INTRODUCTION

This report has been prepared by Rosenberg McGinnis, AIA, Inc. (Rosenberg McGinnis) at the request of McDonough, Holland & Allen on behalf of the building owner CalPERS as an investigation of continuing water intrusion at the Capitol Square Office Building (Project) located at 450 N Street in Sacramento, California. The single building tenant is the California State Board of Equalization (BOE). The on-site property management company has been Compass Management (Compass). Management of the property will transfer to BOE in July of 1998. The investigation outlined in this report was conducted in order to observe and evaluate conditions of specific building components of Capitol Square suspected of contributing to leaks during inclement weather.

Included in this report is a description of the investigation that was performed, an analysis of conditions observed during the investigation, an outline of preliminary recommendations for repair, reference drawings, and photographs of observed conditions. The conclusions contained in this report are based on an evaluation of conditions observed during a limited site investigation. An exhaustive survey of the building was not conducted. Because of the limited nature of the investigation, recommendations for repair are preliminary in nature. A final scope of work can only be defined during the construction document preparation and actual reconstruction process when problematic conditions are fully exposed.

Field investigation work consisted of a preliminary walk-through to view the overall project site and areas of concern on 4 February, 1998 with Compass Management and the Owner's Representatives. Visual inspection, limited exploratory investigation and water testing were conducted on 1, 13, 14, 15, 21, and 22 of April and the 5 and 7 of May, 1998. Pertinent sections of the as-built construction drawings were reviewed. Additional observations of deglazed sections of the curtainwall window, terrace doorway and sidelight and were made on 20 of May, 1998. The terrace ceramic tile was also opened to view the waterproof membrane installation at the building wall at this time. All demolition and repair was performed by Eagle Construction with Capitol City Glass and Walters Tile.

Refer to Appendix A - Drawings for floor plans indicating leak locations and test areas. The leak numbers indicate the location and floor number, ie. 2A indicates a leak at location 'A' on the second floor. Refer to Appendix B - Leak Investigation Summary for a list of all reported leaks and their suspected sources, the investigation and testing schedule and locations and a summary of the watertests performed.

PROJECT DESCRIPTION

The Project consists of a twenty five story office building and a four level parking structure. Construction was completed in January of 1993. The original Architect was Dreyfuss & Blackford Architects (Dreyfuss & Blackford) of Sacramento, and the Contractor was Hensel Phelps of Oakland. Construction of the office building includes a steel frame structure with lightweight concrete floors over steel decking. Curtainwall cladding attached to the steel frame structure is a combination of an aluminum curtainwall glazing system and pre-cast concrete panels which are located at the building corners, the twelfth mechanical floor and the twenty third and twenty fourth floor parapets.

The original four level concrete parking structure encompassed the entire Project block. The northeast portion was removed to construct the office tower as it is now. The fourth (roof) level of the parking structure aligns with the third level of the office building. Adjustments and additions of roof drains were made but the slope of the original parking structure was not altered. Curbs and planters were installed on the garage structure at the cut sections located adjacent to the office building. Also, roof decks extend over occupied office space between the parking structure and the set-back office building at the west and south elevations at the fourth level of the parking structure. A separate elevator core and stairwell service the parking structure from the ground floor of the office building. A covered expansion joint on the roof level of the parking structure separates the parking structure from the office tower on the west and south elevations.

Uses for the first floor of the office tower include the main entry and security services as well as meeting rooms, a reproduction service area and general building services. The remaining upper floors are tenant occupied office space generally with open plans or partition walls forming private offices, service and meeting rooms organized around the central elevator core. The adjacent concrete parking structure has been refurbished to include a ground floor cafeteria, children's daycare center and office space.

The investigation was based on leak reports collected from Compass and reports obtained from the building occupants. A floor plan diagram indicating past and current leak locations was developed by the building tenant and made available for the investigation. The majority of the leaks were reported at the building perimeters of various floors. Each of the built conditions were investigated at typical leak areas and water tested where appropriate to determine the source of water entry to the interior.

INVESTIGATION AND EVALUATION

Evidence of leaks throughout the building have been observed in typical locations such as at the stained ceiling tiles around the perimeter columns or in alignment with the set-back building wall of the floors above. Water staining streaks were often observed on the interior window frames. Leaks were originally suspected to be originating from other obvious sources such as sealant joints, the building expansion joint and numerous roof decks. During the course of the investigation, several sources for leaks, often showing in the same locations, were determined. The general investigation consisted of a combination of visual investigation, watertesting and destructive investigation to reveal the existing construction and paths of water entry at each location.

Visual investigation included the review and documentation of the existing conditions and construction. Areas were compared to the as-built construction drawings whenever possible. Preliminary shop drawings for the storefront and curtainwall construction by Kawneer were obtained for our review on 26 May, 1998. No shop drawings for the pre-cast panels have been reviewed. A survey of the curtainwall was conducted for each floor from a swingstage at typical drops for each elevation and at the south facing, southeast corner of the building.

Watertesting consisted of applying a medium pressure spray, generally 25 to 35 psi, to various suspect elements of the building for a timed period. The tests were continued at each location until the original leak was duplicated. A high pressure spray was used to test the curtainwall elements from the swingstage.

Destructive investigation included the removal of building elements such as ceiling tiles, insulation and wall finishes to view the results of the watertests in enclosed areas. Sections of typical curtainwall areas were disassembled to view the actual construction and installation. Also, an area of the twenty third floor terrace was opened near an entry door and sidelight to view the tile installation and waterproof membrane condition at the building wall.

