Specific and Practical Methods to Improve a BECx Program

Building Enclosure Science in Technology 4
National Institute of Building Science
Kansas City, Missouri
April 13-15, 2015

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National Institute of Building Sciences Provider #G168

BEST4 Conference
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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

1. Understanding of BECx methods to use during design and prior to bid

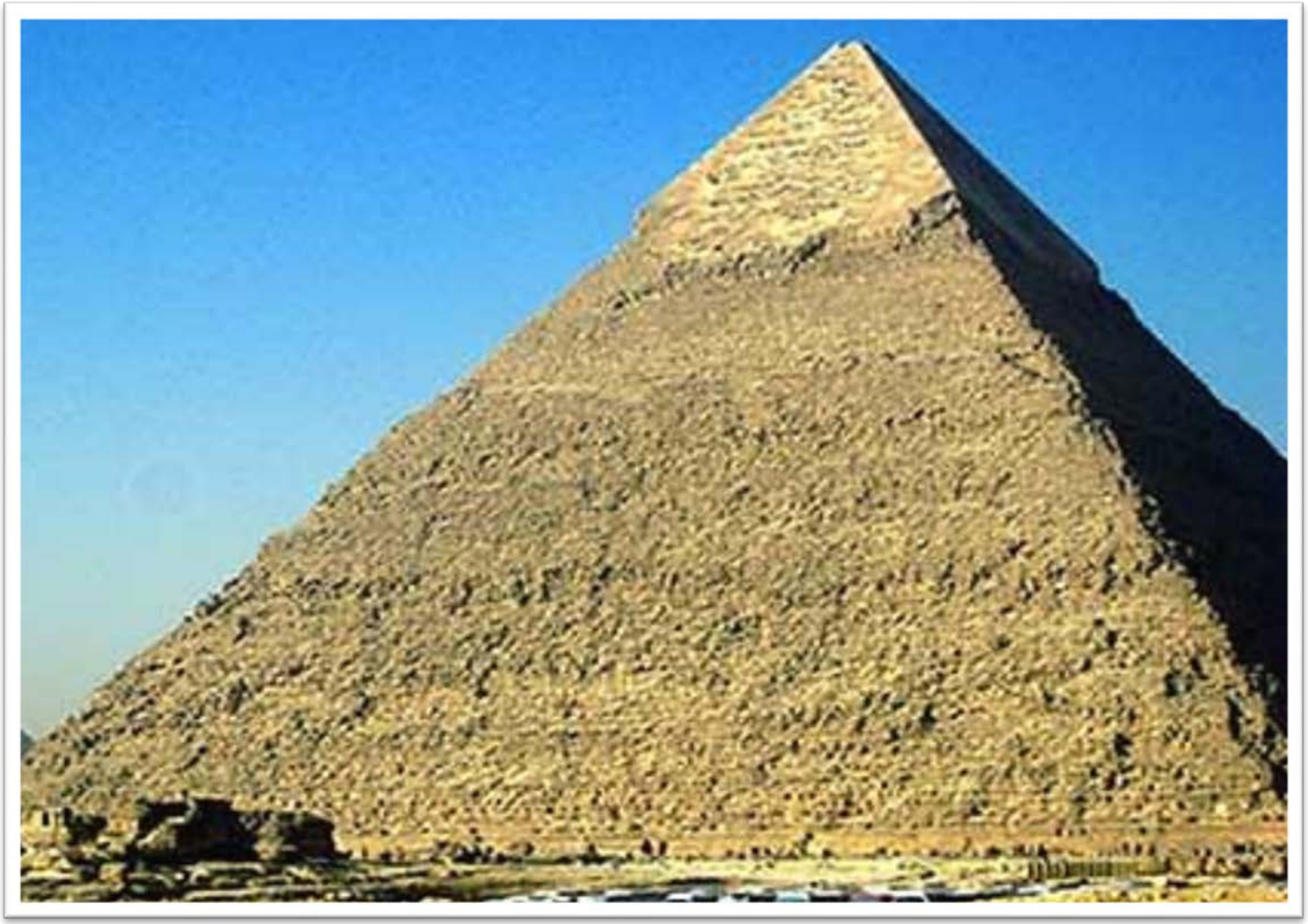
2. Keys to successful implementation of BE mockups

3. Understanding of BECx methods to utilize after bid and during construction

4. The importance of being specific within the BECx framework of specifications, submittals, testing and documentation.

5. Understanding the application of the building enclosure coordination process to building construction and BECx.

Issues with Building Enclosure Performance are Not New



BECx Case Histories

- BECx is an investment.
- Specific steps, *at the right time,* help produce value and reduce risk to the building owner.
- Specificity and timing are critical.
- Time and energy are limited; balance detailed preparation with practical simplicity.

Case History 1: Use of a mockup as a test bed, versus use as performance benchmark.

Case History 2: Deciding when in a sequence of construction to test complex enclosure systems.

