulting Engineers, and GPR Data, have completed the assessment of Parking Structure One. The following is an executive summary of this assessment.

EXISTING CONDITIONS

In the original report, it was noted that parking structures in the range of 50 years old are nearing the end their useful life. Weather, vehicle wear and tear, and age will break down concrete surfaces. Flaws in the original design of structural and storm water drainage systems can accelerate deterioration. Upgraded building code requirements for life/safety, lateral design (seismic), and accessibility can make the structure outdated. New trends in building design for sustainable 'green' structures and the demand for more efficient operation can make the structure functionally obsolete.

At over 46 years old, Parking Structure One meets all the criteria noted above with the following specific comments:

- There is general deterioration of the perimeter beams, slabs and guardrail assembly on all four elevations at levels 3 through 8. Insufficient and improperly built drainage systems at the perimeter cast-in gutter have permitted the rain water runoff to build up and saturate the outer six to nine feet of the structure. This has resulted in corrosion of steel reinforcement and deterioration of the concrete to the point of near failure. The addition of the 1992 / 1993 steel tube section and concrete panel guardrail systems have added to this general deterioration.

- Parking Structure One's original design and the upgrades in 1992 / 1993 appear to meet building code requirements that were in effect at the time. It does not meet current code requirements for guard rail and hand rail mounting heights, lateral design and accessible parking. Upgrading these deficiencies to the current building code is not required at this time. However any repairs or upgrades will be required to meet current codes.

- The structure was not built with sustainable concerns in mind. However, by building type it has minimal impact on the environment around it. Storm water treatment, electrical and lighting, building elevator and the first floor CO2 exhaust system appear to contribute the most demand loads on local utilities. These systems should be considered for upgrades as part of the overall package of work required to extend the building life for another twenty years.

- The interior structure of the building appears to be in good condition with little deterioration of the concrete surfaces at drive lanes and stair towers.

- Remedial work to remove loose and spalling concrete was completed over the 2011 / 2012 winter break. These new exposed conditions should be monitored by PSU staff on a regular basis.

SUMMARY RECOMMENDATIONS

Parking Structure One is located such that it is often the first building seen and used by students, faculty and guests. Yet it has only a small campus sign for identification with Portland State University. FFA recommends that Portland State University consider the restoration and upgrade of Parking Structure One as an opportunity to make a statement about the University, its philosophy and goals.

In order to extend the useful life of Parking Structure One for another twenty years, FFA has developed a series of recommendations:

The following is a summary of recommended restoration and upgrades for Parking Structure One.

1. PSU should provide regular observation to detect further deterioration and loose or spalling concrete. This material should be removed immediately.

2. The existing perimeter guardrail system is in poor condition with certain areas appearing to be in a near failure condition. Welds, structural connections and the concrete around these connections appear to be failing. The entire exterior guardrail system should be replaced with a new cable rail system, at a minimum.

3. Based on the known condition of the perimeter edge beams and outer two concrete waffles slab section, and the inherent design flaw in the perimeter drainage system, we recommend that the beam and outer two waffle slab sections be removed and replaced at levels three through eight on all four sides. This will allow for enhanced drainage and a lighter more efficient structural system

4. A new, lighter and more efficient exterior envelop should be installed in lieu of the existing precast concrete guardrails. The proposed solutions include a base cable guardrail system with options 1 and 2 developed to respond to PSU's immediate need to repair Parking Structure One to achieve another twenty years of operational life.

PSU may want to consider additional upgrades to make the structure more sustainable. These upgrades could include:

- Upgrade lighting with compact fluorescent, HID or LED fixtures.
- Paint interior surfaces white or a light color to increase light reflection.
- Connect storm drain system to bio-filtration system.
- Replace and upgrade the existing passenger elevator.
- Replace and upgrade the existing CO2 exhaust system for the first floor.
- Provide 'green screen' type exterior wall assembly.
- Provide photovoltaic panel system on roof.
- Provide alternative energy charging stations for selected parking spaces.

The scope of work necessary to extend the useful life of Parking Structure One is extensive and will require City Of Portland Design Review and approval as part of the Type III review procedure.

