1.0 Executive Summary

The State of California Department of General Services Real Estate Services Division (DGS) contracted with McGinnis Chen Associates LLP (McGinnis Chen) to conduct a water test investigation of the leaks at the metal framed glass curtainwall and provide recommendations for remedial work at 450 N Street in downtown Sacramento, CA. The scope of this investigation consisted of on-site observation during a wind driven rainstorm, water testing of the curtainwall glazing system and the punched window openings at the pre-cast concrete panels and associated sealant joints. Upon completion of the water testing addition, McGinnis Chen conducted a limited visual survey and partial deglazing of a vision lite and spandrel lite. The investigation conducted was to further examine and evaluate the curtainwall glazing system deficiencies. The following is a brief summary of our findings.

Curtainwall Glazing System:

The curtainwall glazing system utilizes an exterior neoprene fixed gasket to seal and secure the dual pane vision and single pane spandrel glass into the extruded aluminum framing. The neoprene gasket is prematurely deteriorating. Each glass unit has the surrounding aluminum framing corner joint sealed. At the spandrel sill to vision head assembly the horizontal spandrel rail incorporates an interior track with weep holes (3 per rail). The weep holes have reticulated foam baffles in the track. Water is designed to empty into the beauty cap and drain out the ends. During wind driven rainstorms, the track at the horizontal rail fills and over flows onto the suspended ceiling and also wicks up into the batt insulation. Differential pressure water testing and simple spray testing confirmed that the weep design is overwhelmed during wind driven rainstorms.

A continuous deep vertical mullion cover separates the horizontal beauty caps. The deep vertical mullion cover is spliced every 27 ft. (nominal) and a gunnable silicone sealant is used to seal the butt joint of the vertical mullion covers. The sealant is deteriorated and failed at all of the butt joints observed. Water directed at the splice joint resulted in water entering the interior side of the curtainwall and filling the track at the horizontal rail. Additionally, gaps in the sealant are reported by the building engineering staff at the vertical mullion to pre-cast panel joint.

The interior EPDM wedge gasket of the curtainwall system was found disengaged at several locations. This condition indicates a loss of compression of the glazing system. Further investigation into the structural implications of this condition should be completed.

Pre-cast Concrete Panels:

The pre-cast panels are located at the building corners with punched openings, at the roof, 23rd floor deck parapets, and around the 12th floor mechanical level. The dual pane windows in the punched openings are wet sealed. Visible cracks in the pre-cast panels were observed during a limited visual observation. The sealant surrounding the punched window and panel joints appears in good condition. No water was observed at the interior during the water test of the window head or sealant joint above. Sealant smeared over the punched window frame joint is not a proper sealant joint.

Recommendations:

McGinnis Chen recommends that the curtainwall glazing system be fully wet sealed. All aluminum joints and transitions should also be re-sealed. Weep holes should then be installed at the bottom of the horizontal beauty caps to provide alternate drainage. The gaps in sealant at the joint between the vertical mullion to pre-cast panel should be re-sealed.

McGinnis Chen recommends the same repair to the pre-cast concrete panels as was described in the June 1998 Rosenberg McGinnis report. In addition, a proper sealant joint over the punched window frame joints is to be installed.

Budget:

McGinnis Chen estimates the following construction budget:

• Wet seal curtainwall glazing system, add weeps to bottom of horizontal beauty caps, remove and replace sealant at curtainwall to pre-cast concrete joint, new sealant at the pre-cast panel punched window frames, 30% replacement of interior gasket, relocate and fix batt insulation	$1,240,000
• Pre-cast concrete panel repair	$150,000
• Differential pressure test of remedial design mock-up prior to completion of construction documents	$20,000
Total Construction Estimate	$1,410,000

Other Costs:	141,000
▪ General Conditions - 10%	141,000
▪ Overhead and Profit - 5% to 10%	141 000
▪ A/E Design and CA - 10%	8000
▪ Investigation of interior gasket condition - $8,000 (estimate)	211 500
▪ Contingency - 10% to 15%	642 500
	$2,052,500

2.0 Introduction

A. General:

450 N Street is a twenty-five story office building and four level parking structure occupied by the State of California Board of Equalization (BOE). The Construction was completed in January of 1993.

The building is a steel framed structure with lightweight concrete floors over steel decking. The exterior building envelope is a combination of extruded aluminum glazing and pre-cast concrete panels with punched window openings that highlight the building corners; the twelfth floor mechanical floor, and the twenty-third and twenty-fourth floor parapets.