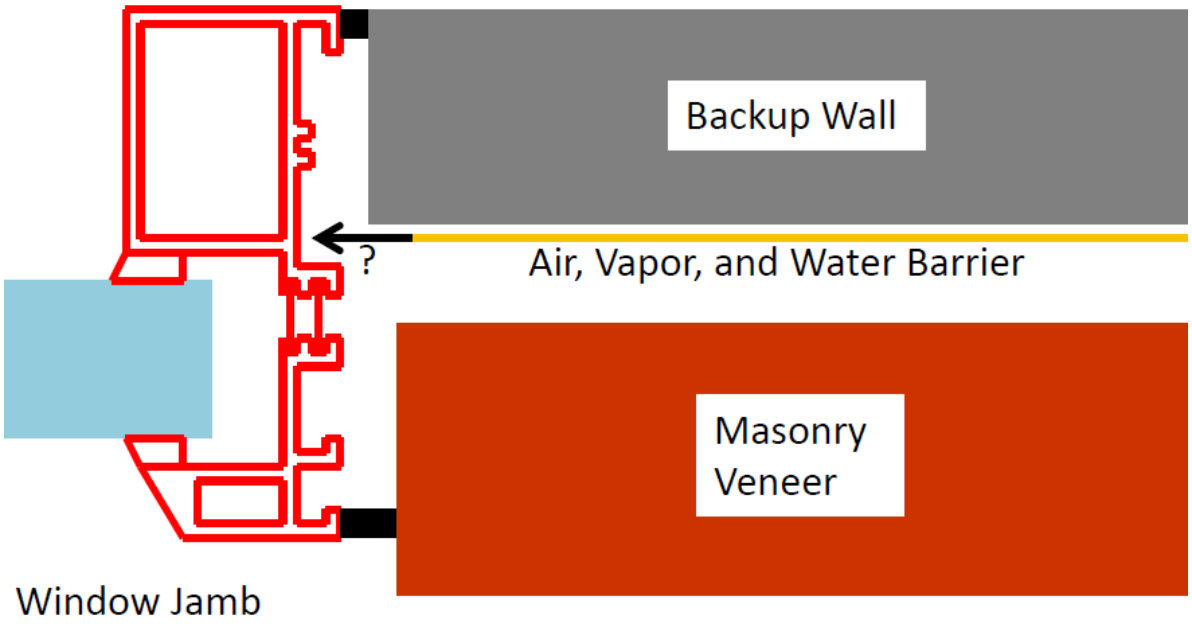
Case History 3: Use of a gap-analysis matrix.

Case History # 1

Implementation of enclosure performance mockups

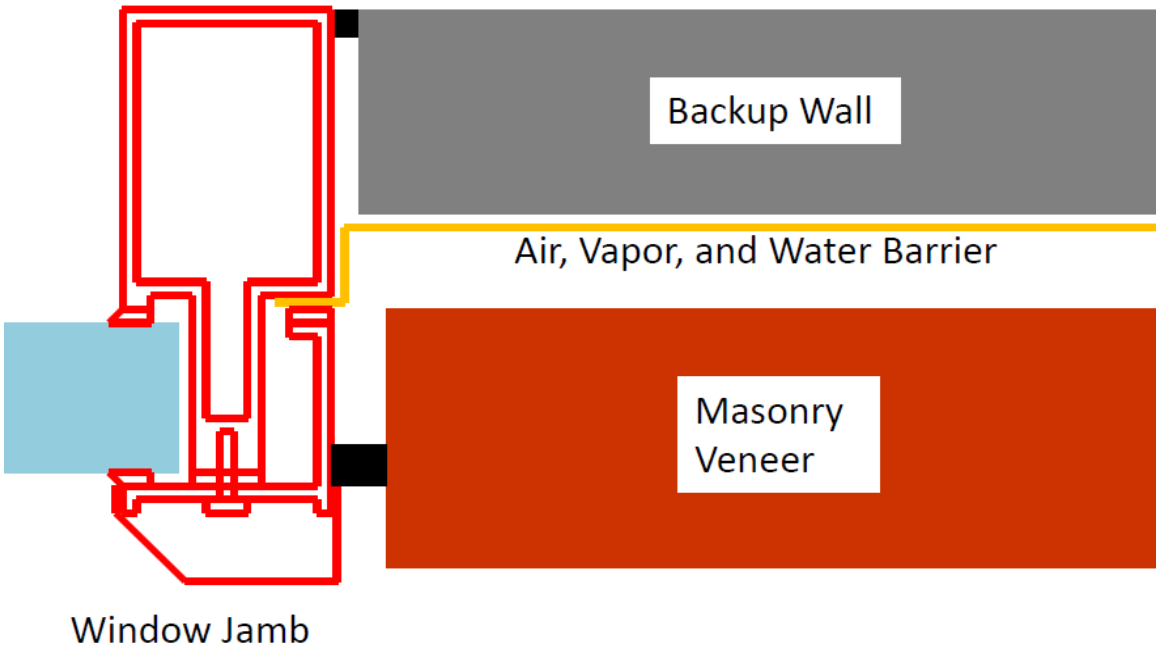
Case History # 1

- Off-structure mockup panel.
- Integration of air barrier and window was complex.



Case History # 1

- New window proposed.
- Mockup not revised due to schedule; work proceeded on building, and performance verification testing was delayed until first work was completed.



Case History # 1

- Mockup performed as a design refinement tool, but not in original intended role of performance verification.
- Result:
  - Late testing,
  - Direct expense to contractor for rework of flashings,
  - Indirect expense to owner due to delays.

Case History # 1

- Decide on this point as early as possible: is the mockup panel there to refine the design, or to be tested to verify performance?

- These two roles are often in conflict.

Case History # 1

1. Ideal: enclosure trades integrate in coordinated shop drawings.
2. Less ideal: enclosure trades coordinate integration on a mockup panel before start of building construction.
3. Not ideal: coordination at first work on the building.

In some cases the second option should be encouraged to avoid the third.

Case History # 1

- Conclusion: if a mockup is a design aid, devise BECx specifications to set aside time for that role, PLUS performance verification testing.
- Ideal project: A/E and BECxA have anticipated enclosure component integration problems, and subcontractors submit coordinated shop drawings.
- However, design the BECx process to accommodate non-ideal revisions and delays.

