Behaviour in relation to fire

The master copy of this document appears on the website:
http://www.agrement.co.za

Other criteria for building and walling systems

- Acoustic performance
- Criteria for condensation
- Quality assurance
- Structural assessment of dry-stack masonry
- Structural strength and stability
- Thermal performance

Related document:

- The performance concept

Republic of South Africa. *National Building Regulations*, Government Notice No R. 2378, Government Gazette No 12780, Pretoria, South Africa, 12 October 1990

P O Box 395 Pretoria 0001
Telephone 012 841 708
Fax 012 841 2539
e-mail agrement@csir.co.za
http://www.agrement.co.za

General

The materials from which a building is constructed have little to do with the risk of fire breaking out in the building provided that good building practice has been followed (for example, combustible materials kept well clear of fire places and stoves, and not built into chimneys).

Investigations have shown that deaths may occur in habitable buildings if a fire develops in the living area at night and the occupants only wake up when the fire is well developed and the building is full of smoke and toxic gases. Both building elements and the contents of building contribute to the development of a fire.

Agrément South Africa's criteria for behaviour in fire are the same as the functional requirements contained in T1(1) of Section T of the National Building Regulations and are aimed at ensuring that the performance of buildings erected according to a certificated building system is such that, during a fire:-

- occupants or users of the buildings are protected and that they may be safely evacuated
- the spread of fire within the building or to any other building is minimised as far as is practicable
- the building has sufficient stability so that other buildings are not endangered
- excessive danger to persons fighting the fire is avoided.

In general it is accepted by Agrément South Africa that if the various prescriptive rules contained in Section T of the National Building Regulations are met, the innovative building system will comply with the abovementioned criteria. However, the evaluation of innovative systems is based on functionally oriented procedures (including tests) and where such an evaluation shows that different prescriptive rules which are peculiar to the system, are appropriate and will ensure compliance with the functional requirements, then such rules will be written into the certificate and will become a condition of certification.

The fire resistance of building elements and/or systems is assessed on information obtained from:-

- standard tests
- fire resistance calculations in accordance with proven formulae
- full scale *ad hoc* tests.

Standard tests have two limitations: they disregard the different heat contributions of different building materials and there is almost no free oxygen available in the furnace during furnace tests and this inhibits the flaming of materials. These tests do not, therefore, necessarily enable one to predict the behaviour of a building element or structure during an actual fire.

A full scale burn-out test is therefore sometimes necessary and is carried out on a specially constructed room that is representative of the building system that is being evaluated. The fire load in the room being tested consists of a mass of timber equivalent in calorific value to the sum of the mass of the combustibles that would be found in a room in normal use. In such a test, the heat produced by the building materials and the combustible contents is cumulative and the total heat to which the structure is subjected and the availability of oxygen is similar to that in most actual fires.

Fire load: The fire load in relation to any particular use (occupancy) of a room is the heat value of the combustible content of a room expressed as the equivalent timber mass per m^2 of such room. The class of hazard of a fire division in a block of dwelling units is determined by the higher of the two permissible fire loads that may exist in any one room or rooms within that division.

In South Africa a fire load density of 20 kg/m^2 to 25 kg/m^2 of floor area is considered to be normal for the contents of the average house (furnishings, linen, clothing, household goods). In a burn-out test the fire load density for an average single storey house of conventional brick construction is taken to be 25 kg/m^2 of floor area. Such a fire load takes about 30 minutes to burn out under average conditions and produces a maximum temperature of approximately 820 °C. A fire load of 50 kg/m^2, burning under the same conditions, burns for about 60 minutes and reaches a maximum temperature of approximately 915 °C.

The assessment of the probable behaviour of a building in fire is based on the results of fire tests that have been carried out on a prototype structure, or on portions of the structure, as well as on experience gained from previous tests that have been conducted on other similar building systems and on reports of actual fires.