In 1998, McGinnis Chen (as Rosenberg McGinnis AIA, Inc.) investigated the curtainwall system as part of an overall building leak investigation and report for McDonough, Holland & Allen, representing CalPERS, the building owner. The following is excerpted from the Executive Summary of the June 1, 1998 report:

"Curtainwall Glazing System: Based on a limited visual survey and testing, an excessive amount of water is infiltrating the curtainwall system through failed glazing gaskets and splice joint sealant failures. The water does not weep out sufficiently and is suspected of causing the majority of the leaks observed at the building perimeters. Further testing is required to determine the actual path of infiltration through the aluminum frame curtainwall system and to provide a repair.

Pre-cast Concrete Panels: All of the pre-cast concrete curtain wall panels have visible cracks. Several of these cracks were determined to be the source of leaks to the interior. All panel cracks should be repaired."

In June of this year, McGinnis Chen conducted the investigation to confirm water source path and the system deficiency to propose a repair recommendation.

B. Design and Construction Participants:

Building Owner:	State of California
Architect of Record:	Dreyfuss & Blackford Architects of Sacramento, CA
General Contractor:	Hensel Phelps of Oakland, CA
Curtainwall Manufacturer:	Kawneer Company, Inc.
Curtainwall Subcontractor:	Architectural Glass and Aluminum of Oakland, CA

C. Methodology:

Phase 1 – Survey: Visual observation of curtainwall system during wind driven rainstorm.

Phase 2 – Review leak records and drawings to identify leak location(s) for water testing.

Phase 3 – Perform water tests to identify leak paths that produce similar results to that observed during driving rain.

Phase 4 – Perform limited visual survey of pre-cast wall and aluminum curtainwall glazing system.

Phase 5 – Conduct exploratory test (limited disassembly of window frames) to determine the path of the leaks observed and perform profile and material analysis of the exterior neoprene gasket.

D. Documents Reviewed:

1. Capitol Square Water Infiltration Investigation Report dated June 1, 1998, prepared by Rosenberg McGinnis, AIA, Inc.

2. Capitol Square Elevation Drawings A3.1, A3.2, A3.3 and A3.4 prepared by Dreyfuss & Blackford Architects.

3. Curtainwall shop drawings prepared by Kawneer--sheets G.1 thru G.2, K-1 thru K-6, E1 thru E17, D1 thru D14, and I1 thru I7 (produced prior to the mock-up).

4. Telephone Conversation Report dated October 16, 1996 to Ken Wallace of Eschbach Co. Inc. from Donna Allen, regarding test pressures for water infiltration testing.

5. Leak Survey by Building Maintenance, Floors 2 thru 24 (APPENDIX C).

3.0 Curtainwall Glazing System:

Description:

The curtainwall glazing system is manufactured by Kawneer Company Inc. The Kawneer name for the curtain wall system installed is "2500 IB Curtain Wall System." The extruded aluminum for the framing is 6063 T5 (6105 – T5 at vertical mullions). The vertical mullions are anchored to each floor. The vertical mullions typically span one floor and are joined with the adjacent vertical mullion 2'-10" below the floor anchor above (APPENDIX B: SK-1). The vision (1" insulated) and spandrel (1/4" single pane) glass is secured into the aluminum framing with an exterior fixed neoprene gasket welded at the corners. The specified "00" shore hardness for the exterior neoprene gasket is 75 + or – 5. The interior EPDM wedge gasket is rolled into position to lock the glazing in place (APPENDIX B: SK-2). The curtainwall glazing system is to weep out any water within the curtainwall frame by channeling the water to a 1/2" deep track at the horizontal rail, that spans between the vertical mullions, and into the horizontal beauty cap where it is to then weep out the ends (APPENDIX B: SK-3). The beauty cap is to be held back 1/16" from the vertical mullion cover to provide the dropout location for the water (APPENDIX B: SK-4). A gold anodized horizontal accent piece is fastened to the vertical mullion with a stainless steel angle clip, creating a bull-nose gold band at each floor level.

Observations:

The interior survey of ceiling stains (APPENDIX C) indicate a large amount of water intrusion (Photos 1 thru 4) at the south elevation and beneath decks. A site visit during a wind driven storm on December 20, 2003 resulted in the observation of the tracks filled with water in the horizontal rail between the spandrel glass sill and vision glass head (Photos 5 and 6). In addition to the water in the track, during wind gusts, the water level would rise in a wave response motion. The origin of the water directed to the track was not evident from this interior observation. The tracks observed had a high degree of dust and construction debris in them and the batt insulation in the ceiling did intermittently rest in the track.

Exterior survey of the curtainwall glazing system showed areas of deteriorated gasket, and detached welded corners (Photos 7 thru 15). The sample taken during the partial deglazing was found to have many cracks, areas compressed and not rebounded, and to have an "A" Durometer reading of 60 (equivalent to "00" Durometer reading of 93). Some gasket repair with wet sealant was observed (Photos 16 and 17).

