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Forensic Engineering Analysis of Alleged Construction Defects

By Michael Stall, PE (NAFE 955M)

Abstract

Information from visual forensic inspections is often used to conclude that building performance failures are caused by construction deficiencies because visual observations are limited to current conditions that seem to indicate that construction is the only cause. Design issues, constructability, product failures, adverse or abnormal weather conditions, post-construction changes, code and ordinance contradictions, lack of maintenance, abuse or neglect, and construction deficiencies contribute to building performance failures. Detailed investigation, coupled with visual observation, is required to understand failures and fairly assign liability.

Keywords

Building performance, building code, construction defect, changed conditions, design defect, conflicting regulations, forensic engineering

Analysis of Alleged Construction Defects

When property owners perceive that buildings have construction defects and retain attorneys to provide their day in court, the forensic engineer must evaluate each alleged defect (in the context of how building performance was affected by project team members) and not jump to the conclusion that all building performance issues are builder defects. In addition to identifying actual construction defects, the forensic engineer also should consider what effect each participant could have on the design, procurement, and building process. **Figure 1** demonstrates how the more important participants can affect building performance.

Each participant in the design, procurement, and construction process should have the goal of creating a code-compliant building that provides good value during its life cycle. However, they do not always succeed, often creating defects that become apparent years after the building is completed — defects a superficial visual observer could conclude are caused by the builder. A thorough forensic engineering analysis must consider the following major issues (as applicable) when evaluating alleged defects:

- Design mistakes, code and ordinance contradictions, constructability, material failures, adverse weather conditions, post-construction changes, neglect and

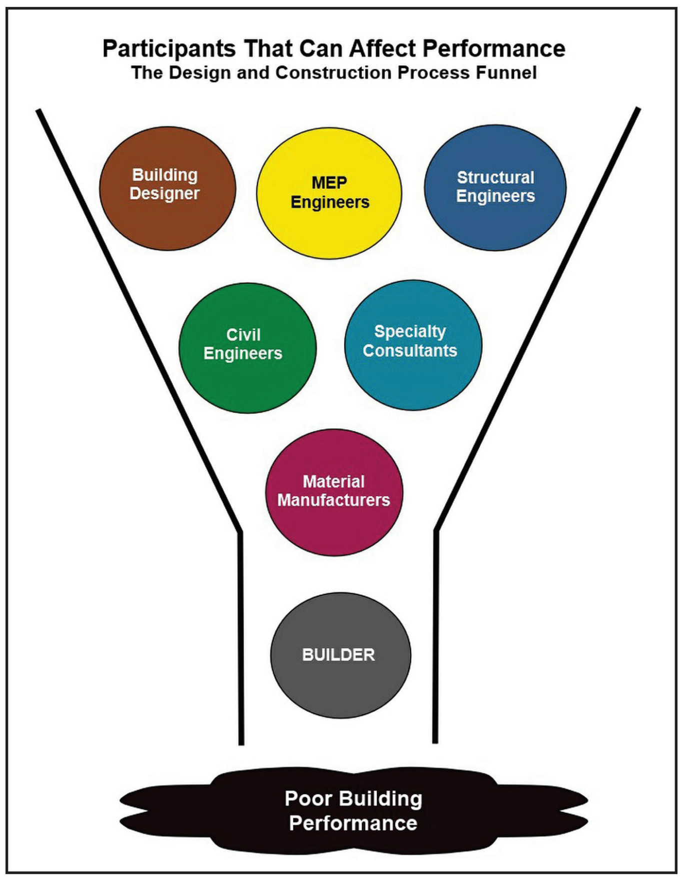

Figure 1
Parties affecting building performance.

Michael D. Stall, PE, 77 Sugar Creek Center Blvd., Suite 210, Sugar Land, Texas 77478, 713-906-0181, mike@mribuilds.com

Figure 2
Defective connection.

maintenance failures, abuse, and actual construction defects contribute to building failures.

- Broad spectrum and detailed historical investigation from design and procurement through construction and maintenance, coupled with current visual observation and assembly testing, may be required to understand which party is responsible for the failures.

It is important to consider these issues as a basis for forensic analysis of building performance to ensure the forensic analysis is diligent, thorough, and accurate.

