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Exposing siding treatments, walls fitted with eaves, and glazing assemblies to firebrand showers

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ABSTRACT

An experimental campaign was undertaken to determine vulnerabilities of siding treatments, walls fitted with eaves, and glazing assemblies to firebrand bombardment using the NIST Dragon installed in the Building Research Institute's Fire Research Wind Tunnel Facility (FRWTF). Experiments were also conducted to determine if firebrands can produce ignition in fine fuels placed adjacent to the wall assembly and whether the subsequent ignition of fine fuels could lead to ignition of the wall assembly itself. These experiments are the first to investigate these vulnerabilities in a systematic fashion. The results of these experimental findings are presented.

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1. Introduction

Fires in the Wildland–Urban Interface (WUI) have resulted in large property loss and destruction throughout the world. Firebrands are known to be a major cause of structural ignition of WUI fires in USA and Australia [1–10].

The WUI fire issue is a structure ignition problem and the best approach to reducing the severity of the problem is to reduce the potential for structures to ignite via scientifically based test standards and building codes [11]. In order to develop scientifically based mitigation strategies, it is necessary to understand the vulnerabilities of structures to firebrand showers. While firebrands have been studied for some time, most of these studies have been focused on how far firebrands fly or spotting distance [12–22]. Unfortunately, very few studies have been performed regarding firebrand generation [23–26] and the ultimate ignition of materials by firebrands [27–31].

Recently, Manzello et al. [32–35] developed an experimental apparatus, known as the NIST Firebrand Generator (NIST Dragon), to investigate ignition vulnerabilities of structures to firebrand showers. The NIST Firebrand Generator is able to generate a controlled and repeatable size and mass distribution of glowing firebrands. The experimental results generated from the marriage of the NIST Dragon to the Building Research Institute's (BRI) Fire Research Wind Tunnel Facility (FRWTF) have quantified the vulnerabilities that structures possess to firebrand showers for the first time [32–35]. These detailed experimental findings are being considered as a basis for performance-based building standards with the intent of making structures more resistant to firebrand attack.

As an example of this, to address an important vulnerability observed in prior experiments, namely firebrand penetration into building vents, NIST worked with the California Department of Forestry and Fire Protection (CALFIRE) as part of a task force in order to reduce mesh size used to cover building vent openings to lessen the potential hazard of firebrand entry into structures. These changes were formally adopted into the 2010 California Code of Regulations, Title 24, Part 2, Chapter 7A, and are effective from January, 2011 [36]. The NIST Dragon is also being used to generate an experimental database to support NIST's Wildland Fire Dynamics Simulator (WFDS) [37].

The present investigation was undertaken to determine vulnerabilities of siding treatments, walls fitted with eaves, and glazing assemblies to firebrand bombardment using the NIST Dragon installed in BRI's FRWTF. Vinyl siding and polypropylene siding were exposed to firebrand showers. The siding treatments were installed in a reentrant corner configuration and the moisture content of the sheathing material was varied. Two different wind tunnel speeds were used to ascertain the influence of wind speed on siding vulnerability to firebrand showers. A reentrant corner configuration was used since it is believed that firebrands may become trapped within the corner post and under the siding itself.

In addition to exposing siding treatments to firebrand showers, experiments were also undertaken to determine eave vulnerability to firebrand showers. A very important, long standing question is whether firebrands may become lodged within

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joints between walls and the eave overhang. There are essentially two types of eave constructions commonly used in California and the USA [38]. In open eave construction, the roof rafter tails extend beyond the exterior wall and are readily visible. In the second type of eave construction, known as boxed in eave construction, the eaves are essentially enclosed and the rafter tails are no longer exposed. Since the open eave configuration is believed to be the most vulnerable to firebrand showers, some jurisdictions prone to intense WUI fires have required eaves to be boxed in. In both construction types, vents may be installed [38]. For this paper, walls fitted with eaves were constructed and exposed to firebrand showers. Since the open eave construction is thought to the worst possible situation, this configuration was used. Experiments were completed by varying the wind speed as well as investigating the influence of vent openings on firebrand accumulation and penetration into open eave configurations.

Finally, glazing assemblies were exposed to firebrand showers. An important question is whether firebrands become trapped, accumulate inside the corner of the framing of glazing assemblies, and lead to window breakage. Two types of glazing assemblies were used for the experiments. The first type was a horizontally sliding window assembly. The second type was a vertically sliding window assembly. Both of these glazing assemblies were double hung since it is also thought that this type of assembly would provide more locations for firebrands to accumulate.

It is very important to realize that to date there have been no experimental methods to generate and visualize wind driven firebrand bombardment to eave construction, various siding treatments, or glazing assemblies in a controlled laboratory setting. These experiments are the first to investigate these vulnerabilities in a systematic fashion. Prior to conducting these experiments, input was collected from interested parties in California (*e.g.* building officials, Office of the State Fire Marshall, code consultants, industry) since large WUI fires have occurred in this state recently [39]. Consequently, details about the type of siding treatments, eave assemblies, and glazing assemblies were obtained from this workshop [39]. Some of these experimental results were presented at a recent conference but this paper greatly expands on the findings presented there [40].

