Zero/Six

BEYOND THE EXTERIOR

November 2017

DESIGNING WIND RESISTANT COMPLEX FACADES AND ROOFTOP EQUIPMENT

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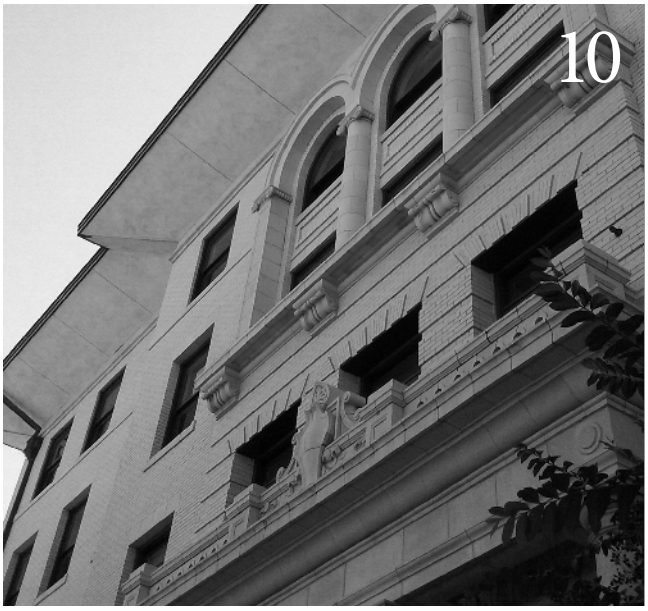


ARCHITECTURAL TESTING HAS EVOLVED TO BECOME A NECESSARY REQUIREMENT FOR MULTIPLE TYPES OF OPENINGS AND CLADDING - WHY NOT ROOFTOP EQUIPMENT AND COMPLEX FACADES

TESTING PROVIDES EMPIRICAL EVIDENCE FOR ENGINEERING CALCULATIONS AS WELL AS FINDS POTENTIAL WEAK POINTS

FEATURED ARTICLE:

DESIGNING WIND RESISTANT COMPLEX FACADES AND ROOFTOP EQUIPMENT

WORDS: MR. JEFFREY BISHOP, PE, LEED GREEN ASSOCIATE

Photo Info : FEMA, Rooftop equipment failures from Hurricane Katrina, Mississippi

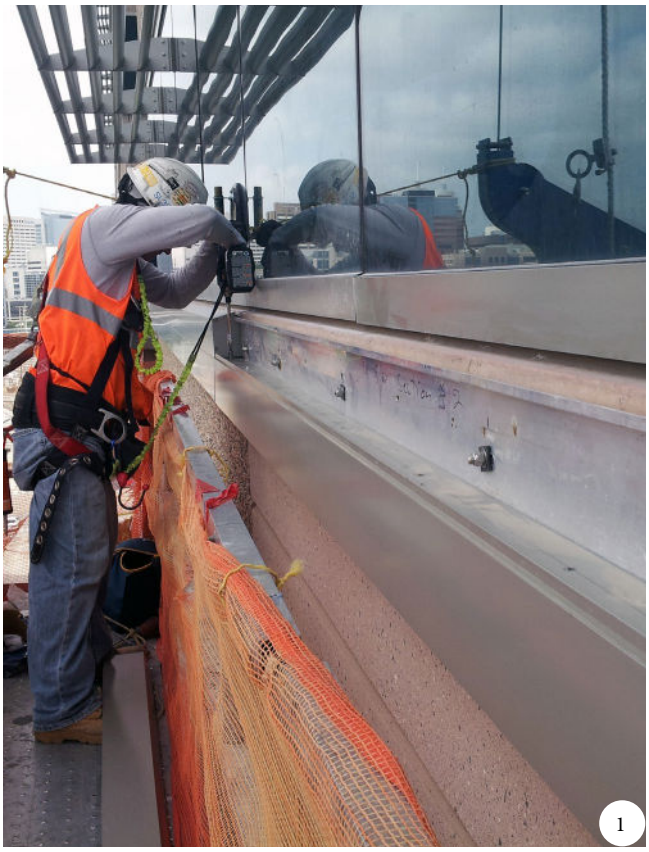
Architectural testing has evolved to become a necessary requirement for multiple types of openings and cladding - why not rooftop equipment and complex facades? Testing provides empirical evidence for engineering calculations as well as finds potential weak points that are either overlooked or impossible to foresee with engineering analysis. These may include:

