The fire safety performance of internal and external walls in multi-storey buildings

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THE ACCEPTABILITY OF THE FIRE RISKS ASSOCIATED WITH MODERN WALLING SYSTEMS

ISO 6707-1 defines cladding as an *external, vertical, or near-vertical non-loadbearing covering to a structure, which typically provides protection from the elements* and a curtain wall as a *non-loadbearing wall positioned on the outside of a building and enclosing it*. Cladding and curtain walls are used to provide a degree of thermal insulation and weather resistance, as well as to improve the appearance of buildings and provide a control element for noise and fire resistance.

Cladding and curtain walls can be constructed from a wide range of materials, including wood, metal, masonry, vinyl, and composite materials comprising a combination of materials such as wood, blends of cement and recycled polystyrene, natural fibres, etc. The design of curtain wall systems also needs to take cognisance of the internal fire safety design requirements and layouts pertaining to division, occupancy and tenancy separating walls or elements to mitigate the internal fire spread within a building. Should the structural non-loadbearing separating elements not form part of the internal walls, it needs to be accommodated within the external building envelope system by means of a structural loadbearing frame. All openings between the external structural system and the separating elements within the building need to be protected with an appropriate fire and smoke seal to complete the separating element meeting the fire safety requirements contemplated by SANS 10400-T.

Fire spread can occur through openings in the external building envelope (cladding and curtain wall systems). Buildings need light and ventilation for their occupants. Accordingly, openable windows may be built into the envelope of a building if alternative ventilation arrangement are not provided for. The remaining external building envelope or walls around the windows also have a very important function as a fire-resistant structural element to act as a fire break to prevent vertical and lateral fire spread on the outside of the building, as well as penetrating the inside of the building and transmitting radiant heat to adjacent buildings. Windows, once opened, are a route for fire spread.

Vertical and lateral fire spread to the outside and the inside of a building can also occur in the insulative cladding fixed to non-combustible surfaces of the building, or the curtain wall assembly fitted to the outside perimeter of the building. Typical causes for fire spread include:

- incorrect application of building insulative systems, such as cavities between the insulation and the exterior surface of the building, absence of fire breaks within the building insulative system, incorrect material used for weather protection over the insulation materials, and incorrect sealing of the perimeters of the building insulative system adjacent to the curtain system or windows;
- failure of the supports or brackets to the structural support frame of the curtain wall system;
- failure of inadequate horizontal and vertical fire and smoke seals between the external and internal division-, occupancy- and tenancy-separating elements inside the building;
- the design of the external building envelope not aligning with the internal fire safety design requirements with regard to division-, occupancy- and tenancy-separating elements;
- failure of the curtain wall assembly (structural or non-structural) incorporating the glass, insulation and weather-protective panels that will move and break free when subject to heat from a fire; and
- incorrect positioning of the window or glazing system in relation to the combustible insulation used in the building envelope system.

On 14 June 2017, a fire broke out at 00:54 in the 24-storey Grenfell Tower block of flats in London. It caused 72 deaths. More than 70 others were injured and 223 people escaped. It was the deadliest structural fire in the UK since 1988, and the worst UK residential fire since the Second World War. The fire is believed to have started by a malfunctioning fridge-freezer on the fourth floor. It spread rapidly up the building's exterior, bringing fire and smoke to all the residential floors. This was due to the building's cladding,

the external insulation and the air gap between the cladding and the insulation. It burned for about 60 hours before finally being extinguished. More than 250 firefighters and 70 fire engines were involved from stations all across London in efforts to control the fire and rescue residents.

The Grenville Tower fire has triggered a series of questions regarding the acceptability of certain types of external claddings to buildings. For example, new laws have recently been introduced in Australia for buildings with "combustible cladding", i.e.:

- any cladding or cladding system comprising metal composite panels, including aluminium, zinc and copper, that is applied to any of the building's external walls or to any other external area of the building; or
- any insulated cladding system, including a system comprising polystyrene, polyurethane or polyisocyanurate, that is applied to any of the building's external walls or to any other external area of the building.