2. Experimental description

Fig. 1 is a drawing of the NIST Firebrand Generator. A brief description of the device is provided here for completeness and follows prior descriptions very closely [34]. This version of the device was scaled up from a first-generation, proof-of-concept Firebrand Generator [34]. The bottom panel displays the procedure for loading the Norway spruce (*picea abies Karst*) tree mulch into the apparatus. Norway spruce (*picea abies Karst*) was chosen since it belongs to the *Pinaceae* family, which includes species such as Ponderosa pine (*Pinus Ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*), common conifer species dominant in the USA. In addition, Norwegian spruce is found in more than 20 states in the USA. These trees were used as a source for mulch for the Firebrand Generator since they were quite easy to locate in Japan.

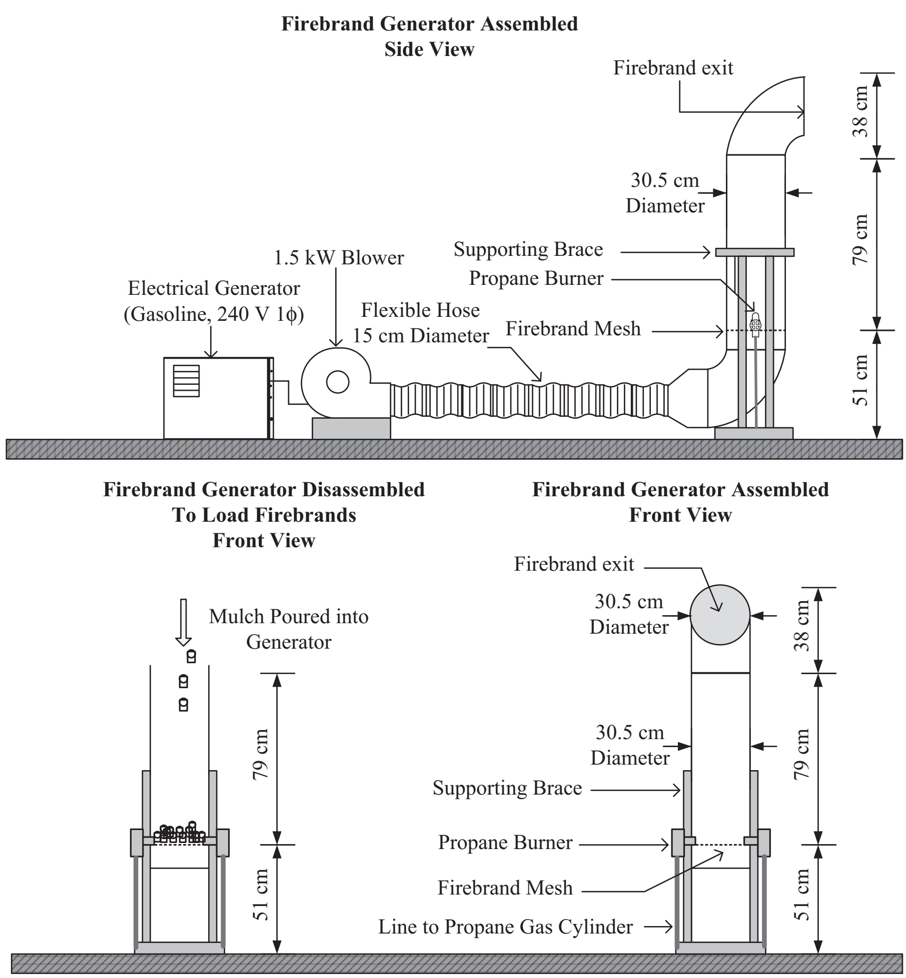

Fig. 1. Schematic of NIST Firebrand Generator.

The mulch pieces were deposited into the firebrand generator by removing the top portion. The mulch pieces were supported using a stainless steel mesh screen (0.35 cm spacing). Two different screens were used to filter the mulch pieces prior to loading into the firebrand generator. The first screen blocked all mulch pieces larger than 25 mm in diameter. A second screen was then used to remove all needles from the mulch pieces. The justification for this filtering methodology is provided below. The mulch loading was fixed at 2.8 kg. The mulch was produced from 6.0 m tall Norway spruce trees. The firebrand generator was driven by a 1.5 kW blower that was powered by a gasoline electrical generator. The gasoline electric generator provided the blower with the necessary power requirements (see Fig. 1). These power requirements were not available at the FRWTF, necessitating the use of a portable power source.

After the Norway spruce tree mulch was loaded, the top section of the firebrand generator was coupled to the main body of the apparatus (see Fig. 1). With the exception of the flexible hose, all components of the apparatus were constructed from stainless steel (0.8 mm in thickness). The blower was then switched on to provide a low flow for ignition (1.0 m/s flow inside the duct measured upstream of the wood pieces). The two propane burners were then ignited individually and simultaneously inserted into the side of the generator. Each burner was connected to a 0.635 cm diameter copper tube with the propane regulator pressure set to 344 kPa at the burner inlet; this configuration allowed for a 1.3 cm flame length from each burner [34]. The Norway spruce mulch was ignited for a total time of 45 s. After 45 s of ignition, the fan speed of the blower was increased (2.0 m/s flow inside the duct measured upstream of the wood pieces). This sequence of events was selected in order to generate a continuous flow of glowing firebrands for approximately six minutes duration.