- For structural performance, ASTM E330 is used for windows, doors, skylights, and curtain walls. This uniform static air pressure difference structural testing, in addition to ASTM E1886 and E1996 impact and cyclic pressure testing, provides valuable data to ensure engineering analysis is correct and the units are performing as required.
- For metal wall and roof panels, ASTM E1592 can be used to test for structural performance.
- Roof membranes can be tested for uplift resistance using ASTM E907.

The desire for hurricane level wind resistance has caused test standards to be created for the majority of architectural components and cladding.

WHEN TESTING STANDARDS ARE NOT AVAILABLE OR APPLICABLE

Other equipment and components that are subjected to wind loads



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on buildings do not currently have test standards to ensure these features perform as intended. At the rooftop this includes equipment such as HVAC and photovoltaic systems as well as duct or pipe chases that are installed across the roof. Walls, signage, light fixtures, and some architectural features like fins and sunshades, don't have a standard for structural performance testing. Free standing signs also do not have a way to test structural performance, and creating a test standard for all of these different pieces of equipment and components would be difficult. The reason for this is that an engineer's judgment comes into play when deciding what testing should be performed for those things of which they are unsure. These decisions may be minor such as movement or vibration, which can cause wear or damage over time. Although not evident at first glance, an engineer may find these unacceptable, so the standard would have to be adapted for the particular component and method of testing.

The reason a test standard would be helpful is that components, such as rooftop units (RTUs) or those attached to curtain wall systems, including fins and sunshades, are typically a delegated design, which have no structural test standard. What this means is that the structural engineer and architect pass the responsibility for ensuring these components meet wind loads to the designers of these components. RTUs are designed by mechanical engineers, where the most important factors are mechanical functions (as it should be). Typically these engineers do not take into consideration


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1. Photo Info : Repair of architectural features
2. Photo Info : Live deflection readout during structural testing
3. Photo Info : IIBHS, Full-scale wind testing on small roof-mounted A/C units
4. Photo Info : Corrosion, improper placement in slot, incorrect fastener

the high wind load potential on a roof. Roofing contractors will attach blocking and possibly attach the RTUs, but the wind resistance of the RTU itself is the responsibility of the manufacturer. Some types of RTUs may require additional mechanical anchors, such as cables or frames, to transfer the wind loads to the structure.

The International Building Code (IBC) and American Society of Civil Engineers (ASCE 7) have had significant changes in the recent editions to give increased attention to rooftop equipment, as many severe wind events have caused failures in this area. For rooftop equipment, IBC now requires the use of ASCE 7, and the 2010 edition of ASCE 7 now includes vertical uplift loads as well as the horizontal loads on RTUs.

RTUs can have issues from wind loads that aren't captured in the required calculations from Chapter 29 of ASCE 7-10. For instance, vibrations can cause the unit to become unbalanced, which will lead to inefficiency and can eventually compromise the attachment. It is difficult to foresee or design for all of the possible incidents and predict the failures that can occur from wind loading without physically testing the units. Studies from wind tunnel testing have shown that different vent styles, and elevating the unit heights above the roof, can have a greater impact on wind loads than location on the roof alone. Another item the code doesn't currently address is windscreens. Although testing has been performed that confirms windscreens will reduce loading on rooftop equipment when properly designed, the IBC code section 1609.1 states "Decreases in wind loads shall not be made for the effect of shielding by other structures."

Physical testing currently on RTUs involves either model or full-scale wind tunnel tests. These give valuable information on structural performance of RTUs which can be used to design the components and attachment, as well as similar RTUs. Other rooftop components, such as satellite dishes, antennas, and piping with supports, should also go through some form of testing to give backup for engineers to consider when designing mountings or attachments for these different components in high wind zones.