> 'Proposals in the Downtown Design District that are over 1,000 square feet in area, or require an exterior alteration and have a value over $368,300.00.'

The Design Review process is very linear in nature and will require extensive planning and coordination with the City of Portland Bureau of Development Services.

FFA recommends that a 'Pre-application conference' be scheduled with the city and that the optional 'Design Advice Request' review also be included. Attached is the City of Portland's published 'Type III Land Use Review Procedure' schedule.

On April 26, 2011, FFA hosted an 'eco-charette' with staff from Portland State University. The goal of the charette was to investigate potential sustainable options for upgrading Portland State University parking structures. Included were: alternative energy production utilizing solar and wind power, high efficiency lighting, storm water mitigation and numerous other opportunities that these large single-use structures offer.

Based on this eco-charette and subsequent analysis, we believe that Parking Structure One has the potential to be a 'net-zero' energy use building with the implementation of sustainable upgrades.

COST ESTIMATE

PORTLAND STATE UNIVERSITY
PARKING STRUCTURE ONE
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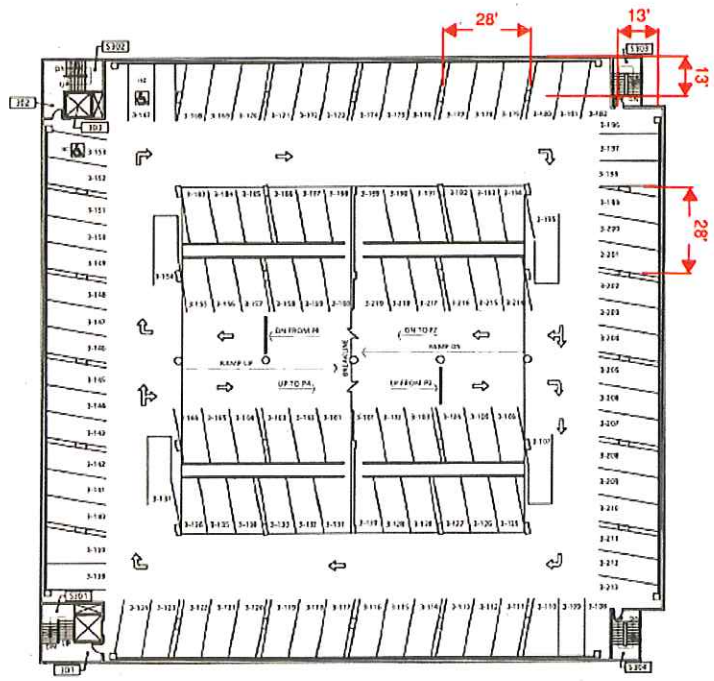
ASSESSMENT

EXISTING CONDITIONS

FFA, KPFF and GPR DATA completed an extensive evaluation of Parking Structure One over three months during November and December of 2011 and January of 2012. To address the existing conditions, the original design and alterations should be reviewed.

ORIGINAL DESIGN

Parking Structure One was originally a five level structure completed in 1966, with an additional three levels being added shortly after and completed in 1967. The building structure is a poured in place concrete column and joist frame with 3' x 3' concrete waffle slabs. At each corner, there are concrete stair towers with elevators at the northwest and south west corners. The south west elevator has not been installed. The structure has two automobile entries / exits on the first floor off S.W Sixth and S. W. Harrison and two automobile entries / exits on the second floor off S.W. Broadway and S.W. Hall.