The Firebrand Generator was installed inside the test section of the FRWTF at BRI. The facility was equipped with a 4.0 m diameter fan used to produce the wind field and was capable of producing up to a 10 m/s wind flow. The wind flow velocity distribution was verified using a hot wire anemometer array. To track the evolution of the size and mass distribution of firebrands produced, a series of water pans was placed downstream of the Firebrand Generator. Details of the size and mass distribution of firebrands produced from the Firebrand Generator are presented below.

3. Results and discussion

Similar to past studies, the input conditions for the Firebrand Generator were intentionally selected to produce glowing firebrands with mass up to 0.2 g. This was accomplished by sorting the Norway spruce tree mulch using a series of filters prior to being loaded into the firebrand generator. The same filtering procedure was used as in past studies. Since the procedure for determining the size and mass distribution was identical to prior work, it is not presented here. In this study, the firebrand size distribution used was commensurate with sizes measured from full scale burning trees as well as distribution obtained from a post-fire survey of actual WUI fire (Angora) [41].

When firebrands contact ignitable fuels, such as structures, they are most likely in a state of glowing combustion, not open flaming. While it is possible for firebrands to remain in a flaming state under an air flow and therefore it is reasonable to assume that some firebrands may still be flaming upon impact, the purpose of this device is to simulate firebrand showers observed in long range spotting and therefore glowing firebrands were desired.

After the size and mass distribution of firebrands produced from the Firebrand Generator was determined, full scale corner assemblies, walls fitted with eaves, and glazing assemblies were installed inside the FRWTF. For all the tests conducted, the Firebrand Generator was located 7.5 m from the assemblies (see Fig. 2). With respect to corner tests, a distance of 7.5 was measured from Firebrand Generator to corner post. A distance of 7.5 from the Firebrand Generator was selected since the purpose of the experiments was to simulate wind driven firebrand bombardment onto structures. Specifically, this distance allowed the structures to be fully engulfed by wind driven firebrand showers.

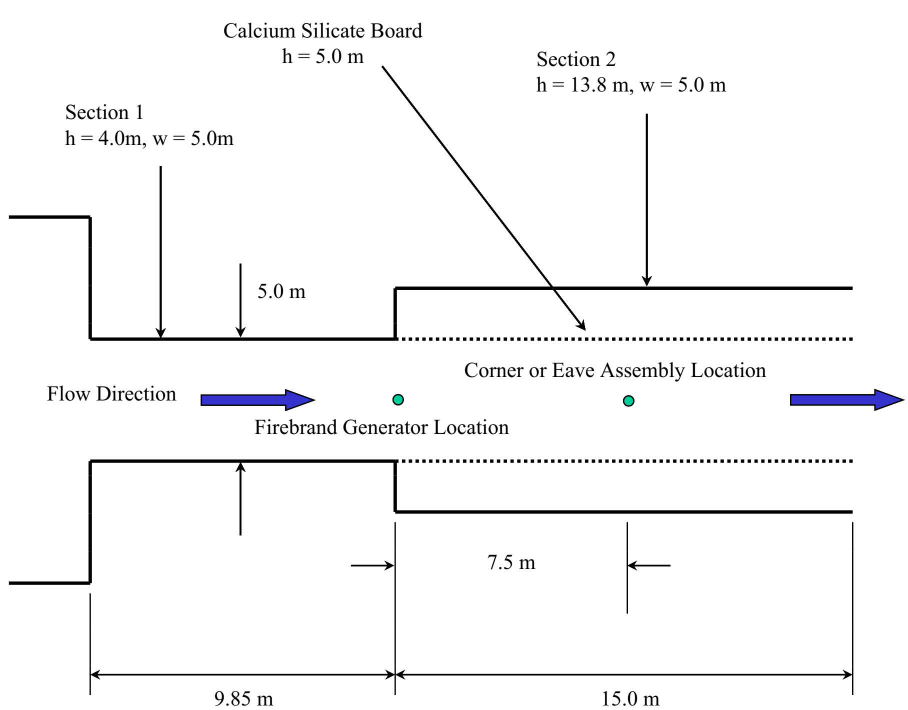

Fig. 2. Schematic of Fire Research Wind Tunnel Facility (FRWTF).

4. Reentrant corner tests fitted with siding treatments

A full scale reentrant corner section (each side was 122 cm wide by 244 cm high) assembly was constructed for testing (shown in Fig. 3a and detail of corner post shown in Fig. 3b). To be able to control the moisture content of the sheathing (oriented strand board—OSB) base layer, the experiments were designed in a modular fashion. Specifically, each side of the 122 cm by 244 cm full section was comprised of 12 separate OSB pieces. This allowed each section to be oven dried and simply reassembled inside the custom mounting frame. For each assembly, a moisture barrier was applied (Tyvek; a registered product of DuPont) and then the siding treatments were applied. The frame was constructed using wood studs with a stud spacing of 406 mm (16″) on center. Two different types of siding treatments were used: vinyl siding and polypropylene siding. Polypropylene siding is newer to the market as compared to vinyl and is used since it has the look and feel of cedar siding. The American Vinyl Siding Institute was contacted for proper installation and construction was performed in accordance with their installation manual [42].