WINDOW FINS AND SUNSHADES

Architectural features like window fins and sunshades are being used more recently as facades are becoming more complex. These features provide shade and thus control solar energy as well as provide aesthetics. Structural failures with these components can cause safety concerns for people on the streets and sidewalks below. Although widely used, these components are typically unique to each project; therefore, little guidance is found in curtain wall literature or building codes. Manufacturers may provide load tables or general calculations, but it isn't always clear to a designer what engineering has been done to back up that information. The wind loads acting on these flexible and lightweight shades and fins are difficult to estimate or even measure with a traditional pressure tap in a wind tunnel test. More recent studies have used hot-wire anemometry to perform wind tunnel tests and provide a better estimate on the attachment loads that are away from the building. Finally, testing on heavy components, such as glass features, is helpful to ensure the engineers understand how the fin behaves with high wind loads. During testing, vibration and permanent deformation may help the engineer refine the design of attachment components to prevent failures in the field.


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Photo Info: Z6 Commissioning performing dynamic wind load testing on curtain wall fins to measure deflection at their Galveston laboratory

ENGINEERS TYPICALLY HAVE TO COME UP WITH AN IMPROVISED TEST TO SEE HOW THEIR BUILDING COMPONENTS PERFORM

CONSIDERATIONS FOR COASTAL WINDS

Aside from high wind loads caused by building height, many high wind loads observed on these architectural features are due to their proximity to the coast. In this location, designers will also observe more intense and frequent rain events as well as sea spray causing corrosion from the salt in the air. Corrosion resistance is important to assure attachment strength and prevent failures over time. Note that using 304 or 316 grade stainless steel fasteners are required by some code revisions in coastal areas.

THERMAL EXPANSION AND CONTRACTION OF METALS

Another design issue is thermal expansion and contraction of metals on these exterior features. Rigid attachment over long spans will end up shearing screws away when the temperature swings. Slotted holes and plastic washers can be used to provide relief from the internal stresses that build up from thermal expansion and contraction on fasteners. Good workmanship is needed to attach these "miscellaneous" building elements. In addition, anchors must be centered on slotted holes to perform properly, and tightening nuts with a torque wrench is usually necessary to achieve a precise tightness.

Signage and lighting are also exterior building components that are difficult to estimate wind loads and do not have a standard test for wind resistance. Signage often fails in a major windstorm and the components can become dangerous projectiles. Exterior lighting attached to the building isn't called out directly in the scope within ASCE 7 Chapter 29 for wind loads on building appurtenances, but it is assumed the solid attached signs method can be used to estimate wind loads on these components. Although attachments can be engineered, the light itself must be able to withstand higher wind loads, which is typically handled by the manufacturer.

CONCLUSION

Developing a test standard that could be used on such a wide range of building components would be difficult, but having actual test data for different types of sunshades, fins, and RTUs for engineers to reference and use in their design of similar components would be helpful. In many cases, such as custom signage, identical configurations could be used worldwide near coasts or high winds, and would be worth having a tested assembly. The test standard would likely require different parts for different types of these miscellaneous building components, and would most likely have different types of apparatus to apply the loading. For architectural testing companies, equipment such as wind generators, deflection gauges, load cells, mock-up walls and roofs are used regularly; however, since standards do not exist for these components, engineers typically have to come up with an improvised test to see how their building components perform.

Photo Info : Z6 Commissioning performing roof membrane uplift resistance testing

CITY HALL ROOF REPLACEMENT

The City of Galveston City Hall is a French Renaissance Revival building; damaged in the great storm of 1900, the staircase, tower, and the entire third floor were removed. A new City Hall was built in 1916 and was used as both a fire and police station. Zero/Six wrote the specifications and provided construction documents for the roof remediation project. Currently, the team is conducting quality assurance observations and additional construction administration tasks to ensure the seamless remediation of the existing clay tile roof in addition to the replacement of a 2-ply modified system that properly tapers to the drainage points.

