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THE FIRE PERFORMANCE OF TIMBER IN BUILDING

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BACKGROUND

This research investigated the fire performance of unprotected timber floors, focussing on composite joist floors, composite box floors and timber-concrete composite floors .The major goal of this research was to develop a simplified design approach for timber floors, validated against the numerical and experimental work.

TIMBER AS A BUILDING MATERIAL

Although timber floor systems have provided the basis for flooring needs for centuries, the development of the skyscraper and with it the proliferation of steel and concrete floor systems has made the use of less efficient traditional timber floor systems obsolete.As timber is a combustible material the situation becomes more complex, as the loss of wood section due to charring, the anisotropy of the material itself.

ABSTRACT

This research investigated the fire performance of unprotected timber floors, focussing on composite joist floors, composite box floors and timber-concrete composite floors. The study of these floors was conducted using the finite element software ABAQUS using a thermo-stress analysis in three dimensions, and with experimental fire tests of floor assemblies. The major goal of this research was to develop a simplified design approach for timber floors, validated against the numerical and experimental work

I. STRUCTURAL FIRE RESISTANCE

- Generally the criteria that must be met to ensure an adequate level of fire resistance has been achieved by a building element are as follows:
- Stability – to prevent the structural collapse of the element.
- Integrity – to prevent the transmission of fire and smoke through the element.
- Insulation – to prevent an unacceptable level of heat being transmitted through the element.

II. STANDARD DESIGN FIRES

When considering the structural fire safety of a building as a whole, it is important that the fire resistance of a structural assembly is quantified in such a way that the relative effectiveness of different assemblies across a range of material types and structural forms can be appropriately assessed and compared. This allows for a multitude of assemblies to be used together in a building while still enabling a quantifiable level of the overall fire resistance of the system

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III. NZS 3603

Currently the fire design procedures for timber in New Zealand are given in NZS 3603 (1993), and consist of a simple charring rate calculation including corner rounding, using a rate of 0.65 mm/min. However this is only applicable to members with minimum dimensions of over 90 mm in any direction, and no further guidance is given for reduced properties under thermal loads or amendments for different product types or species of timber.

IV. EUROCODE 5

The regulations covering the fire design of timber assemblies in Eurocode 5 (CEN, 2004) are comprehensive, encompassing a number of scenarios of protected and unprotected timber. Charring rates are given as both one-dimensional and notional rates (which incorporates corner rounding and fissures), and are specified for softwoods, hardwoods, LVL and panel products. For calculating the fire resistance of members under load two major procedures are proposed.

V. AS 1720.4

The building code of Australia specifies guidelines for designing timber members in AS 1720.4 (2006). The standard specifies a notional charring rate calculation based on the density of the timber at 12% moisture content, and also specifies a zero strength layer of 7.5 mm. This is applicable to all timber members for calculating a residual section and hence the load carrying capacity of that section

VI. AFPA TECHNICAL REPORT 10

Technical Report 10 (AFPA, 2003) produced by the American Wood Council details a comprehensive charring rate method similar to other codes. It consists of a notional charring rate with multiple guidelines on calculating section moduli and strength reduction factors. The charring rate calculation incorporates both corner rounding and a zero strength layer .

VII. STRUCTURAL FIRE DESIGN

The design fire is the key aspect in fire engineering which is usually specified by the practicing fire engineer, hence each fire scenario and the impact of that fire is different from one structure to the next. A design fire will be defined by the particular use of the structure, hence when trying to approximate a large range of possible fire scenarios with a standard fire, obvious issues of applicability will arise.

VIII. THE DESIGN FIRE

The absence of this decay phase in the standard fires may not be an appropriate assumption to design for. It is reasonable to assume that the majority of fuel in a compartment to have been consumed after multiple hours of burning (for a standard building scenario), hence finite fire durations and decay phases should always be considered.

IX. THE DESIGN FIRE PHASES

9.1 GROWTH PHASE

It has been increasingly observed in recent years that new materials such as fabrics and foams used in buildings have much faster growth rates than materials which were commonplace when fires such as the standard ISO 834 fire was proposed. A wealth of literature can be found on the subject of characterising the burning rates of materials, an example of this is foam material which can significantly contribute to the fire load and burning rate of a firecell.