PARKING PLAN THREE

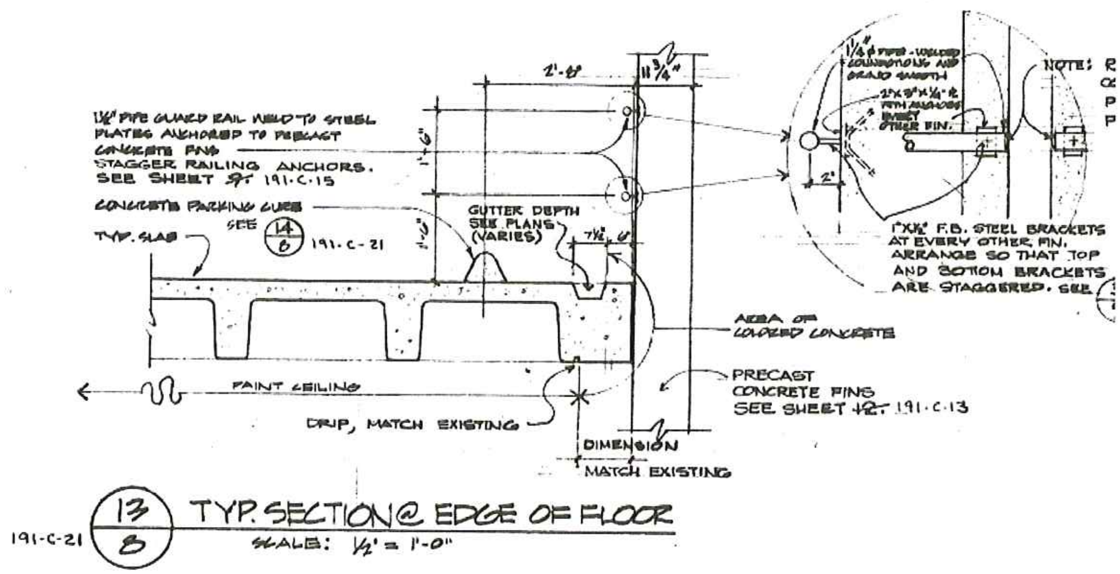
TYPICAL FLOOR PLAN (LEVELS 3-8)

The structural layout of the concrete columns is on a grid pattern with the columns at 28'-0" on center each way. The first row of columns is located 13'-0" back from the property line.

The concrete waffle slab cantilevers from this row of columns 12' to a perimeter beam. This beam provided structural support for the slab edge and original vertical precast concrete fins. The beam also has a cast-in gutter on the top as part of the rain / storm water system.

The gutter system was design to slope from a high point centered on each side and extend 80'+ to vertical rain leaders at each end. Due to the length of the run, the resulting gutter slope is marginal at best.

The original building exterior was composed of vertical pre-cast concrete fins installed at approximately 3' on center. These fins were attached to the perimeter slab edge utilizing and steel flat bar straps cast into the concrete fin and welded to an embed cast in the perimeter beam.