Owner: City of Galveston

Location: Galveston, TX

Type: Remediation

Status: December 2017

Scope of Work: Site Survey Investigation, Preparation of Specifications and Construction Documents, Bidding Process, QA/QC Roof Replacement Monitoring, and Construction Administration

EDUCATION COMPLEX AND MUSIC BUILDING

The new, two-story Education Complex and Music Building at Texas A&M University - Kingsville will replace the 60-year-old Bellamah Music Building to support more students and faculty, tripling the size from 32,000-square-feet to 90,000-square-feet. The state-of-the-art facility will serve as a focal point for the southeast entrance to the campus and allow the University to expand and grow their music department. Features include enhanced rehearsal spaces, classrooms and labs, an administrative office suite, a 450-500-seat performance hall and gathering center, and storage facilities as well as a new 1200-ton central utility plant.

Owner: Texas A&M University - Kingsville

Architect: Brown Reynolds Watford Architects (Rendering provided by BRW Architects)

Contractor: SpawGlass

Location: Kingsville, TX

Type: New Construction

Scale: 90,000 SF

Status: Fall 2019

Cost: $60 million

Scope of Work: Drawing Review, Onsite QA/QC and Reporting, BECx Plan and Specifications, and Commissioning of the Building Envelope, including Mock-up Testing, Air Infiltration Testing per ASTM E783, Roof Membrane Uplift Resistance Testing per ASTM E907, and Static Pressure Water Infiltration Testing per ASTM E1105.

WEST CAMPUS RESIDENCE HALL

The older residence halls on the west side of The University of Texas at Arlington campus are being replaced with two, 500-bed facilities to accommodate the University's continued growth. Similar to Vandergriff Hall, the double occupancy rooms will include amenities students desire today through living and learning spaces that promote social interaction and community engagement. Zero/Six is the Building Envelope Consultant for the project with Z6 Commissioning conducting performance testing, which includes testing 600+ windows systems to ensure they meet the performance requirements outlined in the specifications.

Owner:	The University of Texas at Arlington
Architect:	BOKA Powell, LLC (Rendering provided by BOKA Powell)
Location:	Arlington, TX
Type:	New Construction
Scale:	140,882 SF, 1000-bed
Status:	Fall 2018
Cost:	$30.8 million
Scope of Work:	Drawing Review, Recovery Details, Roof Observation and Reporting, On-site QA/QC and Reporting, BECx Plan and Specifications, and Commissioning of the Building Envelope, including Mock-up Testing, Dynamic Testing, Roof Membrane Uplift Resistance Testing per ASTM E907, Air Infiltration Testing per ASTM E783, Static Pressure Water Infiltration Testing per ASTM E1105, Diagnostic Nozzle Testing, and Electronic Leak Detection (ELD) Testing.

STRATEGIC PARTNER SPOTLIGHT:

McMac Cx

WORDS: MR. DAVID MACLEAN, CPMP, LEED AP BD&C, MCMAC COMMISSIONING SERVICES, LLC

Photo Info : Zero/Six and McMac Cx deliver a presentation on "Whole Building Commissioning"

MCMAC CX WAS FORMED TO ADDRESS THE GROWING RECOGNITION THAT THE FOCUS ON BUILDING PERFORMANCE HAS MOVED BEYOND ENERGY AND WATER EFFICIENCY

Zero/Six is proud to work with some of the best companies in the AEC industry to help deliver innovative solutions that optimize the performance of the entire building. Our goal is to assist our clients in the creation and maintenance of better building envelopes and that means tight working relationships with a range of companies across our field. This month's Strategic Partner Spotlight is David MacLean and his firm McMac Commissioning Services, LLC.

ABOUT MCMAC COMMISSIONING SERVICES, LLC

McMac Commissioning Services, LLC (McMac Cx) is a health focused, commercial building commissioning firm. They provide the technical expertise necessary for Owners, Developers, Architects, Engineers, Contractors and Vendors, to comply with mandatory and voluntary commissioning requirements within the 2015 International Energy Conservation Code (2015 IECC), WELL Building Standard and US Green Building Council - Leadership in Energy and Environmental Design (USGBC LEED) rating systems.

MCMAC CX HAS EXTENSIVE EXPERIENCE IN THE DESIGN, CONSTRUCTION AND OPERATION OF MECHANICAL, ELECTRICAL, AND PLUMBING SYSTEMS

WHAT IS THE STORY BEHIND STARTING MCMAC CX?