The description of the investigation and evaluation of the Project has been divided into the following specific building elements based on the leak source. As stated previously, these various elements often caused leaks visible in common locations. While the effect appeared similar the leak sources were determined to be different in several cases. Refer to Appendix A - Drawings for the floor plans showing numbered leak and test locations referenced in the following descriptions.

Curtainwall Glazing System

The aluminum frame curtainwall was evaluated in several ways, including watertests, visual survey and demolition. Specific portions of the curtainwall were water tested in test areas 3, 5, and 8. A visual survey was conducted from the house swingstage for every floor at a typical drop of each elevation. Additionally, a typical window was deglazed at the twenty third floor south facing terrace and a sidelight was partially deglazed at the east facing terrace to view the existing construction. A copy of preliminary shop drawings were made available for review as well. The curtainwall glazing system was produced by Kawneer and installed by Architectural Glass and Aluminum.

The curtainwall extends from the lowest floor to the twelfth floor, and then from the twelfth floor to the twenty-third floor (See Photograph 1). It then steps back and extends from the twenty-third

floor to the twenty-fifth floor. A typical bay of the curtainwall extends two floors, approximately twenty-five feet and is five feet wide. Glazing alternates between spandrel and vision panels (See SK0). The aluminum curtainwall is a "stick" system constructed of a framework of interior vertical mullions and horizontal rails. It is installed onto the structural steel frame with splice joints incorporated between the vertical mullions. Horizontal rails extend between the mullions to form the heads and sill of the spandrel and vision panels (See SK7 & SK9). Horizontal beauty caps are installed over the rails and mullion covers are installed over the vertical mullions (See SK 10). A premolded neoprene back pressure gasket with heat welded mitered corners is installed into the rail and mullion covers. Glass panels are then installed from the interior, set into the rails with setting blocks and shimmed with an anti-walk block in the mullion. The glazing consists of opaque single pane spandrel panels which span from the ceiling of each floor to the window sill of the floor above and dual pane vision glazing extending from the spandrel panel head rail to the next spandrel panel sill rail. The interior glazing stop and EPDM gaskets are then installed. A bullnose gold trim piece is installed onto the exterior mullion cover in front of the spandrel panel at each structural concrete floor line.

The system was designed to allow water that leaks through the gaskets to weep out into the rail beauty caps and mullion covers. The water was then expected to drain through the 1/16" wide gaps at the ends of the beauty caps and at the bottom of the vertical mullion covers. The four inch deep mullion covers are continuous with splice joints between sections. Horizontal rail beauty caps are one inch deep. The gap between the mullion covers and beauty caps varies from a tight fit to a 1/4" space.

Each section of the frame is designed to be sealed at the intersections to prevent water within the system from migrating to the interior. The mullion frame interior splice plate construction and condition could not be confirmed. The horizontal rails are fastened to the vertical mullions with "L" brackets on the interior. Silicone sealant is installed to form an end dam at the rail to mullion intersection (See SK 8). End dam sealant at the horizontal rail to vertical mullion intersection could not be fully verified in the deglazed section. At one end of the sill rail observed, sealant was spread along the end of the horizontal rail then turned up the vertical rail approximately two inches to form an end dam. The sealant was worked into the corners and up the horizontal rail edges. A small hole in a section of thin sealant was observed in one end which could allow water to enter the wall system (See Photograph 7). The other end had an untooled glob of sealant filling the end section which would block the water from weeping out the end of the beauty cap (See Photograph 8). The spandrel sill rail is formed differently from the vision sill rail. The spandrel sill rail has a track on the interior with a 1/2" lip to collect water that runs down the back of the panel (See SK 9). This track then weeps to the glazing track and then into the beauty cap.

Silicone sealant has been used to seal the joints between the aluminum curtainwall frame and precast panels. The majority of the panel sealant appears to be in good condition and is properly installed. The section of panel sealant over the vertical mullions is installed different than shown in the shop drawings. The top of the vertical mullion has a metal cover plate which has been spread with sealant or in some cases a pre-formed silicone sealant sheet was used (See SK6). The shop drawings show the panel joint running from the window head out and around the edges of the mullion. Instead, the horizontal panel joint was installed continuous along the back of the vertical mullion (See Photograph 2). The four inch depth of the mullion made this section difficult to tool, particularly when the joint was less than 1/2" wide. The joint was left rough or un-tooled and several gaps and holes were observed in these sections. The panel joints at the window sill to precast panels (See SK8) are very narrow (See Photograph 6). In some cases the condition of the sealant could not be viewed. Failure has not been confirmed or observed due to the narrow

joint width and is not likely due to the low movement expected in this area of the frame.

Holes were drilled through the vertical mullions for the gold trim attachment angles. In the majority of the drops viewed, it appears that holes were misdrilled just above the trim and filled with silicone sealant. Some of these silicone patches are disbonding, leaving a hole through the beauty cap.

The overall condition of the aluminum curtainwall system is similar on all elevations, with a slight decrease in gasket problems on the north side. Many of the pre-molded neoprene fixed exterior gaskets have slipped out of the window frame (See Photograph 3). In some cases the welded corners have broken. This glazing gasket seems to have weathered prematurely. The gaskets are in noticeably better condition on the north elevation which is subjected to less harsh sun and weather conditions.