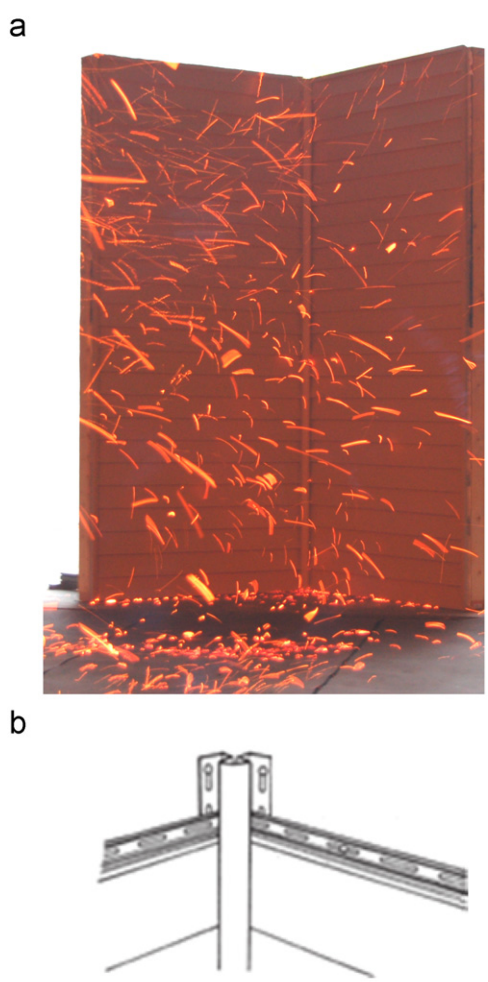

Fig. 3. (a) Picture of vinyl siding corner assembly under firebrand bombardment. (b) Drawing of corner post.

Experiments were performed in an effort to quantify the range of conditions that these assemblies are vulnerable to ignition from firebrand showers. Table 1 displays the parameters that were varied in these experiments. The moisture content of OSB that was not dried was 11% on a dry basis. A starting velocity of 7 m/s was selected since most of the firebrands produced from the Firebrand Generator were observed to be lofted under these conditions. The velocity was subsequently increased to 9 m/s to ascertain if any of the results were velocity dependent. Three replicate experiments were conducted for each wind speed.

For experiments with vinyl siding conducted at 7 m/s and 9 m/s, the firebrands were observed to melt the siding to the point where holes developed through the material. A picture of this is shown in Fig. 4a. While burns were observed in the moisture barrier at both wind speeds (Tyvek), ignition of the OSB sheathing was only observed for vinyl siding tests at 9 m/s and when the sheathing was dried. It is important to point out that the OSB sheathing burned completely through and ignition was observed within the framing members as well (2×4).

For polypropylene siding, firebrands produced melting within the material but no holes were formed within the siding itself (see Fig. 4b). Firebrands were observed to penetrate the corner post and burn holes into the moisture barrier (Tyvek) but ignition was never observed in the OSB sheathing for any wind speed or moisture content considered. Nevertheless, it is important to point out that firebrands easily penetrated the corner post in both siding types.

5. Walls fitted with eaves

Since the open eave construction is thought to be the worst possible situation, this configuration was used. A 244 cm by

Fig. 4. (a) Image of vinyl siding (from bottom) after firebrand exposure at 7 m/s. (b) Image of polypropylene siding after firebrand exposure at 7 m/s.

Table 1
Summary of corner test results for vinyl and polypropylene. NI = No Ignition; SI = Smoldering Ignition.

U_∞ (m/s)	Vinyl siding OSB sheathing dried	Vinyl siding OSB sheathing not dried	Polyproplylene siding OSB sheathing dried	Polyproplylene siding OSB sheathing not dried
7	Siding melted/holes burns on Tyvek OSB NI	Siding melted/holes burns on Tyvek OSB NI	Siding melted burns on Tyvek OSB NI	Siding melted burns on Tyvek OSB NI
9	Siding melted/holes burns on Tyvek OSB SI	Siding melted/holes burns on Tyvek OSB NI	Siding melted burns on Tyvek OSB NI	Siding melted burns on Tyvek OSB NI

244 cm wall fitted with an open eave was constructed for testing. An eave with a total length of 122 cm overhang was constructed and mounted on the wall assembly. While the eave was 122 cm long, the actual overhang used was 61 cm. Since the purpose of these experiments was to determine if any accumulation of firebrands was observed within the eave assembly, the wall was simply fitted with OSB sheathing and was not dried. Specifically, two OSB sheets of 122 cm by 244 cm were screwed to framing members. The wall was constructed using wood framing members spaced 406 mm (16″) on center.

Fig. 5 displays common open eave constructions used in California. The construction found in top panel of Fig. 5 was followed for testing [39]. In half of the experiments, no vent opening was used to simply observe if firebrands actually accumulated within the exposed rafters and subsequent joints (see Fig. 6). In the remaining experiments, vents were installed (see bottom panel) and a mesh was placed within the vent opening (see Fig. 6). For the vent openings, 50 mm holes were drilled into the blocking material and an 8 × 8 mesh (2.75 mm opening) was secured, as recommended in the new, 2010 California WUI code [36]. As in the corner tests described above, three replicate experiments were performed. Table 2 is a summary of the range of parameters used. It is important to point out that only one length of eave overhang was experimented with (61 cm). This is not to say that other eave overhang lengths were not important, just not possible due to cost considerations when conducting so many full-scale experiments.

