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Via Hand Delivery

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DATE: August 6, 2004

FROM: Gary Y. Takeuchi
Deputy Corporation Counsel

RE: Waikiki War Memorial Natatorium

COPIES	DATE	DESCRIPTION
1	July 20, 2004	Letter from Harold Hamada, P.E. to Clifford Lau regarding Walk-Through Inspection Report of the Waikiki War Memorial Natatorium
1	July 2004	Existing Building Structural Condition Report prepared by Wilson Okamoto Corporation

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REMARKS:

Please call me at 523-4718 to discuss the above-referenced matter.

Encs.

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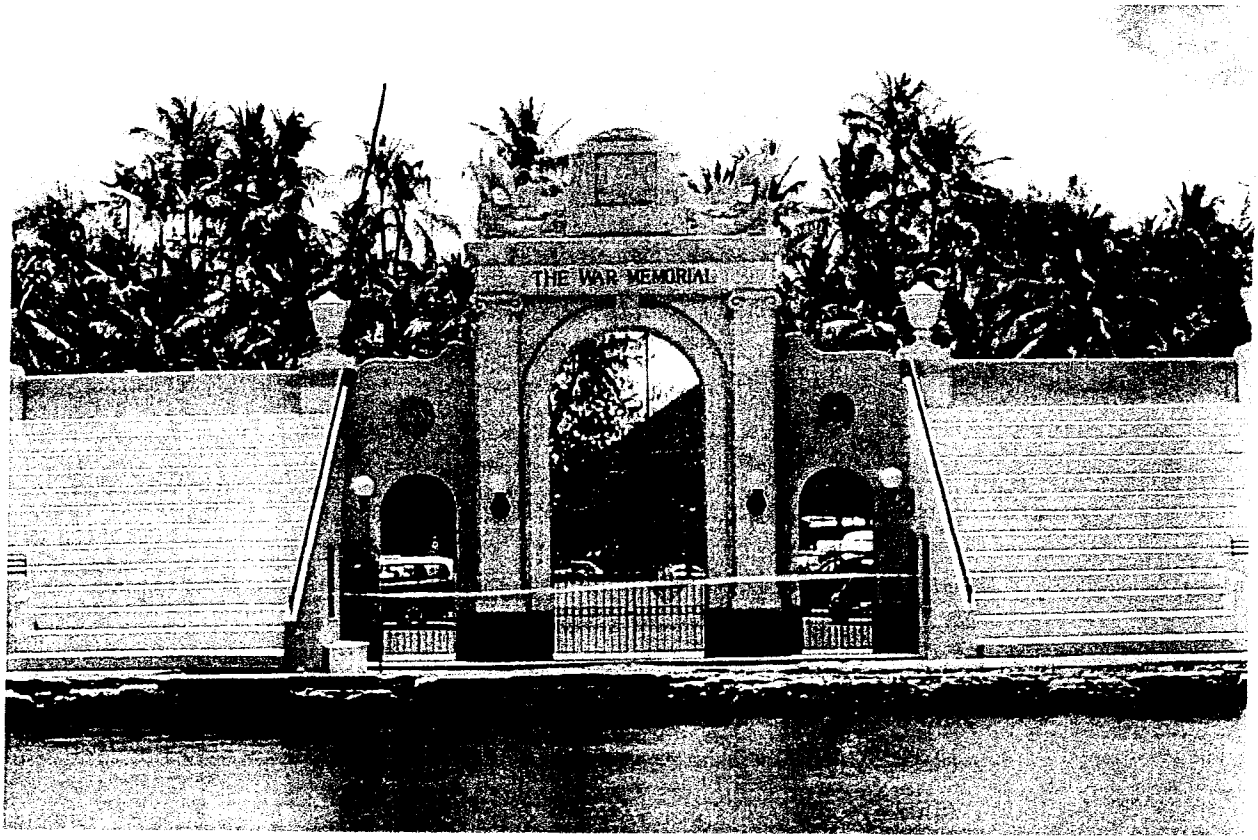
EXISTING BUILDING STRUCTURAL CONDITION REPORT

WAR MEMORIAL NATATORIUM

2815 Kalakaua Avenue

Honolulu, Hawaii



PREPARED FOR:

Department of Design and Construction
City and County of Honolulu

PREPARED BY:

WILSON OKAMOTO CORPORATION
ENGINEERS • PLANNERS
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July 2004

EXISTING BUILDING STRUCTURAL CONDITION REPORT
WAR MEMORIAL NATATORIUM

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I. EXECUTIVE SUMMARY

This report is an evaluation of the existing structural condition of the War Memorial Natatorium provided to document observations and opinions regarding the state of the swim basin structure, which includes the concrete pool deck and perimeter concrete sea walls along with the supporting foundations, and the possible impacts on the adjacent bleacher structure. Opinions are also provided regarding conditions that could develop into potential problems considering continued deterioration of the structure. This evaluation is based on visual field observations and investigations along with a review of documentation provided by the Department of Design and Construction, City and County of Honolulu. No analysis or calculations were performed to verify the structural adequacy of the original design or to verify the conformance of any subsequent addition, repair, or renovation work to present building codes.

The War Memorial Natatorium is located at the Diamond Head end of Waikiki in Honolulu, Hawaii. The facility consists of a concrete ocean fed swim basin structure with an adjacent concrete bleacher structure that was originally built in 1927 with subsequent additions and renovations in 1949 and 2000.

Overall, the swim basin structure appears to be in extremely poor condition. The swim basin structure consists of a concrete pool deck, concrete perimeter sea walls and support elements, which enclose the swim basin. A few sections of the structure have already collapsed and numerous other portions of the structure clearly exhibit signs of structural distress, even to the point of indicating possible impending structural collapse. The majority of the structural deterioration appears to be a result of corrosion and possibly erosion. Deterioration of the concrete deck threatens a number of vital structural elements. Thus, if the progressive deterioration is not mitigated, it could threaten the integrity of the entire swim basin structure, and lead to additional collapses. It is our opinion that the swim basin structure is unsafe and should remain closed to the public until measures are taken to stabilize and/or repair the existing structure.

The progressive deterioration of the swim basin structure also potentially threatens the integrity of the bleacher structure. The perimeter sea walls provide a buffer for the swim basin and the bleacher structures, protecting them from the forces of the open ocean. The failure of the perimeter sea walls would leave the swim basin and the bleacher structures exposed to the ocean tide and wave forces that the swim basin and the bleacher structures were not designed to resist. This exposure could potentially lead to the accelerated deterioration of the bleacher's foundation elements thus threatening its integrity.

The bleacher structure appears to be in good overall condition. There were cracks observed in bleacher support structure finish that appeared to be cosmetic in nature. However, these cracks are potential indicators of corrosion below the bleacher's finish or potential indicators of foundation settlement. The source of the corrosion should be investigated and remedial action taken to halt the progression of that condition in order to protect the bleacher structure from further deterioration. The archway supports and foundation elements should be monitored for any additional foundation settlement. If the foundation settlement progresses, possible schemes for stabilizing the structure could be investigated.

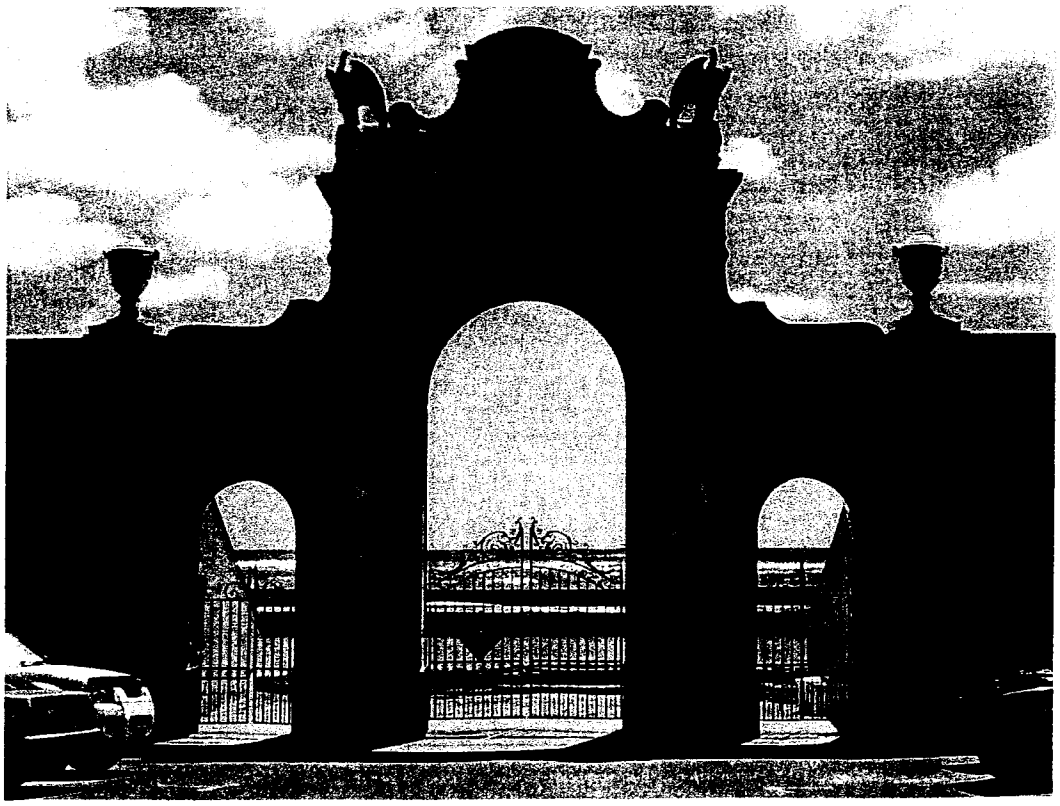
Element	*Condition Summary*
Concrete Deck Slab	• Three sections of the concrete deck slab have collapsed with several other sections showing signs of distress • Extensive cracking, excessive deflection and obvious signs of corrosion • ***Imminent collapse hazard***
Perimeter Sea Walls	• Extensive concrete spalling with numerous segments that have fallen into the adjacent ocean areas • Sections visibly out of plumb • Exposed corroded steel reinforcing • ***Potential collapse hazard***
Bleacher Supports	• Beam supports exhibit cracks in the plaster finish ❖ Potential indicators of corrosion ❖ Potential indicators of support settlement
Slab-On-Grade	• Extensive cracking in areas below the bleacher structure
Entry Arch Support	• Stains and cracking on archway finish ❖ Potential indicators of corrosion ❖ Potential indicators of support settlement
Bleacher Seating Slab and Walls	• Deterioration of resurfacing finish exhibited by extensive cracking and spalling ❖ Potential indicators of corrosion ❖ Exposes substructure to moisture

Table 1 – Condition Summary

II. INTRODUCTION

This report is an evaluation of the existing structural condition of the War Memorial Natatorium provided to document observations and opinions regarding the state of the swim basin structure, which includes the concrete pool deck and perimeter concrete sea walls along with the supporting foundations, and the possible impacts on the adjacent bleacher structure. Opinions are also provided regarding conditions that could develop into potential problems considering continued deterioration of the structure. This evaluation is based on visual field observations and investigations along with a review of documentation provided by the Department of Design and Construction, City and County of Honolulu. No analysis or calculations were performed to verify the structural adequacy of the original design or to verify the conformance of any subsequent addition, repair, or renovation work to present building codes.

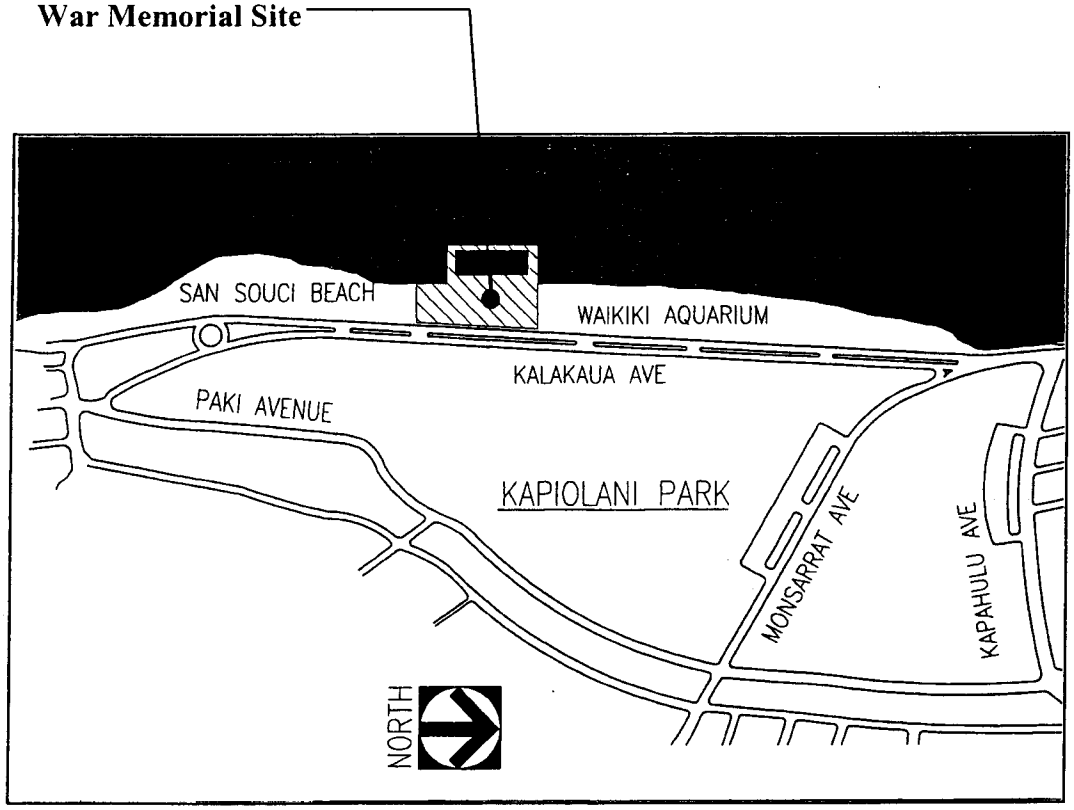
The observations noted are based on visual observations and are not the result of an exhaustive survey, material testing, destructive testing, or other investigative means. Therefore possible defects hidden by finish material or other building elements or defects in locations otherwise inaccessible may not have been identified.



