Evaluation of Existing Structures

An Online Continuing Education Course for Engineers

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Evaluation of Existing Structures

"When Familiarity Breeds Success"

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Introduction

When engineers encounter existing structures, they must be prepared to think creatively and come up with unique solutions. Every opportunity for design is not "green-field" – where there is ample room to provide as much steel or concrete to implement designs as the engineer would like. Many civil/structural engineers love grassroots-type projects and new construction work because they provide opportunities for textbook-type calculations and new designs. Even though such projects present their own problems, those challenges often can be addressed easily because there are few constraints and limitations. However, some projects require engineers to work within confined areas, where design issues cannot be resolved just by throwing more concrete, soil or steel at them. Those situations usually arise because of dimensional or weight limitations and other factors. Often they occur when the project involves an existing structure. The situation can be due to the addition of new equipment in an industrial facility, to building renovations, to the results of a feasibility/impact study or to a multitude of other reasons. Regardless of the reason, when such a situation presents itself, the engineer must first evaluate the existing structure, a process that requires the engineer to be detective, historian and student. Such projects help engineers grow technically and opens the door to expand their field experience and enable them to hold their own both in the office and in the field.

1.0 Know Your Boundaries

Before diving head-first into a project involving an existing structure, the engineer must take the time to decipher the problem. The intent of the structural evaluation should be established and clarified so that all issues can be properly resolved. Is the purpose to minimize modifications, to control construction costs associated with a proposed change, to identify needed repairs/strengthening or a combination of objectives?

Existing structures pose unique situations since the typical types of deliverables and other project controls may not exist. Existing structure evaluations have to be handled differently from new designs and can sometimes require more effort than those associated with new structures.

Ultimately the existing structure evaluation should accomplish the following:

- expose the strengths and weaknesses of the structure.
- identify necessary modifications to the structure required per the project scope.
- justify or dismiss the need for modifications per the project scope.

Once the evaluation is complete, the engineer must tailor the necessary deliverables to cater to the client's expectations and to meet the needs and intent of the project, while holding ethics and safety paramount. An engineer should never qualify a structure or modifications to a structure that is deficient, structurally inadequate or unsafe.

2.0 Do the Legwork

A thorough existing structure evaluation strongly depends on the engineer's legwork – the amount of history and information he or she can gather about the existing structure, the quality of his or her fieldwork and the completeness of the documentation, including any limitations discovered. An existing structure evaluation is only as successful as the information it is based on.

Gathering as much history and information about an existing structure as possible is essential to a successful evaluation, not only because doing that legwork is basic to any good analysis, but also because once the information is compiled, it can serve as a future reference. The engineer must remember that when researching history and background on a structure there is no such thing as too much information.

Drawings research

Finding drawings associated with existing structures that are both accurate and legible can be like winning the lottery. Not all sites and facilities maintain documents as well as others do. Some don't even have a defined document-control system, not to mention controlled copies of drawings. When working with existing structures, the engineer must remember that existing drawings do not always reflect as-built dimensions, member sizes, elevations and other key parameters. What is issued for construction on the design drawings may not have been implemented at all. That is why it is important to use original IFC (issued for construction) and red-line drawings, field modification (RFI/EC/ECN) sketches and even piping drawings, which all can help the engineer draw conclusions and confirm details associated with existing structures.

Existing calculations

Finding existing calculations is even rarer than finding existing drawings. Such calculations provide valuable insight into the structure's original design parameters, the methodology that was used and whatever assumptions were made. Finding existing calculations can provide the foundation for a well-defined methodology and help the engineer determine how little or how much conservatism should be included in any new modifications or additions.

Fieldwork

The primary objective of fieldwork is to conduct a visual assessment of the existing structure and confirm the information documented on drawings and in other findings. It can be a daunting task, depending on the size and condition of the structure. While in the field, the engineer should look for signs of degradation such as warped, corroded or missing members, spalled or cracked concrete, or other signs of modifications. Taking pictures and making field sketches can aid in the final evaluation. When identifying problems, it is imperative to identify the stressors, which may be apparent at first sight or may show up in the results of the evaluation. No matter what, problems cannot be properly resolved unless the root of the problem is identified. The engineer should "listen" to the structure and determine what it is trying to say. Is it overloaded, is it under-designed or is it saying that it does or doesn't have significant design life remaining? Gathering such information is crucial to an accurate and technically correct evaluation.

In some cases, fieldwork may not be an option and the engineer may have to rely heavily on existing drawings and calculations. In other instances, the only way to gather information may be solely by field investigation. Whatever the case, the engineer must document whatever is found.

A photo of a building in downtown Bucharest

A situation where someone had to do some legwork for an evaluation of the existing structure below to make the new addition on top.

3.0 Let the Diagnosis Begin

When the legwork is complete, it is time for the engineer to begin the evaluation process by organizing, reviewing and processing the information he or she gathered and using it to develop the methodology, basic design inputs and necessary assumptions for the new project. To meet the unique challenges in this stage of the evaluation, the engineer must rely on common sense, strong fundamentals, experience and an understanding of design specifications and codes.

