BEST DESIGN PRACTICES FOR WOOD FRAME CONSTRUCTION IN TORNADO PRONE AREAS

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ABSTRACT: An estimated 1,564 tornadoes have ravaged the U.S. this year and caused over 500 fatalities and untold destruction to homes and other light-frame buildings. Tornadoes in the strongest category – EF5 and EF4 on the Enhanced Fujita Scale – caused 75 percent of the deaths. Given the extensive loss of lives and destruction caused by tornadoes, which typically account for nearly 60% of the annual insurance losses, the question does arise about the current design practices for extreme wind loads. This paper addresses the challenges involved in designing tornado resistant homes and the implications of any mandates to make home tornado proof. The best design practices for wood frame construction in tornado prone areas that ensure occupants safety and reduce potential damage are discussed. Emerging technologies for enhancing the performance of residential buildings in these extreme events are also dealt with.

KEYWORDS: Tornadoes, wood-frame construction, design standards

INTRODUCTION

The devastation caused by tornadoes raise an important question about the design standards and practices used for residential construction which is primarily light-frame wood construction. Given the extensive damage and destruction caused to homes by tornadoes (Figure 1), shouldn’t the obvious solution be to design these structures to be tornado-proof. This solution is neither practical nor worth the expense. In order for a building to be considered tornado-proof, the key components of the building – roof, walls, windows, and doors – will have to be missile resistant, i.e. capable of stopping projectiles travelling in excess of 200 mph. Achieving this level of performance would greatly increase the overall cost of construction, a cost-prohibitive approach. Alternately, the building will have to be completely underground – not very practical -- to withstand winds over 200 miles per hour. Even in tornado-prone areas the chances of a tornado striking a particular home during a life span of 50 years is only about 1%. It’s obvious that the solution to designing light-frame wood structures in tornado-prone areas lies in the design of these structures with improved wind resistance and with the ability to protect the life of the occupants.

There has been a very significant amount of research done in the area of testing, analysis and design of light-frame wood structures subject to extreme wind loads. Numerous technical articles and reports by government agencies, wood products industry and research laboratories/institutes provide guidelines for construction of light-frame wood structures for resisting a desired wind speed. Some states in the U.S. -- Florida and North Carolina for example -- have implemented strict building code standards to ensure a certain minimum level of resistance to wind loads. Data collected after the implementation of the stricter building codes have clearly shown the significant reduction or absence of wind storm damage in the newer buildings.

Based on an extensive review of the state-of-the-art in this area of design of wood structures for extreme winds, this paper discusses the best practices for design of light-frame wood structures that have significant level of wind resistance, result in a modest increment in construction costs, and ensure occupants safety through incorporation of tornado shelter within the structure.

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WOOD FRAME CONSTRUCTION DETAILS CRITICAL TO IMPROVED WIND RESISTANCE

The impracticality of building tornado-proof light-frame wood structures requires that design of these structures focus on providing adequate resistance to withstand high wind loads occurring at the fringes of a tornado. The following details in wood frame are important for ensuring the structural integrity of the building and will be discussed in the full paper. The design recommendation for providing satisfactory vertical and lateral load path for the structure and for achieving a desired level of wind resistance will be discussed in context of the construction details.

- Roof sheathing attachment
- Anchorage of roofs to wall and wall to foundation.
- Nailing and anchorage of shear walls.
- Anchorage of roofing material
- Anchorage of gable ends
- Impact resistant glazing
- Anchorage of brick veneer to wood framing and reinforced masonry walls.

The benefits of properly designed details and the associated incremental cost for achieving a desired level of wind resistance will be presented.

Overview of the engineered and prescriptive requirements for wood frame construction recommended by code bodies in the U.S. is presented. It is pertinent to point out that while this design approach does not ensure survivability when in the direct path of a tornado, it does ensure a critical level of performance under extreme wind loads.

TORNADO SHELTER

As mentioned earlier, the absence of tornado-proof construction necessitates the incorporation of a tornado shelter to ensure the survivability of the occupants. Though it is well known that tornado shelters are critical for survival when the building is in the path of a tornado, they are not integrated into the structure in vast majority of buildings built in the Tornado Alley of the U.S. It is this absence of shelters that has caused the large number of deaths this year. The breach of the building envelope due to a missile or loss of a key component of the building in a tornado results in an increase in the internal pressure which coupled with the external suction forces contribute to an immediate loss of the non-tornado-proof structure. In such an occurrence, the occupants' survival can be ensured only with the presence of a tornado shelter within the building. The use of tornado shelters away from the building is not desirable since use of these shelters require exposure to potential flying missiles.

In this paper, the various shelters recommended in wood frame structures will be discussed and their relative merits are discussed. The shelters will include those recommended by the Federal Emergency Management Agency (FEMA) and other research institutes/organization.

NEW TECHNOLOGIES FOR TORNADO PROTECTION

Tornado-proof construction is a challenge with the traditional wood frame construction used in the U.S. The integration of new materials such as carbon fiber, metal mesh and Kevlar in the building envelope hold the promise of providing the protecting needed against missiles flying in the air during a tornado event. These new technologies will require radically new construction concepts that provide improved tornado shelters or possibly completely tornado proof buildings. These technologies will be discussed in the paper.

REFERENCES