BEHAVIOR OF SEALANTS AND RELATED CASE STUDY

Vancouver, May, 11, 2018
Jerry Abendroth, RRC, RWC, REWC, RBEC, RRO, CDT
OVERVIEW

- History of Project
- Discussion of Specifications
- Project Design and As-Built Construction Deficiencies
- Findings and lesson Learned
• Houston includes a minimum 110 mph stipulation in the building code for roof and cladding issues.

• There were two types of glazing systems on the project with only one specification issued. The specification included a high pressure resistance which was above the threshold of the submitted system.

• Testing requirements were clearly outlined in the specifications. No testing was performed on the building envelope systems.

• Knowledge of building envelope deficiencies was observed and noted after the first storm (Hurricane Ike). This knowledge was basically ignored. Notice was given to the hospital (tenant) after Hurricane Ike clean-up to continue with interior buildout.

LEGAL PRECEDENTS
BRIEF HISTORY

- Construction Start – 2006
- Hurricane Ike makes landfall – September 13, 2008
- Interior buildout of the hospital was completed destroyed by water infiltration
- Heaviest rainfall event (at the time) and fourth largest flood event occurred on April 28-29, 2009 – interior buildout of the hospital was flooded and destroyed a second time
3.06 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Contractor will perform non-destructive and destructive field adhesion tests on sealant in accordance with ASTM C 1521.

1. Destructive testing:
   a. Cut 6-inch-long tail of sealant loose from substrate.
   b. Mark tail 1 inch from adhesive bond.
   c. Grasp tail 1 inch from adhesive bond and pull until tail extends to two times published movement capability of sealant. If sealant has not failed, continue pulling to failure.
   d. Record elongation at failure and if failure was adhesive or cohesive.
   e. Observe sealant for complete filling of joint with absence of voids, and for joint configuration in compliance with requirements. Record observations and sealant dimensions.
   f. Perform test every 100 feet for first 1,000 linear feet of joint; if no test failure at two times movement capability occurs, test every 1,000 feet thereafter or approximately once per floor per elevation, whichever is more frequent.
   g. Retain a log of destructive test results and provide to the Architect/Engineer within 24 hours of testing.
   h. Test reports shall include date when sealant was installed, name of person who installed sealant, test date, test location, and whether primer was used.

2. Immediately after testing, Contractor shall replace failed sealant in test areas. Neatly cut out and remove failed sealant, prepare and prime surfaces, and install new sealant. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

3. Sealant not evidencing adhesive failure from testing or noncompliance with requirements will be considered satisfactory.

4. Where Architect/Engineer determines that sealant has failed adhesively from testing or does not comply with requirements, additional testing will be performed to determine extent of non-conforming sealant. Neatly cut out and remove non-conforming sealant, prepare and prime surfaces, and install new sealant. Perform field adhesion tests on new sealant. Additional testing and replacement of non-conforming sealant shall be at Contractor’s expense.
3.06 FIELD QUALITY CONTROL

Field-Adhesion Testing: Contractor will perform non-destructive and destructive field adhesion tests on sealant in accordance with ASTM C 1521.

Perform test every 100 feet for first 1,000 linear feet of joint; if no test failure at two times movement capability occurs, test every 1,000 feet thereafter or approximately once per floor per elevation, whichever is more frequent.

Retain a log of destructive test results and provide to the Architect/Engineer within 24 hours of testing.

Test reports shall include date when sealant was installed, name of person who installed sealant, test date, test location, and whether primer was used.

SPECIFICATIONS - SEALANTS
FIELD QUALITY CONTROL

- Field testing and related inspections and reports and will be performed by a qualified independent testing and inspecting agency.

- Coordination: Coordinate field testing of the curtain wall system with the testing agency so that testing is performed after the curtain wall system construction has been completed for each designated phase of completion but before installation of interior finishes has begun at each location. The curtain wall system contractor shall be responsible for providing a water supply of sufficient pressure and volume to meet the requirements of the field tests specified herein or in section 011900 at any location and height on the building from floor 1 through the top floor.