Splice plates are fastened to the inside of the upper section of the mullion cover while the lower mullion cover is allowed to move against the splice plate as required for thermal movement. A silicone sealant joint seals the opening between the two mullion covers over the splice plate (See Photograph 15). The sealant is installed flush with the face of the mullion cover . The sealant bond line is limited to the 1/16" thickness of the edge of the metal mullion cover. Most of these sealant joints have failed completely. The amount of movement in the metal has broken this bond (See Photograph 4). The splice plate sealant is in noticeably better condition at the shorter sections of vertical beauty caps located above the precast panels at the twelfth floor and north elevation which encounters less thermal movement.

The open gaskets, failed sealant at the splice plate joints, panel joints and end cover plates will tend to allow excessive water into the window wall system. The weep system as it is designed may not be able to weep this increased amount of water. This beauty cap to mullion cover intersection is often a tight fit or possibly blocked by sealant pressed out from the rail installation, which would cause the water to fill the beauty cap and the horizontal rail, especially in windy conditions. It can then only spill into the gaps in the inner sealant or over the back edge of the horizontal rail into the wall system. Evidence of water staining on the interior face of the spandrel panels dripping from the horizontal rail was observed during the investigation. Water stains are also evident on interior vertical mullions dripping down from above the ceiling line.

Watertest number 17 was conducted by spraying water onto the curtainwall where the aluminum frame met the precast panel on the third floor near the garage elevator penthouse. Water passing through the gaskets filled the horizontal rail and leaked out the end of the rail to the interior wall cavity. This water was then trapped inside the wall behind the deck coating and wall base sealant. It eventually saturated the structural slab and the topping slab of the roof deck under the deck membrane and dripped to the floor below at the drain penetration through the structural slab. Some leaks such as 3A, 5B, 5C and 17K are observed set back several feet from the perimeter wall. This may be attributed to the water migration path described above as water enters the curtainwall system, drips down to the structural slab, then migrates through cracks or penetrations to the floor below. Most often the leaks are observed at the perimeter wall where it drips down the spandrel glazing or vertical mullions and show as water stains or drips through the ceiling tiles. Most of these leaks are observed on the east and south "weather " side of the building, although similar construction conditions exist throughout.

Watertest number 18 was conducted in the same location at the mullion splice joint. The silicone sealant showed the typical complete adhsion failure between the ends of the mullions. The splice is located just below the metal band at penthouse roofline. The base of the mullion has been

sealed to the precast panel. Water sprayed onto the splice joint caused a leak immediately to the interior in the same location as test 17 described above. Water in the mullion cover could not weep out the sealed base and ran into the end of the horizontal rail and then into the wall cavity.

Storefront

The storefront curtainwall is located at ground floor of the east and north elevations. Most of the storefront wall is set back under the upper floors of the office building (See Photograph 11). The two story "stick" construction of the storefront system is similar to the aluminum curtainwall system on the upper half. The lower portion of the wall terminates with a storefront kickplate section resting on a threshold at the edge of the slab-on grade (See Photograph 9). Preformed gaskets are installed at the glazing (See SK4). The butt joints of the aluminum frame are sealed with silicone sealant set flush with the face of the metal.

The storefront also has a decorative gold band located at the second floor line (See Photograph 11). Aluminum trim pieces are installed at the top and bottom of the gold panel. Glazing is fit against pre-formed gaskets. Weep holes are designed to be installed in the horizontal rail to weep water bypassing the glazing gaskets into the aluminum trim pieces. Silicone sealant is installed in all of the joints between the trim pieces, gold panel sections and mullions. The sealant joints are located at the front edge of the metal sections and no weep holes were installed in the trim pieces (See SK5).

Leaks 1A and 1B were reported along the east wall line in the reproduction room. Similar leaks were also reported at the north wall of the adjacent printing room, although these were not marked on the floor plan leak log.

Watertest numbers 9 to 13 were conducted opposite leak 1A. The storefront system is set on the threshold which is installed over a formed edge flashing that extends two inches down the face of the concrete slab edge. The butt joint of the edge flashing is offset from the butt joint of the threshold. The first watertest, number 9, was directed at the threshold splice joint. Water appeared on the interior top of the threshold within 40 seconds and traveled along the grooves in the threshold to the adjacent mullion within 5 minutes (See Photograph 10). Test 11 was directed at the failed sealant joint of the sill can butt joint with the same results. The design is similar to that of a storefront door and threshold instead of a watertight wall base. There is no sealant or flashing barrier at the base of the storefront base section.

This sill area was masked off and tests were continued at the upper portions of the storefront system. Several silicone sealant joints had failed in adhesion to the metal at the gold band assembly (See Photograph 12). Movement of the panel and the lack of adhesion to the thin substrate edge may be the cause of sealant failure in the gold panel assembly.Water stains were visible on the exterior face where drips had exited from behind the sealant. Test 13 (See Photograph 13)verified that water can enter the wall assembly and migrate to the interior. Drips to the interior followed stain patterns from the head can and down the vertical mullions within 13 minutes of starting the water spray test (See Photograph 14 & 15).

As with the curtainwall, water is entering the wall system through unsealed butt joints or gaps in the glazing gaskets. The upper half takes in water as with the curtainwall and is trapped in the gold panel. Trapped water then migrates to the interior window head and mullions (See Photograph 16).