9.2 Flashover

Flashover is the transition between the growth and fully developed phase. It is usually defined as the transition from a localised fire to the combustion of all enclosed surfaces in a room (Buchanan, 2001). This leads to a rapid increase in both the temperature and the heat release rate of the compartment, and commonly signifies the transition from a fuel controlled to ventilation controlled fire.

9.3 The Fully Developed Phase

The fully developed phase occurs when the firecell has reached flashover, and is generally characterised by temperatures in excess of 600 – 800°C which suggest all fuel items in the firecell have become fully involved in the fire.The major structural impact from the fire, especially to steel members, occurs during this period due to the high temperatures throughout the duration.

9.4 Decay Phase

When considering the ISO 834 (1999) standard fire used in this research, no decay phase is specified. For longer fire durations it would be likely that the fuel in a compartment would be exhausted and the temperature would decrease as the fire heat flux into the compartment decays. The standard fire gives a constantly growing and persistent fire temperature which may not be representative of the majority of real fires at longer durations.

9.5 Extinguishment

When considering timber in fires, a major point of contention is what happens to the timber members when the fire decays away but the timber still burns. Standard fire resistance tests are usually conducted to a set duration, and the possible effect of persistent burning after the set duration is not considered. This may be due to the reasoning that specific assembly must demonstrate its ability to meet its requirements only for that set period of time, after which it is assumed that fire service intervention occurs, otherwise a collapse may be inevitable. The findings were that the airflow to the furnace played a major role in determining the combustion of the timber after the fire, and a large amount of ventilation was needed to continue combustion on members

9.6 Estimating A Design Fire

Inevitably, all aspects of the most likely fire scenario for a particular structure may not be adequately addressed by the simplified design fires specified in regulations. Therefore a performance based fire engineering approach can be very useful to appropriately design for an expected fire in a space. A major factor dictating the choice of design fire will be the overall design objective. Generally, these objectives may be for the structural assembly to:

Provide a fire resistance rating specified by a code or standard.

· Survive the burnout of a fire compartment.

· Survive until a level of fire brigade intervention or active suppression is incorporated after a period of time.

It should be noted that a great degree of engineering judgement is relied upon at this stage of the process to determine the relevance and importance of each designobjective. Thus, it is important that a conservative approach is taken in the assumptions made about the fire characteristics, in order to encompass a wide range of possible fire scenarios and to ensure the structure is not under designed.

9.7 Some common simplifications when deciding on an appropriate design fire are as follows:

Instantaneous growth and decay phases – commonly known as rectangular fire curves, these types of fires are ideal for situations in which a fuel load or maximum heat release is known, but growth and decay characteristics are not or deemed insignificant. These design fires are generally conservative as they can exaggerate the fire impact on structural members.

· **Parametric growth phases** – in order to account for faster growing fires or more volatile fuels, such as hydrocarbon pool fires. These generally grow to a maximum temperature at which a constant linear trend is followed until fire decay.

· **Linear decay phase** – in order to simplify the estimate of fire decay due to the limited data available in the literature on decay of different materials. Generally taken as a steady decrease from the maximum temperature to ambient, or the assumed compartment temperature immediately after burnout.

· **Adequate ventilation conditions to reach flashover** – it is normally assumed that compartment glazing breaks and there is adequate ventilation for the fire to grow to a maximum temperature or heat release rate and subsequent burnout

REFERENCES

[1.] Aarnio, M. "Glulam Timber Construction and the Fire Resistance Properties of the Joints", Diploma Work, Helsinki School of Technology, Division of Building Engineering, Otnas, Finland, 1979. Aarnio, M. and Kallioniemi, "Fire Safety in Joints of Loadbearing Timber Construction", Research Report No. 233, VTT Technical Research Centre of Finland, Finland, 1983.

[2.] ABAQUS version 6.10.Analysis User's Manual, Dassault Systems Simulia Corporation, Providence, RI, USA, 2010.