Basic Builder-Caused Construction Defects

Figure 2 shows a builder-caused defect where the column-to-beam connection was not constructed as it was designed.

Figure 3 is the applicable drawing detail that specified the required column cap, which was not installed by the contractor. There was no mystery in the design, and there was no logical reason why the specified column cap was not installed by the builder. The possible future observable defect would be a distressed or failed connection after a wind storm of sufficient magnitude to stress the defective connection. **Figure 4** provides another example of a builder-caused defect where this post foundation was not constructed as designed — with the wood post being directly embedded in concrete. **Figure 5** shows the drawing detail that specified the required foundation configuration and anchor.

There was no configuration mystery because the design illustrated how the post was supposed to be connected to the concrete. The future defect will be a rotten column because water will seep through the bricks and not drain away from the wood post. These two examples show contractor mistakes that could lead to serious hidden damage during the building's life cycle.

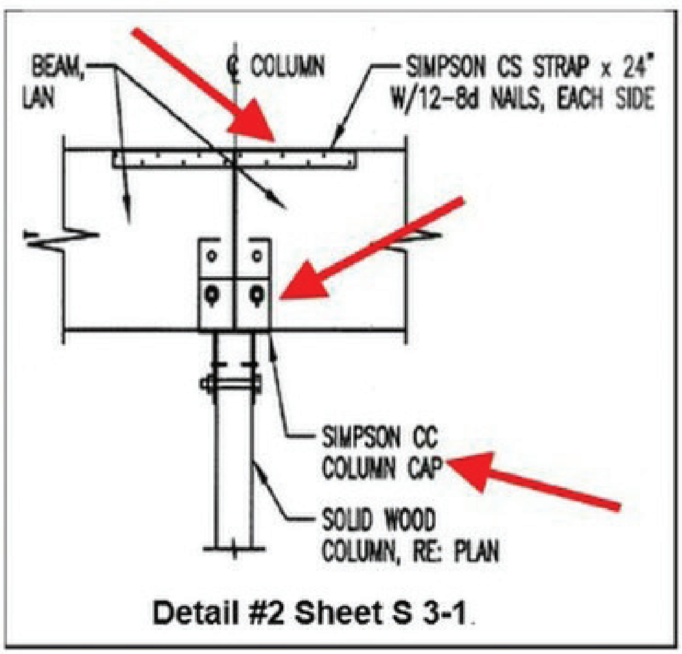

Figure 3
This is how the connection in Figure 2 was designed.

Figure 4
Incorrect configuration.

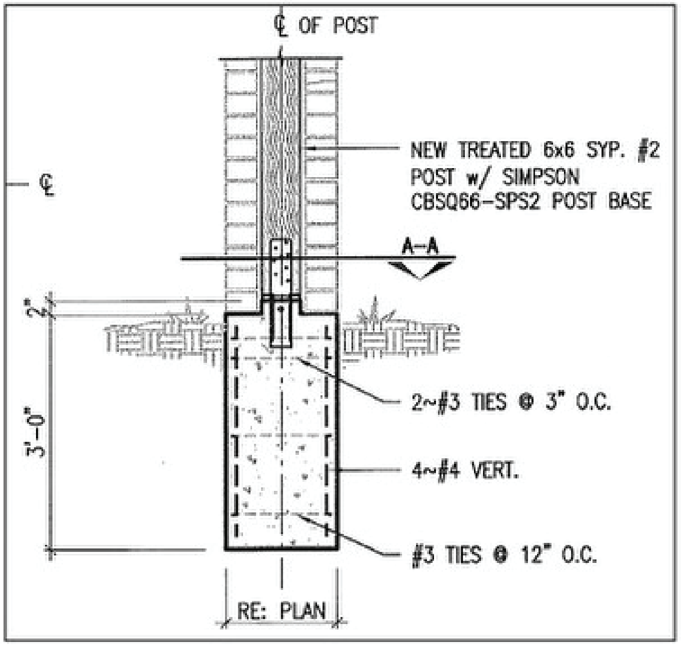

Figure 5
This is how the connection in Figure 4 was designed.

Figure 6 shows a condition where the contractor failed to provide sufficient concrete cover over reinforcing iron in a high-corrosion environment located near the Gulf of Mexico. Visual observations, coupled with investigation of project documentation, revealed how this mistake occurred. The contractor failed to detail and fabricate the horizontal reinforcing column bands correctly, which resulted in more than 500 columns being compromised because of insufficient concrete cover over the bands.