Pre-cast Concrete Panels

Precast concrete panels are incorporated into the curtainwall system at the building corners, base of the walls on the west and south elevations, mechanical (twelfth) floor around the louvers and corner terraces, and at roof parapets. The panels were originally treated with Hydrozo Enviroseal 20 clear sealer to reduce water absorption. Each panel is attached to the building's steel structural frame using embedded steel angles and threaded rod push-pull anchors. Fiberglass batt insulation is attached to the back side of the panels within the wall and ceiling spaces. All panel joints are sealed with a concave silicone sealant joint installed at the front edge of the panel. No shop drawings were reviewed during the course of the investigation.

All of the panels observed have two types of cracks. Short, hairline cracks, likely from shrinkage of the concrete, occur at the rounded edges of the panels. These cracks vary in spacing and are generally found in a series less than an inch apart. They penetrate just the surface of the panel. Larger cracks were also common on the top edge and face of the concrete panels. The visual survey of the curtainwall revealed a common location pattern for each of the vertical or slightly diagonal cracks on the face of the panels. No structural analysis of the concrete or fasteners was performed within the scope of this investigation. Cracks were common at the center of the panel span and at the quarter points (See Photograph 17, 19). The majority of the cracks originated at the lower edge of the panels. Few cracks extended from the top to the bottom edge of the panels. Semi-circular cracks were also observed on the top edge of many panels (See Photograph 18).

Watertests were performed on the cracked areas of the panels (See Photograph 17) and found to cause leaks 2E, 2F and 25A. Water enters the panel, and drips straight down after saturating the batt insulation. Leaks may be attributed to panel cracks and/or the curtainwall glazing conditions at similar conditions found at leaks 2C-D, 2G-L, 21G-H, 22A and 22C-D.

Corner precast panels with punched windows were viewed on the southeast corner. Diagonal cracks were observed originating at the window corners. Hairline cracks were also observed at the back edge of the vertical reveal at nearly every level of these corner panels (See Photograph 20). Panel cracks may be responsible for leaks 7A and 9B showing at the ceiling level.

Panels with a return at the building corners have an additional type of crack. It appears that these panels are cast in a two step process. First, the flat piece is cast, then the return piece is cast to form an 'L'shaped panel. The intersection from these two castings is a "cold joint". Large cracks were observed running along this cold joint (See Photograph 21). No watertests were conducted at these areas, but leaks to the interior are highly probable given the results of the test described below at the precast column covers.

The roof terrace parapets at the 23rd and 25th floors have two sides exposed to the weather. Steel bracket edges embedded in the panels were exposed just above the 23rd floor terrace tile which may contribute to leaks 22A , 22C-E at the building perimeter. The steel bracket edges have severely rusted.

The cracks in the panels are allowing water infiltration into the panels. Eventual rusting and degradation of the structural steel and attachment elements is a concern. A project is currently underway by BOE to apply a clear seal to the panel surface to reduce the amount of minerals

leaching out of the panels onto the window glazing. The panel cracks are not being addressed within the scope of the clear seal application.

Precast Concrete Column Covers & Louvers

Mechanical equipment is located on the twelfth floor, including all of the air intake and output louvers for the heating and ventilating systems throughout the building. The metal louvers are installed on each elevation and are inset from the face of the building. Precast horizontal spandrel panels are located above and below each bank of louvers forming a shelf at the sill and a soffit at the head. In between the spandrel panels at the column centerlines, 'U'-shaped vertical precast column cover forms the return sides at the louver openings. A cold joint is formed at each of the two sides of the covers where the returns are cast against the face. All exterior panel joints are sealed with silicone sealant. The majority of the joints are in good condition. Bird wire has been installed on the sloped horizontal shelf, fastened with shot pins to deter roosting. Wet rooms are located on the perimeter of the entire floor to manage rainwater blown through the louvers. The mechanical equipment is located in the adjacent rooms.

Leaks have been reported at the 11th floor ceiling below the mechanical louvers on the south elevation. Several remedial measures have been performed in the past on the louvers and the wet rooms. Interior sealant joints around louver frames have been re-caulked, and sealant end dams have been installed. Interior qypsum column covers have also been added between the louver frames with sealant at the edges and a waterproof elastomeric coating (See Photograph 22). The floors have a deck coating which appears to be in good condition and slopes to the floor drains.

Water tests 1 to 6 were conducted on various elements of the louver and precast panel construction directly over leak area 11C. The horizontal panel joints and precast shelf were tested below the louver sill and no leak was observed. Failed sections of vertical sealant at the louver frames were also watertested. Water infiltrated to the interior mechanical room, running along the horizontal steel angle upon which the louver frame is set (See Photograph 23). This water eventually dripped to the floor, but did not enter the wall framing at the louver jamb. This is still a potential path of water entry, especially for wind driven rain. A solid metal attachment plate closes the lower portion of the space between the metal louver jamb and the wall framing where the sealant end dam is installed. Water blown into this space will fill the cavity, eventually wetting the backer rod of the external panel joint and wicking into the wall cavity below.

Tests were continued onto the precast column covers and sealant joints. A narrow crack is typically visible at the cold joint on the outer corners of the column cover. Water sprayed onto this cold joint crack re-created the leak occurring in the floor below after an initial test on the lower portion of 20 minutes and a continued test for the full height of the column for 15 additional minutes. The extended time to view the water on the ceiling panel below was due to the fact that after water enters the crack it must saturate the insulation and fireproofing installed against the back of the precast spandrel panel before reaching the window head. Watermarks were also visible along the window head frame, indicating that the water travels horizontally along the frame to points away from the columns. The construction materials between floors could not be verified, however, this same leak could potentially travel to the floors below as it runs down the face of the curtainwall or continuous vertical mullions within the wall cavity.