III. SITE CONDITIONS

The War Memorial Natatorium is located at the Diamond Head end of Waikiki at 2815 Kalakaua Avenue in Honolulu, Hawaii.

The War Memorial Natatorium is built along the Waikiki shoreline with ingress and egress to the parking lot via Kalakaua Avenue, which runs approximately north south through Waikiki. The structure is exposed to the Pacific Ocean on three sides and is bounded by a paved lot on the remaining landside. The swim basin section has been closed to the public since 1979.



IV. BUILDING OVERVIEW

A. Structural System

Visual observations for the War Memorial Natatorium were performed on June 1, 2004 and June 8, 2004. The facility consists of a concrete ocean fed swim basin structure, which is supported on concrete piling, with an adjacent concrete bleacher structure supported on a combination of composite concrete and wood piles and fill along the shoreline.

The record drawings provided to our office indicate that the structure was originally built in 1927. The facility consists of two distinct sections; the swim basin, and bleacher/dressing rooms (See Figure 1). The overall dimensions of the swim basin and bleacher structures are approximately 386 feet parallel to the beach and 194 feet perpendicular to the beach. The swim basin is enclosed on the makai, ewa and Diamond Head sides by perimeter reinforced concrete sea walls that are supported by a single line of reinforced concrete piles, and abuts the bleacher/dressing rooms on the mauka side. The swim basin structure is approximately 330 feet by 120 feet in plan. The concrete pool deck surrounding the swim basin consists of cast-in-place reinforced concrete deck slabs and beams supported by reinforced concrete piles that are embedded into the ocean floor. The concrete piling varies in total length from 9 feet to 22 feet, with a cross section of 16"x16" that tapers to 16"x9" in the last 5 feet of the pile length. The drawings indicate that the concrete piles are embedded into the ocean floor and are also embedded 3 feet into the perimeter concrete walls above.

The 1927 drawings also indicate that the sea floor was dredged to accommodate the varying depth of the swim basin. Rock infill was placed around the piles in the space between the ocean floor and the bottom of the perimeter concrete sea walls on the ewa and the Diamond Head ends. The drawings indicate that the perimeter concrete sea walls on the makai side of the swim basin were placed on the ocean floor. A reinforced concrete wall, placed directly on the ocean floor with pile supports, encloses the mauka side of the swim basin and retains the fill material that occurs on the mauka side of that wall. This wall also provides support for the lower section of the bleacher seating slab and beams as well as the mauka side of the pool deck structure. The 1927 drawings also indicate precast concrete panels on all four interior sides of the swim basin, which are suspended from the concrete beams that run along the interior of the concrete pool deck. An addition in 1949 incorporated a 6" concrete slab, which was placed over the original 6" pool deck slab.

The bleacher seating construction consists of cast-in-place reinforced concrete slabs and riser beams supported by a combination of reinforced concrete walls and columns. Both the walls and columns appear to be supported by concrete grade beams or pile caps and composite concrete and timber piles. The piles that support the bleacher structure are similar to those used to support the swim basin

structure except that a splice piece connects the concrete upper section to a round timber lower section.

The original floor construction below the bleacher seating consists of a 4" thick reinforced concrete slab placed over fill material. The bleacher portion of the War Memorial was restored in 2000. The restoration work included the bleacher seating structure as well as the facilities that are located below the seating structure. Photos taken in 1991 show several areas where the original bleacher support slab and beam soffits had spalled away, exposing heavily corroded steel reinforcing. The 2000 restoration drawings indicate that the deteriorated concrete and steel reinforcing in the bleacher structure and the courtyard walls were removed and that the subsequent repair included concrete patching and replacement of steel reinforcing where required. The drawings also indicate that the concrete bleacher seating structure was repaired and resurfaced with a cementious material.

There are two main structural conditions that influence the overall lateral stability of the swim basin structure against seismic, wind and wave forces. The first condition occurs along the mauka side of the swim basin where both the concrete deck and bleacher structure bear on a reinforced concrete foundation wall (referred to as Wall "A" on the 1927 drawings). In addition to enclosing the mauka side of the swim basin, this wall also functions as a gravity retaining wall that provides a foundation for the bleacher structure and the mauka side of the concrete pool deck as well as retaining the fill below the adjacent slab-on-grade.

The second condition occurs along the perimeter concrete sea walls on the makai, ewa and Diamond Head sides of the swim basin. In the original design, the perimeter concrete walls are supported vertically by a combination of reinforced concrete piles and by their foundation bearing either on the ocean floor or on rock infill below the base of the wall. These walls appear to be supported laterally by a combination of the concrete piles, foundation bearing and the adjacent concrete deck on the interior of the swim basin. The concrete piles and the concrete deck each appear to support the perimeter wall against lateral displacement and the foundation bearing appears to provide the primary overturning resistance for the perimeter walls with secondary resistance provided by the piles.

Although they were probably not designed as such, the concrete deck framing and the concrete piles each appear to provide limited additional lateral support for the perimeter sea walls. The original concrete deck slab and beams tie the three perimeter wall elements together to produce a braced support frame. As noted above, the reinforced concrete piles are embedded into both the ocean floor and the perimeter sea walls, thus providing force resistance in the form of a cantilever. This combination of braced support frame and cantilever piles provides additional lateral support for the swim basin structure against the ocean's forces. These systems would be considered inadequate to resist lateral loads under present codes but are able to provide a degree of resistance to seismic, wind and wave forces.

It should be noted that the many of the structural elements in the swim basin section are inaccessible either due to site constraints or potentially unsafe conditions and the majority of the structural elements in the bleacher section are concealed by architectural finishes and are not visible. Accordingly, these findings are limited to those structural elements or portions of elements that are readily visible.

B. References and Sources

Structural drawings and photos obtained from the Department of Design and Construction, City and County of Honolulu were used as reference in the preparation of this report. These include the drawings from the original construction in 1927, the drawings from the subsequent additions and alterations in 1949, and the drawings from the restoration in 2000.

C. Structural Design Criteria

The 1927 and 1949 drawings do not indicate the structural loading design criteria. The 2000 restoration drawings indicate that the structural design was based on the 1991 Uniform Building Code, seismic zone 2A with a design wind speed of 80 mph, exposure D, and the ACI 318-89 Building Code Requirements for Reinforced Concrete.

D. Visual Observations

1. Swim Basin Structure

Three separate sections of the concrete pool deck were observed to have collapsed into the swim basin. The sections of the concrete deck at the ewa (Photo 4) and Diamond Head (Photo 3) ends of the swim basin reportedly collapsed many years ago and the resulting openings were covered with plywood. The section of the pool deck on the mauka side of the swim basin reportedly started collapsing in early 2004 with sections of both the original 6" slab and 6" topping slab that was added in 1949 falling away from the supporting foundation wall and the concrete beams. In the areas immediately to either side of the collapsed section along the bleachers, sections of the original concrete slab were observed to have fallen away with only the 6" topping slab remaining above (Photos 1 and 2).

Photo 1 - Pool Deck Collapse – Mauka Side (Along Bleachers)

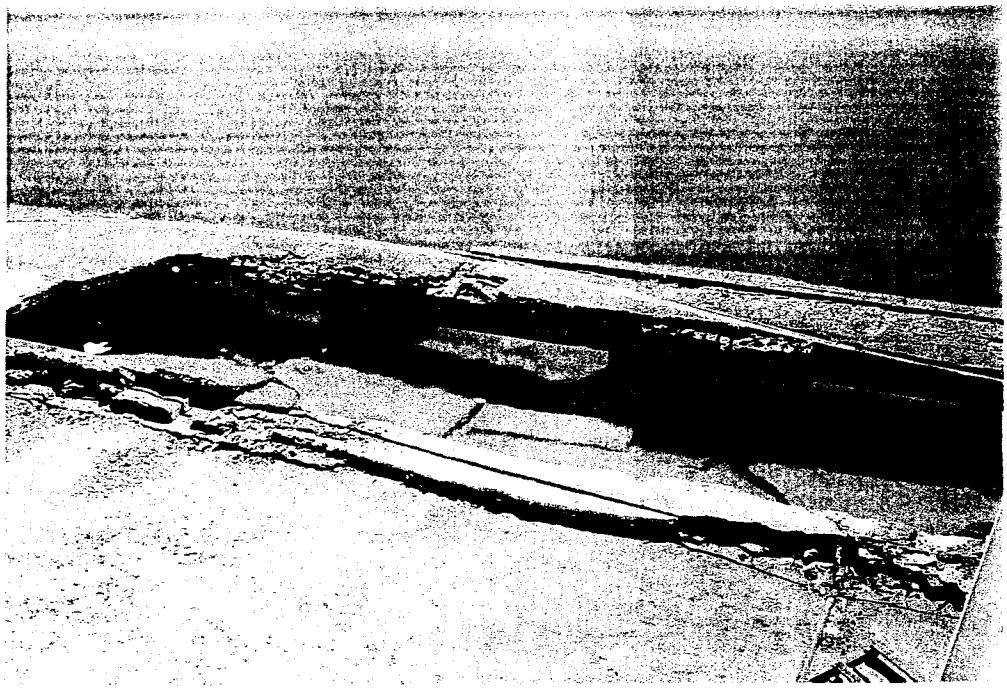


Photo 2 - Pool Deck Collapse – Mauka Side (Along Bleachers)

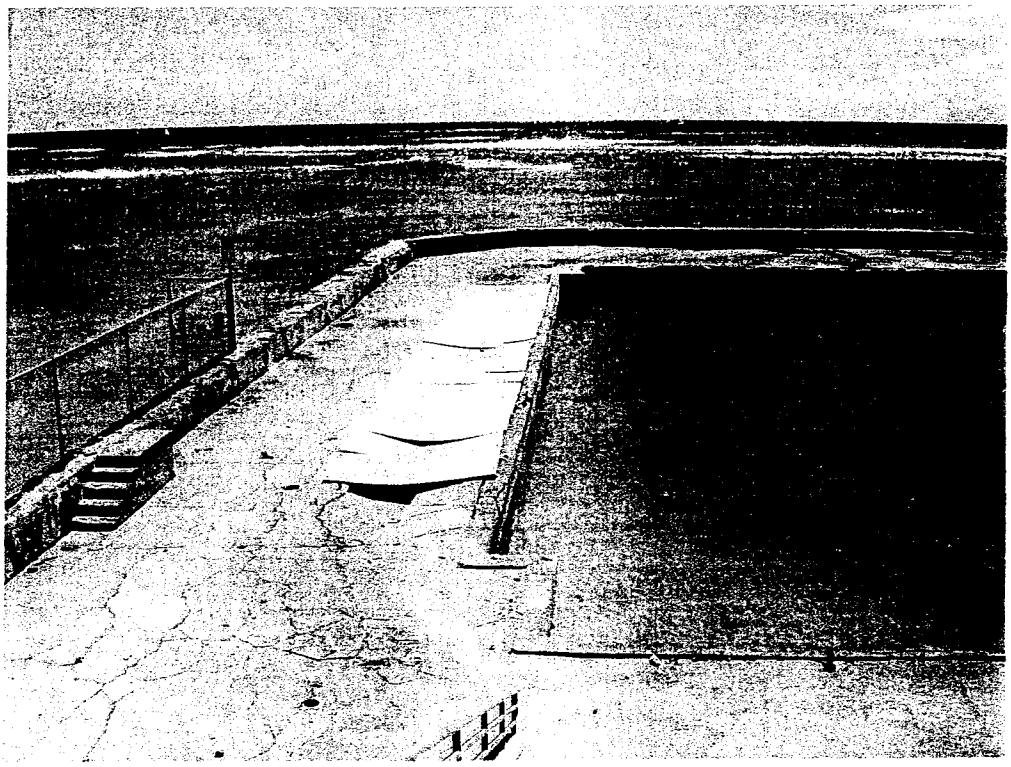


Photo 3 - Pool Deck Collapse – Diamond Head End

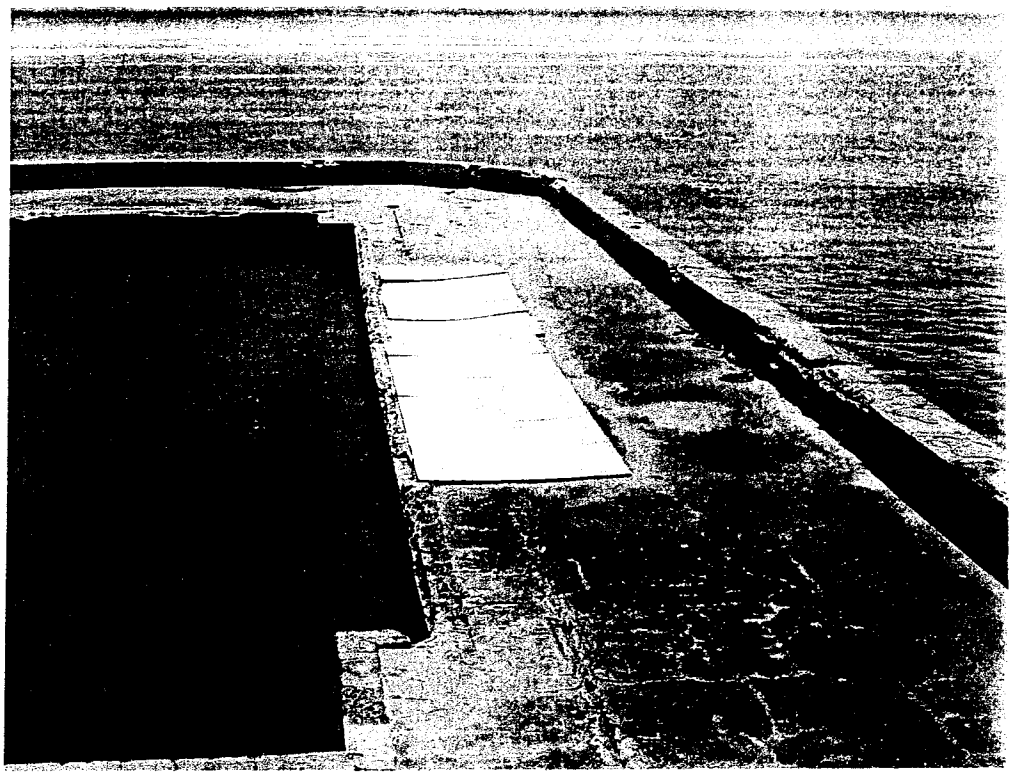


Photo 4 - Pool Deck Collapse – Ewa End

The concrete pool deck slab and beams shows signs of severe distress in several areas as evident by extensive concrete cracking, excessive deflection and obvious signs of corrosion. In some locations, there are cracks or sections where concrete had fallen away which were large enough to see into the water below the pool deck (Photo 8). There are also several locations where the deck slab has cracked along lines that appear to be located directly above the original concrete beams. The slab cracks often appear to extend the full depth of the 1949 concrete topping slab. It is clear that these areas each display signs that indicate structural distress and possible imminent collapse (See Photos 5, 6, 7, 8 & 9 where crack propagates full depth). In fact, photos taken in 1989 appear to show a section of the perimeter sea wall and pool deck slab that were completely detached from the adjacent section in the same area shown in Photo 9. The 1989 photo showed a vertical separation in the perimeter sea wall, which extended into the concrete deck slab at the corner where ewa wall meets the wall on the makai side of the swim basin. The separation between the two wall segments was wide enough to see into the ocean area beyond the perimeter sea wall.