Figure 7
Missing bolts.

Since this was a corrosive environment near the beach, the lack of extra concrete cover as specified by the American Concrete Institute (ACI) for corrosive environments resulted in accelerated corrosion and deterioration.

The following examples show what can appear to be defects caused by the builder, but that could have actually stemmed from some other cause. **Figure 7** appears to show how the builder failed to install bolts in this flight of stairs. Or does it show that the bolts are missing six years

Figure 6
Insufficient concrete cover over reinforcing iron results in corrosion.

Figure 8
Questionable caulking.

after construction, two years after a hurricane damaged the property, and after extensive repair work was done? The visual observation could lead to the conclusion that the builder failed to install the bolts. The detailed forensic evaluation, however, would look beyond what is visible. For example, if removal of the stairs was included in the hurricane damage repair scope, that would likely eliminate the original builder as the cause of these missing bolts.

Figure 8 demonstrates a non-workmanlike caulking application. Based on a visual observation, one could conclude that the builder made a mistake, but that could be wrong. This could be a post-construction hurricane repair activity, the building could have been recaulked and painted, or a condominium owner could have done this. Interviewing the condominium owner, evaluating the layers of paint, researching condominium maintenance records, and considering other information (such as construction punch lists and hurricane repair scopes) could result in the conclusion that this is a post-construction mess not caused by the builder. These two examples show either simple construction defects or deficiencies that could have been caused by activities the builder was not responsible for. The forensic engineer must keep an open mind that will evaluate all information and then make conclusions based on that information.

Figure 9
Stucco contacts patio.

Conflicting Regulations Result in Design and Construction Defects

One example of conflicting regulations is how the Americans With Disabilities Act (ADA) conflicts with the building code and results in a defect, as shown in **Figure 9**.

The ADA requires thresholds to be less than ¾ inches tall and even less in some cases. The typical condominium building threshold is designed for the ADA requirements. Expectably, a door frame will extend down to the threshold and floor. This results in what is shown in **Figure 9** — the bottom edge of stucco walls in contact with the paved patio floor surfaces (to support the door frame), which is contrary to the building code that requires 2 inches of clearance between the bottom of the stucco and paved surfaces. A forensic engineer, evaluating a building for construction defects, could conclude that because the stucco is in contact with the paved patio surface this is a construction defect caused by the builder. This would be an erroneous conclusion because the wall was constructed as it was designed. **Figure 10** shows the design of the exterior walls and patio material interface.

Figure 11 shows the code-required distance between the stucco and the patio, which is not possible unless a system of flashing was designed to cover the bottom plates and the bottom edge of the sheathing — something that would not be acceptable because the threshold elevation would have to be raised to allow continuous integration of the wall flashing with a threshold door pan flashing assembly to ensure the threshold would not leak.

The "solution" is to raise the door threshold to the elevation of the top bottom plate and install a system of integrated door pan and wall flashing, but that would

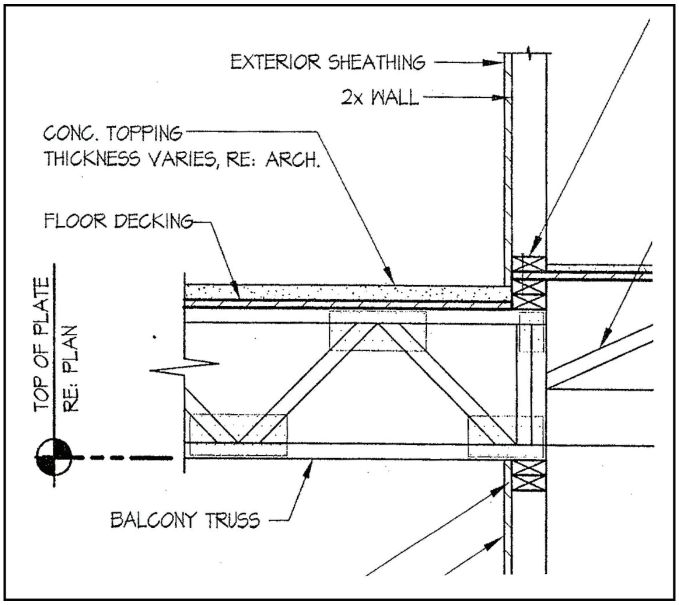

Figure 10
Wall/patio interface design.

