MEMORANDUM

Date: **June 13, 2022**

To: **Mike Witzansky, City Manager**

From: **Ted Semaan, Public Works Director**

Re: **2021/22 Pier Parking Structures Condition Assessment**

As part of the City's ongoing efforts to invest in its infrastructure, the City Council authorized structural assessments of the three waterfront parking structures (North Pier, South Pier, and Plaza Parking Structures) in late 2021 and early 2022. Walker Parking Consultants/Engineers (Walker) was hired to continue work that began in 2012 and has produced two assessment reports, one for the combined waterproofing and structural maintenance assessment of the South Pier Parking Structure and Pier Plaza Parking Structure and the second for the North Pier Parking Structure. The North Pier Parking Structure report was prepared separately because it includes a separate seismic evaluation of the structure in addition to the waterproofing and structural maintenance assessment.

Each report begins with a cover letter / executive summary which identifies various type of deficiencies to be addressed and a recommendation for a budget to address them over a five-year period. The budget for the five-year period is summarized as follows:

South Pier PS / Plaza Parking PS waterproofing & repairs	$15,150,000
North Pier PS waterproofing & repairs	$ 1,536,500
North Pier PS seismic improvements (lump sum)	$ 1,820,000
	$18,506,600

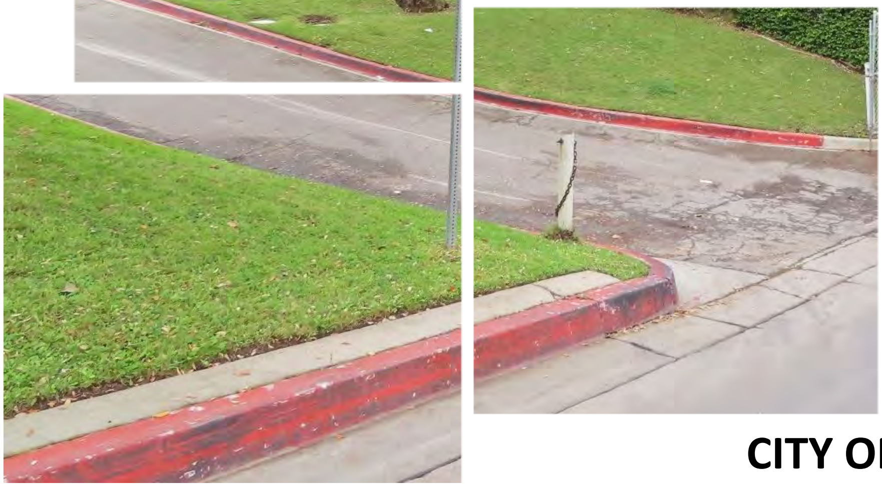
Each report also contains an amortization schedule, reflecting how those costs might be spread over a period of five years for funding consideration. Costs for the first year are summarized as follows:

South Pier PS / Plaza Parking PS waterproofing & repairs	$ 2,095,000
North Pier PS waterproofing & repairs	$ 558,000
North Pier PS seismic improvements (lump sum)	$ 1,820,000
	$ 4,473,000

The existing CIP has approximately $110,000 of carryover funding for Pier Parking Structure Improvements. The proposed FY 2022-23 Budget includes a recommendation of an additional $4,350,000 for the project to fund the first year of recommended waterproofing and repairs, and the seismic retrofit.

Attachments

- Attachment 1 – North Pier Parking Structure 2021 - Condition Assessment Report
- Attachment 2 – South Pier and Plaza Parking Structure 2021 - Condition Assessment Report



BUILDING ENVELOPE

CONSULTING

FORENSIC RESTORATION

PARKING DESIGN

PLANNING

CITY OF REDONDO BEACH NORTH PIER PARKING STRUCTURE 2021-CONDITION ASSESSMENT

CITY OF REDONDO BEACH
Redondo Beach, CA

Prepared for:
Mr. Stephen Proud
Director of Redondo Beach
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WALKER CONSULTANTS

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WC PROJECT No. 37-009397.00 June 06, 2022

EXECUTIVE SUMMARY

The City of Redondo Beach retained Walker Consultants to carry out a Condition Assessment Update of the three existing parking structures - North Pier, South Pier, and Plaza parking structures, and develop a capital improvement program for the facility. This report only includes the North Pier parking structure. The condition assessment report of South Pier and Plaza parking structures was already issued in December 2021 as a separate report. This report includes an updated condition assessment and an updated seismic evaluation of the North Pier parking structure as requested by the City of Redondo Beach. The condition assessment is intended to provide our professional opinion on the current condition of the structural system and other components, such as waterproofing and drainage, that can affect the service life of the structure. In addition, the assessment identifies any needed maintenance and repairs to the structural system and waterproofing components and provides our recommendations for implementing the work. We evaluated the overall general condition of the structures with visual observations and compared our new findings to the 2012 and 2015 Walker findings.

This report also includes the Tier 1 and 2 seismic evaluations of the North Pier Parking Structure. Tier 1 consisted of completion of appropriate standard checklists of evaluation statements to identify potential deficiencies in a structure based on performance of similar structures in past earthquakes. The outcome of this phase is a list identifying the seismic non-compliant deficiencies that could represent risks to the structure. Tier 1 screening evaluations was used as the basis for Tier 2 seismic evaluation. Tier 2 involved engineering analysis to investigate whether deficiencies identified in Tier 1 require mitigation. The outcome of this phase is a retrofit scheme to mitigate structural seismic deficiencies as described in this report. Our investigation found that the seismic performance of the structure has been fair. The 1992 retrofit efforts improved the lateral load carrying capacity and load transfer paths. There are some deficiencies in the retrofit that allow for discontinuous load transfer. The recommended Base Repairs in the appendix D address improving the seismic performance.

On February 14, 2022, Walker sent a draft of this condition assessment report to the City of Redondo Beach. A 5-year repair program formulated in the draft and in this final report was developed considering the City's available annual budget, maximizing benefits from previous work and repair priority, and maintaining parking structure accessibility and occupancy. Also, the 5-year repair program focuses on immediate repairs as well as the necessary repairs to extend the useful service life of the structure. Based on the City of Redondo Beach's request, as an alternative for City to consider, Walker has also developed an opinion of the probable costs of a Ten-Year repair program for the North Pier parking structure in this final report.

This 2021 report incorporates the 2012 and 2015 Walker reports as a reference. Our 2021 findings indicated that, overall, the parking structures have continued to deteriorate compared to the findings reported in the 2012 and 2015 Walker reports. In general, the 2012 and 2015 Walker recommendations remain unchanged except for areas of structures that have been addressed in the 2017 and 2019 repair programs.

IMMEDIATE REPAIRS - RISK MANAGEMENT

Risk Management repairs are those required to address safety issues and to mitigate potential unsafe conditions from a risk management perspective.

- Remove all loose and delaminated concrete from the slab and beam underside where delaminated concrete appears on the surface. Repairs to these areas can be deferred and addressed during the implementation of the base repair program shown below.
- Remove and replace corroded barrier system on the Pier Level of the parking structure.

SUMMARY OF TYPES OF DEFICIENCIES

Durability and Maintenance

- Soffit slab deterioration and spalls with exposed and corroded reinforcement.

- Concrete overlay deterioration and delamination.
- Concrete beam deterioration with exposed and corroded reinforcement.
- Concrete column spalling.
- Concrete wall deterioration and delamination.
- Waterproofing system deficiencies.

Seismic

- Thickening of CIP shear walls on Basement and Pier Levels.
- Addition of carbon fiber wrap at precast double tee stems on Village and Pier Level.
- Addition of slab reinforcement at Shear walls.
- Increase concrete cover at CIP columns at Grid line Y.
- Increased thickness of slab at Shear walls (East-West direction)
- Install new drilled piers.
- Install new concrete shear walls at Pier and Basement Level.

We recommend that the City of Redondo Beach perform the base repair program outlined in this report that will correct the observed seismic deficiencies, and durability deterioration and enhance the waterproofing systems to protect the structural slabs and reduce the potential for water infiltration throughout the structures.

We recommend that the City of Redondo Beach budget approximately $1,536,500 to maintain the North Pier parking structure over the next five years and budget separately a lump sum $1,820,000.00 for recommended seismic structural repairs. The budget costs presented are based on historical data. As a result of the COVID-19 epidemic, prices and schedules have changed. Therefore, these costs should be considered a rough order of magnitude and used for basic planning purposes. The actual costs may not be realized until the project is designed and bid by a contractor. Budgeting for capital improvements and work items will help the City of Redondo Beach plan for necessary funding for the recommended work over the next 5 years. This will help maximize the service life of various components of the structures and maintain the structures in good service condition with minimum downtime.

Please see the attached discussion and appendices for a detailed report of our investigation.

Sincerely,

WALKER CONSULTANTS

June 06, 2022

Behnam Arya, PhD, PE — Date
Senior Consultant

June 06, 2022

Khan Sohban — Date
Senior Engineer, PE

June 06, 2022

Hassan Suhail — Date
Project Engineer I

INTRODUCTION

BACKGROUND INFORMATION

Walker Consultants performed a condition assessment for the North Pier parking structures located in Redondo Beach, California. The Walker Consultants staff conducted the onsite investigation of the parking garage on November 10, 2021. The evaluation and report will provide our professional opinion of the overall condition of the parking structures and update the prior 2012, and 2015 Walker's conditional appraisal reports with recommendations for current repair and preventative maintenance needs to maintain the service life for the structure. The City of Redondo Beach has requested Walker to perform a new condition assessment of the parking structure since the last condition assessment of the parking structure was completed more than six years ago. The condition assessment update consisted of a visual survey and documentation of observations. In addition to condition assessment, Walker also updated the Tier 1 and 2 seismic evaluations of the structure that we performed for the structure in 2012. Walker completed a Tier 1 and Tier 2 building screening procedure in 2012 based on the American Society of Civil Engineers (ASCE) standard ASCE 31-03 "Seismic Evaluation of Exiting Buildings" published in 2004 which was the nationally recognized standard at the time our investigation. The updated Tier 1 and Tier 2 analyses was performed per the ASCE 41-17, which is the current state-of-the-art and generally accepted standard for seismic evaluation of building structures. The seismic checklist and procedures in ASCE 41-17 have been updated compared to ASCE 31-03. Furthermore, the seismic hazard levels in ASCE 41-17 have changed based on earthquakes that have occurred around the globe since 2004 (when ASCE 31-03 was published).

Walker Consultants conducted material testing on several concrete components of the North Pier Parking Structure in 2012 to check the as-built condition and to use their properties for seismic evaluation. However, testing was only performed at the Pier level. The Basement level in 2012 was occupied by the Redondo Beach Fun Factory, which provided a play area for children and families, and was not accessible for testing. The Fun Factory closed in 2017 and the Basement level is now vacant. This has provided an opportunity to conduct additional testing on the structure to obtain information on the original walls of the building at the Basement level. With the approval of the City of Redondo Beach, Walker conducted additional testing on the North Pier Parking Structure. Testing primarily consisted of coring of concrete walls to obtain compressive testing as well exploratory opening of concrete walls to check size and placement of steel reinforcement. The results of new concrete testing were used in our seismic evaluation analysis.

<u>Nomenclature</u>

In the summer of 2011, Walker performed a condition assessment of the parking structures. In June 2012, Walker performed a structural analysis of the North Pier parking structure and prepared an Asset Management Plan (AMP), formerly known as Capital Improvement and Protection Program (CIPP), detailing opinions of probable repair costs over ten years for all three structures. The report was submitted to the City in August 2012 and is referred to herein as the 2012 Walker Report. Also, in October 2015 Walker performed a condition assessment update and prepared opinions of probable costs for two timeline scenarios for the parking structures. The report was submitted to the City in January 2016 and is referred to herein as the 2015 Walker Report. Please refer to the reports mentioned above for additional information.

<u>Previous repairs</u>

As requested by the City of Redondo Beach, the 2015 condition assessments proposed three different scenarios of repair with approximate costs for each option. These options were: A limited three (3) year repair and maintenance program; a 10 – 15-year repair and maintenance program; and an option of full replacement of the Pier Parking Structures. Based on our 2015 condition assessment and the cost associated with the proposed options, the City of Redondo Beach selected the 10 - 15-year repair and maintenance program option. Walker has been awarded several contracts for the development of plans, specifications, and estimates (P, S & E's) to bid the work out to restoration contractors for the Pier Parking Structures. The first round of repairs was performed in 2017 on the South Pier parking structure and the second round of repairs was completed in 2019 on both the South Pier and North Pier structures. It was also conveyed to Walker during our site visits that some repairs were performed on the Plaza Parking Structure as a change order to the previous repair program.

Since 2017, Walker has provided parking structures restoration and maintenance design services for City of Redondo including the following:

- In 2017, the first repair project occurred mainly on the South Pier parking structure, consisting of the removal and replacement of traffic coating, isolated concrete floor repairs, concrete ceiling repairs, partial concrete beam repairs mainly on spandrels projecting out on the west end of the garage, concrete column and wall repairs, replacement of expansion joints, crack and joint treatments, installation of cathodic protection at repairs, and a few miscellaneous repairs.
- In 2019, the second repair project occurred, consisting of the installation of new traffic coating, isolated concrete floor repairs, concrete ceiling repairs, partial and full depth concrete beam repairs, concrete column and wall repairs, replacement of expansion joints, crack and joint treatments, installation of cathodic protection at repairs, replacement of top-level barrier cables and railing, and some miscellaneous repairs. Most of the repairs primarily focused on the Village level of the North Pier parking structures, and some minor repairs were also carried on the Village level of South Pier parking structure.

OBJECTIVES

The objective of this investigation is to provide updates on the overall condition assessment and the seismic evaluation and provide an opinion of probable cost for the necessary repairs, based on the observed conditions as well as our experience with similar parking structure conditions and repair costs. For this investigation and to meet the objective, we performed the following services:

1. Reviewed previous Condition Appraisal Reports prepared by Walker Consultants, dated August 2012 and October 2015 respectively.
2. Reviewed Owner Review Construction documents and project specifications prepared by Walker Consultants, dated January 2017.
3. Reviewed Construction documents and project specifications prepared by Walker Consultants, dated March 2019.
4. Reviewed existing framing plans of the parking structure to aid in our observations.
5. Conducted a field evaluation of the parking structure to document the current exposed conditions of the structural and waterproofing elements. This consisted of visual observation as well as limited non-destructive testing to review the following elements: floors, columns, beams, walls, ceilings, façade, and other structural elements.
6. Identified potential structural related conditions that require immediate attention.
7. Compiled and reviewed all field data to determine possible causes and effects of the documented deterioration.
8. Performed the Tier 1 screening and Tier 2 analysis for seismic evaluation of the North Pier parking structure.
9. Outlined the repair program requirements for a 5-Year AMP.
10. Provided an opinion of probable cost for implementing the repairs.
11. Phased the work according to priority over a multi-year program to assist with fiscal planning.

12. Prepared the current report with a summary of observations, including photographs depicting the areas noted in the report, findings.

The objective of the 5-year Budget Forecast is to provide the City of Redondo Beach with an asset management tool for planning and budgeting of capital expenses over the next 5 years. The 5-year plan recommends restoration capital improvements and work items for this parking facility so that the Owner can maximize the service life of the structure with the least amount of capital cost.

PARKING STRUCTURE DESCRIPTION

The North Pier Parking Structure was constructed in early 1960's and has experienced nearly 70 years of service life. The parking structure is constructed of precast concrete double tees supported on precast columns, beams, and girders. One of the unique aspects of the pre-cast double tee construction is that the tees are spaced apart to allow for closure pour strips along every tee flange. Based on the drawings received, the exposed upper level is referred to as the Village Level, the mid-level is referred to as the Pier Level, and the lowest level is referred to as the Basement Level. The footprint of the structure is 273 feet (north - south) by 123 feet (east - west)

Figure 1 shows an aerial view of the parking structures, and Figures 2 to 4 display the floor plans of the North Pier parking structures. Figures 5 to 8 show overall views of the exterior elevations of the parking structures. Figures 9, and 10 show the recommended locations for traffic coatings. Figure 11 show location of immediate repairs.

Figure 1 – Aerial view of the parking structures (Google Earth Pro)

Figure 2- Basement Level- Slab on Grade, North Pier Parking Structure

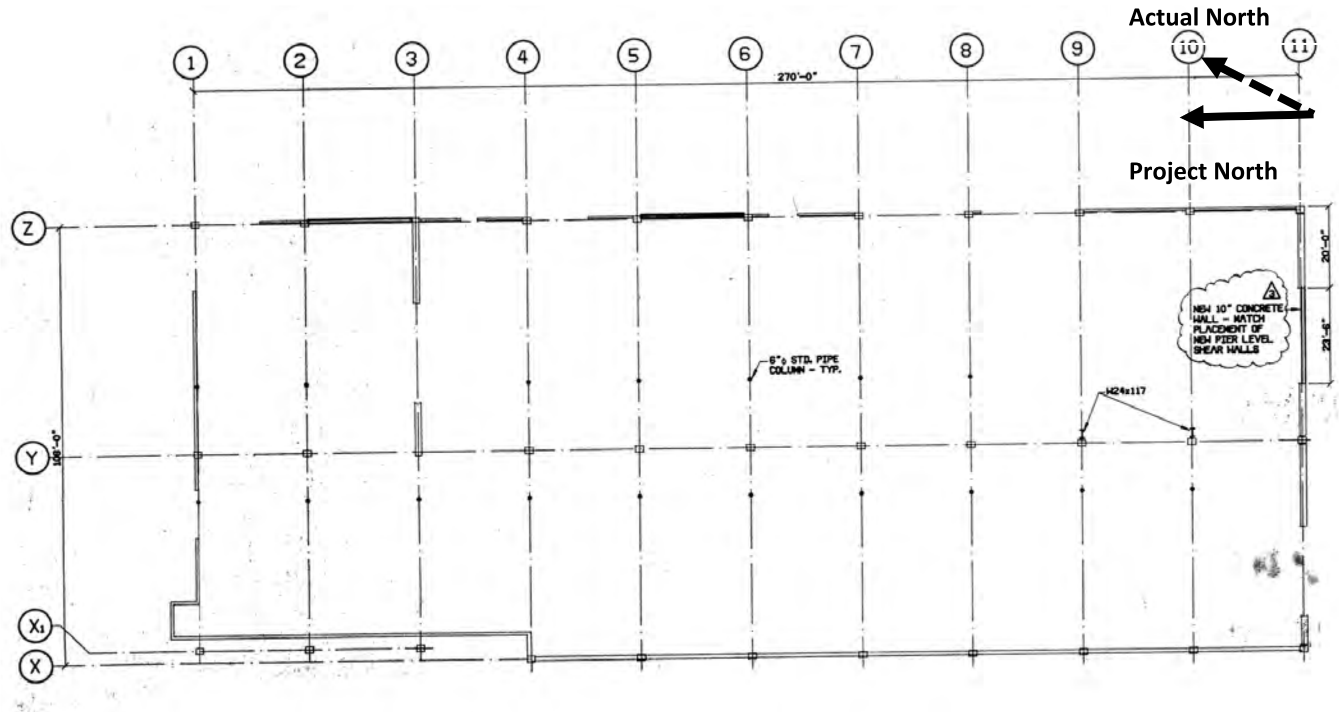


Figure 3- Pier Level Plan, North Pier Parking Structure

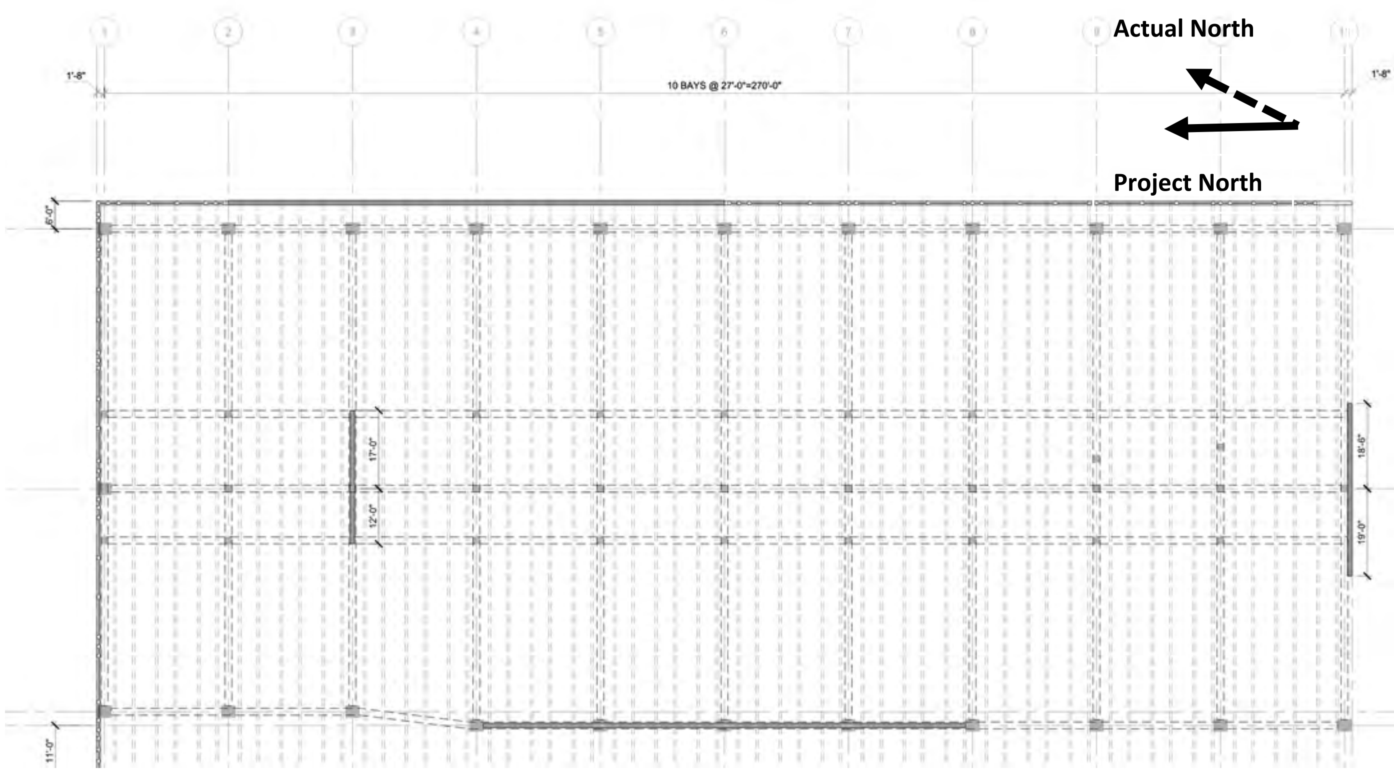


Figure 4-Village Level Plan, North Pier Parking Structure

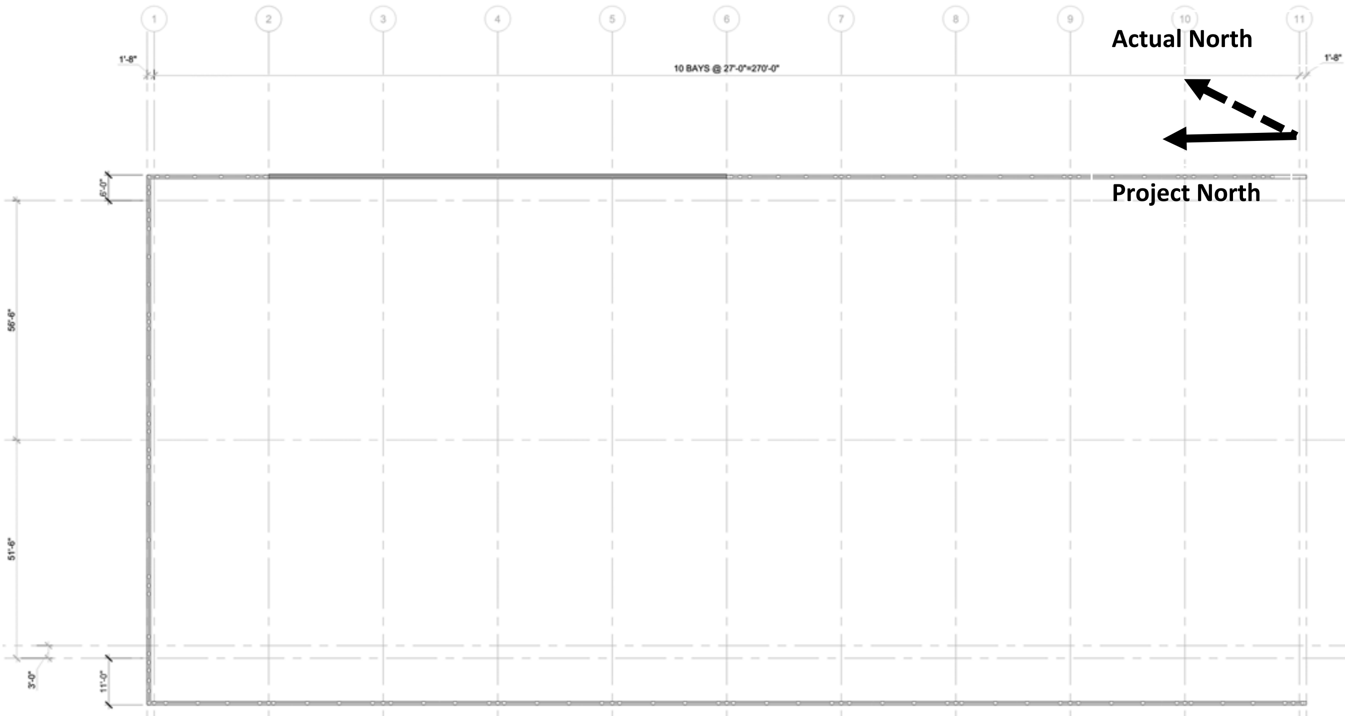


Figure 5- Overview of Village Level, (North Pier Parking Structure) (BA1-219)

Figure 6- Partial North elevation, (North Pier Parking Structure) (SH2-273)

Figure 7- Partial West elevation, (North Pier Parking Structure) (BA1-229)

Figure 8– Partial East elevation, (North Pier Parking Structure) (BA1-282)

RECOMMENDATIONS

Based on our visual observations, we found the North Pier parking structure to be in ***fair*** condition. The concrete floors, ceilings, walls, and columns had some level of deterioration that needs to be addressed. Our assessment did identify specific locations where localized deterioration is visible in the structure. The recent repair project has addressed the significant concrete deterioration and restored components of the waterproofing and structural systems on the Village Level of the parking structure

To improve the parking structure's current condition, we have developed a 5-year repair program for the facility. The 5-year program has an associated Asset Management Plan (AMP). The AMP contains repairs to address the currently deteriorated elements and preventive maintenance to address needs anticipated over the next 5-year period. We recommend that the City of Redondo Beach approximate the budget to implement the program over the next 5 years.

IMMEDIATE REPAIRS - RISK MANAGEMENT

Immediate concerns are defined as items that may reduce pedestrian safety and structural integrity if not completed.

- Remove all loose and delaminated concrete from the slab soffit and beam underside where delaminated concrete appears on the surface. Repairs to these areas can be deferred and addressed during the implementation of the base repair program shown below. This work should be performed by either City personnel or private contractors working under the direction of the City of Redondo Beach.
- Remove and replace corroded barrier system posts on the Pier Level. Particularly on the north and west end of the parking structure.

As always, it is appropriate that Operation staff conduct weekly inspections to check that facility for potential hazard such as open spalls or cavities in the concrete floor, loose concrete, etc. and have them remedied immediately to reduce potential risk of incident.

RECOMMENDED BASE REPAIRS: YEARS 1-5

Based on our findings, we recommend implementation of a structured restoration plan, including repairs to structural elements, repairs of deterioration of the slab, repairs to the parking structure waterproofing systems The recommended restoration program concentrates on repairs to the deteriorated sections of the structure and future protection of its structural components. We recommend implementing the following repairs and maintenance in the next 5 years:

STRUCTURAL ITEMS

- Perform the recommended seismic strengthening recommendations identified in the Seismic evaluation report (Appendix E).
- Repair of all deteriorated concrete slab soffit on the Village and Pier Levels.
- Repair isolated concrete overlay spalls/deterioration on the Pier Level.
- Perform column, beam, and wall repairs in isolated locations on the Pier and Basement Levels.
- Repair of concrete curb at perimeter of parking in isolated locations on the Pier Level.
- Repair cracks in concrete walls, beams, and columns in isolated locations on the Pier and Basement Levels.
- Concrete repairs of the west and east ends of the cantilevered concrete joists.
- Installation of passive galvanic systems in all concrete repairs.

WATERPROOFING WORK ITEM

- Remove existing epoxy-based traffic coating and replace with new urethane traffic membrane on all exposed concrete surfaces on the Pier Level.
- Recoat the existing traffic topping on the Village Level.
- Rout and seal floor cracks on the Pier Level.

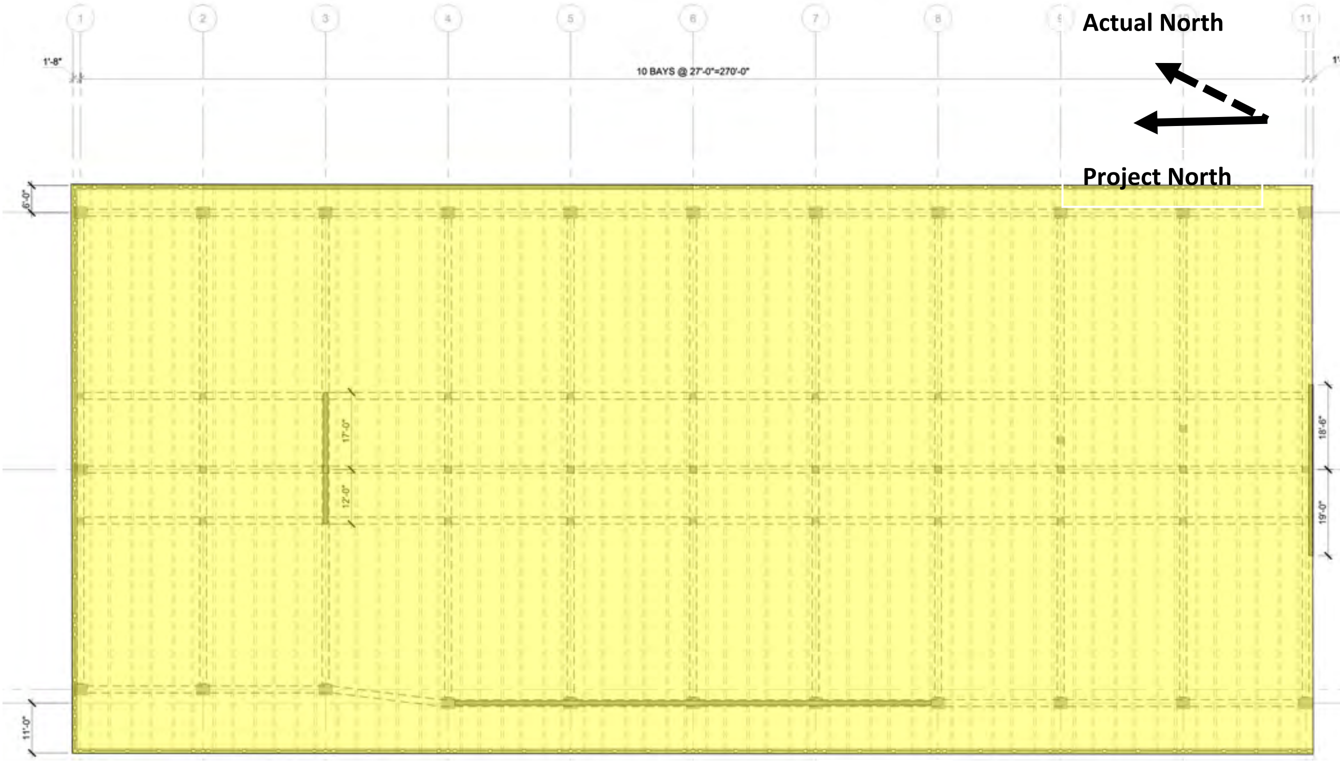
MECHANICAL, ELECTRICAL, AND DRAINAGE WORK ITEMS

- Isolated areas of ponding were observed and should be resolved by either cleaning out the existing drain (if present) or installing a supplementary drain.

MISCELLANEOUS ITEMS

- Clean and paint misc. steel members.
- Repaint traffic markings.
- Paint slab soffit, walls, and columns

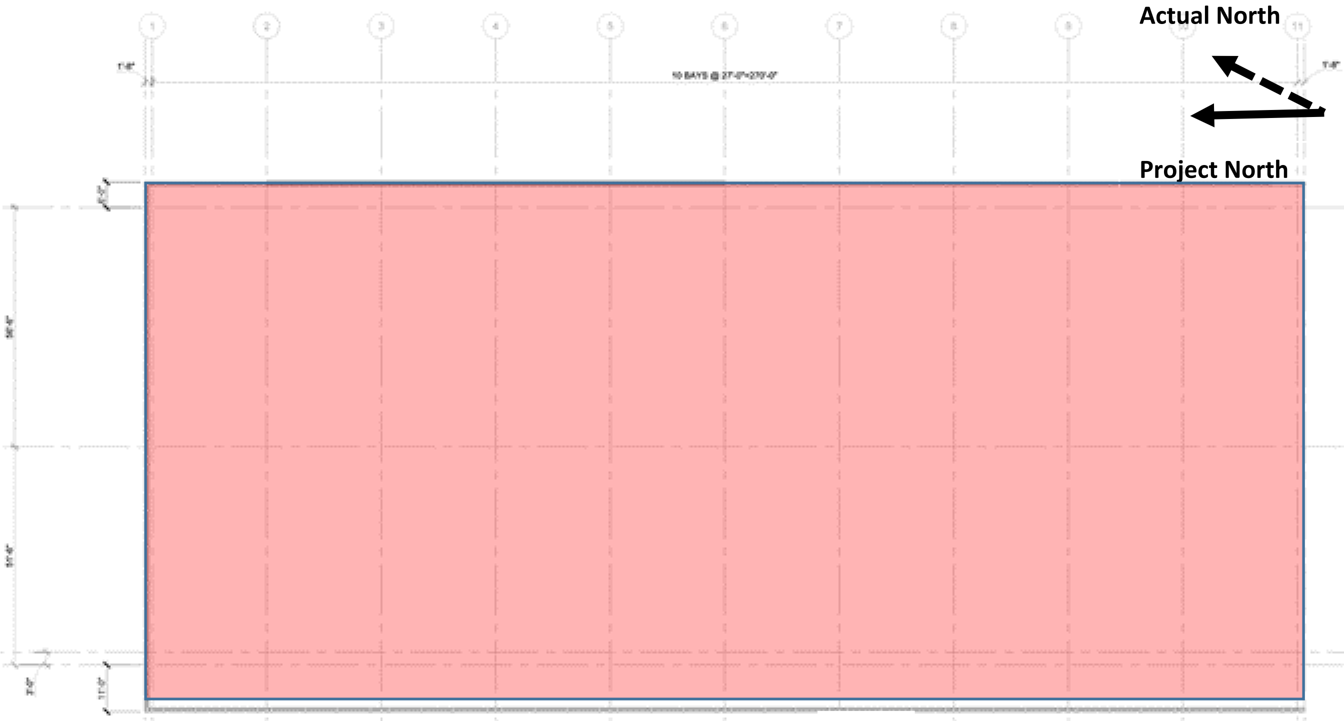
Figure 9– Proposed new traffic membrane, North Parking Pier Structure – Pier level



KEY:


Remove existing traffic coating with new Urethane traffic coating.

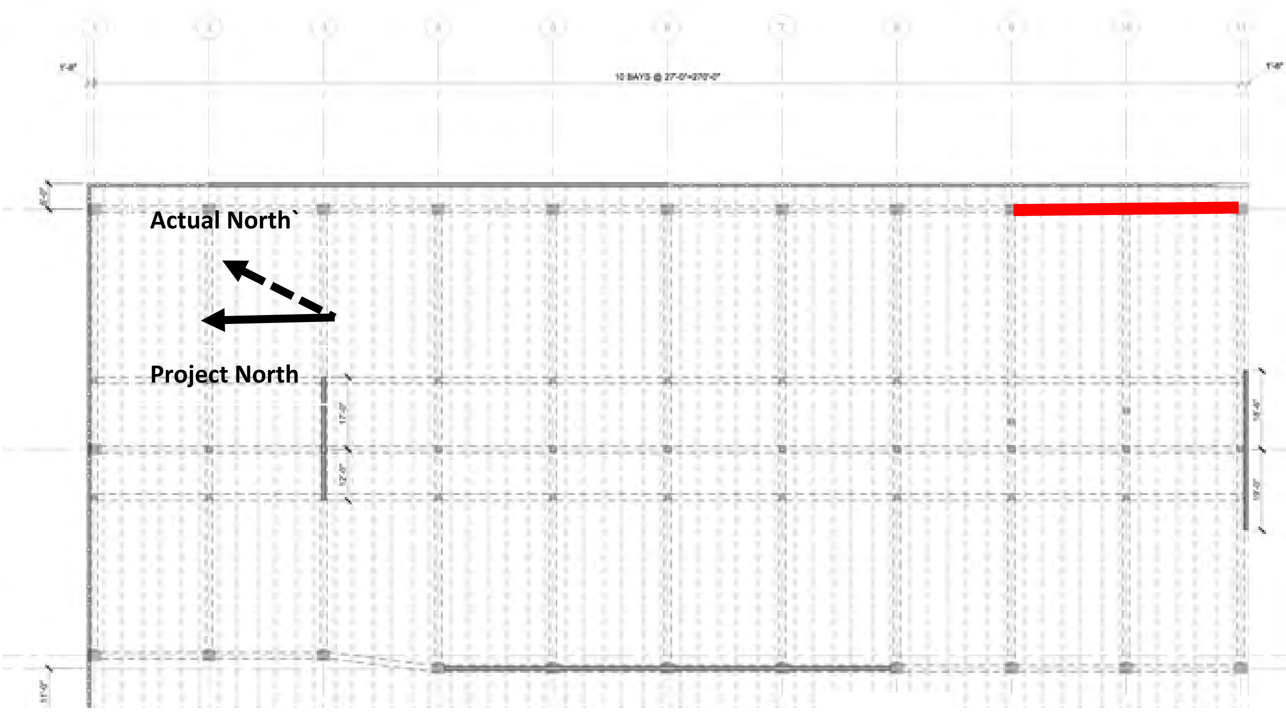
Figure 10– Recoat traffic membrane, North Parking Pier Structure – Village Level



KEY:

Recoat existing traffic coating on Village Level.

Figure 11– Immediate Repair location, North Parking Pier Structure – Pier Level



Note: City personnel should walk through the Pier level every week to knock down any visible loose concrete spalls on the ceiling above.

KEY:

Remove and replace the existing barrier system with new barrier

FUTURE PREVENTATIVE MAINTENANCE

Maintenance performed on a regular basis will take full advantage of the structural repairs and waterproofing work. Without maintenance, the facility will not see the expected service life from the structure or the repairs and waterproofing. Typical maintenance includes routine sealing of joints, recoating of wall and floor membranes along with periodic concrete repairs.

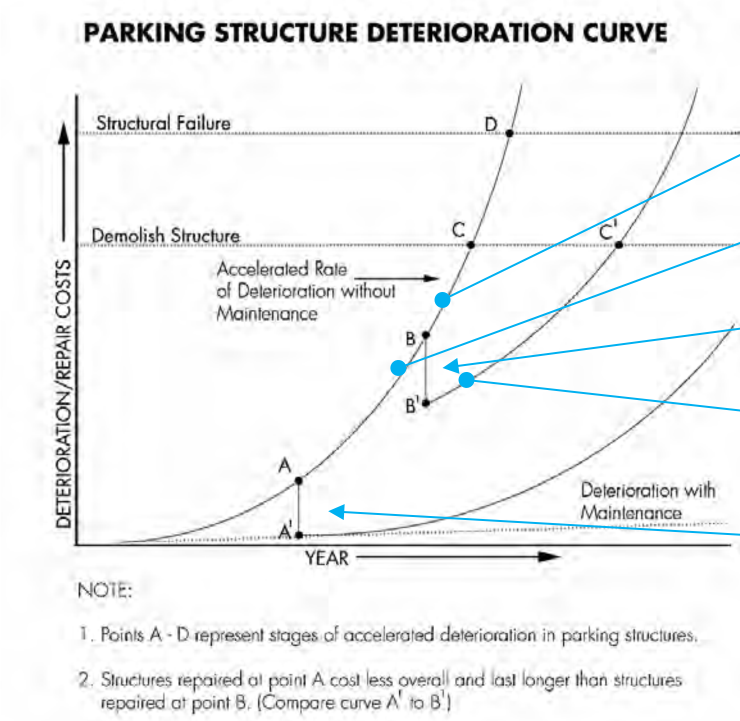
Funds for maintenance of the garage should be accrued yearly considering the life expectancies of certain elements such as sealants, coatings, floor membranes, concrete repairs, etc. The life expectancies expressed vary depending on workmanship, quality of materials, use and exposure to elements. After all the work is completed, the supported level should be washed down at least twice a year.

BENEFITS OF TIMELY REMEDIATION

There are many benefits to providing the repair and preventive maintenance program at the earliest feasible time, in addition to the imminent needs of providing the "Immediate Repairs" listed previously.

Long-term delay of repairs significantly increases cost. The cost to repair and maintain this facility will continue to increase at progressively faster rates when deterioration continues as modeled in the following graph. The main benefits from implementing the recommended repairs and waterproofing are:

- Mitigate the infiltration of water and chlorides.
- Maintain the structural capacity and maintain the service life of the structure.
- Cost savings due to avoidance of structural repairs that are more expensive and facility shutdown.
- Higher levels of service to the users of the facility due to fewer days of downtime because of more extensive structural repairs.
- Provides for a greater degree of safety by inhibiting deterioration mechanisms before they have a chance to cause serious harm.
- Long term delay of repairs significantly increases future costs.
- Less noise21 and disruption both within the garages and the buildings above.



"Poor" Garages are between points B and C

"Fair" and "Good" Garages are between points A and B

Short-term repairs (3-5 years) only move curve slightly (B to B1)

Repaired "Fair" and "Good" Garages are between points B[1] and C[1]

Long-term repairs (12 to 20 years) move curve considerably (A to A1)

OPINION OF PROBABLE COSTS

The table below provides our opinion of probable construction costs for the recommended repairs for a Five-Year restoration maintenance program. The costs were developed using pricing from our database obtained from similar type projects competitively bid in the Los Angeles area.

With the development of repair programs such as in this report, contingency funds must be anticipated and included in any budget for repairs to account for concealed, unknown, or unanticipated conditions. For this type of restoration work, we recommend that a 10% contingency be set aside for potential changes due to unknown conditions. This contingency cost is included in the project costs. The cost estimates are based on 1st Quarter 2022 dollars.

According to the American Concrete Institute Committee 362, *"Repairing an existing deteriorated structure involves many unknowns, uncertainties and risks. Especially with regard to repair of chloride caused corrosion damage, the process is considered an extension of the useful life of the deteriorated structure. It is not equivalent to building a new structure with current technology*."

The cost to perform seismic rehabilitation is not included in Table 1 and should be budgeted separately as a lump sum of $1,820,000.00. Please refer to Table 4 and Appendix D for more information on this cost breakdown.

Table 2, and 3 at the end of this report includes a more detailed cost estimate.

Table 1 - Five-year Repair program–Opinion of Probable Costs

YEAR	BUDGET
2022	$558,000
2023	$773,000
2024	-
2025	-
2026	$192,000
Total	**$1,536,500**

NOTES:
1. Cost opinions are based on historical data and experience with similar types of work and are based on 2022 prices.
2. Actual costs may vary due to time of year, local economy, or other factors.
3. Cost opinions do not include costs for phasing, inflation, financing or other owner requirements, or bidding conditions.
4. Costs have been increased 3% for inflation each year.
5. Cost opinions do not include upgrades if it becomes necessary to bring the structure up to current building code requirements, seismic upgrades, or for ADA or similar items.
6. The structure has not been reviewed for the presence of, or subsequent mitigation of, hazardous materials including, but not limited to, asbestos and PCB.

NOTE: The budget costs presented are based on historic data. The effects of the COVID-19 pandemic have resulted in changing costs and schedules, therefore, these costs should be considered a rough order of magnitude and used for basic planning purposes. Until the project is designed and bid by a contractor the actual costs may not be realized.

Recommended Ten – Year Repair Program (North Pier Parking Structure)

Per City's request, as an alternative for City to consider, Walker has also developed a Ten-Year repair program for the North Pier parking structure. The opinion costs for the recommended 10- year repair program for the North Pier parking structure is currently **$ 2,259,000** in 2022 dollar. The recommended North Pier parking structure maintenance and repair budget for the next ten years is shown below in Table 1.1, followed by a detailed breakdown in Table 5.

Table 1.1 - Ten-year Repair program–Opinion of Probable Costs

YEAR	BUDGET
2022	$558,000
2023	$464,500
2024	$400,500
2025	-
2026	$192,000
2027	-
2028	$137,500
2029	-
2030	$323,500
2031	$183,000
Total	**$2,259,000**

IMPLEMENTATION

The outlined repair program can be competitively bid and executed by experienced restoration contractors. The first step in this process is to obtain a quality set of bidding documents prepared by experienced restoration engineers. These documents should be procured to ensure repairs are designed appropriately and quantities are sufficiently estimated to competitively bid the project by restoration contractors.

DISCUSSION

IMMEDIATE REPAIRS - RISK MANAGEMENT

We observed spalled and loose concrete on multiple locations on both – Village and the Pier Level slab soffit of the North Pier parking structure. The loose concrete can get detached and introduce a life safety hazard to pedestrians. Remove all loose and delaminated concrete from the slab and beam underside where delaminated concrete appears on the surface. Repairs to these areas can be deferred and addressed during the implementation of the base repair program shown below. Walker recommends all supported slabs, beams, columns, and walls to be reviewed on a regular basis by visual means and sounded by hammer tapping along spalls. Any overhead spalled areas found are a potential safety hazard. The City should continue to review areas of potentially loose and cracked concrete and remove them before they become an overhead hazard.

The barrier system on the Village Level has undergone a major renovation as part of the 2019 Repair program. The barrier system on the Village level was in good condition after the renovation. However, the Pier Level perimeter barrier system was not a part of the 2019 Repair program. The existing barrier system has been exposed to ravages of weather and time passage. Peeling of paint and corrosion of steel posts has been observed in many locations on the barrier system. Replacement of existing corroded steel posts located in the southwest end of the parking structure is recommended.

STRUCTURAL WORK ITEMS

Our primary focus of the condition assessment was to identify and update the 2012 and 2015 Walker findings and accordingly develop updated repair protocols that will keep the structures operational for 10 additional years. Over the last few years, the City of Redondo Beach has invested significantly in the repair and maintenance of the three parking structures – North Pier Parking Structure, South Pier Parking Structure, and Plaza Parking structure. This work has been performed per the Walkers 2012 and 2015 AMPs in order to extend the life of the structures. Refer to Walker's 2012 and 2015 condition appraisal reports for more information on causes attributed to the observed deficiencies.

This updated AMP plan is designed to help the City of Redondo Beach plan for repairs, future maintenance, and improvements for the parking structures. The City of Redondo Beach has implemented a limited portion of work for North Pier Parking structure outlined in Walker's original 2012 and 2015 AMPs, respectively. A reduced scope of work was completed in 2017 and 2019 repair programs to maintain the structure for 10 -15 years while discussions of possible new development that incorporated replacement parking were contemplated. This 5-year AMP forecast builds off the limited work and maintenance repairs completed during the past 10-years and provides the capital improvements required to maintain the structure for the next 10-year program.

The parking structure has remained in operation for almost seven decades and has been subjected to harsh environmental conditions over its service life. Physical structural conditions have led us to believe that the structure is overall in fair condition. The field assessment indicates the structure is undergoing structural deterioration in non-repaired areas, primarily to the underside of the village level concrete slab. Our review of this structure suggests deferred preventative maintenance, and the delay of a comprehensive restoration program has led to the current deterioration conditions. The Installation of traffic coating on the Village level during the 2019 Repair program was a significant step to mitigate the potential for reinforcing steel corrosion. The best way to counteract the remaining corrosion process involves applying an electrochemical treatment. This can be achieved by repairing the sections showing spalling or exposed rebars.

Precast concrete double tees stem, beams, and columns had numerous locations that had deteriorated resulting in cracked and spalled concrete. Moisture laden with chlorides that penetrate the concrete creates a situation where the embedded steel reinforcement begins to corrode. The corrosion of the steel reinforcement creates rust formation on the steel which induces stresses into the surrounding concrete. If the stresses to the concrete exceed the tensile strength capacity of the concrete, a crack will occur which will propagate into a delamination, and ultimately a concrete spall. Deterioration of structural elements of the parking structure shortens the effective service life of the structure and the deterioration of the parking structure will accelerate overtime if left unattended.

The Shear wall is cracked and deteriorated in select locations primarily along the south and east wall of the structure. The walls should also be monitored annually for additional cracking.

Overall, concrete curbs on the pier level are in fair condition with limited cracking and other deterioration related issues.

WATERPROOFING SYSTEMS

The traffic coating on the Pier Level has excessive wearing where the coating has worn into the base coat with some areas worn completely through the coating to the concrete substrate. Given the significant wear down and localized areas of debondment of the coating, we recommend that the coating be removed and replaced with a new traffic coating system. Removing the existing system, instead of recoating over the existing system, prevents possible issues with bonding a new system to an existing that may have marginal bond in areas. Removal also allows replacement of the existing joint and crack sealants. These sealants are protected by the traffic topping but in areas where the traffic topping has failed the underlying sealant was observed to be cracked and brittle, which may have contributed to the coating failure along the joint and cracks.

The Village Level received a traffic bearing waterproof membrane as part of the 2019 Repair program. The waterproof membrane is in good condition for its age. Typically, these waterproofing systems have a service life of 7-10 years with proper maintenance. The life of the membrane can be extended by applying a re-coat of the top layer of the system. The re-coat procedure requires cleaning of the surface, preparation of worn or damaged areas with base and intermediate coatings and then an application of a full topcoat with aggregate. Therefore, installation of new traffic marking paint is required after installation of the new traffic topping coating. Our cost opinion includes recoating on the Village Level in Year 5; however, we recommend that the condition of the traffic coating be reviewed to determine if recoating is required at that time.