Photo 5 – Slab Cracking and Deflection at Diamond Head End

Photo 6 - Pool Deck Cracking and Deflection along the Makai Side

Photo 7 - Pool Deck Beam Spalling and Exposed Reinforcing Corrosion

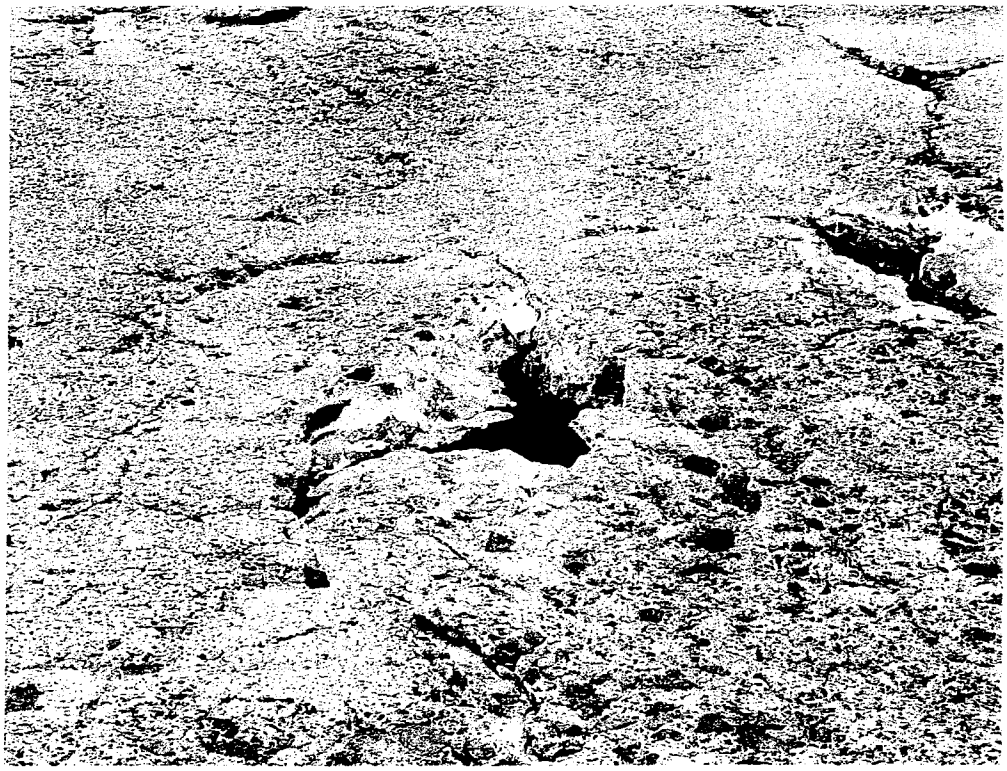


Photo 8 - Pool Deck Slab Deterioration

Photo 9 - Pool Deck Slab Deterioration and Corrosion Stains

The top section of the swim basin's perimeter concrete sea wall has spalled in numerous locations, often exposing heavily corroded steel reinforcing (Photos 10 & 12). There are numerous segments along the outer face of the perimeter sea wall in which a portion of the concrete had fallen into the ocean (Photo 11). There are also several sections of the precast concrete panels, which run along the interior of the pool deck, that have fallen away from their concrete support beams.

Photo 10 - Deterioration of Perimeter Concrete Wall and Precast Concrete Panels

Photo 11 - Concrete Spalling and Reinforcing Corrosion of Perimeter Concrete Wall

Photo 12 - Concrete Spalling and Deterioration of Perimeter Concrete Wall

The far makai ends of the perimeter sea walls at the ewa and Diamond Head ends of the swim basin, which run perpendicular to the shoreline, are visibly out of plumb, sloping out away from the swim basin (Photos 13 & 14). The drawings indicate that the support piles are located in a single line along the length of the perimeter wall on the three ocean sides of the swim basin. During our site visit, the representative from the Department of Design and Construction stated that they had observed locations at the bottom of the perimeter sea walls that were no longer bearing on the ocean floor or on the rock infill that was placed below the base of the perimeter sea walls on the ewa and Diamond Head ends of the swim basin.

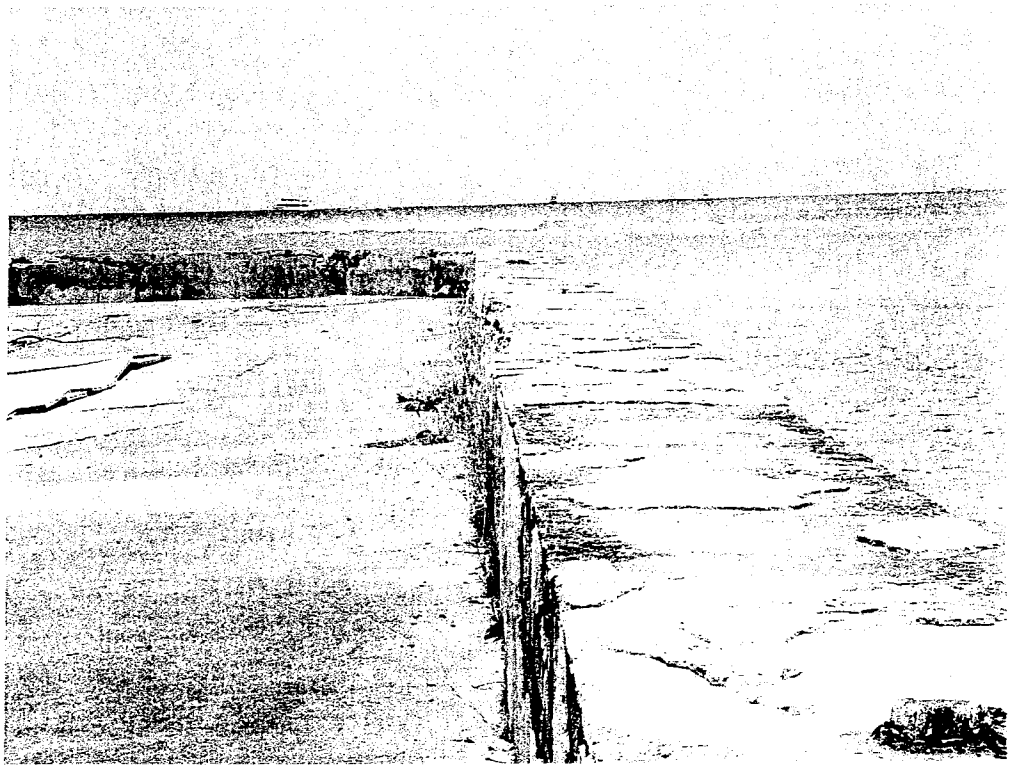


Photo 13 - Tilting of Perimeter Concrete Sea Wall – Ewa End

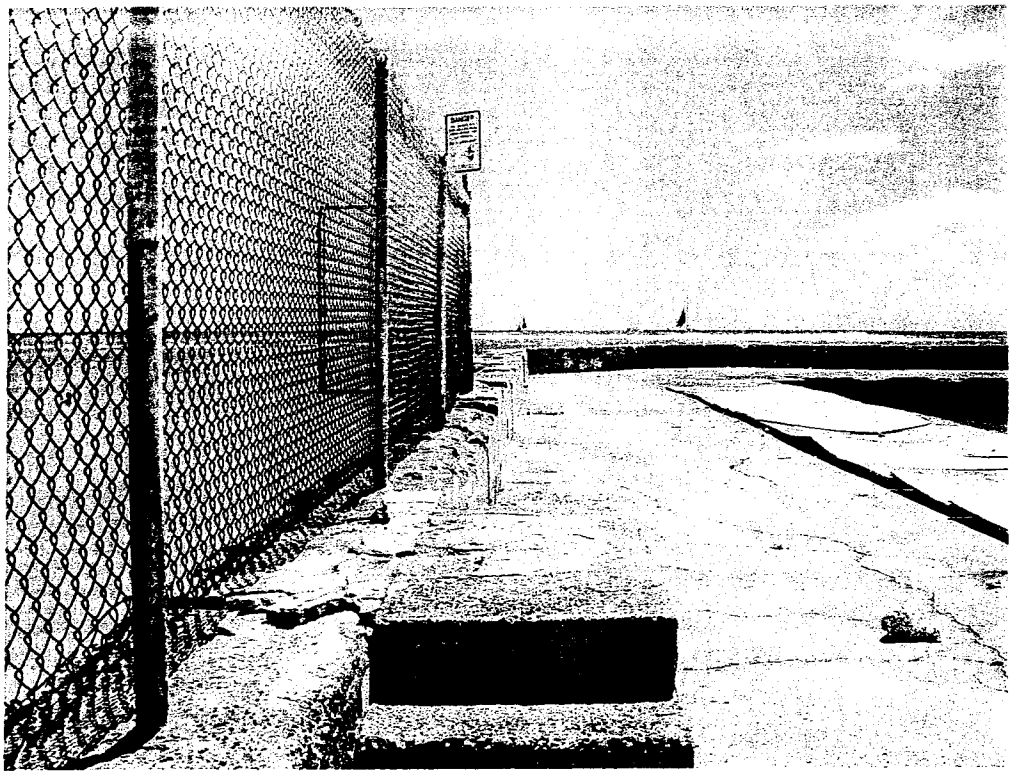


Photo 14 - Tilting of Perimeter Concrete Sea Wall – Diamond Head End

There appears to be a distinct line of steel corrosion and concrete spalling in the ewa/makai corner of the pool deck slab (Photo 15). The 1949 electrical drawings indicate wiring for the pool deck lighting running in approximately the lines where the steel corrosion and concrete spalling occurs. In the area immediately adjacent to the corrosion and concrete spall lines, there appeared to be exposed wiring that was pulled out of the existing concrete deck.

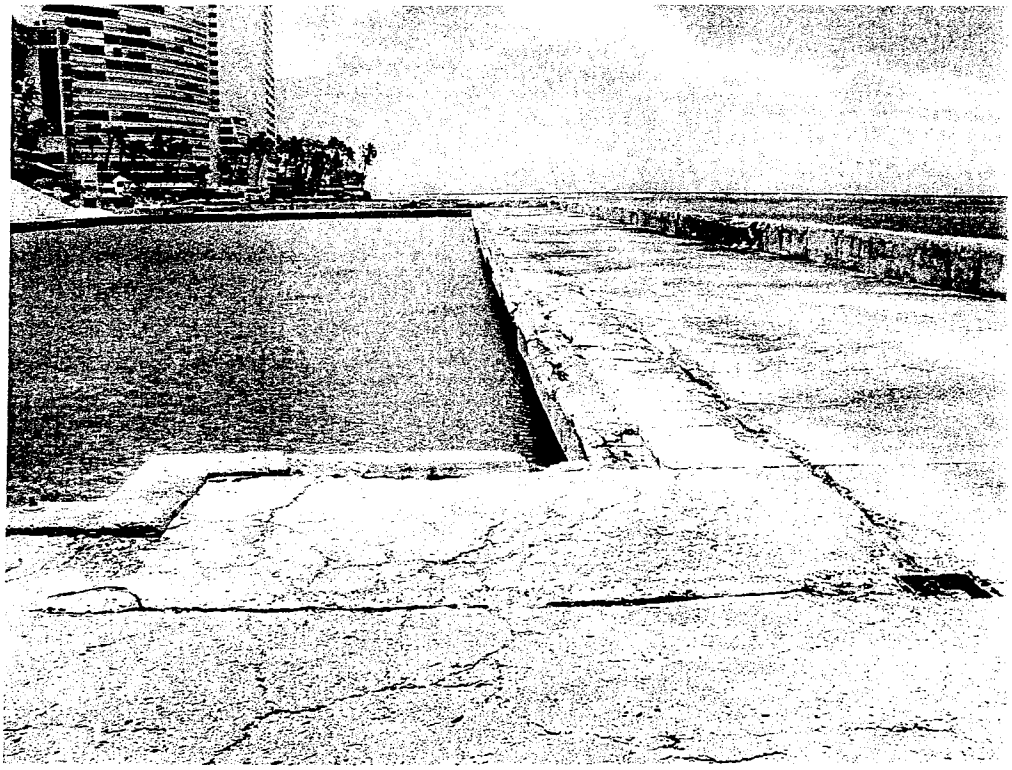


Photo 15 - Pool Deck Deterioration at Ewa/Makai Corner

(Note exposed wiring in the lower left corner of photo)

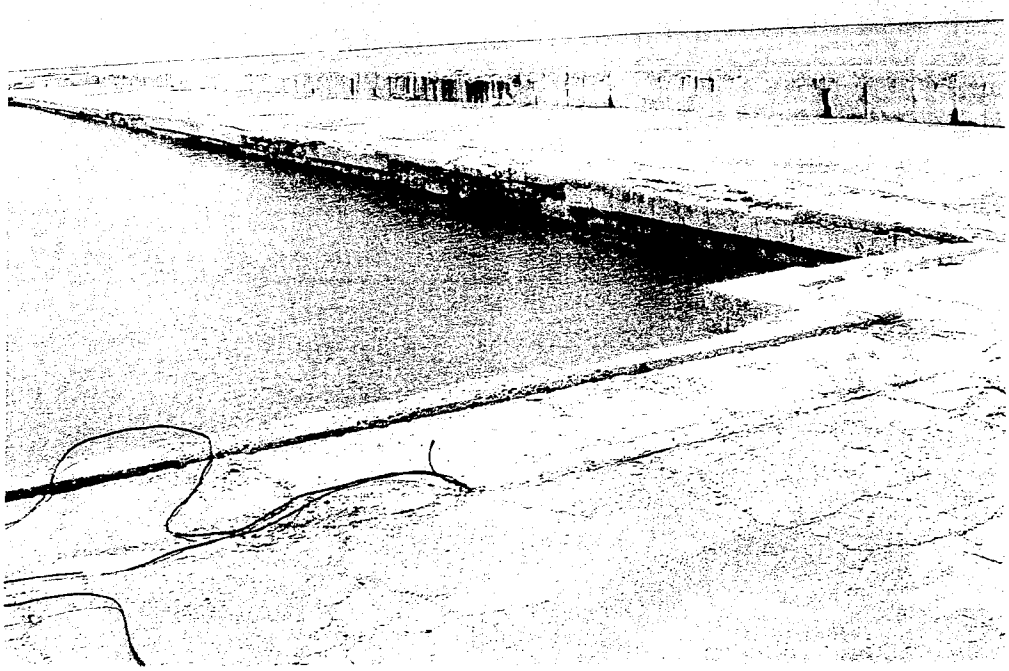


Photo 16 - Pool Deck Deterioration with Exposed Wiring

2. Bleacher Structure

The concrete support beams below the lower section of the bleachers exhibit numerous vertical, diagonal and longitudinal cracks in the plaster finish (Photos 17 & 18). These lower concrete beams bear on the concrete foundation wall on the mauka side of the swim basin. This concrete foundation wall also provides support for the concrete pool deck slab; a portion of which has collapsed.