Figure 12
Failing support walls.

violate the requirements of the ADA. Additionally, the author has found that many deem this detail aesthetically objectionable; therefore, some people would likely object to the aesthetics of a metal flashing band on their balconies.

Design Defects that Look Like Construction Defects

Figure 12 is an example of what was first thought by building owners to be a construction defect, but subsequent investigation and analysis determined the failure was caused by a structural engineering design error.

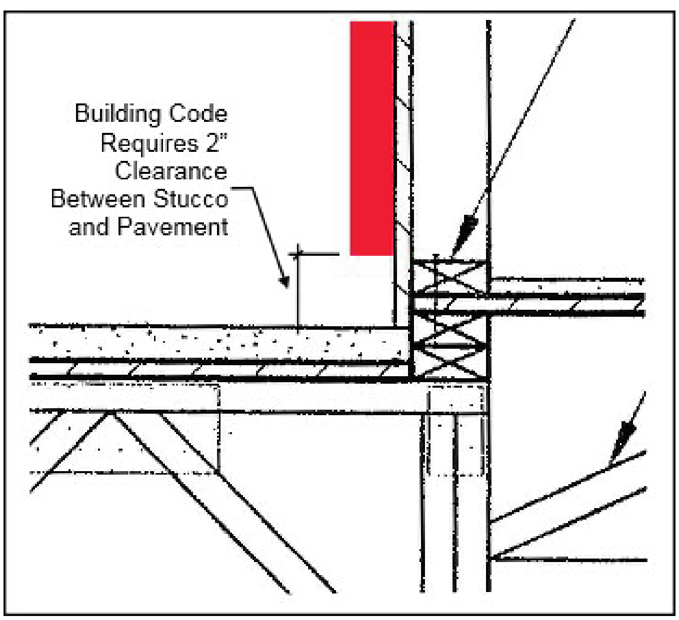

Figure 11
Stucco Code requirement.

The initial forensic engineering observations were of a failing structure that appeared to be collapsing in certain areas. The first possible cause investigated was whether underground utilities in the area were leaking and causing this failure. When an in-depth evaluation of the utilities was performed (using in-line cameras and other location equipment as part of the forensic analysis), the conclusion was that there were no utility leaks causing erosion or failure of the soil around the building.

The next phase of the forensic evaluation was to interview the structural engineer who was honest and admitted that the failure shown in **Figure 12** was a design mistake because the backfilled soil around the building had insufficient strength for the load imposed by the bricks, concrete blocks, and supporting concrete footings. The conclusion of the structural engineer was that to prevent future collapse — and to stabilize the perimeter of the building — helical piers needed to be installed to provide sufficient supporting strength for the footings, concrete blocks, and brick veneer on the four-story building.

Figure 13 shows another design error that was discovered in addition to the failure shown in **Figure 12**. **Figure 13** shows one of the numerous headers that were supporting open spans between the concrete block columns around the perimeter of the building. Other fractures observed at the corners required forensic evaluation

Figure 13
Over-spanned headers.

to determine the cause. The structural engineer reviewed the calculations with the forensic engineer and concluded that the headers were over-spanned for the capacity of the built-up steel header members, proving that this was a design error, not the responsibility of the builder.

Figure 14 shows a combined design and construction error. The over-spanned header shown in **Figure 13** that was incorrectly designed by the structural engineer was also mistakenly cut by the contractor, which resulted in the header improperly bearing a sharp edge rather than the entire width of the member. The original design mistake and this construction error combined to create a design

Figure 14
Incorrectly cut header.

Figure 15
Floor damage.

and construction defect; however, the over-spanned condition caused by the design mistake was the controlling defect because the bearing issue had not caused damage.

Material Failures that Look Like Construction Defects

Figure 15 shows what appears to be damage to a wood floor and door jamb from a leaking threshold and possible construction defect. **Figure 16** shows the wall base flashing just outside of the door is a deteriorated mess of rusted metal.

The initial hypothesis could be that this is a construction defect, but further investigation resulted in a different

Figure 16
Rusted flashing.