McMac Cx was formed to address the growing recognition that the focus on building performance has moved beyond energy and water efficiency. Proven design techniques and off-the-shelf technology make it much easier to exceed minimum code requirements. Astute "Property" Owners, Developers and Designers are coming to the realization that they can positively or negatively impact the health of the communities that form inside and outside their buildings. McMac Cx has the experience and ability to assist the Design and Construction teams in understanding how the design, construction, operation and community interact to meet these new aspirations.

HOW DOES MCMAC CX SUPPORT ZERO/SIX AS A STRATEGIC PARTNER?

McMac Cx has extensive experience in the design, construction and operation of mechanical, electrical and plumbing (MEP) systems. Best practices have historically favored MEP systems when implementing the commissioning process. The USGBC LEED rating

Photo Info : Moody Gardens Rainforest Pyramid

systems and 2015 IECC mandate commissioning of MEP systems. These current standards of care also begin to address the need to include the envelope into the commissioning process. McMac Cx believes that full commissioning of the building envelope is needed to ensure tested performance. This is not the current mandate within the 2015 IECC or the prerequisite of the LEED rating system, so McMac Cx typically works with the Owner to understand what the risks are in not taking the envelope commissioning process to full completion.

WHAT ARE A FEW FAVORITE PROJECTS THAT YOU HAVE WORKED ON?

As a new firm, our favorite projects, for now, were completed while with past firms. When asked this question, immediate thoughts went to Teams and not to Buildings. I have been involved in the construction industry for over 25 years and have had the privilege to be part of some very unique and rewarding projects in various roles including, MEP Project Manager (PM), Sustainability Manger (SM), and Commissioning Manager (CM). Some of my favorite projects are as follows:

1. The rebuild of the Moody Gardens Tropical Rainforest pyramid after Hurricane Ike destroyed the interior (MEP PM, CHP & Associates),

2. LEED Platinum - Mickey Leland Federal Building (MEP PM, CHP & Associates – Increased Energy Efficiency by over 50%),

3. LEED Platinum - George W. Bush Presidential Library (SM, CHP & Associates – Highest rated LEED project in Texas for five years, second highest in the nation for 2 years),

4. LEED Gold – MetroNational Cemex Building (MEP PM, CHP & Associates – First LEED project for David MacLean and Metro National),

5. LEED Gold – DOW Campus Lake Jackson (CM, Sebesta)

WHAT DO YOU ENVISION FOR THE FUTURE OF CONSTRUCTION IN HOUSTON? HOW DO YOU SEE HOUSTON CHANGING IN THE YEARS AHEAD?

Houston will continue to grapple with decisions in the wake of the devastating floods of the past couples of years. Codes and Standards of Care will push the built environment toward more sustainable and resilient construction. We will become more mindful of the impact the built environment has on the overall health (economic, social, physical, emotional, etc) of the communities within and surrounding the buildings we construct. Houston is strong and will continue to rise to the occasion.

Photo Info : George W. Bush Presidential Library

WE WILL BECOME MORE MINDFUL OF THE IMPACT THE BUILT ENVIRONMENT HAS ON THE OVERALL HEALTH (ECONOMIC, SOCIAL, PHYSICAL, EMOTIONAL, ETC) OF THE COMMUNITIES WITHIN AND SURROUNDING THE BUILDINGS WE CONSTRUCT

John Sealy Hospital Mockup

Its a pass! Water infiltration and structural testing complete. UTMB John Sealy Hospital is ready to roll. #Mockup #PerformanceAssurance

National Healthcare Facilities & Engineering Week

In recognition of National Healthcare Facilities and Engineering Week, our team went to Beaumont to cook fajitas for Baptist Hospitals of Southeast Texas personnel! We have spent a lot of time with the staff in the weeks following Hurricane Harvey & appreciate all you do to improve building efficiency to keep patients, staff and visitors safe!