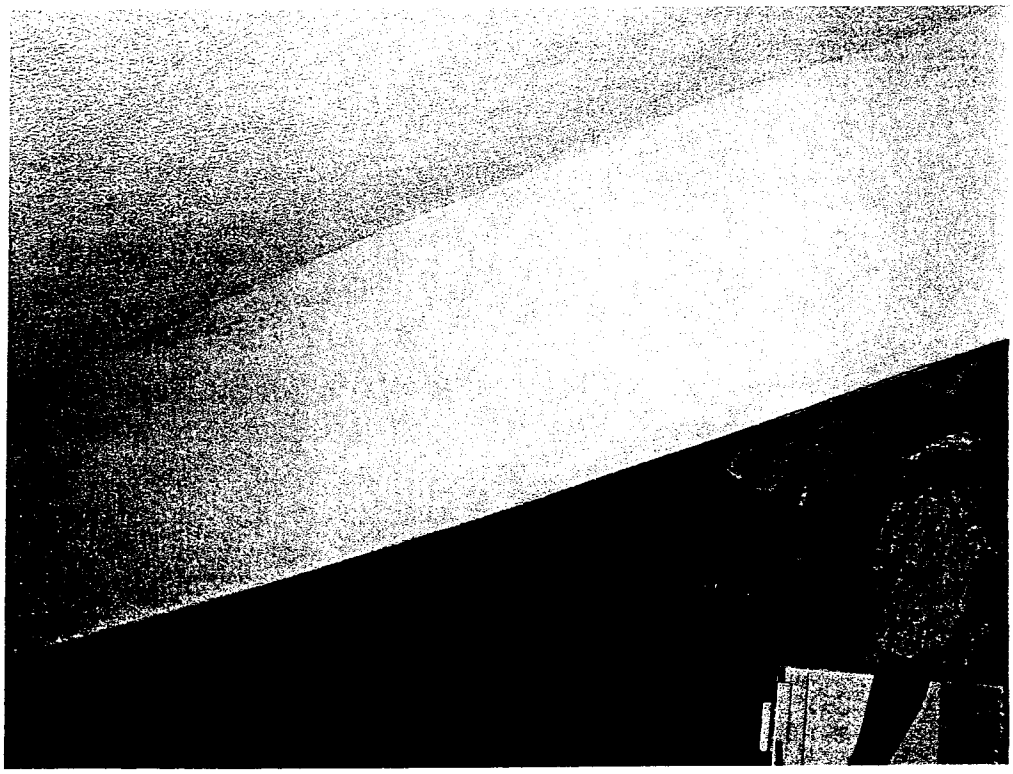


Photo 17 - Vertical Cracks in Lower Bleacher Support Beam

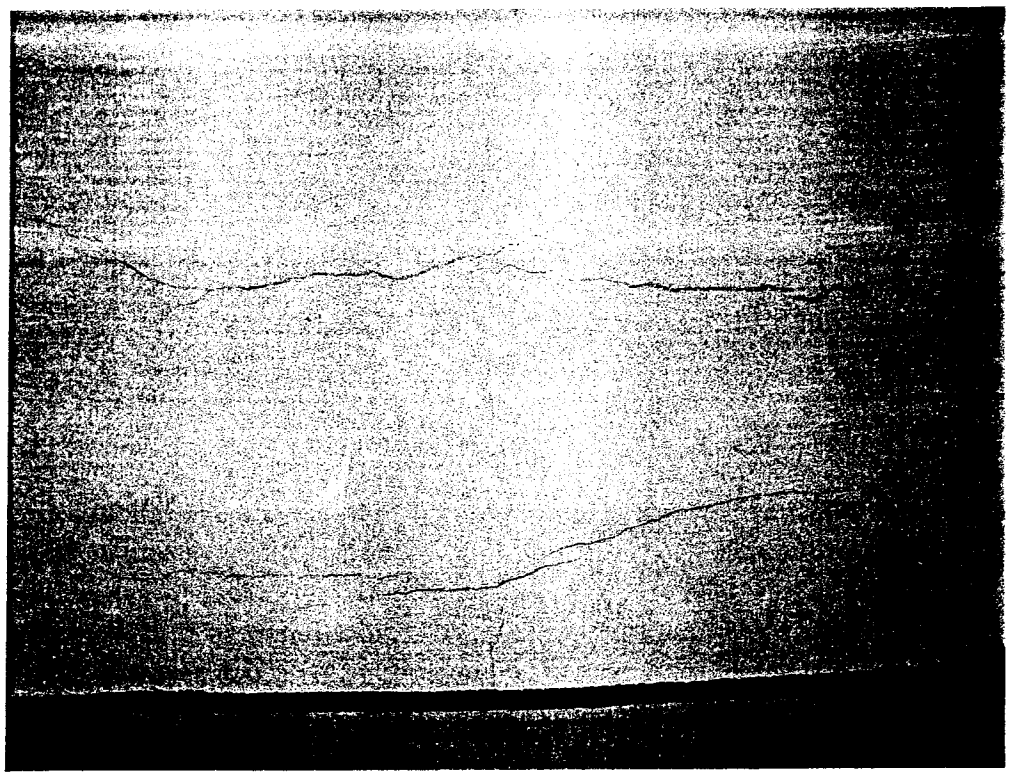


Photo 18 - Longitudinal Cracks in the Lower Bleacher Support Beam

There were numerous cracks observed in portions of the concrete slab-on-grade floor below the bleacher structure (Photo 19). The original slab-on-grade was reportedly removed and replaced during the restoration project in 2000. However, the 2000 renovation drawings indicate that only the exterior slab-on-grade located on the ewa and Diamond Head sides of the bleachers and at the entry archway was replaced with a new 6" reinforced slab-on-grade. In any case, there does not appear to be any slab expansion joints in the areas that were observed below the bleachers.

Photo 19 – Slab-on-grade Floor Cracking

The archway over the main entry to the natatorium shows potential signs of the progression of corrosion as indicated by stains possibly caused by rust leaching on the finished surface (Photo 20).

Photo 20 - Stains on the Entry Arch Finish

In addition to the signs of corrosion, cracks were observed in the finish of the archways over the main entry to the natatorium. The representative from the Department of Design and Construction stated that these cracks did not occur prior to the restoration work in 2000 (Photos 21, 22 & 23).

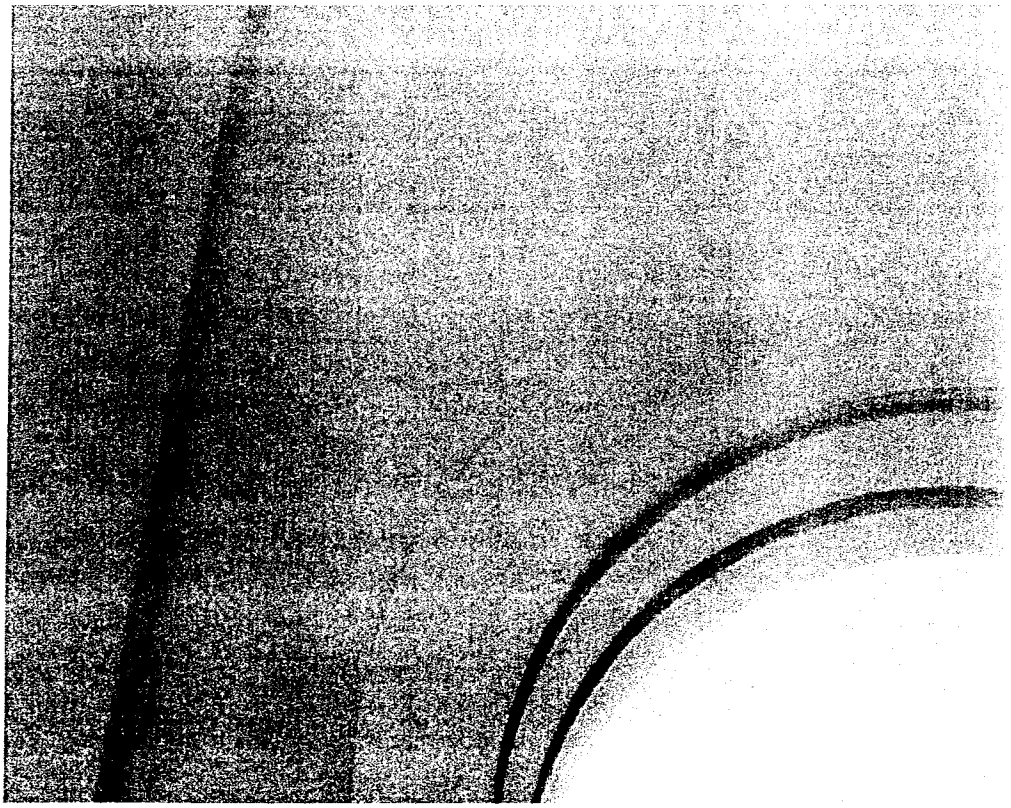


Photo 21 - Cracking in Entry Archway Finish

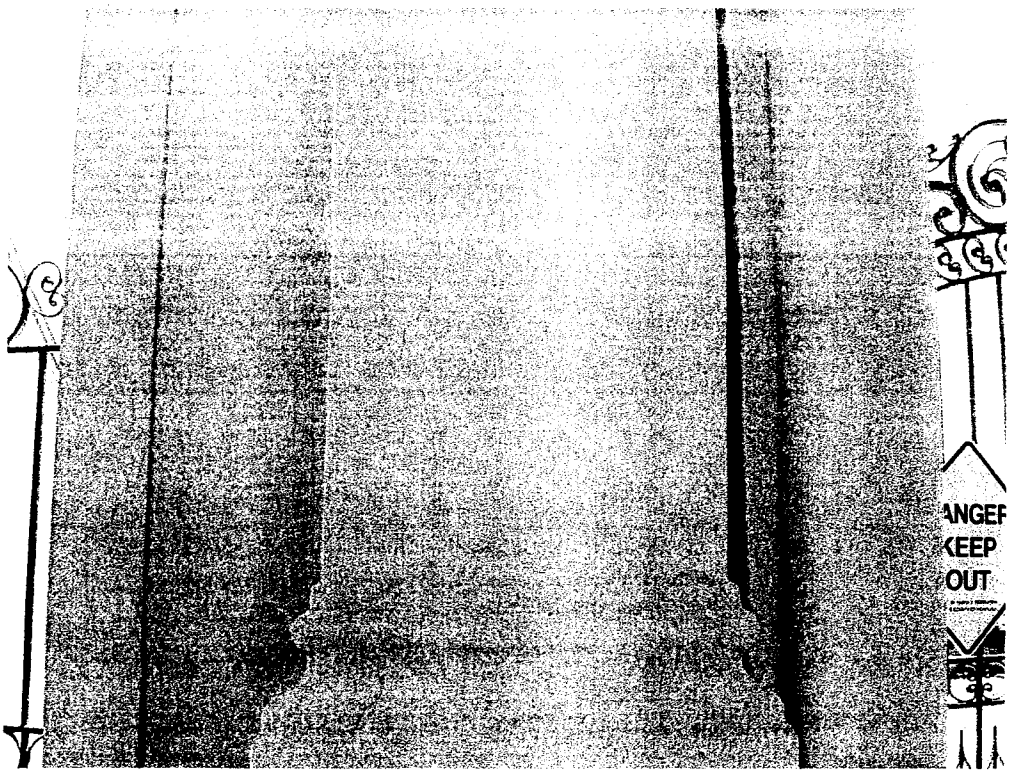


Photo 22 - Cracking in Entry Archway Column Finish

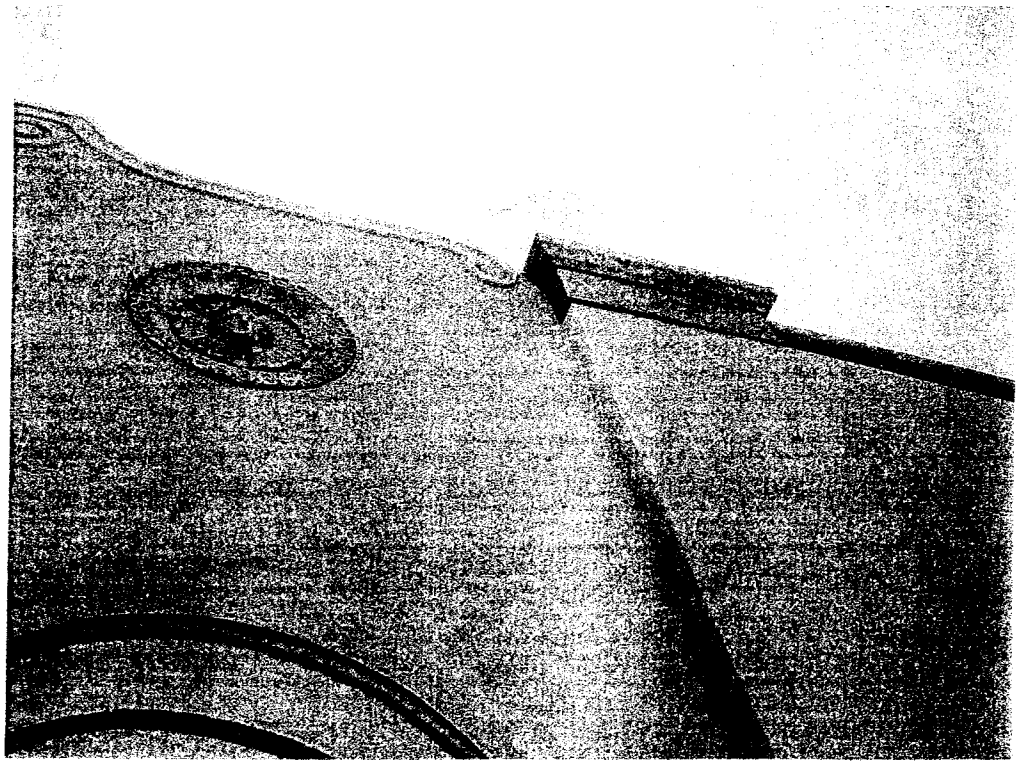


Photo 23 - Cracking in Entry Archway Finish

The bleacher resurfacing finish that was incorporated in the restoration in 2000 shows signs of deterioration. The finish has extensive cracking with sections up to approximately ½" thick spalled off exposing the concrete seating structure underneath the finish (Photo 24).