CONCRETE TESTING AND ANALYSIS

Walker Consultants conducted material testing on several concrete components of the North Pier Parking Structure in 2012 to check the as-built condition and to use their properties for seismic evaluation. However, testing was only performed at the Pier level. The Basement level in 2012 was occupied by the Redondo Beach Fun Factory, which provided a play area for children and families, and was not accessible for testing. The Fun Factory closed in 2017 and the Basement level is now vacant. This has provided an opportunity to conduct additional testing on the structure to obtain information on the original walls of the building at the Basement level. With the approval of the City of Redondo Beach, Walker conducted the following additional testing on the North Pier Parking Structure.

1. Coring of concrete walls to obtain compressive testing
2. Exploratory opening of concrete walls to check size and placement of steel reinforcement

Slater Waterproofing Inc. was engaged to obtain concrete cores and to perform destructive opening on January 12 and 13, 2022 under the direction of Walker staff. Concrete cores were sent to Universal Construction Testing (UCT) for laboratory testing to obtain compressive strength. Details of concrete testing and the lab report prepared by UCT are attached in Appendix B and C, respectively. Ground Penetrating Radar (GPR) was also used on concrete surfaces at test locations prior to destructive opening to locate the embedded rebar and to prevent cutting rebar during the coring process.

SEISMIC EVALUATION

Walker Consultants performed the Tier 1 and 2 seismic evaluations of the North Pier Parking Structure. Walker had completed a Tier 1 and Tier 2 building screening procedure in 2012 based on the American Society of Civil Engineers (ASCE) standard ASCE 31-03 “Seismic Evaluation of Exiting Buildings” published in 2004 which was the nationally recognized standard at the time our investigation. The updated Tier 1 and Tier 2 analyses was performed per the ASCE 41-17, which is the current state-of-the-art and generally accepted standard for seismic evaluation of building structures. The seismic checklist and procedures in ASCE 41-17 have been updated compared to ASCE 31-03. Furthermore, the seismic hazard levels in ASCE 41-17 have changed based on earthquakes that have occurred around the globe since 2004 (when ASCE 31-03 was published). Our evaluations found that the seismic performance of the structure has been fair. The 1992 retrofit efforts improved the lateral load carrying capacity and load transfer paths. There are some deficiencies in the retrofit that allow for discontinuous load transfer. The details of our seismic evaluation and our recommended repairs for improving the seismic performance are included in in the appendix D.

OBSERVATIONS

On November 10, 2021, Walker Consultants performed a condition assessment of the North Pier Parking Structures. The assessment consisted of a visual review of representative exposed structural elements (columns, beams, walls,) and waterproofing elements (sealants and expansion joints). Our assessment also included chain dragging and hammer sounding of representative areas to identify concrete delaminations and possible corrosion of the embedded steel reinforcement. In addition, a limited visual review of the structures' façade was performed from the Ground level.

The following conditions were noted. The referenced photographs are included in Appendix A.

Village Level

- Typical Village Level soffit slab deterioration and spalls with exposed and corroded reinforcement (Photos 1.1 and 1.4).

Pier Level

- Isolated concrete overlay deterioration with exposed reinforcement was observed on the Pier level (Photos 1.5 to 1.6).
- Typical Pier Level soffit slab deterioration and spalls with exposed and corroded reinforcement (Photos 1.7 and 1.8).
- Typical beam deterioration with exposed and corroded reinforcement was observed on the Pier Level (Photos 1.9 to 1.11).
- Isolated concrete curb delamination was observed at perimeter and interior of the parking structure (Photos 1.12 to 1.13).
- Typical sections of the perimeter barrier system posts particularity in the west end of the Pier Level are significantly corroded or damaged (Photos 1.14).
- The epoxy-based traffic coating was in poor condition with excessive wearing where the coating has worn into the base coat with some areas worn completely through the coating to the concrete substrate (Photos 1.15).
- Typical corroded steel beam ledge on the Pier Level of the parking structure (Photos 1.16).

Basement Level

- Typical concrete wall delamination and spalling with exposed rebar on the Basement Level (Photos 1.17 and 1.18).
- Typical beam deterioration with exposed and corroded reinforcement was observed on the Basement Level (Photos 1.19 and 1.20).
- Typical wall cracks were also observed on the Basement Level (Photo 1.21).

Exteriors

- Typical signs of rebar corrosion were observed east elevation of the parking structure (Photo 1.22).
- Typical spandrel beam deterioration with exposed and corroded reinforcement was observed on north and east elevations of the parking structure (Photo 1.23 to 1.25).

LIMITATIONS

This report contains the professional opinions of Walker Consultants based on the conditions observed as of the date of our site visit and documents made available to us by the City of Redondo Beach (Client). This report is believed to be accurate within the limitations of the stated methods for obtaining information.

We have provided our opinion of probable costs from visual observations and field survey work. The opinion of probable repair costs is based on available information at the time of our condition appraisal and from our experience with similar projects. There is no warranty to the accuracy of such cost opinions as compared to bids or actual costs. This condition appraisal and the recommendations therein are to be used by Client with additional fiscal and technical judgment.

It should be noted that our renovation recommendations are conceptual in nature and do not represent changes to the original design intent of the structure. As a result, this report does not provide specific repair details or methods, construction contract documents, material specifications, or details to develop the construction cost from a contractor.

Based on the agreed scope of services, the condition appraisal was based on certain assumptions made on the existing conditions. Some of these assumptions cannot be verified without expanding the scope of services or performing more invasive procedures on the structure. More detailed and invasive testing may be provided by Walker Consultants as an additional service upon written request from Client.

The recommended repair concepts outlined represent current generally accepted technology. This report does not provide any kind of guarantee or warranty on our findings and recommendations. Our condition appraisal was based on and limited to the agreed scope of work. We do not intend to suggest or imply that our observation has discovered or disclosed latent conditions or has considered all possible improvement or repair concepts.
A review of the facility for Building Code compliance and compliance with the Americans with Disabilities Act (ADA) requirements was not part of the scope of this project. However, it should be noted that whenever significant repair, rehabilitation, or restoration is undertaken in an existing structure, ADA design requirements may become applicable if there are currently unmet ADA requirements. Similarly, we have not reviewed or evaluated the presence of or the subsequent mitigation of hazardous materials, including, but not limited to, asbestos, and PCB. In addition, seismic evaluation of the subject parking structure for compliance with the current building code was not part of the scope of this project.

This report was created for the use of Client and may not be assigned without written consent from Walker Consultants. The use of this report by others is at their own risk. Failure to make repairs recommended in this report in a timely manner using appropriate measures for safety of workers and persons using the facility could increase the risks to users of the facility. The client assumes all liability for personal injury and property damage caused by current conditions in the facility or by construction, means, methods, and safety measures implemented during facility repairs. Client shall indemnify or hold Walker Consultants harmless from liability and expense, including reasonable attorney's fees incurred by Walker Consultants as a result of Client's failure to implement repairs or to conduct repairs in a safe and prudent manner.

WC PROJECT No. 37-009397.00`

June 06,2022

TABLE 2- Executive Summary – 5 Year Budget Forecast

Table CS-1
Combined Structures
Executive Summary

WALKER CONSULTANTS

WORK DESCRIPTION	TOTAL COST	2022	2023	2024	2025	2026
Work Categories						
General Conditions	$ 166,000	$ 61,000	$ 84,000	$ -	$ -	$ 21,000
Immediate Repairs	$ 6,000	$ 6,000	$ -	$ -	$ -	$ -
Structural / Concrte Repairs	$ 398,000	$ 398,000	$ -	$ -	$ -	$ -
Waterproofing	$ 468,000	$ -	$ 336,000	$ -	$ -	$ 132,000
Stair Tower Repair	$ 20,000	$ -	$ 20,000	$ -	$ -	$ -
Mechanical / Electrical / Plumbing	$ 75,000	$ -	$ 75,000	$ -	$ -	$ -
Architectural / Miscellaneous	$ 136,000	$ -	$ 129,000	$ -	$ -	$ 7,000
Life Safety	$ 13,500	$ -	$ 13,500	$ -	$ -	$ -
Contingency 10%	$ 127,000	$ 46,500	$ 64,500	$ -	$ -	$ 16,000
Consulting & Engineering Fees	$ 127,000	$ 46,500	$ 64,500	$ -	$ -	$ 16,000
Opinion of Annual Budget (Dollars)	**$ 1,536,500**	**$ 558,000**	**$ 773,000**	**$ -**	**$ -**	**$ 192,000**
Opinion of Annual Budget (Adjusted Future Value)	**$ 1,571,000**	**$ 558,000**	**$ 796,200**	**$ -**	**$ -**	**$ 216,100**

WC PROJECT No. 37-009397.00 June 06,2022

TABLE 3– North Pier Parking Structure– 5 Year Budget Forecast

NO.	WORK DESCRIPTION	5-YEAR TOTAL COST	2022	2023	2024	2025	2026
1.00	**General Conditions**	**$ 166,000**	**$ 61,000**	**$ 84,000**	**$ -**	**$ -**	**$ 21,000**
1.1	General Conditions / Mobilization	$ 166,000	61,000	84,000			21,000
2.00	**Immediate Repairs**	**$ 6,000**	**$ 6,000**	**$ -**	**$ -**	**$ -**	**$ -**
2.1	Remove and Replace barrier system (South - West Corner)	$ 6,000	$ 6,000				
3.00	**Structural / Concrete Repairs**	**$ 398,000**	**$ 398,000**	**$ -**	**$ -**	**$ -**	**$ -**
3.1	Overhead Ceiling Repair	$ 225,000	$ 225,000				
3.2	Concrete Floor Repair - Supported levels	$ 25,000	$ 25,000				
3.2a	Overhead Ceiling Repair - PCP	$ 52,500	$ 52,500				
3.3	Concrete Wall, Beam, Column Repair (Primarily Beams)	$ 75,000	$ 75,000				
3.3a	Concrete Wall, Beam, Column Repair - PCP	$ 10,500	$ 10,500				
3.4	Epoxy injection at concrete beams (Western side)	$ 10,000	$ 10,000				
4.00	**Waterproofing**	**$ 468,000**	**$ -**	**$ 336,000**	**$ -**	**$ -**	**$ 132,000**
4.1	Rout/Seal Cracks	$ 40,000		$ 40,000			
4.2	Construction Joint Sealants	$ 32,000		$ 32,000			
4.3	Remove and Replace Traffic Coating - Pier Level	$ 264,000		$ 264,000			
4.4	Traffic Coating - Recoat - Village Level	$ 132,000					$ 132,000
5.00	**Stair Tower Repair**	**$ 20,000**	**$ -**	**$ 20,000**	**$ -**	**$ -**	**$ -**
5.1	Paint Stairs	$ 20,000		$ 20,000			
6.00	**Mechanical / Electrical / Plumbing**	**$ 75,000**	**$ -**	**$ 75,000**	**$ -**	**$ -**	**$ -**
6.1	Clean Floor Drains and Piping	$ 5,000		$ 5,000			
6.2	Electrical Allowance	$ 35,000		$ 35,000			
6.3	Mechanical Allowance	$ 35,000		$ 35,000			
7.00	**Architectural / Miscellaneous**	**$ 136,000**	**$ -**	**$ 129,000**	**$ -**	**$ -**	**$ 7,000**
7.1	Paint Misc. Metals and Equipment	$ 38,000		$ 38,000			
7.2	Paint Select Soffit/Walls/Columns Locations	$ 54,000		$ 54,000			
7.3	Re-Paint Traffic Markings	$ 14,000		$ 7,000			$ 7,000
7.5	Concrete Curb	$ 30,000		$ 30,000			
8.00	**Risk Management**	**$ 13,500**	**$ -**	**$ 13,500**	**$ -**	**$ -**	**$ -**
8.1	Guardrail Post (Barrier Cable) (North and East side on Pier Level)	$ 13,500		$ 13,500			

	5-YEAR TOTAL COST	2022	2023	2024	2025	2026
Sub Total	$ 1,282,500	$ 465,000	$ 644,000	$ -	$ -	$ 160,000
Contingency 10%	$ 127,000	$ 46,500	$ 64,500	$ -	$ -	$ 16,000
Consulting & Engineering Fees	$ 127,000	$ 46,500	$ 64,500	$ -	$ -	$ 16,000
Opinion of Annual Budget (Dollars)	**$ 1,536,500**	**$ 558,000**	**$ 773,000**	**$ -**	**$ -**	**$ 192,000**
Opinion of Annual Budget (Adjusted Future V	**$ 1,571,000**	**$ 558,000**	**$ 796,200**	**$ -**	**$ -**	**$ 216,100**

TABLE 4–Opinion of Probable Seismic Restoration Repair costs

	Work Item Description	Estimated Cost
1.00	**General Conditions**	
1.10	Mobilization & General Conditions	$25,000
2.00	**Seismic Structural Repairs**	
2.01	Install (24) new drilled piers	$100,000
2.02	Install (5) new concrete shear walls at Pier and Basement Level	$500,000
2.03	Addition of carbon fiber wrapping at Line 3 and X at waffle shear wall at Pier Level	$30,000
2.04	Addition of shear wall drag reinforcement at Village Level at line Z.1	$25,000
2.05	Addition of carbon fiber wrap at precast double tee stems (Village & Pier Level) near line Z	$30,000
2.06	Addition of carbon fiber wrap at CIP Shear walls ends for confinement at line 11 at the Pier Level, at Line Z at CIP columns at lines 2, 3, 5, and 6 at Pier Level	$25,000
2.07	Thickening of CIP shear wall at line Z (2-3) at Basement Level	$25,000
2.08	Thickening of CIP shear wall at line Z (5-6) at Basement Level	$25,000
2.09	Thickening of CIP shear walls at line 3 at Basement Level	$35,000
2.10	Thickening of CIP shear wall at line X (4-11) at Basement Level	$170,000
2.11	Thickening of CIP shear wall at line 11 (at grid Y) at Pier Level	$35,000
2.12	Addition of slab reinforcement at Shear walls (East-West direction) at Village and Pier Level (i.e., chord/drag reinforcement, and shear transfer reinforcement)	$200,000
2.13	Addition of slab reinforcement at Shear walls (North-South direction) at Village and Pier Level (i.e., chord/drag reinforcement, and shear transfer reinforcement)	$200,000
2.14	Strengthen CIP column at Grid line 3 and Z at Pier Level	$25,000
	Repair Subtotal	$1,450,000
	Recommended Contingency (10%)	$145,000
	Engineering Services	$160,000
	Geotechnical Recommendations on Soil condition at the project site	$50,000
	Building Survey Elevations	$15000
	Project Total	**$1,820,000**

TABLE 5– North Pier Parking Structure– 10 Year Budget Forecast

NO.	WORK DESCRIPTION	10-YEAR TOTAL COST	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
1.00	General Conditions	$ 246,500	$ 61,000	$ 50,500	$ 43,500	$ -	$ 21,000	$ -	$ 15,000	$ -	$ 35,500	$ 20,000
1.1	General Conditions / Mobilization	$ 246,500	61,000	50,500	43,500		21,000		15,000		35,500	20,000
2.00	Immediate Repairs	$ 6,000	$ 6,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2.1	Remove and Replace barrier system (South - West Corner)	$ 6,000	$ 6,000									
3.00	Structural / Concrete Repairs	$ 556,500	$ 398,000	$ -	$ 59,000	$ -	$ -	$ -	$ 99,500	$ -	$ -	$ -
3.1	Overhead Ceiling Repair	$ 345,000	$ 225,000		$ 45,000				$ 75,000			
3.2	Concrete Floor Repair - Supported levels	$ 25,000	$ 25,000									
3.2a	Overhead Ceiling Repair - PCP	$ 80,500	$ 52,500		$ 10,500				$ 17,500			
3.3	Concrete Wall, Beam, Column Repair (Primarily Beams)	$ 75,000	$ 75,000									
3.3a	Concrete Wall, Beam, Column Repair - PCP	$ 21,000	$ 10,500		$ 3,500				$ 7,000			
3.4	Epoxy injection at concrete beams (Western side)	$ 10,000	$ 10,000									
4.00	Waterproofing	$ 732,000	$ -	$ 204,000	$ 132,000	$ -	$ 132,000	$ -	$ -	$ -	$ 132,000	$ 132,000
4.1	Rout/Seal Cracks	$ 40,000		$ 40,000								
4.2	Construction Joint Sealants	$ 32,000		$ 32,000								
4.3	Remove and Replace Traffic Coating - Pier Level	$ 396,000		$ 132,000	$ 132,000						$ 132,000	
4.4	Traffic Coating - Recoat - Village Level	$ 264,000					$ 132,000					$ 132,000
5.00	Stair Tower Repair	$ 40,000	$ -	$ 20,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 20,000	$ -
5.1	Paint Stairs	$ 40,000		$ 20,000							$ 20,000	
6.00	Mechanical / Electrical / Plumbing	$ 150,000	$ -	$ 75,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 75,000	$ -
6.1	Clean Floor Drains and Piping	$ 10,000		$ 5,000							$ 5,000	
6.2	Electrical Allowance	$ 70,000		$ 35,000							$ 35,000	
6.3	Mechanical Allowance	$ 70,000		$ 35,000							$ 35,000	
7.00	Architectural / Miscellaneous	$ 150,000	$ -	$ 37,000	$ 99,000	$ -	$ 7,000	$ -	$ -	$ -	$ 7,000	$ -
7.1	Paint Misc. Metals and Equipment	$ 38,000			$ 38,000							
7.2	Paint Select Soffit/Walls/Columns Locations	$ 54,000			$ 54,000							
7.3	Re-Paint Traffic Markings	$ 28,000		$ 7,000	$ 7,000		$ 7,000				$ 7,000	
7.5	Concrete Curb	$ 30,000		$ 30,000								
8.00	Risk Management	$ 13,500	$ -	$ 13,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8.1	Guardrail Post (Barrier Cable) (North and East side on Pier Level)	$ 13,500		$ 13,500								

	5-YEAR TOTAL COST	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Sub Total	$ 1,894,500	$ 465,000	$ 386,500	$ 333,500	$ -	$ 160,000	$ -	$ 114,500	$ -	$ 269,500	$ 152,000
Contingency 10%	$ 189,000	$ 46,500	$ 39,000	$ 33,500	$ -	$ 16,000	$ -	$ 11,500	$ -	$ 27,000	$ 15,500
Consulting & Engineering Fees	$ 189,000	$ 46,500	$ 39,000	$ 33,500	$ -	$ 16,000	$ -	$ 11,500	$ -	$ 27,000	$ 15,500
Opinion of Annual Budget (Dollars)	$ 2,272,500	$ 558,000	$ 464,500	$ 400,500	$ -	$ 192,000	$ -	$ 137,500	$ -	$ 323,500	$ 183,000
Opinion of Annual Budget (Adjusted Future V	$ 2,491,000	$ 558,000	$ 478,500	$ 424,900	$ -	$ 216,100	$ -	$ 164,200	$ -	$ 409,900	$ 238,800

A PHOTOGRAPHS

1. NORTH PIER PARKING STRUCTURE

Photo 1.1- Soffit slab deterioration and spall with exposed reinforcement, Village Level (SH3-79)

Photo 1.2- Soffit slab deterioration and spall with exposed reinforcement, Village Level (SH3-87)

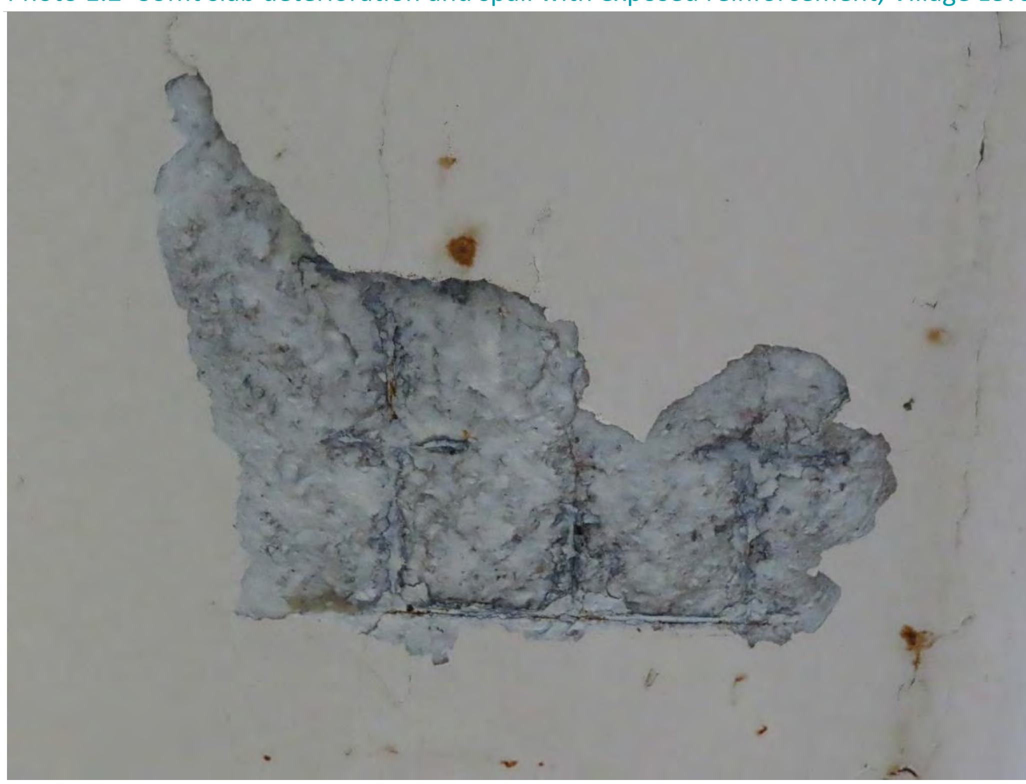


Photo 1.3- Soffit slab deterioration and spall with exposed reinforcement, Village Level (SH3-96)

Photo 1.4- Soffit slab deterioration and spall with exposed reinforcement, Village Level (SH3-98)

Photo 1.5- Concrete floor delamination, Pier Level (SH3-229)

Photo 1.6- Concrete delamination with exposed rebar, Pier Level (SH3-206)

Photo 1.7- Soffit slab deterioration and spall with exposed reinforcement, Pier Level (SH3-312)

Photo 1.8- Soffit slab deterioration and spall, Pier Level (SH3-267)

Photo 1.9- Concrete beam spalls with exposed reinforcement, Pier Level (SH3-31)

Photo 1.10- Concrete beam spall, Pier Level (SH3-201)

Photo 1.11- Concrete beam spall, Pier Level (SH3-197)

Photo 1.12- Concrete curb spall, Pier Level (SH3-35)

Photo 1.13- Concrete curb spall, Pier Level (SH3-189)

Photo 1.14- Corroded barrier post, Pier Level (SH3-192)

Photo 1.15- Compromised traffic coating, Pier Level (SH3-211)

Photo 1.16- Corroded beam ledge, Pier Level (SH3-136)

Photo 1.17- Exposed rebar on wall, Basement Level (SH3-308)

Photo 1.18- Exposed rebar on wall, Basement Level (SH3-308)

Photo 1.19- Concrete beam spall with exposed rebar, Basement level (SH3-303)

Photo 1.20- Concrete beam spall, Basement Level (SH3-271)

Photo 1.21- Concrete wall crack, Basement Level (SH3-256)

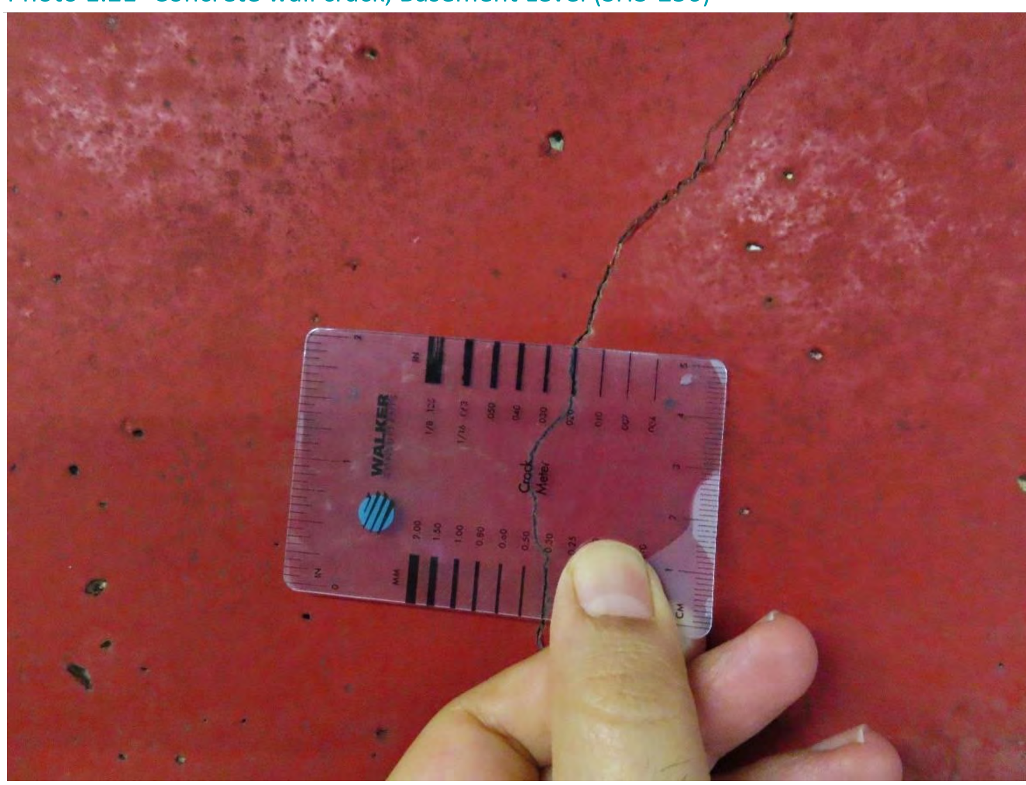


Photo 1.22 - Visual signs of rebar corrosion, Exterior - West elevation (SH2-343)

Photo 1.23- Concrete spandrel beam spall with exposed rebar, Exterior - North elevation (SH2-356)

Photo 1.24- Concrete spandrel beam spall with exposed rebar, Exterior – North-east elevation (SH2-362)

Photo 1.25- Concrete cantilever spandrel beam exposed rebar, Exterior – East elevation (SH2-372)

B MATERIAL TESTING

CONCRETE TESTING AND ANALYSIS

Walker Consultants conducted material testing on several concrete components of the North Pier Parking Structure in 2012 to check the as-built condition and to use their properties for seismic evaluation. However, testing was only performed at the Pier level. The Basement level in 2012 was occupied by the Redondo Beach Fun Factory, which provided a play area for children and families, and was not accessible for testing. The Fun Factory closed in 2017 and the Basement level is now vacant. This has provided an opportunity to conduct additional testing on the structure to obtain information on the original walls of the building at the Basement level. With the approval of the City of Redondo Beach, Walker conducted the following additional testing on the North Pier Parking Structure.

1. Coring of concrete walls to obtain compressive testing
2. Exploratory opening of concrete walls to check size and placement of steel reinforcement

Slater Waterproofing Inc. was engaged to obtain concrete cores and to perform destructive opening on January 12 and 13, 2022 under the direction of Walker staff. Concrete cores were sent to Universal Construction Testing (UCT) for laboratory testing to obtain compressive strength. The lab report prepared by UCT is attached in Appendix C. Ground Penetrating Radar (GPR) was also used on concrete surfaces at test locations prior to destructive opening to locate the embedded rebar and to prevent cutting rebar during the coring process.

COMPRESSIVE STRENGTH

As stated previously, the North Pier Parking Structure was built around 1962. Due to the age of the structure, the original plans were not available for our review. However, we have received a set of as-built plans for the 1992 seismic retrofit of the structure prepared by Theodore E. Anvick (Structural Consulting Engineer) which was dated October 1, 1992. While these plans have adequate information on the added retrofit concrete elements, they do not have any information on the original concrete walls of the structure. Therefore, Walker concrete coring was focused on the original walls of the building. Overall, 15 concrete cores were obtained of which 11 cores were taken from the original concrete walls in the Basement. We also obtained 4 cores from the added concrete walls in 1992 to compare with the compressive strength specified in the 1992 structural drawing. Concrete strength is known to increase with time. An increased concrete strength (expected value) will enhance the wall capacity in resisting earthquake loads and can reduce the extent of the retrofit scheme that might be required to add to the structure for complying with the current seismic standard.

Locations of concrete cores are shown in Figures 2.1 and 2.2. The compressive strength of the selected structural members is shown in Table 1. These compressive strengths were used in our Tier 2 seismic evaluation. Typical photos of coring are shown in photos 2.1 through 2.9.

Compressive strength testing was performed in general conformance with ASTM C 39.

Table 1 – Summary of Compressive Strength Test Results

Core #	Parking Level	Location	Wall Type	Compressive Strength psi
1	Basement	West Wall	Original Construction - 1962	6440
2	Basement	West Wall	Original Construction - 1962	5590
3	Basement	West Wall	Original Construction - 1962	8530
4	Basement	Kitchen Wall (E-W)	Original Construction - 1962	6730
5	Basement	Kitchen Wall (E-W)	Original Construction - 1962	6600
6	Basement	Kitchen Wall (E-W)	Original Construction - 1962	5400
7	Basement	Kitchen Wall (E-W)	Original Construction - 1962	5090
8	Basement	West Wall	Original Construction - 1962	5960
9	Basement	West Wall	Original Construction - 1962	8630
10	Basement	South Wall	Original Construction - 1962	7330
11	Basement	South Wall	Original Construction - 1962	5440
12	Basement	South Wall	Retrofit Wall - 1992	6210
13	Basement	South Wall	Retrofit Wall - 1992	8620
14	Pier	South Wall	Retrofit Wall - 1992	7010
15	Pier	South Wall	Retrofit Wall - 1992	7880

EXPLORATORY OPENING OF CONCRETE WALLS

We also performed destructive testing to expose the steel reinforcement in the concrete walls for measuring bar sizes and spacings. Overall, we exposed steel reinforcement at 8 locations on the walls of which 5 were on the original concrete walls in the Basement. We also exposed 3 locations on the second floor retrofit waffle walls to check the presence of confinement steel in the wall diagonal members. Locations of destructive openings are shown in Figures 2.1 and 2.2. Steel reinforcement sizes and spacings measured during testing are shown in Table 2 and Figures 2.3 and 2.4. During our investigation of the wall opening, we did not observe any significant sign of rusting and deterioration on the exposed bars. Wall steel reinforcement were generally in good condition. We also performed GPR on two of the 1992 retrofit walls at the south end of the parking structure. GPR readings showed that the rebar spacing in these walls generally conform with spacing specified in the 1992 retrofit drawings. Rebar sizes and spacings listed in Table 2 were used in our Tier 2 seismic evaluation. Photos 2.10 – 2.17 show typical reinforcement observed at some of the destructive wall openings.

Table 2 – Summary of Reinforcement Found at Destructive Opening Locations

DT#	Level	Location	Wall Type	Gridlines	Approximate Dimensions of opening	Wall Thickness Measured (in)	Steel Reinforcement Found at Destructive Opening	Notes
1	Basement	West Wal (N-S)l	Original Construction - 1962	X1-3.0	Circular (3" Diam. x 3.5" Depth)	8	Ver: #6 @ 6" O.C. Hor: #5 @ 18" O.C	One Layer rebar was found at the middle of the wall thickness
2	Basement	West Wall (N-S)	Original Construction - 1962	X-10.2	2 Squares of 4" x 4"	8	Ver: #6 @ 6" O.C. Hor: #5 @ 18" O.C.	One Layer rebar was found at the middle of the wall thickness
3	Basement	South Wall (E-W)	Original Construction - 1962	11-X.8	2" x 29"	10	Ver: #6 @ 12" O.C. - 2" Cover Hor: #4 @ 18.5" O.C. - 2.75" Cover	Two Layer rebar was found (one at each face)
4	Basement	Kitchen Wall (E-W)	Original Construction - 1962	3-Y.3	2 Squares of 4" x 6" & 4" x 11"	24	Ver. Bar in the Field of Wall: #4 @ 18" O.C. - 3.125" Cover Ver. Bar at Jamb: #10 @ 6" - 3.5" Cover Hor: #4 @ 12" O.C. - 2.75" Cover - 2.5" Cover	Vertical Jamb Steel: 9 #10 bars (3 layers of 3 #10)
5	Basement	Kitchen Wall (E-W)	Original Construction - 1962	3-Y.9	1 Square of 5" x 5"	24	Ver: Inconclusive for vertical due to access and interference from pie when using GPR. Hor: #4 @ 12" O.C. - 2.75" Cover - 2.5" Cover	Use the same reinforcement found in the other kitchen wall
6	Pier	North Wall (E-W)	Retrofit Waffle Wall - 1992	3-Y.2	4" x 17"	12	Found 2 #6 longitudinal bar @ 8" O.C. along diagonal members - Cover 3.5" No confinement bar was found	Bar was coated
7	Pier	North Wall (E-W)	Retrofit Waffle Wall - 1992	3-X.8	6" x 24"	12	Found 2 #6 longitudinal bar @ 8" O.C. along diagonal members - Cover 2.5" No confinement bar was found	Bar was coated
8	Pier	West Wall (N-S)	Retrofit Waffle Wall - 1992	X-4.2	8" x 24"	12	Found 2 #6 longitudinal bar @ 8" O.C. along diagonal members- Cover 2.5" No confinement bar was found	Bar was coated

2. CONCRETE TESTING PHOTOS

Photo 2.1- Detecting wall steel reinforcement using GPR, West Wall, 1962 Construction - Basement (BA2-9)

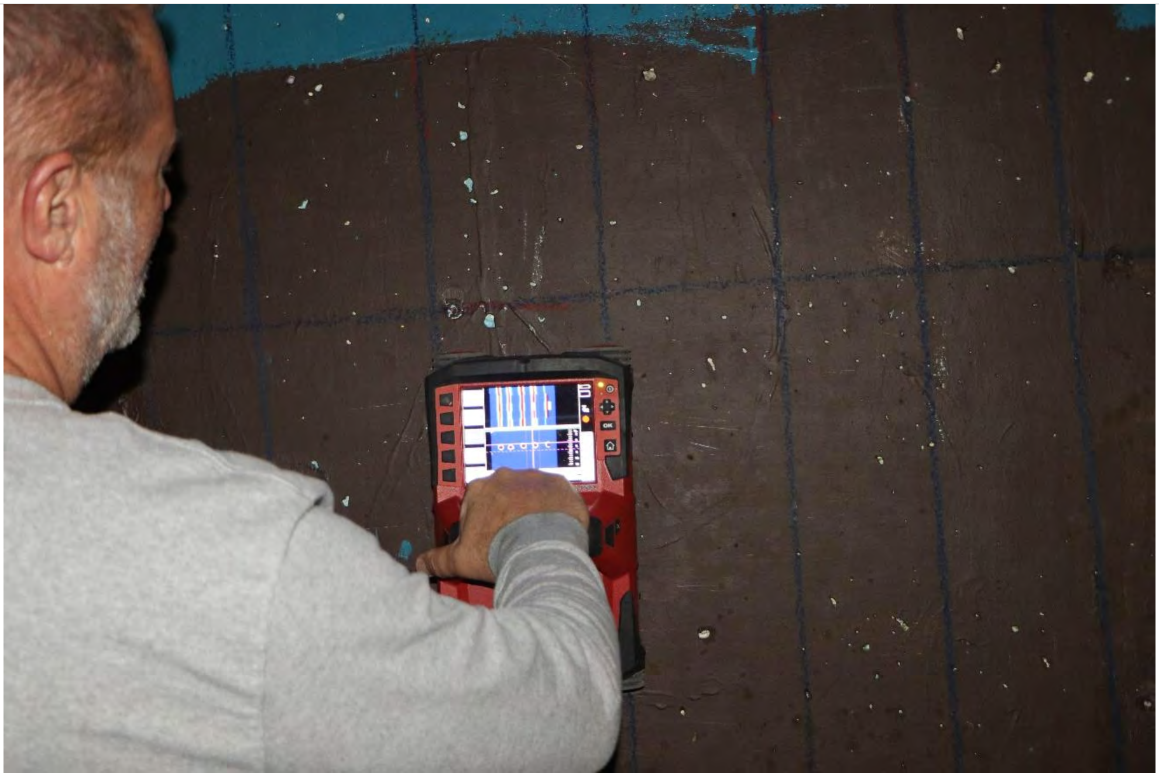


Photo 2.2- Detecting waffle wall steel reinforcement using GPR, East Wall, 1992 Retrofit – Pier Level (BA2-12)

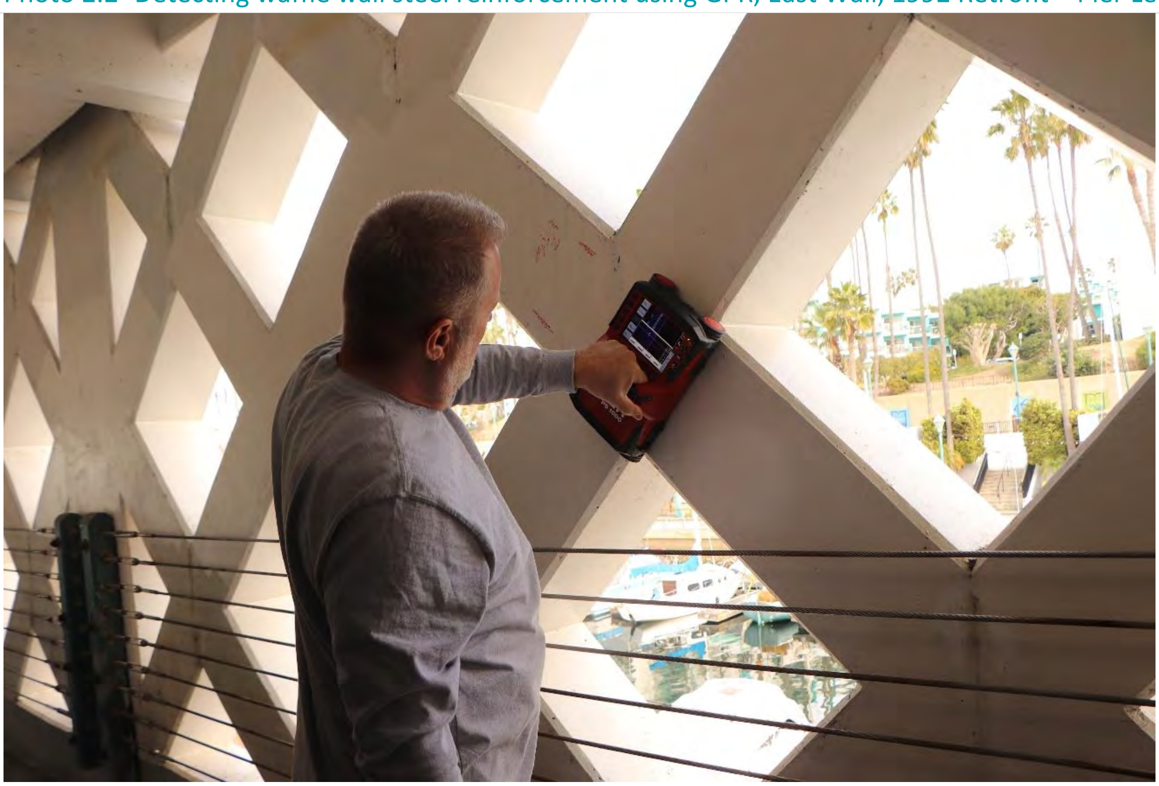


Photo 2.3- Wall steel reinforcement detected using GPR, only longitudinal bar was found, No confinement bar was present, East Wall, 1992 Retrofit – Pier Level (BA2-197)

Photo 2.4- Wall steel reinforcement detected by GPR, South Wall Gridline 11, 1962 Construction - Basement (BA2-128)

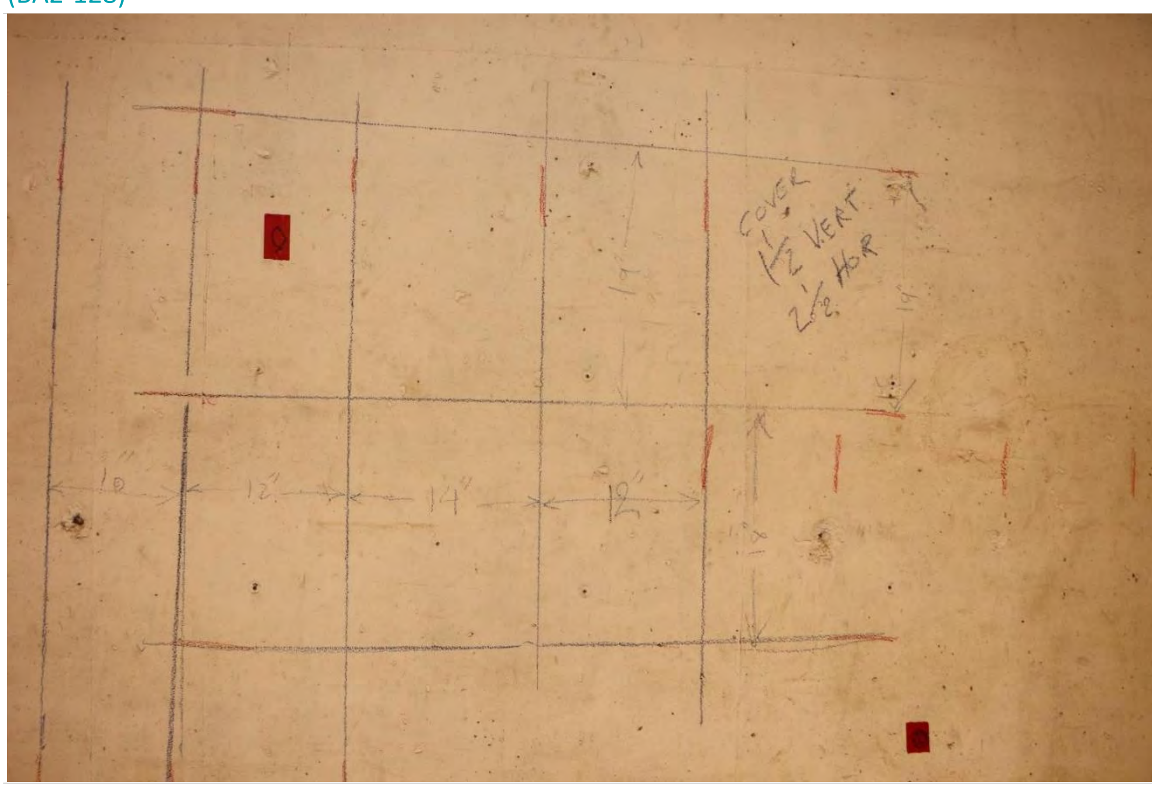


Photo 2.5- Concrete coring, West Wall, 1962 Construction - Basement (BA2-33)

Photo 2.6- Concrete coring, West Wall, 1962 Construction - Basement (BA2-78)

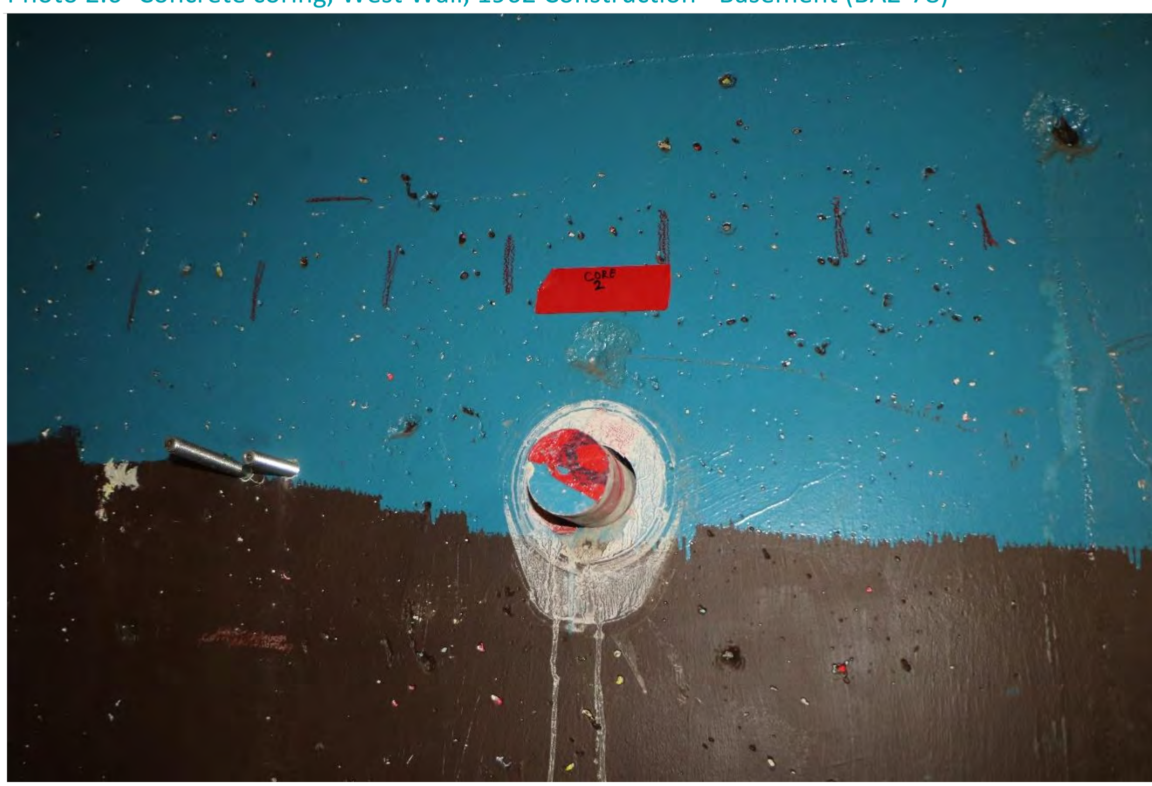


Photo 2.7- Concrete coring, Kitchen wall at gridline 3, 1962 Construction - Basement (BA2-102)

Photo 2.8- Concrete coring, Kitchen wall at gridline 3, 1962 Construction - Basement (BA2-96)

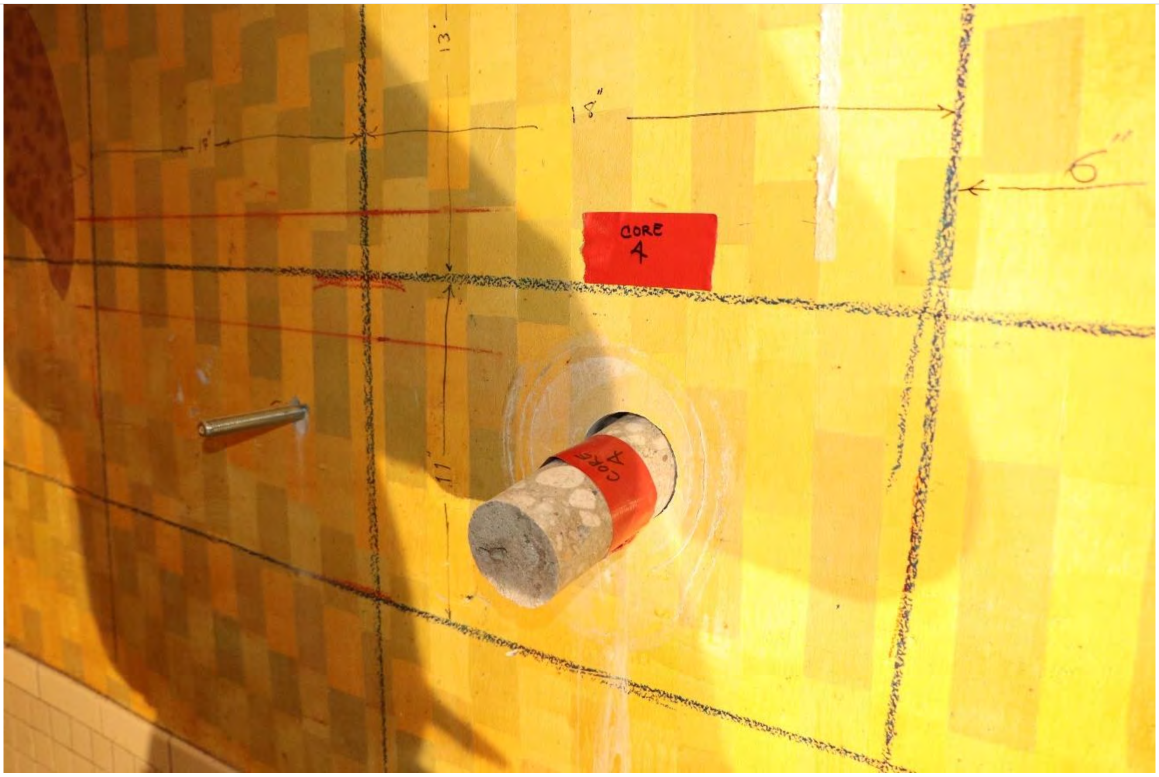


Photo 2.9- Typical concrete core, 3" diameter by 6" length, kitchen wall on gridline 3, 1962 Construction - Basement (BA2-224 and 226)

Photo 2.10—Destructive wall location (DT3), South wall, 1962 Construction - Basement (BA2-404