The New South Wales Environmental Planning and Assessment Amendment (Identification of Buildings with Combustible Cladding) Regulation 2018 requires that owners of residential apartment buildings, other types of residential buildings where people sleep (e.g. hotels, boarding houses, student accommodation), aged-care buildings, hospitals and day surgeries (and any associated single dwellings within the building), shop top housing and public assembly buildings (e.g. theatres, cinemas, schools and churches) having two or more storeys with external combustible cladding, register their building with the NSW Government to enable councils to undertake risk assessments of the fire safety characteristics of such buildings. A ban has also been made on the use of certain aluminum composite panels on the external areas of certain types of buildings.

The Ministries of Housing, Communities and Local Government (UK) are currently consulting regarding a ban on the use of combustible materials in and on external walls of buildings, including building types covered, height threshold, list of exemptions, attachments such as blinds, shutters and awnings, and a proposal to specifically ban the use of metal composite panels in and on the external walls of all buildings. This consultation closes on 13 April 2020. Currently the ban applies to the full height of external walls of buildings with a floor at least 18 metres above ground level and which contain one or more dwellings, an institution, or a room for residential purposes (excluding hostels, hotels, or a boarding house). A height threshold of 11 m is being proposed, as well as an extension of the ban to hotels and hostels.

The Welsh government has with effect from January 2020 banned combustible cladding on all new residential buildings and hospitals over 18 m in height. The Welsh government has also made £3 m available to replace cladding in three residential high-rise buildings in the Welsh social housing sector confirmed as having aluminium composite material systems corresponding with those which failed large-scale fire tests.

THE CURRENT SOUTH AFRICAN APPROACH TO REGULATING THE FIRE PROTECTION OF BUILDINGS

The National Building Regulations establish performance requirements for the fire protection of buildings. These requirements focus on life safety (protection and life safety of occupants), controlling the spread and intensity of a fire, providing retention of stability to ensure smoke control, and the provision of access and equipment for detecting, fighting, controlling and extinguishing fires.

SANS 10400-T provides deemed-to-satisfy provisions in the form of a set of rules which, if correctly applied, enables the performance requirements for walls in terms of the National Building Regulations to be satisfied. These rules were developed in the main around traditional construction technologies, such as loadbearing masonry and concrete or steel-framed building construction and materials and assemblies, which:

- are mostly non-combustible when tested in accordance with the provisions of SANS 10177-5;
- are constructed inside or on the perimeter of the concrete or steel-framed buildings;
- meet the structural fire-resistant requirements for a structural element or component supporting a separating element for divisions, occupancies or tenancies, separating elements, partition walls and external walls in relation to particular applications when tested in accordance with SANS 10177-2; and
- have elements in the assembly of the building which are clearly identified and are found to be non-combustible.

Combustible material can be found in internal walls (partitions, divisions, occupancy and tenancy separating walls) and curtain or insulated building envelopes in new and emerging wall assemblies, many of which are designed to satisfy thermal insulation criteria. All internal walls are required to satisfy fire protection performance requirements in terms of SANS 10400-T. However, in most cases, these separating elements are tested without any electrical service terminations such as plugs, switches, distribution boards and plumbing services like waste pipes which impair the fire rating of the wall.

SANS 10400-T also requires that all external walls incorporate structural fire-resistant elements to meet the requirements for vertical and horizontal fire spread on the outside of the building. However, the evaluation of the fire propagation of these systems falls outside the scope of the deemed-to-satisfy requirements of the National Building Regulations.

CONTROLLING FIRE PROPAGATION WITHIN BUILDINGS

External fire propagation is the major concern with external building insulated systems and non-loadbearing external building envelopes fitted to a building. The external insulation system or building envelopes to the building may include combustible insulation material or non-combustible insulation. However, both these insulation materials may be protected with combustible composite weather-protection panels. The performance of the system cannot be based on the fire performance tests of the individual components of the assembly. The full assembly needs to be tested in accordance with the provisions of SANS 8414-1 for building insulation systems, and SANS 8414-2 for insulated building envelopes. Fire propagation relates to a number of factors, including the framing system, the fixings of the frame, cavities behind the insulation, horizontal and vertical fire breaks in the insulation, fire-stopping and smoke seals at the perimeter of the fire separating elements, external or weather protection used over insulation, the stability of the cladding, etc.