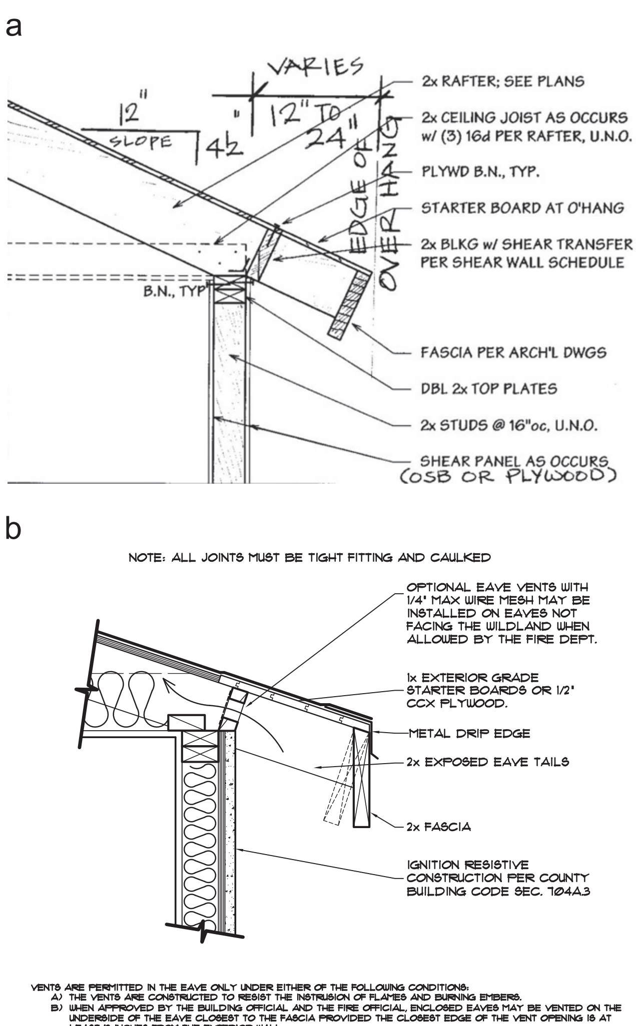

Fig. 5. Construction of common open eave assembly in California. (a) Image is most typical (vents not shown) [39]; (b) image is approved fire resistant construction in San Diego County (vents shown) [43].

Fig. 6. Images of open eave construction with no vents (top) and vents (bottom).

Table 2
Summary of eave experiments; the firebrand exposure time was six minutes.

U_∞ (m/s)	Open eave with no vents	Open eave with vents
7	No accumulation	11 firebrands arrived at vents
9	No accumulation	28 firebrands arrived at vents

Fig. 7a and b displays a typical experiment showing a wall fitted with an eave exposed to firebrand showers from the NIST Dragon inside the FRWTF. For the experiments that used no vent opening, firebrands were not observed to accumulate under the eave over the range of wind speeds considered.

The NIST Fire Dynamics Simulator (FDS) was used to visualize the flow around the eave assembly in the FRWTF in an attempt to gain insight into reasons as to why accumulation of firebrands was not observed under the eave assemblies for wind speeds 7 m/s and 9 m/s [44]. FDS is a computational fluid dynamics model of fire-driven fluid flow and numerically solves a form of the Navier–Stokes equation appropriate for low-speed, thermally driven flow. While FDS was designed with fire in mind, it may be used, as in the case of the simulations conducted in this study, for low-speed fluid flow simulations that do not involve fire [44]. The results of the simulations are presented in Fig. 8. The dimensions of the eave assembly are identical to those used in the actual experiments and numerical