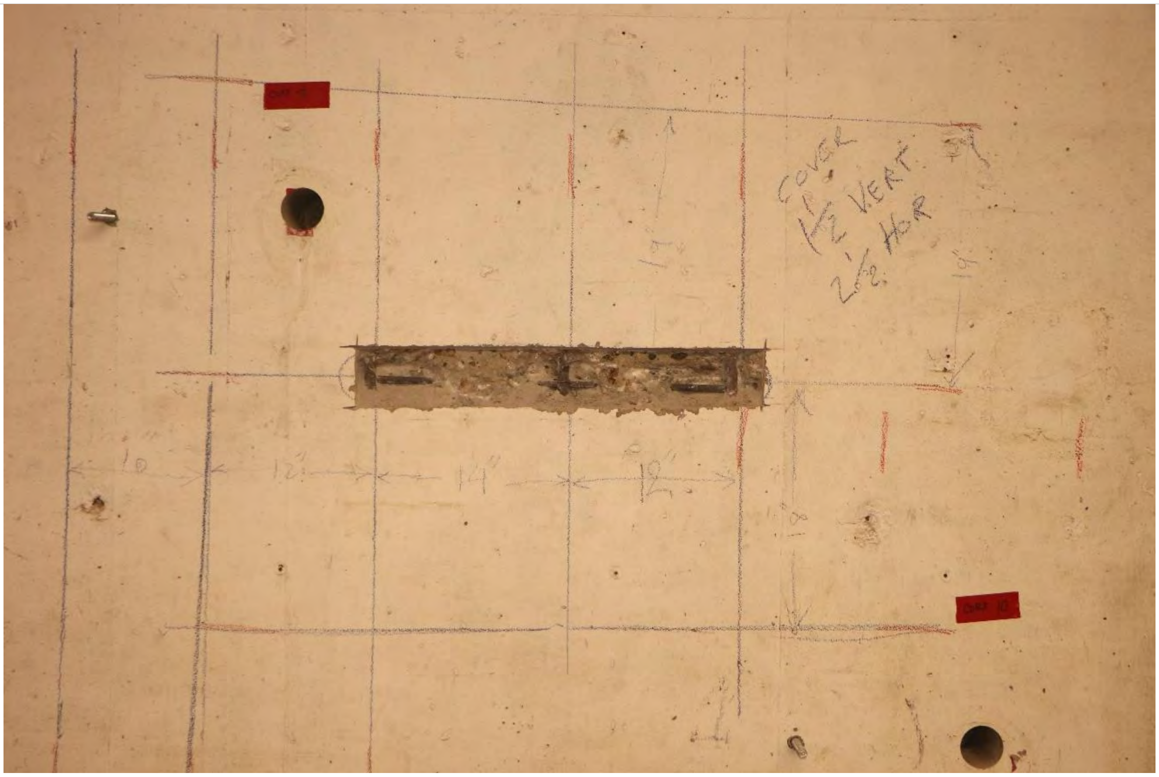


Photo 2.11—Destructive wall location (DT4), Kitchen wall on gridline 3, 1962 Construction - Basement (BA2-568)

Photo 2.12- Opening of diagonal members on waffle wall, Only # 6 longitudinal bar was found, No confinement bar was present, 1992 Retrofit Wall on Gridline 3– Pier Level (BA2-161)

Photo 2.13- Opening of diagonal members on waffle wall, Only # 6 longitudinal bar was found, No confinement bar was present, 1992 Retrofit Wall on Gridline 3– Pier Level (BA2-178)

Photo 2.14— Vertical rebar placement at destructive location (DT3), South wall, 1962 Construction - Basement (BA2-409)

Photo 2.15— Horizontal #4 bar found at the wall destructive opening location DT3, South wall, 1962 Construction - Basement (BA2-344)

Photo 2.16— Vertical #10 bar found at wall jamb, destructive opening location DT4, Kitchen wall on gridline 3, 1962 Construction - Basement (BA2-580)

Photo 2.17— Vertical bar concrete cover measurement at wall jamb, destructive opening location DT4, Kitchen wall on gridline 3, 1962 Construction - Basement (BA2-594)

CONCRETE TESTING FIGURES

Figure 2.1 Locations of Concrete Coring and Exploratory Concrete Openings – Basement Level

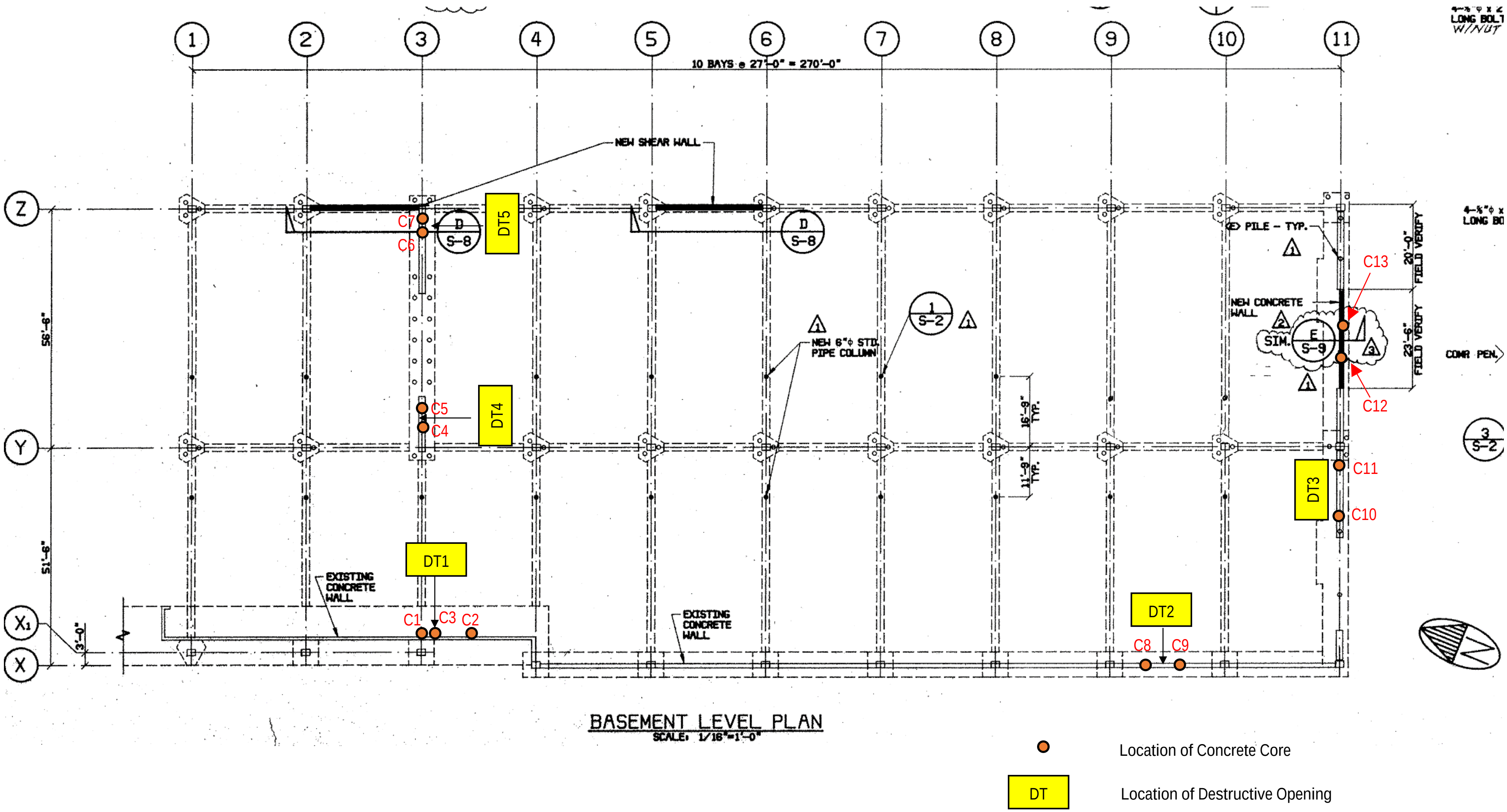


Figure 2.2 Locations of Concrete Coring and Exploratory Concrete Openings – Pier Level

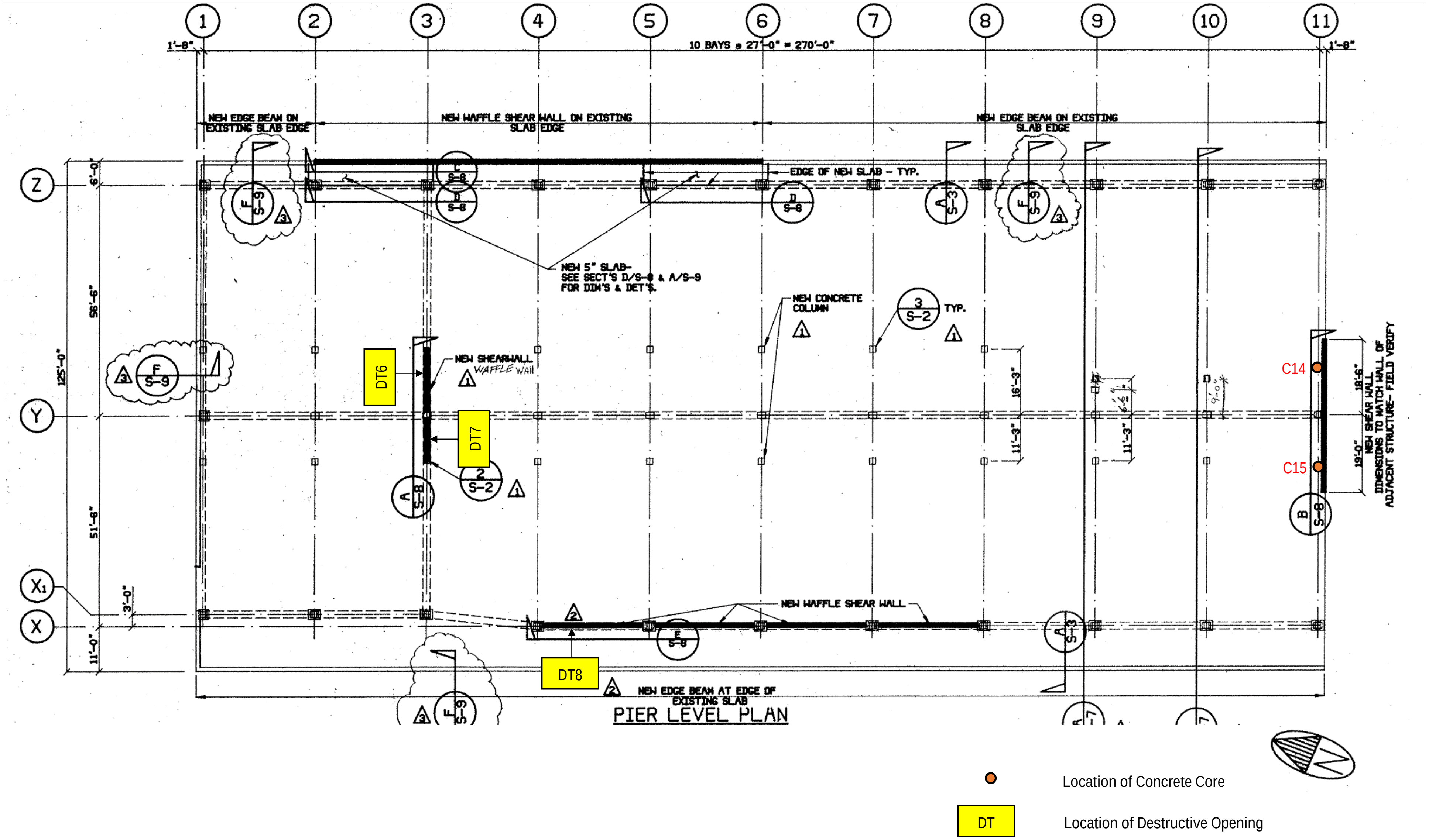


Figure 2.3 Steel reinforcement found at wall destructive openings – Basement Level

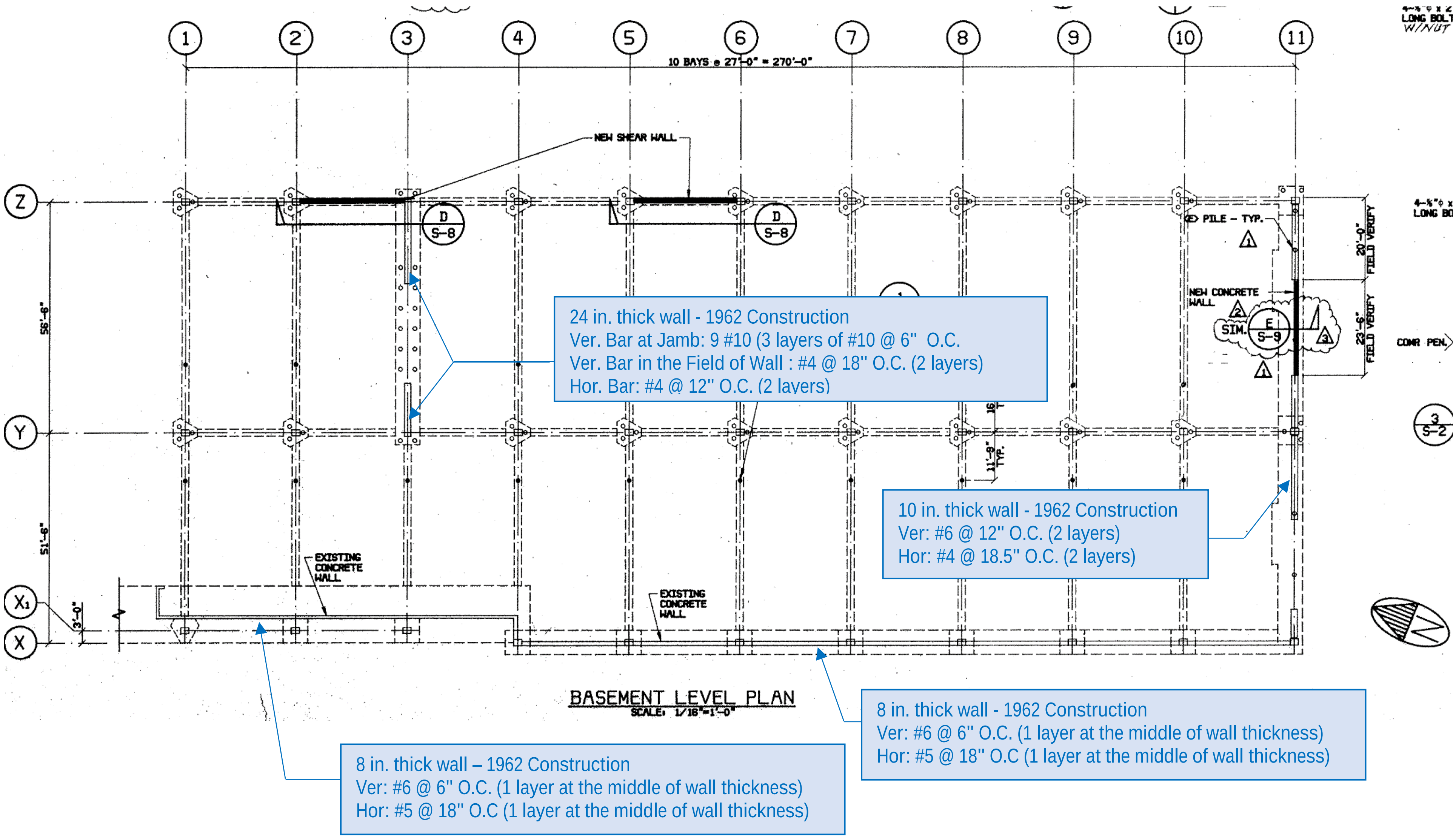
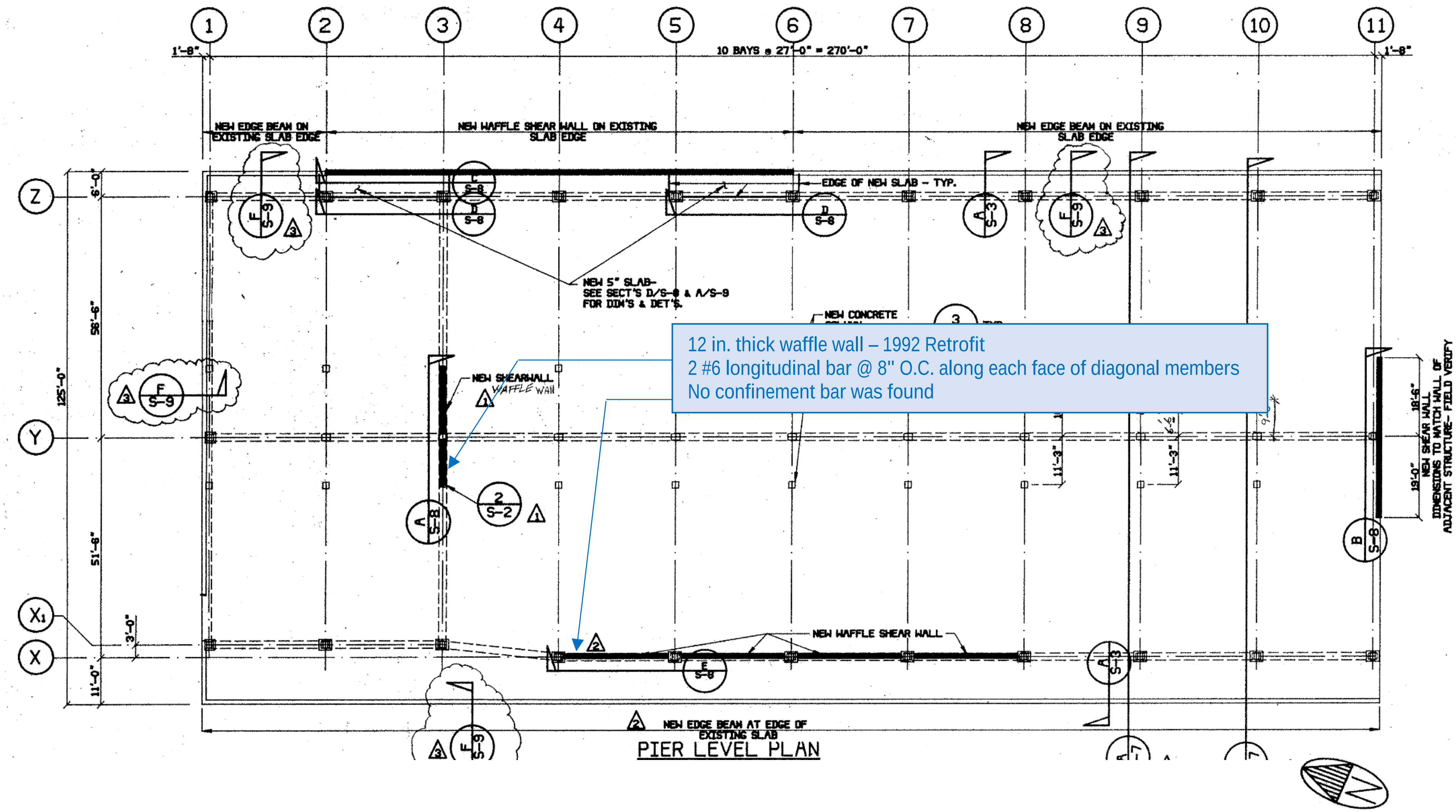


Figure 2.4 Steel reinforcement found at wall destructive openings – Pier Level



C UTC REPORT

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Mr. Behnam Arya, PhD, PE barya@walkerconsultants.com
Walker Consultants
707 Wilshire Blvd, Suite 3650
Los Angeles, CA 90017
PH: 213.335.5191

Re: Compressive Strength of Concrete Core samples
City of Redondo Beach
North Pier Parking Structure
180 Coral Way,
Redondo Beach, CA 90277
Walker Consultants Project No. 37.009397.00

Dear Mr. Arya:

Enclosed please find the results of the compression strength of the fifteen (15) core samples delivered to our laboratories, that were reportedly extracted from the referenced structure and delivered to our laboratories on January 24, 2022.

The **compressive strength** was determined according to the applicable provisions of ASTM C39 "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens".

The concrete cores were identified by others.

The obtained test results are compiled below in Table 1.

****

We appreciate the opportunity to be of continued service to you.
Sincerely yours,

UCT Group LLC

Elena Emerson

Elena I. Emerson
Operations Manager

Table 1. **Compressive Strength of Concrete Core Samples**
(ASTM C 39)

Core ID	Location	Tested Height L (in)	Diam. D (in)	L/D Ratio K	Total Load (lbs)	Compressive Strength (psi)	**Corrected Compressive Strength (psi)**
1	Basement, West Wall, Gridlines X1-3.0	5.47	2.75	1.99 1.00	38,260	**6,440**	**6,440**
2	Basement, West Wall, Gridlines X1-3.5	4.51	2.75	1.64 1.00	34,230	**5,760**	**5,590**
3	Basement, West Wall, Gridlines X1-3.0	3.25	2.75	1.18 0.92	55,060	**9,270**	**8,530**
4	Basement, Kitchen Wall (E-W), Gridlines 3-Y.2	3.48	2.75	1.27 0.93	43,020	**7,240**	**6,730**
5	Basement, Kitchen Wall (E-W), Gridlines 3-Y.4	5.41	2.75	1.97 1.00	39,230	**6,600**	**6,600**
6	Basement, Kitchen Wall (E-W), Gridlines 3-Y.8	5.47	2.75	1.99 1.00	32,060	**5,400**	**5,400**
7	Basement, Kitchen Wall (E-W), Gridlines 3-Y.9	5.48	2.75	1.99 1.00	30,260	**5,090**	**5,090**
8	Basement, West Wall, Gridlines X2-10.2	5.48	2.75	1.99 1.00	35,410	**5,960**	**5,960**
9	Basement, West Wall, Gridlines X2-10.4	5.18	2.75	1.88 1.00	51,290	**8,630**	**8,630**
10	Basement, South Wall, Gridlines 11-X.8	5.40	2.75	1.96 1.00	43,540	**7,330**	**7,330**
11	Basement, South Wall, Gridlines 11-X.9	5.39	2.75	1.96 1.00	32,320	**5,440**	**5,440**
12	Basement, South Wall, Gridlines 11-Y.4	5.48	2.75	1.99 1.00	36,890	**6,210**	**6,210**
13	Basement, South Wall, Gridlines 11-Y.5	5.41	2.75	1.97 1.00	51,200	**8,620**	**8,620**
14	Pier, South Wall, gridlines 11-Y.8	5.43	2.75	1.97 1.00	41,650	**7,010**	**7,010**
15	Pier, South Wall, gridlines 11-Y.9	5.40	2.75	1.96 1.00	46,820	**7,880**	**7,880**
Remarks: The cores were tested in air-dry conditions.							

D SEISMIC EVALUATIONS

WC PROJECT No. 37-009397.00 June 6, 2022

PROJECT UNDERSTANDING

The Redondo Beach North Pier Parking Structure was built in 1962 (see Photo 3.1 and 3.2) and is evaluated based on its current structural capacities. The structure is experiencing significant corrosion-based deterioration, exacerbated by its marine location. Walker was contracted in 2011, and our field investigation identified potential deficiencies with the North Pier parking structure. The City again contracted Walker in 2021 to perform Tier 2 Seismic Evaluation of the North Pier Parking Structure to advise the City as to its structural integrity for seismic and gravity loading, and viable repair alternatives. This summary report will provide findings of our most recent field investigation work in 2021-2022.

SCOPE OF SERVICES

As stated previously, the North Pier Parking Structure was built around 1962. Due to the age of the structure, the original plans were not available for our review. However, we have received a set of as-built plans for the 1992 seismic retrofit of the structure prepared by Theodore E. Anvick (Structural Consulting Engineer) which was dated October 1, 1992. While these plans have adequate information on the added retrofit concrete elements, they do not have any information on the original concrete walls of the structure.

Walker completed a Tier 1 building screening procedure and Tier 2 seismic evaluation in 2021-2-22 based on guidelines established in the nationally recognized publication ASCE 41-17 "Seismic Evaluation of Exiting Buildings". Tier 1 building screening of 2011, performed by Walker, of North Parking Structure identified potential deficiencies in: vertical discontinuity of the lateral force resisting system, torsional stability, deterioration of structural members, and undefined foundation capacity. In order to confirm if the structural deficiencies exist relative to acceptable seismic performance of the structure, the ASCE 31-03 and ASCE 41-06 code requirements and performance acceptance criteria were used in 2012 edition of our report. Since 2012 ASCE has further enhanced the performance acceptance criteria for existing buildings in high seismicity areas. For the current study, the latest edition of ASCE 41-17 is used by Walker and like ASCE 31-03 it also requires structural engineers to perform a deficiency-based seismic evaluation study based on a Tier 2 procedure. This process of deficiency-based evaluation of individual structural elements against maximum demand of force or displacement that can be imposed by the system overall and their corresponding performance will likely determine if the parking structure has adequate strength to resist seismic forces at the inelastic level and determine areas where structural strengthening is required to extend the useful service life of the structure.

It is also important to note that there is an overall increase in seismic demand between the two code models of ASCE 41-06 and ASCE 41-17. Changes are associated with the updates made in seismic parameters established by USGS related to new research on seismic ground motions in the continental US and how soils in high seismicity areas can propagate inertial forces with different earthquake intensities and their associated return periods. Existing structures that were checked previously on the basis of ASCE 41-06 and ASCE 31-03 and have borderline satisfied the performance objective levels of ASCE 31-03 will likely not satisfy the performance objective criteria of ASCE 41-17 as the force or displacement demand of ASCE 41-17 are significantly higher from ASCE 41-06. Recommended repairs at the North Pier Parking Structures are based on the performance acceptance criteria of ASCE 41-17.

SUMMARY OF TIER-2 SEISMIC EVALUATION PER ASCE 41-17

Walker Consultants has completed the Tier-2 Seismic Evaluation of North Pier Parking Structure on the basis of ASCE 41-17. We have evaluated the parking structure using field investigations employing both destructive and non-destructive methods. Based on the findings of field investigative work, we have performed a 3-D finite element computer analysis model of the garage and have checked the structural adequacy of existing lateral load resisting elements. We recommend the following:

SEISMIC REPAIRS REQUIRED

Walker identified the following conditions where seismic repairs should be performed:

1. Add (1) new 21ft long concrete shear wall at line 3 near grid line Z at the Pier Level. The addition of new shear wall will eliminate the discontinuity of shear wall that currently exists as there is a 21ft long shear wall at the Basement Level that was built in 1962 and was part of the original design. The addition of new shear wall at line 3 near line Z will also reduce demand on line 3 existing shear wall at grid line Y at the Pier Level, which is currently showing signs of an overstressed condition in both flexure and shear (See Photo 3.4 and 3.9)
2. Add (1) new 21ft long concrete shear walls at line 7 near line X and (1) new shear wall at line 7 near line Z at the Pier and Basement level. The addition of two new shear walls at line 7 (at Pier and Basement level) will possibly reduce the shear overstress condition of existing shear walls at line 3 and at line 11 at the Pier and Basement level. Future detailed analysis with the addition of new shear walls will be performed in the next phase when seismic restoration phase of the project will be approved by the City. Optimal location of new shear walls apart from line 3 shear wall will be finalized in the next phase. For cost estimation purposes, addition of new shear walls at line 7 is quite reasonable to determine potential costs associated with addition of new shear walls inside garage.
3. Addition of (24) new foundation drilled piers and wall footing at line 7 to support two new shear walls.
4. Strengthening of existing waffle shear wall at line 3 and line Y at the Pier Level as the diagonal braces of existing waffle shear wall are deficient in both axial compression and tension. This condition will improve once the new shear walls are going to be added at line 3 and at line 7 (See Photo 3.5).
5. Strengthening of existing top chord of the waffle shear wall at line Z.1 at the Village level. Addition of new chord reinforcement is required at the Village level (See Photo 3.14).
6. Strengthening of existing double tee stems at waffle shear wall ends at line Z.1 at the Village and Pier level (See Photo 3.15).
7. Strengthening of Shear walls ends to meet ASCE 41-17 confinement reinforcement. X (2-3) and (5-6) to meet requirement of ASCE 41-17 code force limit (See Photo 3.16).
8. Thickening of existing shear wall is required at line X at the Basement level from line 4 to 11 (See Photo 3.13)
9. Thickening of existing shear wall is required at line Z (basement level) from line (2 – 3) and (5 – 6) (See Photo 3.16).
10. Thickening of existing shear walls is required at line 3 at the Basement level. Add horizontal reinforcement at Basement level shear walls along line 3 (see Photo 3.4) where existing shear walls reinforcement in horizontal direction doesn't meet the ASCE 41-17 and ACI 318-14 minimum wall requirement.
11. Add new slab reinforcement at shear walls oriented in the East-West direction at Village and Pier Level at line 3, 7, and 11 (See Photo 3.5, 3.8, and 3.13).
12. Add new slab reinforcement at waffle shear walls at line X and Z.1 at Village Level (See Photo 3.6 and 3.7).
13. Strengthen CIP column at line 3 and Z at Pier Level (See Photo 3.9).
14. Obtain recommendations from a registered Geo-technical engineer to evaluate current soil conditions and associated risk of having soil liquefaction, slope stability failure, and surface fault rupture at the garage site.
15. Obtain building spot elevations at corners and at intermediate points along the length of the garage to monitor any potential movement of garage foundations both vertically and horizontally. The City should contract with a licensed professional surveyor to perform this task.

Although the parking structure was functional at the time of our field investigation, over its life it has experienced several moderate earthquakes which may have softened the structure internally. North Pier parking structure is located very close to active seismic fault lines which can produce an earthquake of M6.0 to 7.0 on a Richter scale.

Over the last fifty years, the City of Redondo Beach has experienced several earthquakes with magnitude 5.0 to 6.0+. Seismic records of Southern California show that those earthquakes have relatively short return period.

Completing the necessary repairs would ensure that the garage would provide "Basic Life Safety Structural Performance" under a moderate seismic event and "Basic Collapse Prevention Structural Performance" under a severe seismic event. At present several structural elements of the parking structure in their current form do not satisfy the performance objectives of both the Life Safety and Collapse Prevention structural performance criteria of ASCE 41-17.

Our opinion of probable seismic restoration repair costs is $1,820,000.00, including a recommended construction contingency and engineering services. Our opinion is based on estimated repair quantities based on our analysis work and historical records of similar types of work. Cost may vary due to procurement method, local economy, phasing, or other factors. Additional engineering services are required to prepare repair documents that can be used to bid and execute the recommended repairs. Figure 3.1, 3.2, and 3.3 show locations of seismic structural repairs on Basement, Pier, and Village Levels respectively. An additional breakdown of the probable repair costs is presented in Table D1.

TIER 2 SEISMIC EVALUATION FINDINGS

In investigating and performing the Tier-2 Seismic Evaluation in accordance with ASCE 41-17 of the North Pier Parking Structure, we found the following:

The North Pier Parking Structure is adequate to provide "Basic Life Safety Structural Performance" under the application of code specified gravity and ASCE 41-17 BSE-1E level seismic loads and "Basic Collapse Prevention Structural Performance" under the application of code specified gravity and ASCE 41-17 BSE-2E level seismic loads. We have not observed any structural cracking in slabs, beams, columns, and walls due to an over-stress condition caused be excessive amount of gravity and seismic loads resisted by these elements during its service life of past 10 years. There is no visible cracking and spalling of concrete associated with corrosion of rebars. No visible cracking in slabs, beams, columns, or walls was observed that can be associated with foundation settlement or overstress condition of foundation elements. Seismic retrofits of 1992 are performing well and have improved the flow of seismic forces from diaphragm to lateral load resisting elements and subsequently to the garage foundation system. As mentioned above that the seismic loads specified in ASCE 41-17 are significantly higher than the seismic loads specified in ASCE 31-03. Due to the increase in forces that were used in 2012 to verify the adequacy of members, there are several locations where the structural capacity of existing shear walls, waffle shear wall diagonal braces, and chord and drag reinforcement near shear walls are no longer meeting the force demands of ASCE 41-17 and therefore do not satisfy the performance objectives of both the Life Safety and Collapse Prevention structural performance criteria of ASCE 41-17.

Walker Consultants has completed both the Tier 1 and 2 seismic evaluations of North Pier Parking Structure. Tier 1 evaluations were performed first in 2021. Tier 1 building screening process was used as the basis for Tier 2 seismic evaluation that was performed by Walker in 2022.

GARAGE DISCRIPTION

Parking Facility at North Pier – Redondo Beach is composed of two supported level parking structure. The existing parking structure is made up of cast-in-place concrete columns and walls, both cast-in-place and precast beams and cast-in-place topping slab placed over precast double tees at the supported levels. The lateral load resisting system for the existing parking structures consists of concrete shear walls in two orthogonal directions. Concrete shear walls are supporting small to negligible tributary area of the supported precast double tee system and can be classified as Bearing Wall System on a conservative basis in both directions. The current analysis provides comprehensive information on the design adequacy related to the seismic upgrades performed in 1992 plus the overall stability, integrity, and redundancy of the structure to withstand garage vertical loads, seismic loads on the basis of ASCE 41-17.

The foundation system for the existing parking structure is composed of spread, strip and drilled pier foundation system. We have no structural information on the size and reinforcement of foundation elements. We have no documentation, if any foundation upgrades were made in the past to address any foundation issues related to distribution of gravity and seismic loads due to the modifications made over the life of the structure. Review of the foundation system is based strictly on the basis of field investigations limited to visual observations. At present, we didn't obtain any new soils investigation report for this project site. Lateral seismic loads at the foundation level will be resisted by passive pressure against the face of the spread, strip and drilled pier caps in conjunction with the allowable lateral frictional resistance at the bottom of spread and strip footings and lateral load resistance capacity of drilled piers. Differential settlement of the structure has already taken place and is not noticeable. No cracking of structural elements is being observed that can be associated with any recent foundation movement.

DESIGN SUPERIMPOSED LOADS

In addition to dead loads, the structure is checked for the following superimposed live loads, with no live load reductions taken in accordance with CBC section 1607:

Light vehicle storage	40 psf
Landscaping	None required
Heavy vehicles	None required
Snow Load	None required

TIER 2 SEISMIC EVLAUTION REQUIREMENTS

The Tier 2 seismic evaluation uses a three-step approach.

1. Induced earthquake forces: Analyze the structure for pseudo lateral forces using Linear Static Procedure (LSP) of ASCE 41-17.
2. Verify structural irregularities and perform Dynamic Analysis using Linear Dynamic Procedures (LDP) of ASCE 41-17.
3. Generate member forces for each structural element using load combinations of ASCE 41-17.

An evaluation of the effects of a seismic event on the structure is performed. We have computed floor masses for each level to determine mass distribution and inertia properties. Frame member geometry, material and section properties for various member sizes and concrete strengths are obtained from field investigative work to calculate frame stiffness. Once stiffness and mass inertia properties are defined, static and dynamic analysis are performed to determine mode shapes and associated periods to use in the lateral analysis.

Lateral loads are calculated according to ASCE 41-17 and applied at 5% of the structure dimension on either side of the center of mass to include the effects of accidental torsion in the garage. The criteria from the ASCE used to check the adequacy of this structure are explained in the Lateral Section of these calculations.

In a building with special concrete shear wall lateral load resisting system, concrete shear walls resist 100% of the lateral loads in accordance with ASCE 7-16 (i.e., ASCE 41-17 BSE-2N) equivalent lateral force procedure or response spectrum analysis approach. Structures designed in conformance with such provisions and principles are expected to be able to;(1) resist minor earthquakes without damage; (2) resist moderate earthquakes without structural damage, but with some nonstructural damage; and (3) resist major or severe earthquakes without major failure of the building or its component members and would perform such that it would offer "Basic Life Safety Structural Performance".

The Tier 2 deficiency-based retrofit requires retrofit of the building such that the deficiencies identified in a Tier 1 screening, or a Tier 2 evaluation are mitigated to achieve compliance with the selected Performance Objective(s). The scope of the Tier 2 deficiency-based retrofit need not expand beyond that necessary to modify the building to comply with a Tier 1 screening or a Tier 2 evaluation.

If the Tier 2 deficiency-based evaluation demonstrates the adequacy of the structure with respect to all of the 'Noncompliant' or 'Unknown' statements in the Tier 1 screening, then the building complies with the ASCE 41-17 standard for the corresponding Performance Objective. If the building is retrofitted in accordance with the deficiency-based retrofit procedure, then the retrofitted building complies with the ASCE 41-17 standard for the corresponding Performance Objectives.

TIER 2 PARTIAL RETROFIT OBJECTIVES

A partial retrofit, which can address a portion or portion of the building without evaluating or rehabilitating the complete lateral force resisting system, shall meet all of the following ASCE 41-17 requirements:

1. Does not result in a reduction in the Structural Performance Level or Nonstructural Performance Levels of the existing building for the same Seismic Hazard Level.
2. Does not create a new structural irregularity or make an existing structural irregularity more severe.
3. Does not result in an increase in the seismic forces to any component that is deficient in capacity to resist such forces, and
4. Incorporate structural elements that are connected to the existing structure in compliance with the requirements of ASCE 41-17 standard.

LATERAL LOAD ANALYSIS

Seismic lateral forces are determined for the parking structure, using ASCE 41-17, and acting in conjunction with the garage vertical loads. An evaluation of the effects of the lateral forces on the structure is performed. The analysis computes floor masses for each level to determine mass distribution and inertia properties. Wall member geometry, material and section properties for various member sizes and concrete strengths are used to calculate building stiffness. Once stiffness and mass inertia properties are defined, a static analysis is performed to determine mode shapes and the associated period of vibration to use in the lateral analysis. Lateral loads are calculated according to ASCE 41-17 and applied at 5% of the structure dimension on either side of the center of mass to include the effects of accidental torsion in the garage.

Seismic Evaluation Procedure:

1. Select structural system.
2. Identify lateral force-resisting system.
3. Identify structural irregularities and any framing system limitations.
4. Select lateral force procedure (i.e., static, or dynamic).
5. Calculate the total design base shear and distribute over height of structure.
6. Elastically analyze building, including torsion effects, including P-delta effects, if necessary.
7. Check story drift limitations.
8. Combine earthquake and factored gravity loads effects. Verify design of lateral force-resisting elements for required strength and verify special detailing.
9. Confirm complete load path to resist earthquake forces.

FINITE ELEMENT COMPUTER MODELING

The following pages contain the computer model used to determine the seismic base shear, distribution of seismic forces over the height of garage, member forces and member deformations. This model uses the entire structural framing system, including lateral load resisting elements and gravity elements to determine structural story drift.

STEY-BY-STEP PROCEDURE FOR TIER 2 SEISMIC EVALUATION

1. LOAD PATH

"When Tier 2 evaluation procedures require evaluation of the continuity of structural elements to be tied together to form a complete load path, continuity shall be evaluated."

Based on available construction documents, seismic restoration of the parking structure was performed in 1992. It is appropriate to assume that seismic deficiencies of the parking structure observed at that time were checked and addressed on the basis of seismic detailing requirements of UBC 1991. Severe cracking in moment frame columns was identified at the base of all CIP columns with tapered section at the Pier Level. This could be associated with seismic forces higher than the design seismic loads used for the design of concrete moment frame columns. Higher seismic forces at Village Level can cause an increase in shear at each moment frame column, which in turn caused an increase in column moments at the base of columns at the Pier Level. Higher shear in columns can also lead to higher inelastic seismic movements which then help in formation of plastic hinges (i.e., cracking) in columns at the point of maximum moment.

All CIP columns at the perimeter with reduced section properties were encased with new concrete cover, with epoxy coated shear and flexural reinforcement to increase the overall design capacity of the columns. Increased shear stiffness of perimeter columns would reduce lateral drift of the parking structure under higher seismic loads. It is possible that the gain in flexural capacity may only take place at the top of column because of proper embedment of new vertical reinforcement.

Waffle shear walls were added in both directions between Village and Pier Levels to increase the lateral force resisting capacity of the parking structure (See Photo 0.5, 0.6, 0.7). Waffle shear wall along line Z.1 between grid lines 2 and 6 is not continuous between Pier and Foundation Level. Local thickening of diaphragm at shear wall ends between grid lines 2 – 3 and 5 – 6 is being provided at Pier Level for transfer of shear wall forces from waffle shear wall to two new concrete shear walls added along line Z between Pier and Foundation Level. Waffle shear wall system behaves very much like a Truss system with diagonal braces resisting lateral shear forces applied by the diaphragm as tension and compression axial forces of its diagonal braces. Since the waffle shear wall along line Z.1 is supported by overhanging precast double tees and when tees experience any vertical load from truss diagonal braces, they deform vertically. The vertical deformation caused by the movement of tees supporting the truss shear wall system then generates tension and compression forces in top and bottom chords of the truss. Waffle shear walls along line Z.1 (2-6) at the Village level and shear walls along line Z (2-3) and (5-6) at the Pier level have a lateral offset distance between them as 6ft, there is out-of-plane discontinuity of vertical lateral force resisting system between the two lines of shear walls that are close to each other and connected laterally by a rigid diaphragm at the Village and Pier Level. This out-of-plane, discontinuity of vertical lateral force resisting element is not preferred, but is allowed by ASCE 7-05, ASCE 7-10, and ASCE 7-16 for even newer buildings that are located within seismic design category D, E and F. For a building with out-of-plan discontinuity, ASCE 7-16 requires special detailing of slab collector elements for transferring forces at the required strength level. ***ASCE 41-17 has no such procedure available for Tier 2 Evaluation for buildings with local discontinuity in load path.***

Commentary of section 5.4.2.3 states: "*The adequacy of the elements and connections below the vertical discontinuities shall be evaluated as force-controlled elements. The adequacy of struts and diaphragms to transfer load from discontinuous elements to adjacent elements shall be evaluated".* At Pier Level, diaphragm was thickened locally to increase its shear design capacity and to transfer forces from waffle shear wall along line Z.1 to two shear walls located below Pier Level along line Z that were also added when garage restoration was performed in 1992. To address additional vertical shear demand at precast double tees, due to the use of ASCE 41-17 higher seismic forces, carbon fiber wrapping is required at precast double tee stems at waffle shear wall end bays.

New concrete wall was added in 1992 at the Basement level along line 11 to increase the overall length of existing shear wall at line 11. New gravity columns were added in 1992 near grid Y – in the long direction of the garage at Pier and Basement Levels. It is not clear why the designer decided to use 18-inch square concrete columns between Village and Pier Level and supported the same columns using 6-inch round steel columns between Pier and Foundation Level. New waffle shear wall along line 3 is being supported at its western end by a 6-inch round steel column below Pier level (See Photo 3.11). This in-plane discontinuity in shear wall causes reduction in shear wall stiffness along line 3 at the Basement Level.

New 2 ½ inch thick overlay was added over the entire double tee system at the Village Level (See Photo 3.3) in 1992. It is our understanding that this modification was made to address higher diaphragm loads based on the requirements of UBC 1991. At Village Level, additional slab drag reinforcement was added near the shear wall along line 11. ASCE 41-17 diaphragm forces are significantly higher than the UBC 1991 diaphragm forces. Chord and drag collector elements shall be evaluated as force-controlled and they both will require retrofit in terms of addition of new chord and diaphragm steel at the Village and Pier Level.

No foundation upgrades were documented in the construction documents of 1992 seismic retrofit. No visible cracking in beams, columns or walls was observed in 2011 and in 2021 that can be associated with foundation settlement or overstress condition of foundation elements.

a. Shear strength capacity of diaphragm is verified at all supported levels using provisions of ASCE 41-17 to satisfy that the load path is in compliance and is acceptable.
b. Steel column supporting discontinuous wall has the design strength to resist the maximum axial force that can develop in accordance with ASCE 41-17. The connections of discontinuous elements to the supporting member shall be adequate to transmit the forces for which the discontinuous element was required to be designed.

2. WEAK AND SOFT STORY

The vertical force distribution provided by ASCE 41-17 section 7.4.1.3.2 is adequate for regular structures with no stiffness discontinuities. Weak and soft story can significantly affect the vertical distribution of seismic forces and, for this reason Response Spectrum Analysis (i.e., Linear Dynamic Procedure – LDP) is performed, which can account for stiffness irregularities over the height of the structure. Response spectrum parameters were established using USGS seismic design parameters for the project site. For basic Life Safety structural performance, site specific response spectrum is being generated for an earthquake having 5% Probability of Exceedance in 50 years with a mean return period of 975 years. According to ASCE 41-17, Earthquake Hazard Level associated with this type of earthquake is defined as BSE-2E (i.e., Basic Safety Earthquake Level 2) and is appropriate for building where "Basic Collapse Prevention Structural Performance" is required.

3. GEOMETRY

"An analysis in accordance with the Linear Dynamic Procedure of ASCE 41-17 section 5.2.4 shall be performed. The adequacy of the lateral force resisting elements shall be evaluated."

Linear Dynamic Analysis is performed to verify capacity of all lateral load resisting elements.

4. VERTICAL DISCONTINUTIES

"The adequacy of elements below vertical discontinuities shall be evaluated to support gravity forces and overturning forces generated by the capacity of the discontinuous elements above. The adequacy of struts and diaphragms to transfer load from discontinuous elements to adjacent elements shall be evaluated."

Steel columns supporting discontinuous shear wall at line 3 at the Basement Level is verified and its connections need to be verified for factored axial tension and compression loads. There is no visible sign of connection movement at the top and bottom. There is no visible cracking in the slab near and around the steel column that is associated with any grade beam movement underneath the steel column because of past earthquake activities in the area since 1992. Since the grade beams are soil supported and have already experienced several earthquakes of moderate intensity, it is appropriate to assume that the grade beams underneath the steel columns can transfer vertical loads to the nearest drilled pier without going into any major distress. A case of a beam on elastic foundation is how Walker has analyzed the performance of the grade beam at line 3. Grade beams that are away from drilled piers are not taking any substantial axial, flexural and shear loads.

Adequacy of precast double tees is verified between grid line Z and Z.1 at the Village and Pier Level. At both locations precast double tees are overstressed in transferring vertical shear load to PT beam along line Z at both levels.

5. MASS

No change is mass is anticipated at Village and Pier Level except a small section of top chord of waffle shear wall along line Z.1 needs to be increased to add additional drag or chord reinforcement at the truss at the Village Level. A small section of CIP topping slab needs to be placed at the Village Level to provide additional diaphragm reinforcement near the shear wall at line Z.1

6. TORSION

Small change in torsional shear is anticipated due to the proposed addition of new shear walls at the Pier and Basement Level to help reduce shear overstress condition at existing shear walls along line 3, X, and Z.

7. DETERIORATION OF CONCRETE

No significant deterioration of concrete was observed at gravity and lateral load resisting elements.

8. POST-TENSION OR PRE-STRESS ANCHORS

No corrosion of anchors/end fittings or spalling of concrete is observed near gravity and lateral load resisting elements at the Village, Pier and Basement level.

9. CONCRETE WALL CRACKS

No significant diagonal cracking in concrete shear walls is observed at Pier and Village level.

10. SHEAR STRESS CHECK

Using ASCE 41-17 section 5.5.3.1.1, we found shear walls as overstressed in shear at the Basement Level at line X (4 – 11), at line Z (2-3) and (5-6), and shear walls along line 3. We have assumed compressive strength of shear walls to be equal to 5000psi to 7000 psi based on Compressive Strength field test values obtained in 2022. To compensate for this condition, (1) new shear wall is recommended for line 3 at the Pier Level only and (2) new shear walls are to be added at both the Pier and Basement Level at line 7.

11. WALL THICKNESS AND PROPORTIONS

Using ASCE 41-17 section 5.5.3.1.1 and 5.5.3.1.2, we found shear walls thickness to be increased at the Basement Level at line X (4 – 11), at line Z (2-3) and (5-6), and shear walls along line 3. We also found that the shear wall thickness at line 11 at the Pier Level should also be increased to resist ASCE 41-17 force demand.

12. REINFORCING STEEL

At the Pier level, shear wall reinforcement ratios for both wall vertical and horizontal reinforcement are greater than the required ratios but shear wall at line 11 is overstressed in shear and requires additional horizontal reinforcement. At the Basement level, shear wall reinforcement ratio for wall vertical reinforcement is in the range of 0.0018 and are acceptable. However, reinforcement ratio for wall horizontal reinforcement at shear walls along line X, Z and line 3 are low. Wall shear stresses are also above the allowable shear stress values at those grid lines. To compensate for this condition, additional new shear walls are recommended for line 3 at the Pier Level and (2) new shear walls at line 7 at both Pier and Basement Level.

13. COUPLING BEAMS AT SHEAR WALLS

At Pier Level, diagonal braces of waffle shear wall along line 3 near line Y and along line X are performing similar to how coupling beams work for segmented shear walls. Those diagonal braces are showing overstressed condition for axial tension and compression. To compensate for this condition, additional new shear walls are recommended for line 3 at the Pier Level near line Z and at line 7 at both Pier and Basement Level. Strengthening of waffle shear wall diagonal braces is also recommended.

14. CONFINEMENT REINFORCEMENT

Infill shear walls along line Z.1 at the Basement Level are confined by existing CIP columns. Majority of shear walls at the Pier and Basement Level are without any special closely spaced confinement reinforcement. However, there are no signs of any cracking at the existing shear walls. Carbon fiber wrapping would be considered for providing confinement to shear wall ends to satisfy this requirement.

15. TRANSFER OF SHEAR WALLS OR WALL CONNECTIONS

Diaphragm is connected to shear walls at all supported levels. Amount of shear transfer reinforcement provided is appeared to be on the low side at all shear walls. Amount of shear transfer reinforcement is not adequate based on the forces obtained from the Linear Dynamic Procedure. Drag and collector reinforcement at the East-West direction shear walls is not known and may possibly be on the low side of design requirements.

16. FOUNDATION DOWELS

There is no information available on Foundation dowels and further testing is required in future to determine this design item. Shear walls are connected to grade beams at all locations. Destructive testing in 2022 at several shear wall locations have established that existing shear walls have adequate wall vertical reinforcement. There are two shear walls along line 3 at the Basement Level where shear walls have flexural overstress condition. To compensate for this condition, additional new shear walls are recommended for line 3 at the Pier Level and at line 7 at both Pier and Basement Level.

17. DEFLECTION COMPATIBILITY

Based on 3-D computer analysis and verification of member forces, shear capacity of columns is adequate to resist factored flexural, axial and shear loads. There is only one CIP column at grid line 3 and line Z which is showing signs of shear overstress as it is in the direction of drag forces building towards shear wall at grid line 3 and line Y. To compensate for this condition, additional new shear wall is recommended for line 3 at the Pier Level and at line 7 at both Pier and Basement Level.