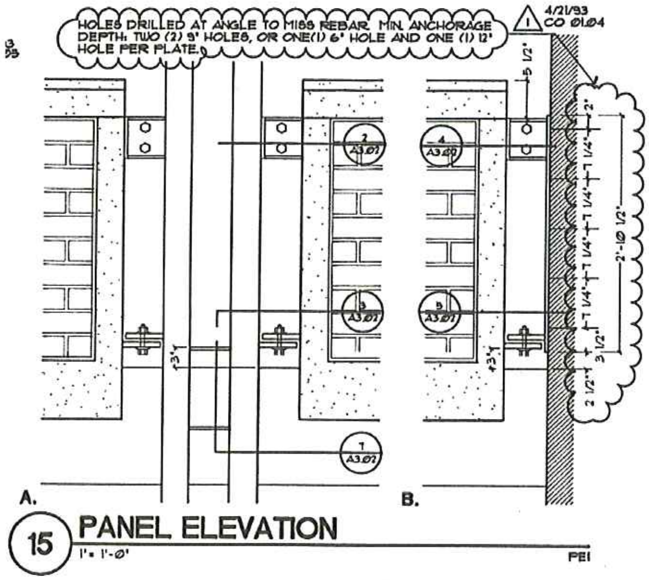


ORIGINAL SLAB / GUTTER DETAIL WITH PRE-CAST CONCRETE FINS

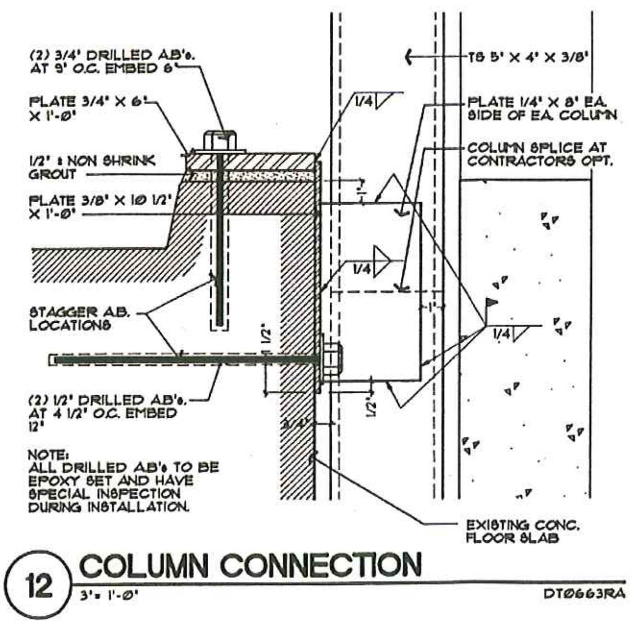
1992 / 1993 UPGRADE

Part of a general building upgrade in 1992, the pre-cast concrete fins were removed. A new exterior panel / guardrail system was installed.

This new system consists of pairs of 6" x 6" steel tube section columns spanning from the third floor to the roof level. These tubes are anchored to each slab with two anchor bolts. These columns in turn carry horizontal precast concrete panels. The concrete panels provide the required car barrier and guardrail for each level.



1992 PRECAST PANEL GUARDRAIL ELEVATION



1992 PRECAST PANEL CONNECTION DETAIL

EXISTING CONDITIONS

The evaluation team made several visits to the building to review the current conditions with one consistent observation resulting from each visit: rain and storm water are not being properly dealt with by the existing gutter / rain leader system. The on-going failure of this system results in standing water at all levels and each side. This standing water is then migrating through cracks in the concrete, around cast-in embeds, loose anchor bolts and through other gaps and spalls, ultimately corroding the structural reinforcement in the concrete beams and waffles. Significant amounts of water also cascade down the face of the building on the west, south and at times the east elevations causing additional deterioration in the precast concrete panels and support structure.

West elevation saturated by rain run-off and over-flowing gutter system. Moss, mildew and general 'muck' coat several panels.

West elevation saturated by rain run-off and overflowing gutter system. Fifth floor looking up at sixth floor perimeter concrete beam.

TESTING AND OBSERVATIONS

TESTING

As part of the extended evaluation and testing approved in November of 2011, GPR Data was hired to complete a survey of the building. GPR Data has extensive experience in surveying structures to document existing conditions and the deterioration of structural elements. In the case of PS-1 the concrete columns, beams and waffle slab were thoroughly inspected and tested.

GPR Data utilized Ground Penetrating Radar (GPR) as a nondestructive geophysical method that produces a continuous cross-sectional profile or record of subsurface features, without drilling, probing, or digging. Ground penetrating radar (GPR) profiles are used for evaluating the location and depth of buried objects and to investigate the presence and continuity of natural subsurface conditions and features.

Ground penetrating radar operates by transmitting pulses of ultra-high frequency radio waves (microwave electromagnetic energy) down into the ground through a transducer (also called an antenna). The transmitted energy is reflected from various buried objects or distinct contacts between different earth materials. The antenna then receives the reflected waves and stores them in the digital control unit.

The PSU Parking Structure provides the perfect medium to use GPR and various antennas and methodologies to map steel reinforcement, depth of concrete, voids and corrosion on structural components.

Mike Edwards from GPR DATA supervised the testing and inspection in late December. The results of this survey are documented on the GPR Report (appendix item #9)

A brief summary by floor follows:

First Floor – Looking up at bottom of second floor slab:

Little deterioration noted. A few waffles show minor cracking and spalling. Generally this level appears to be in good condition.

Second Floor - looking up at bottom of third floor slab:

Deterioration noted on 3.5 sides of the structure. Perimeter concrete beam and 2+ waffles back. Deteriorated gutters need to be replaced. Concrete on waffle slab beams need to be removed and reinforcement checked for deterioration / replacement.

Third Floor - looking up at bottom of fourth floor slab:

Deterioration noted on 1.5 to 2 sides of the structure. Deteriorated gutters need to be replaced. Concrete on waffle slab beams need to be removed and reinforcement checked for deterioration / replacement.

