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**How and why building envelopes fail, from a building forensics expert**

*Part one of a five-part series on diagnosing and avoiding cladding, glazing, and roofing failures from building forensics expert IBA Consultants.*

Mark Baker, president of IBA Consultants  
 June 8, 2009  
 Building Design and Construction



The building envelope. At its simplest definition, it's the exterior or shell of a building that repels the elements. At its most complex definition, it's an engineering system that meshes elements such as structural integrity, moisture control, temperature control, and air pressure boundaries into a single design strategy.

When the building envelope system is designed and constructed properly, very few occupants pay attention. But when the building envelope fails (and even the best built projects do in time), everyone notices the building's aesthetic loss, interior damage and, in some cases, life-threatening structural failure and eventual litigation (Figure 1).

In this exclusive editorial series, we will share our investigations of cladding, glazing, and roofing failures to help you design and construct envelope systems that meet the structural standards necessary to provide durability, aesthetic quality, and protection from the elements.

What is failure? In 50% of the cases we've investigated around the country, failure comes in the form of moisture that penetrates the building exterior or is trapped within the envelope system during construction or occupancy. Moisture intrusion either leads to mold growth (figure 2) or slowly degrades the integrity of the envelope system to the point of structural failure. In most cases, rain penetration is the primary source of moisture intrusion. Condensation and entrapped moisture are also prevalent on the buildings we've investigated.

Other common building envelope failures involve non-structural aesthetic issues, including glass delamination and material finish failures, as well as structural and life-safety concerns, such as cracking and component separation. In the most extreme instances, these issues can be life threatening.

What are the main reasons envelope systems fail? We commonly see four causes that contribute to failure:

**1. Design deficiencies.** Architects occasionally specify materials or design systems that are inappropriate for their intended use. Common mistakes include specifying materials that are incompatible



Figure 1

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with materials with which they come into contact or have inadequate performance criteria for thermal movement, structural capacity, or water penetration resistance. Issues also arise when subcontractors try to reduce the weight, size, or amount of building envelope components (aluminum, glass, sealants, flashing, etc.) required on a project (Figure 3). This can lead to inadequate performance or capacity of the materials specified.

**2. Material failure.** It's also common for properly specified materials to fail to meet the published performance levels. This could be a result of errors in the manufacturing, handling, or storing of the product or components within the product. Common examples include degrading sealant adhesion, laminated glass delamination, and metal fatigue. While the anticipated performance levels are often based upon measured statistical performance, the strength of materials varies (Figure 4).

**3. Poor workmanship.** During construction booms, the problem of poor workmanship is exasperated as a result of having many inexperienced, unsupervised, and untrained personnel working on projects. It is common to find building envelope components not installed per the manufacturing specifications. Word to the wise: Putting the right people in the right job goes a long way toward proper installation and overall profitability.

**4. Acts of nature.** Even with flawless installations, bad things can happen to good work when environmental conditions exceed those that were anticipated during design. The effects of hurricane-force wind loads, driving rain, and extreme temperature fluctuations can overload a properly designed and constructed building envelope, causing damage to the system and making it vulnerable to further deterioration or failure. While failures of this type cannot be stopped, many can be prevented through routine inspection and maintenance to identify small problems before they become big ones.

So what happens when you think failure has occurred? An investigation approach is no different than when a person is sick and goes to the doctor. The investigator will first check the symptoms using noninvasive methods to uncover the extent of the problem. In some cases, more-invasive tests need to be completed to identify the cause and the available treatments or repair alternatives for the condition.

Regardless of the cause of failure, a systematic, step-by-step investigative process provides the best results to uncover the truth. By doing this, remedial repair actions can be selected to properly address the root cause of a problem and not just the symptoms. As such, any investigation needs to include the following steps:

1. Identification of symptoms and understanding the problem
2. Review and evaluate the original design intent
3. Verification of as-built condition
4. Determine current condition (i.e., identification of component deterioration)
5. Evaluation of deviations between original design, as-built, and current condition
6. Identification of potential causes of failure
7. Determination of appropriate diagnostic investigation and testing for each of the identified potential causes (destructive vs. non-destructive)
8. Analysis of results of selected investigative and testing methods
9. Implementation, evaluation, and testing of trial repairs
10. Preparation of report indicating the results of the failure investigation and recommendations for repair alternatives

In this exclusive editorial series, we will present case studies examining the failure of several common exterior materials, why they failed, and what lessons can be learned from it.

**About the author**

Mark Baker is president of IBA Consultants, ([www.ibaconsultants.com](http://www.ibaconsultants.com)) a leading building envelope consulting firm specializing in the identification and elimination of potential and existing wall cladding, glazing, glass, roofing, and waterproofing system failures. Baker serves as vice chair of the American Society of Civil Engineers (ASCE), Construction Quality Management and Inspection Committee. He can be reached at [mbaker@ibaconsultants.com](mailto:mbaker@ibaconsultants.com) or (888) 550-4422.



Figure 2



Figure 3



Figure 4

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