- Testing Agency: The testing agency will be engaged by the Owner and Owner, Architect, and/or the Building Envelope Consultant will identify the location of the tests to be performed.

- Testing Services: Testing and inspecting of representative areas of glazed aluminum curtain walls shall take place as installation proceeds to determine compliance of installed assemblies with specified requirements.
  
  - Water Penetration: Areas shall be tested according to ASTM E 1105 at a minimum uniform static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in “Performance Requirements” Article, but not less than 15.0 lbf/sq. ft. (300 Pa), and shall not evidence “uncontrolled” water penetration.
  
  - Test Area: Two unitized units in width, but not less than 10 feet (9.1 m), by one story of glazed aluminum curtain wall including the stack joint.

  - Test Frequency: Perform tests in each test area as directed by Architect, Building Envelope Consultant, or Owner. Perform at least three tests, prior to 10%, 35%, and 70% percent completion.
FIELD QUALITY CONTROL

- The tests shall be conducted in the presence of the Architect and/or the Exterior Wall Consultant at mutually selected areas of installed work. The typical test area shall be a minimum of two units in width or 10 feet by the floor height so that a minimum of one vertical mullion and one intermediate horizontal (each side) are included in the specimen.

- Glazed aluminum curtain walls will be considered defective if they do not pass tests and inspections.
  - Where water penetration occurs, make necessary modifications to the Work as approved by the Architect and/or Exterior Wall Consultant and retest. Continue the process until the work passes the test. Once deficiencies are correct in the tested work, make corrections to the balance of the work to ensure that all work complies with the performance criteria.
  - Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of replaced or additional work with specified requirements.

- Provide test reports including documentation of remedial measures required to achieve passing test results for each test location.
FIELD QUALITY CONTROL

- Field testing and related inspections and reports and will be performed by a qualified independent testing and inspecting agency.

- Water Penetration: Areas shall be tested according to ASTM E 1105 at a minimum uniform static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than 15.0 lbf/sq. ft. (300 Pa), and shall not evidence “uncontrolled” water penetration.

- The tests shall be conducted in the presence of the Architect and/or the Exterior Wall Consultant at mutually selected areas of installed work. The typical test area shall be a minimum of two units in width or 10 feet by the floor height so that a minimum of one vertical mullion and one intermediate horizontal (each side) are included in the specimen.

SPECIFICATIONS - GLAZING
PERFORMANCE REQUIREMENTS

- General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.

- Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.

- FM Approvals Listing: Provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system. Roofing system must meet the design intent and wind uplift capabilities associated with the uplift rating requirements listed in this specification and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.
  
  - Fire/Windstorm Classification: Class 1A-90.
  - Hail Resistance Rating: SH.

SPECIFICATIONS - ROOFING
- Design Phase
  - Lack of developed specifications
  - Inadequate specifications and drawing details
- Construction Phase
  - Insufficient QA/QC testing (preconstruction and field)
  - Lack of coordination and supervision
  - Poor installation
  - Damage by other trades
  - Lack of third party participation

• PROJECT DESIGN AND AS-BUILT CONSTRUCTION DEFICIENCIES
• SEALANT DEFICIENCIES

- A single line of sealant was illustrated on the project drawings.
- The glazing subcontractor contacted Dow Chemical to perform adhesion, compatibility and stain testing.
- Dow stated that the precast concrete required the use of a primer for proper adhesion to the substrate.
- It was determined that one glazing crew installed the primer as prescribed by the manufacturer – the other did not.
- The result was infiltration between the sealant joint and aluminum frame.
SEALANT DEFICIENCIES

Pull tests performed at windows during investigation, after storm event
SEALANT DEFICIENCIES

Sealant joints with improper profiles
A single line of sealant was illustrated on the project drawings (at precast joints).

The waterproofing subcontractor (responsible for installing sealant at all precast to precast joints) did not contact the manufacturer to perform adhesion, compatibility and stain testing.

All sealant at the precast joints was installed without a primer required for proper adhesion to the substrate.

There was over 5,000 feet of sealants installed at the precast to precast joints.