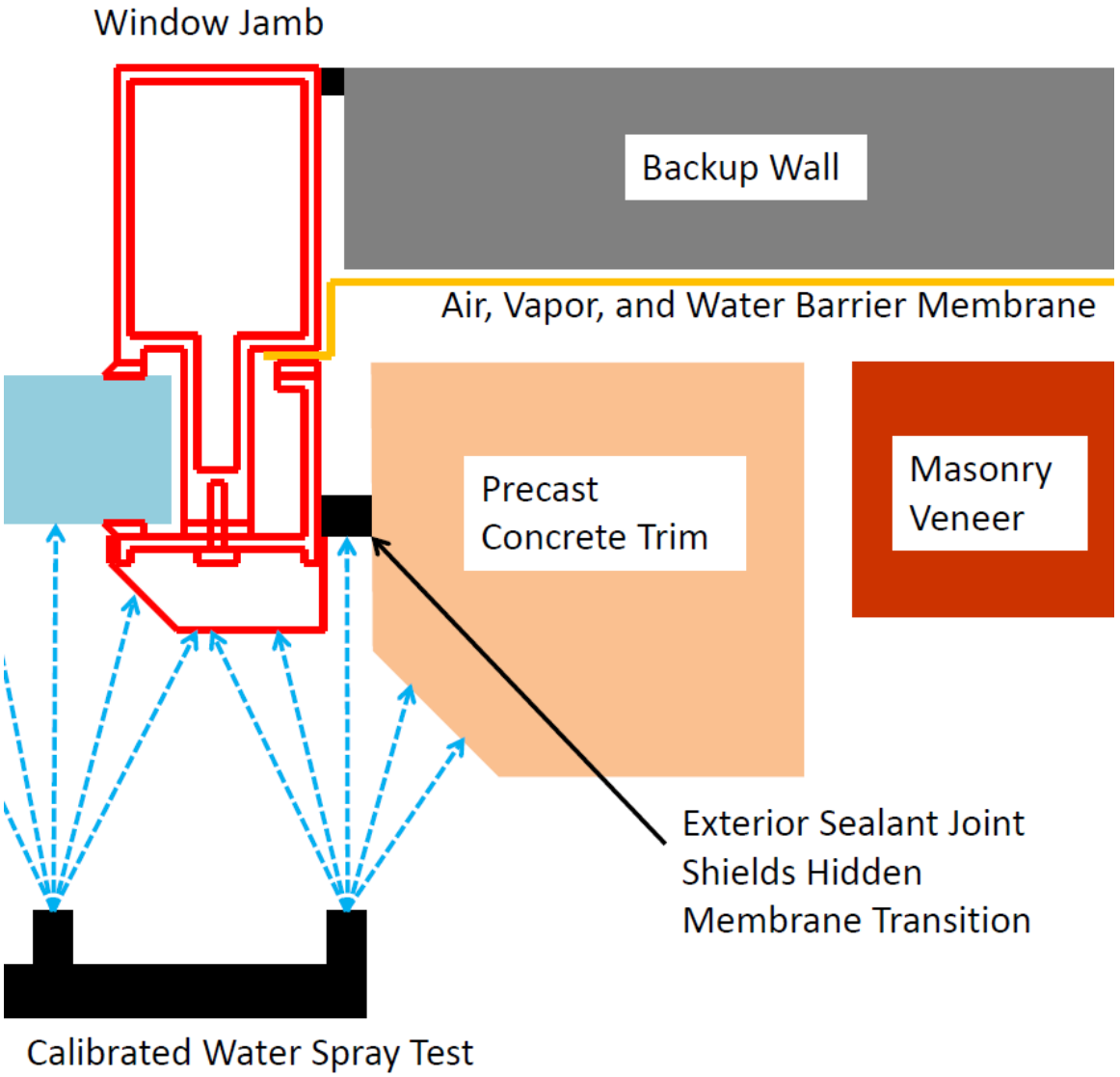
Case History # 2

Specificity in performance verification testing

Case History # 2

- ASTM E1105 spray rack and pressure chamber water testing, specified in two steps:
  1. Window assembly alone.
  2. Window perimeter.
- Window surrounded by precast trim.
- Drainage layer behind the precast trim.
- No distinction in specifications for when to test within construction sequence.

Case History # 2



Case History # 2

- If tested with sealant in place, no water reaches the interface of the air/water barrier with the window perimeter.
- If tested without the sealant in place, the configuration of the window and surrounding construction does not represent the finished condition.

Case History # 2

- Either configuration can be argued.
- Conclusion: the testing specifications must be clear when in the sequence of construction to test.
- A small amount of effort to establish this prior to release of the bid documents avoids later complications and arguments, when test failures have a dramatic impact on cost and schedule.

Case History # 3

Responsibility matrix and gap analysis

- Project required a complex series of laboratory tests for a curtainwall window system.
- Air infiltration, water infiltration, and blast resistance.
- Required a project-specific and accurate laboratory mockup including surrounding construction.

Case History # 3

- Contractor's schedule did not anticipate the work.

- The applicable specifications were split between Division 1 and Division 8, and the contractor had confusion on responsibility.

Case History # 3

- BECxA was brought in by owner only at beginning of construction.
- A responsibility matrix was developed to consolidate all inspection and performance verification testing.
- However, the momentum of the contractors schedule was difficult to overcome, and adding the required testing resulted in delays.