ZERO/SIX OUT&ABOUT

▲ Window Performance

Z6 Commissioning, LLC utilizing multiple boom lifts and crews at The University of Texas at Arlington West Campus Residence Hall to get the job done! The team is currently testing 600+ window systems per ASTM E1105! #QualityControl #ISOaccredited #BECx #WindowPerformance

◄ New Heights

Zero/Six Consulting inspectors went to new heights this week, climbing the Engineering Building at The University of Texas at Dallas to perform #QualityAssurance inspections and conduct a sealant pull test! #ADayintheLife #workout

SMPS Austin Event ►

The team enjoyed meeting other AEC industry professionals at the SMPS Austin luncheon event covering the, "Reorganization of UT Facilities and Construction." As one of our biggest clients, we enjoyed learning from speakers Dave Dixon and Bob Rawski on The University of Texas Office of Facilities Planning and Construction (OFPC) reorganizing to become the office of Capital Planning and Construction (CPC).

◄ Performance Assurance

The Z6 Commissioning, LLC team performed water infiltration testing per ASTM E1105 for their client Anchor-Ventana Glass at an office building in Austin.

INDUSTRY COLLABORATOR

WORDS: MR. DAVID MACLEAN, CPMP, LEED AP BD&C, MCMAC COMMISSIONING SERVICES, LLC

2015 INTERNATIONAL ENERGY CONSERVATION CODE, STATE OF TEXAS ENERGY CODE ADOPTION, LOCAL AUTHORITY JURISDICTION, ADOPTION AND ENFORCEMENT, DESIGN & CONSTRUCTION DUE DILIGENCE AND RISK ABATEMENT

ADOPTION OF THE 2015 IECC HAS ADDED SIGNIFICANT SCOPE BY MANDATING COMMISSIONING. THIS REQUIRES THAT THE BUILDING ENVELOPE, HVAC, DOMESTIC HOT WATER HEATING AND LIGHTING CONTROLS SYSTEMS BE COMMISSIONED BY AN INDEPENDENT, THIRD-PARTY CONSULTANT THAT IS NOT DIRECTLY INVOLVED IN THE DESIGN OR CONSTRUCTION OF THE BUILDING.

BACKGROUND:

Texas updated its Statewide Energy codes in 2016 by adopting the 2015 version of the International Energy Conservation Code (IECC). Since Texas is a "Home Rule State" it cannot mandate statewide adoption without a review process by local governments / Authority having Jurisdiction (AHJs). These local bodies must individually adopt the code by ordinance and then provide enforcement. This adoption and internalization is still ongoing by AHJs throughout Texas.

There are about 1200 cities, towns and villages in Texas that have a responsibility to adopt and enforce energy codes. State law allows local jurisdictions to adopt amendments to the energy code, but must have the amendments reviewed by the Texas A&M University Energy Systems Laboratory to ensure that they comply. It is difficult to determine where each AHJ is currently at in the process, nor how

COMMISSIONING PLAN DOCUMENTATION FOR PERMIT

Project Name: _____

Project Address: _____ Permit Number: _____

Commissioning Provider: _____

Company/Entity address: _____

CxPro Phone Number: _____ CxPro email address: _____

CxPro Certification (if required) _____

ITEM #	COMMISSIONING DOCUMENTATION COMPLETED	APPROVAL
	1. Commissioning Project Design Requirements	
	Project commissioning requirements, listing of equipment to be commissioned, system performance requirements, commissioning specification shown on project contract documents.	
	2. Commissioning Plan	
	Initial commissioning plan (for Permit) completed with required contents and provided for Owner and AHJ review	

Photo Info : Commissioning plan documentation sample form

well they are enforcing all requirements.

To make this more confusing, Texas Counties have no enforcement authority. So, if you are designing or building outside one of the 1200 cities, towns or villages, that may or may not have adopted 2015 IECC, with or without amendments, you will need to check their requirements. Despite not having enforcement authority, counties may adopt an energy code and issue permits. Counties are encouraged to do this as there is a very real lack of clarity about roles and responsibilities.

This ongoing adoption of the 2015 IECC (with or without local amendments) and inconsistent enforcement causes confusion among Owners, Designers, Contractors, Vendors and Local AHJs.

2015 IECC - SECTION C408 - SYSTEMS COMMISSIONING - ADDED AHJ RESPONSIBILITIES:

Adoption of the 2015 IECC has added significant scope by mandating commissioning. This requires that the Building Envelope, HVAC, Domestic Hot Water Heating and Lighting Controls Systems be commissioned by an independent, third-party consultant that is not directly involved in the design or construction of the building.

