Fire Hazards with Vertical Greenery Systems

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Vertical greenery systems (VGSs) have been widely used [1] in new green construction projects in dense urban areas with limited green living spaces to mitigate the urban heat-island effect. A VGS features plants grown on façades inside or outside buildings. Several examples are shown in Figure 1.

Green façades are popular because they can reduce wall surface temperatures in tropical urban areas up to 12°C [2]. However, Fischetti has described possible adverse environmental effects of greenery systems [3]. Additionally, vine-type plants [4] installed for vertical growth can be ignited by a window plume [5] from a post-flashover room fire, as shown in Figure 2. The fire hazards associated with VGSs that are demonstrated in scale modelling experiments (see Figure 3) show that fire spread pattern and rate depend on the plants and their geometrical arrangements.

Fire hazards of VGSs are usually not the primary considerations on building stakeholder minds when developing green construction [6, 7]. Fortunately, the fire hazard concerns of green architecture are often identified by fire department officials.

In many locations, building codes and standard fire tests are not available for such green architectural features [7–9]. For VGSs, fire behavior has only been evaluated on the basis of preliminary studies of standard tests for normal roofs and walls [8,9] as recommended by the Green Building Council in the United States. Approval Standard FM 4477 [10] was proposed to evaluate the performance of vegetative roof systems related to fire, and the fire performance of green roofs and walls was included [11] in the United Kingdom and in Sweden [12] based on preliminary studies with existing fire tests.

Appropriate fire scenarios for testing green constructions are not yet available, nor is there any systematic compilation of published articles reporting fire incidents in green constructions that include VGSs.

Knez has pointed out the fire risks of climbing, hydroponic and modular VGSs [13]. However, the consequences of burning plants grown on VGSs have not yet been investigated thoroughly. A possible reason is that very few fire incidents have been documented in green construction [8] — not enough to attract sufficient public concern. For example, a fire incident involving a VGS was reported [14] in a semi-enclosed beer garden in August 2012 in Sydney, Australia. At this incident, a patron tried to light a cigarette with a candle and a
nearby fern ignited. The fire spread quickly in only a few seconds. It was found that the green wall did not contain a proper irrigation system and the plants had been hand-watered. Furthermore, some synthetic plants were also integrated into the green wall system.

Poorly irrigated VGSs can be a possible ignition source since dry plants burn faster and produce more heat compared to wet plants. This behavior was demonstrated in the scale modelling test on the green wall as shown in Figure 3. In this experiment, plant samples of selected species with different moisture contents were tested with a cone calorimeter [1]. The transient heat release rate of fresh plants was not significant upon ignition, but the transient heat release rate increased when moisture content decreased. Key fire parameters $f$, including peak heat release rate, average effective heat of combustion, peak carbon dioxide concentration and peak carbon monoxide concentration, decreased with moisture content (MC).

An empirical curve on $f$ can be fitted in terms of $f_o$, the value $f$ at zero MC and an experimental parameter $a$ as:

$$f = f_o \exp (-MC/a)$$

It is obvious that vegetation grown on building façades provides fuel for the spread of fires. The direct action of a window flame plume [5] can ignite plants, including dry or dead leaves, planter boxes, foams, and laminar layers of felt sheets. Heat, flame, smoke and hazardous chemicals generated from burning plants and VGS accessories can spread to different parts of the building and to nearby areas. The heat and toxicity of the smoke can affect firefighters if they lack appropriate personal protection equipment. All of this means that the scientific aspects of VGS fires should be further investigated and better understood.

More attention [7,8] should be paid on assessing fire hazards of green buildings. Although there have not been many exterior wall fires, their resulting consequences in terms of the extent of fire spread can be very serious. For VGSs that are integrated into exterior walls, fire spread through the VGS should be carefully monitored. In particular, the scenario identified earlier [5] involving a window plume from a post-flashover room fire, as in Figure 2, can ignite plants in the VGS, resulting in different fire hazards under different conditions. The fire load is low when the plants are green and there are few dry leaves or branches [5], but can be high otherwise. Thus, exterior vegetative covering on a façade requires a more-detailed fire hazard assessment.
References

13. N. Knez, Reaction to fire of green façades and roofs (No. 2015), Solvenian National Building and Civil Engineering Institute, Brussels, November 2014.

(i) Taiwan.  
(ii) Hong Kong.

(a) Exterior VGS.
(i) Green corridor. (ii) Green wall.

(b) Interior VGS.

Fig. 1: Examples of vertical greenery systems.

Window plume
Post-flashover fire

Fig. 2: Window plume acting on the upper wall of façade.
(a) The scale model.  
(b) Wet plants.  
(c) Dry plants.

Fig. 3: Scale modelling test on green wall.

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