Case History # 3

Example Responsibility Matrix – Joint Sealants

Building Enclosure System	Mockup Required Per Specifications	Specification Sections	Test / Inspection Procedure Description	Mockup, Pre-Construction, or Post-Construction	Test / Inspection Standards	Test Criteria	Remarks	RESPONSIBILITIES[1] PER SPECIFICATIONS			
								Construction Manager / Subcontractor	A/E	BECxA	Product Manufacturer
Joint Sealants	Yes - sample installations at locations per A/E, 1 week prior to construction	079200 1.7	Preconstruction laboratory compatibility and adhesion testing by manufacturer performed on submitted samples of all building materials in contact with sealant	Testing performed prior to sample installations	ASTM C794, ASTM C1135, ASTM C1248, ASTM C1087	Per test standard	Anticipate performing test 3 months prior to construction. Perform C1135 testing in project-specific environmental conditions. Provide written reports for all test results.	Provide for manufacturer's testing			Lab testing
		019119 3.2	Adhesion pull test for each sealant and each substrate	Pre-construction	ASTM C1521 Method A	Cohesive failure				X	Observe testing
		079200 1.5	Adhesion pull tests	Pre-construction and during construction	Hand pull test procedure in specifications	Cohesive failure; for each sealant and substrate: 10 tests for first 900 ft, then one test ea. additional 900 ft	Representative of A/E and sealant manufacturer to be present. Provide written reports for all test results.	X	Direct location of testing, observe testing		Observe testing

Footnotes: [1] - Responsibilities are in addition to Contractor's quality control program and the BECxA audit of each work item

Case History # 3

Conclusions:

- Develop as early as possible.

- Performs two functions:
  - Pre-bid: a gap analysis tool, so all testing work assigned to a specific party, without duplication.
  - Post-bid: communication tool to focus attention.

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Risk Management of Building Enclosures

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Thank you for the opportunity to be here today

Humbled to visit with such an assembled group of professionals

Provide some observations on enclosures
Our discussions today are based upon risk management of building enclosures on over 200 projects and 15 years using BECP during construction

Some people drink from the fountain of knowledge. Others just gargle."

-- Robert Anthony,
American business professor

What is requisite
for a project to have a chance to have a building enclosure that performs ?

A design /construction team that has assembled project documents that roadmap the path to enclosure performance


Need spine surgery?
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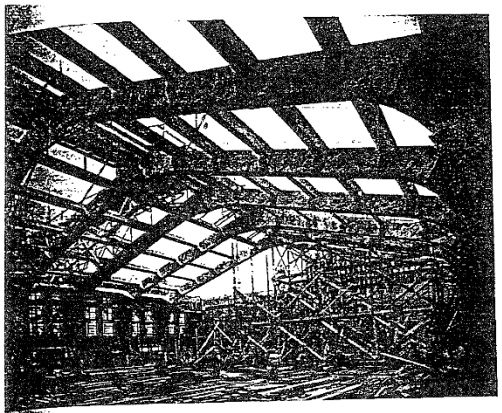
Title 2--Ten (10) Items that Architects, Engineers, Construction Managers, General Contractors, and Design Builders should implement within their projects to minimize building enclosure risks

Questions For The Construction Team

- Are we improving the building enclosure construction process ?

The Industry Must Be Improving The Building Enclosure Because We Have Better Tools ?

- Computer Modeling - Thermal, Moisture
- BIM
- Virtual Mock Ups
- Integrated Project Delivery
- Co Located Design and Construction personnel during DD+CD
- Construction site web portals/ wireless communications
- Tablet computers
- Drones
- Prevention thru Design- PtD



...forced concrete framing is a feature of the new Illinois armories. Note ... purlins rest on brackets monolithic with bents. Each second purlin is ...forced as a strut.

...ulated that the arch legs ...poured independent of the ...concrete wall below this ...are separated from the ...joints and project 1 in. ...wall line in order to con... construction joint. ...first construction joint ...roof level, the legs are ...olithically with the wall ...top of the window sash ...construction joint is ...rocedure was necessary ...architectural design on ...the wall made vertical ...joints undesirable. ...out this scheme suc... important to ascertain ...teral deflection would ...haunches when the ...full load; also to ...sliding motion at ...to eliminate pres... contact with the ...third construction ...the inclined rafter ...way between haunch ...stem of construction ...bled the work to be ...nits and had the addi... of eliminating high ...forms by reducing ...ours.

...ion equipment

...armory the principal ...equipment was a ...carrying a complete form system for two adjacent arches with their connecting purlins. The traveler also included a concrete hoist tower. When concreting of one unit was complete and the concrete set, the entire unit was moved ahead two panels and the operation repeated; the purlins in the intermediate or connecting panels were poured later. A 3,000 lb. per sq.in. concrete (at 28 days) was specified for all exterior work. However, to expedite pouring of the arches, high-early-strength cement concrete (3000 lb. in 3 days) was specified for the inclined rafters and purlins.

Personnel

The project is being carried out by the Illinois Armory Board with S. Milton Eichberg as supervising architect and Lieut. Joseph A. Crum, as technical supervisor. The WPA organization constructing the armories is under the supervision of A. M. Crain, director of operations. The writer was consulting engineer on the structural design of the thirteen armories.

How to Build Leaky Brick Walls With Good Materials

A. B. MacMillan
Vice-president, Aberthaw Company, Boston, Mass.

No attempt will be made here to describe how to produce good brick walls. The problem after all is reasonably simple, and therefore capable of solution. However, judging from examples on every hand, much effort has gone into the production of leaky walls, even though carefully specified and selected materials were used. Up to the present time, in so far as the writer knows, there has been no concerted effort to educate the public to understand exactly how poor walls may be produced at will. There are a number of steps in the process; for some the owner and designer are responsible, and for some the builder may take all credit.

Without attempting to place the responsibility for any of the steps individually on either of the several participants, let us consider what these steps are.