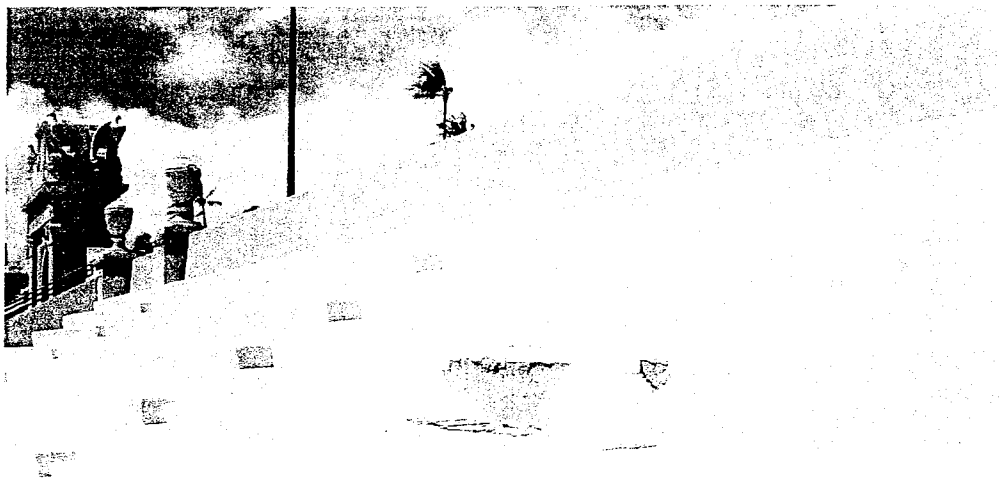


Photo 24 – Cracking and Spalling in Bleacher Seating Finish

Photo 25 - Cracking in Bleacher Seating Finish

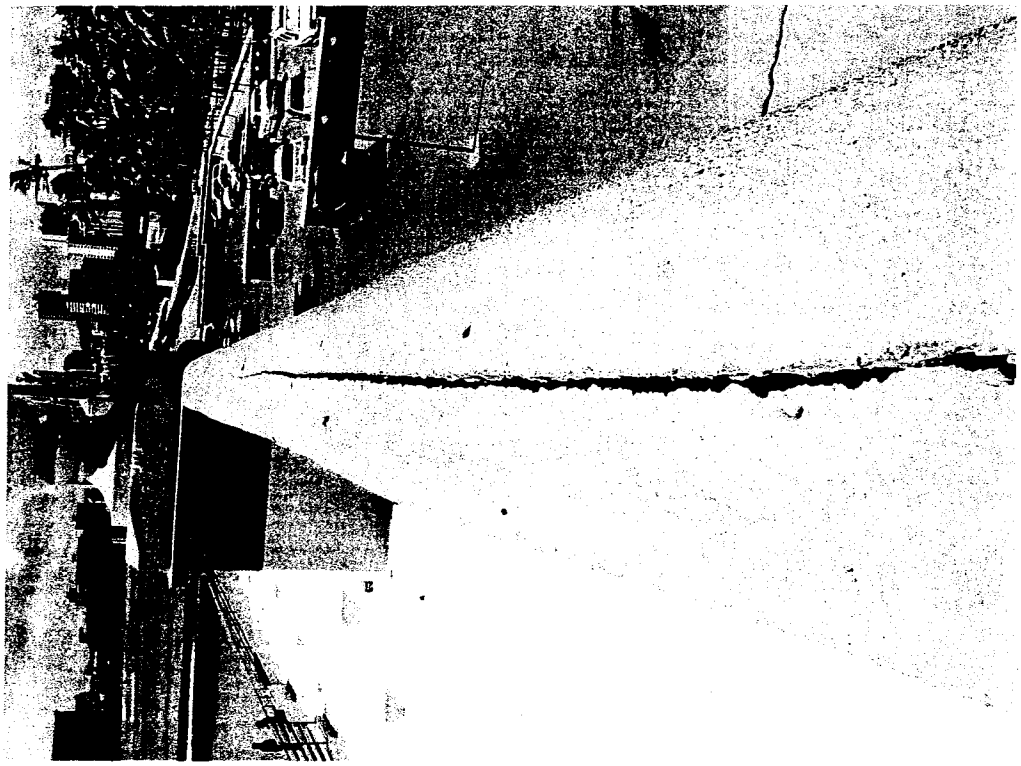


Photo 26 - Cracking at Top of Bleacher Seating Wall Finish

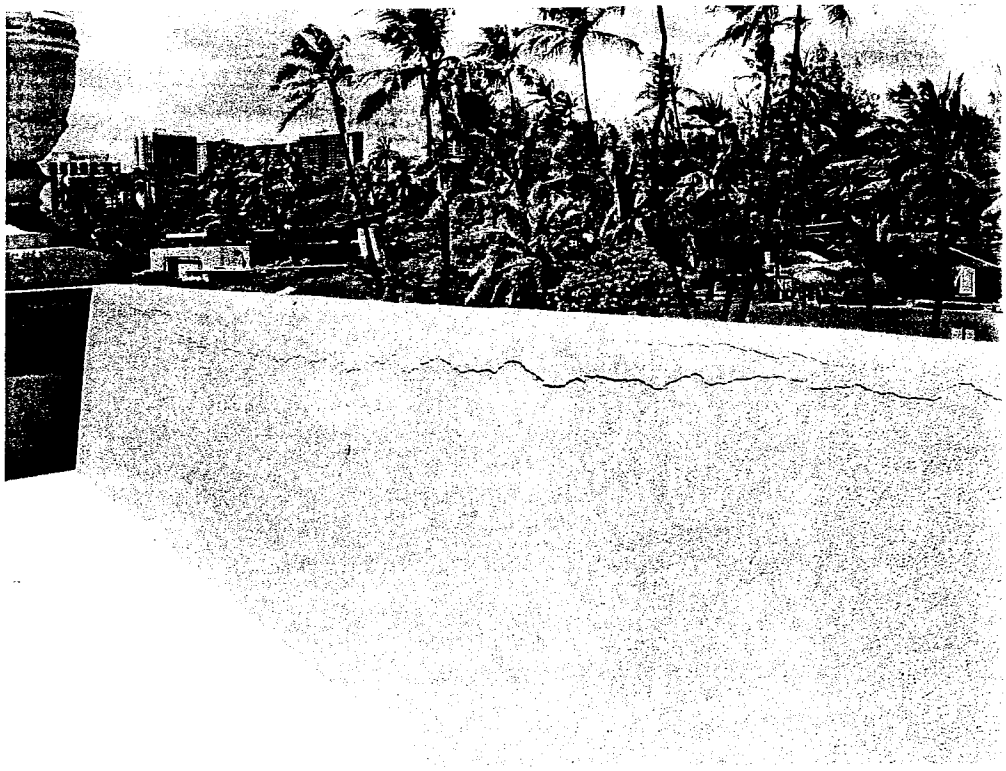


Photo 27 - Cracking at Top of Bleacher Seating Wall Finish 2

V. CONCLUSIONS

Swim Basin Structure

Overall, the swim basin structure appears to be in extremely poor condition. A few sections of the structure have already collapsed and several other portions of the structure clearly exhibit signs of structural distress, even to the point of indicating possible impending structural collapse. The pattern of cracking and deflections in the slabs and beams indicate that local failures have occurred, leaving portions of the concrete swim basin structure without a positive and defined load path. The majority of the structural deterioration appears to be a result of corrosion and possibly erosion. Corroding steel typically expands to a volume equal to approximately three to six times that of the original steel. This expansion induces tensile stresses in the concrete that result in cracks, delaminations and spalls. In addition, as the steel reinforcing bar rusts, it loses strength via loss of bond with the concrete and a reduction in the cross section of sound steel. This deterioration of the steel reinforcing obviously diminishes the load carrying capacity of the affected structural member and creates a potentially unsafe condition. The concrete cracking and spalling also makes the steel reinforced concrete member more susceptible to corrosion by providing additional entry points for moisture, thus accelerating the deterioration process. Being located along the shoreline, the structure is under constant exposure to seawater. Subsequently, this exposure will generally lead to the continued propagation of steel reinforcing corrosion and concrete deterioration. In consideration of the observed levels of corrosion of the reinforcing steel, ensuing failures are likely to occur suddenly as there is insufficient remaining reinforcing steel to allow for a slower, ductile mode of failure.

There appears to be two principal conditions that contribute to the potential failure modes of the swim basin structure. The first condition is the partial loss of the perimeter concrete sea wall's foundation bearing support, as noted by the Department of Design and Construction. As previously discussed in the building overview, the foundation bearing provides vertical support and overturning resistance for the perimeter sea walls. As a result of the partial loss of the foundation bearing support, overturning forces on the wall are transferred to the concrete piles, forces that the concrete piles were not designed to resist. It is our opinion that the existing concrete piles alone are inadequate to completely support the perimeter sea wall. This condition is made worse by the straight-line configuration of the piles that requires overturning and shear forces to be resisted by bending in the piles. The observed tilting of the perimeter concrete sea walls is a probable indicator of this condition. Furthermore, the continued erosion of the foundation bearing, which is provided by the remaining ocean floor and the rock infill, will only serve to exacerbate this condition.

The second condition is the continued deterioration and partial loss of the concrete pool deck slab. As discussed previously, the pool deck slab provides an essential component of lateral support for the perimeter sea walls as well as creating a braced support frame that is formed by the makai, ewa and Diamond Head sides of the swim basin structure. This support frame provides additional stability for the sea walls against the pressures

exerted on the wall from the ocean's waves. The continued deterioration and collapse of the concrete pool deck significantly reduces the strength and stiffness of the concrete support frame, thus making the perimeter sea walls much more susceptible to damage. In this scenario, subsequent pool deck collapses reduces the stiffness of the support frame, leaving the makai, ewa and Diamond Head sides of the swim basin to sway with the ocean's tides and waves. It is our opinion that the repetitive nature of the ocean's tidal and wave forces and continued corrosion of the concrete members will eventually break apart the perimeter sea wall and the remaining portions of the pool deck slab. These structural elements are in extremely brittle condition due to corrosion of the steel reinforcing.

The progression of these degenerative conditions would lead to the collapse of a portion of the perimeter sea wall. It is our opinion that the collapse of the perimeter sea wall will be incremental in nature with each successive wall section collapsing suddenly as the weight of the concrete and the ocean's forces exceed the capacity of the deteriorated structure. Furthermore, the deteriorated perimeter sea wall poses a significant hazard to users of the surrounding beach and ocean areas. In addition to a potential sudden wall collapse, the spalling sections of perimeter concrete wall also present a fall hazard to those in the adjacent ocean areas.

It is clear that corrosion and erosion significantly contribute to the deterioration of the War Memorial Natatorium, which threatens the integrity of a number of vital structural elements. Thus, if the progressive deterioration is not mitigated, it could potentially threaten the integrity of the entire swim basin structure, and lead to additional collapses. Mitigation of the corrosion damage would require demolition and reconstruction of the structure. It is our opinion that the swim basin structure is unsafe and should remain closed to the public until measures are taken to stabilize and/or repair the structure. The lateral displacement and concrete deterioration of the perimeter sea wall should be monitored for potential fall hazard to the adjacent ocean and beach areas. However, it is also our opinion that the further deterioration of the concrete deck along the bleachers does not appear to have the potential for immediate catastrophic influence on the foundation of the bleacher structure provided the that the foundation wall (Wall "A"), which supports the lower section of the bleacher structure, is in satisfactory service condition and that the perimeter sea walls remain intact and protects the bleacher structure from the open ocean. In order to satisfy this condition, the foundation wall should be examined to verify the adequacy to support the vertical load of the bleacher structure and to retain the fill material on the mauka side of the foundation wall. Examination of the foundation wall should include both a condition survey and structural calculations, as this member is vital to the stability of the bleacher structure. Due to site constraints, we were unable to assess the condition of the existing wall during our site visits.

As discussed previously, the continued deterioration of the pool deck slab threatens the integrity of the perimeter sea walls, making them more susceptible to damage and could potentially lead to the collapse of the perimeter sea walls. However, this progressive structural deterioration not only threatens the perimeter sea walls, but also potentially

threatens the integrity of the bleacher structure. The perimeter sea walls provide a buffer for the swim basin and the bleacher structures, protecting them from direct exposure to the forces of the open ocean. The failure of the perimeter sea walls would leave the swim basin and the bleacher structures exposed to the ocean tide and wave forces that the swim basin and the bleacher structures were not designed to resist. This exposure could potentially lead to the accelerated deterioration of the bleacher's support structure through corrosion of foundation elements and erosion of the subgrade, thus threatening its integrity.

