Fire Hazards of Exterior Wall Assemblies Containing Combustible Components

Information Bulletin

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Many combustible materials are used today in commercial wall assemblies to improve energy performance, reduce water and air infiltration, and allow for aesthetic design flexibility. These assemblies include Exterior Insulation Finish Systems (EIFS), metal composite claddings, high-pressure laminates, and weather-resistive barriers (WRB). The combustibility of the assembly components directly impacts the fire hazard. For example, the insulation component of EIFS, and other emerging related systems (for example Structural Insulation Finish Systems (SIFS)) is combustible foam which exhibits rapid flame spread upon fire exposure. There have been a number of documented fire incidents involving combustible exterior walls but a better understanding was needed of the specific scenarios leading to these incidents to inform current test methods and potential mitigating strategies.

The Foundation initiated a project with an overall goal to develop the technical basis for fire mitigation strategies for fires involving exterior wall systems with combustible components. The goal of this first phase project is to compile information on typical fire scenarios which involve the exterior wall, compile relevant test methods and listing criteria as well as other approval/regulatory requirements for these systems, and to identify the knowledge gaps and the recommended fire scenarios and testing approach for possible future work.

The following conclusions are drawn from Phase I of this project. The full report is available on the Foundation website.

- A broad range of different types of combustible exterior wall assemblies are in common use including exterior insulated finish systems (EIFS), metal composite cladding, high pressure laminates and a range of other systems. These exterior wall systems are typically complex assemblies of different material types and layers which may include vertical cavities with or without fire stopping.
- The key initiating fire can be one of two possible types of fires:
    - I. Fires external to the building (other burning buildings, external ground fires) or
    - II. Fires internal to the building originating in a floor that have resulted in breaking the windows and ejecting flames on the façade
- Key mechanisms of fire spread after initiating event include:
    - I. Fire spread to interior of level above via openings such as windows causing secondary interior fires on levels above resulting in level to level fire spread (leap frogging)
    - II. Fire spread on the external surface of the façade assembly, if combustible
    - III. Flame spread within an interval vertical cavity /air gap or internal insulation layer. This may include possible failure of any fire barriers if present, particularly at the junction of the floor with the external wall.
    - IV. Heat flux impacts causing degradation/separation of non-combustible external skin (loss of integrity) resulting on flame spread on internal core
    - V. Secondary external fires to lower (ground) levels arising from falling burning debris or downward fire spread.

VI. Channelling of convective heat and re-radiation between surfaces such as corners or in channels can accelerate flame spread.

- Statistics relating to exterior wall fires have been reviewed. Statistical data relating to exterior wall fires is very limited and does not capture information such as the type of exterior wall material involved, the extent of fire spread, or the mechanism of fire spread. Exterior wall fires appear to account for somewhere between 1.3% and 3% of the total structure fires for all selected property types investigated. However for some individual property types exterior wall fires appear to account for a higher proportion of the structure fires, the highest being 10% for storage type properties. . This indicates that exterior wall fires are generally low frequency events, particularly compared to fires involving predominantly the interior.
- The percentage of exterior wall fires occurring in buildings with sprinkler systems installed ranges from 15-39% for the building height groups considered. This indicates that whilst sprinklers may have some positive influence, a significant percentage of external wall fires still occur in sprinkler protected buildings, which may be due to both external fire sources or failure of sprinklers. On this basis it is recommended that controls on flammability of exterior wall assemblies should be the same for sprinkler protected and non-sprinkler protected buildings
- Review of fire incidents around the world indicates that although exterior wall fires are low frequency events, the resulting consequences in terms of extent of fire spread and property loss can be potentially very high. This has particularly been the case for incidents in countries with poor (or no) regulatory controls on combustible exterior walls or where construction has not been accordance with regulatory controls.
- Combustible exterior wall systems may present an increased fire hazard during installation and construction prior to complete finishing and protection of the systems. The 2009 CCTV Tower Fire and 2010 Shanghai fire in China are examples of large fires occurring during construction.
- An overview of existing research related to fire performance of exterior combustible walls is provided. The Fire Code Reform Centre funded a research report on fire performance of exterior claddings[1] provides an excellent overview of the previous research in to the year 2000. Appendix D of this report also provides a list of related research literature for further reading. It follows from this research review that the façade fire safety problem can be divided into four parts:
    - Specification of fire development and the heat flux distribution both inside the enclosure and from the façade flames originating from the fire in the enclosure. This requirement is prerequisite for the following parts.
    - Fire resistance of the façade assembly and façade – floor slab junction including structural failure for non-combustible and combustible façade assemblies
    - Fire spread on the external surface of the façade assembly if combustible due to the flames form the enclosure fire
    - Fire spread and propagation inside the façade insulation, if combustible, due to the enclosure fire
- Regulations vary from country to country. Five aspects of regulation have been identified to influence the risk of fire spread on exterior wall systems. These include reaction to fire