18. UPLIFT AT PILE CAPS

We didn't observe any major problem with the gravity system, diaphragms, and slab-on-grade that suggests that current state of pile foundation system is any risk to the Basic Life Safety of the structure. However, our current analysis shows significant amount of lateral shear resisted by 12" round piles at line 3 and at line 11. Without knowing the amount of reinforcement in those concrete piles it is difficult to establish their demand capacity ratios in terms of flexure and shear loads. To compensate for this condition, additional new concrete piles are recommended for line 7 for new concrete shear walls that are recommended at the Basement Level.

19. LIQUEFACTION

We would recommend that the City hire a registered geo-technical engineer to evaluate current soil conditions near the garage site and to determine risk of having soil liquefaction at the garage site.

20. SLOPE FAILURE AND SURFACE RUPTURE

We would recommend that the city hire a registered geo-technical engineer to evaluate current soil conditions near the garage site and to determine risk of having soil/rock slope failure and surface fault rupture at the garage site.

21. FOUNDATION PERFORMANCE

We would recommend that the City shall consider hiring a registered surveyor to establish garage benchmark elevations to monitor any possible building movement due to any seismic event or due to any soil's related issue.

22. OVERTURNING

At Basement Level, shear wall along line 3 near line Z is showing overstressed condition in flexure. Remainder of shear walls at Village and Pier Level are adequate in flexure or overturning. To compensate for this condition, additional new shear walls are recommended for line 3 at the Pier Level and at line 7 at both Pier and Basement Level.

23. TIES BETWEEN FOUNDATION ELEMENTS

We didn't observe any distress at foundation walls or slabs at upper levels that suggests that there is any movement of soil at the foundation level that suggests that current state of pile foundation system is any risk to the Basic Life Safety of the structure. However, our current analysis shows significant amount of lateral shear resisted by 12" round piles at line 3 and at line 11. Without knowing the amount of reinforcement in those concrete piles it is difficult to establish their demand capacity ratios in terms of flexure and shear loads. To compensate for this condition, additional new concrete piles are recommended for line 7 for new concrete shear walls that are recommended at the Basement Level.

Table D1 - Opinion of Probable Costs for Conceptual Repair

	Work Item Description	Estimated Cost
1.00	**General Conditions**	
1.10	Mobilization & General Conditions	$25,000
2.00	**Seismic Structural Repairs**	
2.01	Install (24) new drilled piers	$100,000
2.02	Install (5) new concrete shear walls at Pier and Basement Level	$500,000
2.03	Addition of carbon fiber wrapping at Line 3 and X at waffle shear wall at Pier Level	$30,000
2.04	Addition of shear wall drag reinforcement at Village Level at line Z.1	$25,000
2.05	Addition of carbon fiber wrap at precast double tee stems (Village & Pier Level) near line Z	$30,000
2.06	Addition of carbon fiber wrap at CIP Shear walls ends for confinement at line 11 at the Pier Level, at Line Z at CIP columns at lines 2, 3, 5, and 6 at Pier Level	$25,000
2.07	Thickening of CIP shear wall at line Z (2-3) at Basement Level	$25,000
2.08	Thickening of CIP shear wall at line Z (5-6) at Basement Level	$25,000
2.09	Thickening of CIP shear walls at line 3 at Basement Level	$35,000
2.10	Thickening of CIP shear wall at line X (4-11) at Basement Level	$170,000
2.11	Thickening of CIP shear wall at line 11 (at grid Y) at Pier Level	$35,000
2.12	Addition of slab reinforcement at Shear walls (East-West direction) at Village and Pier Level (i.e., chord/drag reinforcement, and shear transfer reinforcement)	$200,000
2.13	Addition of slab reinforcement at Shear walls (North-South direction) at Village and Pier Level (i.e., chord/drag reinforcement, and shear transfer reinforcement)	$200,000
2.14	Strengthen CIP column at Grid line 3 and Z at Pier Level	$25,000

Repair Subtotal	$1,450,000
Recommended Contingency (10%)	$145,000
Engineering Services	$160,000
Geotechnical Recommendations on Soil condition at the project site	$50,000
Building Survey Elevations	$15000
Project Total	**$1,820,000**

APPENDIX B – TIER 1 SCREENING CHECKLIST

Table 1. Tier 1 Screening – Collapse Prevention Basic Configuration Checklist (Reproduced herein ASCE 41-17, Table 17-2)

Status	Evaluation Statement	Tier 2 Reference	Commentary Reference
Low Seismicity			
Building System—General			
C NC N/A U	LOAD PATH: The structure contains a complete, well-defined load path, including structural elements and connections, that serves to transfer the inertial forces associated with the mass of all elements of the building to the foundation.	5.4.1.1	A.2.1.1
C NC N/A U	ADJACENT BUILDINGS: The clear distance between the building being evaluated and any adjacent building is greater than 0.25% of the height of the shorter building in low seismicity, 0.5% in moderate seismicity, and 1.5% in high seismicity.	5.4.1.2	A.2.1.2
C NC N/A U	MEZZANINES: Interior mezzanine levels are braced independently from the main structure or are anchored to the seismic-force-resisting elements of the main structure.	5.4.1.3	A.2.1.3
Building System—Building Configuration			
C NC N/A U	WEAK STORY: The sum of the shear strengths of the seismic-force-resisting system in any story in each direction is not less than 80% of the strength in the adjacent story above.	5.4.2.1	A.2.2.2
C NC N/A U	SOFT STORY: The stiffness of the seismic-force-resisting system in any story is not less than 70% of the seismic-force-resisting system stiffness in an adjacent story above or less than 80% of the average seismic-force-resisting system stiffness of the three stories above.	5.4.2.2	A.2.2.3
C NC N/A U	VERTICAL IRREGULARITIES: All vertical elements in the seismic-force-resisting system are continuous to the foundation.	5.4.2.3	A.2.2.4
C NC N/A U	GEOMETRY: There are no changes in the net horizontal dimension of the seismic-force-resisting system of more than 30% in a story relative to adjacent stories, excluding one-story penthouses and mezzanines.	5.4.2.4	A.2.2.5
C NC N/A U	MASS: There is no change in effective mass of more than 50% from one story to the next. Light roofs, penthouses, and mezzanines need not be considered.	5.4.2.5	A.2.2.6
C NC N/A U	TORSION: The estimated distance between the story center of mass and the story center of rigidity is less than 20% of the building width in either plan dimension.	5.4.2.6	A.2.2.7

Moderate Seismicity (Complete the Following Items in Addition to the Items for Low Seismicity)			
Geologic Site Hazards			
C NC N/A U	LIQUEFACTION: Liquefaction-susceptible, saturated, loose granular soils that could jeopardize the building's seismic performance do not exist in the foundation soils at depths within 50 ft (15.2 m) under the building.	5.4.3.1	A.6.1.1
C NC N/A U	SLOPE FAILURE: The building site is located away from potential earthquake-induced slope failures or rockfalls so that it is unaffected by such failures or is capable of accommodating any predicted movements without failure.	5.4.3.1	A.6.1.2
C NC N/A U	SURFACE FAULT RUPTURE: Surface fault rupture and surface displacement at the building site are not anticipated.	5.4.3.1	A.6.1.3
High Seismicity (Complete the Following Items in Addition to the Items for Moderate Seismicity)			
Foundation Configuration			
C NC N/A U	OVERTURNING: The ratio of the least horizontal dimension of the seismic-force-resisting system at the foundation level to the building height (base/height) is greater than $0.6S_a$.	5.4.3.3	A.6.2.1
C NC N/A U	TIES BETWEEN FOUNDATION ELEMENTS: The foundation has ties adequate to resist seismic forces where footings, piles, and piers are not restrained by beams, slabs, or soils classified as Site Class A, B, or C.	5.4.3.4	A.6.2.2

Note: C = Compliant, NC = Noncompliant, N/A = Not Applicable, and U = Unknown.

Table 2. Tier 1 Screening–Collapse Prevention Structural Checklist for Building Types C2 and C2a (Reproduced herein ASCE 41-17, Table 17-24)

Status	Evaluation Statement	Tier 2 Reference	Commentary Reference
Low and Moderate Seismicity			
Seismic-Force-Resisting System			
C NC N/A U	COMPLETE FRAMES: Steel or concrete frames classified as secondary components form a complete vertical-load-carrying system.	5.5.2.5.1	A.3.1.6.1
C NC N/A U	REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2.	5.5.1.1	A.3.2.1.1
C NC N/A U	SHEAR STRESS CHECK: The shear stress in the concrete shear walls, calculated using the Quick Check procedure of Section 4.4.3.3, is less than the greater of 100 lb/in.^{2} (0.69 MPa) or $2\sqrt{f'_c}$.	5.5.3.1.1	A.3.2.2.1
C NC N/A U	REINFORCING STEEL: The ratio of reinforcing steel area to gross concrete area is not less than 0.0012 in the vertical direction and 0.0020 in the horizontal direction.	5.5.3.1.3	A.3.2.2.2
Connections			
C NC N/A U	WALL ANCHORAGE AT FLEXIBLE DIAPHRAGMS: Exterior concrete or masonry walls that are dependent on flexible diaphragms for lateral support are anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections have strength to resist the connection force calculated in the Quick Check procedure of Section 4.4.3.7.	5.7.1.1	A.5.1.1
C NC N/A U	TRANSFER TO SHEAR WALLS: Diaphragms are connected for transfer of seismic forces to the shear walls.	5.7.2	A.5.2.1
C NC N/A U	FOUNDATION DOWELS: Wall reinforcement is doweled into the foundation with vertical bars equal in size and spacing to the vertical wall reinforcing directly above the foundation.	5.7.3.4	A.5.3.5
High Seismicity (Complete the Following Items in Addition to the Items for Low and Moderate Seismicity)			
Seismic-Force-Resisting System			
C NC N/A U	DEFLECTION COMPATIBILITY: Secondary components have the shear capacity to develop the flexural strength of the components.	5.5.2.5.2	A.3.1.6.2
C NC N/A U	FLAT SLABS: Flat slabs or plates not part of the seismic-force-resisting system have continuous bottom steel through the column joints.	5.5.2.5.3	A.3.1.6.3
C NC N/A U	COUPLING BEAMS: The ends of both walls to which the coupling beam is attached are supported at each end to resist vertical loads caused by overturning.	5.5.3.2.1	A.3.2.2.3
Diaphragms (Stiff or Flexible)			
C NC N/A U	DIAPHRAGM CONTINUITY: The diaphragms are not composed of split-level floors and do not have expansion joints.	5.6.1.1	A.4.1.1
C NC N/A U	OPENINGS AT SHEAR WALLS: Diaphragm openings immediately adjacent to the shear walls are less than 25% of the wall length.	5.6.1.3	A.4.1.4
Flexible Diaphragms			
C NC N/A U	CROSS TIES: There are continuous cross ties between diaphragm chords.	5.6.1.2	A.4.1.2
C NC N/A U	STRAIGHT SHEATHING: All straight-sheathed diaphragms have aspect ratios less than 2-to-1 in the direction being considered.	5.6.2	A.4.2.1
C NC N/A U	SPANS: All wood diaphragms with spans greater than 24 ft (7.3 m) consist of wood structural panels or diagonal sheathing.	5.6.2	A.4.2.2
C NC N/A U	DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS: All diagonally sheathed or unblocked wood structural panel diaphragms have horizontal spans less than 40 ft (12.2 m) and aspect ratios less than or equal to 4-to-1.	5.6.2	A.4.2.3
C NC N/A U	OTHER DIAPHRAGMS: Diaphragms do not consist of a system other than wood, metal deck, concrete, or horizontal bracing.	5.6.5	A.4.7.1
Connections			
C NC N/A U	UPLIFT AT PILE CAPS: Pile caps have top reinforcement, and piles are anchored to the pile caps.	5.7.3.5	A.5.3.8

Note: C = Compliant, NC = Noncompliant, N/A = Not Applicable, and U = Unknown.

PROJECT PHOTOS

Photo 3.1- Construction of North Pier Parking Structure in 1962

Photo 3.2- Construction of North Pier Parking Structure - 1962

Photo 3.3- 2 ½-inch-thick overlay of CIP topping slab – Village Level

Photo 3.4- 24-inch-thick shear wall at line 3 and Y at Basement Level

Photo 3.5- 12-inch-thick waffle shear wall at line 3 and Y at Pier Level

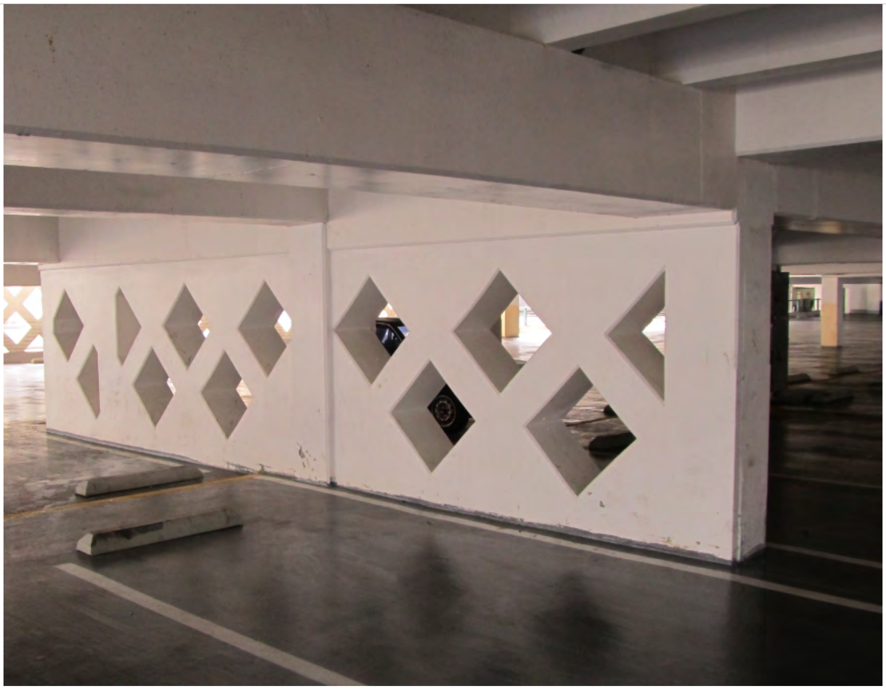


Photo 3.6- 12-inch-thick waffle shear wall along line X at Pier Level

Photo 3.7- 12-inch-thick waffle shear wall at line Z.1 at Pier Level

Photo 3.8- 10-inch-thick shear wall at line 11 and Y at the Pier Level

Photo 3.9- CIP columns at line 3 and Z at the Pier Level

Photo 3.10—CIP Columns at Line X.7 and Y.3 at the Pier Level

Photo 3.11—6-inch round steel columns at line X.7 and Y.3 at the Basement Level

Photo 3.12- 8-inch-thick CIP Retaining Wall at line X and X.1 at Basement Level

Photo 3.13- Shear wall along line 11 at Basement Level

Photo 3.14- Truss chords at waffle shear wall at line Z.1 at the Village and Pier Level

Photo 3.15- Precast double tee stems at waffle shear wall ends at line Z.1 at the Village and Pier Level

Photo 3.16- CIP Columns at shear wall ends at line Z at the Pier and Basement Level

PARKING STRUCTURE AREAS WITH PROPOSED SEISIMIC RESTORATION PER ASCE 41-17 RECOMMENDATIO

Work Item Legend

Item No.	Work Item Description
1.00	**General Conditions**
1.10	Mobilization & General Conditions
2.00	**Seismic Structural Repairs**
2.01	Install (24) new drilled piers
2.02	Install (5) new concrete shear walls at Pier and Basement Level
2.03	Addition of carbon fiber wrapping at Line 3 and X at waffle shear wall at Pier Level
2.04	Addition of shear wall drag reinforcement at Village Level at line Z.1
2.05	Addition of carbon fiber wrap at precast double tee stems (Village & Pier Level) near line Z
2.06	Addition of carbon fiber wrap at CIP Shear walls ends for confinement at line 11 at the Pier Level, at Line Z at CIP columns at lines 2, 3, 5, and 6 at Pier Level
2.07	Thickening of CIP shear wall at line Z (2-3) at Basement Level
2.08	Thickening of CIP shear wall at line Z (5-6) at Basement Level
2.09	Thickening of CIP shear walls at line 3 at Basement Level
2.10	Thickening of CIP shear wall at line X (4-11) at Basement Level
2.11	Thickening of CIP shear wall at line 11 (at grid Y) at Pier Level
2.12	Addition of slab reinforcement at Shear walls (East-West direction) at Village and Pier Level (i.e., chord/drag reinforcement, and shear transfer reinforcement)
2.13	Addition of slab reinforcement at Shear walls (North-South direction) at Village and Pier Level (i.e., chord/drag reinforcement, and shear transfer reinforcement)
2.14	Strengthen CIP column at Grid line 3 and Z at Pier Level

Figure 3.1-Sesimic Structural Work Item Locations– Basement Level

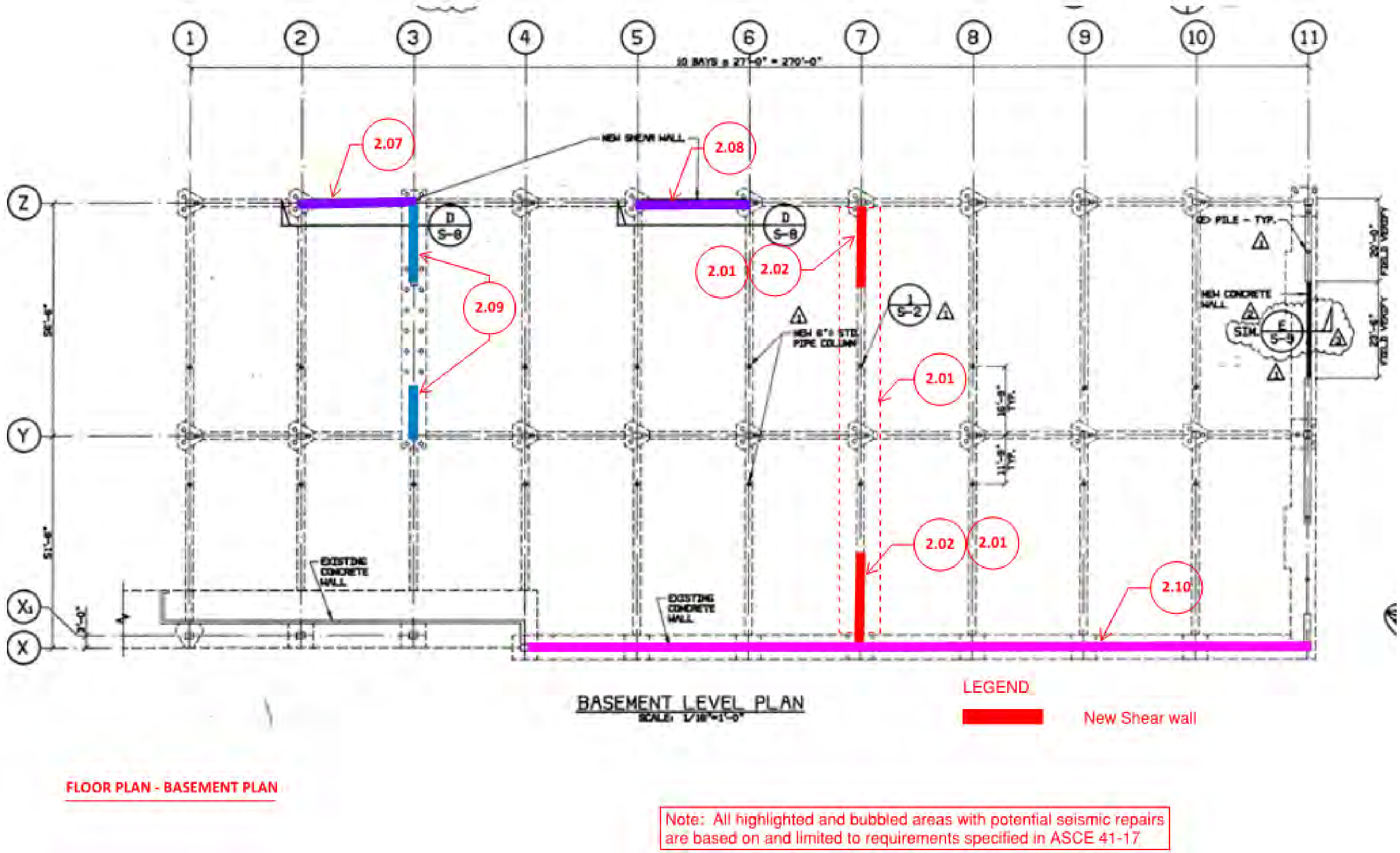


Figure 3.2-Sesimic Structural Work Item Locations–Pier Level

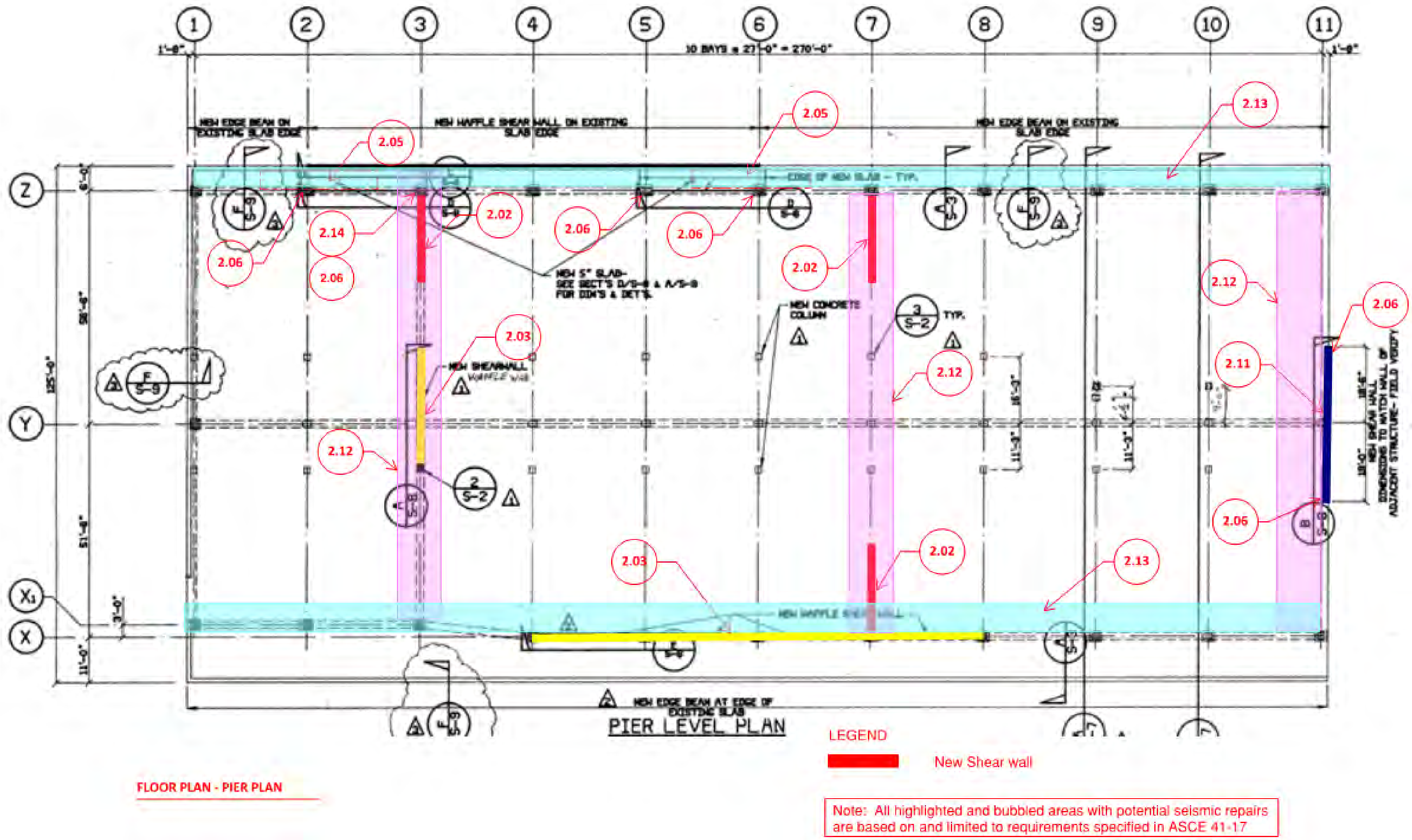
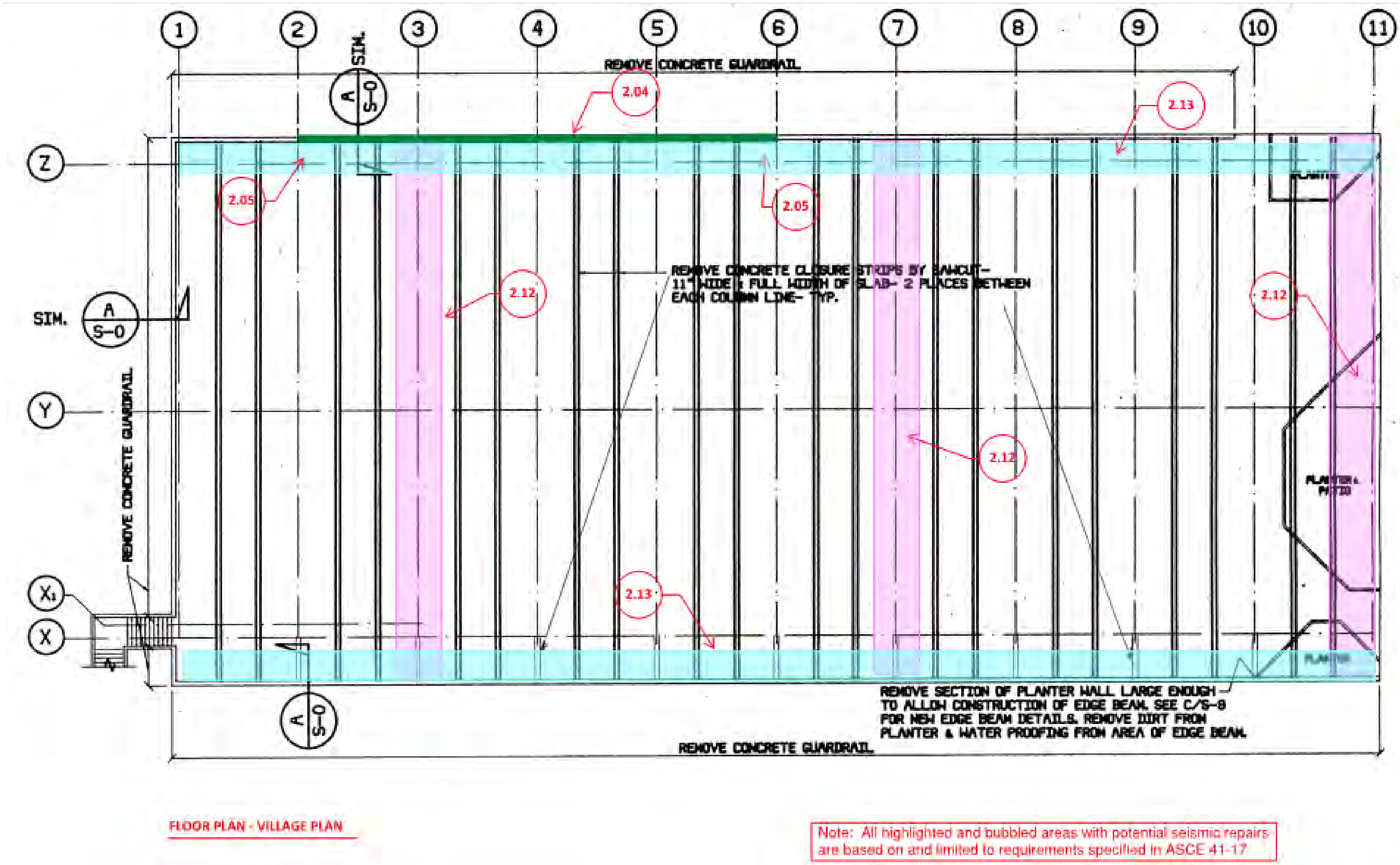
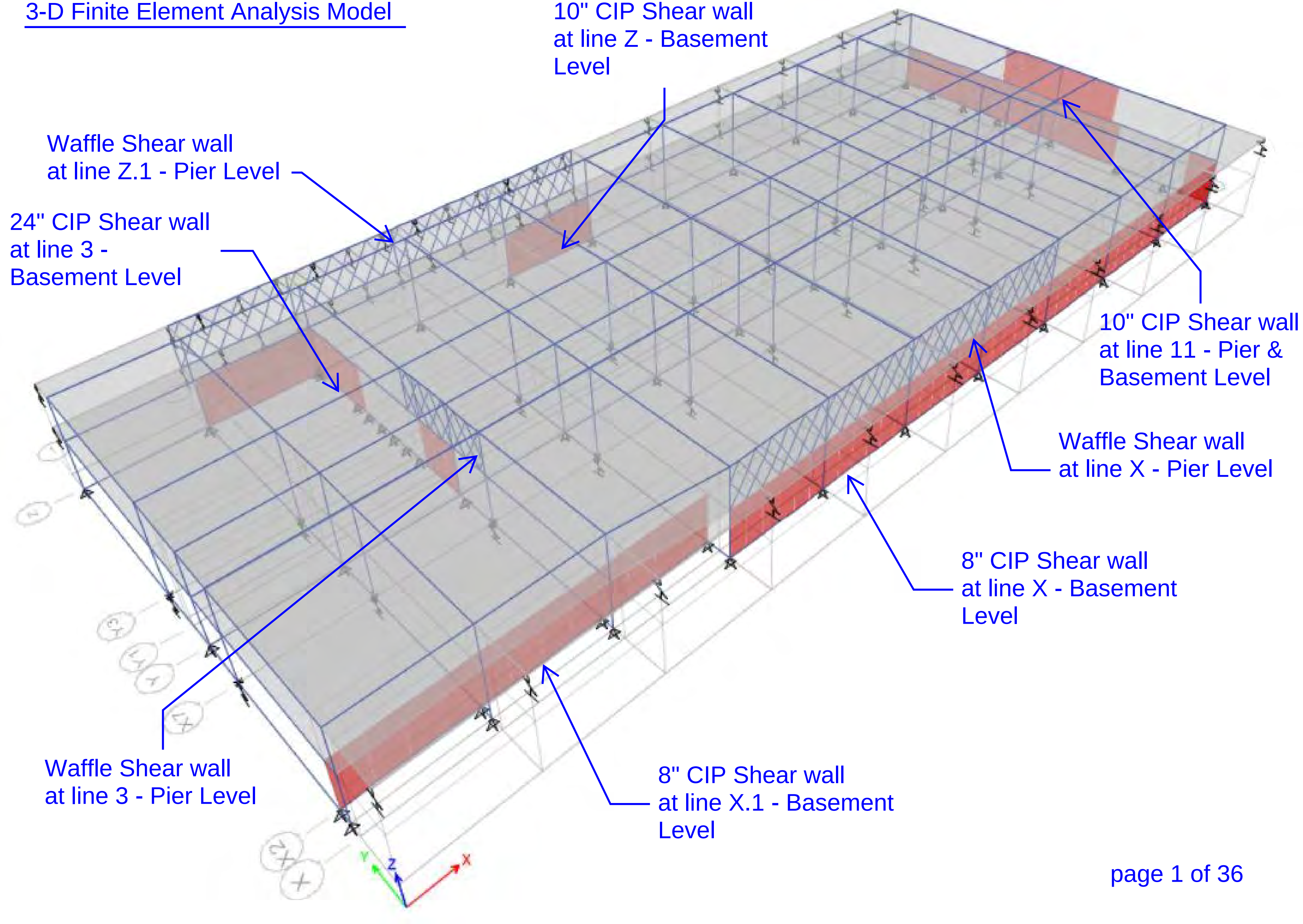


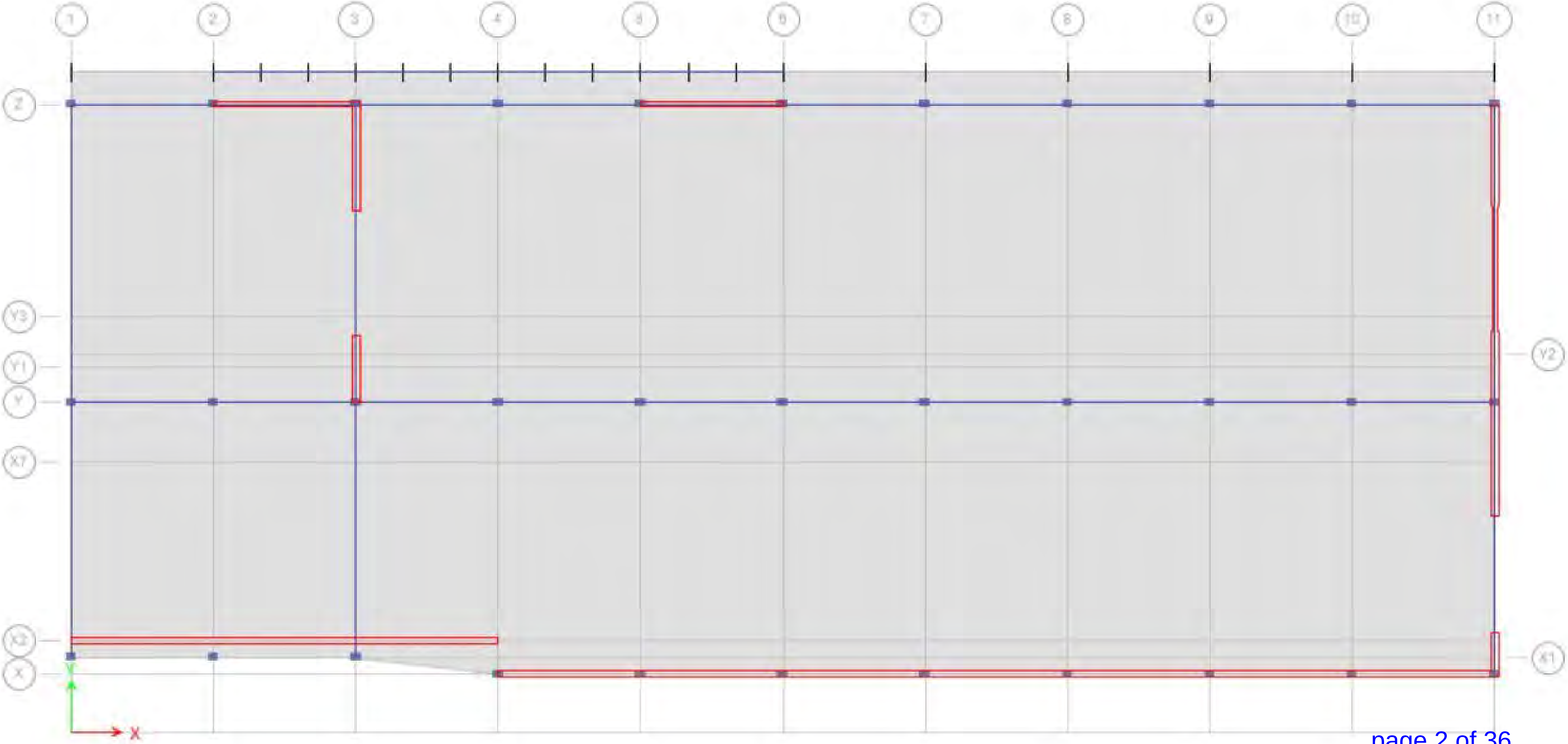
Figure 3.3-Sesimic Structural Work Item Locations– Village Level



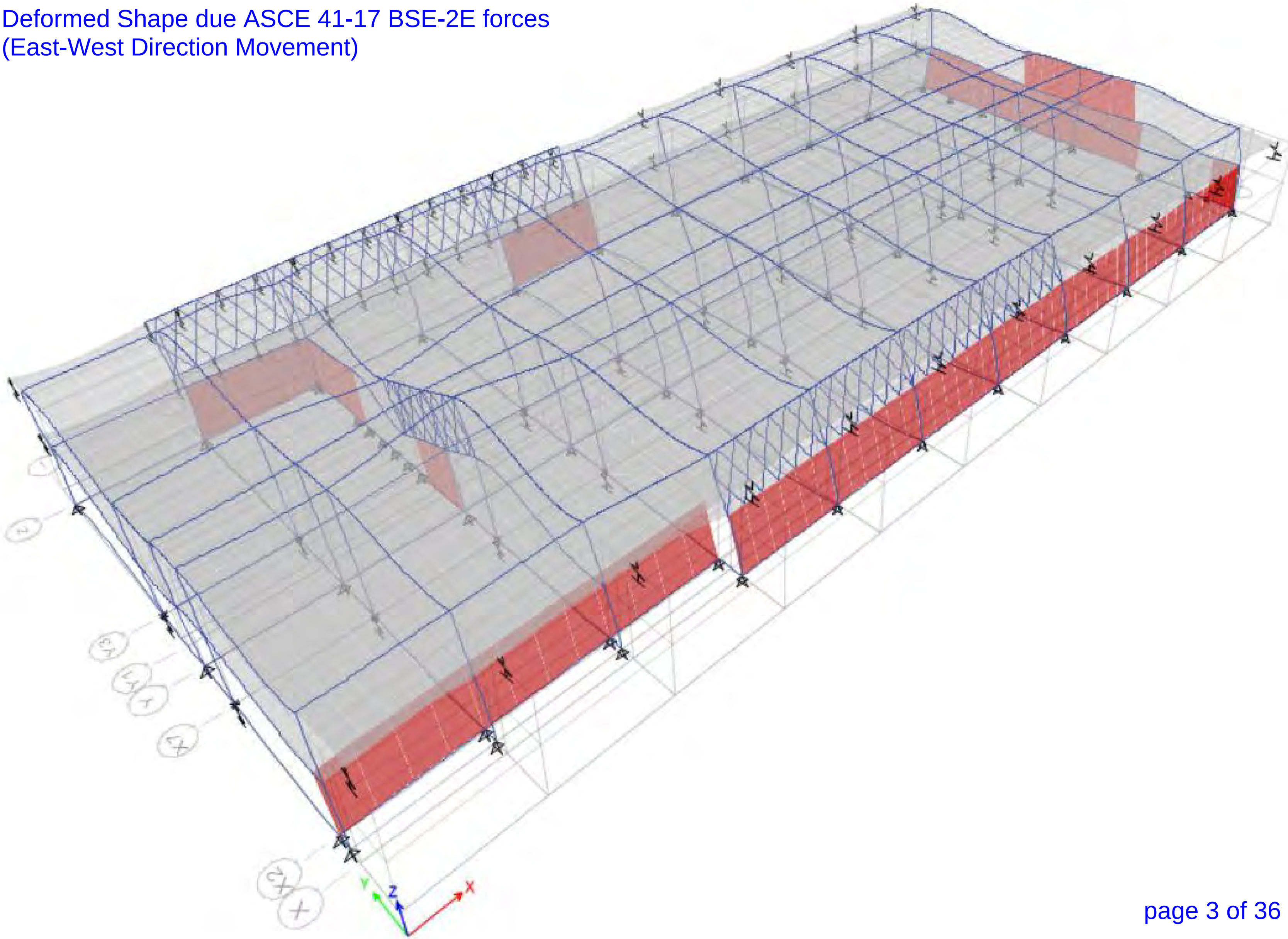
3-D Finite Element Analysis Model



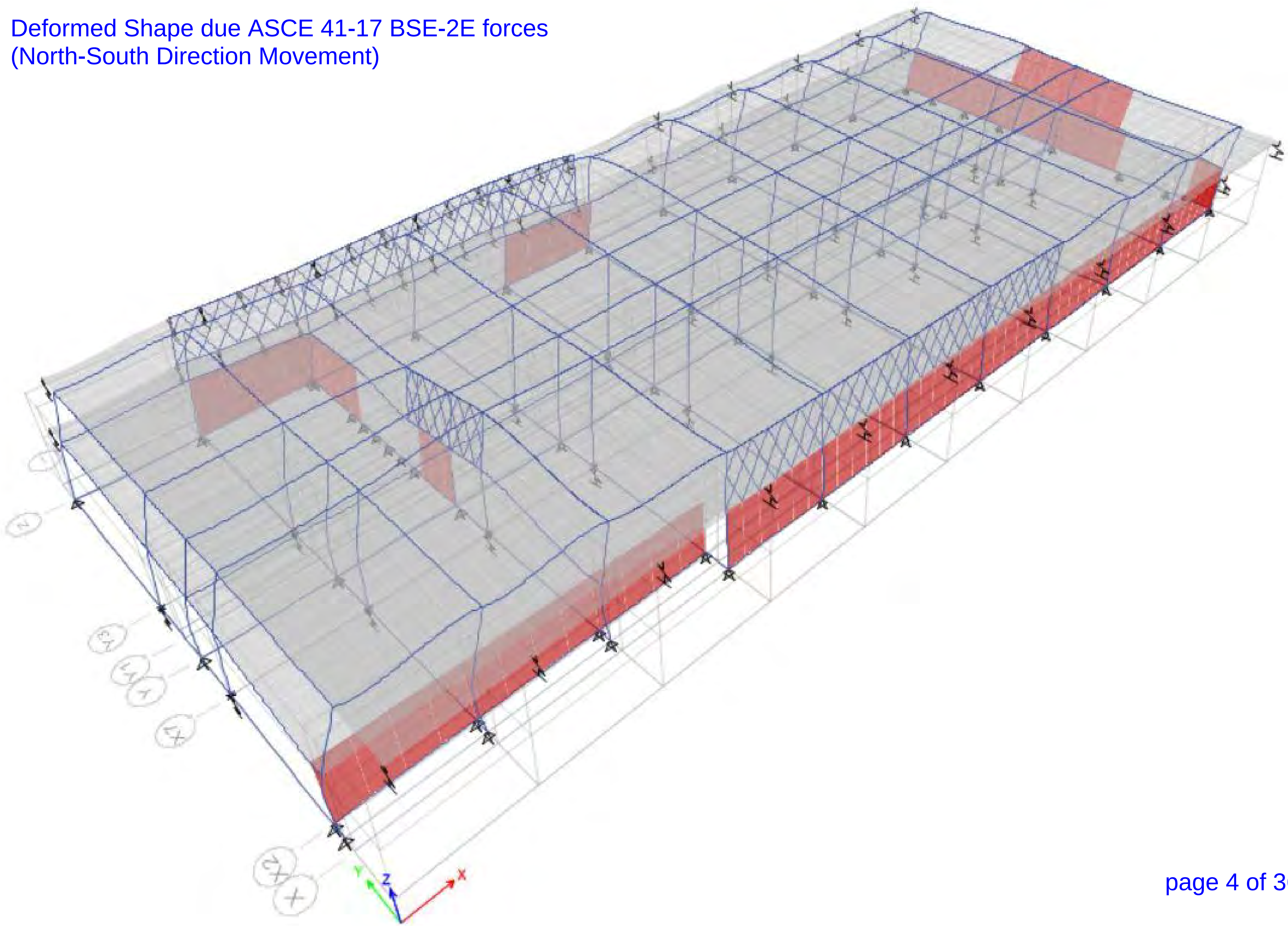
Plan Layout of Shear walls



Deformed Shape due ASCE 41-17 BSE-2E forces
(East-West Direction Movement)



Deformed Shape due ASCE 41-17 BSE-2E forces
(North-South Direction Movement)



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CLIENT	City of Redondo Beach	**SECTION**	ASCE 41-17
PROJECT	North Pier	**SHEET**	1 **OF** 2
JOB No	37-009397.00	**DRAWING NO**	
CALCULATION BY	Sohban S. Khan	**DATE**	02-10-2022
CHECKED BY	Sohban S. Khan	**DATE**	
APPROVED BY		**Units**	Kips-inches
OBJECT	**Seismic parameters per ASCE 41-17**		

Given Data:

Determine DCR for each action item like, axial, moment and shear applied on a primary component. If component DCR exceeds the lesser of 3.0 and the m-factor for the component action and structure has any irregularity then Linear Static Procedure for analysis is not applicable.

Assume, $DCR_{max} := 3.0$ using initial values of C1, C2, Cm equal 1.0

No. of stories, $N_s := 2$

Concrete or Masonry shear wall building, $C_m := 1.0$ See Table 7-4

Site Class, D Site class factor, $a := 60$ for Site Class D, E, and F

Fundamental period of the building, $T_{1x} := 0.2$ $T_{1y} := 0.29$

Ratio of required elastic strength to the yield strength,

$$\mu_{strength} := \max\left(\frac{DCR_{max}}{1.5} \cdot C_m, 1.0\right)$$ from Appendix C7.4.1.3 - Eq: C7-3

$\mu_{strength} = 2$

$$C_{1x} := 1 + \frac{\mu_{strength} - 1}{a \cdot T_{1x}^{\ 2}} \qquad C_{1x} = 1.417 \qquad C_{1y} := 1 + \frac{\mu_{strength} - 1}{a \cdot T_{1y}^{\ 2}} \qquad C_{1y} = 1.198$$

$$C_{2x} := 1 + \frac{1}{800} \cdot \left(\frac{\mu_{strength} - 1}{T_{1x}}\right)^2 \qquad C_{2x} = 1.031 \qquad C_{2y} := 1 + \frac{1}{800} \cdot \left(\frac{\mu_{strength} - 1}{T_{1y}}\right)^2 \qquad C_{2y} = 1.015$$

$C_{1x} \cdot C_{2x} = 1.461$ $C_{1y} \cdot C_{2y} = 1.216$

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For Concrete Shear walls, m-factors are defined in Chapter 10 for different wall conditions

$m_{max} := 4$ (Assume but will verify later)

Per Table 7-3 Maximum value of $C_1C_2 = 1.4$ for $m_{max} = 4$

Selection of BPOE

BSE-2E S_{xs} = 1.413

BSE-1E S_{xs} = 0.81

BSE-2E/BSE-1E = 1.744

If ratio of Collapse Prevention m-factor to Life Safety m-factor is less than 1.744,
Collapse Prevention in the BSE-2E will be more severe performance objective.