First, there is compatability of materials. Just as incompatability in marriage leads to divorce, so in building materials it leads to separation. Each material used has characteristics peculiarly its own. For instance, the coefficient of expansion of brick masonry is approximately 0.0000031; that of limestone 0.0000044; and that of concrete 0.0000067. This simply means that in a length of 100 ft. with a temperature change of 100 deg., neglecting the effect of moisture, brick masonry if unrestrained would expand or contract $\frac{3}{8}$ in.; limestone 9/16 in.; and concrete 13/16 in.

Plain arithmetic

It is evident then that if an artificial stone (concrete) coping is placed on top of a brick wall and the end joints between adjacent stones are filled with a hard mortar, the stone in its endeavor to move twice as far as the supporting brickwork, in response to temperature

How to Build Leaky Brick Walls with Good Materials – Letter to Editor to the EN& R magazine

changes, must either be restrained and prevented from moving by the brickwork or else will crack the brickwork or slide on the brickwork; in either case openings will be made through which water can enter the wall. Obviously, if limestone were used for the coping, the movement would be much less, and the marriage might prove successful.

Having thus insured the formation of fissures, the next step is to try to prevent the water going any further. This can be done with flashings. Naturally, if the flashing is laid on a smooth bed of dry mortar with elastic cement at the outer edge; if the outside edge of the flashing is turned down ½ or ¾ in. to form a drip; if the edge on the inside is turned down two courses for a cap flashing, or up if required as a cutoff elsewhere in the wall; if the joints in the copper are made by first tinning the edges of the sheets, then locking them together and soldering the seams so that the joints are thoroughly filled and covered with solder; if all these things are done penetration of water will be stopped at this point.

But as this is not what we want to accomplish, let us lay our flashing on the top of the rough brickwork, keeping the edge ½ in. or more back from the surface of the wall so that it will not mar the appearance of the outside face. Next, let us simply lap or, at most, form lock seams without tinning and soldering the copper sheets when they lap. This will insure that any water which penetrates to the copper can readily go through the several joints or, if by any chance they happen to resist the flow of water, it can find its way to the outer edge of the flashing and thence down into the irregularities in the masonry below.

Another excellent way to assure a leaky wall is never to seal the copper flashings around and against the wall columns. This is particularly effective in the case of steel columns where the space between the flanges is usually filled very roughly with brick bats, mortar, and empty pockets so as to form a natural channel for the passage of moisture.

In laying up the brickwork, after the mason gets his line stretched and mortar bed laid, simply butter the outer edge of the brick to be placed and tap it into place. This will appear to give a full joint on the outside and if the owner happens to notice that it is not full all of the way back just tell him that this is common practice and that when the next bed of mortar is laid it will be squeezed down and fill the joint. Never admit to him or anyone else that the pocketed air will prevent this filling, because if all joints were thoroughly filled it might hinder getting what we are striving for—a poor wall with good materials. To insure further that the wall will be poor, lay up several courses of brick without changing the line or plumbing the face, then rack the wall until it is plumb and true. Doing this will guarantee that joints will be opened; also it saves money in laying.

There are still a few more precautions that should not be forgotten. Don't parge the back of the face brick; this might act as a barrier and stop some leaks. In laying the back-up bricks simply slap them into place on the mortar bed when no one is watching, without buttering the ends or sides, and cover the top face with more mortar as fast as possible so that the inspector can't see that the joints are not filled. Naturally, a little mortar must be used at vertical joints on the inside face of the wall because if these were left entirely open someone might notice it.

These notes could be further amplified to cover the use of membrane flashings, how to treat windows, doors, etc., but sufficient hints have been given so that any careless or unscrupulous builder who follows them can be sure to produce a poor wall with high maintenance cost at will, however excellent the materials used may be.

Water Softening Proposed at St. Paul, Minn.

CONVERSION of part of the St. Paul filter plant into a water softening unit has been kept in mind in planning the $600,000 filter plant extension put under contract last year, as noted in the annual report of the Board of Water Commissioners. This extension includes six new filter units, with increase in flocculator and clarifier basin capacity. With softening treatment, the hard water of the Mississippi River would be of better quality and color. While the cost of operation would be increased by $6 or $7 per million gallons it would result in much greater saving to the consumers. Further expense will be needed for land and equipment for the softening plant, but the present investment represents a large part of the cost.

Only 2.64 miles of 4- to 12-in. pipe and only 628 new services were put in during 1937. Contracts were let for three steel pipe lines and two electric centrifugal pumps to improve conditions in the high pressure district. These pipe lines are of 20-, 24- and 30-in. diameter, and it is stated that the bids for cast-iron and steel showed a saving of $50,000 for the latter.