Fourth Floor - looking up at bottom of fifth floor slab:

Deterioration noted on all 4 sides of the structure. Perimeter concrete beam and 2+ waffles back. Deteriorated gutters need to be replaced. Concrete on waffle slab beams need to be removed and reinforcement checked for deterioration / replacement.

Fifth Floor - looking up at bottom of sixth floor slab:

Deterioration noted on all 4 sides of the structure. Perimeter concrete beam and 2+ waffles back. Deteriorated gutters need to be replaced. Concrete on waffle slab beams need to be removed and reinforcement checked for deterioration / replacement.

Sixth Floor - looking up at bottom of seventh floor slab:

Deterioration noted on 3 sides of the structure. Perimeter concrete beam and 2+ waffles back. Deteriorated gutters need to be replaced. Concrete on waffle slab beams need to be removed and reinforcement checked for deterioration / replacement.

Seventh Floor - looking up at bottom of eighth floor slab:

Deterioration noted on 2.5 sides of the structure. Perimeter concrete beam and 2+ waffles back. Deteriorated gutters need to be replaced. Concrete on waffle slab beams need to be removed and reinforcement checked for deterioration / replacement.

Eighth Floor – Top level:

South and north sides show rust stains from deterioration of reinforcement. Perimeter concrete guardrail wall reinforcement connecting the walls to the slab is exposed in many locations with extensive corrosion visible.

OBSERVATIONS

GUTTERS

The existing gutter system was designed to have a nominal slope from the center of the building to drains at each end. This run exceeds 80' and drops about 2" or about 0.2% slope. With building settlement, the gutters are essentially flat or in some cases have a reverse slope (sloping away from the drain). The results in water standing in the gutter and saturating the concrete beam, or overflowing the gutter and run down the face of the concrete beam. This constant condition of saturation and overflow in conjunction with seasonal freeze / thaw cycles has caused the general deterioration of the concrete beams and slabs below.


Seventh floor, west elevation, standing water at center of span and dry drains at each end.


Seventh floor, west elevation, south end of gutter.


Fifth floor, west, note dry drain with standing water in gutter


Fifth floor, west elevation, standing water in drain


Fourth floor, west, standing water in gutter

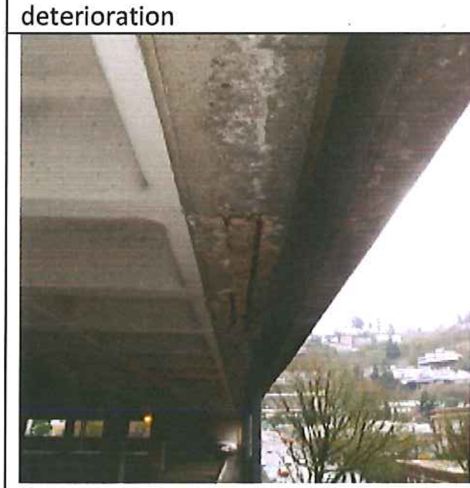

Third floor, north, standing water in gutter

PERIMETER BEAMS

The perimeter concrete beams have cast-in embeds for the original vertical concrete fins and anchor bolts for the 1992 tube section columns. These embeds provide an open path for water overflowing from the gutter above. This water penetration and the freeze / thaw cycle has caused additional corrosion and expansion of the beam reinforcement. Expansion of the rebar or 'rust jacking' causes deterioration of the concrete, which in turn, exposes more reinforcement to water and the resulting corrosion / expansion cycle continues. There is extensive visible deterioration of the concrete cover on the perimeter beams in many locations.