Shear walls controlled by Shear w/ axial load

m_{LS} = 2
m_{CP} = 3

mCP/mLS = 1.5

Non-conforming Shear walls in flexure, low axial & shear

m_{LS} = 2.5
m_{CP} = 4

mCP/mLS = 1.6

Collapse Prevention @ BSE-2E will govern the Evaluation

Project Title: North Pier Parking Structure
Project Engineer: Sohban S. Khan, P.E.
Engineer of Record:
Date: 2/11/2022

Historical Seismic Force Comparison

Seismic Dead Weight = 9661 kips (prior to 1991 repairs)
Seismic Dead Weight = 10728 kips (after 1991 repairs)

UBC/ASCE 7 seismic code forces

Year	Acc. %W	V_e		% diff
1961	0.1333	1287.81	Service Level	1.0
1991	0.1833	1966.44	Service Level	1.53
2005	0.269	2885.83	Factored Level	1.13
2010	0.218	2338.70	Factored Level	0.81
2016	0.253	2714.18	Factored Level	1.16

ASCE 31/41 Pseudo Lateral forces (BSE-2E) - Tier 2

X-Direction Psuedo Lateral Forces

Year	Acc. %W	V_{xe}		% diff
2012	1.547	16596.22	ASCE 31-03	1.0
2013	1.743	18698.90	ASCE 41-13	1.13
2017	2.059	22088.95	ASCE 41-17	1.18

ASCE 31/41 Pseudo Lateral forces (BSE-2E) - Tier 2

Y-Direction Psuedo Lateral Forces

Year	Acc. %W	V_{xe}		% diff
2012	1.308	14032.22	ASCE 31-03	1.0
2013	1.474	15813.07	ASCE 41-13	1.13
2017	1.741	18677.45	ASCE 41-17	1.18

ASCE 31/41 Pseudo Lateral forces (BSE-1E) - Tier 2

X-Direction Psuedo Lateral Forces

Year	Acc. %W	V_{xe}		% diff
2012	0.887	9515.74	ASCE 31-03	1.0
2013	1.096	11757.89	ASCE 41-13	1.24
2017	1.18	12659.04	ASCE 41-17	1.08

ASCE 31/41 Pseudo Lateral forces (BSE-1E) - Tier 2

Y-Direction Psuedo Lateral Forces

Year	Acc. %W	V_{xe}		% diff
2012	0.75	8046.00	ASCE 31-03	1.0
2013	0.9266	9940.56	ASCE 41-13	1.24
2017	0.9979	10705.47	ASCE 41-17	1.08

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CLIENT	City of Redondo Beach	**SECTION**	ASCE 31-03
PROJECT	North Pier	**SHEET**	1 **OF** 6
JOB No	37-009397.00	**DRAWING NO**	
CALCULATION BY	Sohban S. Khan	**DATE**	12-15-2021
CHECKED BY	Sohban S. Khan	**DATE**	
APPROVED BY		**Units**	Kips-inches

OBJECT **ASCE 31-03 Seismic Force Distribution for Tier 1 Analysis**

Given Data:

Project zip code = 90277   Latitude = 33.839 North, Longitude = -118.389 West

Ref: Table 1613.5.2

Site Class, D   Stiff soil
N = 15 to 509, su= 1000 to 2000 psf, vs = 600 to 1200 ft/sec

Seismci Hazard Level = BSE-2N - (i.e., seismic hazard with a 2% probability of exceedence in 50 years)

Mapped spectral accelerations for short periods	$Ss := 1.466 \cdot g$	per SEAOC Maps
Mapped spectral accelerations for a 1-sec. period	$S_1 := 0.624 \cdot g$	per SEAOC Maps
Site coefficient Fa as function of Ss and Site Class,	$Fa := 1.0$	per Table 2-3
Site coefficient Fv as function of S1 and Site Class,	$Fv := 1.5$	per Table 2-3

Design Spectral Response Acceleration Parameters:

$S_{xs} := Fa \cdot Ss$ $S_{xs} = 1.466 \cdot g$ Ref: Eq (2-1)

$S_{x1} := Fv \cdot S_1$ $S_{x1} = 0.936 \cdot g$ Ref: Eq (2-2)

These are the spectral design values for BSE-2N

Seismic Use Group,   II   "Parking Structure falls under Risk Category II"

$T_s := \frac{S_{x1}}{S_{xs}}$ $T_s = 0.638$

$T_0 := 0.2 \cdot T_s$ $T_0 = 0.128$

$\beta := 0.05$ $B_1 := \frac{4}{(5.6 - \ln(100 \cdot \beta))}$ $B_1 = 1.002$

$T_L := 8$

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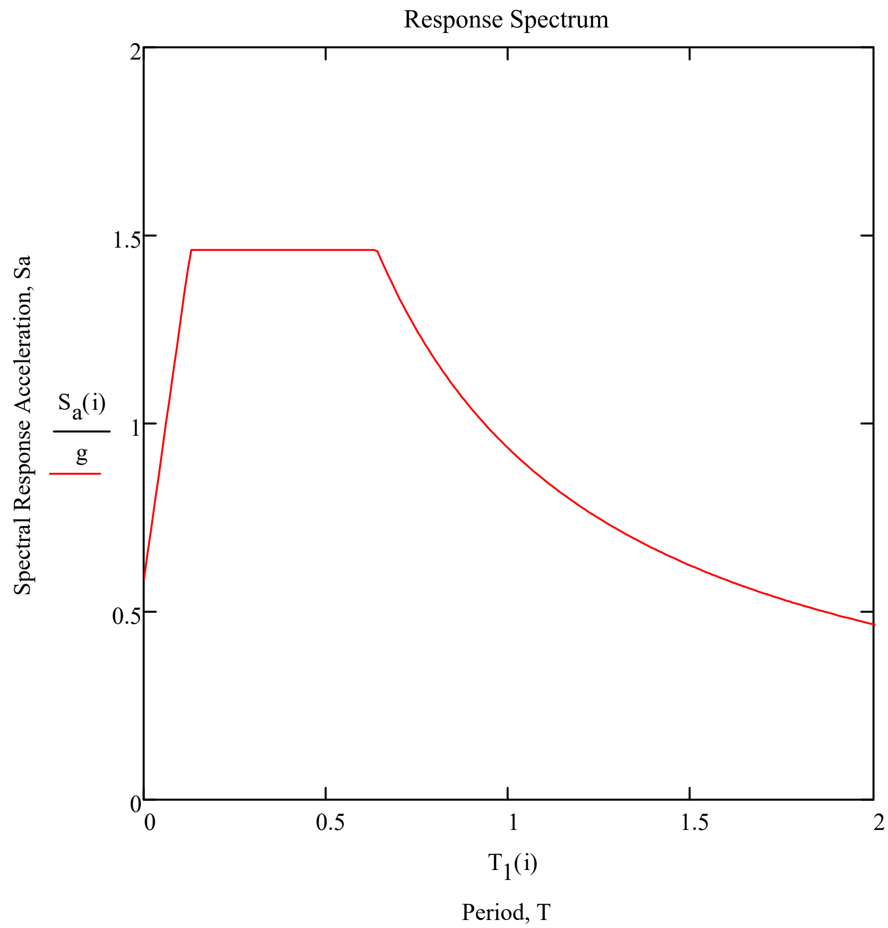
$i := 0, 0.01 .. T_L \qquad T_1(i) := i$

Response Spectrum

$$S_a(i) := \begin{cases} S_{xs} \cdot \left[\left(\dfrac{5}{B_1} - 2 \right) \cdot \dfrac{T_1(i)}{T_s} + 0.4 \right] & \text{if } T_1(i) \le T_0 \\ \dfrac{S_{xs}}{B_1} & \text{if } T_0 < T_1(i) < T_s \\ \dfrac{S_{x1}}{\left(B_1 \cdot T_1(i) \right)} & \text{if } T_s < T_1(i) < T_L \\ \dfrac{T_L \cdot S_{x1}}{\left(B_1 \cdot T_1(i)^2 \right)} & \text{if } T_1(i) > T_L \end{cases}$$



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$S_{DS\_1N} := 0.67 \cdot S_{xs}$ $\quad S_{DS\_1N} = 0.982 \cdot g$ These are the spectral design values for BSE-1N
$S_{D1\_1N} := 0.67 \cdot S_{x1}$ $\quad S_{D1\_1N} = 0.627 \cdot g$

$S_{DS\_2E} := 0.7437 \cdot S_{xs}$ $\quad S_{DS\_2E} = 1.09 \cdot g$ These are the spectral design values for BSE-2E
$S_{D1\_2E} := 0.758 \cdot S_{x1}$ $\quad S_{D1\_2E} = 0.709 \cdot g$

$S_{DS\_1E} := 0.4263 \cdot S_{xs}$ $\quad S_{DS\_1E} = 0.625 \cdot g$ These are the spectral design values for BSE-1E
$S_{D1\_1E} := 0.385 \cdot S_{x1}$ $\quad S_{D1\_1E} = 0.36 \cdot g$

Building Structure is assigned level of Seismicity as 'High'

Number of supported levels $N := 2$ Seismic shear is distributed to 2 levels above Ground Level

Building story heights $h := (13 \;\; 11 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0)$

Total Height of the building $hn := \sum_{i=1}^{N} h^{\langle i-1 \rangle}$ $\quad |hn| = 24$ Heights from E.T.F to Mid-Ridge Height

Building fundamental Time Period
in two orthogonal directions

$C_t := 0.02$ $\quad x := 0.75$ $\quad Ta := C_t \cdot (|hn|)^x$ $\quad Ta = 0.217$

$T'a := 0.1N$ $\quad T'a = 0.200$

$C_u := 1.4$ $\quad Tx_{calc} := 0.13$ $\quad Ty_{calc} := 0.29$

$T_{max} := C_u \cdot Ta$ $\quad T_{max} = 0.304$

Area of typical floor in square foot $Af := 33750$

Structural dead load at 2nd level in pounds per square foot $w1 := 145$ $\quad A1 := 31968$

Structural dead load at typical supported level in pounds per square foot $w\_typ := 145$

Structural dead load at roof level in pounds per square foot $wr := 205$ $\quad Ar := 33750$

Seismic dead load in kips $W := \frac{[w1 \cdot A1 + w\_typ \cdot (N-2) \cdot Af + wr \cdot Ar]}{1000}$ $\quad W = 11554.11$

Calculation for Design Base Shear in X and Y direction (using ASCE 31-03) - Tier 1

$C := 1.2$ $\quad S_{a\_tier1} := \min\left(\frac{S_{xs}}{g}, \frac{S_{x1}}{Ta \cdot g}\right)$ $\quad S_{a\_tier1} = 1.466$

$C \cdot S_{a\_tier1} = 1.759$

$V := C \cdot S_{a\_tier1} \cdot W$

$V = 20325.99$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-2N level

$V_{2E} := 0.7437 \cdot V \qquad V_{2E} = 15116.44$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-2E level

$V_{1E} := 0.4263 \cdot V \qquad V_{1E} = 8664.97$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-1E level

Vertical Distribution of Seismic Lateral Forces $\qquad i := 1..N$

$$w'(i) := \begin{cases} w1 \cdot \dfrac{A1}{1000} & \text{if } i = 1 \\ w\_typ \cdot \dfrac{Af}{1000} & \text{otherwise} \end{cases} \qquad h(i) := \begin{cases} \left| h^{\langle i-1 \rangle} \right| & \text{if } i = 1 \\ \left| h^{\langle i-1 \rangle} \right| & \text{otherwise} \end{cases}$$

$$w(i) := \begin{cases} wr \cdot \dfrac{Ar}{1000} & \text{if } i = N \\ w'(i) & \text{otherwise} \end{cases} \qquad h'(i) := \sum_{j=1}^{i} h(j)$$

$i := N..N-1$

$$k_x := \begin{cases} 1 & \text{if } Tx_{calc} \le 0.5 \\ 1 + 0.5 \cdot (Tx_{calc} - 0.5) & \text{otherwise} \end{cases} \qquad k_x = 1$$

$$k_y := \begin{cases} 1 & \text{if } Ty_{calc} \le 0.5 \\ 1 + 0.5 \cdot (Ty_{calc} - 0.5) & \text{otherwise} \end{cases} \qquad k_y = 1$$

$$C_{vx}(i) := \left[\frac{w(i) \cdot h'(i)^{k_x}}{\sum_{i=1}^{N} \left(w(i) \cdot h'(i)^{k_x} \right)} \right] \qquad C_{vy}(i) := \left[\frac{w(i) \cdot h'(i)^{k_y}}{\sum_{i=1}^{N} \left(w(i) \cdot h'(i)^{k_y} \right)} \right]$$

$$Fx(i) := C_{vx}(i) \cdot V_{1E} \qquad Sx(x) := \sum_{i=x}^{N} Fx(i)$$

$$Fy(i) := C_{vy}(i) \cdot V_{1E} \qquad Sy(x) := \sum_{i=x}^{N} Fy(i)$$

i =	$C_{vx}(i) =$	$C_{vy}(i) =$	h'(i) =
2	0.734	0.734	24
1	0.266	0.266	13

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$$\sum_{i=1}^{N} C_{vx}(i) = 1 \qquad \sum_{i=1}^{N} C_{vy}(i) = 1$$

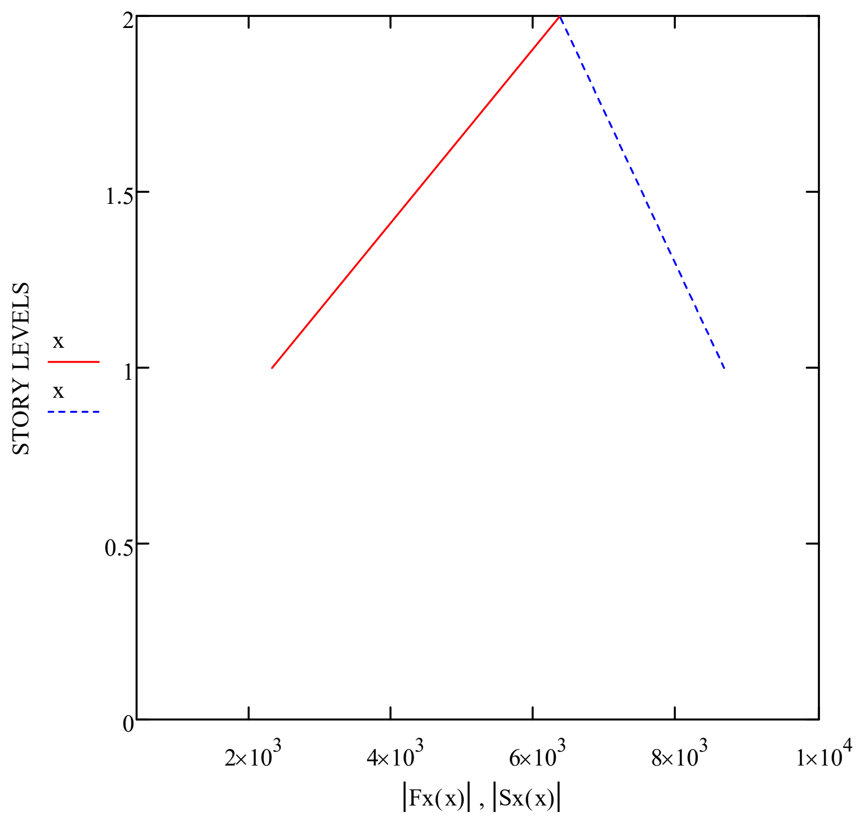
- ***Design story forces (Pier and Village level)***

Story Weight | **Lateral Story Forces** | **Cumm. Story shears**

$w(i) =$	$\lvert Fx(i)\rvert =$	$\lvert Fy(i)\rvert =$	$\lvert Sx(i)\rvert =$	$\lvert Sy(i)\rvert =$
6918.8	6357.74	6357.74	6357.74	6357.74
4635.4	2307.23	2307.23	8664.97	8664.97

$x := 1 .. N$

DISTRIBUTION OF SEISMIC FORCES



LATERAL FORCE & STORY SHEAR

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- **Diaphragm Seismic Forces**

$i := 1 .. N$

$$Fpx(x) := \frac{\sum_{i=x}^{N} Fx(i) \cdot w(x)}{\sum_{i=x}^{N} w(i)} \qquad Fpy(x) := \frac{\sum_{i=x}^{N} Fy(i) \cdot w(x)}{\sum_{i=x}^{N} w(i)}$$

- ***Design diaphragm seismic forces (Pier and Village level)***

$i := N .. N - 1$

$i =$	$w(i) =$	$Fpx(i) =$	$Fx(i) =$	$\frac{Fpx(i)}{Fx(i)} =$	$\frac{Fx(i)}{w(i)} =$
2	6918.75	6357.74	6357.74	1	0.919
1	4635.36	3476.27	2307.23	1.507	0.498

$i =$	$w(i) =$	$Fpy(i) =$	$Fy(i) =$	$\frac{Fpx(i)}{Fy(i)} =$	$\frac{Fy(i)}{w(i)} =$
2	6918.75	6357.74	6357.74	1	0.919
1	4635.36	3476.27	2307.23	1.507	0.498

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PROJECT	North Pier	**SHEET**	1 **OF** 6
JOB No	37-009397.00	**DRAWING NO**	
CALCULATION BY	Sohban S. Khan	**DATE**	12-15-2021
CHECKED BY	Sohban S. Khan	**DATE**	
APPROVED BY		**Units**	Kips-inches

OBJECT **ASCE 41-17 Seismic Force Distribution for Tier 1 Analysis**

Given Data:

Project zip code = 90277   Latitude = 33.839 North, Longitude = -118.389 West

Ref: Table 1613.5.2

Site Class, D   Stiff soil
N = 15 to 509, su= 1000 to 2000 psf, vs = 600 to 1200 ft/sec

Seismci Hazard Level = BSE-2N - (i.e., seismic hazard with a 2% probability of exceedence in 50 years)

Mapped spectral accelerations for short periods	$Ss := 1.9 \cdot g$	per SEAOC Maps
Mapped spectral accelerations for a 1-sec. period	$S_1 := 0.686 \cdot g$	per SEAOC Maps
Site coefficient Fa as function of Ss and Site Class,	$Fa := 1.0$	per Table 2-3
Site coefficient Fv as function of S1 and Site Class,	$Fv := 1.7$	per Table 2-3

Design Spectral Response Acceleration Parameters:

$S_{xs} := Fa \cdot Ss$ $S_{xs} = 1.9 \cdot g$ Ref: Eq (2-1)

$S_{x1} := Fv \cdot S_1$ $S_{x1} = 1.166 \cdot g$ Ref: Eq (2-2)

These are the spectral design values for BSE-2N

Seismic Use Group,   II   "Parking Structure falls under Risk Category II"

$T_s := \frac{S_{x1}}{S_{xs}}$ $T_s = 0.614$

$T_0 := 0.2 \cdot T_s$ $T_0 = 0.123$

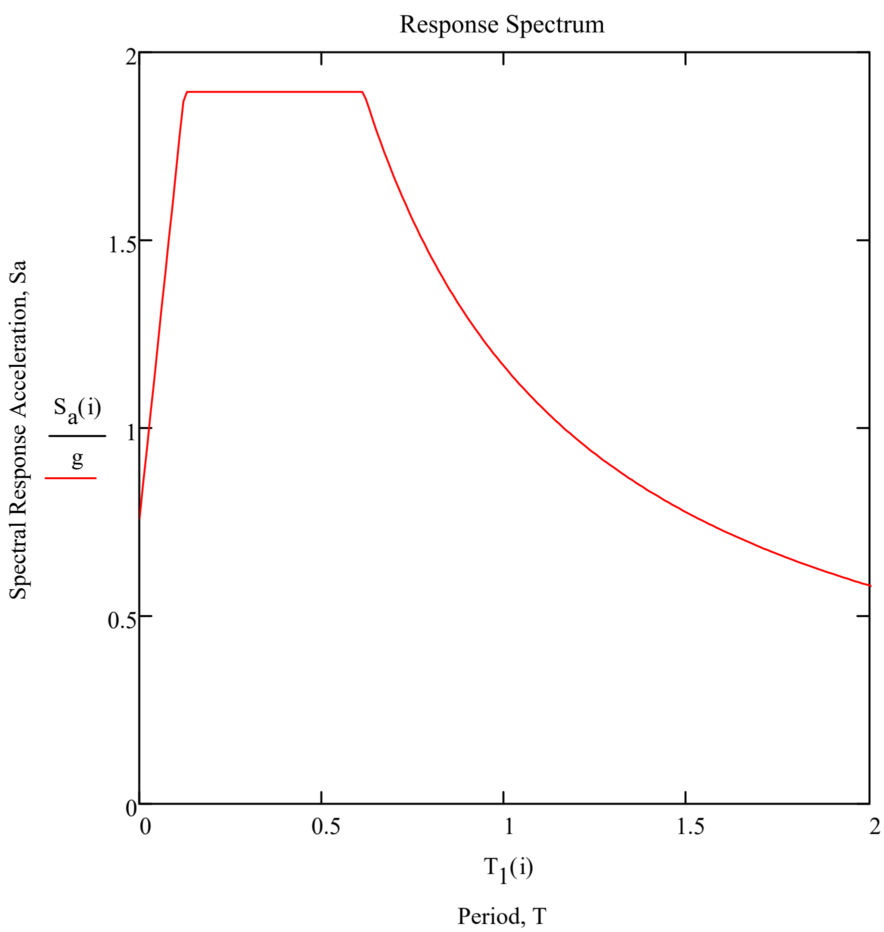
$\beta := 0.05$ $B_1 := \frac{4}{(5.6 - \ln(100 \cdot \beta))}$ $B_1 = 1.002$

$T_L := 8$

$i := 0, 0.01 .. T_L \qquad T_1(i) := i$

Response Spectrum

$$S_a(i) := \begin{cases} S_{xs} \cdot \left[\left(\dfrac{5}{B_1} - 2 \right) \cdot \dfrac{T_1(i)}{T_s} + 0.4 \right] & \text{if } T_1(i) \le T_0 \\ \dfrac{S_{xs}}{B_1} & \text{if } T_0 < T_1(i) < T_s \\ \dfrac{S_{x1}}{\left(B_1 \cdot T_1(i) \right)} & \text{if } T_s < T_1(i) < T_L \\ \dfrac{T_L \cdot S_{x1}}{\left(B_1 \cdot T_1(i)^2 \right)} & \text{if } T_1(i) > T_L \end{cases}$$



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$S_{DS\_1N} := 0.67 \cdot S_{xs}$ $\quad S_{DS\_1N} = 1.273 \cdot g$ These are the spectral design values for BSE-1N

$S_{D1\_1N} := 0.67 \cdot S_{x1}$ $\quad S_{D1\_1N} = 0.781 \cdot g$

$S_{DS\_2E} := 0.7437 \cdot S_{xs}$ $\quad S_{DS\_2E} = 1.413 \cdot g$ These are the spectral design values for BSE-2E

$S_{D1\_2E} := 0.758 \cdot S_{x1}$ $\quad S_{D1\_2E} = 0.884 \cdot g$

$S_{DS\_1E} := 0.4263 \cdot S_{xs}$ $\quad S_{DS\_1E} = 0.81 \cdot g$ These are the spectral design values for BSE-1E

$S_{D1\_1E} := 0.385 \cdot S_{x1}$ $\quad S_{D1\_1E} = 0.449 \cdot g$

Building Structure is assigned level of Seismicity as 'High'

Number of supported levels $N := 2$ Seismic shear is distributed to 2 levels above Ground Level

Building story heights $h := (13 \;\; 11 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; 0)$

Total Height of the building $hn := \sum_{i=1}^{N} h^{\langle i-1 \rangle}$ $\quad |hn| = 24$ Heights from E.T.F to Mid-Ridge Height

Building fundamental Time Period in two orthogonal directions

$C_t := 0.02$ $\quad x := 0.75$ $\quad Ta := C_t \cdot (|hn|)^x$ $\quad Ta = 0.217$

$T'a := 0.1N$ $\quad T'a = 0.200$

$C_u := 1.4$ $\quad Tx_{calc} := 0.13$ $\quad Ty_{calc} := 0.29$

$T_{max} := C_u \cdot Ta$ $\quad T_{max} = 0.304$

Area of typical floor in square foot $Af := 33750$

Structural dead load at 2nd level in pounds per square foot $w1 := 145$ $\quad A1 := 31968$

Structural dead load at typical supported level in pounds per square foot $w\_typ := 145$

Structural dead load at roof level in pounds per square foot $wr := 205$ $\quad Ar := 33750$

Seismic dead load in kips $W := \dfrac{[w1 \cdot A1 + w\_typ \cdot (N-2) \cdot Af + wr \cdot Ar]}{1000}$ $\quad W = 11554.11$

Calculation for Design Base Shear in X and Y direction (using ASCE 41-17) - Tier 1

$C := 1.2$ $\quad S_{a\_tier1} := \min\left(\dfrac{S_{xs}}{g}, \dfrac{S_{x1}}{Ta \cdot g}\right)$ $\quad S_{a\_tier1} = 1.9$

$C \cdot S_{a\_tier1} = 2.28$

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$V := C \cdot S_{a\_tier1} \cdot W$

$V = 26343.37$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-2N level

$V_{2E} := 0.7437 \cdot V$ $\quad V_{2E} = 19591.56$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-2E level

$V_{1E} := 0.4263 \cdot V$ $\quad V_{1E} = 11230.18$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-1E level

<u>Vertical Distribution of Seismic Lateral Forces</u> $\qquad i := 1..N$

$$w'(i) := \begin{vmatrix} w1 \cdot \frac{A1}{1000} & \text{if } i = 1 \\ w\_typ \cdot \frac{Af}{1000} & \text{otherwise} \end{vmatrix} \qquad h(i) := \begin{vmatrix} \left| h^{\langle i-1 \rangle} \right| & \text{if } i = 1 \\ \left| h^{\langle i-1 \rangle} \right| & \text{otherwise} \end{vmatrix}$$

$$w(i) := \begin{vmatrix} wr \cdot \frac{Ar}{1000} & \text{if } i = N \\ w'(i) & \text{otherwise} \end{vmatrix} \qquad h'(i) := \sum_{j=1}^{i} h(j)$$

$i := N..N-1$

$$k_x := \begin{vmatrix} 1 & \text{if } Tx_{calc} \le 0.5 \\ 1 + 0.5 \cdot (Tx_{calc} - 0.5) & \text{otherwise} \end{vmatrix} \qquad k_x = 1$$

$$k_y := \begin{vmatrix} 1 & \text{if } Ty_{calc} \le 0.5 \\ 1 + 0.5 \cdot (Ty_{calc} - 0.5) & \text{otherwise} \end{vmatrix} \qquad k_y = 1$$

$$C_{vx}(i) := \left[\frac{w(i) \cdot h'(i)^{k_x}}{\sum_{i=1}^{N} \left(w(i) \cdot h'(i)^{k_x} \right)} \right] \qquad C_{vy}(i) := \left[\frac{w(i) \cdot h'(i)^{k_y}}{\sum_{i=1}^{N} \left(w(i) \cdot h'(i)^{k_y} \right)} \right]$$

$Fx(i) := C_{vx}(i) \cdot V_{1E}$ $\qquad Sx(x) := \sum_{i=x}^{N} Fx(i)$

$Fy(i) := C_{vy}(i) \cdot V_{1E}$ $\qquad Sy(x) := \sum_{i=x}^{N} Fy(i)$

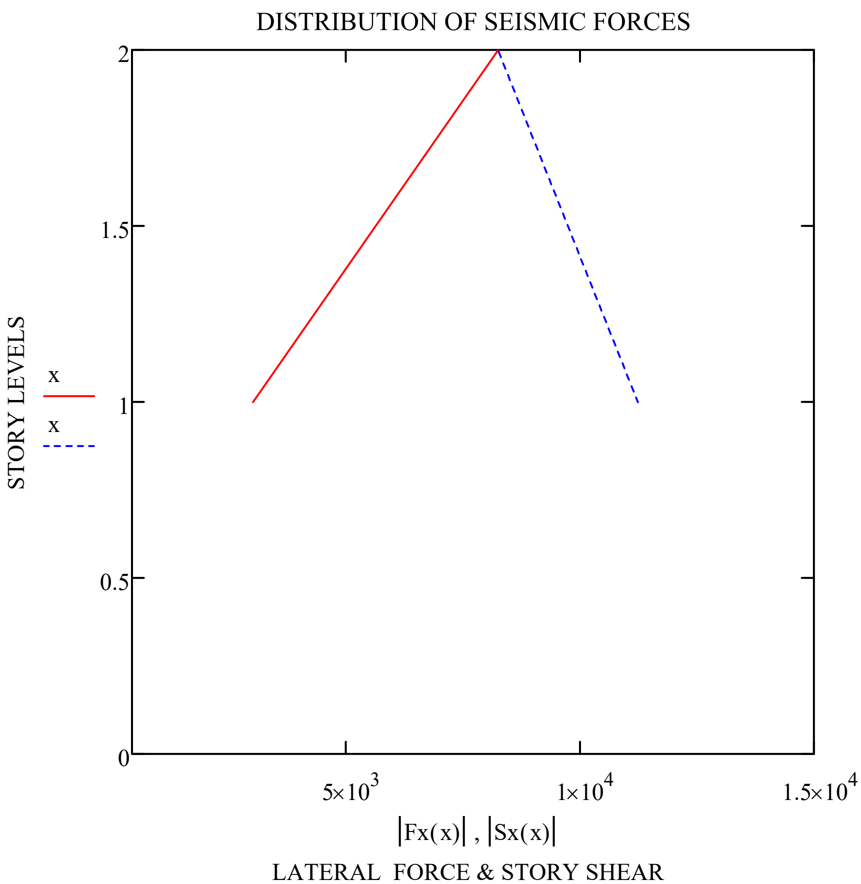
i =	$C_{vx}(i) =$	$C_{vy}(i) =$	h'(i) =
2	0.734	0.734	24
1	0.266	0.266	13

$$\sum_{i=1}^{N} C_{vx}(i) = 1 \qquad \sum_{i=1}^{N} C_{vy}(i) = 1$$

- ***Design story forces (Pier and Village level)***

Story Weight	**Lateral Story Forces**		**Cumm. Story shears**	
$w(i) =$	$\lvert Fx(i)\rvert =$	$\lvert Fy(i)\rvert =$	$\lvert Sx(i)\rvert =$	$\lvert Sy(i)\rvert =$
6918.8	8239.91	8239.91	8239.91	8239.91
4635.4	2990.27	2990.27	11230.18	11230.18

$x := 1 .. N$



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- **<u>Diaphragm Seismic Forces</u>**

$i := 1..N$

$$Fpx(x) := \frac{\sum_{i=x}^{N} Fx(i) \cdot w(x)}{\sum_{i=x}^{N} w(i)} \qquad Fpy(x) := \frac{\sum_{i=x}^{N} Fy(i) \cdot w(x)}{\sum_{i=x}^{N} w(i)}$$

- ***<u>Design diaphragm seismic forces (Pier and Village level)</u>***

$i := N..N-1$

$i =$	$w(i) =$	$Fpx(i) =$	$Fx(i) =$	$\frac{Fpx(i)}{Fx(i)} =$	$\frac{Fx(i)}{w(i)} =$
2	6918.75	8239.91	8239.91	1	1.191
1	4635.36	4505.4	2990.27	1.507	0.645

$i =$	$w(i) =$	$Fpy(i) =$	$Fy(i) =$	$\frac{Fpx(i)}{Fy(i)} =$	$\frac{Fy(i)}{w(i)} =$
2	6918.75	8239.91	8239.91	1	1.191
1	4635.36	4505.4	2990.27	1.507	0.645

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CLIENT City of Redondo Beach **SECTION** ASCE 41-17

PROJECT North Pier **SHEET** 1 **OF** 7

JOB No 37-009397.00 **DRAWING NO**

CALCULATION BY Sohban S. Khan **DATE** 02-10-2022

CHECKED BY Sohban S. Khan **DATE**

APPROVED BY **Units** Kips-inches

OBJECT **ASCE 41-17 Seismic Force Distribution for Tier 2 Analysis**

Given Data:

Project zip code = 90278 Latitude = 33.839 North, Longitude = -118.389 West

Ref: Table 1613.5.2

Site Class, D Stiff soil
N = 15 to 509, su= 1000 to 2000 psf, vs = 600 to 1200 ft/sec

Seismci Hazard Level = BSE-2N - (i.e., seismic hazard with a 2% probability of exceedence in 50 years)

Mapped spectral accelerations for short periods $Ss := 1.9 \cdot g$ per SEAOC Maps

Mapped spectral accelerations for a 1-sec. period $S_1 := 0.688 \cdot g$ per SEAOC Maps

Site coefficient Fa as function of Ss and Site Class, $Fa := 1.0$ per Table 2-3

Site coefficient Fv as function of S1 and Site Class, $Fv := 1.7$ per Table 2-3

Design Spectral Response Acceleration Parameters:

$S_{xs} := Fa \cdot Ss$ $S_{xs} = 1.9 \cdot g$ Ref: Eq (2-1) These are the spectral design values for BSE-2N

$S_{x1} := Fv \cdot S_1$ $S_{x1} = 1.17 \cdot g$ Ref: Eq (2-2)

Seismic Use Group, II "Parking Structure falls under Risk Category II"

$$T_s := \frac{S_{x1}}{S_{xs}} \qquad T_s = 0.616$$

$$T_0 := 0.2 \cdot T_s \qquad T_0 = 0.123$$

$$\beta := 0.05 \qquad B_1 := \frac{4}{(5.6 - \ln(100 \cdot \beta))} \qquad B_1 = 1.002$$

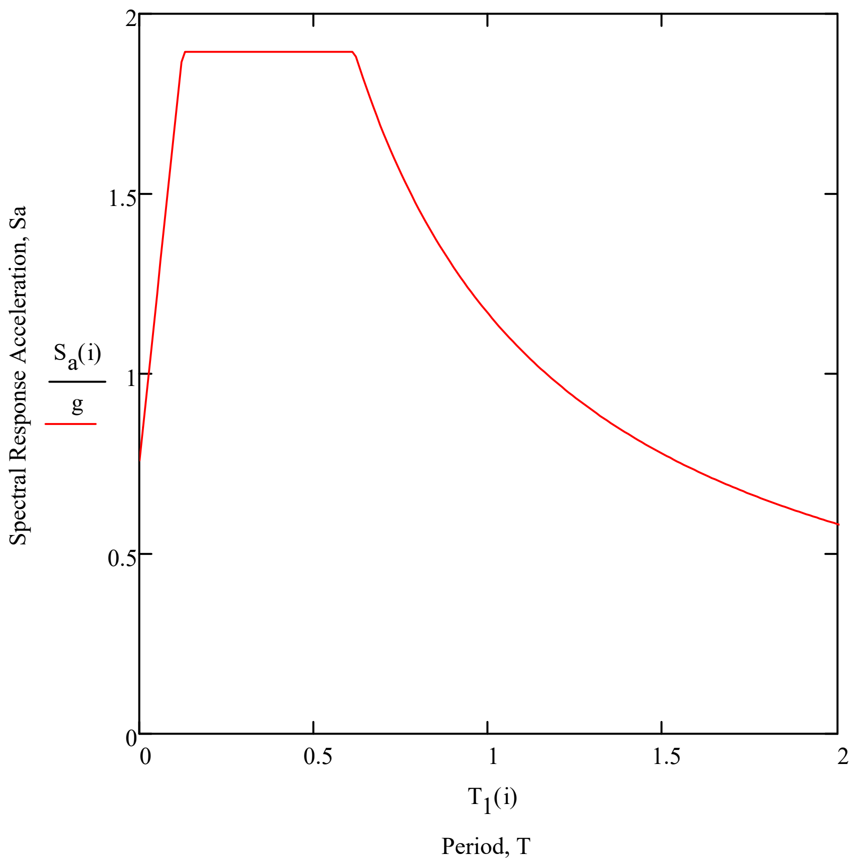
$$T_L := 8$$

$i := 0, 0.01 .. T_L \qquad T_1(i) := i$

Response Spectrum

$$S_a(i) := \begin{cases} S_{xs} \cdot \left[\left(\dfrac{5}{B_1} - 2 \right) \cdot \dfrac{T_1(i)}{T_s} + 0.4 \right] & \text{if } T_1(i) \le T_0 \\ \dfrac{S_{xs}}{B_1} & \text{if } T_0 < T_1(i) < T_s \\ \dfrac{S_{x1}}{\left(B_1 \cdot T_1(i) \right)} & \text{if } T_s < T_1(i) < T_L \\ \dfrac{T_L \cdot S_{x1}}{\left(B_1 \cdot T_1(i)^2 \right)} & \text{if } T_1(i) > T_L \end{cases}$$

Response Spectrum



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$S_{DS\_1N} := 0.67 \cdot S_{xs}$ $S_{DS\_1N} = 1.273 \cdot g$ These are the spectral design values for BSE-1N
$S_{D1\_1N} := 0.67 \cdot S_{x1}$ $S_{D1\_1N} = 0.784 \cdot g$

$S_{DS\_2E} := 0.7437 \cdot S_{xs}$ $S_{DS\_2E} = 1.413 \cdot g$ These are the spectral design values for BSE-2E
$S_{D1\_2E} := 0.758 \cdot S_{x1}$ $S_{D1\_2E} = 0.887 \cdot g$

$S_{DS\_1E} := 0.4263 \cdot S_{xs}$ $S_{DS\_1E} = 0.81 \cdot g$ These are the spectral design values for BSE-1E
$S_{D1\_1E} := 0.385 \cdot S_{x1}$ $S_{D1\_1E} = 0.45 \cdot g$

Building Structure is assigned level of Seismicity as 'High'

Number of supported levels $N := 2$ Seismic shear is distributed to 2 levels above Ground Level

Building story heights $h := (13\ \ 11\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0)$

Total Height of the building $hn := \sum_{i=1}^{N} h^{\langle i-1 \rangle}$ $|hn| = 24$ Heights from E.T.F to Mid-Ridge Height

Building fundamental Time Period
in two orthogonal directions

$C_t := 0.02$ $x := 0.75$ $Ta := C_t \cdot (|hn|)^x$ $Ta = 0.217$

$T'a := 0.1N$ $T'a = 0.200$

$C_u := 1.4$ $Tx_{calc} := 0.13$ $Ty_{calc} := 0.29$

$T_{max} := C_u \cdot Ta$ $T_{max} = 0.304$

Area of typical floor in square foot $Af := 33750$

Structural dead load at 2nd level in pounds per square foot $w1 := 147$ $A1 := 31968$

Structural dead load at typical supported level in pounds per square foot $w\_typ := 147$

Structural dead load at roof level in pounds per square foot $wr := 179$ $Ar := 33750$

Seismic dead load in kips $W := \frac{[w1 \cdot A1 + w\_typ \cdot (N-2) \cdot Af + wr \cdot Ar]}{1000}$ $W = 10740.55$

Calculation for Design Base Shear in X and Y direction (using ASCE 41-17)

X-Direction Seismic Lateral Forces

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$C_{1x} := 1.417$ $C_{2x} := 1.031$ $C_{1x} \cdot C_{2x} = 1.461$ $C_m := 1.0$ $S_a := \dfrac{S_{xs}}{B_1 \cdot g}$ $S_a = 1.896$

$C_m \cdot C_{1x} \cdot C_{2x} \cdot S_a = 2.769$

$V_x := C_m \cdot C_{1x} \cdot C_{2x} \cdot S_a \cdot W$

$V_x = 29742.85$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-2N level

$V_{x\_2E} := 0.7437 \cdot V_x$ $V_{x\_2E} = 22119.76$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-2E level

$V_{x\_1E} := 0.4263 \cdot V_x$ $V_{x\_1E} = 12679.38$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-1E level

Y-Direction Seismic Lateral Forces

$C_{1y} := 1.198$ $C_{2y} := 1.015$ $C_{1y} \cdot C_{2y} = 1.216$ $C_m \cdot C_{1y} \cdot C_{2y} \cdot S_a = 2.305$

$V_y := C_m \cdot C_{1y} \cdot C_{2y} \cdot S_a \cdot W$

$V_y = 24755.8$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-2N

$V_{y\_2E} := 0.7437 \cdot V_y$ $V_{y\_2E} = 18410.89$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-2E level

$V_{y\_1E} := 0.4263 \cdot V_y$ $V_{y\_1E} = 10553.4$ kips - Pseudo Seismic Force For Linear Static Procedure at BSE-1E level

Vertical Distribution of Seismic Lateral Forces

$i := 1..N$

$$w'(i) := \begin{array}{|l} w1 \cdot \dfrac{A1}{1000} \text{ if } i = 1 \\ w\_typ \cdot \dfrac{Af}{1000} \text{ otherwise} \end{array} \qquad h(i) := \begin{array}{|l} \left| h^{\langle i-1 \rangle} \right| \text{ if } i = 1 \\ \left| h^{\langle i-1 \rangle} \right| \text{ otherwise} \end{array}$$

$$w(i) := \begin{array}{|l} wr \cdot \dfrac{Ar}{1000} \text{ if } i = N \\ w'(i) \text{ otherwise} \end{array} \qquad h'(i) := \sum_{j=1}^{i} h(j)$$

$i := N..N-1$

$$k_x := \begin{array}{|l} 1 \text{ if } Tx_{calc} \le 0.5 \\ 1 + 0.5 \cdot \left(Tx_{calc} - 0.5 \right) \text{ otherwise} \end{array}$$

$k_x = 1$

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$$k_y := \begin{cases} 1 & \text{if } Ty_{calc} \le 0.5 \\ 1 + 0.5\cdot(Ty_{calc} - 0.5) & \text{otherwise} \end{cases} \qquad k_y = 1$$

$$C_{vx}(i) := \left[\frac{w(i)\cdot h'(i)^{k_x}}{\sum_{i=1}^{N}\left(w(i)\cdot h'(i)^{k_x}\right)}\right] \qquad C_{vy}(i) := \left[\frac{w(i)\cdot h'(i)^{k_y}}{\sum_{i=1}^{N}\left(w(i)\cdot h'(i)^{k_y}\right)}\right]$$

$$Fx(i) := C_{vx}(i)\cdot V_{x\_2E} \qquad Sx(x) := \sum_{i=x}^{N} Fx(i)$$

$$Fy(i) := C_{vy}(i)\cdot V_{y\_2E} \qquad Sy(x) := \sum_{i=x}^{N} Fy(i)$$

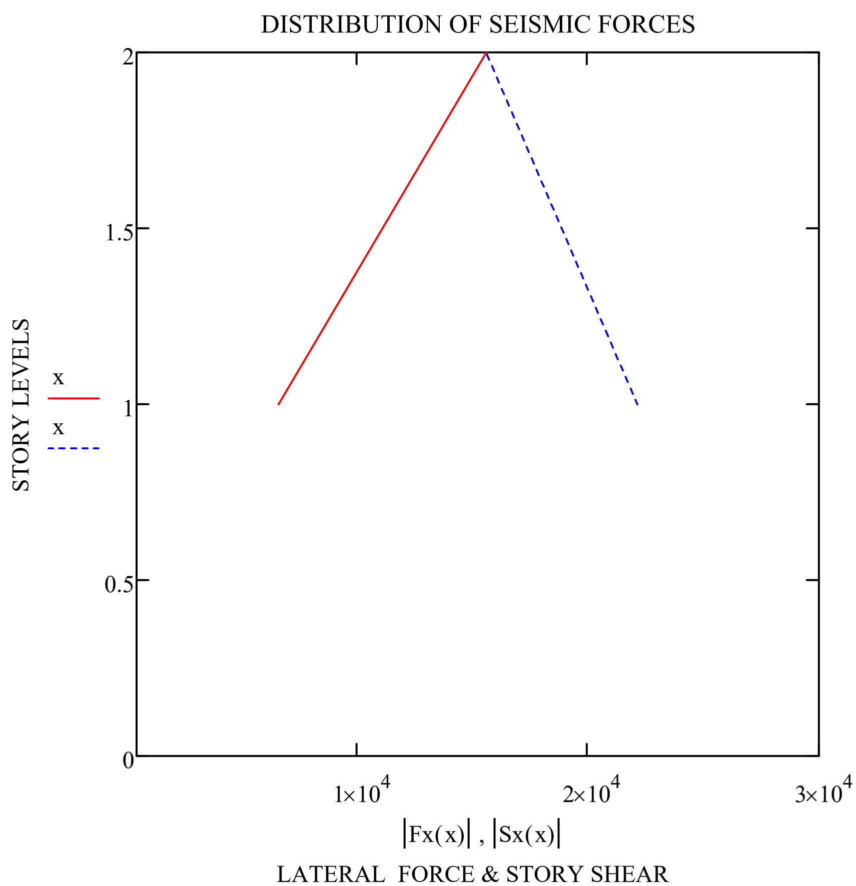
$i =$	$C_{vx}(i) =$	$C_{vy}(i) =$	$h'(i) =$
2	0.704	0.704	24
1	0.296	0.296	13

$$\sum_{i=1}^{N} C_{vx}(i) = 1 \qquad \sum_{i=1}^{N} C_{vy}(i) = 1$$

- ***Design story forces (Pier and Village level)***

Story Weight $w(i) =$	Lateral Story Forces $\lvert Fx(i)\rvert =$	$\lvert Fy(i)\rvert =$	Cumm. Story shears $\lvert Sx(i)\rvert =$	$\lvert Sy(i)\rvert =$
6041.3	15562.55	12953.14	15562.55	12953.14
4699.3	6557.21	5457.74	22119.76	18410.89

$x := 1 .. N$



- **Diaphragm Seismic Forces**

$i := 1 .. N$

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$$Fpx(x) := \frac{\sum_{i=x}^{N} Fx(i)\cdot w(x)}{\sum_{i=x}^{N} w(i)} \qquad Fpy(x) := \frac{\sum_{i=x}^{N} Fy(i)\cdot w(x)}{\sum_{i=x}^{N} w(i)}$$

- ***Design diaphragm seismic forces (Pier and Village level)***

$i := N..N-1$

$i =$	$w(i) =$	$Fpx(i) =$	$Fx(i) =$	$\frac{Fpx(i)}{Fx(i)} =$	$\frac{Fx(i)}{w(i)} =$
2	6041.25	15562.55	15562.55	1	2.576
1	4699.3	9678.03	6557.21	1.476	1.395

$i =$	$w(i) =$	$Fpy(i) =$	$Fy(i) =$	$\frac{Fpy(i)}{Fy(i)} =$	$\frac{Fy(i)}{w(i)} =$
2	6041.25	12953.14	12953.14	1.201	2.144
1	4699.3	8055.29	5457.74	1.773	1.161

Project Title: North Pier Parking Structure
Project Engineer: Sohban S. Khan, P.E.
Engineer of Record:
Date: 2/14/2022

Shear wall Flexural and Shear Capacity Check

Wall ID	Wall thick (in.)	Wall Length (ft.)	Wall f'c psi	Steel fy ksi	**Flexure m-factor** LS	CP	**Shear m-factor** LS	CP	**knowledge k-factor**	Code Model	Pseudo Force Level	Wall Axial P_G (kips)	Wall Shear V_{UD} (kips)	Wall Moment M_{UD} (kips)
Pier Level at Line 11/Y	10	37.5	5500	60	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	295	4876	62420
Basement Level at Line 11/Y	15.5	78	5500	50	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	555	7720	60306
Basement Level at Line 11/X	10	9	7000	50	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	183	384	2991
Basement Level at Line 3/Y	24	13	6600	50	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	771	2350	34374
Basement Level at Line 3/Z	24	21	5200	50	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	173	8161	80010
Basement Level at Line Z/(2-3)	10	29	5500	50	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	110	3769	30870
Basement Level at Line Z/(5-6)	10	29	5500	50	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	112.5	4144	33475
Basement Level at Line X2/(1-3)	8	82	5500	50	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	582	2272	27104
Basement Level at Line X2/(4-11)	8	189	5500	50	2	2.5	2.5	3	1.00	ASCE 41-17	BSE-2E	582	13610	113424

Wall ID	Wall thick (in.)	Wall Length (ft.)	$P_G/(t_w l_w f`c)$	$V_{UD}/(t_w l_w \sqrt{f`c})$	$V_{DE}/(t_w l_w \sqrt{f`c})$	Confined Boundary	Wall Moment M_{CE} (kips)	Wall Shear V_{CE} (kips)	DCR Flexure	DCR Shear	Wall Shear Design, V_{DE}	Performance Acceptance Status Flexure	Performance Acceptance Status Shear
Pier Level at Line 11/Y	10	37.5	0.01	14.61	6.97	Yes	25578	1558.46	2.440	3.13	2325.27	Wall is OK in Flexure	Wall is Overstressed in Shear
Basement Level at Line 11/Y	15.5	78	0.01	7.18	7.88	No	101703	5271.10	0.593	1.46	8475.25	Wall is OK in Flexure	Wall is OK in Shear
Basement Level at Line 11/X	10	9	0.02	4.25	2.50	No	2716	299.52	1.101	1.28	226.33	Wall is OK in Flexure	Wall is OK in Shear
Basement Level at Line 3/Y	24	13	0.03	7.73	4.06	No	14801	776.81	2.322	3.03	1233.42	Wall is OK in Flexure	Wall is Overstressed in Shear
Basement Level at Line 3/Z	24	21	0.01	18.71	3.98	No	20830	1144.41	3.841	7.13	1735.83	Wall is Overstressed in Flexure	Wall is Overstressed in Shear
Basement Level at Line Z/(2-3)	10	29	0.01	14.60	5.42	No	16798	1038.17	1.838	3.63	1399.83	Wall is OK in Flexure	Wall is Overstressed in Shear
Basement Level at Line Z/(5-6)	10	29	0.01	16.06	5.59	No	17312	1038.17	1.934	3.99	1442.67	Wall is OK in Flexure	Wall is Overstressed in Shear
Basement Level at Line X2/(1-3)	8	82	0.01	3.89	17.65	No	123667	2348.41	0.219	0.97	10305.58	Wall is OK in Flexure	Wall is OK in Shear
Basement Level at Line X2/(4-11)	8	189	0.01	10.11	11.30	No	182400	5412.79	0.622	2.51	15200.00	Wall is OK in Flexure	Wall is OK in Shear

Wall ID	Remarks
Pier Level at Line 11/Y	Wall is overstressed in Shear for both Life Safety and Collapse Prevention
Basement Level at Line 11/Y	Wall is OK in Flexure and Shear for both Life Safety and Collapse Prevention
Basement Level at Line 11/X	Wall is OK in Flexure and Shear for both Life Safety and Collapse Prevention
Basement Level at Line 3/Y	Wall is overstressed in Shear for both Life Safety and Collapse Prevention
Basement Level at Line 3/Z	Wall is overstressed in Flexure and Shear for both Life Safety and Collapse Prevention
Basement Level at Line Z/(2-3)	Wall is overstressed in Shear for both Life Safety and Collapse Prevention
Basement Level at Line Z/(5-6)	Wall is overstressed in Shear for both Life Safety and Collapse Prevention
Basement Level at Line X2/(1-3)	Wall is OK in Flexure and Shear for both Life Safety and Collapse Prevention
Basement Level at Line X2/(4-11)	Wall is overstressed in Shear for both Life Safety and Collapse Prevention

Table 10-6. Component Ductility Demand Classification

Maximum Value of DCR or Displacement Ductility	Descriptor
<2	Low ductility demand
2 to 4	Moderate ductility demand
>4	High ductility demand

Table 10-21. Numerical Acceptance Criteria for Linear Procedures—R/C Structural Walls and Associated Components Controlled by Flexure

Conditions			m-Factors[a]				
			Performance Level				
				Component Type			
				Primary		Secondary	
			IO	LS	CP	LS	CP
i. Structural walls and wall segments							
$\frac{(A_s - A'_s)f_{yE} + P}{t_w l_w f'_{cE}}$[b]	$\frac{V}{t_w l_w \sqrt{f'_{cE}}}$[c]	Confined Boundary[d]					
≤0.1	≤4	Yes	2	4	6	6	8
≤0.1	≥6	Yes	2	3	4	4	6
≥0.25	≤4	Yes	1.5	3	4	4	6
≥0.25	≥6	Yes	1.25	2	2.5	2.5	4
≤0.1	≤4	No	2	2.5	4	4	6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
≥0.25	≥6	No	1.25	1.5	1.75	1.75	2
ii. Structural wall coupling beams[e]							
Longitudinal reinforcement and transverse reinforcement[f]		$\frac{V}{t_w l_w \sqrt{f'_{cE}}}$[c]					
Conventional longitudinal reinforcement with conforming transverse reinforcement		≤3	2	4	6	6	9
		≥6	1.5	3	4	4	7
[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Diagonal reinforcement		NA	2	5	7	7	10

[a] Linear interpolation between values listed in the table shall be permitted.
[b] P is the axial force in the member. Alternatively, use of axial loads determined based on limit-state analysis shall be permitted.
[c] V is the shear force calculated using limit-state analysis procedures in accordance with Section 10.7.2.4.
[d] A boundary element shall be considered confined where transverse reinforcement exceeds 75% of the requirements given in ACI 318 and spacing of transverse reinforcement does not exceed $8d_b$. It shall be permitted to take modeling parameters and acceptance criteria as 80% of confined values where boundary elements have at least 50% of the requirements given in ACI 318

Table 10-22. Numerical Acceptance Criteria for Linear Procedures—R/C Structural Walls and Associated Components Controlled by Shear

Conditions		m-Factors				
		Performance Level				
			Component Type			
			Primary		Secondary	
		IO	LS	CP	LS	CP
i. Structural walls and wall segments[a]						
$\frac{(A_s - A'_s)f_{yE} + P}{t_w l_w f'_{cE}} \le 0.05$		2	2.5	3	4.5	6
$\frac{(A_s - A'_s)f_{yE} + P}{t_w l_w f'_{cE}} > 0.05$		1.5	2	3	3	4
ii. Structural wall coupling beams[b]						
Longitudinal reinforcement and transverse reinforcement[c]	$\frac{V_d}{t_w l_w \sqrt{f'_{cE}}}$					
Conventional longitudinal reinforcement with conforming transverse reinforcement	≤3	1.5	3	4	4	6
	≥6	1.2	2	2.5	2.5	3.5
Conventional longitudinal reinforcement with nonconforming transverse reinforcement	≤3	1.5	2.5	3	3	4
	≥6	1.2	1.2	1.5	1.5	2.5

[a] The shear shall be considered to be a force-controlled action for structural walls and wall segments where inelastic behavior is governed by shear and the design axial load is greater than $0.15\ A_g f'_{cE}$. It shall be permitted to calculate the axial load based on limit-state analysis.
[b] For secondary coupling beams spanning <8 ft 0 in., with bottom reinforcement continuous into the supporting walls, secondary values shall be permitted to be doubled.
[c] Conventional longitudinal reinforcement consists of top and bottom steel parallel to the longitudinal axis of the coupling beam. Conforming transverse reinforcement consists of (a) closed stirrups over the entire length of the coupling beam at a spacing ≤ $d/3$, and (b) strength of closed stirrups $V_s \ge 3/4$ of required shear strength of the coupling beam.
[d] V is the design shear force calculated using limit-state analysis procedures in accordance with Section 10.7.2.4.1.

and spacing of transverse reinforcement does not exceed $8d_b$. Otherwise, boundary elements shall be considered not confined.

