RESEARCH in Progress

Coalition for Advanced Wood Structures
a university, industry, government partnership

Uncertainty Analysis of Wood Structural Systems

Recent research results have shown significant differences in load distribution between experimental and theoretical structural analysis. In particular, significant load distribution discrepancies appeared in what should be symmetric regions of an instrumented Forest Products Laboratory (FPL) wood demonstration house. Thus, some uncertainty in load distribution exists that is not fully accounted for in design practice, particularly with regard to members within wood structural systems. This may result in discrepancies from the expected and as-designed safety levels of components.

Background

Several factors may lead to load distribution discrepancies, including non-ideal member geometry, differing degrees of joint and member stiffness, the influence of nonstructural components, as well as other effects. For a particular existing structure, it may be possible to identify some of these effects and account for them both experimentally and analytically. However, even if these effects can be properly analyzed, it is unlikely that these results can directly help future modeling efforts. This is because a large unknown in wood structures is the spatial placement and magnitude of these anomalous effects. Thus, even if appropriate local effect models could be developed, it would not in general be known where to place them in a future analytical model of a different structure to help refine its predictive capabilities.

The proper solution for a problem of this nature, in which significant uncertainties are present, requires the introduction of probabilistic methods. This, in conjunction with refined analytical modeling as well as experimentation and data collection, may lead to the best results.

Objectives

Objectives of this research are to identify, quantify, and model the sources and effects of uncertainty in the behavior of wood structural systems under static and dynamic loads.

Specific objectives include the following:

- Identify sources of discrepancies between experimental and theoretical load distribution results. The goal here is to account for these affects numerically (i.e., through finite element modeling). This objective will be aided by experimental results to be obtained from another research project that is not part of this study.
- Statistically quantify structural system resistance effects due to variations in construction and develop a reliability model that includes this effect. Depending on the outcome of the results, an adjustment of design load and resistance factors may be recommended.

Approach

1. Collect existing data. The existing FPL research house in Florida is an excellent source of uncertainty data. Two other future instrumented structures, an additional house in Florida and another at Mississippi State University, will comprise the bulk of these data. However, other applicable experimental results may be used if available.
2. Identify sources of discrepancies. As much as possible, it is best to determine precisely what effects are

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causing the variability. The sources and magnitudes of variation can be found analytically (numerical modeling) by examining the effects of various construction parameters. This study may also draw from existing experimental results.

3. Develop statistical parameters. Once the data are collected, they must be analyzed and put in a form useful for probabilistic analysis. Statistical parameters will be developed in reference to the theoretical exact values, not due to modeling simplifications and errors. In this process, care must be taken to avoid duplication in variance from other known sources for which more exact data are available (for example, material stiffness, material strength, and dimensions).
4. Determine the effects of variation on design. Load and resistance factors in the National Design Specification for Wood Structures were obtained considering sources of resistance variance that did not include construction variance as described in this study. If the variance in load distribution is significant, this suggests that members designed as standalone components may have greater safety than previously believed compared to those members placed in a system in which the load distribution has greater uncertainty. This effect must be accounted for in design to maintain consistent levels of safety.

Expected Outcomes

This project will result in an analysis of load distribution uncertainties for wood structures and a classification of uncertainty, if possible, by source. It will determine the effect of this uncertainty on the reliability of components within structural systems and provide recommendations to account for these uncertainties in design.

Timeline

This work started in August 2007 and will be completed by March 2009 (see the following schedule).

Tasks, Estimated Completion Date

Literature search and background research, completed

Analysis of existing data (FPL Florida House), completed

Numerically model sources of uncertainty, in progress

Collect new data (Mississippi State University house), 4/1/08

Additional numerical analysis, 5/1/08

Construct reliability models, 10/15/09

Compute reliability of components, 1/15/09

Make recommendations for revisions, 2/15/09

Cooperators

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