Eighth floor west elevation concrete beam deterioration

Eighth floor east elevation concrete beam deterioration



Seventh floor west elevation concrete beam deterioration

Seventh floor east elevation concrete beam deterioration

Seventh floor north elevation concrete beam deterioration

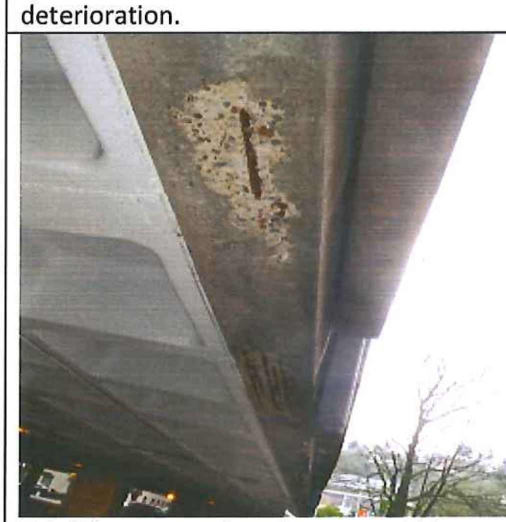
Sixth floor west elevation concrete beam deterioration

Sixth floor west elevation concrete beam deterioration

Fifth floor west elevation concrete beam deterioration.

Fifth floor west elevation concrete beam deterioration.

Fifth floor east elevation concrete beam deterioration.

 Fifth floor east elevation concrete beam deterioration.	 Fifth floor north elevation concrete beam deterioration.
 Fourth floor west elevation concrete beam deterioration.	 Fourth floor west elevation concrete beam deterioration.
 Third floor west elevation concrete beam deterioration.	 Third floor east elevation concrete beam deterioration.

Third floor east elevation concrete beam deterioration.

Third floor east elevation concrete beam deterioration.

WAFFLE SLAB JOISTS

Waffle slab joists running perpendicular to the perimeter beam also show signs of deterioration caused by the same water saturation, freeze / thaw cycle and rust jacking. The amount of deterioration is difficult to determine. The general deteriorated condition of the perimeter beam and adjacent waffles would tend to indicate that reinforcement placed in the waffle beams has deteriorated as well.

Waffle joists at fourth floor north elevation

Waffle joists at fifth floor north elevation

Waffle joist at fourth floor east elevation

WAFFLE SLAB

The waffle slab construction method was common for this type of structure in the 1960's. The actual concrete thickness is less than three inches at the deck. This relatively thin slab allows for only nominal reinforcement which is usually wire mesh. With the constant freeze / thaw cycle of the saturated perimeter beam, the perimeter waffles in many areas show signs of deterioration. The deterioration is typically evident in the oil stains and film at the cracks and in more advanced areas with rust stains, concrete spalls and exposed wire mesh.

Waffle at seventh floor slab, west elevation

Waffle at seventh floor slab, south elevation

Waffle at Sixth floor slab, north elevation

Waffle at fifth floor slab, north elevation

Waffle at fourth floor slab

Waffle at fifth floor slab, west elevation

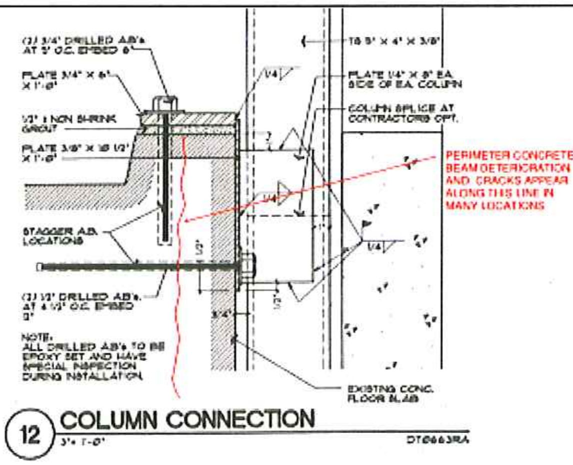
STEEL TUBE SECTION FRAME

The steel tube section frame installed in 1992 / 1993 has also added to the overall deterioration of the structure. Each steel tube section is approximately 52' long and anchored to the perimeter beam at each floor. These tube sections are continuous with no allowance for thermal expansion or individual slab deflection. The tube section anchors are installed on the outer half of the beam and outside what appears to be a general line of deterioration in the beam.

The constant stress created by these conditions and the appearance of cracks noted in the bottom of the perimeter beam, indicate that deterioration within the beam could be significant.

Remedial work undertaken by Portland State University to remove loose and spalling concrete over the winter break tends to confirm this situation.

