Investigative Peer Reviews

What are they, really, and what do they entail?

By Cole Graveen, P.E., S.E.

Structural engineering consulting firms are occasionally hired to review a design performed by another engineering firm. The review is frequently a traditional pre-construction structural peer review performed to achieve a better project outcome. The practice of having a traditional peer review performed is becoming more commonplace for Risk Category III and IV buildings, which include tall buildings, buildings with large occupant loads, and essential structures. Peer review is also commonplace for structures designed using performance-based procedures or with new or innovative framing systems. Traditional structural peer reviews may be performed at the request of the owner or developer, to expedite a building department review, or because it is required by the building code or performance-based design guide. These reviews generally occur in a cooperative environment. Other types of reviews can also occur.

A less traditional type of structural peer review is an investigative peer review. This type of review occurs when something has gone wrong and originates either during construction or after the structure has been completed. The party requesting the investigative review is interested in whether or not the structural design has caused or contributed to problems that have occurred. An investigative peer review evaluates the structural design and may identify errors or omissions. These reviews are often made more complicated compared to typical reviews as the exchange of documents and information may be delayed or restricted depending upon the relationships between the parties involved and the circumstances initiating the review.

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The author has been involved in several investigative peer reviews where the parties have become adversarial, and the initial design information provided for review consists of only the drawings and a computer model input file. This article addresses investigative peer reviews performed under similar circumstances. Fundamental engineering review tasks are presented with a focus on tasks required to review the structural analysis and design performed using electronic calculations and computer analysis models.

Background

Several organizations have produced guidelines or rules addressing engineering peer reviews. A list of references known to the author is provided with the online version of this article. Many of these documents were developed for individual states or cities. However, in 2013, the Council of American Structural Engineers (CASE) published a national practice guideline, Guideline 962-G: *Guidelines for Performing Project Specific Peer Reviews for Structural Projects*. This

Guideline is both comprehensive and in-depth, providing information on many aspects of peer review while including specific details on engineering tasks performed in a structural review. While Guideline 962-G is written to address traditional pre-construction structural peer reviews, much of the information contained within can be applied to investigative peer reviews.

Initiation

The phone rings, and on the line is an attorney whose contractor client is being blamed for a localized failure that occurred in a recently constructed building. The stakes are high as the building owner is suffering a loss of use and wants the structure fixed now. The contractor claims they built what the engineer put on the drawings, and it is not their fault. The attorney wants to know if the engineer's design caused or contributed to the failure. The contractor's records include the drawings and specifications, and the engineer's calculations will be available soon.

Scope Review

This fictional but realistic scenario sets the stage for an investigative peer review. Just like a traditional peer review, the process does not begin until the scope of the review has been established with the client. The client is often focused on the specific portion of the building with the performance problem; however, a broader review approach is almost always necessary. The structural peer reviewer needs to have at least a general understanding of the overall building design. It should also be made clear to the client that any initially agreed upon scope may need to be expanded. As the investigation proceeds and both the structural design and the details surrounding the project are unveiled, the need to review certain aspects of the design in more depth may become apparent. Also, in most investigative peer reviews, including this example, not all of the project information is immediately available.

Documents

Regardless of what information is initially provided, the peer reviewer needs to clearly communicate to their client what documents are needed for the review. Merely stating the "design documents" or the "drawings and calculations" will likely result in receiving the bare minimum of documentation, making it difficult to review

the design or even possibly not getting information for portions of the structure. The list of requested items should include: the project drawings (at a minimum the structural and architectural drawings), the project specifications, design summaries or narratives, engineering reports, structural calculations (hand-written and computer output), copies of the electronic files for computer output calculations and for structural analysis and design performed using computer models, RFI's, addenda/Supplementary Instructions from the engineer, and documents produced by specialty structural designers involved in the project.

The latest versions of these documents should be obtained so that the changes that occurred during the design and construction process are included. Record drawing sets are not always produced but, if available, will incorporate such changes. Otherwise, reviewing RFI's, engineers' field sketches and directives, and addenda may be necessary to understand the final design.

If a design summary or project narrative is available, it can significantly assist with understanding the design intent and criteria. It will likely describe the gravity and lateral load systems and building code design criteria. It should also include project-specific design criteria such as floor deflection and vibration limits, building drift limits, and design loads determined from site-specific studies such as wind tunnel testing, seismic site class testing, and seismic ground motion hazard analysis. The summary may also indicate how software programs were used in the analysis and design of the building (more on this later).