The external wall system may also contain structural elements, in which case the system utilises a double-frame system (structural and non-structural). The structural frame supports the curtain wall and ties it back to the structural system of the building. The non-structural frame for the weather envelope needs to be attached to the structural frame and designed to meet the fixing requirements for the glass, insulation and weather panels. The fire resistance of the structural elements can be determined by means of tests in accordance with the provisions of SANS 10177-2. However, the fire performance of the assembly as a whole in relation to flame spread can only be evaluated using large-scale tests as provided for in SANS 8414-2. These two tests enable the fire performance of the system as a whole to be evaluated, as they take into account the design of the primary structural steel frame, the structural fixing of the frame to the building, fire protection requirements, fire and smoke-seal requirements along the perimeter of the floors, horizontal and vertical fire separations (positions and requirements), assembly and fixing of the secondary frame system, smoke seals (if required) and materials used (consumables).

MITIGATING THE RISK OF FIRE PROPAGATION IN INTERNAL AND EXTERNAL WALLS

There are two broad approaches to mitigate the risks of fire propagation in non-loadbearing internal and external walls of buildings. The first approach is applicable to buildings with non-combustible loadbearing walls or framed buildings with concrete floor slabs where non-loadbearing walls are:

- supported inside the building or on the perimeter of the concrete slab; and
- are of masonry construction or a construction which has a fire resistance when tested in accordance with the provisions of SANS 10177-2, suitable for the application in which it is used, as stipulated in the relevant provisions of SANS 10400-T.

Internal dividing walls used as divisions, occupancies or tenancies in a building may not have service penetrations such as electrical plugs, switches or distribution boards and plumbing services, unless these walls have been tested with services and comply with the fire resistance requirements as set out in Clause 4.6 of SANS 10400-T. The protection of openings provisions of Clause 4.10 of SANS 10400-T apply where any external wall of any division wall or floor is less than 1 m measured horizontally or vertically from an opening in another division. This clause requires a minimum path of flame travel around a wall having a fire resistance equal to at least half required for the element separating the divisions from one vertical or horizontal opening to another to be more than 1 000 mm via a separating element (see Figure 1).