Building Expansion Joint

An approximate 8 inch separation exists between the four level concrete parking garage and the office tower. This expansion joint allows for the differential movement of the two structures. The expansion joint runs the full length of the building on the west and south elevations. The gap is enclosed by a flexible neoprene cover at each of the raised roof decks at the roof level of the garage structure (See Photograph 24). The condition of any additional waterproofing component within the expansion joint could not be verified. Deck coating extends over the flexible joint cover and up the cast concrete wall separating the parking area from the office building and is also turned up the face of the precast panels of the curtainwall.

Terminations of the neoprene cover at the deck edges and at the elevator penthouse were viewed. Debris has settled at the depressions found in these locations, keeping the area damp. This could cause deterioration of the deck coating and joint cover. Gaps were also noticed at each of the termination points, where sealants had disbonded from the several layers of the joint cover sheets. The flexible cover turns down the deck edge at the elevator penthouse and building edge, and is therefore, partially protected from water entry through these gaps. No leaks to the building interior have been attributed to the neoprene expansion joint cover at this time.

At the center of the west elevation, the joint extends under the exterior threshold of the garage elevator on the west elevation of the office building. A roof overhang on the elevator penthouse protects the roof level threshold and a sloped ramp had been added at the elevator entry doors to ensure that water drains away from this joint. Because the threshold is protected, water does not appear to breach the expansion joint. No tests were conducted at this level of the elevator threshold.

The joint cover turns down the concrete at the sides of the elevator penthouse to run vertical to the slab level and then turns horizontal again as it runs under the threshold. The point at which the joint turns down from the elevated roof deck is terminated by a metal closure piece. This metal closure piece butts into the wall of the penthouse (See Photograph 25). No sealant joint has been incorporated into this intersection leaving a point of potential water entry into the deck topping slab and expansion joint. Both sides of the penthouse are similar. This may contribute to the water infiltrating between the topping and structural slabs described in the Third Floor Roof Decks below.

Garage Elevator Penthouse

A penthouse encloses the elevators servicing the parking garage structure on the west elevation (See Photograph 26). This elevator core is inset into the office building first and second floors. The third and remaining upper floors are stepped back behind the back wall of the elevator core. The penthouse exterior wall finish is a modified EIFS system. A thin layer of an acrylic coating is spray applied to a rigid insulation board. The finished appearance is similar to cement plaster although the wall system is intended to have a watertight acrylic surface, unlike cement plaster which relies on building paper as the water barrier under the porous cement finish.

The penthouse roof overhang is constructed using a metal trim system similar to the gold panel installed on the storefront system described above (See Photograph 27). All joints between the horizontal aluminum and gold metal panel are sealed at the front edge with silicone sealant. The gap at the butt joints are filled with silicone sealant. The top aluminum section also serves as roof

edge flashing. This section overlaps the single ply Trocal roofing membrane (See Photograph 28). A silicone joint is installed between the lower aluminum trim piece on the overhang and an aluminum trim piece at the top the penthouse wall.

The roofing membrane is reported to be a recent installation, as leaks were attributed to the previous roof membrane. No sealant or counterflashing is present between the edge flashing and roof membrane, which allows ponded water to run directly under the edge flashing into the metal wall construction. The space was found to be wet prior to the watertests. Flood test numbers 19 and 20 indicate that the roof ponds at points away from the drain, often near the metal edge flashing. Water running under the edge flashing in test 19 entered the penthouse and office building wall framing immediately. The water was allowed to run at a very low volume for 60 minutes during test number 19a to determine if this was the source of leak 2K into the second floor. No leak was observed until test 20 when the pressure was again increased to a medium flow. Water dripped after 7 minutes from the deck drain penetration. Water entering the wall from the roof and became trapped behind the deck coating and wall base sealant in the same location as described above for the curtainwall test number 17. After saturating the topping slab and structural slab, water migrated through the deck drain penetration to the floor below. All slab penetrations would be subject to leaks once the slab becomes saturated and may explain leaks 2J and 2L which also occur below similar conditions.

Parking Garage Floor Slab

The four level parking garage adjacent to the office building is a thirty-four year old concrete structure. The construction is a combination of precast and cast-in-place concrete. It was modified during the construction of the new office building to remove the northeast quadrant of the structure where the office building now stands. The remaining ground floor was renovated to house the interior occupied spaces for the mail room, reproduction room, cafeteria, daycare center and service corridors. A deck coating was applied to the second level slab surfaces above these occupied spaces. The remaining levels have numerous shrinkage cracks throughout the entire field of the floor slabs. The bays between the structural columns at the perimeter of the parking garage are open to the weather except at the office building walls.

Deck drains are located on each floor throughout the garage. Some drains were relocated when the section of the garage was removed but the slope of the slab was not revised. Several of the floor drains appear to be in high spots of the slab. This allows water that is blown in from the perimeters, brought in on the vehicles or dripped through cracks and cold joints from the upper levels to pond in the low sections of the floor slabs (See Photograph 29).

A concrete curb was installed at the cut edge of the slab which runs along the building expansion joint. A concrete wall was installed on this curb. Planters are located along the top of this wall a the fourth level. The planters on the top of the walls at the garage perimeters have all recently had new waterproof membranes installed.