General Review Tasks

The specific review tasks and sequence for an investigative peer review will depend upon the nature of the structural failure or performance problem and the agreed-upon scope. As previously stated, however, the reviewer will need to have at least a general understanding of the overall building design. Certain review tasks apply to any investigative review. These tasks include:

- *Understanding the design criteria and building code requirements*. The review should independently verify the appliable edition of the building code and material design standards and compare the design criteria contained within the code and standards to the project requirements. State or local amendments to the locally adopted national model building code may change design requirements and need to be understood.
- *Identifying portions of the structure where the design was delegated to others and evaluating if the submittal documents and design calculations for those delegated items apply to the review scope*. If a review of delegated designs is necessary, both the delegated design itself and the compatibility with the primary structure require review.
- *Identifying the gravity and lateral load resisting systems and diaphragm types in the structure*. Having a global understanding of the structural design will aid in the review of both the overall building behavior and the analysis and design of specific building members.
- *Performing an initial review of the provided printed calculations, electronic files, and design summary or project narrative to identify the subject matter of each document*. It is essential to understand early on if the analysis and design of the entire structure are

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contained in the received documents. If the analysis or design of portions of the structure is not addressed therein, requests for additional information can be made if necessary.

Once these general tasks have been completed, more focused and in-depth peer review tasks can be performed – the specific aspects of the design to be reviewed, and to what degree, will be dictated by the review scope, the complexity of the structure, and the detail provided in the calculations. Independent analysis and design calculations are typically performed on a limited basis to check the results in the provided calculations.

Digital Reviews

Electronically-created structural calculations and structural analysis and design performed using computer models present unique challenges to an investigative peer review. Merely reviewing printed output and summary reports from a program provides a limited amount of information. Even the built-in default reports available in many programs do not typically provide enough detail regarding the selected setting options and input or model definition to adequately describe what the software is solving and how it is solving it. Opening the software and reviewing the electronic files is the best way to understand what has been done.

The investigative review tasks presented below were developed with a focus on software where the structure or portion of the structure is modeled and then analyzed. However, many of the tasks are also applicable to more straightforward engineering calculation software. A comprehensive review consists of the following areas of the structural model.

Software Review: Determine the software version used to create the electronic files and, if at all possible, use the same version to open and review the contents. Opening older files in newer versions of the software can sometimes result in settings being reset to defaults. A newer version may have revised input menus or additional input options, which may reset when the newer version opens the older file. Different software settings will change results, which may then mislead the peer reviewer. When it is not possible to use the same version, the changes between versions should be researched.

Model Purpose: The analysis and design of tall or complex structures may be accomplished using multiple software programs or using multiple models created from the same software package. There could be a model simply used for the analysis of the structure, to apply the design loads to the structure, distribute them to the individual members, and determine the member forces, with separate programs for designing the members using those forces. There could also be separate models for gravity load analysis, lateral load analysis, and serviceability checks. If a design narrative or summary report does not describe the purpose of multiple models, the investigative reviewer will need to review each electronic file and software package to evaluate its purpose.

General Model Definition: Compare the model to the project drawings and specifications to evaluate if the model is representative of the intended construction. This includes the overall vertical and plan dimensions, the individual member locations, member sections, base of column support conditions, and the connections between members, including member offsets, rigid zones, and end releases.

Material Definitions: Software typically has default settings for concrete, steel, masonry, and timber material properties. These default settings usually need to be changed, or copied and modified, to account for multiple steel grades, concrete and masonry strengths, or to account for increased or reduced stiffness properties. A single material may require multiple material property definitions. Models using advanced analysis types may require nonlinear material properties.

Property Modifiers: Adjusting the default member stiffness is commonly performed in structural analysis. For example, concrete beam-column joints are modeled with larger stiffness, while reduced member stiffnesses may be used for serviceability analysis. This can be accomplished in multiple ways, such as by modifying material properties as mentioned above, by applying property modifiers to section definitions or individual members, or by using user-defined members.

Load Cases and Combinations: Compare the design loads to the loads contained in the model and review the load combinations for compliance with building code criteria. Note that if advanced analyses are being used, such as response spectrum, time-history, or nonlinear analysis, the means of combining the design loads may be different than when a straightforward linear static analysis is used.

Design Modules: Member design is performed based on the results of the analysis. This may be performed in a separate stand-alone program or within the same program. If the program is separate, the transfer of member forces from the analysis program to the design program should be reviewed. In any design program, the design settings will need to be reviewed for agreement with the type of analysis performed, proper edition of the material design standard, and both global and individual member settings, which include items such as unbraced lengths and prescriptive minimum and maximum limits.

Model Integrity: Verify that the model runs without errors or warnings. If errors or warnings appear in the log or output file, they need to be investigated to determine if they significantly affect the results.

Model Results: Review deformed shape plots and member force plots to evaluate if the behavior of the structure makes sense. These plots illustrate the load paths and member behavior and are the easiest way to find unintended results. Compare the individual load case sum-of-reactions to the intended applied loads. This is a simple way to verify that the design loads were entered correctly into the program.

Summary

An investigative peer review evaluates the structural design after something has gone wrong. Unlike a traditional pre-construction peer review, the peer reviewer and the designers are usually not able to interact. This restricts the exchange of information and places greater importance on obtaining the design documents, calculations, and related information. As such, an essential characteristic of an investigative peer reviewer is the ability to communicate to their client which documents are needed and why.

The review of electronic calculations and analysis models is typically a part of an investigative peer review. These files need to be opened within the software to understand and evaluate the structural analysis and design performed with the software.▪

References are included in the PDF version of the article at **STRUCTUREmag.org**.

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