

# The Influence of Travelling Fires on the Response of a Concrete Frame

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The ideas in this paper introduce a **fundamental change** in the way we design buildings to resist fire. Previous engineering methods do not adequately address the changing **risks posed by fire** to our large buildings and **iconic structures**.

Travelling fires allow engineers to capture the key physical processes in a simple and easy to apply **design tool**.

## What happens in a building fire?

When fires occur in **small rooms** (less than 100 m<sup>2</sup>), their behaviour can be roughly predicted. They follow the same pattern:

- A **growth** phase;
- Compartment **flashover**; and
- A **decay** phase.

Though there are local temperature variations, the overall behaviour in the compartment is relatively uniform.



When fires occur in **large rooms**, their behaviour is much more difficult to predict. Fires like this can have a number of different features; they can:

- Move (or **travel**) around the room;
- Burn over a very **long duration**; and
- Induce very **variable temperatures**.

These types of fire are becoming increasingly common as architects aspire to an open-plan aesthetic.

## How do we normally design buildings?

Traditional methods of design assume **uniform burning** throughout a room regardless of its size.

Historically (from c.1900), buildings have been built with a **fire resistance period**. This is the duration which the building could resist a furnace test. Since the 1980s, “**natural**” fires – similar to small room fires – have been used to design buildings; nevertheless, these fires always assume uniform burning.

## Travelling Fire Approach



Fig. 3 - Idealised travelling fire

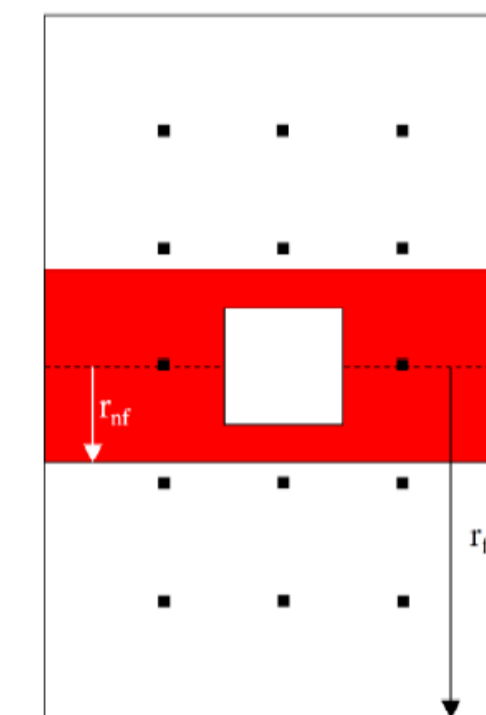


Fig. 4 - Travelling fire moves across compartment

This paper introduces the concept of travelling fires for structural design. The fundamental characteristics of a design tool are that it must:

- Capture the **key behaviours**; and
- Remain sufficiently generalised to allow **easy application**.

A key distinction between the travelling fires approach and the conventional room fires method is that the emphasis is on **creating a tool for design** rather than predicting the exact fire that may occur.

Research has shown that travelling fires have two distinct areas:

- The **near field** – a very hot area (~1200°C) close to the seat of the fire; and
- the **far field** – the cooler area (between 100°C and 1200°C) further away from the seat of the fire.

As the fire travels from one part of a building to another, the structure undergoes **pre-heating**, then **super-heating**, and then **cooling**. The new travelling fires design approach includes each of these.