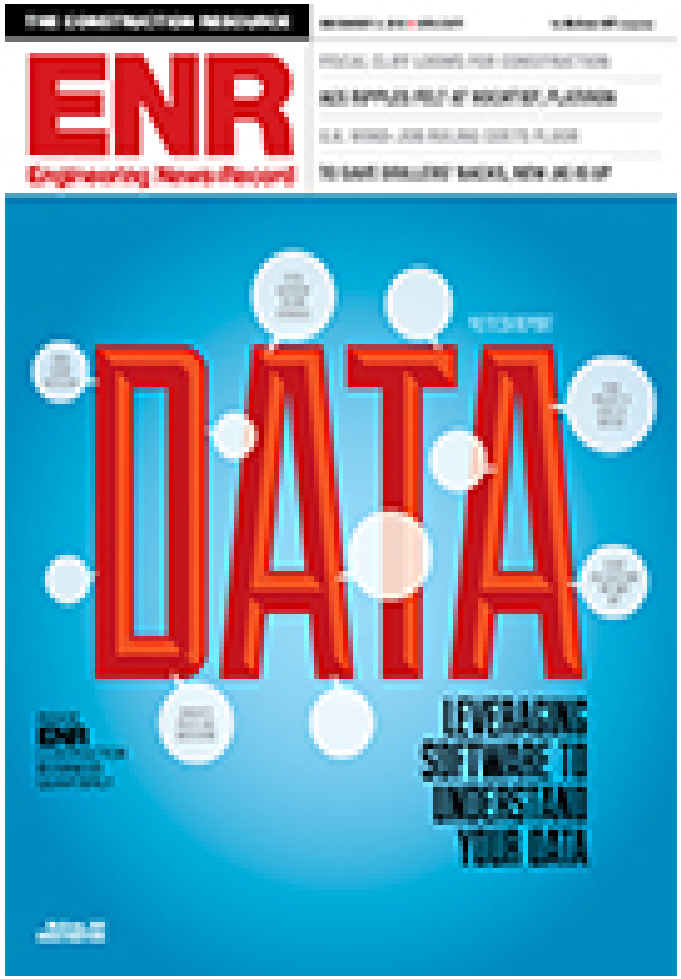
The water at St. Paul is treated by coagulation, sedimentation, filtration and chlorination. Cost of chemicals is mainly for the aluminum sulphate used as a coagulant. In 1926, this cost was $4.44 per million gallons, but a change in the baffles of the mixing chamber reduced this to $2.84. In 1930 it dropped to $1.74, but since then the average has been $2.17. This gradual increase in cost may be due to the raw water requiring more coagulant for decolorization and clarification, or to the consumer demand for a higher quality of water. In passing through the lake system, the water undergoes a marked loss of suspended matter, resulting in the lowering of turbidity and color. Total consumption for 1937 was 8,997,000,000 gal., or a daily average of 24,650,000, considerably less than for 1936, but the maximum day's consumption was 52,100,000, or a 24 per cent overload at the filter plant.

The cost of filter operation averaged $6.995 per million gal. With 613.47 miles of mains, the cost of all repair and maintenance, including hydrants and street work, was $64.51 per mile, while maintenance cost was $33.78 per mile of main and $3.63 per hydrant. The pressure ranges from 30 to 120 lb., and there were 63 leaks in mains during the year

December 1, 1938

IS ‘QUALITY MANAGEMENT’ AN OXYMORON ?

ENR Article - Issue: 12/03/2012
Contractors Confront the Growing Costs of Rework



ENR Article - Issue: 12/03/2012
Contractors Confront the Growing Costs of Rework

Rework plagues U.S. commercial construction projects, causing problems ranging from longer construction schedules and late delivery to worker injuries and billions a year in lost revenue. In the long term, rework can also affect a construction company's reputation and its ability to attract new business.

The problem of rework has been largely ignored by the construction industry, but tighter profit margins during the recent recession have prompted contractors to look for new ways to shave expenses as well as boost earnings. Preventing, or at least curtailing, rework is one cost-cutting measure embraced by more and more contractors. Those efforts include using processes such as building information modeling and lean construction techniques to detect and correct mistakes virtually, as well as common-sense practices such as involving owners, users and other stakeholders throughout planning and construction.

When you think about doing a job that costs a total of $100 million, you can spend something like $900,000 on rework," says Wayne Crew, Construction Industry Institute (CII)director. "The questions become: Can you afford that and how much effort do you put into saving $900,000?"

Contractors Confront the Growing Costs of Rework - ENR

The Cost of Rework-- $$$$

Rework costs—including labor, materials, equipment and subcontractors—can run from 2% to 20% of a project's total contract amount. That equates to an estimated total of $15 billion a year, according to the Construction Industry Institute.

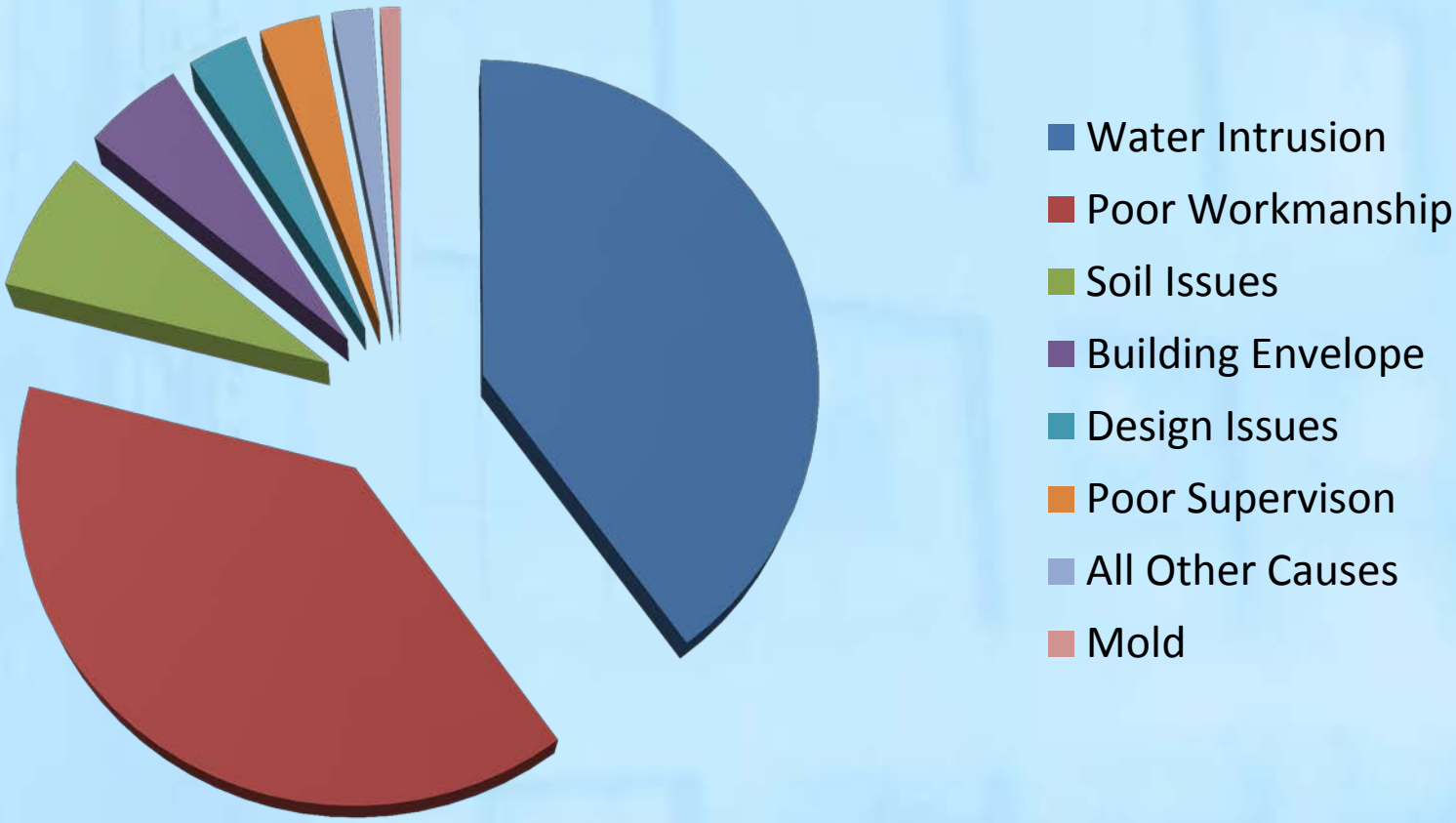
Breaking that down further, the institute found the direct cost of rework averaged 2.4% of total contract value for standard industrial construction projects and 12.4% for civil and heavy industrial projects.