Interior gaskets have fallen or have disengaged from their wedged lock position (Photo 18). This phenomenon is reported to be at the west and south elevations. The extent and cause is not known.

The sealant at the splice for the vertical mullion was found to have failed at all of the splices (Photos 19 and 25). Fasteners at the splices were observed to be loose, missing and not caulked.

The horizontal beauty cap was observed to be typically narrower than the face to face dimension of the vertical mullion (Photo 26) per the shop drawing notes; however, locations of sealed ends (Photos 27 and 28) and one end tight to the vertical mullion (Photo 29) were encountered.

The interior sealant at the framing corners observed during this investigation was found to be well applied and performing properly. That is, no leaks were observed to pass through the sealant. The investigation conducted in 1998 did identify a hole at the corner sealant of one window assembly.

At the transition of the glass curtain wall head to the pre-cast panels at the mechanical floor several sealant failures were observed (Photo 30). The building engineering staff has reported observing gaps in the sealant joint between the curtain wall vertical mullion and pre-cast concrete panels.

The screw fasteners for the horizontal gold anodized bull nose trim piece were not caulked. Incorrectly located field-drilled holes for the trim piece were observed to not be sealed.

Attempts were made to de-glaze several windows, but were aborted due to glazing blocks improperly placed at the jambs. If deglazing is required during remedial repairs, this condition may impact the cost and method of repair.

Water Tests:

As recommended in the 1998 investigation, differential pressure water testing was conducted in accordance with ASTM E1105 procedures and simple spray testing conducted in accordance with AAMA 501.2-83 procedures. The specified positive pressure for the differential pressure water infiltration testing is 10 psf (1.92 inches of water) as referenced in the Phone Conversation Report.

Test #1	**Differential Pressure Water Test**
Location	East elevation, south end, at ceiling of Floor 21 (SK-5) (Photos 31 and 32).
Results/Notes	15 minutes, no water observed at interior. Water streamed out of horizontal beauty cap ends away from test chamber.

Test #2	**Differential Pressure Water Test**
Location	East elevation, south end, at vision sill of Floor 22 (SK-5).
Results/Notes	20 minutes, no water observed at interior. Water streamed out of horizontal beauty cap ends away from test chamber.

Test #3	**Differential Pressure Water Test**
Location	East elevation, south end, at ceiling of Floor 22 (SK-5).
Results/Notes	5 minutes, no water observed at interior. Water streamed out of horizontal beauty cap ends away from test chamber.

Test #4	**Differential Pressure Water Test**
Location	East elevation, south end, at ceiling of Floor 22 (SK-5). Horizontal beauty cap ends away from the test chamber taped over.
Results/Notes	45 seconds, water filled up the track at the horizontal rail (Photo 33). Test stopped to prohibit overflow.

Test #5	**Differential Pressure Water Test**
Location	East elevation, south end, at vision sill of Floor 22 (SK-5). Horizontal beauty cap ends away from the test chamber taped over.
Results/Notes	5 minutes, no water observed at track of horizontal rail at ceiling of Floor 21. Not able to observe track at vision sill. Water remained in track at ceiling of Floor 22 where Test #4 was conducted earlier.

Test #6	**Spray Test**
Location	East elevation, south end, at ceiling of Floor 22 (SK-6). Horizontal beauty cap ends away from the test were taped over.
Results/Notes	3 minutes, water filled track of horizontal rail at ceiling of Floor 22.

Test #7	Spray Test
Location	East elevation, south end, at ceiling of Floor 22 (SK-6) (Photo 34). **NO TAPE** over horizontal beauty cap ends away from the test.
Results/Notes	3 minutes, water filled track of horizontal rail at ceiling of Floor 22.

Test #8	Spray Test
Location	East elevation, south end, at ceiling of Floor 22 (SK-6). Horizontal beauty cap ends away from the test were taped over.
Results/Notes	4 minutes, water filled track of horizontal rail at ceiling of Floor 22.

Test #9	Spray Test
Location	East elevation, south end, at vertical mullion splice joint above the ceiling of Floor 22 (SK-6). Horizontal beauty cap ends away from the test were taped over.
Results/Notes	4.5 minutes, water filled track of horizontal rail at ceiling of Floor 22.

Evaluation and Recommendation:

Premature deterioration of the exterior fixed neoprene gasket is the largest contributor to water infiltration. Cracks in the neoprene material and space between the permanently compressed gasket and glass provide access for rain to enter the interior frame. Water also enters the interior frame at the failed sealant at the vertical mullion splice joint. This water infiltration in combination with the small weep openings at the beauty cap ends and the positive wind load at the south elevation (for typical storm path) prohibits weeping and causes the water in the horizontal tracks to overflow onto the interior drop ceiling grid system and panels.