The slabs tend to slope toward the west elevation of the office building. Water penetrates the cold joint between the original garage slab and new curb and the elevator thresholds and migrates to the floor below at each level as seen during watertest numbers 8, 27 and 28 (See Photograph 32). A project is currently underway by BOE to apply a traffic deck coating to the roof level slab and curbs to prevent water migration through the cracks and cold joints.

A low concrete curb is installed along the north column line of the second level garage separating the parking area from the slab overhanging the daycare play yard and outdoor cafeteria seating. The deck membrane over this portion of the slab appears to be in generally good condition in the areas of the reported leaks into the cafeteria below. A gap between deck membrane layers was observed where it turns up the curb near the column at Watertest 7 (See Photograph 30). Also a sealant joint between the curb and column has begun to fail. The water test flooded the deck membrane on the north side of the curb on the second garage level directly above leak 1D. Within 6 minutes, water infiltrated the gaps in the membrane and sealant at the curb began running down the concrete beam directly above the leak area (See Photograph 31).

Garage Stairwell Penthouse

A fourth level penthouse encloses the stairwell access to the parking garage near the northwest corner of the office building. The original stairwell was oval in shape. New squared cement plaster walls were built at the south side of the penthouse. The stairwell is inset within the ground floor cafeteria. Water sheets down the continuous space between the inner original wall and the new stairwell wall and floods the floor of the cafeteria at the wallbase. The interior wall and landing finishes are water damaged at each level of the stairwell.

Watertests 27 to 29 were conducted at various elements of the stairwell penthouse. The concrete slab was flood tested at the base of the wall at the fourth level. Water dripped through the cracks in the slab to the garage floors below at the areas of ponded water and against the stairwell wall. Although cracks ran under the stairwell walls, no water was observed to migrate through the interior framing of the penthouse.

The cement plaster wall is sealed to the slab at the wall base. This sealant has failed in several locations. Water test 28 directed a spray at this joint. The test had to be stopped before determining if this is a source for water to enter the stairwell interior because an excessive amount of water was dripping through the slab cracks and cold joints onto the parked cars in the levels below.

The penthouse roof was then water tested. The built up roof has a gravel surface with metal edge flashing and a single scupper on the north side. When the roof was flooded the water drained away from the scupper to spill over the edge on the south side, directly over the entry door (See Photograph 33). Water dripped down the door frame and migrated over and under the metal threshold installed on the slab surface to the interior of the penthouse. The water on the interior tracked along the base of the wall to run into the space between the original curved wall and the new framed wall (See Photograph 34). This same condition has been verified after actual rain storms. The curved wall is continuous to the ground floor. Water entering this cavity would run down the wall to the ground floor where it shows as a leak in the cafeteria.

Mechanical Floor Corner Planters

Precast panels form landscaped planters on the recessed building corners of the twelfth mechanical floor (See Photograph 35). The planters are on the perimeter of the exterior corner deck (See Photograph 36). The deck coating appears to be in good condition. Leaks have been reported at the eleventh floor ceiling directly below the planters. Flooding of the planter for watertest number 34 confirmed that the leaks are from a defective waterproof membrane in the

planter. A leak along the full length of the window wall was re-created within 5 minutes (See Photograph 34).

Compass reported that one of the corner planter membranes has been replaced to address leaks below. The membranes in the remaining two corner planters are probably in the same condition as the planter tested. It is likely that the leak 11E is also from the planter above.

Third Floor Roof Decks

Third floor roof decks are located along the west and south elevations of the office building. These decks are raised slightly above and accessible only from the fourth level of the adjacent parking garage (See Photograph 38). The decks extend over second level office spaces and are bordered by the building expansion joint and the set-back office tower curtain walls. An elastomeric deck coating is installed over a topping slab which is sloped to the deck drains. The deck membrane extends over the flexible expansion joint cover and up the concrete planter walls on one edge and up the precast curtainwall panels on the other edge. The membrane is in good condition in most areas with the exception of the southeast section of the deck. The surface of the deck coating in this area is pitted and beginning to delaminate (See Photograph 39). It is possible that these pinholes were caused by outgassing of water trapped in the topping slab under the coating in the original installation.

The decks terminate on the north and east elevations in alignment with the office building. The elastomeric deck coating runs under a metal edge flashing (See Photograph 40). The edge flashing is formed to provide a low curb at the deck edge. The raised section is a squared "U" shape. This flashing butts up to the building wall at one end and the flexible expansion joint cover at the other. A horizontal leg extends over the precast panel and extends 1-/2" down the face of the precast panel onto the wall below the deck (See Photograph 41). The section turned down over the deck edge does not have a closure piece at the open end. This open end is set flush with a horizontal reveal in the precast corner panel on the office building wall. The opening extends well into the wall framing cavity above the top edge of the precast panel. Watertest number 23 was performed at the edge flashing to building intersection above leak 2B. A medium spray was directed to the building wall for ten minutes. No leak was observed below. The spray direction was then slightly adjusted and water was heard to bounce against the interior of the metal edge flashing and immediately dripped down the backside of the precast panel to the leak area below. While most rainwater will tend to sheet straight down the wall, wind driven rain or water directed by the precast panel reveal will enter the end of the edge flashing and travel directly into the wall cavity.