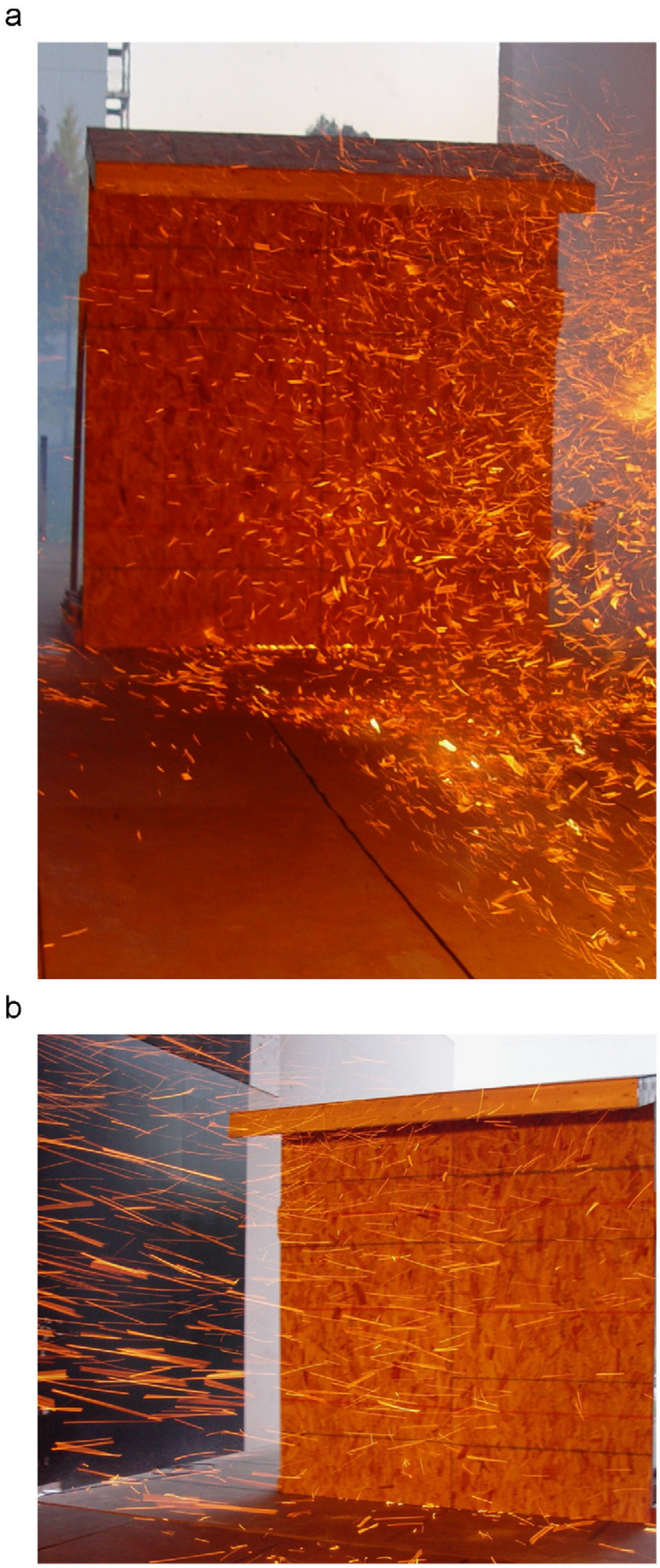

Fig. 7. Image of wall fitted with eave under firebrand bombardment.

grid spacing was 5 cm. As mentioned, the flow profile inside the FRWTF was mapped out using a series of hot wire anemometers (21 point array). Based on these measurements, the flow profile was observed to be uniform. As a result, in these simulations, the flow profile inside FRWTF was assumed uniform and fixed at 9 m/s (Fig. 8). It is important to point out that these simulations considered only air flow and do not include the seeding of firebrands into the flow. Current work at NIST is aimed at incorporating a firebrand transport model into Fire Dynamics Simulator (FDS). Although firebrands are not modeled, the resulting air flow profiles demonstrate why accumulation of firebrands was difficult under the eave. Specifically, the presence of the wall results in a large stagnation zone in front of the wall that becomes more pronounced as wind speed was increased (while not shown, the same behavior was observed for simulations at 7 m/s). In addition, under the eave there is a area of little or no flow velocity that would be required to drive the firebrands into the joints between the eave and wall assembly.

When vents were installed, cameras were placed both in front and behind of the eave assembly in order to quantify the number of firebrands arriving at the vent locations. At 7 m/s, the number of firebrands arriving at the vent location was 10 ± 1 (average $\pm$ standard deviation). As the velocity was increased to 9 m/s, the total number of firebrands arriving at the vent location increased to 28 ± 2 (average $\pm$ standard deviation). While the number of firebrands arriving at the vent locations increased as the wind speed increased, it was very small as compared to the number of firebrands that bombarded the wall/eave assembly (see Fig. 7a and b).

For building ventilation, common vents include gable vents, foundation vents, and eave or soffit vents. Gable vents and eave vents are used for attic ventilation and foundation vents are used to provide air flow to crawl space areas. In prior work, Manzello et al. [35] conducted numerical simulations to determine whether more firebrands would be expected to arrive at a vent placed vertically (such as a gable or foundation vent) as compared to eave vent. The reason for conducting the simulation in that study was to determine a vent configuration that would allow an intense flux of firebrands from the NIST Firebrand Generator since the focus there was investigating the ability of firebrands to ignite materials placed behind a building vent. It was found that for a vent placed under an eave, the simulations demonstrated that a great deal of flow recirculation exists, implying less likelihood for firebrands to actually arrive at such a location. On the other hand, for a vent placed vertically and not under an eave, it is far easier for air flow to arrive less perturbed at this location.

The experimental results reported here confirm these simulations. As compared to experimental results presented in [35], far more firebrands were observed to arrive at a vertically placed vent as compared to eave vents used this study. The experiments presented in this paper, coupled to the results in Manzello et al. [35], have provided the first comparison of the ability of wind driven firebrands to arrive at different vent configurations.

Firebrand entry into vents has long been thought to be important. Based on input garnered from the NIST workshop in California [39], for the present experiments using vents, it was desired to construct the wall from a combustible material to determine whether the wall itself could be ignited by firebrands within the time of the firebrand exposure (six minutes). Prior work by Manzello et al. [32,35] used non-combustible construction to investigate only vent penetration and ignition of materials inside the structure. During the experiments conducted at 9 m/s, the base of the wall actually ignited due to the accumulation of firebrands. These experiments demonstrate that it was very easy to produce ignition outside the structure since many firebrands were observed to accumulate in front of the structure during the tests. Although some firebrands were observed to enter the vents, the ignition of the wall assembly itself demonstrates the dangers of wind driven firebrand showers and that if only firebrand resistant vents are used, other vulnerabilities around a structure must be considered. It must be noted that the base of wall assembly ignited without the presence of other combustibles that may be found near real structures (e.g. mulch, vegetation).