Most, if not all, AHJs have never been involved in a project that has been commissioned by a third-party Commissioning Agent. They have not been provided the training to understand the Commissioning process, nor what the final deliverable should look like for them to approve. Additionally, local AHJs have not been given additional monies, time or training to ensure that this new mandatory commissioning requirement is fulfilled. Therefore, we are seeing inconsistent implementation of the Commissioning Process by the Owners, Designers and Contractors, as well as sporadic enforcement by AHJs.

> THE 2015 IECC IS VERY CLEAR ON WHAT DIRECTION THE OWNERS, DESIGNERS AND CONTRACTORS MUST TAKE IN RESPECT TO COMMISSIONING THEIR PROJECTS

On the other hand, the 2015 IECC is very clear on what direction the Owners, Designers and Contractors must take with respect to commissioning their projects. Prior to final inspection, a registered design professional or approved agency shall provide evidence of system commissioning and completion. All appropriate standards

of care are referenced within 2015 IECC, for adherence purposes. In fact, the 2015 IECC places such value on the commissioning process that the release of the Certificate of Occupancy, by the AHJ, hinges on the Owner certifying that he is in receipt of the Preliminary Commissioning Report (with deficiencies, deferred testing and conditions required) prior to Final Inspection by the AHJ. The AHJ can and should request a copy of this Preliminary Commissioning Report. This is aggressive and is intended to ensure that the Owner engages a Commissioning Agent early in the Design process and that the Design and Construction Teams understand that the Commissioning Process is directly connected to the success of obtaining a Certificate of Occupancy by the Owner.

The lack of local official adoption of the 2015 IECC or direct AHJ official sign-off on commissioning, does not give Owners, Designers or Contractors the liberty to ignore any portion of the commissioning process on their projects. In unincorporated areas of counties, Owners, Designers and Contractors are still responsible for meeting the requirements of the codes even though the counties do not have enforcement authority.

Failure to effectively perform commissioning on your project sets you up for the risk of systems not performing properly. Additionally, since 2015 IECC is the new standard of care for construction in Texas, ignoring commissioning sets you up for a higher risk of litigation due to system failure. Commissioning continues to produce buildings that perform better, are more comfortable, and have more knowledgeable facility staff.

COMMISSIONING CONTINUES TO PRODUCE BUILDINGS THAT PERFORM BETTER, ARE MORE COMFORTABLE, AND HAVE MORE KNOWLEDGEABLE STAFF

WHAT IS NEXT:

Over the past year, South-central Partnership for Energy Efficiency as a Resource (SPEER) has been very effective in reaching out to local AHJs to assist them with the adoption of the 2015 IECC. SPEER recognizes that it is important to involve stakeholders in the review process, create fact sheets for policy makers, and to have an idea of what reactions to expect from stakeholders. Properly engaged stakeholders can provide you with valuable input, improve outcomes, and build consensus and trust. It can also increase transparency and lead to better decision making.