Figure 17
Rusted flashing.

conclusion. The owner of this condominium unit had an extensive collection of large potted plants and citrus trees on the patio that was serviced by a drip watering system, which resulted in a chronically wet patio. Additionally, the floor drain (located about 4 feet from this wall) was at a higher elevation, so water was not directed away from the flashing. Steel flashing is galvanized when it is manufactured, but when it is cut during fabrication, the exposed edges are no longer as corrosion resistant as the surface. Normal industry standards are to install metal flashing without corrosion-protective measures on the edges. The solution to this problem was to use lead-coated copper flashing with soldered seams, which are more corrosion resistant than cut galvanized sheet metal. Lead-coated copper was not specified by the designer either because the designer was not aware of it or because it cost more money than the developer wanted to spend. Economics, the designer, the developer, the contractor, and the material provider all had a role in choosing the flashing material that failed.

Figure 18
Observed "defect."

Figure 17 shows a situation that was observed throughout a 28-building condominium near the beach. This was a disappointing situation for the condominium owners because the condominiums were only about six years old when this evaluation was performed. A cursory visual inspection could lead to the preliminary conclusion that either the wrong flashing material was specified by the designer or the builder failed to use the correct material. Metallurgical evaluation of flashing material that was not rusted showed the galvanizing code for seaward properties, which requires heavier galvanizing than what is used in buildings located away from the beach. In this case, the correct flashing was specified by the designer, but the builder ordered the wrong material.

Post Construction Changes Can Appear to Be Construction Defects

Figure 18 illustrates what a forensic engineer identified as a failure to grade this side of the building with a swale for proper drainage as required by the code. That engineer concluded that the contractor or developer failed to meet the standard of care because the configuration of this side of the property did not meet the building code requirements for slope and drainage. In fact, the engineer surveyed elevations near the neighboring structure on top of pavers installed after construction and used that as "evidence" to suggest the contractor or developer caused defective drainage on this side of the building.

One of the important elements of a forensic evaluation the engineer failed to perform was to investigate the history of the condominium project before making definitive conclusion that the builder or developer failed to meet the standard of care. **Figure 19** is a photograph that was taken during construction, showing clear evidence that over time, site conditions (and related drainage) had changed between the buildings; the photo shows no bamboo was growing during construction and that there was a

Figure 19
Different site condition.

fence between the properties.

Reviewing construction photographs and researching the building inspection documentation (which showed the original drainage configuration was code-compliant and approved by the city) were basic forensic engineering evaluation steps that should have been taken prior to reaching final conclusions. Had the engineer performed this diligent analysis, he should have reached the conclusion that the site had been changed materially during the eight years since construction — and that the builder and developer had no responsibility for the changes.

Conclusion

The following elements should be considered when performing forensic engineering evaluation of buildings to provide a realistic, detailed, and fair evaluation of building performance issues, design-related elements, material failures, post-construction changes, and construction defects caused by the builder.

- Building performance is affected by numerous participants in the design, procurement, and construction process that can contribute to a constructed defect — not just the builder.
- Forensic engineering analysis of building performance issues requires more evaluation than just observing the current condition of so-called "construction deficiencies" because the current condition can appear to be builder-caused construction defects when they were caused by other issues or project participants.
- Conditions that appear to be defects can include code and ordinance conflicts, such as the ADA conflict shown in **Figures 9, 10,** and **11**, product and material failures, adverse or abnormal weather conditions, post-construction changes, lack of maintenance, abuse, and neglect.
- The forensic engineer must evaluate the available design documents, the building code, and other regulatory requirements to understand how those elements affect the building's performance.
- When feasible, the forensic engineer should also evaluate project records, photographs taken during construction, maintenance records, performance complaints, owner interviews, engineer interviews, material specifications, submittals, shop drawings and other pertinent information that can provide more insight than the limited understanding provided by current observable conditions.

It is generally understood that the duty of forensic engineers is to serve the public interest by practicing their ethical and professional functions in a thorough and disciplined manner that reflects reality, honesty, independence, and a commitment to do what is right. They have a duty to the client, and they are neither the engineer of record, nor the triers of fact. Instead, they are generally retained not to make improvements to the building but to render opinions on causation and possibly liability. This duty means that observations of current conditions must be coupled with detailed evaluation of all available relevant information to fairly assign responsibility for building defect issues.