[e] For secondary coupling beams spanning <8 ft 0 in., with bottom reinforcement continuous into the supporting walls, secondary values shall be permitted to be doubled.

[f] Conventional longitudinal reinforcement consists of top and bottom steel parallel to the longitudinal axis of the coupling beam. Conforming transverse reinforcement consists of (a) closed stirrups over the entire length of the coupling beam at a spacing $\leq d/3$, and (b) strength of closed stirrups $V_s \geq 3/4$ of required shear strength of the coupling beam.

Project Title: North Pier Parking Structure
Project Engineer: Sohban S. Khan, P.E.
Engineer of Record:
Date: 2/14/2022

Shear wall Reinforcement Check

Wall ID	Wall thick (in.)	Wall Length (ft.)	Wall f`c (psi)	Wall Jamb Reinf.	Wall Reinf. Vertical	Wall Reinf. Horizonatal	Wall Reinf. Av (in^2/ft)	Steel fy ksi	Reinf Ratio	Ratio Limit	Shear m-factor LS	Shear m-factor CP	Code Model	Pseudo Force Level	Wall Axial P_G (kips)	Wall Shear V_{UD} (kips)
Line X (Basement Level)	8	88	5500		#6 @ 6" OC (center)	#5 @ 18" OC (center)	0.207	40	0.0022	0.002	2.5	3	ASCE 41-17	BSE-2E	772	2272
Line X (Basement Level)	8	189	5500		#6 @ 6" OC (center)	#5 @ 18" OC (center)	0.207	40	0.0022	0.002	2.5	3	ASCE 41-17	BSE-2E	2045	13610
Line Z (Basement Level) (2 - 3)	10	28	5500		#4 @ 12" OC (EF)	#4 @ 12" OC (EF)	0.400	60	0.0033	0.002	2.5	3	ASCE 41-17	BSE-2E	836	3599
Line Z (Basement Level) (5 - 6)	10	28	5500		#4 @ 12" OC (EF)	#4 @ 12" OC (EF)	0.400	60	0.0033	0.002	2.5	3	ASCE 41-17	BSE-2E	836	3811
Line 3 (Basement Level) at Line Y	24	13	6600	(9) #10	#4 @ 6" OC (EF)	#4 @ 18" OC (EF)	0.267	60	0.0009	0.002	2.5	3	ASCE 41-17	BSE-2E	725	2306
Line 3 (Basement Level) at Line Y	24	21	5200	(9) #10	#4 @ 6" OC (EF)	#4 @ 18" OC (EF)	0.267	60	0.0009	0.002	2.5	3	ASCE 41-17	BSE-2E	725	8161
Line 11 (Pier Level) at Line Y	10	37.5	7000		#4 @ 12" OC (EF)	#4 @ 12" OC (EF)	0.400	60	0.0033	0.002	2.5	3	ASCE 41-17	BSE-2E	295.5	5227

Wall ID	Wall thick (in.)	Wall Length (ft.)	Wall f`c (psi)	P/tw lw f`c	V/tw lw √f'c	Allowable Shear Stress (psi)	Wall Shear Stress (psi)	Wall Shear V_{CE} (kips)	DCR shear	Wall Shear Status	Wall Reinf. Status	Remarks
Line X (Basement Level)	8	88	5500	0.02	3.626	148.32	107.58	1980.51	1.15	OK	OK	Old wall built in 1962
Line X (Basement Level)	8	189	5500	0.02	10.114	148.32	300.04	4253.59	3.20	Not Good	OK	Old wall built in 1962
Line Z (Basement Level) (2 - 3)	10	28	5500	0.05	14.443	148.32	428.45	1170.37	3.08	Not Good	OK	New wall built in 1992
Line Z (Basement Level) (5 - 6)	10	28	5500	0.05	15.294	148.32	453.69	1170.37	3.26	Not Good	OK	New wall built in 1992
Line 3 (Basement Level) at Line Y	24	13	6600	0.03	7.581	162.48	246.37	816.33	2.82	Not Good	Not Good	Old wall built in 1962
Line 3 (Basement Level) at Line Y	24	21	5200	0.02	18.712	144.22	539.75	1208.25	6.75	Not Good	Not Good	Old wall built in 1962
Line 11 (Pier Level) at Line Y	10	37.5	7000	0.01	13.883	167.33	464.62	1652.99	3.16	Not Good	OK	New wall built in 1992

Table 10-22. Numerical Acceptance Criteria for Linear Procedures—R/C Structural Walls and Associated Components Controlled by Shear

Conditions		IO	Primary LS	Primary CP	Secondary LS	Secondary CP
		m-Factors				
		Performance Level				
			Component Type			
i. Structural walls and wall segments[a]						
$\frac{(A_s - A'_s)f_{yE} + P}{t_w l_w f'_{cE}} \leq 0.05$		2	2.5	3	4.5	6
$\frac{(A_s - A'_s)f_{yE} + P}{t_w l_w f'_{cE}} > 0.05$		1.5	2	3	3	4
ii. Structural wall coupling beams[b]	$\frac{V_d}{t_w l_w \sqrt{f'_{cE}}}$					
Longitudinal reinforcement and transverse reinforcement[c]						
Conventional longitudinal reinforcement with conforming transverse reinforcement	≤3	1.5	3	4	4	6
	≥6	1.2	2	2.5	2.5	3.5
Conventional longitudinal reinforcement with nonconforming transverse reinforcement	≤3	1.5	2.5	3	3	4
	≥6	1.2	1.2	1.5	1.5	2.5

[a] The shear shall be considered to be a force-controlled action for structural walls and wall segments where inelastic behavior is governed by shear and the design axial load is greater than 0.15 $A_g f'_{cE}$. It shall be permitted to calculate the axial load based on limit-state analysis.
[b] For secondary coupling beams spanning <8 ft 0 in, with bottom reinforcement continuous into the supporting walls, secondary values shall be permitted to be doubled.
[c] Conventional longitudinal reinforcement consists of top and bottom steel parallel to the longitudinal axis of the coupling beam. Conforming transverse reinforcement consists of (a) closed stirrups over the entire length of the coupling beam at a spacing ≤ $d/3$, and (b) strength of closed stirrups $V_s \geq 3/4$ of required shear strength of the coupling beam.
[d] V is the design shear force calculated using limit-state analysis procedures in accordance with Section 10.7.2.4.1.

Table 10-6. Component Ductility Demand Classification

Maximum Value of DCR or Displacement Ductility	Descriptor
<2	Low ductility demand
2 to 4	Moderate ductility demand
>4	High ductility demand

Project Title: North Pier Parking Structure
Project Engineer: Sohban S. Khan, P.E.
Engineer of Record:
Date: 2/14/2022

Waffle Shear wall Axial, Flexural and Shear Check

Wall ID	Truss Depth (in.)	Truss Width (in.)	Truss Length (ft)	Wall f'c psi	Axial m-factor LS	Axial m-factor CP	Flexure m-factor LS	Flexure m-factor CP	Shear m-factor LS	Shear m-factor CP	knowledge k-factor	Long. Reinf. As (in^2)	Tie Reinf. Av (in^2)	Ties Sp. (in)	Steel fy ksi
Shear wall truss at line Z	12	12	2	5000	1	1	3	4	1.2	1.5	1	1.76	0.11	24	60
Shear wall truss at line Z	12	12	2	5000	1	1	3	4	1.2	1.5	1	1.76	0.11	24	60
Shear wall truss at line X	12	12	2	5000	1	1	3	4	1.2	1.5	1	1.76	0.11	24	60
Shear wall truss at line X	12	12	2	5000	1	1	3	4	1.2	1.5	1	1.76	0.11	24	60
Shear wall truss at line 3	12	12	2	5000	1	1	3	4	1.2	1.5	1	1.76	0.11	24	60
Shear wall truss at line 3	12	12	2	5000	1	1	3	4	1.2	1.5	1	1.76	0.11	24	60

Wall ID	Truss Depth (in.)	Truss Width (in.)	Truss Length (ft)	Av Reinf Ratio	Compression Axial Load Puf (kips)	Tension Axial Load Tuf (kips)	Puf/Ag f'c	As Reinf Ratio	Truss Shear V_{UD} (kips)	Truss Moment M_{UD} (kips)	$M_{UD}/(V_{UD}\ d)$	V/tw lw √f'c	Truss Moment M_{CE} (kips)	Truss Shear V_{CE} (kips)	Compression Truss Axial P_{CE} (kips)	Tension Truss Axial T_{CE} (kips)
Shear wall truss at line Z	12	12	2	0.0004	256.5	255.5	0.356	0.006	3.3	4.5	0.130	0.162	33.26	23.66	369.26	95.04
Shear wall truss at line Z	12	12	2	0.0004	239	250	0.332	0.006	3.3	4.5	0.130	0.162	33.26	23.66	369.26	95.04
Shear wall truss at line X	12	12	2	0.0004	428	416	0.594	0.006	3.3	4.5	0.130	0.162	33.26	23.66	369.26	95.04
Shear wall truss at line X	12	12	2	0.0004	388	371	0.539	0.006	3.3	4.5	0.130	0.162	33.26	23.66	369.26	95.04
Shear wall truss at line 3	12	12	2	0.0004	974.5	864	1.353	0.006	43	82	0.182	2.111	33.26	23.66	369.26	95.04
Shear wall truss at line 3	12	12	2	0.0004	646.5	360	0.898	0.006	25	44	0.168	1.228	33.26	23.66	369.26	95.04

Wall ID	Truss Depth (in.)	Truss Width (in.)	Truss Length (ft)	DCR axial (comp.)	DCR axial (tension)	DCR flexure	DCR shear	Truss Shear V_O (kips)	Truss Shear V_p (kips)	Vp/Vo	Performance Acceptance Status Axial (Compression)	Performance Acceptance Status Axial (Tension)	Performance Acceptance Status Flexure	Performance Acceptance Status Shear
Shear wall truss at line Z	12	12	2	0.69	2.69	0.14	0.14	46.87	33.264	0.71	Wall Truss OK in Axial Compression	Wall Truss OK in Axial Tension	Wall Truss OK in Flexure	Wall Truss is OK in Shear
Shear wall truss at line Z	12	12	2	0.65	2.63	0.14	0.14	46.87	33.264	0.71	Wall Truss OK in Axial Compression	Wall Truss OK in Axial Tension	Wall Truss OK in Flexure	Wall Truss is OK in Shear
Shear wall truss at line X	12	12	2	1.16	4.38	0.14	0.14	46.87	33.264	0.71	Wall Truss NG in Axial Compression	Wall Truss NG in Axial Tension	Wall Truss OK in Flexure	Wall Truss is OK in Shear
Shear wall truss at line X	12	12	2	1.05	3.90	0.14	0.14	46.87	33.264	0.71	Wall Truss NG in Axial Compression	Wall Truss NG in Axial Tension	Wall Truss OK in Flexure	Wall Truss is OK in Shear
Shear wall truss at line 3	12	12	2	2.64	9.09	2.47	1.82	46.87	33.264	0.71	Wall Truss NG in Axial Compression	Wall Truss NG in Axial Tension	Wall Truss OK in Flexure	Wall Truss is Overstressed in Shear
Shear wall truss at line 3	12	12	2	1.75	3.79	1.32	1.06	46.87	33.264	0.71	Wall Truss NG in Axial Compression	Wall Truss NG in Axial Tension	Wall Truss OK in Flexure	Wall Truss is OK in Shear

Waffle Shear wall Truss Top & Bottom chord Axial Check

Wall ID	Truss Depth (in.)	Truss Width (in.)	Wall f'c psi	Axial m-factor LS	Axial m-factor CP	Shear m-factor LS	Shear m-factor CP	knowledge k-factor	Long. Reinf. As (in^2)	Tie Reinf. Av (in^2)	Ties Sp. (in)	Steel fy ksi	Av Reinf Ratio	Compression Axial Load Puf (kips)	Puf/Ag f'c	As Reinf Ratio
Shear wall truss at line Z	14	10	5000	1	1	5	8	1	6	0.11	24	60	0.0005	188	0.269	0.025
Shear wall truss at line Z	12	12	5000	1	1	5	8	1	4.74	0.2	30	60	0.0006	160	0.222	0.013

Wall ID	Truss Depth (in.)	Truss Width (in.)	Wall f'c psi	Tension Axial Load Tuf (kips)	Truss Shear V_{UD} (kips)	Compression Chord Axial P_{CE} (kips)	Tension Chord Axial T_{CE} (kips)	Chord Shear V_{CE} (kips)	DCR Axial (comp.)	DCR Axial (tension)	DCR shear	Performance Acceptance Status Axial Compression	Performance Acceptance Status Axial Tension	Performance Acceptance Status Shear
Shear wall truss at line Z	14	10	5000	501	16.6	483.34	324	23.65	0.39	1.55	0.70	Truss Chord is OK in Axial Compression	Truss Chord is NG in Axial Tension	Truss Chord is OK in Shear
Shear wall truss at line Z	12	12	5000	132	13.7	455.65	255.96	25.16	0.35	0.52	0.54	Truss Chord is OK in Axial Compression	Truss Chord is OK in Axial Tension	Truss Chord is OK in Shear

Table 10-21. Numerical Acceptance Criteria for Linear Procedures—R/C Structural Walls and Associated Components Controlled by Flexure

Conditions			m-Factors[a]				
			Performance Level				
				Component Type			
				Primary		Secondary	
			IO	LS	CP	LS	CP
i. Structural walls and wall segments							
$\frac{(A_s - A'_s)f_{yE} + P}{t_w l_w f'_{cE}}$ [b]	$\frac{V}{t_w l_w \sqrt{f'_{cE}}}$ [c]	Confined Boundary[d]					
≤0.1	≤4	Yes	2	4	6	6	8
≤0.1	≥6	Yes	2	3	4	4	6
≥0.25	≤4	Yes	1.5	3	4	4	6
≥0.25	≥6	Yes	1.25	2	2.5	2.5	4
≤0.1	≤4	No	2	2.5	4	4	6
≤0.1	≥6	No	1.5	2	2.5	2.5	4
≥0.25	≤4	No	1.25	1.5	2	2	3
≥0.25	≥6	No	1.25	1.5	1.75	1.75	2
ii. Structural wall coupling beams[e]							
Longitudinal reinforcement and transverse reinforcement[f]		$\frac{V}{t_w l_w \sqrt{f'_{cE}}}$ [c]					
Conventional longitudinal reinforcement with conforming transverse reinforcement		≤3	2	4	6	6	9
		≥6	1.5	3	4	4	7
Conventional longitudinal reinforcement with nonconforming transverse reinforcement		≤3	1.5	3.5	5	5	8
		≥6	1.2	1.8	2.5	2.5	4
Diagonal reinforcement		NA	2	5	7	7	10

[a] Linear interpolation between values listed in the table shall be permitted.
[b] P is the axial force in the member. Alternatively, use of axial loads determined based on limit-state analysis shall be permitted.
[c] V is the shear force calculated using limit-state analysis procedures in accordance with Section 10.7.2.4.
[d] A boundary element shall be considered confined where transverse reinforcement exceeds 75% of the requirements given in ACI 318 and spacing of transverse reinforcement does not exceed $8d_b$. It shall be permitted to take modeling parameters and acceptance criteria as 80% of confined values where boundary elements have at least 50% of the requirements given in ACI 318 and spacing of transverse reinforcement does not exceed $8d_b$. Otherwise, boundary elements shall be considered not confined.
[e] For secondary coupling beams spanning <8 ft 0 in., with bottom reinforcement continuous into the supporting walls, secondary values shall be permitted to be doubled.
[f] Conventional longitudinal reinforcement consists of top and bottom steel parallel to the longitudinal axis of the coupling beam. Conforming transverse reinforcement consists of (a) closed stirrups over the entire length of the coupling beam at a spacing ≤ $d/3$, and (b) strength of closed stirrups $V_s \geq 3/4$ of required shear strength of the coupling beam.

Table 10-6. Component Ductility Demand Classification

Maximum Value of DCR or Displacement Ductility	Descriptor
<2	Low ductility demand
2 to 4	Moderate ductility demand
>4	High ductility demand

Table 10-22. Numerical Acceptance Criteria for Linear Procedures—R/C Structural Walls and Associated Components Controlled by Shear

Conditions		m-Factors				
		Performance Level				
			Component Type			
			Primary		Secondary	
		IO	LS	CP	LS	CP
i. Structural walls and wall segments[a]						
$\frac{(A_s - A'_s)f_{yE} + P}{t_w l_w f'_{cE}} \leq 0.05$		2	2.5	3	4.5	6
$\frac{(A_s - A'_s)f_{yE} + P}{t_w l_w f'_{cE}} > 0.05$		1.5	2	3	3	4
ii. Structural wall coupling beams[b]						
Longitudinal reinforcement and transverse reinforcement[c]	$\frac{V_d}{t_w l_w \sqrt{f'_{cE}}}$					
Conventional longitudinal reinforcement with conforming transverse reinforcement	≤3	1.5	3	4	4	6
	≥6	1.2	2	2.5	2.5	3.5
Conventional longitudinal reinforcement with nonconforming transverse reinforcement	≤3	1.5	2.5	3	3	4
	≥6	1.2	1.2	1.5	1.5	2.5

[a] The shear shall be considered to be a force-controlled action for structural walls and wall segments where inelastic behavior is governed by shear and the design axial load is greater than 0.15 $A_g f'_{cE}$. It shall be permitted to calculate the axial load based on limit-state analysis.
[b] For secondary coupling beams spanning <8 ft 0 in. with bottom reinforcement continuous into the supporting walls, secondary values shall be permitted to be doubled.
[c] Conventional longitudinal reinforcement consists of top and bottom steel parallel to the longitudinal axis of the coupling beam. Conforming transverse reinforcement consists of (a) closed stirrups over the entire length of the coupling beam at a spacing ≤ $d/3$, and (b) strength of closed stirrups $V_s \geq 3/4$ of required shear strength of the coupling beam.
[d] V is the design shear force calculated using limit-state analysis procedures in accordance with Section 10.7.2.4.1.

Table 10-10a. Numerical Acceptance Criteria for Linear Procedures—Reinforced Concrete Columns Other Than Circular with Spiral Reinforcement or Seismic Hoops as Defined in ACI 318

			m-Factors[a]				
			Performance Level				
				Component Type			
				Primary		Secondary	
$\left(\frac{N_{UD}}{A_g f'_{cE}}\right)$	ρ_t	V_{yE}/V_{ColOE}	IO	LS	CP	LS	CP
Columns not controlled by inadequate development or splicing along the clear height[b]							
≤ 0.1	≥ 0.0175	≥ 0.2 < 0.6	1.7	3.4	4.2	6.8	8.9
≥ 0.7	≥ 0.0175	≥ 0.2 < 0.6	1.2	1.4	1.7	1.4	1.7
≤ 0.1	≤ 0.0005	≥ 0.2 < 0.6	1.5	2.6	3.2	2.6	3.2
≥ 0.7	≤ 0.0005	≥ 0.2 < 0.6	1.0	1.0	1.0	1.0	1.0
≤ 0.1	≥ 0.0175	≥ 0.6 < 1.0	1.5	2.7	3.3	6.8	8.9
≥ 0.7	≥ 0.0175	≥ 0.6 < 1.0	1.0	1.0	1.0	1.0	1.0
≤ 0.1	≤ 0.0005	≥ 0.6 < 1.0	1.3	1.9	2.3	1.9	2.3
≥ 0.7	≤ 0.0005	≥ 0.6 < 1.0	1.0	1.0	1.0	1.0	1.0
≤ 0.1	≥ 0.0175	≥ 1.0	1.3	1.8	2.2	6.8	8.9
≥ 0.7	≥ 0.0175	≥ 1.0	1.0	1.0	1.0	1.0	1.0
≤ 0.1	≤ 0.0005	≥ 1.0	1.1	1.0	1.1	1.7	2.1
≥ 0.7	≤ 0.0005	≥ 1.0	1.0	1.0	1.0	1.0	1.0
Columns controlled by inadequate development or splicing along the clear height[b]							
≤ 0.1	≥ 0.0075		1.0	1.7	2.0	5.3	6.8
≥ 0.7	≥ 0.0075		1.0	1.0	1.0	2.8	3.5
≤ 0.1	≤ 0.0005		1.0	1.0	1.0	1.4	1.6
≥ 0.7	≤ 0.0005		1.0	1.0	1.0	1.0	1.0

[a] Values between those listed in the table shall be determined by linear interpolation.
[b] Columns are considered to be controlled by inadequate development or splicing where the calculated steel stress at the splice exceeds the steel stress specified by Eq. (10-1a) or (10-1b). Acceptance criteria for columns controlled by inadequate development or splicing shall never exceed those of columns not controlled by inadequate development or splicing.

Table 10-13. Numerical Acceptance Criteria for Linear Procedures—Reinforced Concrete Beams

Conditions			m-Factors[a]				
			Performance Level				
				Component Type			
				Primary		Secondary	
			IO	LS	CP	LS	CP
Condition i. Beams controlled by flexure[b]							
$\frac{\rho - \rho'}{\rho_{bal}}$	Transverse reinforcement[c]	$\frac{V}{b_w d \sqrt{f'_{cE}}}$ [d]					
≤0.0	C	≤3 (0.25)	3	6	7	6	10
≤0.0	C	≥6 (0.5)	2	3	4	3	5
≥0.5	C	≤3 (0.25)	2	3	4	3	5
≥0.5	C	≥6 (0.5)	2	2	3	2	4
≤0.0	NC	≤3 (0.25)	2	3	4	3	5
≤0.0	NC	≥6 (0.5)	1.25	2	3	2	4
≥0.5	NC	≤3 (0.25)	2	3	3	3	4
≥0.5	NC	≥6 (0.5)	1.25	2	2	2	3
Condition ii. Beams controlled by shear[b]							
Stirrup spacing ≤ $d/2$			1.25	1.5	1.75	3	4
Stirrup spacing > $d/2$			1.25	1.5	1.75	2	3
Condition iii. Beams controlled by inadequate development or splicing along the span[b]							
Stirrup spacing ≤ $d/2$			1.25	1.5	1.75	3	4
Stirrup spacing > $d/2$			1.25	1.5	1.75	2	3
Condition iv. Beams controlled by inadequate embedment into beam–column joint[b]							
			2	2	3	3	4

Note: f'_{cE} in lb/in.^{2} (MPa) units.
[a] Values between those listed in the table shall be determined by linear interpolation.
[b] Where more than one of conditions i, ii, iii, and iv occurs for a given component, use the minimum appropriate numerical value from the table.
[c] "C" and "NC" are abbreviations for conforming and nonconforming transverse reinforcement. Transverse reinforcement is conforming if, within the flexural plastic hinge region, hoops are spaced at ≤ $d/3$, and if, for components of moderate and high ductility demand, the strength provided by the hoops (V_s) is at least 3/4 of the design shear. Otherwise, the transverse reinforcement is considered nonconforming.
[d] V is the shear force calculated using limit-state analysis procedures in accordance with Section 10.4.2.4.1.

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Project Title: North Pier Parking Structure
Project Engineer: Sohban S. Khan, P.E.
Engineer of Record:
Date: 2/14/2022

Deformation Compatibility Check

Column ID	Level	Col Width (in.)	Col. Depth (in.)	Column Clear Height (ft.)	Column f'c psi	Col. Steel Fy ksi	Model Code	Pseudo Lateral Force	Col. Axial Load (kips)	Max. Probable Col. Moment (k-ft)	Max. Probable Col. Shear (kip)	Col. Shear Reinf. (in^2/ft)	Spacing Ties (in.)
Line 3/Z	Village	36	28	8.33	3000	60	ASCE 41-17	BSE-2E	159	3380	405.76	0.4	12
	Village	36	28	8.33	3000	60	ASCE 41-17	BSE-1E	49	1952	234.33	0.4	12
Line 1/Z	Village	30	28	8.33	3000	60	ASCE 41-17	BSE-2E	73	1081	129.77	0.4	12
	Village	30	28	8.33	3000	60	ASCE 41-17	BSE-1E	73	715	85.83	0.4	12
Line 5/Y	Village	18	22	8.33	3000	60	ASCE 41-17	BSE-2E	289	536	64.35	0.4	12
	Village	18	22	8.33	3000	60	ASCE 41-17	BSE-1E	286	255.5	30.67	0.4	12

Table 10-6. Component Ductility Demand Classification

Maximum Value of DCR or Displacement Ductility	Descriptor
<2	Low ductility demand
2 to 4	Moderate ductility demand
>4	High ductility demand

Column ID	Level	Col Width (in.)	Col. Depth (in.)	Column Clear Height (ft.)	Col. Shear Capacity, Vn (kip)	P/(Ag f'c) (calculated)	Av/(bw s) (calculated)	V/(bw d √ f'c) (calculated)	Axial m-factor LS	Axial m-factor CP	Knowledge k	DCR	Column Shear Status	Remarks
Line 3/Z	Village	36	28	8.33	166.42	0.05	0.001	7.35	2	2.5	0.90	2.438	Not Good	Column above Shear wall Boundary Element
	Village	36	28	8.33	166.42	0.02	0.001	4.24	2	2.5	0.90	1.408	OK	Column above Shear wall Boundary Element
Line 1/Z	Village	30	28	8.33	148.02	0.03	0.001	2.82	2	2.5	0.90	0.877	OK	
	Village	30	28	8.33	148.02	0.03	0.001	1.87	2	2.5	0.90	0.580	OK	
Line 5/Y	Village	18	22	8.33	87.38	0.22	0.002	2.97	2	2.5	0.90	0.736	OK	
	Village	18	22	8.33	87.38	0.22	0.002	1.41	2	2.5	0.90	0.351	OK	

Table 10-10a. Numerical Acceptance Criteria for Linear Procedures—Reinforced Concrete Columns Other Than Circular with Spiral Reinforcement or Seismic Hoops as Defined in ACI 318

			m-Factors[a]				
			Performance Level				
				Component Type			
				Primary		Secondary	
$\left(\frac{N_{UD}}{A_g f'_{cE}}\right)$	ρ_t	V_{yE}/V_{ColOE}	IO	LS	CP	LS	CP
Columns not controlled by inadequate development or splicing along the clear height[b]							
≤ 0.1	≥ 0.0175	≥ 0.2 < 0.6	1.7	3.4	4.2	6.8	8.9
≥ 0.7	≥ 0.0175	≥ 0.2 < 0.6	1.2	1.4	1.7	1.4	1.7
≤ 0.1	≤ 0.0005	≥ 0.2 < 0.6	1.5	2.6	3.2	2.6	3.2
≥ 0.7	≤ 0.0005	≥ 0.2 < 0.6	1.0	1.0	1.0	1.0	1.0
≤ 0.1	≥ 0.0175	≥ 0.6 < 1.0	1.5	2.7	3.3	6.8	8.9
≥ 0.7	≥ 0.0175	≥ 0.6 < 1.0	1.0	1.0	1.0	1.0	1.0
≤ 0.1	≤ 0.0005	≥ 0.6 < 1.0	1.3	1.9	2.3	1.9	2.3
≥ 0.7	≤ 0.0005	≥ 0.6 < 1.0	1.0	1.0	1.0	1.0	1.0
≤ 0.1	≥ 0.0175	≥ 1.0	1.3	1.8	2.2	6.8	8.9
≥ 0.7	≥ 0.0175	≥ 1.0	1.0	1.0	1.0	1.0	1.0
≤ 0.1	≤ 0.0005	≥ 1.0	1.1	1.0	1.1	1.7	2.1
≥ 0.7	≤ 0.0005	≥ 1.0	1.0	1.0	1.0	1.0	1.0

Table 10-13. Numerical Acceptance Criteria for Linear Procedures—Reinforced Concrete Beams

			m-Factors[a]				
			Performance Level				
				Component Type			
				Primary		Secondary	
Conditions			IO	LS	CP	LS	CP
Condition i. Beams controlled by flexure[b]							
$\frac{\rho - \rho'}{\rho_{bal}}$	Transverse reinforcement[c]	$\frac{V^d}{b_w d \sqrt{f'_{cE}}}$					
≤0.0	C	≤3 (0.25)	3	6	7	6	10
≤0.0	C	≥6 (0.5)	2	3	4	3	5
≥0.5	C	≤3 (0.25)	2	3	4	3	5
≥0.5	C	≥6 (0.5)	2	2	3	2	4
≤0.0	NC	≤3 (0.25)	2	3	4	3	5
≤0.0	NC	≥6 (0.5)	1.25	2	3	2	4
≥0.5	NC	≤3 (0.25)	2	3	3	3	4
≥0.5	NC	≥6 (0.5)	1.25	2	2	2	3
Condition ii. Beams controlled by shear[b]							
Stirrup spacing ≤ *d*/2			1.25	1.5	1.75	3	4
Stirrup spacing > *d*/2			1.25	1.5	1.75	2	3
Condition iii. Beams controlled by inadequate development or splicing along the span[b]							
Stirrup spacing ≤ *d*/2			1.25	1.5	1.75	3	4
Stirrup spacing > *d*/2			1.25	1.5	1.75	2	3
Condition iv. Beams controlled by inadequate embedment into beam–column joint[b]							
			2	2	3	3	4

Note: f_{cE} in lb/in.^{2} (MPa) units.
[a] Values between those listed in the table shall be determined by linear interpolation.

Columns controlled by inadequate development or splicing along the clear height[b]						
≤ 0.1	≥ 0.0075	1.0	1.7	2.0	5.3	6.8
≥ 0.7	≥ 0.0075	1.0	1.0	1.0	2.8	3.5
≤ 0.1	≤ 0.0005	1.0	1.0	1.0	1.4	1.6
≥ 0.7	≤ 0.0005	1.0	1.0	1.0	1.0	1.0

[a] Values between those listed in the table shall be determined by linear interpolation.
[b] Columns are considered to be controlled by inadequate development or splicing where the calculated steel stress at the splice exceeds the steel stress specified by Eq. (10-1a) or (10-1b). Acceptance criteria for columns controlled by inadequate development or splicing shall never exceed those of columns not controlled by inadequate development or splicing.

ASCE 41-17

[b] Where more than one of conditions i, ii, iii, and iv occurs for a given component, use the minimum appropriate numerical value from the table.
[c] "C" and "NC" are abbreviations for conforming and nonconforming transverse reinforcement. Transverse reinforcement is conforming if, within the flexural plastic hinge region, hoops are spaced at ≤ $d/3$, and if, for components of moderate and high ductility demand, the strength provided by the hoops (V_s) is at least 3/4 of the design shear. Otherwise, the transverse reinforcement is considered nonconforming.
[d] V is the shear force calculated using limit-state analysis procedures in accordance with Section 10.4.2.4.1.

BUILDING ENVELOPE

CONSULTING

FORENSIC RESTORATION

PARKING DESIGN

PLANNING

CITY OF REDONDO BEACH SOUTH PIER AND PLAZA PARKING STRUCTURES 2021-CONDITION ASSESSMENT

CITY OF REDONDO BEACH

Redondo Beach, CA

Prepared for:

Mr. Stephen Proud
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WC PROJECT No. 37-009397.00

June 06, 2022

EXECUTIVE SUMMARY

The City of Redondo Beach retained Walker Consultants to carry out a Condition Assessment Update of the three existing parking structures - North Pier, South Pier, and Plaza parking structures. This report only includes the South Pier and Plaza parking structures. The North Pier parking structure is issued as a separate report which includes a condition assessment and an updated seismic evaluation. This assessment is intended to provide our professional opinion on the current condition of the structural system and other components, such as waterproofing and drainage, that can affect the service life of the structural system. In addition, the assessment identifies any needed maintenance and repairs to the structural system and waterproofing components and provides our recommendations for implementing the work. We evaluated the overall general condition of the structures with visual observations and compared our new findings to the 2012 and 2015 Walker findings.

On December 22, 2021, Walker sent a draft of this condition assessment report to the City of Redondo Beach. The two repair programs discussed in the draft and in this final report were developed considering the City's available annual budget, maximizing benefits from previous work and repair priority, and maintaining parking structure accessibility and occupancy. The first program is to perform risk management items and isolated structural or waterproofing repairs all in a Single-Year. This repair recommendation cannot address all deterioration or stop future deterioration from developing. Additional repair programs can be implemented after the completion of an initial repair program to extend the life of the structure further. The second option focuses on a Five-Year restoration program with the service life extension program focusing on immediate repairs as well as the necessary repairs to extend the useful service life of the structure. Based on the City of Redondo Beach's request, as an alternative for City to consider, Walker has also developed an opinion of the probable costs of a Ten-Year repair program for the South Pier parking structure in this final report.

This 2021 report incorporates the 2012 and 2015 Walker reports as a reference. Our 2021 findings indicated that, overall, the parking structures have continued to deteriorate compared to the findings reported in the 2012 and 2015 Walker reports. In general, the 2012 and 2015 Walker recommendations remain unchanged except for areas that have been addressed in the 2017 and 2019 repair programs.

The repair plan proposed herein primarily consists of traffic membrane installation, structural repair, corrosion abatement, and Village level wearing slab and pavers replacement/modification of the south parking structure to maintain the life of the structure.

The one immediate concern is to remove all loosely adhered spalled concrete from the soffit of the parking decks. There should be a review the soffit on a regular basis for loosely adhered spalled concrete.

IMMEDIATE REPAIRS - RISK MANAGEMENT

Risk Management repairs are those required to address safety issues and to mitigate potential unsafe conditions from a risk management perspective.

- Remove all loose and delaminated concrete from the slab and beam underside where delaminated concrete appears on the surface. Repairs to these areas can be deferred and addressed during the implementation of the base repair program shown below. Based on Walker's recommendation, these delaminated and loose concrete areas were removed by City personnel. It is highly recommended that work should be continued and included in a regular maintenance program.

SUMMARY OF TYPES OF DEFICIENCIES

South Pier Parking Structure

- Concrete floor deterioration and delamination.

- Exposed and rusted slab mild steel reinforcement at numerous locations.
- Soffit slab deterioration and spalls with exposed and corroded reinforcement.
- Concrete beam deterioration with exposed and corroded reinforcement.
- Concrete column spalling.
- Waterproofing system deficiencies.

Plaza Parking Structure

- Concrete floor deterioration and delamination.
- P/T beam tendon damage.
- Concrete wall spalling with exposed rebars.
- Waterproofing system deficiencies

We recommend that the City of Redondo Beach perform the base repair program outlined in this report that will correct the observed deficiencies/deterioration and enhance the waterproofing systems to protect the structural slabs and reduce the potential for water infiltration throughout the structures.

We recommend that the City of Redondo Beach budget approximately **$15,150,500** to maintain the facility over the next 5 years. The budget costs presented are based on historical data. As a result of the COVID-19 epidemic, prices and schedules have changed. Therefore, these costs should be considered a rough order of magnitude and used for basic planning purposes. The actual costs may not be realized until the project is designed and bid by a contractor. Budgeting for capital improvements and work items will help the City of Redondo Beach plan for necessary funding for the recommended work over the next 5 years. This will help maximize the service life of various components of the structures and maintain the structures in good service condition with minimum downtime.

Please see the attached discussion and photo appendix for a detailed report of our investigation.

Sincerely,

WALKER CONSULTANTS

June 06, 2022

Behnam Arya, PhD, PE — Date
Senior Consultant

Suhail Hassan

June 06, 2022

Hassan Suhail — Date
Project Engineer I

INTRODUCTION

BACKGROUND INFORMATION

Walker Consultants performed a condition assessment for the South Pier and Plaza parking structures located in Redondo Beach, California on November 3rd, 4th and 10th 2021. The evaluation and report will provide our professional opinion of the overall condition of the parking structures and update the prior 2012 and 2015 Walker's conditional appraisal reports with recommendations for current repair and preventative maintenance needs to maintain the service life for these structures. The City of Redondo Beach has requested Walker to perform a new condition assessment of the parking garages since the last condition assessment of the parking structures was completed more than 6 years ago. The condition assessment update consisted of a visual survey and documentation of observations. It was limited to the supported structural slabs of parking levels, respective exposed rooftop plaza levels and the slabs-on-ground. The condition assessment did not include the occupied retail areas below or between the North Pier and Plaza parking structures nor the commercial timber-frame buildings on top of the South Pier parking structure.

Nomenclature

In the summer of 2011, Walker performed a condition assessment of the parking structures. In June 2012, Walker performed a structural analysis of the North Pier parking structure and prepared an Asset Management Plan (AMP), formerly known as Capital Improvement and Protection Program (CIPP), detailing opinions of probable repair costs over ten years for all three structures. The report was submitted to the City in August 2012 and is referred to herein as the 2012 Walker Report. Also, in October 2015 Walker performed a condition assessment update and prepared opinions of probable costs for two timeline scenarios for the parking structures. The report was submitted to the City in January 2016 and is referred to herein as the 2015 Walker Report. Please refer to the reports mentioned above for additional information.

Previous repairs

As requested by the City of Redondo Beach, the 2015 condition assessments proposed three different scenarios of repair with approximate costs for each option. These options were: A limited three (3) year repair and maintenance program; a 10 – 15-year repair and maintenance program; and an option of full replacement of the Pier Parking Structures. Based on our 2015 condition assessment and the cost associated with the proposed options, the City of Redondo Beach selected the 10 - 15-year repair and maintenance program option. Walker has been awarded several contracts for the development of plans, specifications, and estimates (P, S & E's) to bid the work out to restoration contractors for the Pier Parking Structures. The first round of repairs was performed in 2017 on the South Pier parking structure and the second round of repairs was completed in 2019 on both the South Pier and North Pier structures. It was also conveyed to Walker during our site visits that some repairs were performed on the Plaza Parking Structure as a change order to the previous repair program.

Since 2017, Walker has provided parking structures restoration and maintenance design services for City of Redondo including the following:

- In 2017, the first repair project occurred mainly on the South Pier parking structure, consisting of the removal and replacement of traffic coating, isolated concrete floor repairs, concrete ceiling repairs, partial concrete beam repairs mainly on spandrels projecting out on the west end of the garage, concrete column and wall repairs, replacement of expansion joints, crack and joint treatments, installation of cathodic protection at repairs, and a few miscellaneous repairs.
- In 2019, the second repair project occurred, consisting of the installation of new traffic coating, isolated concrete floor repairs, concrete ceiling repairs, partial and full depth concrete beam repairs, concrete

column and wall repairs, replacement of expansion joints, crack and joint treatments, installation of cathodic protection at repairs, replacement of top-level barrier cables and railing, and some miscellaneous repairs. Most of the repairs primarily focused on the Village level of the North Pier parking structures, and some minor repairs were also carried on the Village level of South Pier parking structure.

OBJECTIVES

The objective of this investigation is to perform an update on the overall condition assessment and provide an opinion of probable cost for the necessary repairs, based on the observed conditions as well as our experience with similar parking structure conditions and repair costs. For this investigation and to meet the objective, we performed the following services:

1. Reviewed previous Condition Appraisal Reports prepared by Walker Consultants, dated August 2012 and October 2015 respectively.
2. Reviewed Owner Review Construction documents and project specifications prepared by Walker Consultants, dated January 2017.
3. Reviewed Construction documents and project specifications prepared by Walker Consultants, dated March 2019.
4. Reviewed existing framing plans of the parking structure to aid in our observations.
5. Conducted a field evaluation of the parking structure to document the current exposed conditions of the structural and waterproofing elements. This consisted of visual observation as well as limited non-destructive testing to review the following elements: floors, columns, beams, walls, ceilings, façade, and other structural elements.
6. Identified potential structural related conditions that require immediate attention.
7. Compiled and reviewed all field data to determine possible causes and effects of the documented deterioration.
8. Outlined the repair program requirements for a Single-Year AMP.
9. Outlined the repair program requirements for a 5-Year AMP.
10. Provided an opinion of probable cost for implementing the repairs.
11. Phased the work according to priority over a multi-year program to assist with fiscal planning.
12. Prepared the current report with a summary of observations, including photographs depicting the areas noted in the report, findings.

The objective of the 5-year Budget Forecast is to provide the City of Redondo Beach with an asset management tool for planning and budgeting of capital expenses over the next 5 years. The 5-year plan recommends restoration capital improvements and work items for this parking facility so that the Owner can maximize the service life of the structure with the least amount of capital cost.

PARKING STRUCTURE DESCRIPTION

South Pier Parking Structure

The South Pier Parking Structure was constructed in 1973 and has experienced 48 years of service life. The parking structure was constructed of cast-in-place conventionally reinforced concrete slabs, beams, girders, and columns. From drawings received, the exposed plaza upper level is referred to as the Village Level, the mid-level is referred to as the Pier Level, and the lowest level is referred to as the Basin Level.

The Village Level has several multi-story wood framed structures used for commercial purposes. Sidewalks and curbs outline a roadway and circular drives throughout the level. The roadway serves as access to the Village

Level of the North Parking Structure. Signage at the South Pier entrance to the Village Level limits vehicle weight to 6,000 pounds.

Plaza Parking Structure

The Plaza Parking Structure was constructed in 1981 and has experienced 40 years of service life. The structure is constructed of post tensioned cast-in-place concrete slabs, beams, girders, and traditional reinforced columns. From drawings received, the exposed upper parking level is referred to as the Plaza Level, the mid-level is referred to as the Pier Level, and the lowest level is referred to as the Basin Level.

The Plaza Level has concrete planters that contain sod, soil, and lightweight filler material on a waterproofed concrete slab. The waterproofing has a filter fabric and drainage layer. The Plaza Level is used for pedestrian traffic only. Portions of this level have a masonry tile application, grouted in-place. Drains are located along the west perimeter wall. Concrete planters surround the perimeter of the structure at this level on the west and north elevations.

Figure 1 shows an aerial view of the parking structures, and Figures 2 to 8 display the floor plans of the South and Plaza parking structures. Figures 9 to 14 show overall views of the exterior elevations of the parking structures. Figure 15 to 17 shows the recommended locations for traffic coatings.

Figure 1 – Aerial view of the parking structures (Google Earth Pro)

Figure 2- Basin Level- Slab on Grade, South Pier Parking Structure

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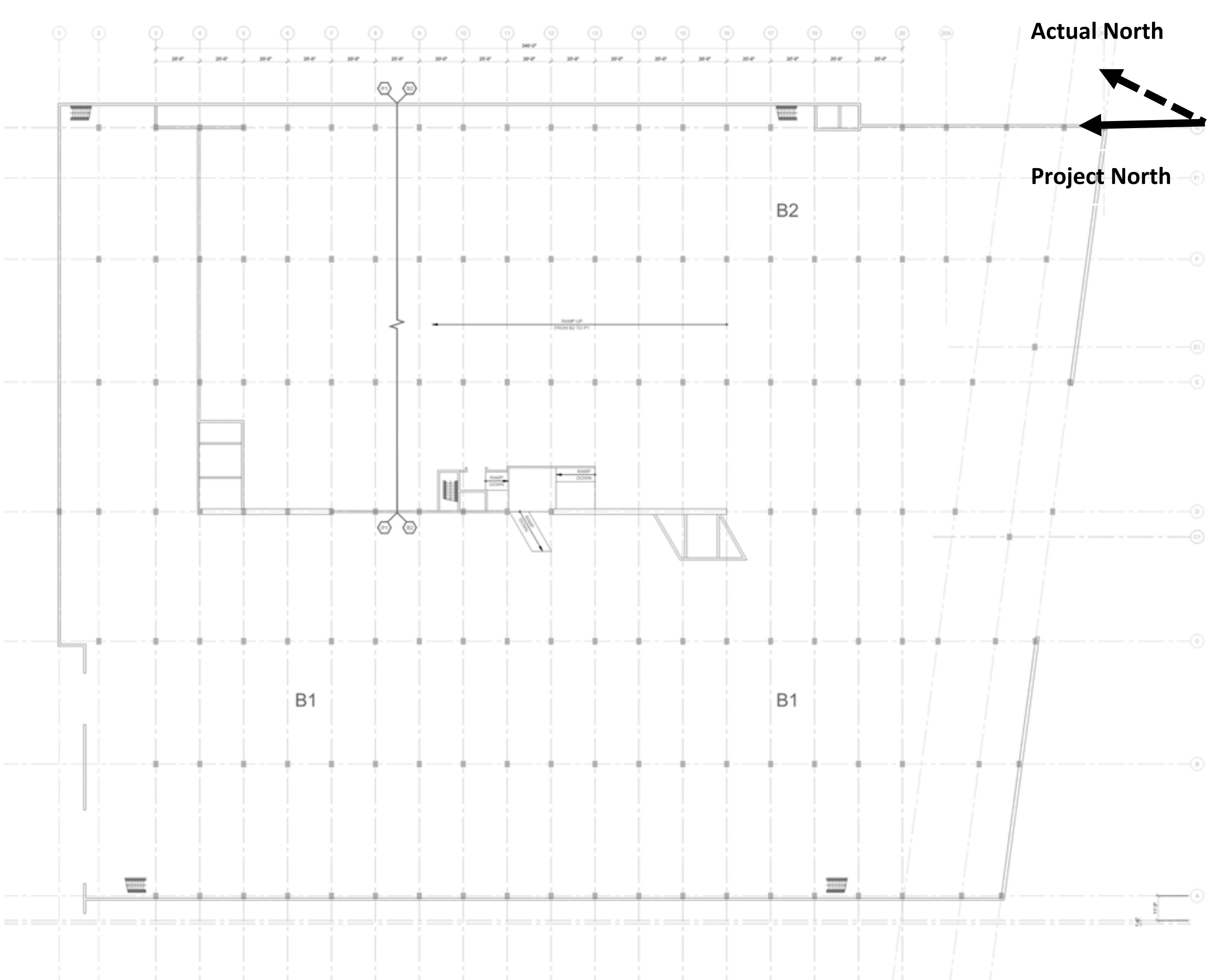


Figure 3-Lower Pier Level, South Pier Parking Structure

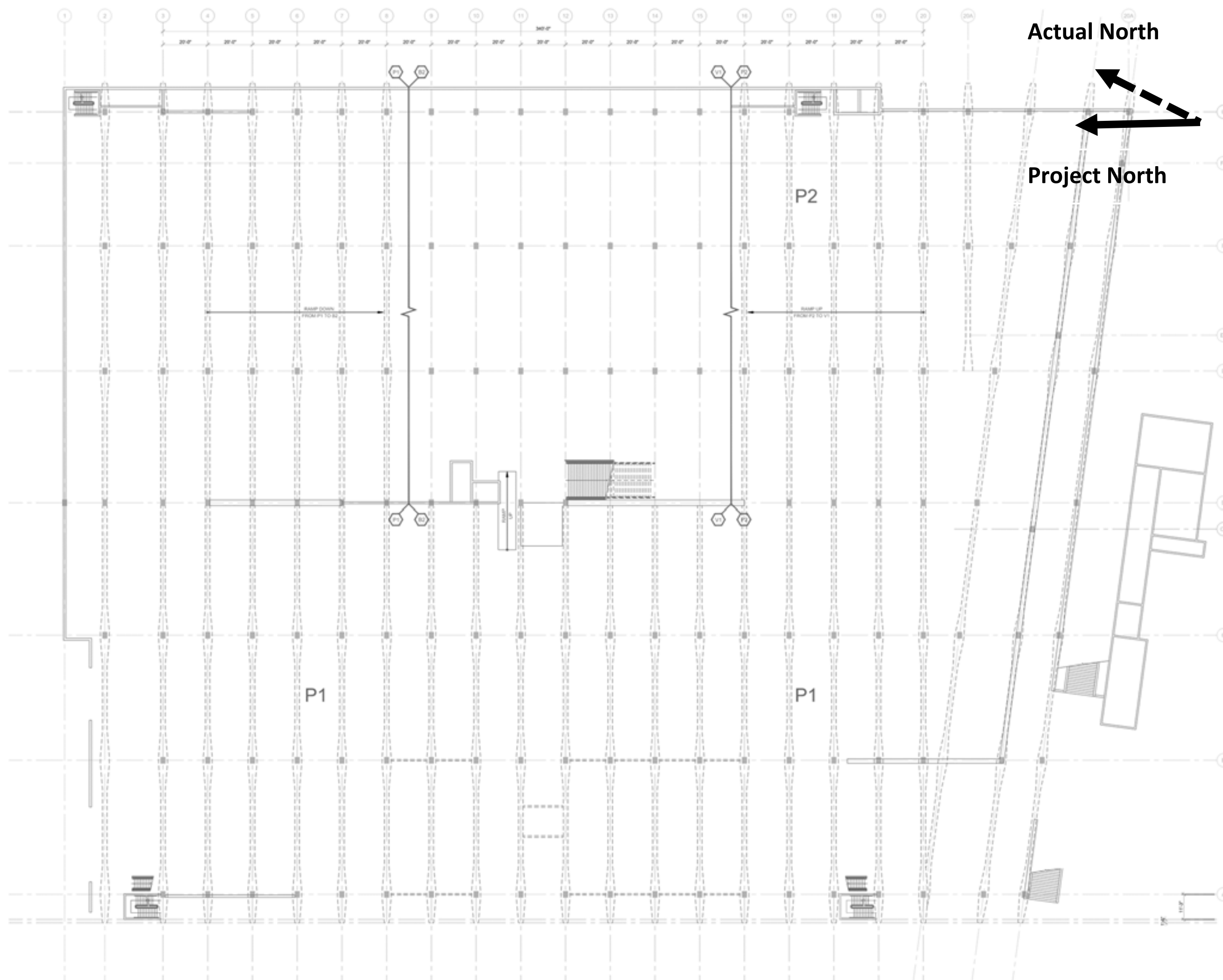


Figure 4- Partial Upper Pier and Lower Village Levels, South Pier Parking Structure