The north deck edge was found to have similar construction with a large hole leading directly into the wall cavity behind the precast panel. No water tests were conducted at this location, but results can be assumed to be similar to the east deck edge. The gap in the edge flashing to wall framing intersection appears to be the cause of leak 2M.

Twenty Third Floor Terraces

Rooftop terraces are located at each of the four elevations on the twenty third floor. The office building wall is stepped back to the first column line from the twenty-third to the twenty-fifth floor, forming rectangular terraces over the office spaces below. Each of the terraces appear to have

similar construction. Each deck is sloped to the deck drains located along the centerline of the terraces. Concrete tree planters are located along the centerline of the terraces as well.

The parapet wall is formed from precast panels with a metal rail installed on the top edge (See Photograph 43). A urethane sealant joint is installed on the three parapet wall to terrace deck tile intersections. The exposed edge of several metal attachment plates embedded in the precast panels are visible above the line of the tile. Typical cracks as described above in "Precast Concrete Panels" are visible on the terrace side of each panel.

The office building wall is constructed of the typical aluminum frame curtainwall system described above (See Photograph 42). Precast panels are located at the base of the wall at the terrace level and at the top of the wall forming the parapet on the twenty-fifth floor. Access to the terraces is provided through doors incorporated into the curtainwall at various locations on each elevation (See Photograph 44). Full height sidelights border the storefront style doors. Metal thresholds extending between the sidelights, are set in sealant at the raised edge of the structural slab. A topping has been installed to slope the interior floor up to form a flush transition over the threshold from the interior to the exterior. Silicone sealant joints are installed at the panel to tile intersections and around the door and sidelight joints as with the curtainwall joints.

Leaks have been reported on all elevations on the floor near the doors of several of the offices on the twenty-third floor and into the ceiling spaces of the offices below the terraces of the twenty-second floor. Some of the leaks on the twenty-second floor align with the set-back building wall while others are located at the perimeter wall. Remedial measures have been performed in the past with limited success. Most of these measures included installation of sealant at the door thresholds and frames and the sidelight sills. Weep holes have been drilled through the beauty caps of the sidelights.

Watertest numbers 21 and 22 were conducted on the terrace tile finish, door and sidelight of the east facing terrace above leak 22M (See Photograph 42). This leak is reported to be heavy and steady during all rainy weather. Flood tests to the tile near the door did not reproduce the leak after 15 minutes. The water spray was then directed at the door and sidelight curtainwall assembly (See Photograph 45). After five minutes, the interior carpet became saturated opposite the door jamb and sidelight window. Several minutes later, drips through the structural slab occurred in the same location as leak 22M.

On a subsequent day of testing the tile and topping slab were opened to view the membrane installation at the door, sidelight and precast panel in the vicinity of the test area (See Photograph 46). The following observations were made (See SK1, SK2 & SK3). The terraces are built with a liquid applied waterproof membrane and protection board over the structural concrete slab which is 1-1/4" below the interior structural slab level. The step in slab levels occurs in alignment with the face of the curtainwall. A sand and mortar setting bed lies under the ceramic tile and mortar joints. The exterior tile and mortar bed is one inch higher than the interior structural slab at the building wall. The tiles were found to be loose, lifted from the setting bed by the excessive moisture underneath. The mortar bed was of a very sandy mix and remained wet after several days of clear weather. A blue primer or filler was installed between the mrtar bed and the tile. Some small, thick sections of this resin were observed turned up and over the concrete slab edge.

The mortar bed was removed to reveal a protection board over the slab membrane. The horizontal slab membrane turned up the structural slab edge and extended 1/4" onto the raised interior slab at the precast panel. The mortar bed tapered down to the structural slab beyond the deck

membrane. The structural slab was left exposed within the wall cavity between the tapered mortar bed and the interior sloped topping. Water entering the mortar bed through the porous grout joints between the tiles throughout the terrace, could drain from the edge of the mortar bed directly onto the exposed structural slab in the wall cavity below the precast panel.

A second membrane was installed under the door threshold and a portion of the sidelight over the mortar bed, turned down the raised slab edge and then ran horizontally for several inches onto the first layer of protection board. A white, uncured mastic was installed between the vertical double layers of membrane. The second membrane terminated at the top of the sloped interior topping. This is a largely ineffective method to waterproof the threshold.

The sidelight window was deglazed to view the interior frame assembly. The sidelight was constructed as shown in the shop drawings with two exceptions. The first exception, was that weep holes had been installed on the lower edge of the face of the sill beauty cap to allow water that bypasses the gaskets, drains through weeps in the upper section of the horizontal rail to the beauty cap, can then drain to the exterior. These weeps should improve the performance of the system because the water can drain more freely than if relying only on the gaps between the ends of the beauty caps and the vertical mullions for drainage. The second exception to the shop drawings was found to be the main source of the leak through the sidelight window. Additional weep holes had been drilled into the lower edge of the horizontal rail at the sill (See Photograph 47). As water filled the beauty caps, it flowed through the lower holes in the rail directly to the interior of the building.

While the topping slab termination is a potential source for water migration along the full length of the curtainwall, the additional holes in the sidelight sill rails are the main source of leaks concentrated around the entry doors. Typical curtainwall defects discussed above such as end dam sealant failures and precast panel cracks are also potential sources for water infiltration into the building interior at this level.

The silicone sealant used at the wall base joint is incompatible with the urethane sealant used at the parapet base joint. The corner where these two materials meet is subject to sealant failure which would increase the amount of water entering the wall cavity beyond the deck membrane edge.