The collapse of the perimeter sea wall also has significant potential environmental impacts. The loss of the perimeter sea wall would pollute the surrounding ocean areas through the release of the debris, resulting from the partial collapse of the pool deck slab, and the silty sediments, which were observed in the bottom of the swim basin. The result would clearly have a negative impact on the water clarity and quality. In addition, the loss of the perimeter sea wall would alter the current erosion patterns and could potentially threaten the adjacent beach areas.

Possible actions to stabilize and/or repair the structure could include the following:

- Repair/reconstruction of the swim basin structure with improvements to be able to resist imposed vertical and lateral forces with additional measures to control corrosion of the steel reinforcing
- Installation of a shoring wall which encloses the entire swim basin structure to mitigate collapse hazards to the surrounding ocean areas
- Construction of a new swim basin structure that completely encloses the existing swim basin structure, thus allowing the removal of the existing structure and minimizing the release of construction debris into the open ocean
- Implementation of the 2000 repair drawings for the swim basin structure

Note that the implementation of the 2000 repair drawings will require an extensive review of the existing structure for compatibility. Since the development of those repair plans, the existing structure has continued to deteriorate which could potentially make portions of the detailed repair procedure obsolete. For example, the 2000 repair drawings indicate a condition along the perimeter sea wall in which the existing wall and pile appear to be used in conjunction with supplemental steel reinforcing and concrete cover. In this particular case, the serviceability of the existing wall and the existing pile capacity need to be verified prior to proceeding with the 2000 repair procedure.

Implementation of the 2000 repair drawings would bring back some of the features of the original structural design and would also serve to restore the integrity of the swim basin structure. However, it is our opinion that this repair should only be temporary and is adequate to restore the exiting structure merely for the short term. Although we did not measure the concrete chloride content, given the extent of the reinforcing corrosion which were observed, it would be prudent to assume that the concrete chloride levels are high enough to continue the corrosion of any remaining steel reinforcement. This in effect renders the majority of the existing concrete elements unusable for long-term structural use.

The stabilization/repair actions listed above do not take into consideration any long-term implications such as the maintenance of the structure, the corrosion and erosion of the structure and any effects on the surrounding beach and ocean areas, or the capability of the structure to withstand storm level ocean forces. They also do not address any environmental impacts, which could result from the implementation of any of these courses of action. The actions listed above are simply possible solutions in order to mitigate the hazard to the surrounding beach areas or to return the structure to safe operating conditions.

Bleacher Structure

In contrast to the swim basin structure, the bleacher structure appears to be in good overall condition. The cracks observed in the bleacher support structure finish generally appeared to be cosmetic in nature. However, these cracks are potential indicators of corrosion below the bleacher's finish as well as additional entry points for moisture. The source of the corrosion should be investigated and remedial action taken to halt the progression of that condition in order to protect the bleacher structure from further deterioration.

The cracks observed in the finishes covering the concrete support beams in the lower section of the bleachers are likely due to corrosion of the reinforcing steel. However, it could also be a potential indicator that the supporting foundation wall (Wall "A") is settling and/or rotating away from the bleacher structure resulting in stress cracks in the support beam and finish. During our site visits, the inaccessibility of the foundation wall and the finish that covered the bleacher support beams precluded the additional investigation required to support a conclusion. The cracks observed in the archway over the main entry are a possible indicator of foundation settlement in that location. We recommend that the archway and bleacher supports and foundation be monitored for any additional settlement or movement. Deflection gages or elevation surveys could establish if the structure is experiencing ongoing settlements. If the foundation settlement progresses, possible schemes for stabilizing the structure could be investigated.

The cracking of the slab-on-grade floor below the bleacher structure appears to be the result of shrinkage, possibly due to the lack of expansion joints, or the result of settlement of the subgrade. However, this does not appear to be an urgent structural issue.

VI. APPENDIX

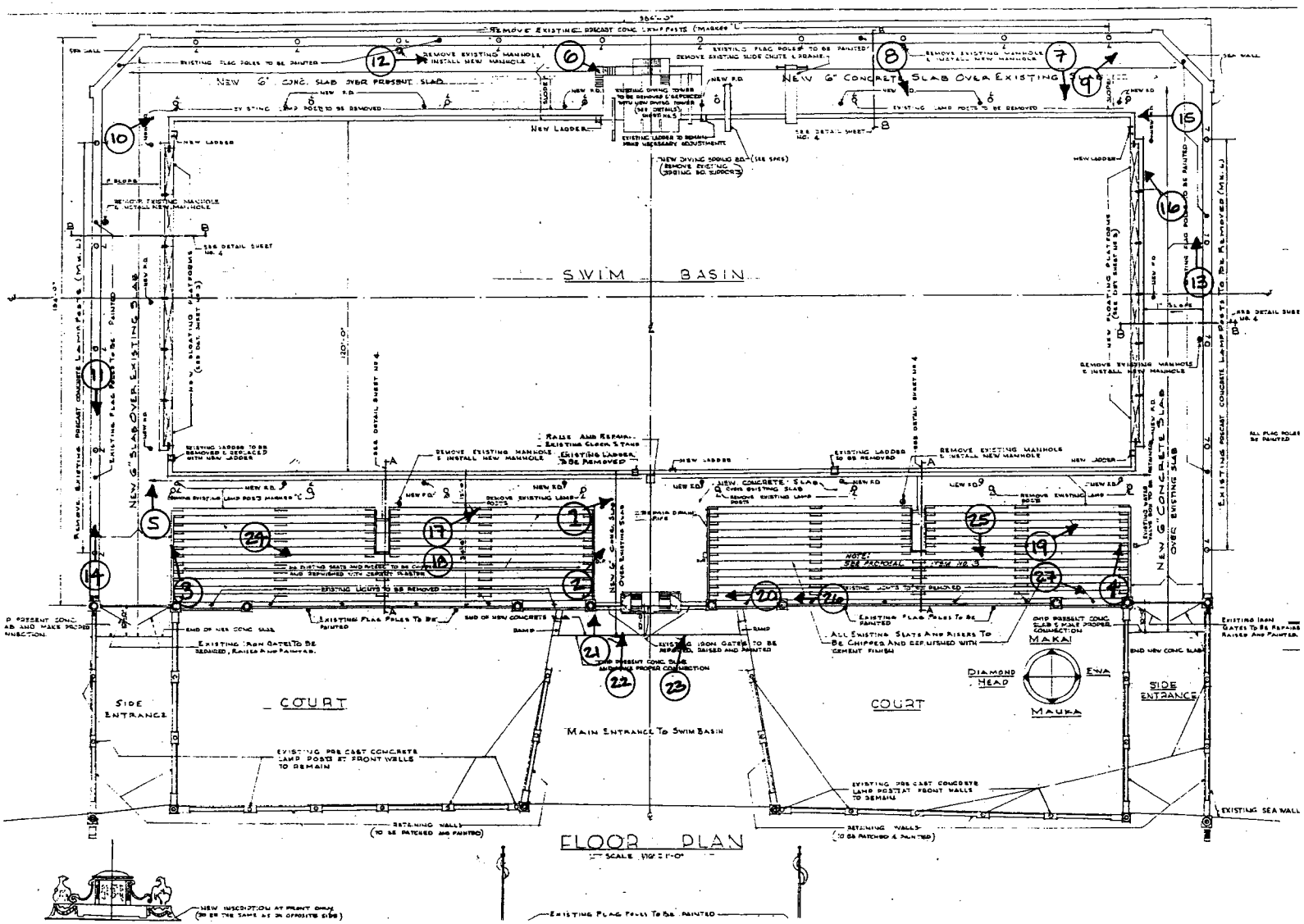


Figure 1 - Photo Key Plan

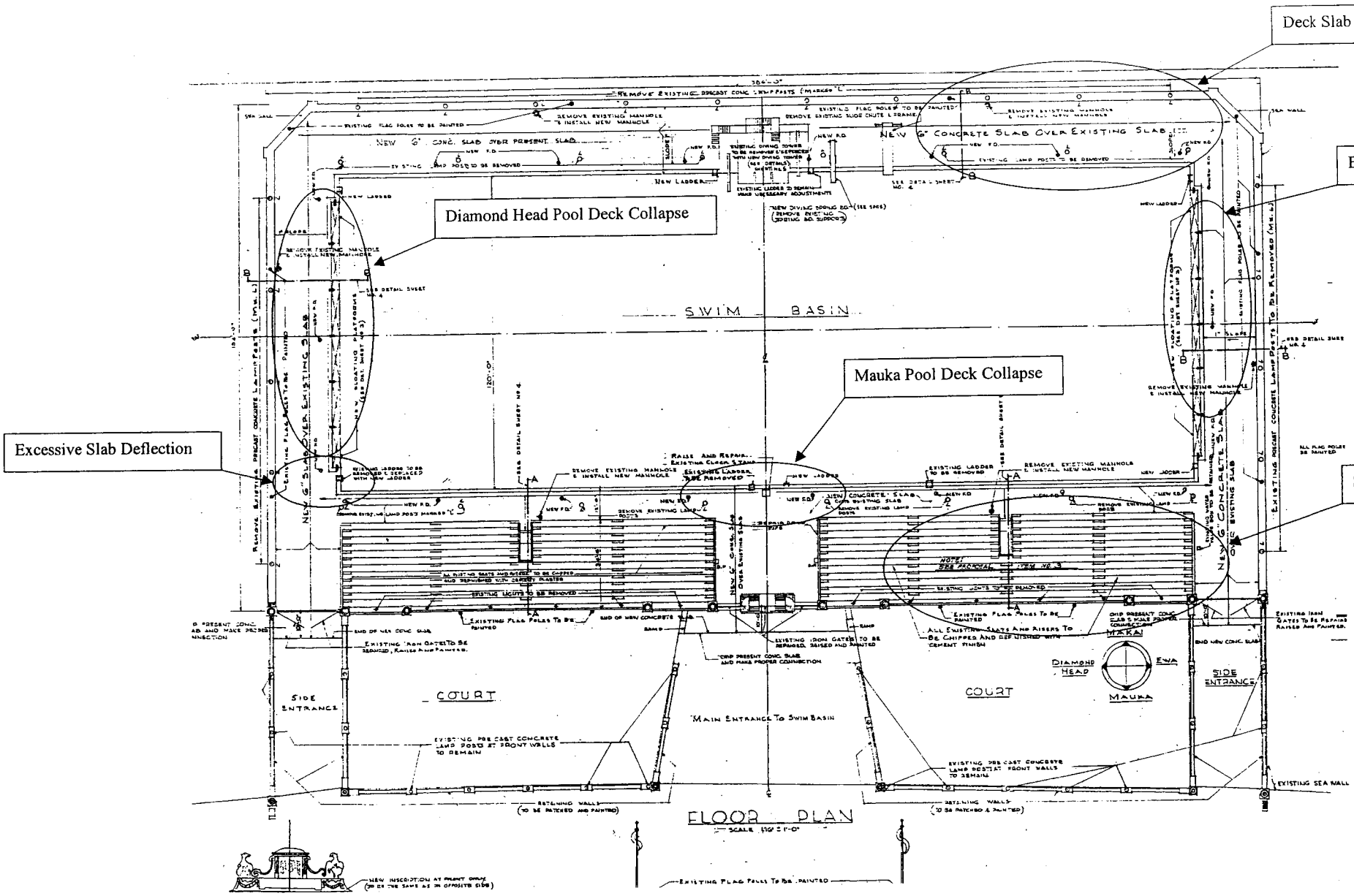


Figure 2 - Damage Plan

LEO A DALY

20 July 2004

Mr. Clifford Lau
Chief, Facilities Division
Department of Design and Construction
City and County of Honolulu
650 South King Street, 11th Floor
Honolulu, HI 96813

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SAN ANTONIO
WACO
WASHINGTON, DC

Subject: Walk-Through Inspection Report of the Waikiki War Memorial Natatorium

Dear Mr. Lau:

The collapse of a portion of the pool deck of the Waikiki War Memorial Natatorium triggered a request by the City and County of Honolulu to LEO A DALY Company to conduct a "walk-through" structural assessment of the facilities. This assessment includes a visual observation of the bleachers, showers and restrooms and the pool deck to determine the structural integrity of the facility and to recommend retrofit for any deficiencies.

The visual inspection was carried out on May 24, 2004. Clifford Lau and Rodney Bothelo represented the City and County of Honolulu. Sam Ustare and Harold Hamada represented LEO A DALY.

Under a previous contract with the City and County of Honolulu, LEO A DALY was selected to design renovations of the spectator bleachers, the entrance, and the shower and restroom facilities. This work was completed in 2000.

OBSERVATIONS

Bleachers

The renovations of the bleachers consisted of placing an overlay on the existing concrete surface. In the four years time period following the renovation, extensive cracks have appeared in the overlay. Lost of bond between the overlay and the concrete surface appears to be the cause of the cracks. The bleachers exist in a very severe environment. It is exposed to severe ultra-violet rays and a marine environment with high concentration of chlorides. The cracks are aesthetically unsightly, but the bleachers are structurally sound and will support the loads they were designed to accommodate.

Showers and Restrooms

The shower and restroom facilities are located under the bleachers. The bearing walls and supporting beams were visually inspected. The inspection revealed several cracks in the supporting beams and bearing walls. The City and County has been patching the cracks to prevent water infiltration and retard corrosion of the reinforcing steel. Four photos are shown in Figure 1 and are representative of the photos taken during inspection. Photos "A" and "B" are examples of cracks observed during the inspection. Photos "C" and "D" show the crack repairs on the underside of the supporting beam. In general, the shower and restroom facilities are in good structural condition.

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LEO A DALY

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Pool Deck

The pool deck is in poor condition. There are extensive cracks, scaling, delaminating, spalling, pop-outs. The cause of these deficiencies is the corrosion of the reinforcing steel.

Delamination occurs when layers of concrete separate at or near the level of the top or outermost layer of reinforcing steel. The major cause of the delamination is expansion of corroding reinforcing steel. This is commonly caused by intrusion of chlorides or salt. The corrosion product (rust) occupies up to 10 times the volume of the corroded steel, which it replaces. The photographs of sections of the sea wall show these phenomena. Figure 2 is a collection of four photos showing delamination. The reinforcing steel in most cases has corroded to the point where it is ineffective as reinforcement.

Structural cracks are caused by dead load and live load stresses and are divided into two categories:

- Flexural cracks
- Shear cracks

Flexural cracks are vertical and start in the maximum tension zone or the maximum moment region and proceed toward the compression zone. At the mid-span of members, flexure cracks can sometimes be found at the bottom of the member where bending or flexural stress is greatest.