of exterior wall systems, fire stopping of cavities and gaps, separation of buildings, separation of openings vertically between stories of fire compartments and sprinkler protection. Of these, the reaction to fire regulation requirements are expected to have the most significant impact on actual fire performance and level of fire risk presented by exterior wall assemblies.

- Some countries including Australia have stringent reaction to fire requirements that the exterior walls must be non-combustible. However in practice combustible systems are applied as fire engineered alternative solutions, however as no full-scale test is used or typically referred to in Australia the basis for alternative solutions is often limited to performance in small scale tests.
- New Zealand primarily applies the cone calorimeter ISO 5660 for regulation of exterior walls. This appears to be the only country to do this.
- Countries such as the USA, UK, and some European countries specify full-scale façade testing but then permit exemptions for specific types of material based on small-scale fire testing. The United Arab Emirates has recently drafted and is applying regulations using full scale façade testing combined with small scale tests in response to a spate of fire incidents involving metal clad materials in 2011-2012
- A range of different full-scale façade tests have been reviewed and are in use around the world. The geometry, fire source, specimen support details, severity of exposure and acceptance criteria varies significantly for different tests. Existing research has identified that exposure to the exterior wall system is generally more severe for an internal post flashover fire with flames ejecting from windows than for an external fire source. For this reason, almost all of the full scale façade fire tests simulate an internal post flashover fire. However it is possible for the severity external fires at ground level on fuel loads such as back of house storage areas and large vehicle fires to equal or exceed internal post flashover fires. The impact of exterior fire sources can be even more severe if they occur hard against re-entrant exterior wall corners. Although most full-scale façade tests simulate an internal post flashover fire, these tests may also set a suitable level of performance with regards to a limited external fire severity.
- Full-scale façade tests with a wing wall are currently the best method available for determining the fire performance of complete assemblies which can be influenced by factors which may not be adequately tested in mid to small scale tests. These factors include the severity of fire exposure, interaction of multiple layers of different types of materials, cavities, fire stopping, thermal expansion, fixings and joints.
- Full-scale tests are usually very expensive.
- Intermediate-scale tests including ISO 13785 Part 2, the Vertical channel test and the Single Burning Item (SBI) test and also a variety of room corner tests are less expensive however they may not correctly predict real-scale fire behaviour for all types of materials due to less severe fire exposures, less expanse of surface material to support fire growth and flame spread, and less incorporation of end use construction such as joints, fire stopping and fixings etc. Except for the SBI, Intermediate scale tests are currently not used for regulation but may be used for product development.
- A range of different small scale tests exist and are used for regulation in different countries. Small scale tests often are only applied to individual component materials and represent very specific fire exposure conditions. Small scale tests can provide misleading results for materials which are complex composites or assemblies. This is particularly the case where

a combustible core material may be covered by a non-combustible or low-combustible material or a highly reflective surface. There is currently no practical method of predicting real scale fire performance from small-scale tests for the broad range of exterior wall systems in common use.

- Small scale tests may provide acceptable benchmarks for individual material components. However further validation against full-scale tests may be required to support this. Small scale tests (in particular the cone calorimeter) can also be useful for doing quality control tests on materials for systems already tested in full-scale or for determining key flammability properties for research and development of fire spread models.
- The test method should include a wing wall and also assess downward fire spread.
- Investigation into the impact channels and part channels formed by balconies have on fire spread should be investigated.

Recommendations and options for further test based research for consideration as Phase II have been provided in section **Error! Reference source not found.** of the full report, which is available on the Foundation website.

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