MITIGATING IGNITION OF JAPANESE STYLE TILE ROOFING ASSEMBLIES

Sayaka Suzuki[1] and Samuel L. Manzello[2]
[1]National Research Institute of Fire and Disaster, Japan
[2]National Institute of Standards and Technology, USA

1. INTRODUCTION

The 2016 Itoigawa City fire that occurred in Niigata, Japan, is an example of a recent large-scale urban fire in Japan. In the USA, large scale wildland-urban interface (WUI) fires are becoming more common, as evidenced by multiple WUI fires all over the Western USA in 2020.

Based on post-fire investigation surveys, it was reported that roofing assemblies were ignited by firebrand showers in both countries. Subsequent experimental work by the authors demonstrated these vulnerabilities. In the USA, it has also been demonstrated that tile roofing assemblies are known to be the ignition points by firebrands [1]. **Figure 1** demonstrates the dangers of firebrand showers to tile roofing assemblies.

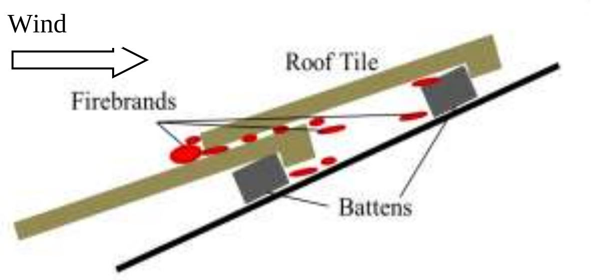

Figure 1 Firebrand penetration mechanisms under roof tiles; no specific tile type is shown [2]

A larger problem is what to do regarding the multitude of old roofing assemblies still present in Japan and the USA. It is not cost effective to take all these assemblies down and improve the ignition resistance of the underlayment. It is particularly important to the fire service, since in the event of a large outdoor fire event, ignitions are not often visible under roofing assemblies. The tiles obscure the smoldering ignitions that occur from the penetrated firebrands and often by the time the more hazardous smoldering to flaming ignitions occur, it may be too late to attempt to save the structure.

To this end, experimental work is underway to develop effective mitigation strategies that fire services may use in the event of large outdoor fire outbreaks. In this work, as a first step, wetting strategies were employed on roofing assemblies to determine if water application may reduce the penetration of firebrands under the tiles. The experiments made use of the authors firebrand generator technology coupled to well controlled wind facilities, as there is no point to conduct experiments under conditions that are not controlled.

2. EXPERIMENTS

Experiments were performed by using the full-scale Continuous-Feed Firebrand Generator. The experiments were conducted in the Building Research Institute's (BRI) Fire Research Wind Tunnel Facility (FRWTF). Experimental details are described [3] for Japanese style roofing assemblies. Only a short summary is provided here, as the procedures are similar, but the major changes were the application of water applied to the roofing assemblies just prior to start of the experiments (described in detail below).

The roofing assemblies were placed 2 m from the Continuous-Feed Firebrand Generator. A roof angle of 25 ° was used for all the roofing assemblies for direct comparison to prior work [2]. The overall dimensions of each roofing assembly were 1.2 m by 0.6 m. The wind speeds were 6 m/s and 9 m/s.

Prior to the experiments, water was applied to roofing assemblies. The premise of using water was to determine if wetting of roofing assemblies would result in less firebrand penetration under the tiles and thus mitigate ignition of the assemblies. The variables that were considered were wind speed, the total amount of water applied (in kg), and time to observe penetration. In these scoping experiments, the firebrand showers were intentionally selected to be in a glowing (smoldering) combustion state. The combustion state of the firebrands produced using the firebrand generator may easily be adjusted (smoldering, flaming, or combination of the two).

3. RESULTS & DISUSSIONS

In this work, two different wind speeds were considered, 6 m/s and 9 m/s. These wind speeds were selected to not only compare to prior work but are predicated on those measured in actual WUI fires or urban fires [3]. The amount of water applied before the firebrand generator and wind were applied were 1 kg or 2 kg. **Figure 2** displays a typical experiment for an applied wind speed of 6 m/s and 2 kg of water applied to the tiles. It is important to note the water did not remain uniform on the surface due to the unevenness of the Japanese roof tiles, even though the water was evenly applied. During the the experiments, it was observed that water gradually dried out from wind and possibly accumulated firebrands absorbed water as they landed on the roof tile surface. Firebrands were also observed to be trapped in the water, on the surface, and extinguished.

After the desired firebrand exposure, either 10 min or 20 min, the roof tiles were removed and the number of firebrands that penetrated under the roof tiles was counted, for each case. Firebrands penetrated under the tiles, yet the battens were not charred, and no smoldering ignitions were observed as shown in **Fig. 3**.

Figure 2 Image of a typical experiment. Applied wind speed of 6 m/s. 2 kg of water was sprayed onto the tiles just prior to the start of the experiments.

Figure 3 Battens and underlayment after the time have been removed. Applied wind speed of 6 m/s and 2 kg of water was applied before an experiment.

The number of firebrands that penetrated under the roof tiles were counted after each experiment. **Figure 4** shows the comparison of the number of firebrands penetrated under the tiles per unit area. With water applied before the experiment,

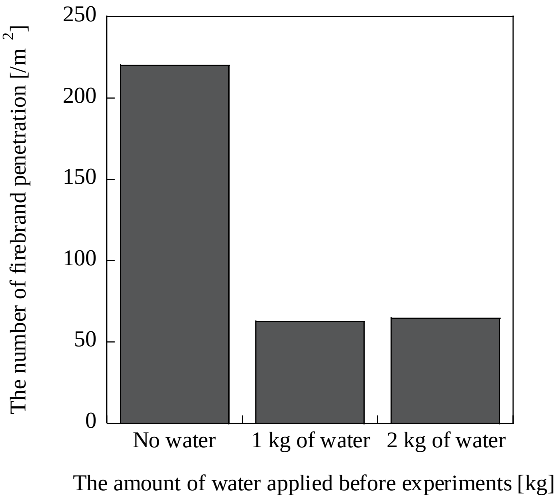

Figure 4 Comparison of the number of firebrands penetrated under roof under 6 m/s

the numbers decreased significantly, by 70 %. At the same time, **Fig.4** showed little difference to the reduction rate whether the amount of applied water was 1 kg or 2 kg. It is possible that a similar amount of water remained on the surface of roof tiles for both cases (1 kg or 2 kg of applied water).

4. PRACTICAL IMPLICATIONS

While exposure to wind-drive firebrand showers are a well-known vulnerability to ignition, to the authors knowledge, this is the first study to begin to investigate simple mitigation strategies for roofing assemblies**.** This study shows that the total amount of applied water may not be important, as no difference was observed from 1 kg to 2 kg. It would be important to know the minimum amount of water needed to prevent firebrands from igniting roofs for a certain time.

5. SUMMARY

In these experiments, scoping experiments were conducted to determine if wetting strategies were able to reduce the number of firebrands that penetrated the tile roofing assemblies and therefore mitigate ignition. Based on these early findings, none of the roofing assemblies ignited once water was applied prior to the experiments. The water acted to quench firebrands that landed on the roof tiles. More experimental work is required to verify these findings over a range of conditions.

5. REFERENCES

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[3] Suzuki, S. Manzello, S.L., Fire Technology, 56, (2020) 2315-2330