Fire resistance

“Fire resistance” is defined in the National Building Regulations as the shortest period for which a building element or component will comply with the requirements for stability, integrity and insulation when tested in accordance with SANS 10177-2.

It is important that the whole building element should be tested and not just the material or materials from which it is made. This means that a building element that includes joints or other construction details must be tested with the joints or other details included in the test specimen since the joints in a prefabricated wall element (to take a typical example) generally offer the least resistance to fire.

Flame spread

This is the rate at which a flame travels over the surface of a material. It bears no relation to fire resistance and the two terms should not be confused.

It has been found that when some materials have been tested in the apparatus described in ASTM E286-69, *Surface flammability of building materials using an 8 ft (2,44 m) tunnel furnace,* the spread of flame has been zero, but when these same materials were

tested in the fire laboratory's fire corridor, the materials flamed and spread fire fairly rapidly. The test method described in ASTM E286-69 does not, therefore, predict the likely spread of flame and smoke of all materials in actual fires.

The fire laboratory which generally evaluates the fire behaviour aspects of building innovations on behalf of Agrément South Africa, relies on spread of flame and development of smoke tests carried out either in its fire corridor or its fire channel test equipment to predict the likely behaviour of building materials in actual fires.

Fire characteristics of unprotected steel sections

SANS 10100-1, *The structural use of concrete*

BS 8110-1:1997, *Structural use of concrete*.

Brozzetti J, Law M, Petterson O, Witteveen J. *Safety concept and design for fire resistance of steel structures*, IABSE Surveys S-22/83, Switzerland.

Buildings that are more than two storeys high will generally be of reinforced concrete, or of fire protected steel sections or of load bearing masonry. The minimum cross sectional dimensions for reinforced concrete work and the concrete cover to be provided over the steel reinforcement are given in the National Building Regulations and appropriate codes of practice such as SANS 10100-1 and BS 8110-1.

Unprotected steel sections can have an inherent fire resistance, which can be calculated from the following formula:

$$\Delta_{Ts} = \frac{\alpha}{P_s C_{Ps}} \frac{F_s}{V_s} (T_t - T_s) \Delta_t$$

where Δ_{Ts} = change in steel temperature in time interval Δ_t (°C)

α = coefficient of heat transfer at surface of section exposed to fire (W/m^2 °C)

P_s = density of steel (kg/m^3)

C_{Ps} = specific heat of steel (J/kg °C)

F_s = surface area per unit length of steel exposed to fire (m^2/m)

V_s = volume per unit length of steel section exposed to fire (m^3/m)

Δ_t = time interval (s) (the time interval must be small, ie one twelfth of required fire resistance)

T_t = fire exposure temperature at time t (°C)

T_s = steel temperature (°C) = $T_{sp} + \Delta_{Ts}$

T_{sp} = temperature at end of previous time interval (°C)

The calculation is commenced by taking T_s to be equal to the ambient temperature and then carrying out respective calculations where the steel temperature is increased in increments until a temperature of 550 °C is reached.

To achieve a fire resistance greater than that indicated by calculation for the particular metal thickness or to obtain fire resistance ratings for thinner metal thicknesses, it is necessary to

apply some form of fire protection to the steel building elements. This can be achieved by totally encasing the steel in concrete so as to give sufficient cover to obtain the design fire resistance, or by various other means. The concrete cover can also be calculated.

Requirements of the national building regulations

Matters that affect the performance of buildings in case of fire and that are generally not dealt with in the technical evaluation reports for Agrément certification, include:

- the adequacy of feeder and emergency routes insofar as it concerns numbers of such routes, width, travel distance, provision of doors, headroom, etc and the adequacy of lifts, escalators, stairways and passages
- the provision of fire fighting equipment and water supply for fire fighting purposes
- wall linings and decorative finishes
- fitted floor coverings
- the manner in which services are recessed into structural or separating elements
- smoke control
- air conditioning and ventilation systems
- access to buildings for fire fighting and rescue purposes.

Such matters must comply with the relevant requirements of the National Building Regulations.