The membrane termination was not verified at the parapet edge or at individual deck penetrations. These areas should be the subject of further testing and investigation if leaks not associated with the curtainwall persist at the deck perimeters.

Roof Penthouse

The twenty-fifth floor penthouse contains elevator and mechanical equipment and is used by the building engineers as a workshop, storage space, offices and locker rooms. The penthouse footprint is recessed approximately fifteen feet from the twenty fourth floor perimeter. The fifteen foot wide roofdeck is sloped and coated with urethane deck coating. Window washing davits are installed along the deck edge at the parapet. The walls of the penthouse are made of a sloped standing seam roof with battens set on a 4" raised concrete curb. The roof of the penthouse is a urethane coated raised helipad approximately 50' x 50'. A framed wall with an exterior finish of acrylic coating over rigid wall boards, divides the penthouse into two sections. The east section houses HVAC equipment and is fully exposed to the exterior above and at the base of the metal

roofing. The same elastomeric deck coating is installed at the deck and in the exposed HVAC equipment area. Decks are sloped to the drains located in the center of the decks. A single door through the metal wall provides access to the deck on the west side. A door through the framed divider wall provides access to the HVAC equipment area and a metal gate opens from this space to the deck on the east side. The structural slab has been left exposed in the interior workshop and storage areas.

Leaks 24C to 24J into the ceiling spaces of the floor below are located on the north side of the building. Watertests 30 verified that the leaks do not originate from the curb edge flashing or the termination of the metal roof on the curb. The deck coating appeared to be in good condition and is turned sufficiently up the concrete curb.

Elevator economizer fan equipment has been installed near the center of the north wall. The intake duct penetrates the metal wall approximately four feet above the deck. The battens covering the standing seams are sealed at the base to the exterior economizer duct. Several holes between the metal wall and the duct were observed. These small holes were not sealed or flashed. Watertest 31 directed a medium spray of water at the metal wall above the economizer penetration. Within one minute, water was observed to leak into the holes in the wall on the top and sides of the duct. Also, water running down the face of the roofing became trapped behind the batten sealant at the base of the standing seams and ran to the interior through the cut edge of the penetration.. It is suspected that once water accumulates on the structural slab, it will migrate through cracks to drip down the slab penetrations and cause the leaks occurring at the ceiling below. This economizer penetration is likely contributing to leaks 24D to 24F.

Defects in the intersection of the concrete curb, metal wall and framed wall were observed. No water tests were performed in these locations. On the north corner, a large gap exists between the deck coating and counter flashing. It is possible that water from the deck and wall can be directed into this gap to saturate the interior structural slab, eventually causing leak 24G observed in the ceiling below. The curb on the south side is completely open for a length of six inches at the level of the exterior deck. Water on the deck can run directly into the penthouse interior, to saturate the slab and travel to the floor below. This is the most likely source of for leak 24A.

An additional potential source for leak 24A are the gaps in the exterior finish of the divider wall. Cracks have formed in the exterior acrylic coating at each untaped edge of the wall boards. Also, the conduit penetrations from the electrical panels mounted to this wall are not sealed. Each of these gaps would allow water to enter the wall framing and drip down to the interior structural slab.

Leaks 24H and J are located under the drain of the twenty-fifth floor roof deck. Water ponds around this drain, continuously standing outside the rim and appears to be penetrating the edge of the deck coating. Saturation of the slab below the deck coating will lead to further degradation of the coating.

Leak 24C is located directly under the shower of the engineers locker room. It is set back far enough from the penthouse wall that this leak can only be attributed to plumbing or wetting of the structural slab from the locker room use or cleaning.

Leak 24B is located directly under the drain for the penthouse waterheater. As with 24C, it is set-back from the penthouse wall and can only be attributed to the drain or spillage onto the floor slab.

Helipad

A helipad is constructed on the roof of the penthouse. The raised landing platform sidewalls are framed using metal studs. Wallboards with an acrylic coating skirt the perimeter of the stud framing. The wallboard is set into 'J'-molding which has been turned backwards, with the long attachment leg on the face of the wall. The coating extends over the 'J'-molding. Cracks in the coating have formed along the edge of the molding and at the wallboard edges which appear to be untaped. This wall finish terminates an inch above the deck.

The roof deck coating extends several inches under the landing area, beyond the face of the wall. The termination of the coating could not be verified. Overall the roof deck coating appears to be in fair condition. Several small areas of the coating have begun to blister and lift from the substrate. No leaks have been attributed to the helipad elements at this time.

Remedial sealant joints were observed between the helipad sidewall and roof deck coating. This may have an adverse effect on the weeping of water from behind the helipad skirt. It may also trap water blown in from the deck surface at the ends of the joint. Further review of this sealant joint is required.

Other Issues

Several issues not related to the reported leaks came to our attention during the course of our investigation. Potential defects and water damage were noted in areas adjacent to reported leaks. These issues appear to have gone unnoticed or unreported. We recommend further investigations be conducted to determine the appropriate course of action for these issues. The items listed below are indicated with circled numbers on the first and third floor plans.

1. Leaks into the first floor wall at the entry door to the conference rooms located near the cafeteria street entrance.
2. The stucco finish on the original garage access stairwell on the north side cannot weep at the wall base and has severely deteriorated at the ground level.
3. Metal flue covers located on the roof of the parking garage at the northeast wall near the expansion joint are not well flashed.