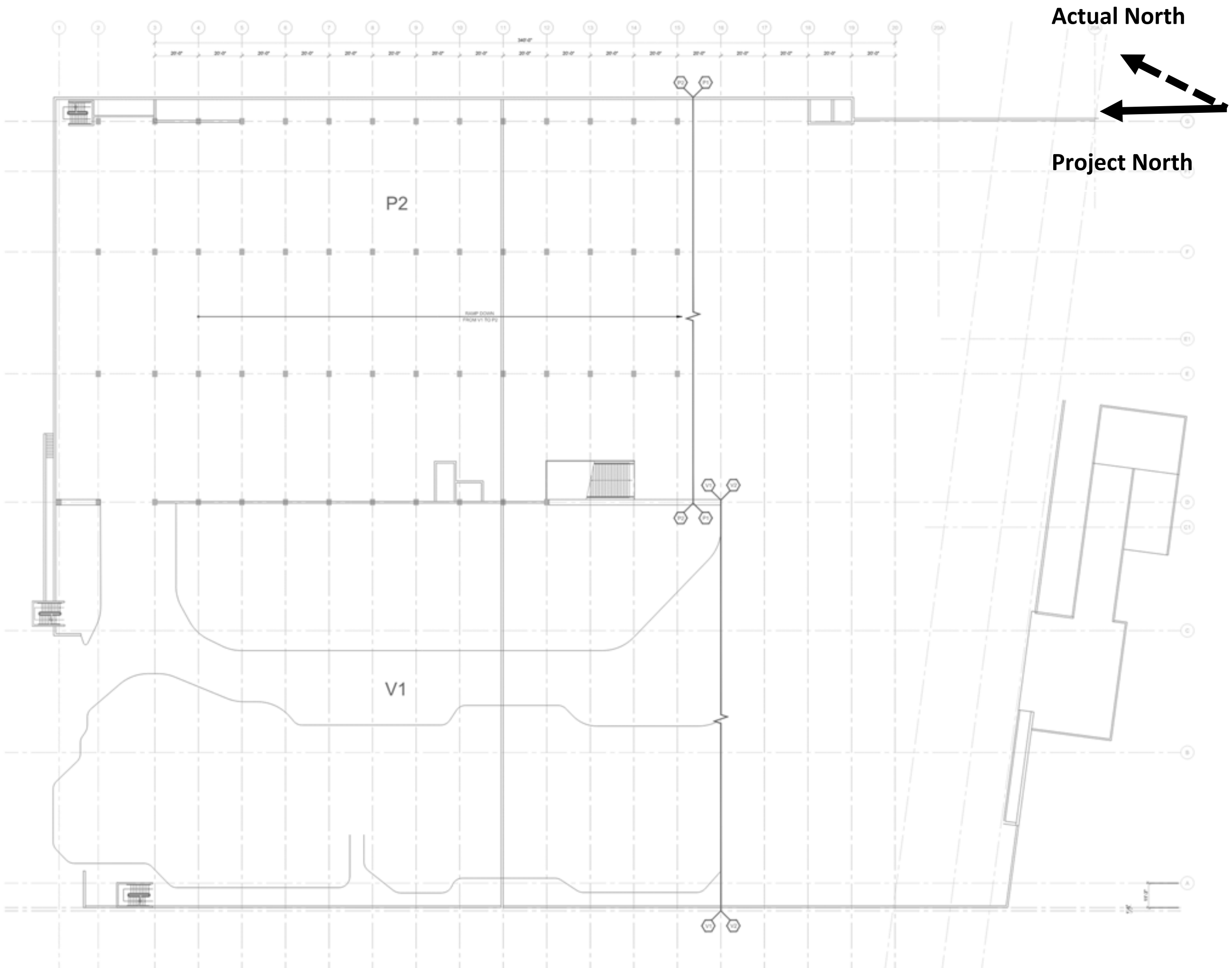


Figure 5- Upper Village and Partial Lower Village Levels, South Pier Parking Structure

Figure 6- Basin Level, Plaza Parking Structure

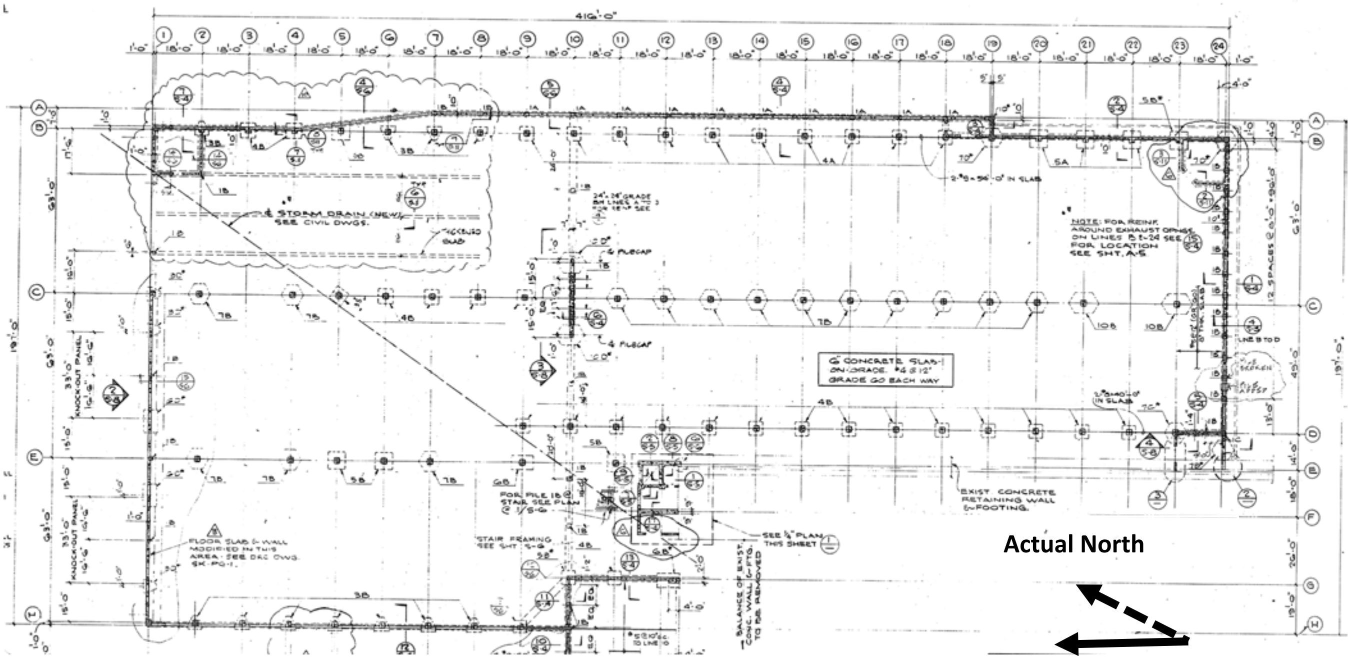


Figure 7- Pier Level, Plaza Parking Structure

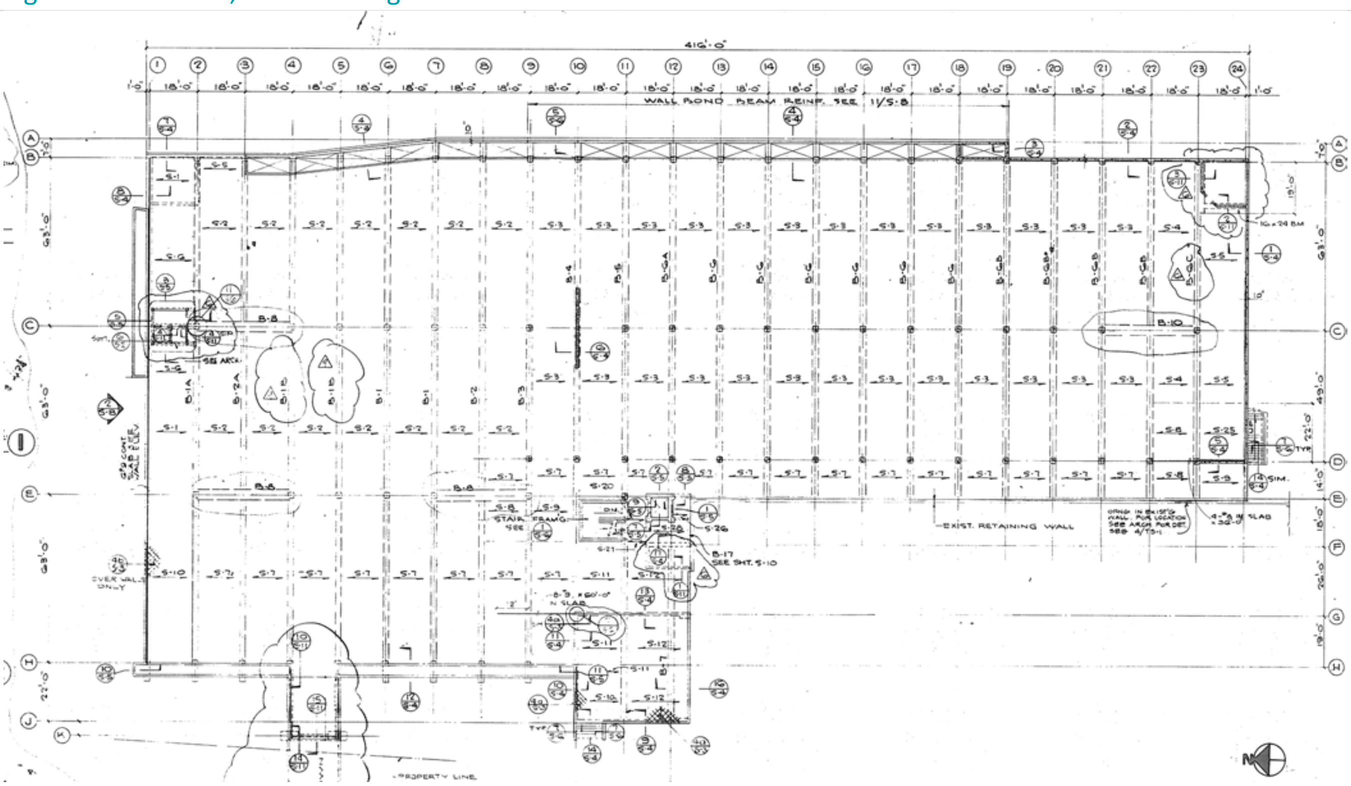


Figure 8- Plaza Level, Plaza Parking Structure

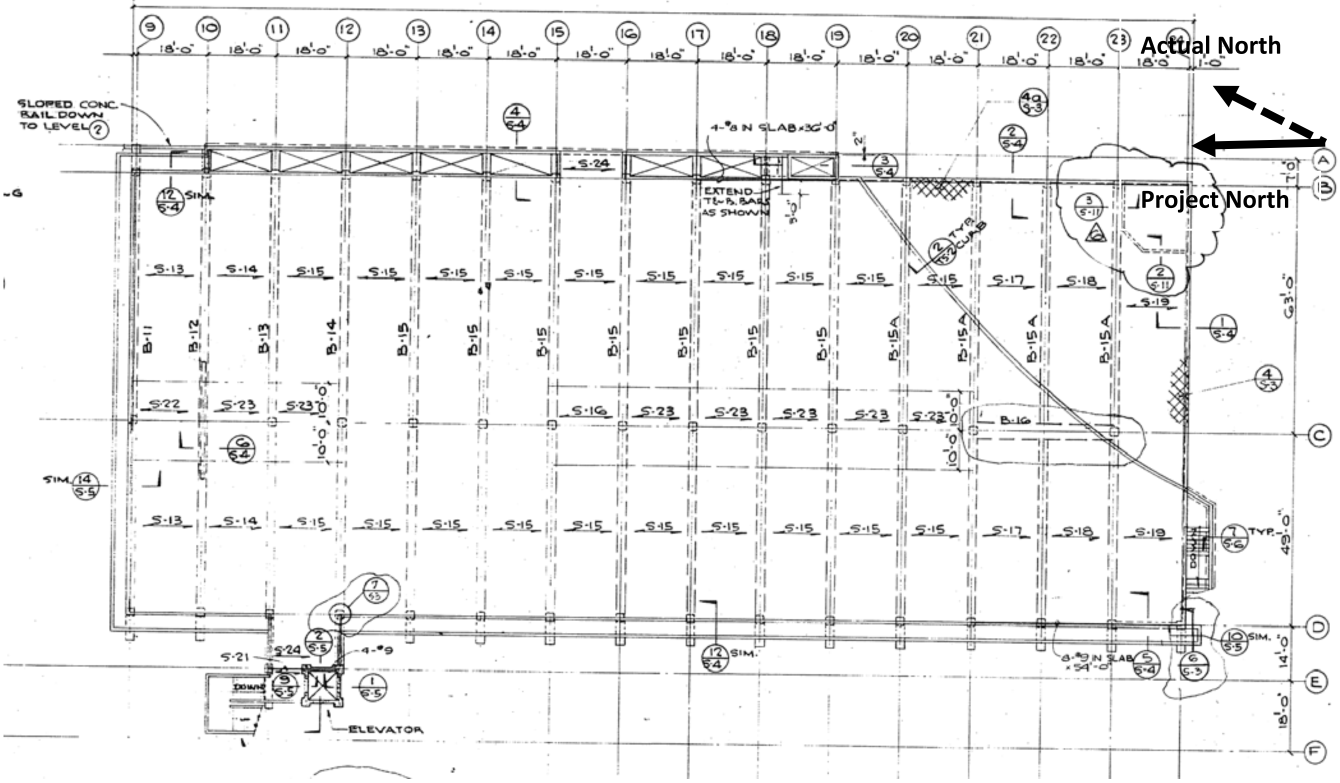


Figure 9- Overview of Village level, (South Pier Parking Structure) (BA1-167)

Figure 10- Partial North elevation, (South Pier Parking Structure) (SH2-71)

Figure 11- Partial West elevation, (South Pier Parking Structure) (SH2-248)

Figure 12– Overview of Plaza level, (Plaza Parking Structure) (BA1-293)

Figure 13– North elevation, (Plaza Parking Structure) (BA1-304)

Figure 14– Partial West elevation, (Plaza Parking Structure) (BA1-290)

RECOMMENDATIONS

Based on our visual observations, we found the South parking structure to be in ***fair*** condition and the Plaza parking structure in ***good*** condition. In the South parking structure, the concrete floors, ceilings, walls, and columns had some level of deterioration that needs to be addressed. Our assessment did identify specific locations where localized deterioration is visible in the structure. The Plaza parking structure is in good condition. The recent repair project has addressed the significant concrete deterioration and restored components of the waterproofing and structural systems. Based on the current condition of the Plaza parking structure, we recommend relatively fewer repair and protection actions. The implementation of these actions will further increase the long-term service life of the structures and improve the City's investment in the property.

To improve the parking structure's current condition, we have developed a Single Year and a 5-year repair program for the facility. The single-year repair program also has a cost associated with performing the recommended repair program shown in Table 1, and the 5-year program has an associated Asset Management Plan (AMP), respectively. The 5-year AMP contains repairs to address the currently deteriorated elements and preventive maintenance to address needs anticipated over the next 5-year period. It is important to note that some work items in the 5 -year program, such as recommended repairs on the Village level of the South Pier parking structure, are phased in multiple years. This phasing is provided as an option to the City considering allocated funds per fiscal year. We recommend that the City of Redondo Beach approximate the budget to implement the program over the next 5 years.

As stated above, two options are proposed - the first option is to perform risk management items and isolated structural or waterproofing repairs all in a Single-Year. This repair recommendation cannot address all deterioration or stop future deterioration from developing. Additional repair programs can be implemented after the completion of an initial repair program to extend the life of the structure further. The second option focuses on a Five-Year restoration program with the first-year service life extension program focusing on immediate repairs as well as the necessary repairs to extend the useful service life of the structure.

Please find below our recommendations based on our visual survey, selected impact acoustics survey, previous structural drawings, and documentation provided to us. We also reviewed the 2012 and 2015 Walker reports. The recommendations listed below are in synchronization with the 2012 and 2015 recommendations with relevant updates and editions.

IMMEDIATE REPAIRS - RISK MANAGEMENT

Immediate concerns are defined as items that may reduce pedestrian safety and/or structural integrity if not completed.

- Remove all loose and delaminated concrete from the slab and beam underside where delaminated concrete appears on the surface. Repairs to these areas can be deferred and addressed during the implementation of the base repair program shown below. Based on Walker's recommendations, the delaminated and loose concrete was removed by City personnel. It is highly recommended that work should be continued and included in a regular maintenance program.

RECOMMENDED BASE REPAIRS: YEARS 1-5

Based on our findings, we recommend implementation of a structured restoration plan, including repairs to structural elements, repairs of deterioration of the topping slab, repairs to the parking structure waterproofing systems and improvements to the facility drainage system to manage water runoff within the structure to address structural concerns, reduce future repair costs, and effectively extend the useful service life of the parking structure. The recommended restoration program concentrates on repairs to the deteriorated sections of the structure and future protection of its structural components. We recommend implementing the following repairs and maintenance in the next 5 years:

STRUCTURAL ITEMS

South Pier

- Remove and replace existing wearing slab on the Village level.
- Remove and replace existing brick pavers on the Village level.
- Partial and full depth concrete repair of all deteriorated structural slab concrete top and underside surfaces on the Village level.
- Partial and full depth concrete repair of all deteriorated structural slab concrete top and underside surfaces on the Pier level.
- Repair isolated spalling of the beam located below the expansion joint present towards the south side.
- Partial depth concrete beam, column, and wall repair on the Pier and Basin levels.
- Installation of passive cathodic protection systems in all repaired areas.
- Rout and seal unsealed cracks and replace failing crack sealant.
- Removal of all planters on the Village level, install concrete as needed.
- Complete the replacement of the entire fire suppression system of the structure.

Plaza Parking Structure

- Repair damaged P/T beam on the Basin level.
- Repair spalled precast concrete panels on the Village level.
- Repair trip hazards at stair tower landing slab and stair treads.
- Repair of a limited deteriorated structural slab concrete top and underside surfaces and beams/girders on the Pier level. Installation of passive cathodic protection systems.
- Partial depth concrete beam, column wall repair on the Basin level.
- Provide protective paint applications on all mechanical/electrical piping, conduit, and fixtures.

WATERPROOFING WORK ITEM

South Pier

- Install a plaza waterproofing system consisting of a fluid-applied urethane waterproofing membrane with drainage and filter fabric layers on top of the structural slab of the Village level.
- Install waterproofing sheathing along the base perimeters of the building structures on top of the Village level.
- Install new waterproofing coating on the remaining east side and west side of the Pier level.
- Recoat waterproofing membrane on the east side of the Pier level.
- Install supplementary drains and incidental piping in select locations of the Village level slab and/or at planter locations.

Plaza Parking Structure

- Recoat the existing urethane traffic membrane on the exposed portion of the Pier level.
- Install a urethane traffic membrane on the remainder of the Pier level.
- Application of topical corrosion-inhibitor and surface-penetrating sealers on all exposed surfaces that are not coated.
- Waterproofing repairs at tooled joints, cracks, vertical and cove conditions.

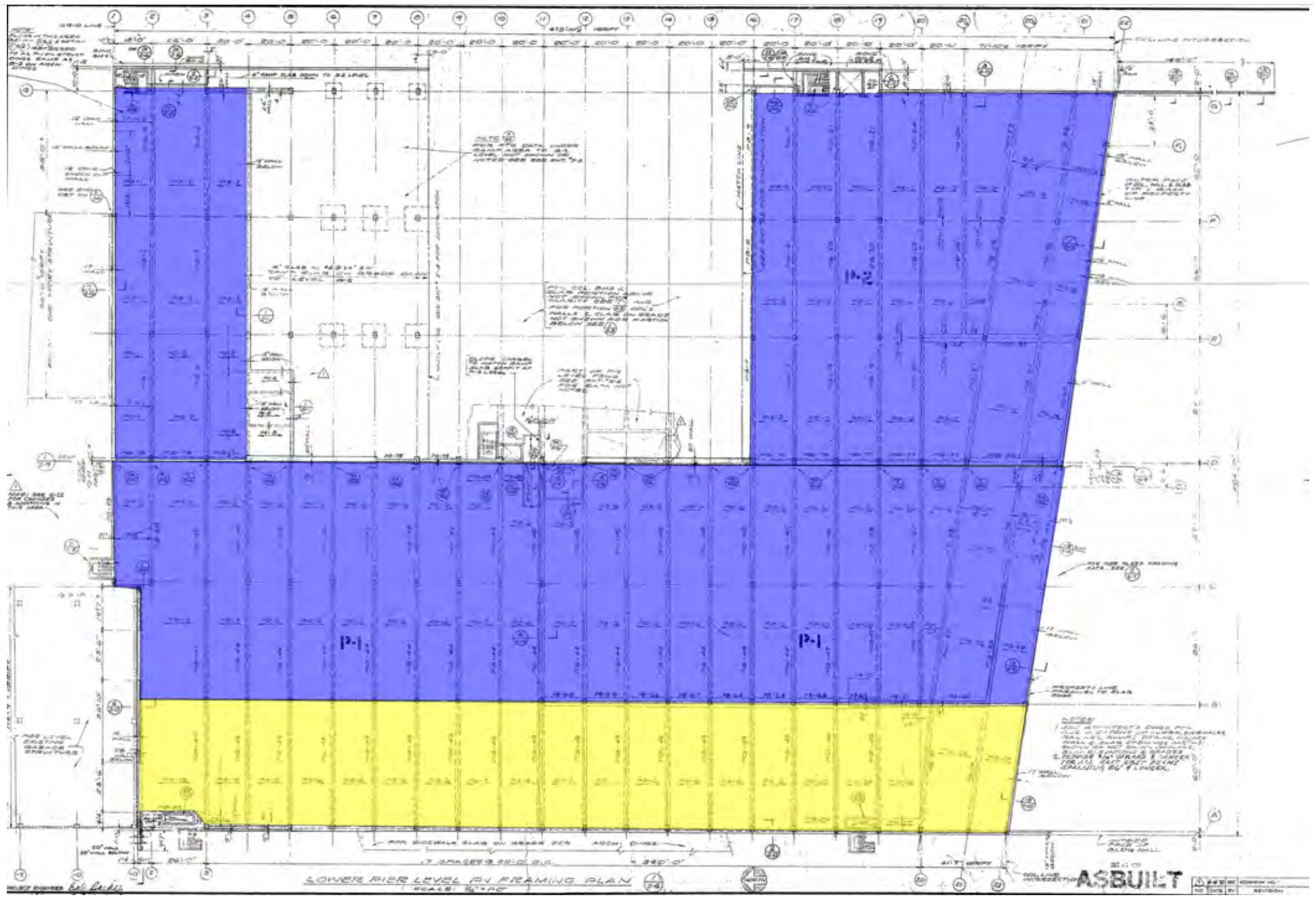
MECHANICAL, ELECTRICAL, AND DRAINAGE WORK ITEMS

- Isolated areas of ponding were observed and should be resolved by either cleaning out the existing drain (if present) or installing a supplementary drain.

MISCELLANEOUS ITEMS

- Clean and paint steel members of all stairs and fencings.
- Repaint traffic markings.

Figure 15– Proposed new traffic membrane and existing traffic membrane locations, Partial South Parking Pier Structure – Pier level

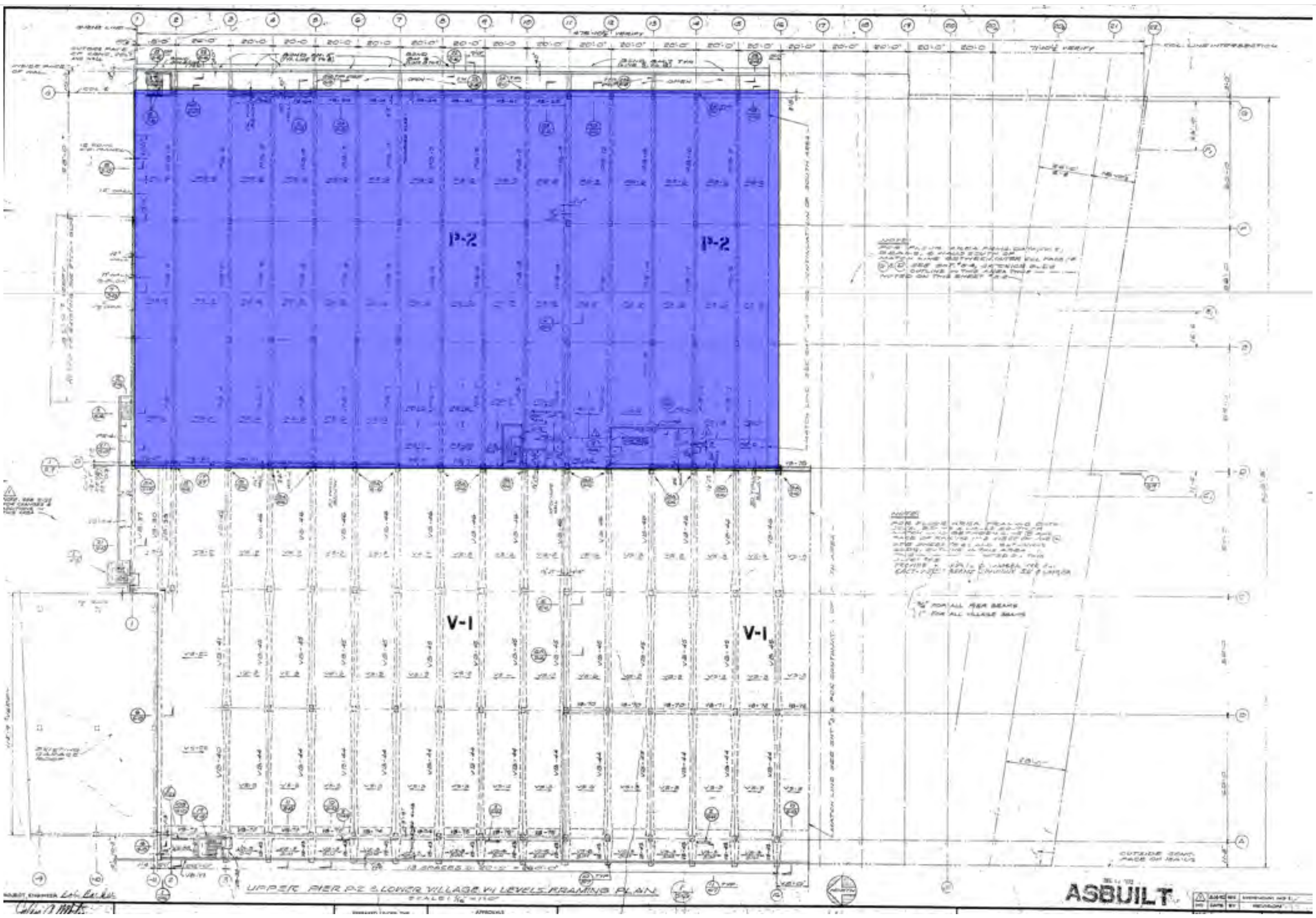


KEY:

RECOAT EXISTING TRAFFIC MEMBRANE

INSTALL NEW TRAFFIC MEMBRANE

Figure 16– Proposed new traffic membrane and existing traffic membrane locations, Partial South Parking Pier Structure- Pier level

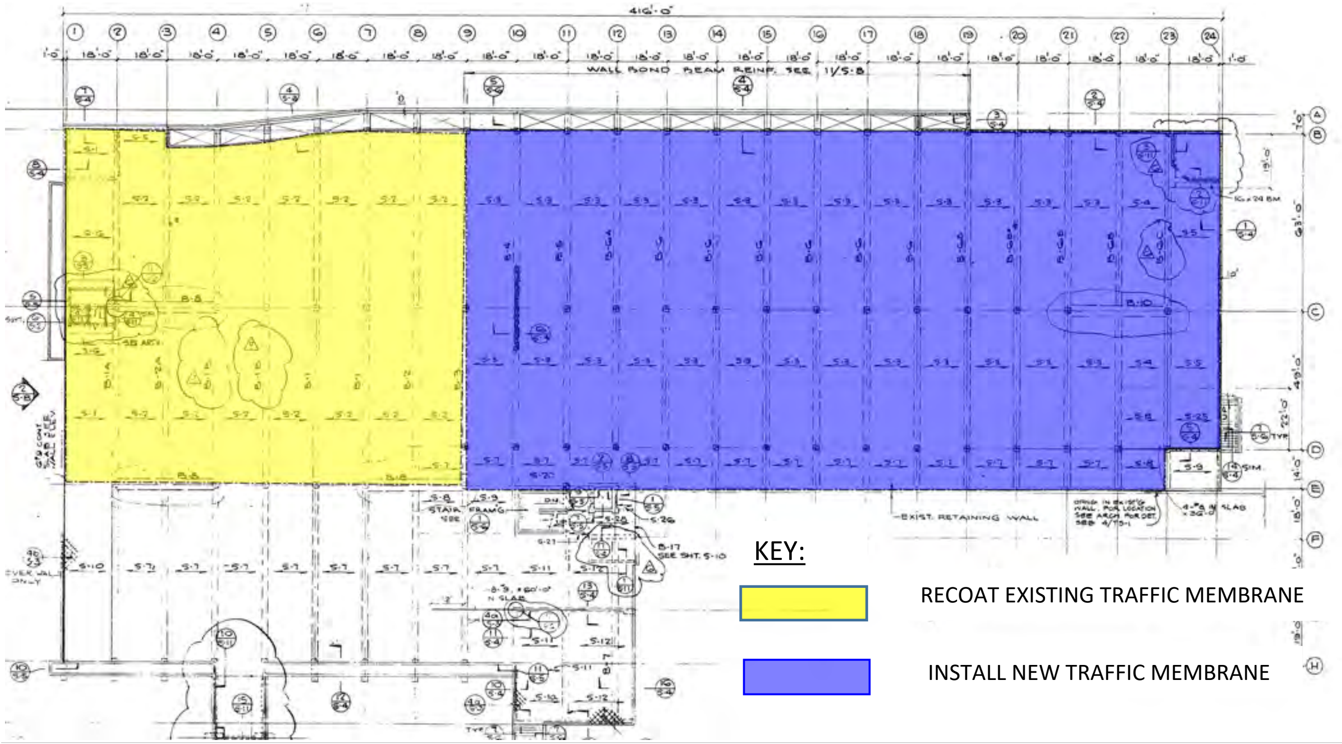


KEY:

RECOAT EXISTING TRAFFIC MEMBRANE

INSTALL NEW TRAFFIC MEMBRANE

Figure 17— Proposed new traffic membrane and existing traffic membrane locations, Plaza Parking Structure - Pier level



FUTURE PREVENTATIVE MAINTENANCE

Maintenance performed on a regular basis will take full advantage of the structural repairs and waterproofing work. Without maintenance, the facility will not see the expected service life from the structure or the repairs and waterproofing. Typical maintenance includes routine sealing of joints, recoating of wall and floor membranes along with periodic concrete repairs.

Funds for maintenance of the garage should be accrued yearly considering the life expectancies of certain elements such as sealants, coatings, floor membranes, concrete repairs, etc. The life expectancies expressed vary depending on workmanship, quality of materials, use and exposure to elements. After all the work is completed, the supported level should be washed down at least twice a year.

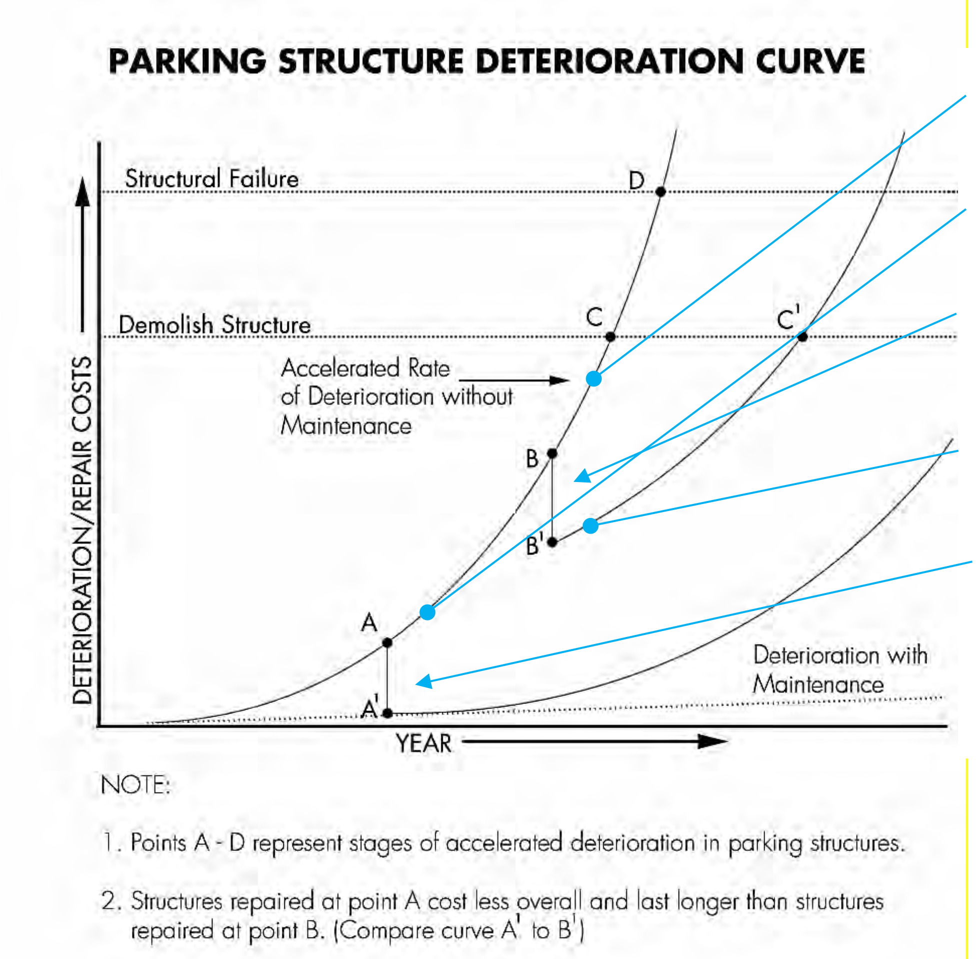
BENEFITS OF TIMELY REMEDIATION

There are many benefits to providing the repair and preventive maintenance program at the earliest feasible time, in addition to the imminent needs of providing the "Immediate Repairs" listed previously.

Long-term delay of repairs significantly increases cost. The cost to repair and maintain this facility will continue to increase at progressively faster rates when deterioration continues as modeled in the following graph. The main benefits from implementing the recommended repairs and waterproofing are:

- Mitigate the infiltration of water and chlorides.
- Maintain the structural capacity and maintain the service life of the structure.
- Cost savings due to avoidance of structural repairs that are more expensive and facility shutdown.
- Higher levels of service to the users of the facility due to fewer days of downtime because of more extensive structural repairs.

- Provides for a greater degree of safety by inhibiting deterioration mechanisms before they have a chance to cause serious harm.
- Long term delay of repairs significantly increases future costs.
- Less noise and disruption both within the garages and the buildings above.



"Poor" Garages are between points B and C

"Fair" and "Good" Garages are between points A and B

Short-term repairs (3-5 years) only move curve slightly (B to B1)

Repaired "Fair" and "Good" Garages are between points B^1 and C^1

Long-term repairs (12 to 20 years) move curve considerably (A to A1)

OPINION OF PROBABLE COSTS

The table below provides our opinion of probable construction costs for the recommended repairs for a Single Year restoration maintenance program. The costs were developed using pricing from our database obtained from similar type projects competitively bid in the Los Angeles area. We anticipate the work would be performed during daytime working hours and the work is phased around an operating garage. Costs for a single year restoration maintenance program are based upon single year construction and do not include inflation and escalation factors typically included for multi-year construction.

According to the American Concrete Institute Committee 362, *"Repairing an existing deteriorated structure involves many unknowns, uncertainties and risks. Especially with regard to repair of chloride caused corrosion damage, the process is considered an extension of the useful life of the deteriorated structure. It is not equivalent to building a new structure with current technology*."

With the development of repair programs such as in this report, contingency funds must be anticipated and included in any budget for repairs to account for concealed, unknown, or unanticipated conditions. For this type of restoration work, we recommend that a 10% contingency be set aside for potential changes due to unknown conditions. This contingency cost is included in the project costs. The cost estimates are based on second Quarter 2022 dollars.

For a detailed breakdown of each repair program, please see *Appendix* A of this report.

Table 1 – Single year Repair Program-Opinion of Probable Cost

YEAR	BUDGET
2022	$ 2,145,000
Total	**$ 2,149,500**

Recommended Five – Year Repair Program

The table below provides our opinion of probable construction costs for the recommended repairs for a Five-Year restoration maintenance program.

A multi-year phasing scheme has its benefits with respect to capital outlay and phasing of work to maintain greater operation capacity within the facility. Multi-year planning allows the owner to budget capital expenditures annually without creating a significant burden to the budget in any single year. The disadvantage to a multi-year phasing plan is continued degradation of the non-repaired areas. In addition, the cost of the repair program can be expected to grow due to inflation, wage increases, and multiple mobilizations by the contractor.

The following multi-year plan and table outline the effects of inflation, multiple mobilizations, and the growth of deterioration over the multi-year period. Appendix A at the end of this report includes a more detailed cost estimate for this approach.

Table 2 - Five-year Repair program–Opinion of Probable Costs

YEAR	BUDGET
2022	$ 2,095,000
2023	$ 3,320,000
2024	$ 5,016,000
2025	$ 4,423,500
2026	$ 296,000
Total	**$ 15,150,500**

NOTES:

1. Cost opinions are based on historical data and experience with similar types of work and are based on 2022 prices.
2. Actual costs may vary due to time of year, local economy, or other factors.
3. Cost opinions do not include costs for phasing, inflation, financing or other owner requirements, or bidding conditions.
4. Costs have been increased 3% for inflation each year.
5. Cost opinions do not include upgrades if it becomes necessary to bring the structure up to current building code requirements, seismic upgrades, or for ADA or similar items.
6. The structure has not been reviewed for the presence of, or subsequent mitigation of, hazardous materials including, but not limited to, asbestos and PCB.

NOTE: The budget costs presented are based on historic data. The effects of the COVID-19 pandemic have resulted in changing costs and schedules, therefore, these costs should be considered a rough order of magnitude and used for basic planning purposes. Until the project is designed and bid by a contractor the actual costs may not be realized.

Recommended Ten – Year Repair Program (South Pier Parking Structure)

Per City's request, as an alternative for City to consider, Walker has also developed a Ten-Year repair program for the South Pier parking structure. The opinion costs for the recommended 10- year repair program for the South Pier parking structure is currently **$ 16,970,000** in 2022 dollar. The recommended South Pier parking structure maintenance and repair budget for the next ten years is shown below in Table 3, followed by a detailed breakdown in Appendix A.

Table 3 - Ten-year Repair program (South Pier Parking Structure)–Opinion of Probable Costs

YEAR	BUDGET
2022	$ 1,967,000
2023	$ 1,250,000
2024	$ 1,642,000
2025	$ 2,067,000
2026	$ 2,657,000
2027	$ 2,339,000
2028	$ 1,886,500
2029	$ 1,540,000
2030	$ 152,500
2031	$ 1,469,000
Total	**$ 16,970,000**

IMPLEMENTATION

The outlined repair program can be competitively bid and executed by experienced restoration contractors. The first step in this process is to obtain a quality set of bidding documents prepared by experienced restoration engineers. These documents should be procured to ensure repairs are designed appropriately and quantities are sufficiently estimated to competitively bid the project by restoration contractors.

DISCUSSION

Walker developed the original AMP program for the parking structures in 2012 for the City of Redondo Beach. The AMP is a dynamic plan that is most effective when scheduled maintenance is performed, and the plan is updated periodically. Since 2012, the City of Redondo Beach has engaged Walker to perform updated evaluations and planning in 2015. The City of Redondo Beach has performed isolated concrete and waterproofing repairs between 2017 and 2019 for needed repairs and preventative maintenance on the parking structures. The purpose of this update is to bring the asset management plan up-to-date based on the previously completed work and Walker's observations of the parking structures current condition.

The following discussion section provides a brief explanation of the survey findings to aid in understanding the nature and causes attributing to observed deficiencies, deterioration mechanisms, maintenance problems, and damage which form the basis of our recommendations. Refer to Walker's 2012 and 2015 condition appraisal reports for more information on causes attributed to the observed deficiencies.

Our primary focus of the condition assessment was to identify and update the 2012 and 2015 Walker findings and accordingly develop updated repair protocols that will keep the structures operational for 10 to 15 additional years. In addition to this, we have developed a Single-year repair program that only includes risk management items and isolated structural or waterproofing repairs as discussed below.

OPTION A: SINGLE-YEAR PROGRAM

This repair option includes risk management items and isolated structural or waterproofing repairs. But, as seen in the above figure, repairs cannot address all deterioration or stop future deterioration from developing. This typical scenario is represented by Curve B in the figure above. As seen in this curve, the repair program can address only some of the deterioration, and new deterioration begins to form in areas that were not repaired and at areas surrounding the repairs due to the galvanic ring anode effect.

Additional repair programs can be implemented after the completion of an initial repair program to extend the life of the structure further. But, because new deterioration is anticipated to develop in areas outside of the previous repairs and the life of concrete repairs performed is typically less than the original construction, each future repair program is anticipated to be larger and more costly.

OPTION B: 5-YEAR PROGRAM

This repair option includes risk management items and addresses structural and waterproofing repairs/upgrades to extend the service life of the structure for a limited period. This repair does partially address the corrosion occurring at the spalled areas. This option includes applying a high-performance waterproofing system on the Village slab of the South Parking structure. This waterproofing system will need minimum maintenance and can extend the service life of the garage beyond 10 - 15 years.

Below, please find a review of the conditions of the Redondo Beach South and Plaza Parking Structure.

IMMEDIATE REPAIRS - RISK MANAGEMENT

We observed spalled and loose concrete on multiple locations on both – Pier and the Village level ceiling of the South parking structure. The loose concrete can get detached and introduce a life safety hazard to pedestrians. Remove all loose and delaminated concrete from the slab and beam underside where delaminated concrete appears on the surface. Repairs to these areas can be deferred and addressed during the implementation of the base repair program shown below. Based on Walker's recommendation, these delaminated and loose concrete were removed by City personnel. It is highly recommended that work should be continued and included in a regular maintenance program. Walker recommends all supported slabs, beams, columns, and walls to be reviewed on a regular basis by visual means and sounded by hammer tapping along spalls. Any overhead spalled areas found are a potential safety hazard. The City should continue to review areas of potentially loose and cracked concrete and remove them before they become an overhead hazard.

STRUCTURAL WORK ITEMS

Concrete deterioration is typically caused by the restrained movement of the structure, water intrusion and corrosion of the embedded reinforcement.

Corrosion of steel is an expansive process. As the corrosion expands in size, the corroded product pushes outward on the surrounding concrete. When the bursting forces exceed the tensile strength of the concrete, cracking, delamination, and eventually spalling occur within the concrete. Concrete deterioration within structural elements (floors, beams, and columns) is a concern because the deterioration could result in a reduction of the load-carrying capacity. Manifested concrete deterioration will frequently lead to an acceleration of the deterioration and increased repair costs.

Concrete deterioration is especially harmful to the reinforcement contained within. Steel reinforcement is highly susceptible to corrosion, which occurs when iron (steel) is exposed to oxygen and moisture over time. However, when steel is encased in concrete or mortar, the cementitious material provides a protective oxide layer around the steel reinforcement and prevents the corrosion process from occurring. When steel reinforcement corrodes, it expands causing more cracking and spalling which then decreases the passive corrosion resistance. This self-fueling cycle is why it is important to perform repairs as early as feasibly possible to reduce the amount of deterioration the structure experiences.

STRUCTURAL

South Pier Parking Structure

The 2012 and 2015 condition assessments indicated through both observations and material testing that the parking structures are experiencing varying degrees of deterioration. Based on our observations, the condition of the South Pier parking structure has worsened over time. The most likely explanation for this worsening of the structural durability is due to the delay in implementation of the repair recommendations proposed by Walker in 2012 and 2015 condition assessment reports. However, the replacement of the expansion joint on the Village level was a significant step to hinder the water intrusion. We also noticed the repairs performed during the 2017 repair program at the West end of the South parking structure on the spandrel beams seemed to be working well. During the investigation, several regions were identified where fresh concrete spalling was evident mostly on the elevated slabs.

Even though the parking structure is currently in fair condition, corrosion related deterioration was found throughout the structure. The structure has not yet been greatly affected by the occurring corrosion activity and can be repaired and protected now to mitigate further deterioration. If protection and repairs to the structure are again deferred, then the corrosion activity will continue to deteriorate the structure at an accelerated rate. We have proposed two possible options of repairs and protection. See Appendix A for further information.

Most of the concrete deterioration in the South Pier parking structure is related to long-term environmental exposure that has led to corrosion of the embedded reinforcing steel. In typical reinforced concrete structures, the reinforcing steel is protected from corrosion by a high pH layer that the concrete forms around the reinforcing steel. The high pH layer can breakdown over time when the concrete is exposed to carbon dioxide or chlorides. Once the high pH layer has broken down, reinforcing steel corrosion can occur when water and oxygen are present.

To mitigate the potential for reinforcing steel corrosion, we provide a two-part strategy to provide long-term corrosion protection:

1. The first part of the corrosion protection strategy is the installation of a waterproof membrane coating on the concrete surfaces (discussed in the following section) to eliminate water penetration into the deck and slow the corrosion process.
2. The second part of the corrosion protection strategy involves the application of an electrochemical treatment to counter the remaining corrosion process after the water is shut off.

Plaza Parking Structure

The recent repair project has addressed the significant concrete deterioration and restored components of the waterproofing and building systems. The concrete structural elements within the Plaza parking structure were generally in good condition, with only a few minor isolated areas of spalled or delaminated cover concrete noted in the entire structure. We recommend repairing these areas by removing all loose concrete and concrete immediately surrounding embedded reinforcement, cleaning any corrosion off the embedded reinforcement, applying a corrosion-inhibiting coating to the exposed reinforcement, and finishing the area with a high-performance repair mortar to stop the spread of the damage at this early stage. Also, we identified one partially exposed and damaged post-tensioning beam tendon on the Basin level. We recommended repairing the P/T tendon in both proposed repair programs. In addition, concrete stair deterioration was observed. Deteriorated concrete steps can be a trip hazard to pedestrians and should be repaired. We also identified several unsealed cracks on the Pier level with direction parallel to the primary P-T reinforcement. Based on our visual observation, we do not believe these cracks are a structural concern and it is likely that these cracks were present during Walkers last condition assessment and are now visible. We recommend routing and sealing these cracks to keep moisture away from the reinforcement.

WATERPROOFING SYSTEMS

Waterproofing is essential for structures to meet, and in some cases exceed, their intended lifespan especially in structures exposed to acidic environments such as the South Pier and Plaza parking structures. Parking structures are unique in that they are often exposed to the elements and consequently are often overlooked in terms of their waterproofing measures. Cracking, spalling, or exposed joints are all opportunities for moisture intrusion. Concrete itself is a porous material and will inherently allow some moisture to penetrate beyond the surface. Water intrusion is detrimental to the structural integrity and lifespan of a structure, especially for reinforced concrete or steel structures. Waterproofing membranes or sealers are often used in addition to crack and joint sealants to protect the underlying structural elements and prevent water ingress.

South Pier Parking Structure

The Village level consists of a supported deck over the parking structure. The Village level is comprised of topping slab, planters, existing buildings, and brick paved walkways and driveways laid over a structural deck slab. All these components must be thoughtfully designed and detailed to produce a comprehensive and effective system.

Due to the buried and layered nature of the waterproofing elements in similar deck systems, leaks are difficult to discern and locate. It is possible to visually observe leaks through the underside of structural slabs; however, since moisture can migrate laterally above and through the slab, it can be difficult to detect and locate breaches using this method. Test methods such as thermal imaging, and low and high voltage testing exist to provide effective means of locating and repairing leaks within a plaza system.

At the raised sidewalk plaza area, there were several failed sealant joints and unsealed cracks. It is believed that there is a waterproofing system beneath the raised sidewalk. Buried waterproofing systems typically have a life expectancy of 30+ years and can be very costly to replace because they require the removal of the sidewalk. We recommend a program be developed to replace the buried waterproofing system as needed. Our 5-year cost opinion includes full replacement of the plaza waterproofing and concrete topping slab.

Plaza Parking Structure

With the repairs completed under the recent restoration project, the implementation of a preventative maintenance plan provides a programming tool for the City to budget for future maintenance needs of the Plaza parking structure. This preventative maintenance plan focuses on the maintenance cycle of waterproofing items such as traffic membrane, sealants, expansion joints, and other items that protect underlying materials and not day-to-day operational maintenance such as sweeping, trash removal, and cleaning.

With the Plaza parking structure located near the marine environment, the focus of the maintenance will be installing new traffic membrane on the remainder of the Pier level structural slab and recoating the existing traffic coating on the Pier level. Traffic coating also typically sees wear on the high abrasion areas such as sharp turns along main travel paths and requires recoating with a texture coat in 6- 8 years. Sealants and expansion joints on covered levels typically have a service life of 10-12 years.

OBSERVATIONS

On November 3, 4, and 10, 2021, Walker Consultants performed a condition assessment of the South and Plaza Parking Structures. The assessment consisted of a visual review of representative exposed structural elements (columns, beams, walls,) and waterproofing elements (sealants and expansion joints). Our assessment also included chain dragging and hammer sounding of representative areas to identify concrete delaminations and possible corrosion of the embedded steel reinforcement. In addition, a limited visual review of the structures' façade was performed from the Ground level.

The following conditions were noted. The referenced photographs are included in Appendix B.