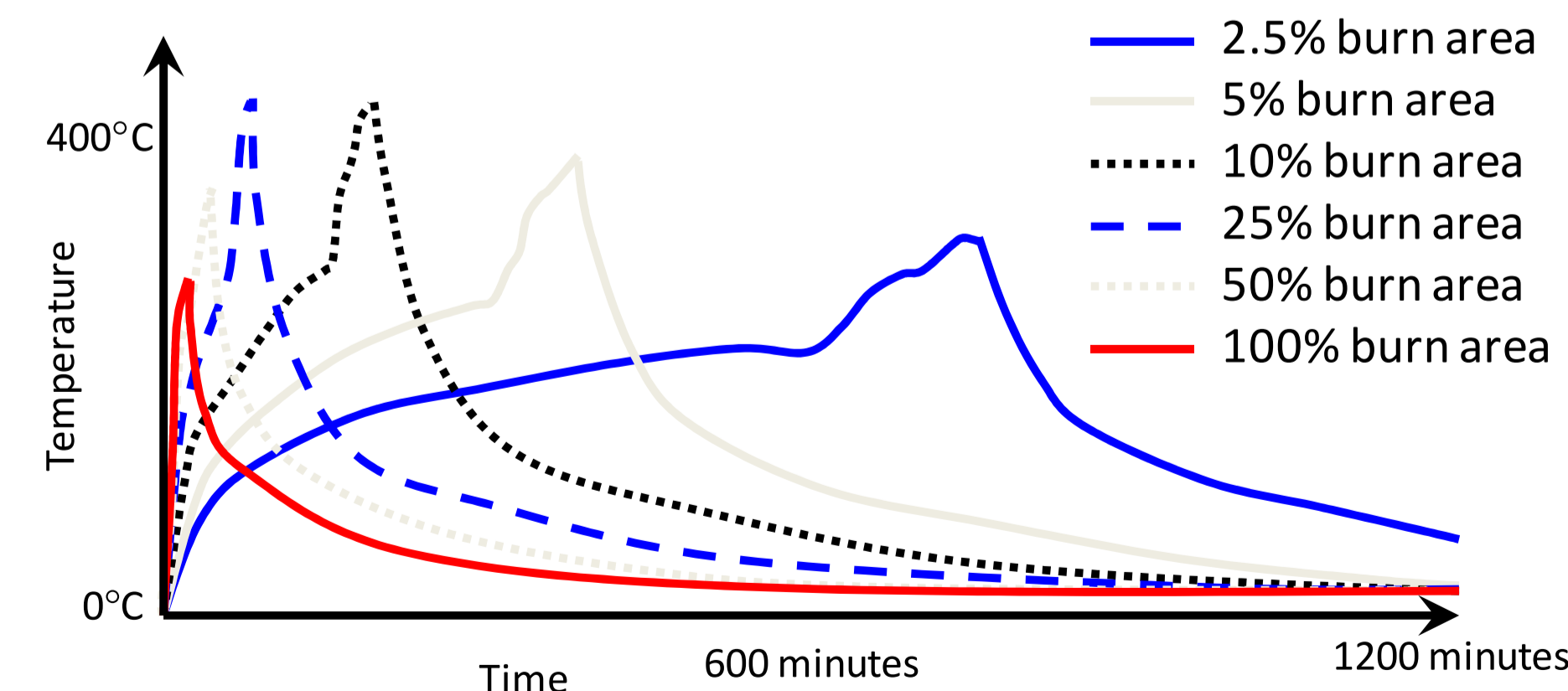


Fig. 5 - Temperature of the structure

It has been found that, for concrete structures, the most severe fires are those that engulf approximately **25% of the floor** at any one time.

## Implications for Design

A computer model of a conventional concrete building was used to study the impact of travelling fires in comparison to current design approaches. It was found that the travelling fires can be **significantly more detrimental** to the building than either the “standard fire”, or the conventional compartment fire.

This means that current design techniques **do not adequately capture** the likely behaviour of the structure during a fire.

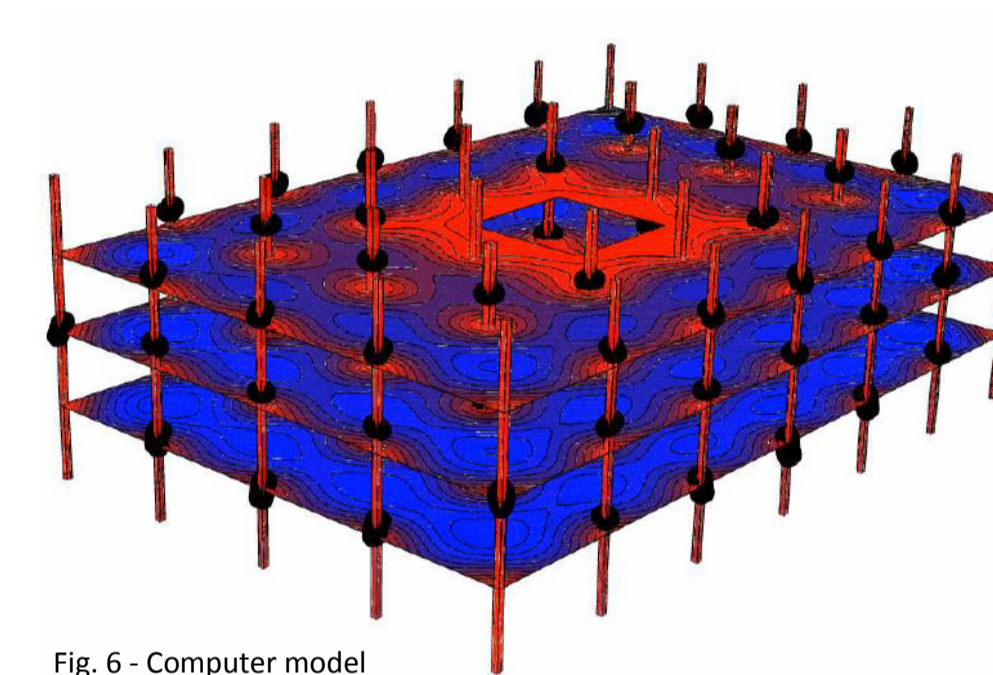


Fig. 6 - Computer model



Fig. 7 - London and its iconic structures

Modern computers allow design engineers to run multiple analyses considering **many different possible fires** – previously this would have been unfeasible.

## Conclusions

Applying travelling fires to building design is a **fundamental shift** in understanding how structures behave and how we can design them to resist fire.

This has been driven by:

- Increased **understanding** of fire and structural behaviour;
- The increasing demands of **architects** and designers;
- The desire to **optimize** the structural protection strategy; and
- Enabling **technology**.

As buildings are getting taller, and structural tolerances become smaller, it becomes increasingly important to ensure that we have accurately assessed the **risk posed by fire**.

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