The disengaged interior EPDM wedge gasket and permanently compressed exterior neoprene gasket indicate that the glass is not fully secured and possibly a safety issue that was not part of the intended scope of McGinnis Chen's investigation. McGinnis Chen recommends a survey of the interior EPDM wedge gasket to evaluate the extent and severity of this condition.

MCA recommends that the exterior glazing system be wet sealed (a portion of the exterior gasket is recommended to be cut away to complete the exterior wet seal work). The horizontal beauty caps are to be sealed utilizing an extruded silicone tape sealant. And the horizontal beauty cap should have two slotted weep holes installed (one at each end) along the bottom. The splice joints at the vertical mullions are also to be sealed by using a preformed silicone boot. All loose fasteners are to be re-installed and caulked, and un-caulked fasteners at the exterior framing system are to be caulked. The tracks should be cleaned of dust and debris and the weep holes checked for obstructions. The batt insulation in the ceiling should be adjusted and fixed to assure that it cannot rest in the track.

The sealant between the glass curtainwall system to the pre-cast panels should be replaced.

As part of the budget for remedial work to correct the water leaks, an allowance to replace 30% of the EPDM wedge gasket with a "thicker" profile is included. However, the full extent and implication of the altered glazing system is not fully understood at this time. Further investigation of this condition is recommended to resolve the structural component of the glazing system assembly and to insure that the waterproofing work is not detrimental or hinders possible structural repairs to the glazing system.

At this time, a wet seal repair is recommended over re-glazing to minimize cost and tenant impact.

4.0 Pre-cast Concrete Panels and Punched Window Assembly:

Description:

Pre-cast concrete panels are used as architectural features at the building corners and 12th floor mechanical floor and parapets. The corner panels have punched window openings sealed with silicone sealant. Panel joints also utilize silicone sealant. The June 1998 Rosenberg McGinnis report stated "The panels were originally treated with Hydrozo Enviroseal 20 clear sealer to reduce water absorption".

Water tests were conducted to identify possible water intrusion at punched window sealant joints and pre-cast panel joints. A limited visual survey was done at one corner elevation, "one drop", to assess the current pre-cast concrete panel surface condition.

Observations:

The sealant at the punched window openings and panel joints was observed to be in good condition. A clear sealant has been applied to the head/jamb (Photo 35) frame joints. The application of this sealant appears to be smeared over the joint and does not bridge the joint.

The limited visual surface survey reinforced the findings presented in the June 1998 Rosenberg McGinnis Report. Cracks at the corners of the punched openings were common (Photos 36 thru 38). Vertical cracks through horizontal reveals (Photos 39), isolated pitting (Photo 40) and spalls were also observed. Water tests were not conducted at the pre-cast concrete panel cracks.

Water tests:

Simple spray testing conducted in accordance with AAMA 501.2-83 procedures.

Test #10	**Spray Test**
Location	South elevation, east end of Floor 22, at punched window head sealant joint (SK-7).
Results/Notes	15 minutes, no water observed at the interior.

Test #11	**Spray Test**
Location	South elevation, east end of Floor 22, at panel joint sealant above window head (SK-7).
Results/Notes	15 minutes, no water observed at the interior.

Evaluation and Recommendation:

Based on the visual observations and water testing of the punched window perimeter sealant and panel joint sealant, McGinnis Chen concludes that these components are performing as designed and no replacement is required at this time. The smeared sealant over the vertical frame joint (Photo 35) is not a proper sealant joint and should be replaced with an extruded silicone tape sealant joint.

The recommendations for repairs to the pre-cast concrete panels presented in the June 1998 Rosenberg McGinnis report are still valid:

> *"No work is required to address the hairline cracks found on the surface pre-cast panels. All larger structural and cold joint cracks in the panels should be repaired to prevent further water infiltration and degradation of the structural and attachment steel components. A low –modulus epoxy injection would be the least visible repair method."*

The Precast/Prestressed Concrete Institute's "Architectural Precast Concrete", 2nd Edition, states that cracks wider than 0.005" that are exposed to weather should be repaired. The extent and quantity of these cracks is not known, however, estimating that there is 500 ft of crack over 0.005" wide at each elevation on the tower, there would be approximately 2,000 lf of crack repair. The cost of this repair is estimated to be $150,000. This estimate is purely speculative as no quantitative survey of cracks and crack widths was performed.

Additional repairs described in the June 1998 Rosenberg McGinnis report for the pre-cast concrete column covers and louvers should also be conducted.

END OF REPORT