Fire Safe Affordable Housing for WUI Communities

A recent increase in the frequency and severity of wildfires, driven primarily by climate change and land management practices, in conjunction with a steady growth of the Wildland–Urban Interface or WUI (the area where vegetation and structures intermix) produced a dramatic increase in the loss of residential structures and human life due to wildfire (doi.org/10.1016/j.jnlssr.2020.06.009). Unless addressed, the economic and environmental losses and social disruptions associated with progressively more severe WUI fire events will have a profound negative impact on the World population. This impact is especially strongly felt by communities of limited economic means where WUI fires may cause a permanent displacement of vulnerable populations.

Solving this WUI fire problem will require a multifaceted approach including reductions in greenhouse gas emissions (to address the climate change), adoption of science-based land management practices, improvements in community and emergency planning considering an increased wildfire threat, and development of residential structures resistant to WUI fires. The last component is the focus of this white paper. The WUI-fire-resistant structures must possess high ignition resistance and resistance to structure-to-structure fire spread. More specifically, these structures should be able to withstand the intrusion and accumulation of embers (firebrands), external radiant heat flux from an approaching fire front or adjacent structures and limited direct flame impingement from adjacent outbuilding and/or vegetation fires. If the structure does ignite, its peak heat release rate must be limited to prevent ignition of surrounding structures by radiation and ember production. At the same time, the cost of a WUI-fire-resistant structure must not significantly exceed that of a traditional structure it aims to replace to make this replacement economically feasible.

To successfully design such structures, a broad range of technical approaches will have to be explored and assessed in a systematic manner. These approaches include, but are not limited to, optimization of the geometry of the structure and its major components to minimize exposure of its most vulnerable elements to firebrands and thermal radiation from the approaching fire front, development and utilization of new composite materials and assemblies for external surfaces characterized by improved ignition resistance and reduced burning rate, and integration of automatic shields, screens and/or active fire suppression systems, such as external sprinklers.

This exploration and assessment will be performed in four phases. During phase I, through analysis of the data collected in recent major WUI fires and large-scale experiments emulating these fires, key engineering performance targets for the new structures will be identified such that an achievement of these targets would signify a qualitative improvement in survivability of the structures during a WUI fire event. In phase II, various approaches to attain these performance targets will be tested through laboratory-scale experiments and modeling. Exploration of new approaches (not used in the current fire protection engineering practice) will be emphasized. During phase III, combinations of best performing approaches will be analyzed at the system level to attain designs that harvest the synergy of these approaches and balance their performance (including reliability) against the cost of their deployment and maintenance. In the final phase, phase IV, a single-family home will be built to demonstrate the final engineering solution; its fire performance will be showcased by comparing it with a conventional structure with the same living space dimensions and comparable cost in a specially designed full-scale test. As a part of this project, it is also proposed to organize an international student design competition tentatively titled “Wildfire Safe Affordable Housing Challenge”. The aim of this competition will be to promote the knowledge and understanding of fire safety among future professionals educated in STEM and to help generate “outside the box” solutions for current and future fire safety needs.