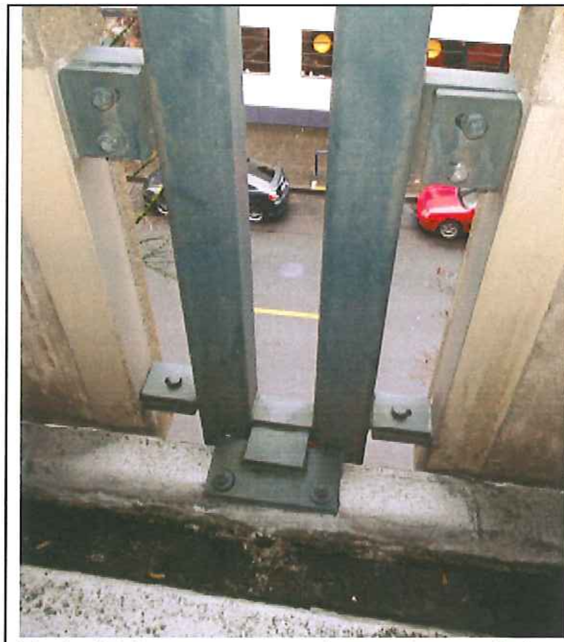
West elevation perimeter beam deterioration at steel tube section connection.



Tube section connection detail.

South Elevation eighth level slab /T.S. connection, note extensive deterioration of concrete beam at this location.

East Elevation eighth level slab /T.S. connection, note repair plate installed and water stained saturated concrete beam.

 Typical T.S. connect to perimeter beams, bolts installed in the outer 3" of the beam	 Deterioration of the perimeter beam occurs at or near many of the T.S. connections.
 West elevation, sixth floor	 North elevation, seventh floor


West elevation , deterioration at or immediately adjacent to the tube section connections


East elevation , deterioration at or immediately adjacent to the tube section connections


West Elevation, Fifth floor deterioration of concrete perimeter beam at T.S. connection


East Elevation, Fourth floor deterioration of concrete perimeter beam at T.S. connection

PRECAST GUARDRAIL PANELS

The pre-cast concrete guardrail panels installed as part of the 1992 / 1993 replacement are supported by the steel tube section frame noted above. The 'new' panels provide a guardrail function and by code must be able to withstand a 6000# impact at any point for a vehicle.

These panels were to have slotted connections at each end to allow for thermal expansion and building movement. However, the installation indicates that the slotted connection capacity was taken up in the original installation. Thus the concrete panels are unable to expand and contract with the thermal conditions. The result is that many of the panels appear to be permanently bowed out up to 2" in the middle of the panel span. Internal cracks may have developed that could lead to significantly less structural capacity in the event of a vehicle impact.

East Elevation, bowed precast panels


South Elevation, bowed panel at fifth floor east end


South Elevation, bowed panels. Some panels bow out as much as 2" in the center


Typical Panel connection, note slotted holes at top connect opposite from bottom connection. Panel cannot move at this connection


Typical panel /slab edge gap at end connection (1/2" +/-) Third floor north elevation center panel


Typical panel 'bow' at center gap between panel and slab edge (1 1/2" to 2") Third floor north elevation center panel

In addition to the lack of expansion capacity in the 1992 / 1993 column and panel installation, the panels on the west and south elevations have been subjected to constant saturation from the overflowing gutters. These saturated panels have undergone repeated freeze / thaw cycles over the years and may have significantly reduced structural capacity due to this situation.


West elevation, center panels, moss, mildew growth on panels due to water running down the face and saturating the panels.


West elevation panel at level three, gutters at levels seven, six and five directly above do not drain. Water over flows the gutter at midspan while drains at each end remain dry. Heavy overflow conditions saturate the panels and edge beams below causing a buildup of moss and mildew and continuous deterioration of the steel reinforcement.

East Elevation, north end, similar conditions to the west elevation. The slope of the gutter in these areas is negative, causing water to overflow the gutter and run down the face of the panels.