The result was extensive water infiltration through the sealant joints.
SEALANT DEFICIENCIES

Pull tests conducted during investigation after storm event
SEALANT DEFICIENCIES

Pull tests and push tests conducted during investigation after storm event.
The precast clips were out of position – sealant was installed around the clips.

Braided backer rod.
The precast patches acted as funnels for water to bypass the sealant.
PRECAST DEFICIENCIES

- Cracks in the precast panels exceeded the tolerance listed in the specifications.
- Cracks in the panels exceeded the tolerances listed in the submittals and product literature.
- In many instances, the panel joints were not finished and did not provide a proper substrate for the sealant profile.
- There was over 5,000 feet of precast to precast joints on the project which exacerbate the problems of water infiltration through the joints.
PRECAST DEFICIENCIES

Precast cracks out of tolerance
PRECAST DEFICIENCIES

Precast panel edges out of tolerance
GLAZING DEFICIENCIES

- Over 1440 punched window openings were included in the building design.
- The punched windows were assembled offsite and shipped to the project from Arkansas to Houston, Texas.
- Testing of the windows (factory or field testing) was not performed per the specifications.
- Leaks were apparent before, during and after the Hurricane Ike storm, event.
- After notification of potential leak problems, no action was taken to discover the root cause of the problems or to attempt remediation.
GLAZING DEFICIENCIES

Horizontal/vertical transition was not sealed in the factory
GLAZING DEFICIENCIES

The windows arrived on site out-of-tolerance

The end dams were not probably sealed
GLAZING DEFICIENCIES

There were openings through the sealant and the aluminum frames.
The building was over 500 feet tall; the glass tower was even higher.

The specifications included an 1A-90 FM requirement which did not meet wind uplift standards for the higher roofs.

Water infiltration through the roof membrane and flashings was not observed after Hurricane Ike.

Infrared surveys indicated water infiltration in most roof areas.
ROOF DEFICIENCIES

Installed slopes were incorrect allowing water to pond in areas beyond the allowable limits of the warranty.
Numerous openings in roof membrane and flashings
ROOF DEFICIENCIES

Water seeping through base flashings
ROOF DEFICIENCIES

Negative pressure testing of installed roof system indicated extremely low wind resistance.
ROOF DEFICIENCIES

Negative pressure testing of installed roof system indicated extremely low wind resistance.
Test cuts indicated the ribbons of adhesive were not properly placed.
ROOF DEFICIENCIES

Massive water infiltration under the roof membrane and insulation
FINDINGS AND LESSON LEARNED

- Sealants – Types of Staining
  - Plasticizer leaching/migration
  - Plasticizer runoff
  - Surface/dirt accumulation stain
  - Halo Effect
FINDINGS AND LESSON LEARNED

Plasticizer Leaching/Migration
FINDINGS AND LESSON LEARNED

Plasticizer Runoff/Streaking
FINDINGS AND LESSONS LEARNED

Dirt Accumulation
FINDINGS AND LESSON LEARNED
Halo Effect
FINDINGS AND LESSON LEARNED

- It was found that it is not sufficient to require a sealant test log without verification. The sealant tests should be logged and submitted to the architect to verify the testing has been completed.

- Should drops from swing stages be included in the consultant's scope of work? The answer appears to be yes, that if sample verification is to be effective.

Field Adhesion Test – ASTM 1193-09
Diagram Test A
FINDINGS AND LESSON LEARNED

- General Contractor/Architect

- The General Contractor and Architect were combined as a design build entity for this project at the direction of the owner.

- The general Contractor did not self-perform or engage third-party testing for the testing required by the specifications.

- The general Contractor and Architect were both found at fault for this omission.

- The consultant was also found liable for this omission.
Owner

- The owner had recently acquired the General Contractor a year before construction commenced. The General Contractor did not have experience on larger buildings and had never constructed a Highrise building.

- The Owner engaged the Architect on a “fast track” basis to meet an “ambitious” construction schedule. The design was “basic” in nature without proper detailing.

- Everyone accepted the liability for this schedule, and the resultant problems.

FINDINGS AND LESSON LEARNED
Thank you!

Questions

BEHAVIOR OF SEALANTS AND RELATED CASE STUDY