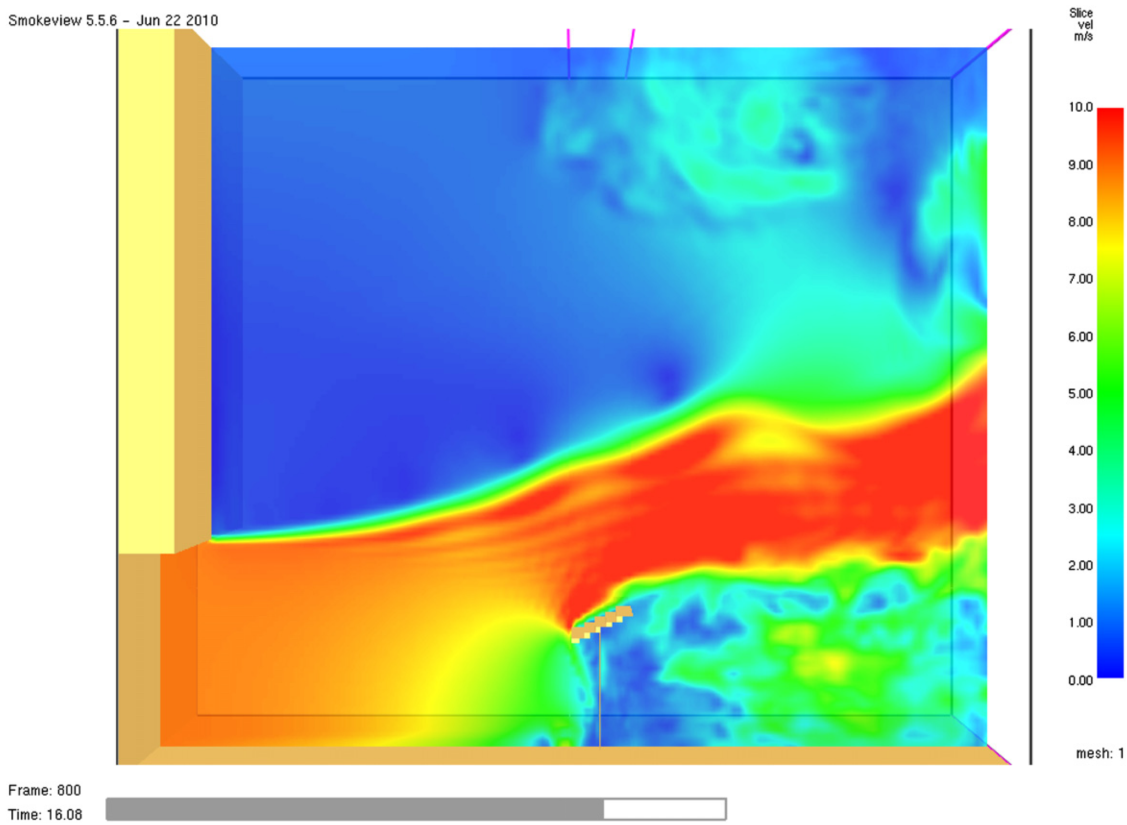

Fig. 8. FDS simulations of air flow around eave assemblies for a wind speed of 9 m/s.

As discussed below, the presence of combustibles placed near the test wall only made ignition easier.

6. Glazing assemblies

Glazing assemblies were exposed to firebrand showers to determine whether firebrands become trapped, accumulate inside the corner of the framing of glazing assemblies, and lead to window breakage. Two types of glazing assemblies were used for the experiments. The first type was a horizontally sliding window assembly. The second type was a vertically sliding window assembly. Both of these glazing assemblies were double hung since it was also thought that this type of assembly would provide more locations for firebrands to accumulate.

The size of each of the glazing assembly was the same, 91 cm by 91 cm. To mount these assemblies, a 244 cm by 244 cm wall fitted with an open eave was constructed for testing. The wall was constructed using wood framing members spaced 406 mm (16″) on center. OSB was applied over the wood framing members and a moisture barrier was installed over the OSB. Vinyl siding was applied over the moisture barrier. An eave with a total length of 122 cm was constructed and mounted on the wall assembly. For completeness, an image of a typical experiment is shown in Fig. 9.

For each window assembly considered, two different wind speeds were used. Specifically, the window assemblies were exposed to firebrand showers at wind tunnel speeds of 7 m/s and 9 m/s. It was observed that firebrands accumulated within the framing and this behavior was more pronounced for the vertically sliding glazing assembly, as suspected. Yet, in none of the experiments did the framing sustain sufficient damage for the window assembly to cause glass fallout and/or breakage.

Fig. 9. Picture of wall/eave assembly fitted with a vertically sliding, double hung window exposed to firebrand showers at a wind tunnel speed of 9 m/s.

