Student project

Key Topics:
- engineering [1]
- severe weather [2]

The overall structural response of light framed timber construction (i.e., the structural system of a house) to wind loads is still poorly understood. Light framed construction is difficult to analyse due to the myriad of connection types and load sharing between structural and non-structural members. This study is determining the load redistribution and progressive failure mechanisms of the structure to severe wind events through structural analysis, computer simulation and physical testing. Outcomes of this study will enable the design and construction of more resilient structural systems (including connections) and techniques for retrofitting existing structures.

Research team

Student researcher

[Image of Dr Korah Parackal]

Full description

Research Question:
The overall structural response of light framed timber construction (i.e., structural system of a house) to wind loads is still poorly understood. This study will determine the load redistribution and progressive failure of the structure to wind loading through structural analysis, computer simulation and physical testing. Results of this study will enable the design and construction of more resilient structural systems (including connections) and techniques for retrofitting older structures.

Description:
This study will make use of computer analysis techniques that have been developed for seismic engineering to analyse the plastic behavior of light framed timber construction. Wind tunnel studies will be conducted to collect time-histories of wind loads on the structure. Physical testing of connections will then be performed to determine their hysteretic and plastic behavior. Results from these tests will be analysed and models with appropriate plastic hinge properties of connections developed. Simulations will then be conducted to obtain a better understanding of load redistribution and progressive structural failure. Outcomes of this study include revised design methods for timber framed structures and optimal techniques for retrofitting old structures.

Background and Significance:
Satisfactory structural performance of housing under extreme wind events is critical for limiting damage and loss of life. However, due to limited engineering input and the complexity in traditional forms of house construction, houses built prior to the 1980s in Australia are vulnerable to wind damage. Traditional forms of construction rely on a myriad of connections and fasteners that form a 'hold down chain' transferring load from the roof structure to the ground. The failure of any component of this chain can result in a progressive failure of the structure. Although manufacturers often test capacities of individual components, the overall behavior of the entire structure is not generally well understood and standard structural analysis methods are often unable to determine response due to complexities such as load sharing and the effect of load transfer to non-structural elements.

Current research has sought to develop influence coefficients and probabilities of failure of structural components. These have been most useful for determining the behavior of individual connections. However, the use of influence coefficients is limited, as these coefficients constantly change as the loads are redistributed during loading due to progressive failure and plastic behavior of connections.

It is hypothesized that these limitations in analysis can be overcome by applying methods used in Seismic Engineering. Economic design for seismic loading makes use of a structure's plastic capacity to withstand forces and hence a reliable knowledge of plastic behavior of connections. From research into connections including fatigue loading and hysteretic behavior, new plastic hinge properties can be defined in numerical models for light framed construction.

Methods and Techniques:
This project will use the James Cook University Boundary Layer Wind Tunnel for scale model testing, the Structures Lab for full scale connection testing and commercial or open source FEM software for numerical simulations.

Using data from research conducted by institutions such as the Cyclone Testing Station, the fatigue and plastic behavior of connections will be defined and Numerical models will be produced using FEM software. These models with plastic hinge and time history capabilities, will be able to determine overall structural response when subjected to wind loads or pushover analysis. Thus, structural connections will be analysed and designed by accounting for the behavior of the entire structure.

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   Prof John Ginger
   James Cook University

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