South Parking structure

Village Level

- Chain drags sounding of the Village level floor revealed isolated floor deterioration. Sounding the previous floor repairs indicated delamination which indicated that the repairs are not generally performing acceptably. Isolated floor cracks were also observed (Photo 1.1 to 1.5).
- Typical concrete topping deterioration with exposed and corroded reinforcement was observed primarily on the Village level along drive lanes (Photos 1.6 and 1.7).
- Typical Village level soffit slab deterioration and spalls with exposed and corroded reinforcement (Photos 1.8 and 1.9).
- Typical cracked and spalled pavers at Village level (Photos 1.10 and 1.11).
- Expansion joint cover plate bolts were seen projecting out, missing or loose (Photos 1.12 and 1.13).
- Typical deteriorated / spalled concrete planter walls (Photos 1.14).
- Fiber reinforcing wrap on the underside soffit surfaces of the Village level is deteriorated due to the moisture entrapment (Photos 1.15 and 1.16).

Pier Level

- Chain drags sounding of the Pier level floor revealed isolated floor deterioration. Sounding the previous floor repairs indicated delamination which indicated that the repairs are not generally performing acceptably. Isolated floor cracks were also observed (Photo 1.17 and 1.18).
- Typical concrete slab deterioration with exposed and corroded reinforcement was observed primarily on Pier level on the northeastern side (Photos 1.19 to 1.21).
- Isolated slab edge deterioration and spalls with exposed and corroded reinforcement (Photos 1.22 and 1.23).
- Isolated concrete wall delamination and spalling with exposed rebars (Photos 1.24 and 1.25).
- Typical Pier level soffit slab deterioration and spalls with exposed and corroded reinforcement (Photos 1.26 to 1.28).
- Isolated beam deterioration with exposed and corroded reinforcement was observed primarily below the expansion joint (running north-south at south end of the garage) with other isolated locations (Photos 1.29 and 1.30).
- Urethane traffic membrane was observed in poor to fair condition on the West side of the entire Pier level. Most of the high-traffic turning radii has worn surfaces with aggregate roll-out observed (Photos 1.31 and 1.32)

- The fiber reinforcing wraps with added concrete cover at select columns on the west elevations were observed. Also, some of the underside soffit surfaces of the Pier Level had received fiber reinforcing wrap (Photos 1.33).
- Underside drain piping was corroding (Photo 1.34 and 1.35).

Basin Level

- Typical slab on grade spalls (Photo 1.36 and 1.37).
- Minor isolated concrete spalling was observed at the corners of the interior columns at a few locations on the basement and main parking levels (Photo 1.38).

Stair Towers

There are five stair towers servicing the garage: stair #1, located on the northeast side of the garage; stair #2, located on the southeast side of the garage; stair #3, located on the northwest side of the garage; stair #4, located on the southwest side of the garage; and stair #5, located in the center on the middle spline of the garage. Overall, all stair systems appear in fair to good condition, with the following observed:

- Stair #2, 3, and 4:
    - Stair treads coating are peeled off (Photo 1.39 and 1.40).
- Stair #5:
    - Corrosion can be seen on all steel railing surfaces (Photo 1.41 and 1.42).

Plaza Parking structure

Plaza Level

- Typical precast concrete spandrel deterioration with exposed and corroded reinforcement (Photo 2.1 and 2.2).
- Missing roof tiles above the stair tower were observed (Photo 2.3).
- Drains were plugged with leaves and minor amounts of trash (Photo 2.4).

Pier Level

- Isolated concrete floor deterioration with exposed and corroded reinforcement was observed primarily on Pier level (Photos 2.5).
- Isolated Pier level soffit slab corner deterioration and spalls with exposed and corroded reinforcement (Photos 2.6 and 2.7).
- Typical floor cracks were also observed (Photo 2.8).
- Typical ceiling cracking was observed parallel to most of the beams of the Pier Level (Photo 2.9)

Basin Level

- Isolated delaminated concrete ceiling (Photo 2.10).
- Isolated delamination on the concrete walls exposing corroded reinforcement (Photo 2.11 and 2.12).
- Concrete stair deterioration was observed (Photo 2.13 and 2.14).
- Isolated damaged P/T rebar of a concrete beam (Photo 2.15).

Exteriors

- Slab edge spalling and exposed rebar was observed mainly at the southwest end of South Pier parking garage. (Photo 3.1).
- Isolated concrete curb delamination was observed at the south end of South Pier parking garage (Photo 3.2).
- Isolated concrete wall delamination with exposed corroded rebar was observed on the south end of the South Pier parking garage (Photo 3.3).

LIMITATIONS

This report contains the professional opinions of Walker Consultants based on the conditions observed as of the date of our site visit and documents made available to us by the City of Redondo Beach (Client). This report is believed to be accurate within the limitations of the stated methods for obtaining information.

We have provided our opinion of probable costs from visual observations and field survey work. The opinion of probable repair costs is based on available information at the time of our condition appraisal and from our experience with similar projects. There is no warranty to the accuracy of such cost opinions as compared to bids or actual costs. This condition appraisal and the recommendations therein are to be used by Client with additional fiscal and technical judgment.

It should be noted that our renovation recommendations are conceptual in nature and do not represent changes to the original design intent of the structure. As a result, this report does not provide specific repair details or methods, construction contract documents, material specifications, or details to develop the construction cost from a contractor.

Based on the agreed scope of services, the condition appraisal was based on certain assumptions made on the existing conditions. Some of these assumptions cannot be verified without expanding the scope of services or performing more invasive procedures on the structure. More detailed and invasive testing may be provided by Walker Consultants as an additional service upon written request from Client.

The recommended repair concepts outlined represent current generally accepted technology. This report does not provide any kind of guarantee or warranty on our findings and recommendations. Our condition appraisal was based on and limited to the agreed scope of work. We do not intend to suggest or imply that our observation has discovered or disclosed latent conditions or has considered all possible improvement or repair concepts.

A review of the facility for Building Code compliance and compliance with the Americans with Disabilities Act (ADA) requirements was not part of the scope of this project. However, it should be noted that whenever significant repair, rehabilitation, or restoration is undertaken in an existing structure, ADA design requirements may become applicable if there are currently unmet ADA requirements. Similarly, we have not reviewed or evaluated the presence of or the subsequent mitigation of hazardous materials, including, but not limited to, asbestos, and PCB. In addition, seismic evaluation of the subject parking structure for compliance with the current building code was not part of the scope of this project.

This report was created for the use of Client and may not be assigned without written consent from Walker Consultants. The use of this report by others is at their own risk. Failure to make repairs recommended in this report in a timely manner using appropriate measures for safety of workers and persons using the facility could increase the risks to users of the facility. The client assumes all liability for personal injury and property damage caused by current conditions in the facility or by construction, means, methods, and safety measures implemented during facility repairs. Client shall indemnify or hold Walker Consultants harmless from liability and expense, including reasonable attorney's fees incurred by Walker Consultants as a result of Client's failure to implement repairs or to conduct repairs in a safe and prudent manner.

APPENDIX-A

TABLE A1 - Executive Summary – 5 Year Budget Forecast

Table CS-1
Combined Structures
Executive Summary

WALKER CONSULTANTS

WORK DESCRIPTION	TOTAL COST	2022	2023	2024	2025	2026
Work Categories						
General Conditions	$ 1,648,000	$ 228,000	$ 361,000	$ 545,500	$ 481,000	$ 32,500
Structural / Concrete Repairs	$ 7,060,500	$ 1,149,000	$ 1,717,000	$ 3,114,500	$ 1,080,000	$ -
Waterproofing	$ 3,646,000	$ 360,000	$ 680,000	$ 520,000	$ 2,086,000	$ -
Stair Tower Repair	$ 55,000	$ 3,000	$ -	$ -	$ -	$ 52,000
Mechanical / Electrical / Plumbing	$ 136,500	$ -	$ 8,000	$ -	$ -	$ 128,500
Architectural / Miscellaneous	$ 71,500	$ -	$ -	$ -	$ 38,500	$ 33,000
Functional & Accessibility	$ 5,000	$ 5,000	$ -	$ -	$ -	$ -
Contingency 10%	$ 1,264,000	$ 175,000	$ 277,000	$ 418,000	$ 369,000	$ 25,000
Consulting & Engineering Fees	$ 1,264,000	$ 175,000	$ 277,000	$ 418,000	$ 369,000	$ 25,000
Opinion of Annual Budget (Dollars)	**$ 15,150,500**	**$ 2,095,000**	**$ 3,320,000**	**$ 5,016,000**	**$ 4,423,500**	**$ 296,000**
Opinion of Annual Budget (Adjusted Future Value)	**$ 16,484,000**	**$ 2,158,000**	**$ 3,522,300**	**$ 5,481,200**	**$ 4,978,800**	**$ 343,200**

TABLE A1.1 – South Pier Parking Structure – 5 Year Budget Forecast

ITEM NO.	WORK DESCRIPTION	5-YEAR TOTAL COST	2022	2023	2024	2025	2026
1.00	**General Conditions**	**$ 1,555,500**	**$ 214,000**	**$ 352,000**	**$ 545,500**	**$ 415,000**	**$ 29,000**
1.1	General Conditions / Mobilization	$ 1,555,500	214,000	352,000	545,500	415,000	29,000
2.00	**Structural / Concrete Repairs**	**$ 6,924,500**	**$ 1,065,000**	**$ 1,665,000**	**$ 3,114,500**	**$ 1,080,000**	**$ -**
2.1	Partial Depth Concrete Floor Repair - Supported Slabs	$ 1,350,000			$ 1,350,000		
2.2	**Partial Depth Concrete Repair - Supported Slabs - PCP**	$ 157,500			$ 157,500		
2.3	Replacement of Wearing Slab - Village Level Drive Lanes / Parking	$ 1,470,000	$ 630,000	$ 560,000	$ 280,000		
2.4	Concrete Repair - Ceilings	$ 400,000	$ 400,000				
2.5	Concrete Repair - Columns, Beams, Walls	$ 100,000			$ 100,000		
2.6	**Concrete Repair - Columns, Beams, Walls and Ceilings - PCP**	$ 42,000	$ 35,000		$ 7,000		
2.7	Curbs and Walks	$ 125,000			$ 125,000		
2.8	Remove Planters	$ 25,000		$ 25,000			
2.9	Replacement of Wearing Slab - Village Level Walks (Pavers)	$ 1,890,000		$ 630,000	$ 630,000	$ 630,000	
2.10	Replacement of Walks - Village Level	$ 1,350,000		$ 450,000	$ 450,000	$ 450,000	
2.11	Slab on Grade	$ 15,000			$ 15,000		
3.00	**Waterproofing**	**$ 3,225,000**	**$ 360,000**	**$ 680,000**	**$ 520,000**	**$ 1,665,000**	**$ -**
3.1	Plaza-Type Waterproofing System - Village Level Drive Lanes	$ 840,000	$ 360,000	$ 320,000	$ 160,000		
3.2	Plaza-Type Waterproofing System - Walks	$ 1,080,000		$ 360,000	$ 360,000	$ 360,000	
3.3	Rout/Seal Cracks	$ 72,000				$ 72,000	
3.4	Contruction Joint Sealants	$ 37,000				$ 37,000	
3.5	Cove Sealants	$ 30,000				$ 30,000	
3.6	Foundation Waterproofing - Village Level Buildings Bases	$ 126,000				$ 126,000	
3.7	Traffic -Rated Deck Coating - Replace - West Pier Level	$ 640,000				$ 640,000	
3.8	Traffic Coating - Partial East Pier Level	$ 400,000				$ 400,000	
4.00	**Stair Tower Repair**	**$ 40,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 40,000**
4.1	Paint Stair Structure Frame	$ 20,000					$ 20,000
4.2	Paint Hand Railings	$ 20,000					$ 20,000
5.00	**Mechanical / Electrical / Plumbing**	**$ 117,500**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 117,500**
5.1	New Drain Installation	$ 35,000					$ 35,000
5.2	New Piping Installation	$ 35,000					$ 35,000
5.3	Drain Repair/Replacement	$ 12,500					$ 12,500
5.4	MEP Allowance	$ 30,000					$ 30,000
5.5	Clean and Flush Drains/Pipes	$ 5,000					$ 5,000
6.00	**Architectural / Miscellaneous**	**$ 53,000**	**$ -**	**$ -**	**$ -**	**$ 20,000**	**$ 33,000**
6.1	Paint Ceilings, Walls, and Columns - Spot Repair	$ 30,000					$ 30,000
6.2	Repair Timber Railing Posts & Attatchments	$ 3,000					$ 3,000
6.3	Re-Paint Traffic Markings	$ 20,000				$ 20,000	
	Sub Total	$ 11,915,500	$ 1,639,000	$ 2,697,000	$ 4,180,000	$ 3,180,000	$ 219,500
	Contingency 10%	$ 1,192,000	$ 164,000	$ 270,000	$ 418,000	$ 318,000	$ 22,000
	Consulting & Engineering Fees	$ 1,192,000	$ 164,000	$ 270,000	$ 418,000	$ 318,000	$ 22,000
	Opinion of Annual Budget (2021 Dollars)	**$ 14,299,500**	**$ 1,967,000**	**$ 3,237,000**	**$ 5,016,000**	**$ 3,816,000**	**$ 263,500**
	Opinion of Annual Budget (Adjusted Future Value)	**$ 15,542,000**	**$ 2,026,100**	**$ 3,434,200**	**$ 5,481,200**	**$ 4,295,000**	**$ 305,500**

Note: Future value cost based on inflation; 3% annually

TABLE A1.2 - Plaza Parking Structure – 5 Year Budget Forecast

ITEM NO.	WORK DESCRIPTION	5-YEAR TOTAL COST	2022	2023	2024	2025	2026
1.00	**General Conditions**	**$ 92,500**	**$ 14,000**	**$ 9,000**	**$ -**	**$ 66,000**	**$ 3,500**
1.1	General Conditions / Mobilization	$ 92,500	14,000	9,000		66,000	3,500
2.00	**Structural / Concrete Repairs**	**$ 136,000**	**$ 84,000**	**$ 52,000**	**$ -**	**$ -**	**$ -**
2.1	Partial Depth Concrete Stair Repair	$ 75,000	$ 75,000				
2.2	**Partial Depth Concrete Repair - PCP**	$ 9,000	$ 9,000				
2.3	Concrete Repair - Columns, Beams, Walls and Ceilings	$ 45,000		$ 45,000			
2.4	**Concrete Repair - Columns, Beams, Walls and Ceilings - PCP**	$ 4,500		$ 4,500			
2.5	Precast Spandrel Repair	$ 2,500		$ 2,500			
3.00	**Waterproofing**	**$ 421,000**	**$ -**	**$ -**	**$ -**	**$ 421,000**	**$ -**
3.1	Expansion Joint Replacement	$ 25,000				$ 25,000	
3.2	Rout/Seal Cracks	$ 40,000				$ 40,000	
3.3	Construction Joint Sealants	$ 8,000				$ 8,000	
3.4	Traffic Topping Membrane	$ 256,000				$ 256,000	
3.5	Traffic Topping Membrane - Recoat	$ 90,000				$ 90,000	
3.6	Cracks (Chemical Grout Injection)	$ 2,000				$ 2,000	
4.00	**Stair Tower Repair**	**$ 15,000**	**$ 3,000**	**$ -**	**$ -**	**$ -**	**$ 12,000**
4.1	Paint Stair Structure Frame	$ 7,000					$ 7,000
4.2	Paint Hand Railings	$ 5,000					$ 5,000
4.3	Roof Tiles	$ 3,000	$ 3,000				
5.00	**Mechanical / Electrical / Plumbing**	**$ 19,000**	**$ -**	**$ 8,000**	**$ -**	**$ -**	**$ 11,000**
5.1	Clean Light Fixture Lenses	$ 2,000					$ 2,000
5.2	Clean and Flush Drains/Pipes	$ 12,000		$ 8,000			$ 4,000
5.3	Check CO Monitors	$ 1,000					$ 1,000
5.4	Light Fixture Replacement	$ 500					$ 500
5.5	Relamp Fixtures	$ 500					$ 500
5.6	Routine Elevator Maintenance	$ 3,000					$ 3,000
6.00	**Architectural / Miscellaneous**	**$ 18,500**	**$ -**	**$ -**	**$ -**	**$ 18,500**	**$ -**
6.1	Paint Ceilings, Walls, and Columns	$ 12,000				$ 12,000	
6.2	Reset Parking Bumpers (Wheel stops)	$ 1,500				$ 1,500	
6.3	Re-Paint Traffic Markings	$ 5,000				$ 5,000	
7.00	**Functional & Accessibility**	**$ 5,000**	**$ 5,000**	**$ -**	**$ -**	**$ -**	**$ -**
7.1	Repair Broken Tendon Allowance	$ 5,000	$ 5,000				

	5-YEAR TOTAL COST	2022	2023	2024	2025	2026
Sub Total	$ 707,000	$ 106,000	$ 69,000	$ -	$ 505,500	$ 26,500
Contingency 10%	$ 72,000	$ 11,000	$ 7,000	$ -	$ 51,000	$ 3,000
Consulting & Engineering Fees	$ 72,000	$ 11,000	$ 7,000	$ -	$ 51,000	$ 3,000
Opinion of Annual Budget (2021 Dollars)	**$ 851,000**	**$ 128,000**	**$ 83,000**	**$ -**	**$ 607,500**	**$ 32,500**
Opinion of Annual Budget (Adjusted Future Value	**$ 942,000**	**$ 131,900**	**$ 88,100**	**$ -**	**$ 683,800**	**$ 37,700**

Note: Future value cost based on inflation; 3% annually

TABLE A2 - Executive Summary – Single - Year Budget Forecast

Table CS-1
Combined Structures
Executive Summary

WORK DESCRIPTION	TOTAL COST
Work Categories	
General Conditions	$ 234,000
Structural / Concrete Repairs	$ 1,128,500
Waterproofing	$ 400,000
Mechanical / Electrical / Plumbing	$ 15,000
Architectural / Miscellaneous	$ 5,000
Functional & Accessibility	$ 5,000
Contingency 10%	$ 179,500
Consulting & Engineering Fees	$ 179,500
Opinion of Annual Budget (Dollars)	**$ 2,149,500**

TABLE A2.1 – South Pier Parking Structure – Single Year Budget Forecast

ITEM NO.	WORK DESCRIPTION	2022
1.00	**General Conditions**	**$ 220,000**
1.1	General Conditions / Mobilization	$ 220,000
2.00	**Structural / Concrete Repairs**	**$ 1,044,500**
2.1	Partial Depth Concrete Floor Repair - Supported Slabs	$ 450,000
2.2	**Partial Depth Concrete Repair - Supported Slabs - PCP**	$ 52,500
2.3	Concrete Repair - Ceilings	$ 400,000
2.4	Concrete Repair - Columns, Beams, Walls	$ 100,000
2.5	**Concrete Repair - Columns, Beams, Walls and Ceilings - PCP**	$ 42,000
3.00	**Waterproofing**	**$ 400,000**
3.1	Traffic Coating - Partial East Pier Level	$ 400,000
4.00	**Mechanical / Electrical / Plumbing**	**$ 15,000**
4.1	MEP Allowance	$ 10,000
4.2	Clean and Flush Drains/Pipes	$ 5,000
5.00	**Architectural / Miscellaneous**	**$ 5,000**
5.1	Re-Paint Traffic Markings	$ 5,000
	Sub Total	$ 1,684,500
	Contingency 10%	$ 168,500
	Consulting & Engineering Fees	$ 168,500
	Opinion of Annual Budget (2021 Dollars)	**$ 2,021,500**

TABLE A2.2 - Plaza Parking Structure – Single Year Budget Forecast

ITEM NO.	WORK DESCRIPTION	2022
1.00	**General Conditions**	**$ 14,000**
1.1	General Conditions / Mobilization	$ 14,000
2.00	**Structural / Concrete Repairs**	**$ 84,000**
2.1	Partial Depth Concrete Stair Repair	$ 75,000
2.2	**Partial Depth Concrete Repair - PCP**	$ 9,000
2.3	Concrete Repair - Columns, Beams, Walls and Ceilings	$ -
2.4	**Concrete Repair - Columns, Beams, Walls and Ceilings - PCP**	$ -
2.5	Precast Spandrel Repair	$ -
3.00	**Stair Tower Repair**	**$ 3,000**
3.1	Roof Tiles	$ 3,000
4	**Functional & Accessibility**	**$ 5,000**
4.1	Repair Broken Tendon Allowance	$ 5,000
		5-YEAR TOTAL COST
	Sub Total	$ 106,000
	Contingency 10%	$ 11,000
	Updated Condition Assessment	$ -
	Consulting & Engineering Fees	$ 11,000
	Opinion of Annual Budget (2021 Dollars)	**$ 128,000**

TABLE A3– South Pier Parking Structure – Ten Year Budget Forecast

ITEM NO.	WORK DESCRIPTION	10-YEAR TOTAL COST	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
1.00	General Conditions	$ 1,846,000	$ 214,000	$ 136,000	$ 178,500	$ 225,000	$ 289,000	$ 254,500	$ 205,000	$ 167,500	$ 16,500	$ 160,000
1.1	General Conditions / Mobilization	$ 1,846,000	$ 214,000	$ 136,000	$ 178,500	$ 225,000	$ 289,000	$ 254,500	$ 205,000	$ 167,500	$ 16,500	$ 160,000
2.00	Structural / Concrete Repairs	$ 7,678,500	$ 1,065,000	$ 585,000	$ 1,029,500	$ 648,000	$ 1,150,500	$ 1,150,500	$ 1,150,500	$ 899,500	$ -	$ -
2.1	Partial Depth Concrete Floor Repair - Supported Slabs	$ 1,921,000			$ 450,000		$ 450,000	$ 346,000	$ 450,000	$ 225,000		
2.2	Partial Depth Concrete Repair - Supported Slabs - PCP	$ 231,500			$ 52,500		$ 52,500	$ 47,500	$ 52,500	$ 26,500		
2.3	Replacement of Wearing Slab - Village Level Drive Lanes / Parking	$ 1,470,000	$ 630,000	$ 560,000	$ 280,000							
2.4	Concrete Repair - Ceilings	$ 500,000	$ 400,000					$ 100,000				
2.5	Concrete Repair - Columns, Beams, Walls	$ 100,000			$ 100,000							
2.6	Concrete Repair - Columns, Beams, Walls and Ceilings - PCP	$ 51,000	$ 35,000		$ 7,000			$ 9,000				
2.7	Curbs and Walks	$ 125,000			$ 125,000							
2.8	Remove Planters	$ 25,000		$ 25,000								
2.9	Replacement of Wearing Slab - Village Level Walks (Pavers)	$ 1,890,000				$ 378,000	$ 378,000	$ 378,000	$ 378,000	$ 378,000		
2.10	Replacement of Walks - Village Level	$ 1,350,000				$ 270,000	$ 270,000	$ 270,000	$ 270,000	$ 270,000		
2.11	Slab on Grade	$ 15,000			$ 15,000							
3.00	Waterproofing	$ 4,265,000	$ 360,000	$ 320,000	$ 160,000	$ 841,000	$ 576,000	$ 536,000	$ 216,000	$ 216,000	$ -	$ 1,040,000
3.1	Plaza-Type Waterproofing System - Village Level Drive Lanes	$ 840,000	$ 360,000	$ 320,000	$ 160,000							
3.2	Plaza-Type Waterproofing System - Walks	$ 1,080,000				$ 216,000	$ 216,000	$ 216,000	$ 216,000	$ 216,000		
3.3	Rout/Seal Cracks	$ 72,000				$ 72,000						
3.4	Contruction Joint Sealants	$ 37,000				$ 37,000						
3.5	Cove Sealants	$ 30,000				$ 30,000						
3.6	Foundation Waterproofing - Village Level Buildings Bases	$ 126,000				$ 126,000						
3.7	Traffic -Rated Deck Coating - Replace - West Pier Level	$ 1,280,000				$ 240,000	$ 240,000	$ 160,000				$ 640,000
3.8	Traffic Coating - Partial East Pier Level	$ 800,000				$ 120,000	$ 120,000	$ 160,000				$ 400,000
4.00	Stair Tower Repair	$ 80,000	$ -	$ -	$ -	$ -	$ 40,000	$ -	$ -	$ -	$ 40,000	$ -
4.1	Paint Stair Structure Frame	$ 40,000					$ 20,000				$ 20,000	
4.2	Paint Hand Railings	$ 40,000					$ 20,000				$ 20,000	
5.00	Mechanical / Electrical / Plumbing	$ 187,500	$ -	$ -	$ -	$ -	$ 117,500	$ -	$ -	$ -	$ 70,000	$ -
5.1	New Drain Installation	$ 70,000					$ 35,000				$ 35,000	
5.2	New Piping Installation	$ 35,000					$ 35,000					
5.3	Drain Repair/Replacement	$ 12,500					$ 12,500					
5.4	MEP Allowance	$ 60,000					$ 30,000				$ 30,000	
5.5	Clean and Flush Drains/Pipes	$ 10,000					$ 5,000				$ 5,000	
6.00	Architectural / Miscellaneous	$ 81,000	$ -	$ -	$ -	$ 8,000	$ 41,000	$ 8,000	$ -	$ -	$ -	$ 24,000
6.1	Paint Ceilings, Walls, and Columns - Spot Repair	$ 30,000					$ 30,000					
6.2	Repair Timber Railing Posts & Attachments	$ 3,000					$ 3,000					
6.3	Re-Paint Traffic Markings	$ 48,000				$ 8,000	$ 8,000	$ 8,000				$ 24,000
		10-YEAR TOTAL COST	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Subtotal (Pre - General Conditions)	$ 12,292,000	$ 1,425,000	$ 905,000	$ 1,189,500	$ 1,497,000	$ 1,925,000	$ 1,694,500	$ 1,366,500	$ 1,115,500	$ 110,000	$ 1,064,000
	Sub Total	$ 14,138,000	$ 1,639,000	$ 1,041,000	$ 1,368,000	$ 1,722,000	$ 2,214,000	$ 1,949,000	$ 1,571,500	$ 1,283,000	$ 126,500	$ 1,224,000
	Contingency 10%	$ 1,416,000	$ 164,000	$ 104,500	$ 137,000	$ 172,500	$ 221,500	$ 195,000	$ 157,500	$ 128,500	$ 13,000	$ 122,500
	Consulting & Engineering Fees	$ 1,416,000	$ 164,000	$ 104,500	$ 137,000	$ 172,500	$ 221,500	$ 195,000	$ 157,500	$ 128,500	$ 13,000	$ 122,500
	Opinion of Annual Budget (2022 Dollars)	$ 16,970,000	$ 1,967,000	$ 1,250,000	$ 1,642,000	$ 2,067,000	$ 2,657,000	$ 2,339,000	$ 1,886,500	$ 1,540,000	$ 152,500	$ 1,469,000
	Opinion of Annual Budget (Adjusted Future Value)	$ 19,214,000	$ 1,967,000	$ 1,287,500	$ 1,742,000	$ 2,258,700	$ 2,990,500	$ 2,711,600	$ 2,252,600	$ 1,894,100	$ 193,200	$ 1,916,800

APPENDIX-B

1.SOUTH PIER PARKING STRUCTURE

Photo 1.1- Concrete delamination, Village level (BA1-50)

Photo 1.2- Concrete delamination, Village level (SH1-167)

Photo 1.3- Delaminated previous repair, Village level (BA1-111)

Photo 1.4- Cracks on concrete floor slab, Village level (SH1-165)

Photo 1.5- Cracks on concrete floor slab, Village level (BA1-80)

Photo 1.6- Exposed rebar on floor, Village level (SH1-168)

Photo 1.7- Exposed rebar on floor, Village level (SH1-180)

Photo 1.8- Soffit slab deterioration and spalls with exposed reinforcement, Village level (SH1-8)

Photo 1.9- Soffit slab deterioration and spalls with exposed reinforcement, Village level (MM1-52)

Photo 1.10- Typical spalled and cracked pavers, Village level (BA1-113)

Photo 1.11- Typical spalled and cracked pavers, Village level (SH1-190)

Photo 1.12- Expansion joint cover plate bolts projecting out, Village level (BA1-139)

Photo 1.13- Expansion joint cover plate bolts projecting out, Village level (SH1-185)

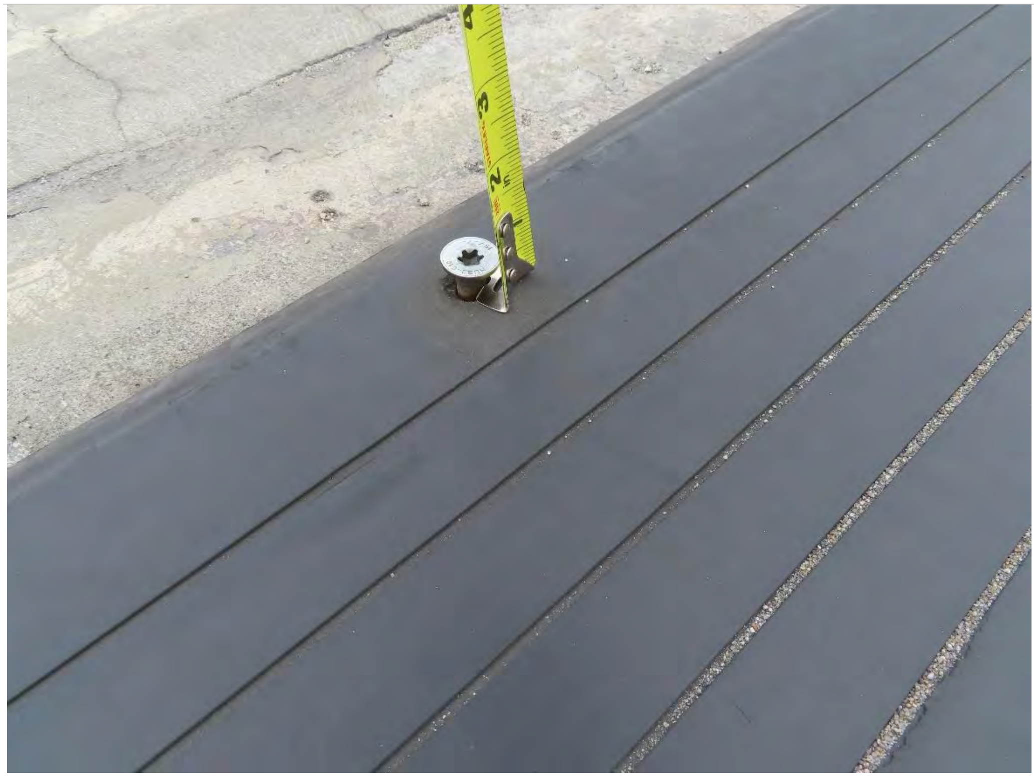


Photo 1.14- Typical spalled concrete planter walls, Village level (BA1-58)

Photo 1.15- Deteriorated fiber reinforcing wrap, Village level (SH1-88)

Photo 1.16- Deteriorated fiber reinforcing wrap, Village level (SH1-96)

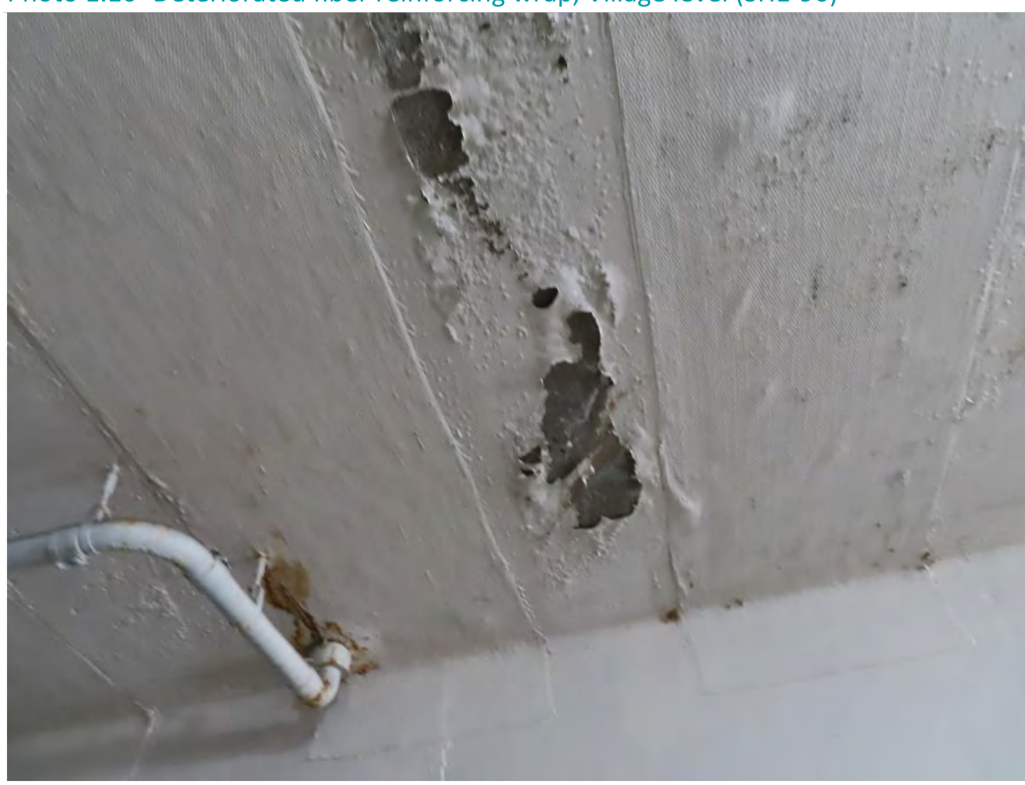


Photo 1.17- Concrete delamination, Pier level (SH2-7)

Photo 1.18- Concrete delamination, Pier level (SH2-21)

Photo 1.19- Exposed rebar on floor, Pier level (SH2-8)

Photo 1.20- Exposed rebar on floor, Pier level (SH2-17)

Photo 1.21- Concrete spalling at slabs, Pier level (SH2-10)

Photo 1.22- Isolated slab edge spall, Pier level (MM1-129)

Photo 1.23- Isolated slab edge spall, Pier level (SH1-198)

Photo 1.24- Exposed rebar on wall, Pier level (SH1-117)

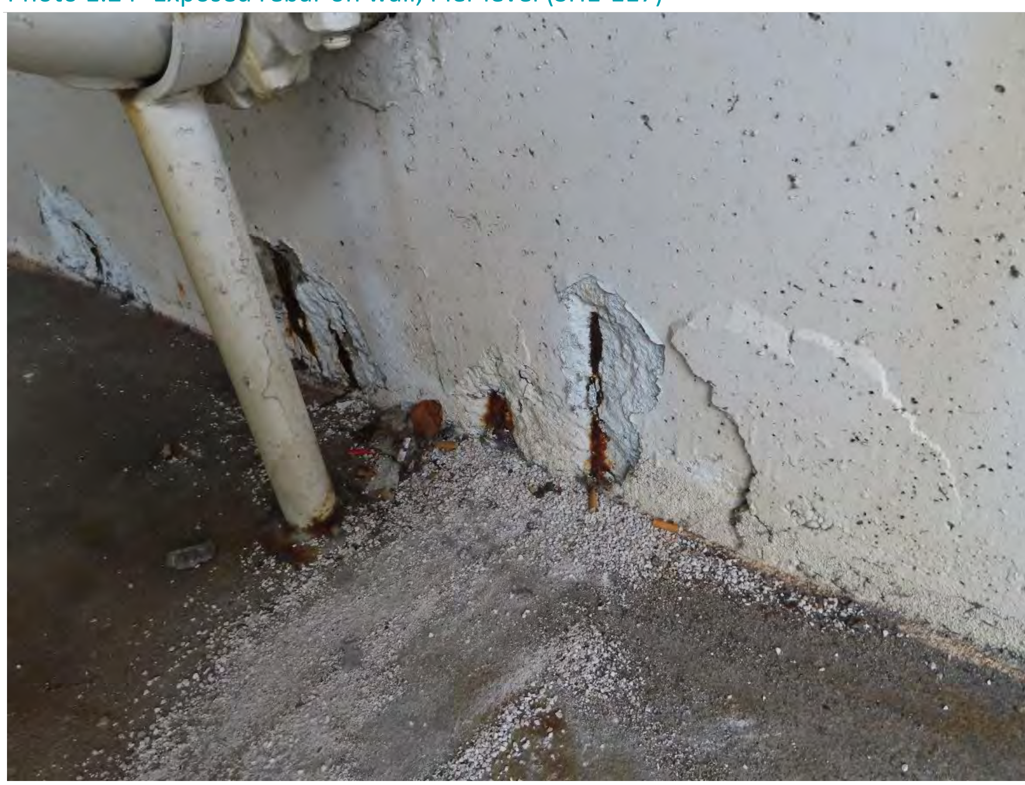


Photo 1.25- Exposed rebar on wall, Pier level (SH1-118)

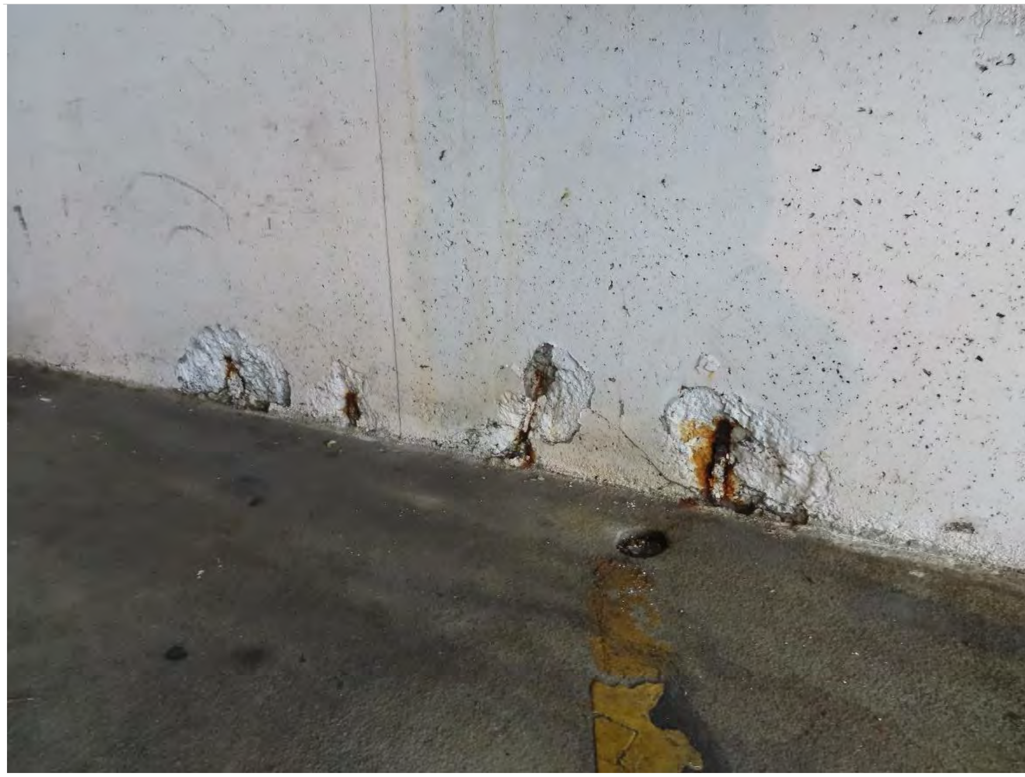


Photo 1.26- Soffit slab deterioration and spalls with exposed reinforcement, Pier level (SH1-258)

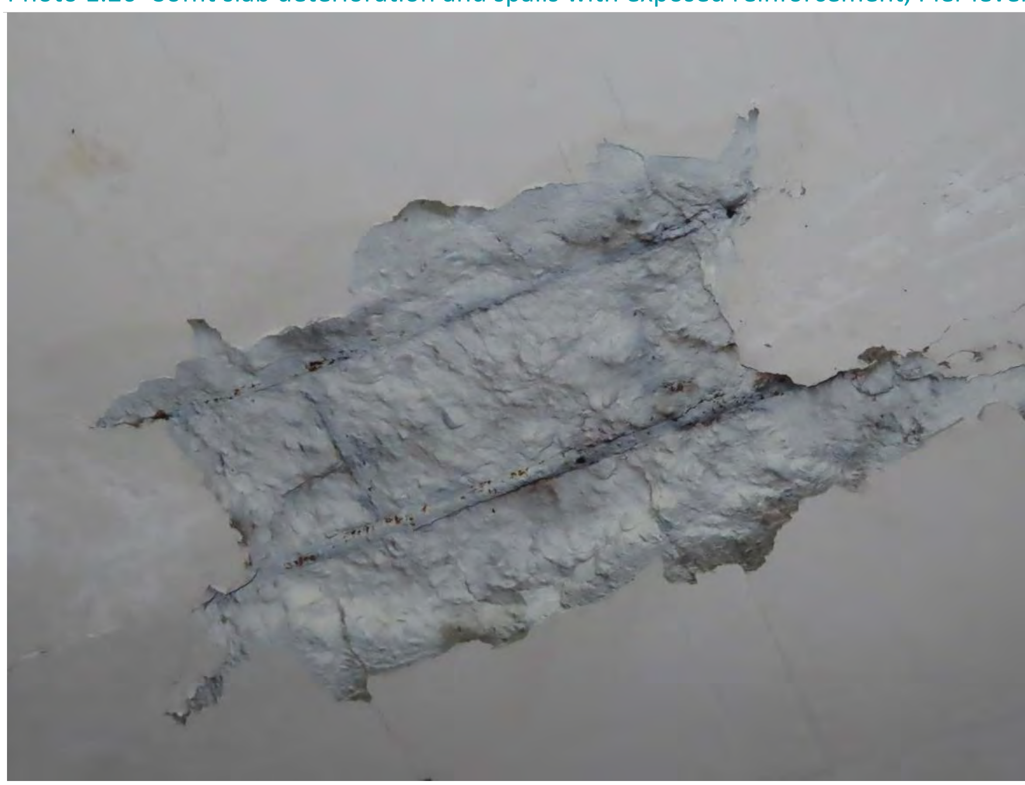


Photo 1.27- Soffit slab deterioration and spalls with exposed reinforcement, Pier level (SH2-58)

Photo 1.28- Soffit slab deterioration and spalls with exposed reinforcement, Pier level (SH1-249)

Photo 1.29- Concrete beam spalling below the expansion joint, Pier level (MM1-45)

Photo 1.30- Concrete beam spalling below the expansion joint, Pier level (MM1-46)

Photo 1.31- Compromised traffic membrane, Pier level (SH1-52)

Photo 1.32- Compromised traffic membrane, Pier level (SH1-48)

Photo 1.33- Fiber reinforcing wraps with added concrete cover, Basin level (SH1-271)

Photo 1.34- Corroded drainpipe, Pier level (MM1-33)

Photo 1.35- Corroded drainpipe, Pier level (MM1-82)

Photo 1.36- Deteriorated slab on grade, Basin level (SH2-44)

Photo 1.37- Deteriorated slab on grade, Basin level (SH2-48)

Photo 1.38- Isolated concrete column spalls, Basin level (SH1-241)

Photo 1.39- Typical stair coating worn off, (SH2-88)

Photo 1.40- Typical stair coating worn off, (SH2-118)

Photo 1.41- Corroded stair railing, (SH2-103)

Photo 1.42- Corroded stair railing, (SH2-104)

2. PLAZA PARKING STRUCTURE

Photo 2.1- Spalled precast concrete spandrel with exposed rebar, Plaza level (SH2-265)

Photo 2.2- Spalled precast concrete spandrel with exposed rebar, Plaza level (SH2-266)

Photo 2.3- Missing roof tiles on the stair tower, Plaza level (SH2-130)

Photo 2.4- Clogged drains, Plaza level (SH2-267)

Photo 2.5- Exposed rebar on floor, Pier level (SH2-155)

Photo 2.6- Soffit slab deterioration and spalls with exposed reinforcement, Pier level (BA1-326)

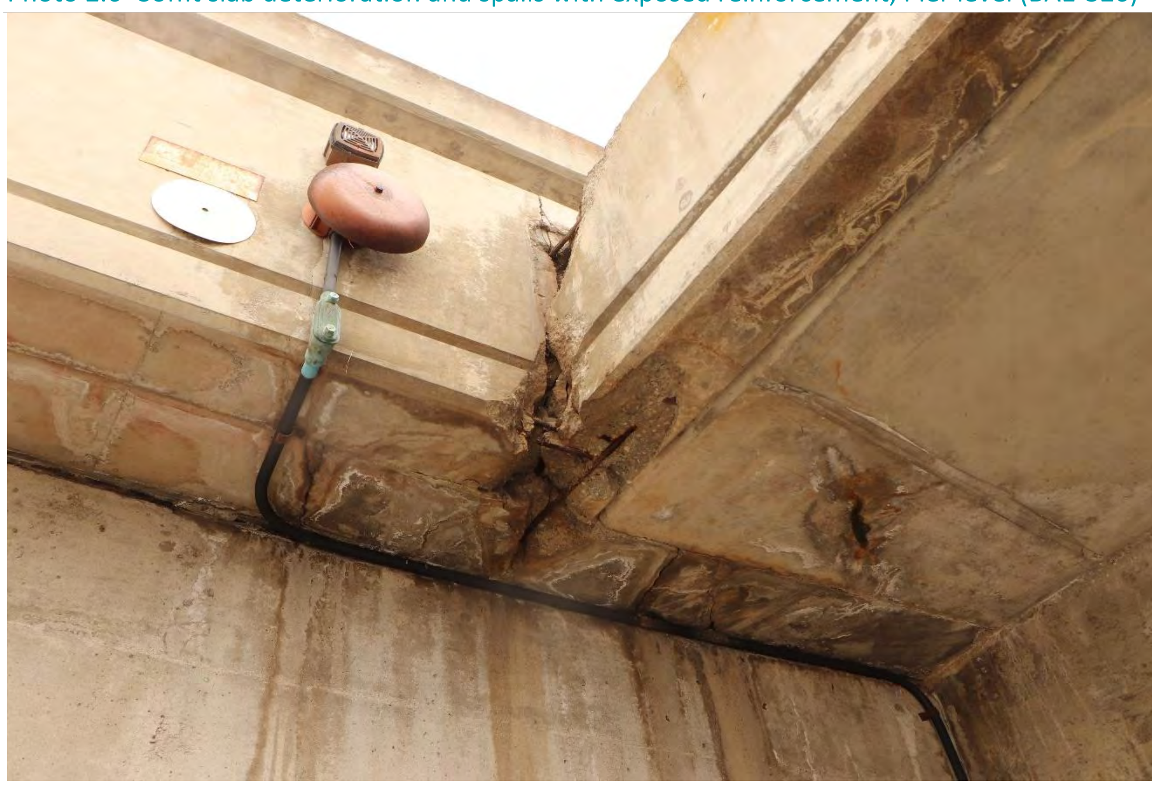


Photo 2.7- Soffit slab deterioration and spalls with exposed reinforcement, Pier level (BA1-327)

Photo 2.8- Cracks on concrete floor slab, Pier level (SH2-151)

Photo 2.9- Cracks underside of concrete slabs, Pier level (BA1-319)

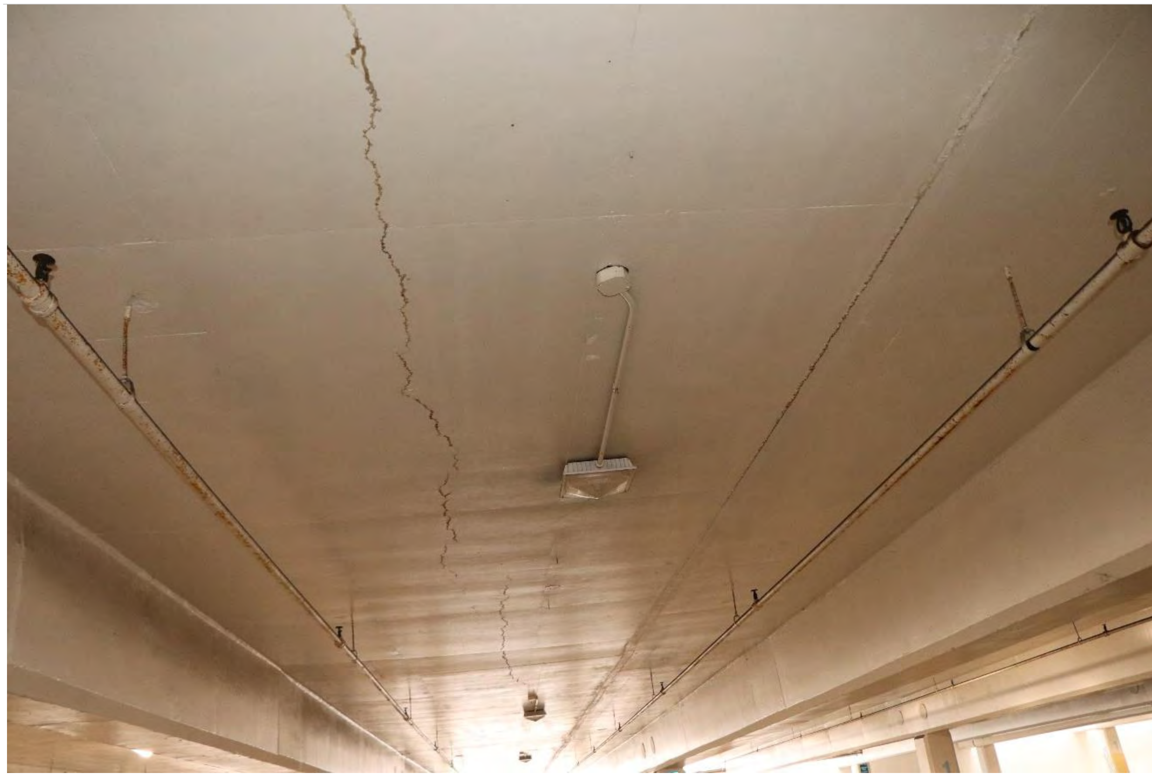


Photo 2.10- Concrete spalling underside the slabs, Pier level (SH2-185)

Photo 2.11- Exposed rebar on wall, Basin level (SH2-166)

Photo 2.12- Exposed rebar on wall, Basin level (SH2-198)

Photo 2.13- Damaged concrete stair treads and risers, (SH2-206)

Photo 2.14- Damaged concrete stair treads and risers, (SH2-209)

Photo 2.15- Damaged beam P/T rebar, Basin level (SH2-174)

3. EXTERIORS

Photo 3.1- Exposed and corroded rebar, Exterior - South elevation (SH2-252)

Photo 3.2- Exposed and corroded rebar, Exterior - South elevation (SH2-257)

Photo 3.3- Concrete delamination, Exterior - South elevation (SH2-262)