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Experimental investigation of wood decking assemblies exposed to firebrand showers

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ABSTRACT

Wildland-Urban Interface (WUI) fires have become a problem of great concern across multiple continents. An important mechanism of structure ignition in WUI fires and urban fires is the production of firebrands. During WUI fires, decking assemblies have been observed to be an ignition vulnerability based on post-fire damage surveys conducted by NIST and elsewhere. The authors have conducted scoping experiments and demonstrated the dangers of the dynamic process of continual, wind-driven firebrand showers landing on decking assemblies for wind speeds of 6 m/s. In this study, eight full-scale experiments were conducted with wood decking assemblies under a wind speed of 8 m/s. The basis for these new investigations was twofold: observe possible vulnerabilities of wood decking assemblies to continuous, wind-driven firebrands at higher wind speed as firebrand accumulation patterns were expected to be influenced by wind speed, and examine if wall ignition occurred due to the burning decking assembly. To this end, sections of wood decking assemblies (1.2 m by 1.2 m) were constructed and attached to a reentrant corner assembly. The deck/reentrant corner assembly was then exposed to continuous, wind-driven firebrand bombardment generated by a full-scale Continuous Feed Firebrand Generator installed in the Fire Research Wind Tunnel Facility (FRWTF) at the Building Research Institute (BRI) in Japan. The mass of firebrands required for flaming ignitions under a wind speed of 8 m/s was considerably less compared with those under a wind speed of 6 m/s. This result is postulated to be due to higher firebrand surface temperatures as the wind speed was increased. For the decking assembly to wall ignition studies, the interface between the decking assembly and the wall appeared to be a weak point; this is not addressed in the current test methods.

1. Introduction

Large outdoor fires, such as Wildland-Urban Interface (WUI) fires in USA, bushfires in Australia, and urban fires in Japan are a major concern. In particular, structure ignitions are a major problem. An important factor for structure ignitions in large outdoor fires is acceleration of fire spread caused by firebrands produced from burning structures [1].

In large outdoor fires, decking assemblies have been observed to be an ignition vulnerability based on post-fire damage surveys conducted by the National Institute of Standards and Technology (NIST), the Insurance Institute for Business & Home Safety (IBHS), and the Commonwealth Scientific and Industrial Research Organization (CSIRO) [2–4]. Recently, the use of decking assemblies has also become more popular in Japan.

The Office of the State Fire Marshal (OFSM) in California adopted the test method known as State Fire Marshal (SFM) STANDARD 12-7A-4 [5]. The SFM test method is intended to determine the response of decks to firebrand exposure and is similar to ASTM E2726 [6], and was proposed at a time when WUI fire science was in its infancy. Both of those test methods are extensions of the ASTM E108 roof test [7]. A firebrand is simulated by placing a burning wood crib on top of a section of a decking assembly under an air flow. The dynamic process of multiple firebrands bombarding decking materials as a function of time is not adequately represented or simulated in this standard. Based on firebrand attack from real WUI fires, it is expected that multiple firebrands would deposit within gaps/crevices between or on deck boards. In addition to not simulating a dynamic firebrand attack, the California and ASTM test methods do not fully consider possible differences between the size and mass of firebrands produced from burning vegetation and structures. As WUI fire science has developed further, the limitations of this test method have received increased attention.

Most recently, Hasburgh et al. [8] conducted preliminary experiments to determine wall ignition vulnerabilities exposed to burning decking assemblies. In their experiments, the decking assemblies were 609 mm by 711 mm, and these were attached to a wall fitted with heat flux gages and thermocouples. Two ignition sources were considered: a below deck flame exposure using a propane burner, and an above deck test using a Class A burning brand (largest), both taken from the SFM test method above. For the Class A firebrand ignition experiments, the experimental data showed that wind speeds of 2.9 m/s and 5.4 m/s had the highest temperature and heat flux on the wall from the burning decking