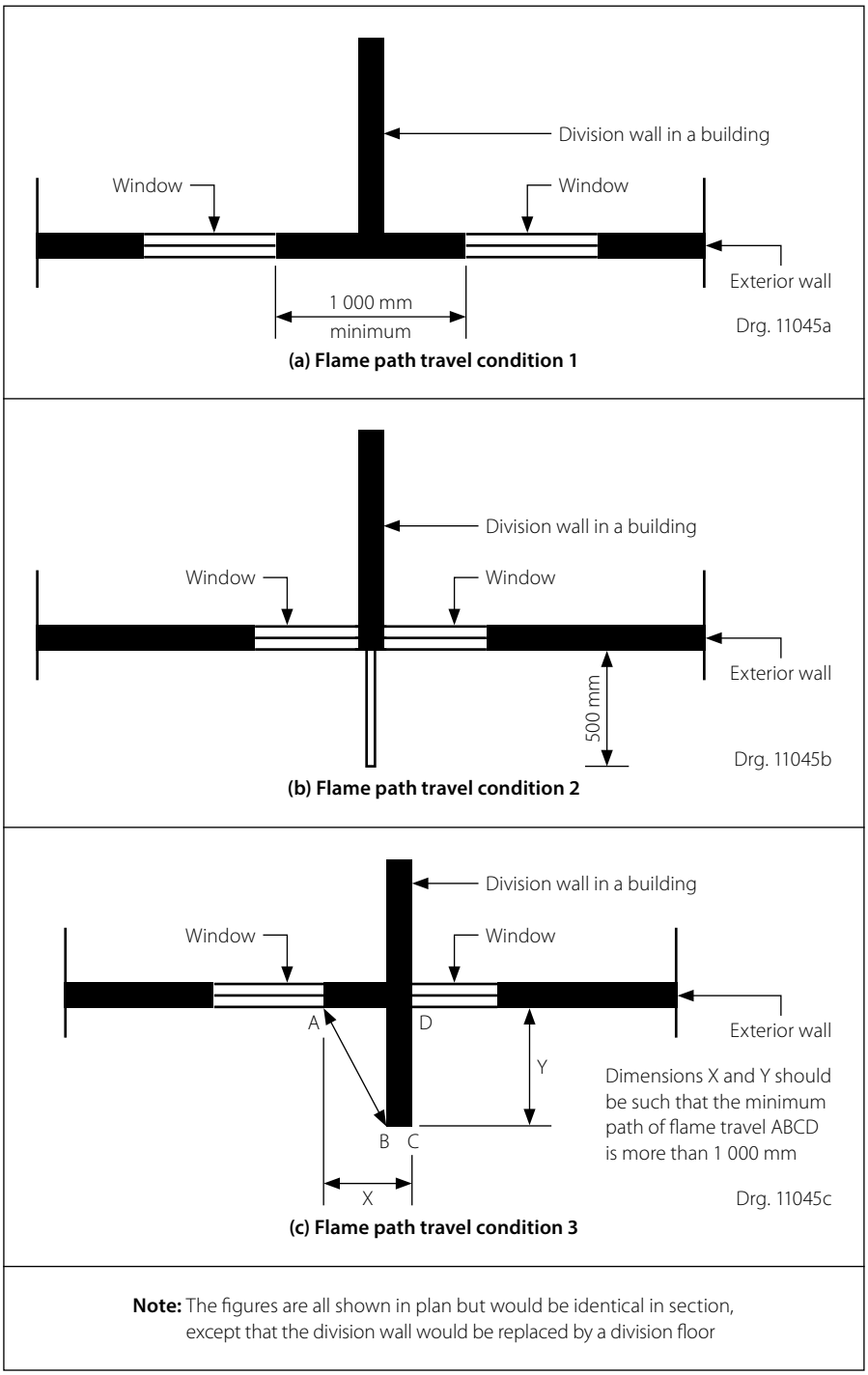

Figure 1 Flame path travel between openings (SANS 10400-T)

The second approach is applicable to curtain wall systems (external non-loadbearing walls positioned on the outside of a building and enclosing it) and insulative cladding systems (external, vertical, or near-vertical non-loadbearing covering) fitted to non-combustible substrates. Such walls or systems need to:

- satisfy the fire propagation requirements of SANS 8414-1 or SANS 8414-2;
- have a fire resistance when tested in accordance with the provisions of SANS 10177-2, suitable for the application in which it is used, as stipulated in the relevant provisions

of SANS 10400-T, provided that the fire resistance of the structural frame supporting the curtain wall including its fixings has a fire resistance not less than that required for the structural system of the building.

ASSEMBLIES FITTED TO THE OUTSIDE OF BUILDINGS

External building fires very often start within combustible assemblies added to the outside of the building, such as signs, advertising boards, external building façade advertising on buildings, sunshades, canopies and blinds. Such assemblies may be fixed only to non-combustible external walls either at ground-floor level or in the storey immediately above ground level, provided that it is not above an exit or in a position where, in the event of a fire, it would render the exit un-useable.

Any combustible assembly other than those satisfying the aforementioned requirements needs to be suitably tested in the context of the installation or the way it would be applied or fitted to the building. Testing of such components can vary from small-scale to large-scale testing to evaluate the likely fire behaviour of the system. Small-scale testing or material classification relates only to the fire properties of the respective material and is not intended to confirm the fitness-for-purpose of the system as a whole.

The structural fixing and the fire behaviour of the respective applications need to be such that no collapse of the system or any flaming debris should fall down to ground level and endanger pedestrians or occupants evacuating the building. □

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