CAST-IN PLACE GUARDRAIL WALLS

At the eighth floor (roof level) the perimeter cast in place concrete guard rail is part of the original structure. At the base of the guard rail is a 'cold joint' between the concrete slab and the concrete wall. This joint is in line with the top of the gutter. When the gutter is filled with water, the joint becomes saturated. The reinforcement bars that cross this joint show significant signs of corrosion, expansion, rust jacking and concrete spalling.

Eighth level, south guardrail, standing water at center while drains at ends are dry. Water is saturating the panel's cold joint and causing corrosion of steel reinforcement.

Eighth level, west guardrail, standing water at center while drains at ends are dry. Water is saturating the panel's cold joint and causing corrosion of steel reinforcement.


Eighth level, south guardrail, exposed panel reinforcement and deteriorated water proofing at cold joint


Eighth level, east guardrail, exposed panel reinforcement and deteriorated water proofing at cold joint


Eighth level, north guardrail, exposed panel reinforcement and deteriorated water proofing at cold joint

IMMEDIATE RECOMMENDATIONS

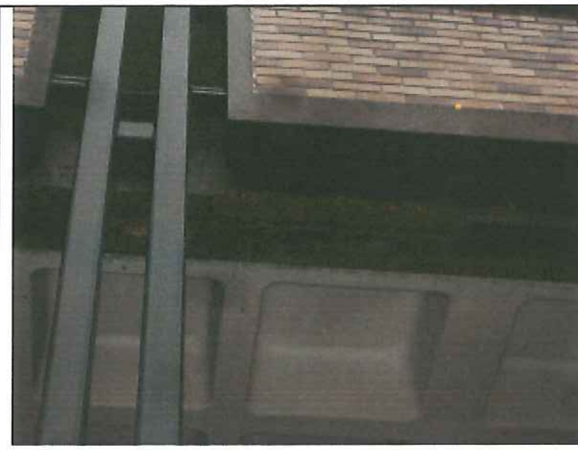
GPR DATA performed their testing and inspection in late December. During this process, it was noted that in many locations loose or spalling concrete was occurring throughout the structure. They identified these locations on floor plans and recommended that PSU address these areas immediately.

PSU contracted with Pioneer Waterproofing to remove loose or spalling concrete identified or as necessary. This work was completed in early January 2012.

In most locations where this remedial work was done, structural reinforcement is now exposed. The exposed steel rebar shows extensive deterioration and corrosion. Left in this condition, the corrosion will continue and even accelerate.

At areas of remedial work to remove loose or spalling concrete, PSU should provide regular observation for further deterioration and loose or spalling concrete. This material should be removed immediately.

West entry, deteriorated concrete at beam



West elevation level 3, deteriorated concrete at beam at tube section connection.

West Elevation, perimeter beam connection at N.W. stair.

West Elevation, rebar is completely disengaged from the concrete beam.

East Elevation, perimeter beam concrete removal at several locations

East Elevation, rebar is completely disengaged from the concrete beam.

LONG TERM RECOMMENDATIONS

UPGRADE DESIGN CRITERIA

The base design concept consists of the minimum vehicle barrier system allowed by the Oregon Structural Specialty Code. These criteria set the minimum structural and life / safety requirements as follow:

The 2010 Oregon Structural Specialty Code (OSSC) has the following criteria for Vehicle Barrier Systems:

> **406.2.4 Vehicle barrier systems.** Vehicle barrier systems not less than 2 feet 9 inches shall be placed at the end of drive lanes and at the end of parking spaces....

> **1607.7.7 Vehicle barrier systems.** Vehicle barrier systems for passenger vehicles shall be designed to resist a single load of 6,000 pounds applied horizontally in any direction to the barrier system....

The Vehicle Barrier System will also serve as the typical guard rail system and as such will need to meet typical guardrail requirements including:

> **1013.2 Height.** Required guards shall be less than 42 inches high....

> **1013.3 Opening Limitations.** Required guards shall not have openings which allow passing of a sphere 4 inches in diameter...

The City of Portland Design review process requires that any upgrades to Parking Structure One will need to be reviewed and approved by the City through a Type III procedure:

> Proposals in the Downtown Design District that are over 1,000 square feet
> in area, or require an exterior alteration and have a value over #368,300.00.