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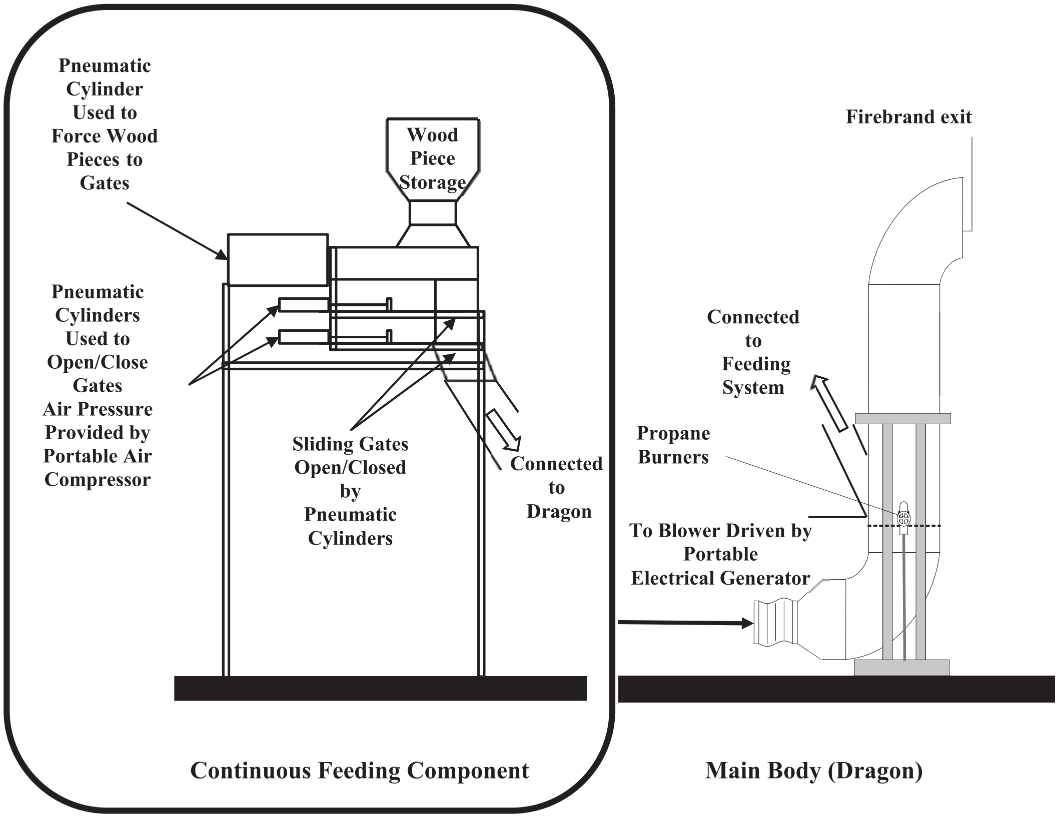

Fig. 1. Schematic of full-scale continuous feed firebrand generator. This version of the device is designed to generate firebrand showers using Douglas-fir wood pieces.

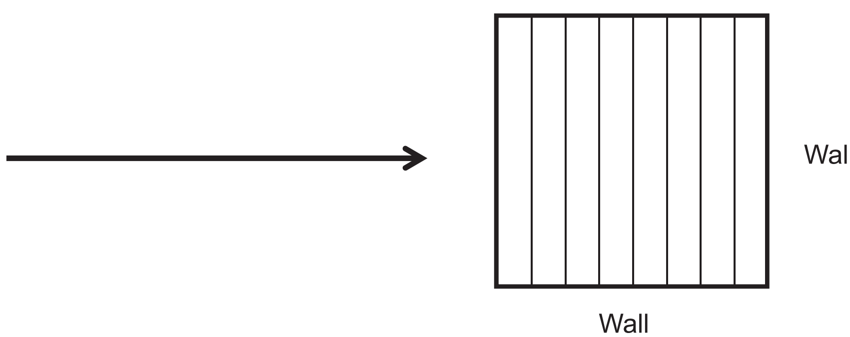

Fig. 2. Orientation of deck boards with respect to the direction of the firebrand-laden flow. Note that this drawing is for illustration purposes and is not intended to reflect the total number of deck boards used per experiment or the actual dimensions of the decking assembly itself [9].

assembly. Hasburgh et al. [8] suggested that test methods developed in their paper and the data obtained can be used to gain insight into how a burning wood deck contributes to structural ignition. However, as pointed out by the authors, a great deal of work remains to be done, as the number of experiments were limited [8].

The authors conducted experiments and demonstrated the dangers of the dynamic process of continual, wind-driven firebrand showers landing onto wood decking assemblies [9]. The accumulation of glowing firebrands resulted in flaming ignition of the deck boards. It was also observed that ignition of the deck boards produced smoldering ignition in the supporting members under the decking assembly. In that work, the wind speed was limited to 6 m/s (to compare to existing test methods already discussed). These experiments were the first to investigate wood decking vulnerabilities to wind-driven firebrand showers with firebrand size and mass distribution linked to those determined from burning vegetation and an actual WUI fire [9].

In this study, a series of experiments were conducted with similar wood decking assemblies under a wind speed of 8 m/s, a higher wind speed than the previous study. The reason for this is to examine possible vulnerabilities of wood decking assemblies to continuous, wind-driven firebrands under higher wind speed as firebrand accumulation patterns were expected to be influenced by wind speed. As described in detail below, as wind speeds were increased from 6 m/s to 8 m/s, a transition in firebrand accumulation patterns has been observed for firebrand flow in front of walls. Another purpose was to examine the possibility of deck to wall ignition, as prior experiments did not consider this aspect. An important aspect of the work presented here is that the decking assemblies coupled to reentrant corner assemblies are realistic scales, and the firebrand sizes were predicated on results measured from burning vegetation and actual WUI fires. Some details of these experiments were presented at a recent conference [10], but this paper presents these experimental results for the peer-reviewed literature in depth.