7. Ignition of wall assemblies due to fine fuels

Experiments were also conducted to determine if firebrands can produce ignition in fine fuels placed adjacent to the wall assembly and whether the subsequent ignition of fine fuels could lead to ignition of the wall assembly itself. Dead tree needles were placed adjacent to the wall assembly to simulate fine fuels likely to be placed near a structure (such as pine straw mulch). The basis for using pine needles was predicated on the fire hazard expected from this fuel source observed in reduced scale experiments. In prior work, using reduced scale experiments, Manzello et al. [30] demonstrated that glowing firebrands are capable of

Fig. 10. In the top image, firebrands have caused smoldering ignition in the mulch bed. In the bottom image, smoldering ignition has transitioned to flaming ignition and the wall assembly has ignited.

producing smoldering ignition of pine needle beds and under an applied air flow, smoldering ignition of pine needle beds was observed to transition to flaming ignition.

Firebrands were observed to ignite the needle bed via smoldering ignition. The smoldering ignition became self-sustaining, and a transition to flaming ignition was observed (see Fig. 10). The flaming ignition in the needles subsequently melted the vinyl siding and produced self-sustaining smoldering ignition at the base of the wall assembly (within the OSB; this OSB was not even dried). Additional experiments using polypropylene siding placed adjacent to fine fuels were not conducted.

8. Placing results in context of real WUI fires

It must be stated that in real WUI fires, firebrand showers have been observed for several hours and with winds in excess of 20 m/s [45]. It was not possible to conduct experiments using higher wind speeds since the FRWTF was not designed to generate a wind field in excess of 10 m/s. It was also not possible to increase the duration of firebrand showers using this version of the NIST Dragon.

In any event, these experiments are the first to investigate these structure vulnerabilities to firebrand showers in systematic fashion and are important to demonstrate the influence of combustibles located too close to structures. It is hoped that future work can consider longer firebrand exposures under higher wind speeds as well as different firebrand size/mass distributions tied to various WUI exposures. Additional structure configurations should also be tested such as boxed in eaves, more siding types, and a greater range of sheathing moisture contents. In fact, increased duration of firebrand showers is now possible with the newly developed full scale continuous feed Firebrand Generator. The new continuous Dragon is capable of generating firebrand showers of any duration. Work is also in progress to determine firebrand production (size/mass) from building components and full scale burning structures (*e.g.* [46]). This data will allow the NIST Dragon to generate various types of firebrand distributions.

Finally, it is worth noting that the NIST Dragon technology has revolutionized WUI research and is being reproduced by other research laboratories. Specifically, the Insurance Institute for Business and Home Safety (IBHS) has used the NIST Dragon concept to generate firebrand showers in their full scale wind tunnel facility [47]. With this pioneering research, it is now possible to bring the guesswork out of structure vulnerability to ignition from wind driven firebrand showers. Since the IBHS wind tunnel has the capability of conducing higher wind speeds than BRI's FRWTF, NIST plans to partner with them to conduct additional experiments for wind speeds over 10 m/s.

9. Summary

For experiments with vinyl siding, the firebrands were observed to melt the siding to the point where holes developed through the material. While burns were observed in the moisture barrier at both wind speeds (Tyvek), ignition of the OSB sheathing was only observed for vinyl siding tests at 9 m/s and when the sheathing was dried. It is important to point out that the OSB sheathing burned completely through and ignition was observed within the framing members as well (2×4). For polypropylene siding, firebrands produced melting within the material but no holes were formed within the siding itself. Firebrands were observed to penetrate the corner post and burn holes into the moisture barrier (Tyvek) but ignition was never observed in the OSB sheathing for any wind speed of moisture content considered. Nevertheless, it is important to point out that firebrands easily penetrated the corner post in both siding types.

A systematic study was also undertaken to determine eave vulnerability to firebrand showers. For the experiments that used no vent opening, firebrands were not observed to accumulate under the eave over the range of wind speeds considered. FDS simulations were used to provide insight into this behavior. Specifically, the presence of the wall results in a large stagnation zone in front of the wall that becomes more pronounced as wind speed was increased. In addition, under the eave there is a area of little or no flow velocity that would be required to drive the firebrands into the joints between the eave and wall assembly.

When vents were installed in the eave assembly, at 7 m/s, the number of firebrands arriving at the vent location increased as the wind speed was increased. While the number arriving at the vent locations increased as the wind speed increased, it was very small as compared to the number of firebrands that bombarded the wall/eave assembly. To illustrate this issue, during the experiments conducted at 9 m/s, the base of the wall actually ignited due to the accumulation of firebrands. While vents have long been thought to be important, these experiments actually show that is was easy to produce ignition outside the structure since many firebrands were observed to accumulate in front of the structure itself.

For experiments that considered glazing assembly vulnerability to firebrand showers, it was observed that firebrands accumulated within the framing. As suspected, this behavior was more pronounced for the vertically sliding glazing assembly. Yet, in none of the experiments did the framing sustain sufficient damage for the window assembly to cause glass fallout and/or breakage.

Experiments were also conducted to determine if firebrands can produce ignition in fine fuels placed adjacent to the wall assembly and whether the subsequent ignition of fine fuels could lead to ignition of the wall assembly itself. Firebrands were observed to ignite the needle bed via smoldering ignition, the smoldering ignition become self-sustaining, and a transition to flaming ignition was observed. The flaming ignition in the needles subsequently melted the vinyl siding and produced self-sustaining smoldering ignition at the base of the wall assembly (within the OSB; this OSB was not even dried). Clearly, the presence of combustibles placed near the test wall only made ignition easier.

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