The first step is to reference applicable design codes for guidance pertinent to the evaluation of existing structures.

- The International Building Code (IBC) provides some guidance and information for a broad range of structure types and for handling some existing appurtenances.
- The American Institute of Steel Construction (AISC) Specification for Structural Steel Buildings contains some information regarding existing structures. It focuses on gravity loads and refers the engineer to ASCE 7 for additional loading conditions. AISC also discusses testing methods for material and bolt strength verification. The AISC specification ultimately leaves the technicalities of the evaluation to the engineer.

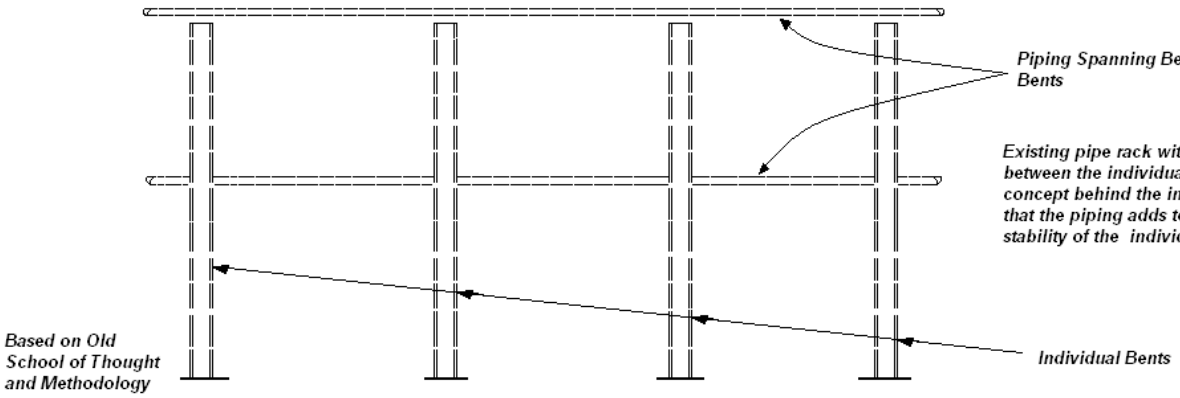
- ASCE 7 (American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures) discusses existing structures in relation to structurally dependent and structurally independent additions and modifications. It does not go into specific technical details but does provide general guidance on how to handle existing building modifications.

IBC, AISC and ASCE 7 may be used together to formulate the best solution and basis for an existing structure evaluation. Other applicable codes may also be used and can vary from project to project. IBC and AISC provide guidance for assessing and evaluating the existing structure, whereas ASCE 7 provides the basis for primary load definitions in regards to application, magnitude and load combinations. The primary loads defined in ASCE 7 should be tailored to fit the evaluation of the existing structure; they should be project specific and technically correct in regards to the intended service of the structure.

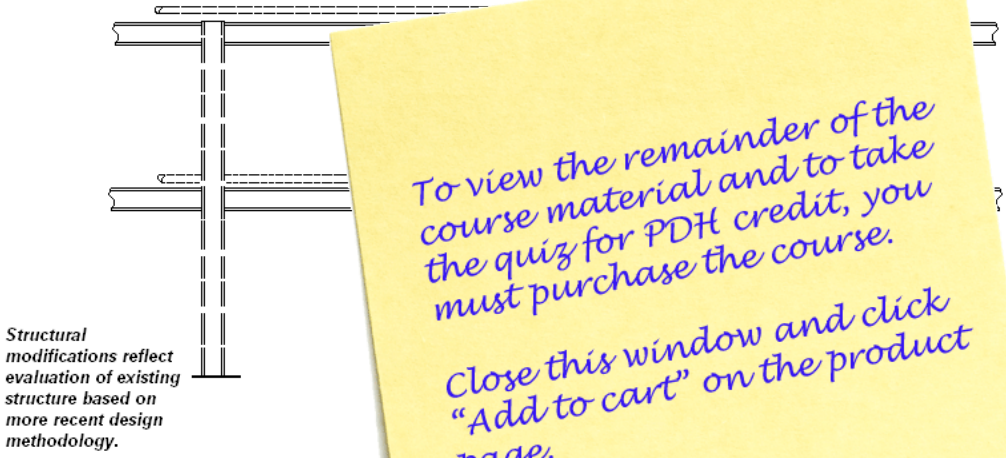
Issues with Applying New Design Codes to Existing Structures

Evaluating existing structures using current industry codes and specifications can potentially yield unfavorable results, which is why it is critical to determine the original design basis of the existing structure. An example of this would be the modern methodology for designing pipe racks in a monolithic structure with bracing and struts versus the older method of designing pipe racks with a number of individual bents carrying pipe. That is not to say that the particular methodology associated with the older design is or was incorrect. What it shows is that new methodologies and new design approaches can pose problems when analyzing existing structures.

***Example*:**



Elevation View
(Existing)



Revised stability equatio oblems with existing structure evaluations. Us seismic) vs. the old 0.9D + W/E will definite