Shear cracks are diagonal cracks that usually occur in the web of a member. Normally, these cracks are found near the bearing area and begin at the bottom of the member and extend diagonally toward the center of the member.

Non-structural cracks are divided into three categories:

- Temperature cracks
- Shrinkage cracks
- Mass concrete cracks

These cracks are relatively minor and generally do not affect the load carrying capacity of the member. They can however, provide openings for migration of water and contaminants (chlorides) which can lead to serious corrosion problems.

The structural elements of the Waikiki War Memorial Natatorium were exposed to the different mechanisms of cracking during its lifetime. The resulting deterioration is evident in the photos shown. Sections of the pool deck have failed and fallen into the water. A section of the failed pool deck at the entrance is shown in Figure 3. The collapsed deck is located between the bleachers and in the vicinity of the arch entrance to the War Memorial. The location is shown in Photo "A." Close-ups of the failed deck are shown in Photos "B," "C" and "D."

In Photo "B," the cracked slab section with the light gray color represents the most recent failure. The light brown cracked slab sections (on either side) represent the old failure. The light gray surface area in Photo "B" represents approximately ten percent of the total fractured surface area and this light gray surface area supported the slab weight prior to collapse.

The photo in the lower left-hand side (Photo "C") is another view of the collapsed deck. It is speculated that there are areas of the pool deck under similar circumstance and on the verge of falling into the water. The pool deck is structurally unsound and on the verge of failing. The deck is not recoverable and there is no means of retrofitting it. It is strongly recommended that the public be kept off the pool deck. The fourth photo in Figure 3 (Photo "D") is taken at another location of the deck. Here the failure section is not as large, but adjoining sections may combine with the smaller section and collapse at any time.

Figure 4 summarizes the status of the pool deck. Photo "A" shows the delamination of the pool deck along the perimeter of the pool. In the background the renovated bleachers are shown. Photo "B" shows the collapsed deck at the diamond-head end of the pool deck. A similar collapsed section at the opposite, Ewa-end, exists but is not shown in the collection of photos. The two bottom slides (Photos "C" and "D") are photos of the pool deck with extensive cracks. The two photos represent the typical condition of the pool deck.

The sea wall surrounding the pool area is in poor condition. The photos in Figure 2 show extensive and severe cracking. There are areas of the wall where corrosion has completely eliminated the reinforcing. Retrofit of the sea wall is not possible. Extensive reconstruction of the sea wall is necessary. In some areas a complete replacement of sections may be necessary.

RECOMMENDATIONS

Bleachers

The bleachers are located above the restroom and shower facilities. The bleachers are structurally sound. Minor cosmetic repairs can eliminate the shallow spider web cracks.

The bleachers face the ocean and spectator events are rare so its customary use is questionable.

Shower and Restrooms

The shower and restroom facilities are in good condition. No retrofit is required. The shower and restroom facilities may continue to be open to the public.

Pool Deck

The pool deck and sea wall are deteriorated to the point that retrofit is not possible. It is recommended that the pool deck and sea wall be repaired as a measure for public safety.

Because the sea wall is the primary factor which created the sandy beach at Sans Souci, the removal of the sea wall is not possible. It traps the sand which is deposited in front of Sans Souci. The only option to eliminate this safety hazard and protect the existing coastal features is the reconstruction of the pool deck and sea wall structure.

SUMMARY

Condition of Structure

- Pool Deck

  Sections of the deck are falling into the pool or sea. The deck is a significant part of the structure. It represents a diaphragm which connects the sea wall to piers which are supported on piles. This structural system resists the lateral forces of the sea. Without the deck, the sea walls will act as a cantilever wall which is a more flexible system. The sea wall will fail in sections without the deck. The failure will not be catastrophic, but will occur progressively; one section at a time.

- Sea Wall

  The portion of the sea wall above the water-line is in poor condition. The portion of the sea wall below the water line appears to be in good condition. The condition of the piles supporting the sea wall is unknown. However, there is no reason to believe that the capped wood piles have lost their ability to support the sea wall. Without the pool deck, the sea wall will be more susceptible to progressive collapse.

Consequences of No Action

The consequence of no action is the progressive collapse of the structure. The pool deck will continue to break apart. Loss of the pool deck will weaken the sea wall. The sea wall will progressively collapse. Where the pool deck has collapsed, the sea wall will collapse. The corners of the sea wall will be the last portion of the wall to collapse. Lost of the sea wall will cause the foundation supporting the bleachers to move and weaken the structural system. Since the bleachers represent heavier loads on the beach in comparison to the deck and sea wall it is speculated that the collapse of the bleachers will be catastrophic.

Possible Solutions to Mitigate the Impact of Further Collapse

The structural fix using the existing plans would not require the bottom of the pool be backfilled to the design depth of –6 ft MSL in order to provide the necessary support for the pool walls.

Dredging of the soft sediments in the existing pool bottom is not necessary in order to undertake structural re-construction.

Replacing the pool deck, driving additional piles, repairing the top of the sea wall are the minimum repair requirements to ensure that the ocean-based portion of the Memorial is able to (A) retain Sans Souci Beach and (B) protect the land-based portion of the Memorial from storm wave attack. The construction of the openings, while recommended for cost effectiveness, is not structurally required at this time. It is believed that the use of existing plans will expedite the process to reconstruct the Memorial structure. It is believed that that the existing permits are sufficient.

Please call me at 521-8889, if there are any questions.

Very truly yours,

LEO A DALY

Harold S Hamada

Harold S. Hamada, P.E.
Senior Structural Engineer

HSH:jsm

Encl.

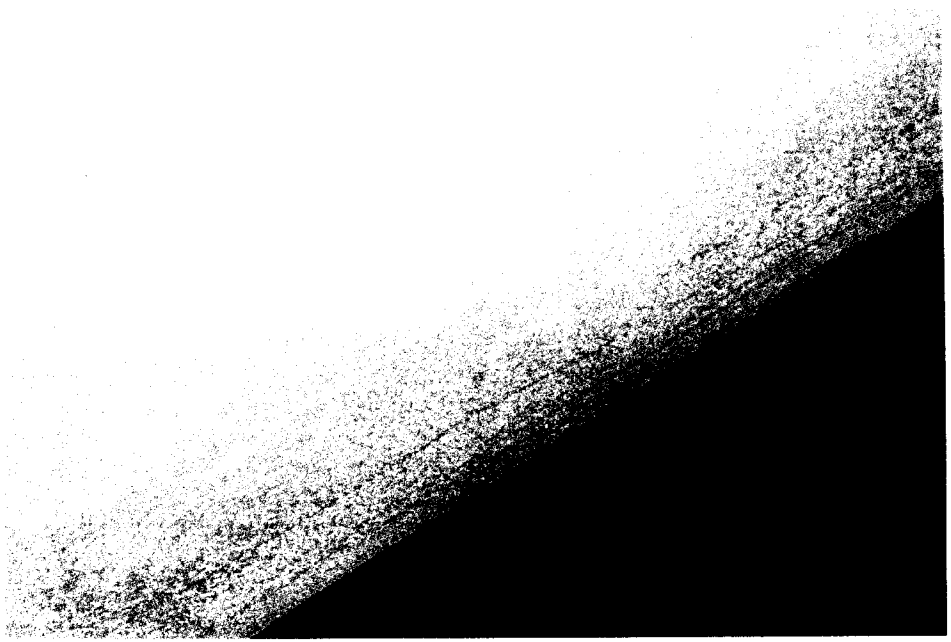

Photo A. Beam cracks.

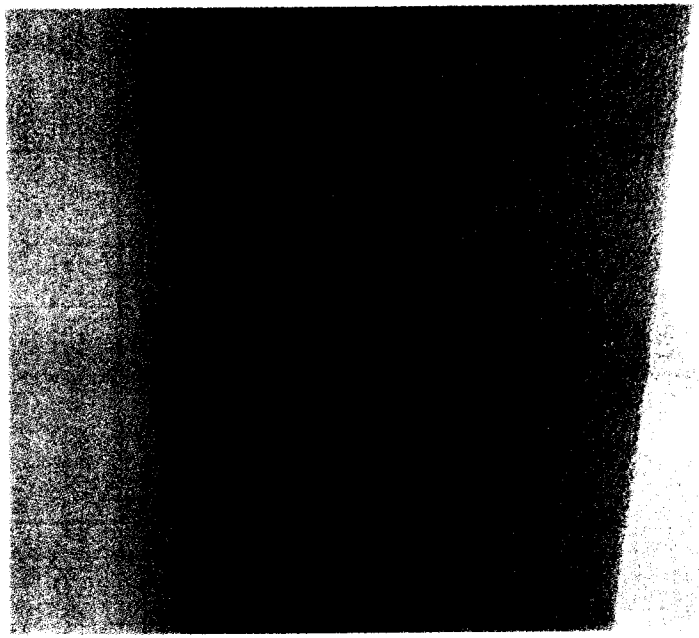

Photo B. Wall cracks.

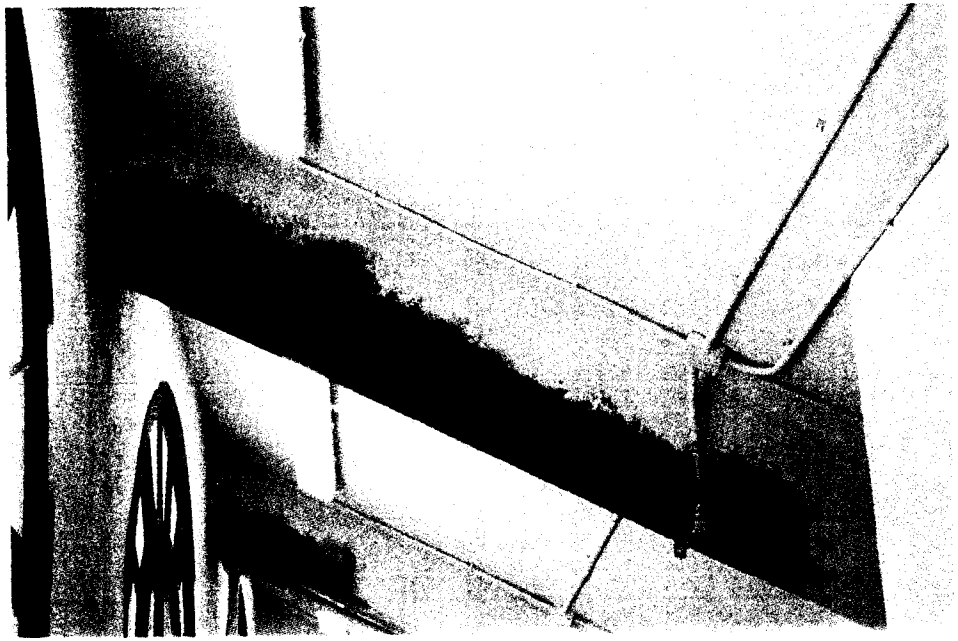

Photo C. Supporting beam crack repair.

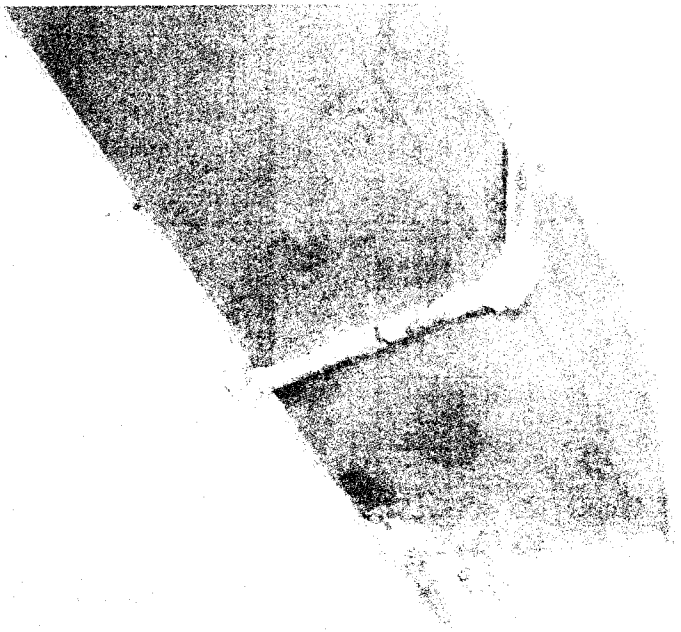

Photo D. Supporting beam crack repair.

Figure 1

Photo A. Sea wall (corner delamination).

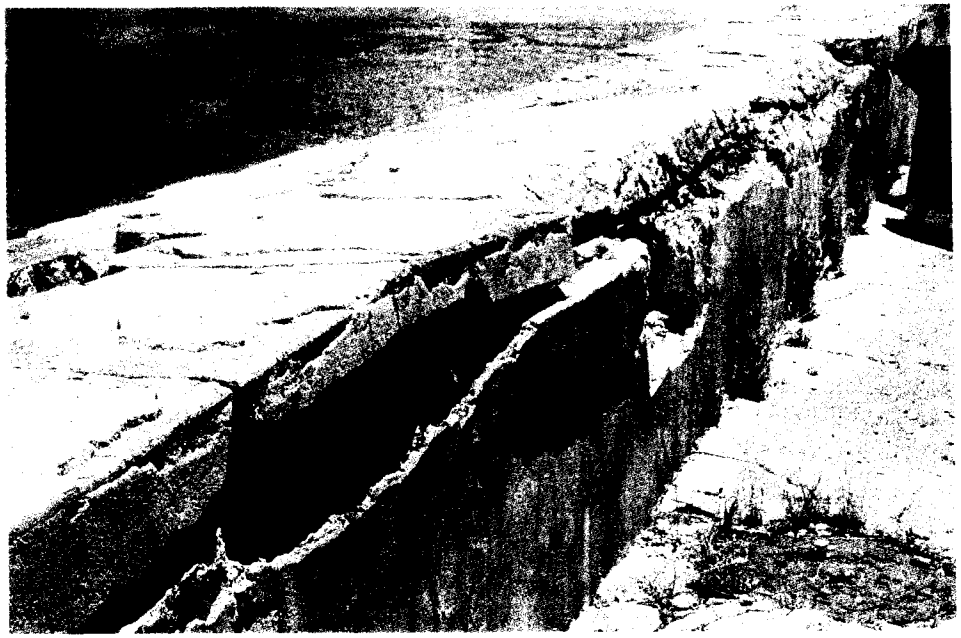

Photo B. Sea wall (top delamination).

