

# Investigation of the role of fire retardant treatment in the failure of wooden trusses

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**Abstract** An investigation of failed metal plate connected wood trusses provided an opportunity to study the long-term effects of fire-retardant treatment (FRT) on dimension lumber. Specimens of lumber that were originally treated with mono-ammonium phosphate were removed from the roof framing of a multi-unit residential building in the state of New Jersey in the United States after nearly 20 years of service. Approximately 170 samples were removed from the building, yielding a sufficient number of test specimens for a statistically robust data set. The samples were prepared and mechanically tested in bending and tension, and the results were compared to previously published research, code provisions, and strength values for new, untreated lumber. Testing was performed on both full-size lumber and small clear specimens in accordance with applicable ASTM standards. The results of the laboratory analysis indicate that the FRT wood removed from building had approximately half the expected strength of untreated wood of the same species. These laboratory results, when compared to previously published data for less aged FRT lumber, suggest that the strength loss is progressive over time rather than a simple reduction at the time of manufacture.

**Keywords** metal plate connected wood trusses, fire retardant treatment, strength testing

## 1. EXTENDED ABSTRACT

After a strong wind and rain storm in the summer of 2006, a residence hall in the state of New Jersey in the United States was inspected by building staff for damage. During the walkthrough, separations between ceiling tiles in the dining room of the building were observed and the ceiling appeared to be sagging. Structural engineers were requested to conduct more detailed investigations which revealed that the wood roof trusses above the dining room had been severely compromised by a large number of failed members. Markings on the truss components confirmed that they had received a proprietary fire-retardant treatment (FRT) that used mono-ammonium phosphate.

A detailed field investigation and laboratory tests were conducted to gain an understanding of the cause of the failure of the wood components in the roof trusses. The type of failure gives clues to the condition

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of the wood, as indicated by brash or splintering failures in the wood or failure of the truss plates to hold the wood in place. Non-degraded wood typically exhibits a splintering failure with a jagged, uneven surface. Brash failures exhibit more of an abrupt, smooth surface because of the breakdown of the wood fibers that give the wood its strength. The type and extent of failures observed in the facility was indicative of a systemic problem. Built approximately in 1988, the roof supports for the building have been subjected to wind and snow loads but the frequency of failures observed seldom occur without some other factor(s) influencing the failures. It is these factors that were of interest in this investigation.

Chemicals used for fire-retardant treatment in the U.S. in the late 1980s through early 1990s are known to degrade wood in environments of elevated temperature and humidity, lowering its strength. Such conditions are often present in roofs of buildings along the east coast of the U.S. Mono-ammonium phosphate is a chemical treatment known to degrade both plywood and solid lumber resulting in a loss of strength over time. Based on the failures observed and what is known about the types of treatments used, it was reasonable to assume that the plywood and lumber had lost strength since installation. While some attempts have been made by others to quantify the loss of strength due to these treatments, there are a number of factors that preclude making an accurate estimate of remaining strength of the lumber in a facility of this age. Most estimates would be based on research that was limited to a few years of exposure rather than the nearly 20 years that the products have experienced in this facility.

One hundred seventy samples were cut from 2 x 4 members of trusses in the facility. The samples were separated into two groups for conducting bending and tension tests in accordance with American Society for Testing and Materials test protocols. Bending and tension tests were selected so that comparisons could be made to published research on the same chemical treatments during the 1980s and to gain an understanding of the remaining strength of the 2-inch by 4-inch lumber used in the trusses. Results of the field investigation, the laboratory tests and a comparison to other research results are presented in the paper.