Some construction industry executives and consultants call the CII's annual dollar estimates low. "The $15-billion figure is a drop in the bucket," says McLin / Fails Management Intitute/FMI.

Building Enclosure Management is an Industry Wide Challenge

- **In 2013, the US Census Bureau estimated the value of construction in the US at $883.9 billion in the following categories:**
- **Private Construction** $622.8 B
- **Public Construction** $261.1 B
- **In 2012, Zurich estimates the insurance industry spent about $5 billion to settle Construction Defect (CD) claims in the United States**
  - This equates to approximately 20,000 new CD claims for 2012 based on Zurich's average CD claim value of $250K
- **Zurich data indicates there are 55 new CD claims reported every day**
- **CD claims cost the insurance industry about $14 million per day**

Zurich Construction Defect claims study results



Questions For The Construction Team

- Are project design and construction teams proactive with the verification and assurance of the building performance for the six sides of the box for the building enclosure?

Zelda Says

- The building enclosure poses multiple risks to the management of a building project. While there are proactive construction management /construction firms that have implemented internal programs and processes to co-ordinate the building enclosure inclusive of construction document review, mock ups, and field performance testing there remain those projects that construct ‘buildings with issues’. These projects provide headline news of non performance and litigation.

Questions For The Construction Team

- What word should be banned in construction?
- What is both the most overused and the most misused word in design and construction that begins with the letter Q?

Zelda Says:

- 'Quality' is a word that is overused and misused within both the design and construction industry. 'Quality' is a word that requires definition – 'It' must be defined by the user .– In the instance of a construction project 'it' must be defined by your specific plans and specifications.
- Unfortunately there are as many definitions for the word 'quality' as there are construction team members involved with a project.
- Suggest to substitute the word **performance** for the **'Q' word**

QUALITY

PERFORMANCE

Replace the use of the word

Quality

With the word – **PERFORMANCE**

- Ten (10) Items that Architects, Engineers and Construction Managers/General Contractors /Design Builders should implement within their projects to minimize building enclosure risks and assure that their projects are proactive for the delivery of enclosure performance

Building Enclosure Coordination Process

Building Enclosure Coordination Process (BECP):

The process by which the construction team designs and constructs the performance of building enclosure materials, components, assemblies and systems to meet defined performance objectives of the project as required by the project contract documents- plans and specifications.

Questions For The Construction Team

- What are the top ten items that successful projects instigate to manage risks to the building enclosure?

1.Require the CM/GC to provide the implementation of a Building Enclosure Co-ordination Process (BECP)

- Require the CM/GC to provide a BECP and a specific individual responsible for the coordination of the building enclosure interfaces with subcontractors and manufacturers

2. Integrated specifications

- Cross link the individual specifications across all specification divisions

2. Integrated Specifications Continued…

Division 1 – Provide sections for mockup, performance testing , site specific performance plan, construction & temporary protection, scheduling with tasks included for the building enclosure field testing :

- Submittals, shop drawings, building enclosure trade installation activities, mock ups, lab testing, field performance testing.
- Temporary protection of the installed enclosure materials.
- Shop Drawings integrated to demonstrate the continuity of the air, water and thermal barriers.
- Compatibility of materials regarding waterproofing, air barrier, roofing sealants, and fenestration.

3. Responsibility Matrix

- Utilize to perform a ‘Gap Analysis’ of the specifications and provide a roadmap for the building enclosure first level QC, performance testing, and documentation required within the specifications.

3. Performance Verification Specifications- 14000

- Provide specific listings of the responsibilities for each member of the Construction Team in reference to the enclosure.