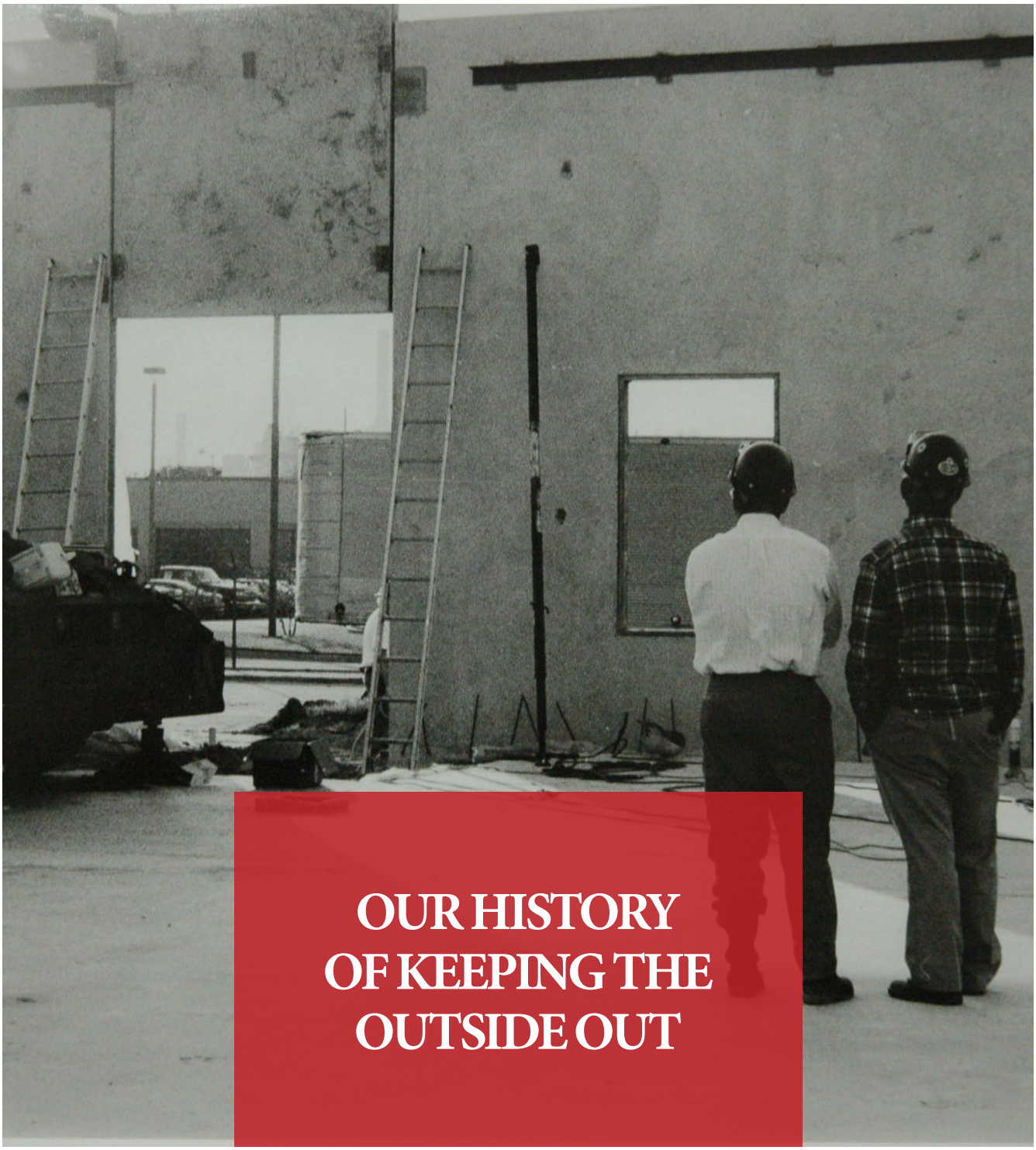
It is now time to drill down further into this process and provide

tools that allow all AHJs across Texas to use standard forms that ensure that Owners, Designers and Contractors are completing the Commissioning Process as mandated. Since Texas allows AHJs to utilize ComCheck to verify compliance, it should be relatively simple to use a similar type of form for Owners, Designers and Contractors to sign off on to confirm their due diligence on the project. A review of the Preliminary Commissioning Report by the AHJ should be expected. Beyond this step, more training of the AHJs, Owners, Designers and Contractors needs to occur such that the Commissioning Process becomes a seamless part of all construction activities.

In my capacity as Chair of the USGBC Texas Gulf Coast Region and as a Commissioning Firm Owner, I have started an initiative to reach out to local AHJs, SPEER, ASHRAE, Commissioning Firms, etc., with the goal of sharing best practices, developing standardized pathways and forms that AHJs can adopt as they utilize limited resources to verify compliance with all aspects of the newly adopted 2015 IECC.

If you are interested in being part of this effort, please drop me a note at david.maclean@mcmaccx.net.

> MORE TRAINING OF THE AHJS, OWNERS, DESIGNERS AND CONTRACTORS NEEDS TO OCCUR SUCH THAT THE COMMISSIONING PROCESS BECOMES A SEAMLESS PART OF ALL CONSTRUCTION ACTIVITIES



OUR HISTORY OF KEEPING THE OUTSIDE OUT

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