Photo C. Sea wall (side delamination).

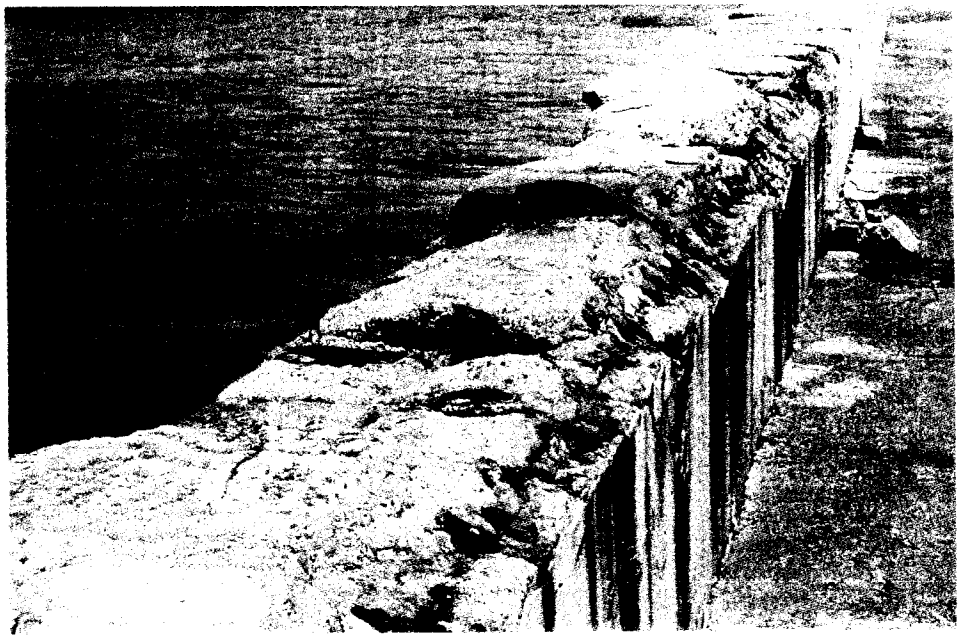

Photo D. Seal wall.

Figure 2

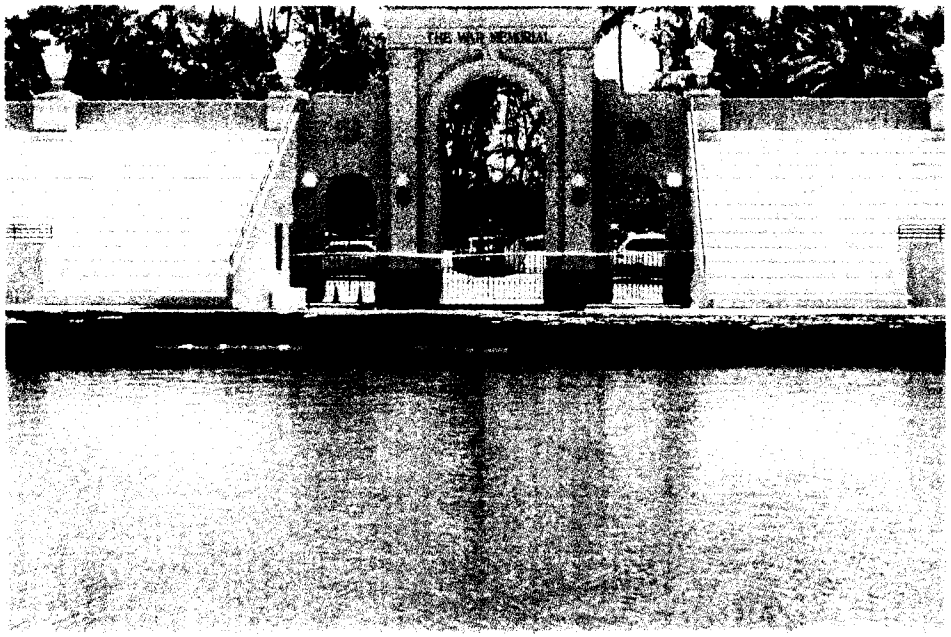

Photo A. Collapsed deck at central archway.

Photo B. Collapsed deck at entrance.

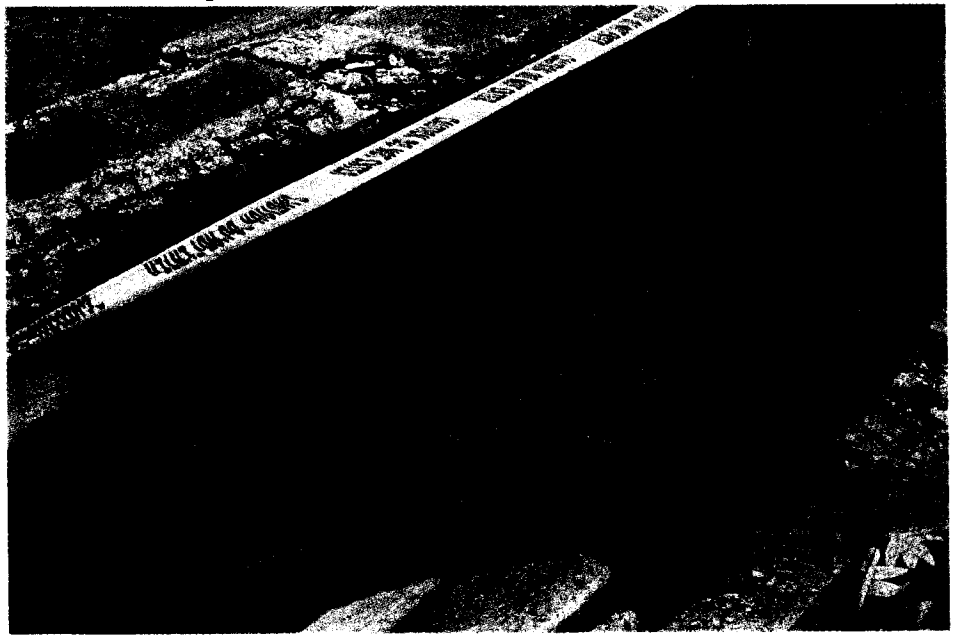

Photo C. Collapsed deck at entrance.

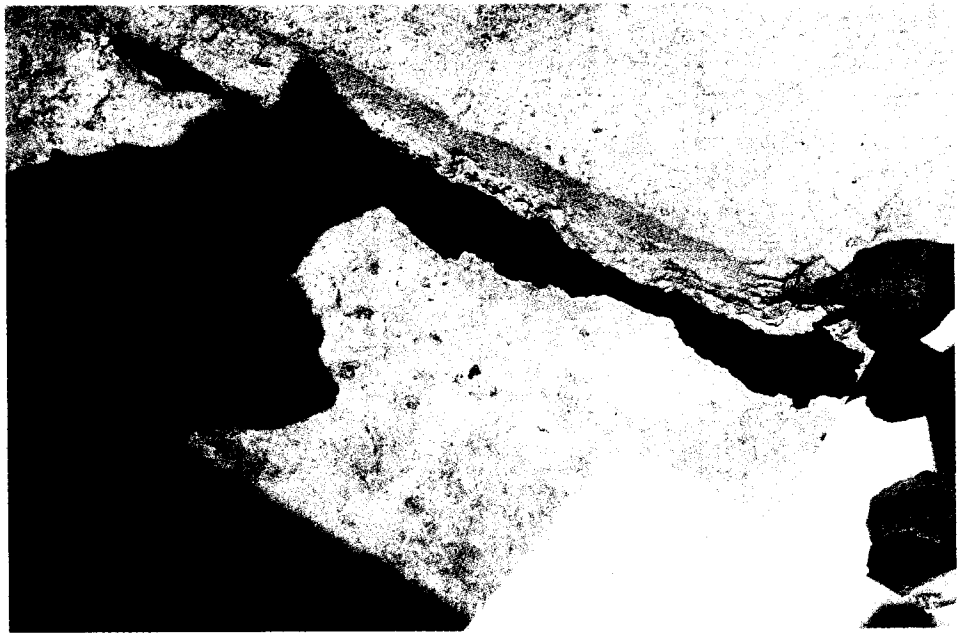

Photo D. Cracks at wheel chair niche.

Figure 3

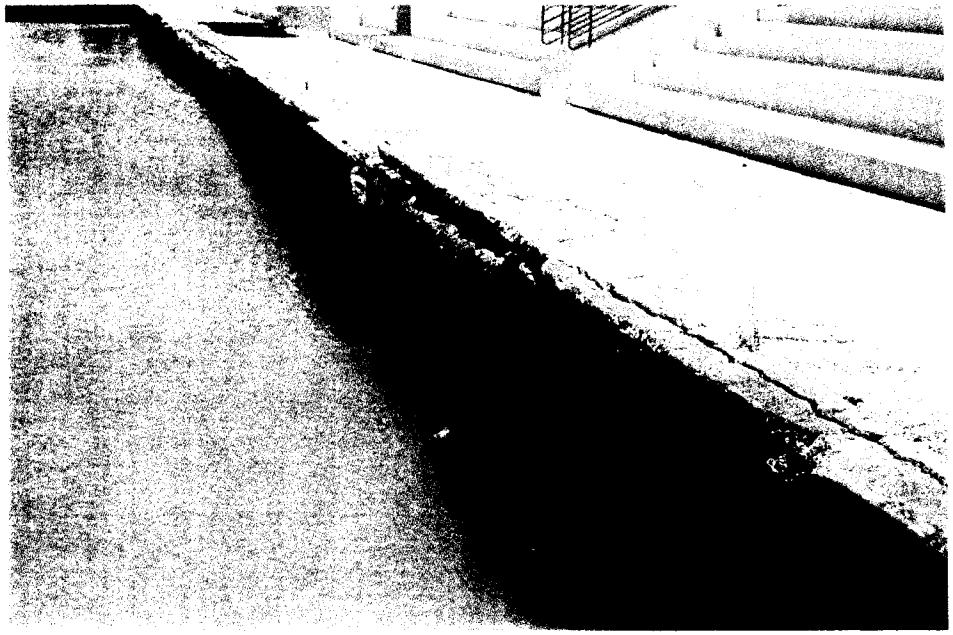

Photo A. Mauka pool wall..

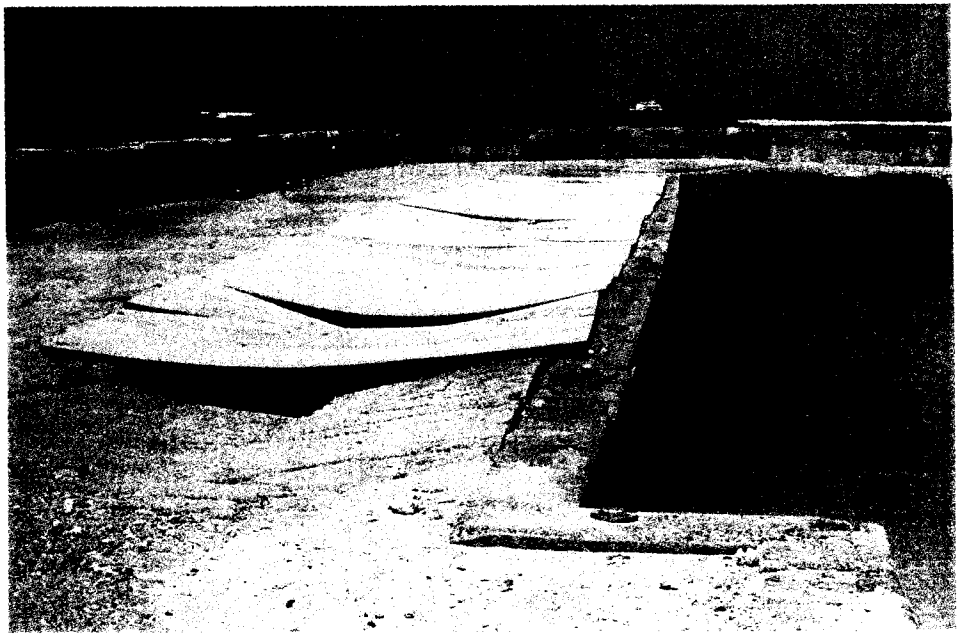

Photo B. Diamond Head deck.

Photo C. Pool deck.

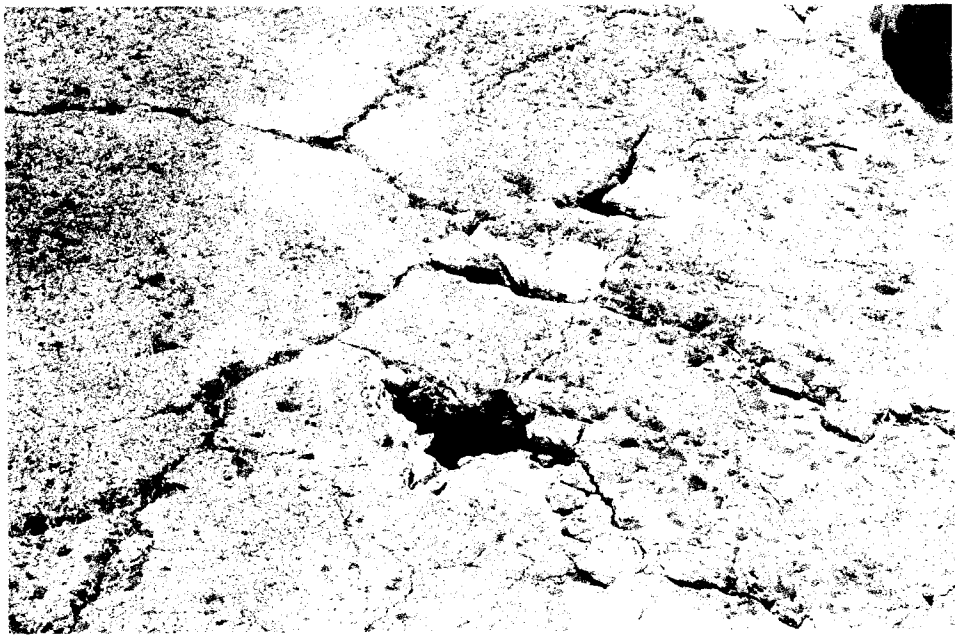

Photo D. Pool deck.

Figure 4