4.Performance Specifications

- **Specific delegation within the specifications of the individual responsibilities of each party to the project**
  - Owner, Architect, Consultants
  - Construction Manager, General Contractor
  - Subcontractors for the Enclosure
  - Manufacturers
  - Independent Testing Agencies

5.Coordinated Shop Drawings

- Require the submittal of coordinated shop drawings specific to the project.

- The coordination between trades is similar to above ceiling coordination for Mechanical, Plumbing, Electrical, Fire Protection, and Communications

6. CM/GC Responsible for 1st Level Performance Control Verification

- Require the CM/GC to create and implement a non-conformance process to inspect, document, track and require formal submittals for approval prior to field repairs and requiring mock ups of field repair work.

7. Pre-Construction Meetings

CM/GC Coordinates an Enclosure Coordination Meeting attended by all the enclosure subcontractor trades with a detailed agenda and published meeting minutes naming the specific responsibilities of each subcontractor for the preparation of substrates and protection of installed wall materials.

Require Pre-construction meetings to be scheduled after the shop drawings are approved and a minimum of 4 weeks prior to the start of construction activity

8. Require Site Constructed Mock Ups That Are Field Performance Tested

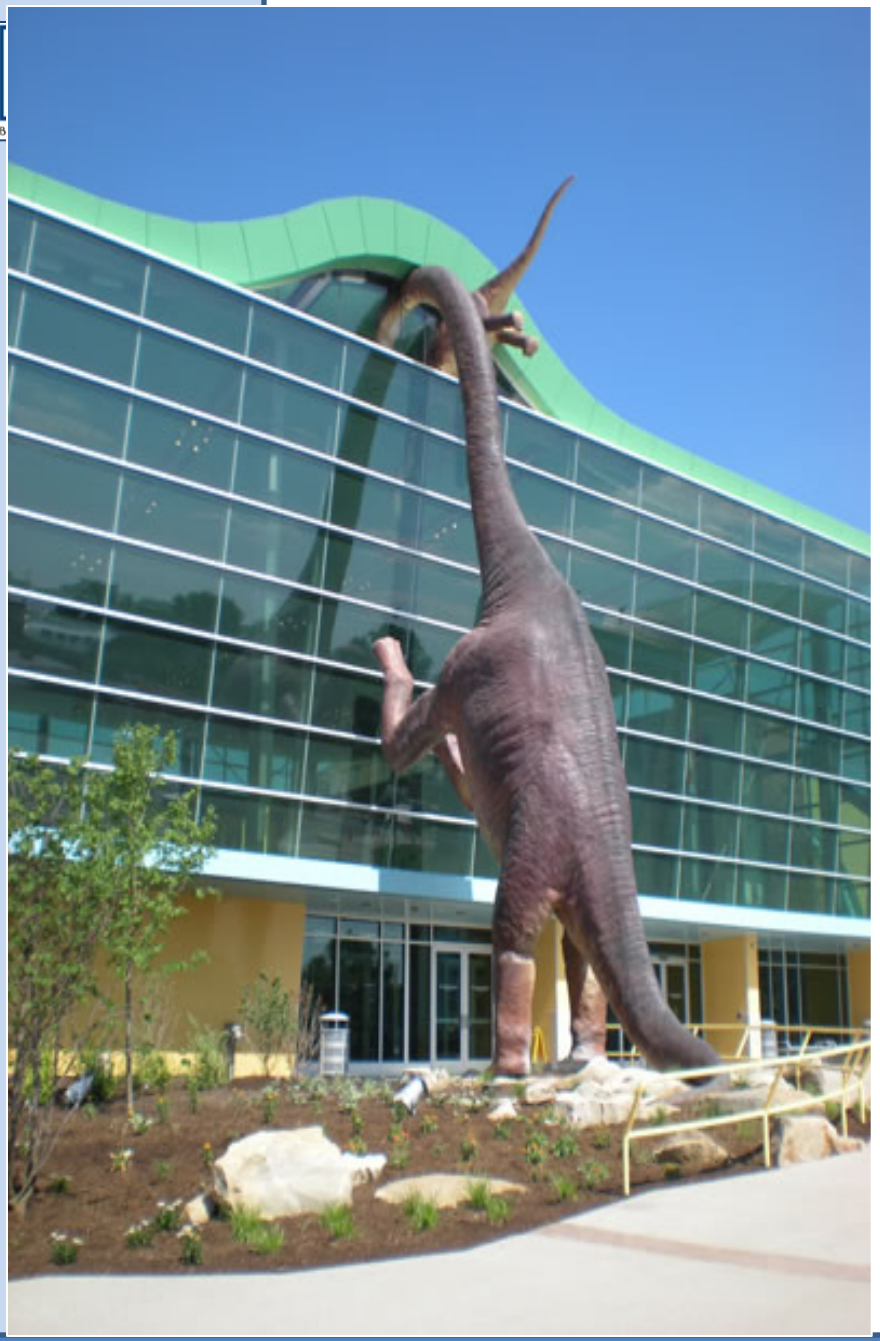
- Utilize a separate Mock Up specification placed in Division 1

9. Field Performance Testing and Documentation by the CM/GC

- The project specifications provide requirements for first level field testing, locations, frequency, scheduling and the acceptance metrics.

10. A 10 Month Warranty Walk Through for the Building Enclosure

- Utilize the enclosure issues log and punch lists to discuss the current enclosure observed performance with a walk through attended by the Owner, Facility Maintenance Personnel, Construction Manager, General Contractor, subcontractors, and Manufacturer's technical representatives.



Thank you

Remember whatever you do – "do it well"

You can not improve what you do not measure.

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Zelda says

“Thank You For Your Attendance and Interest in Improving Building Enclosures ”

QUALITY

Some people drink from the fountain of knowledge. Others just gargle."

-- Robert Anthony,
American business professor