



Out of range

How often are engineering tools not adapted to designer needs? A survey of the University of Edinburgh campus by **A Jonsdottir** and **G Rein** underlines the narrow design fire specifications of the Eurocodes for many new buildings

EVERY engineer and architect uses the tools available when designing a new building or redesigning an old one. But is everything in the design compatible with the relevant tools? In the case of structural fire safety engineering, there are obstacles in the design process that need further attention, particularly when architectural features are outside the range of applicability of the standards and codes.

All over the world and indeed in Europe are old and new buildings with unconventional complex or large spaces that do not conform to the design fire specifications and limits set out in the Eurocodes – that is, height less than 4m, floor plan

under 500m², opening factor (representing the amount of ventilation) and the b-factor (thermal inertia, which takes into account the density, the specific heat and the thermal conductivity of the boundary) not too high or too low, and no openings in the roof. (Eurocodes are harmonised technical rules for the design of construction works in Europe, which will provide an alternative to national design rules and ultimately replace them.)

This means that some buildings/enclosures with, for example, high atriums, large windows on one or two walls, or a glass facade are outside the applicability of Eurocode 1: *Actions on structures*. Many older buildings – for example,

churches, theatres, castles, palaces and mansions, all with large high-ceiling halls – lie outside the Eurocode, but these structures were built before rules and regulations about fire safety were made and are therefore not included in this discussion.

New buildings may also fall outside the range of Eurocode 1. For instance, high-rise buildings, sport halls, theatres, shopping centres, warehouses, airports, train stations and others commonly feature large atriums, glass facades and other modern features built in all kind of shapes and forms. The list is long and will grow in the future as innovative architectural and fire engineering solutions continue to break the barriers of originality.

University of Edinburgh surveys

To get some idea of what is the built reality regarding the above limits of Eurocode 1, a survey of King’s Buildings Campus (KB) at the University of Edinburgh was undertaken. Twenty-eight of the main buildings in the campus were inspected with those limitations in mind. Also, the most modern building at the university, the Informatics Forum which was opened in June 2008, was inspected in detail. The buildings covered in the surveys are primarily used as teaching and research facilities.

A glass wall reaching between floors



King’s Buildings

Of the 28 buildings surveyed in KB, there are 26 that have one or more enclosures that fall outside the applicability of the Eurocode. In most of the buildings, the number of rooms out of range is 3-4% of the total rooms but, in some cases, this value is 13-17%. These buildings would not usually be considered unconventional in any way and none of them count as high-rises. Rather, they are ordinary, everyday-functioning buildings containing offices, laboratories and lecture rooms.

One interesting question came to mind when undertaking the survey: what about typical stairways? Stairways feature in all buildings over one storey, and the height in them is always over 4m. This would suggest that stairways never fit into the applicability of the code. On the other hand, fuel load is usually very limited or almost down to nothing in stairways – and a performance-based design takes that into account, while a prescriptive design does not.

Table 1 shows the results in terms of number of rooms in KB. The enclosures with the opening factor out of range are the same as the ones with the lining thermal inertia out of range. This is due to the fact that if, for example, one or more walls is made of

Areas where the height is over 4m and skylights are in the roof



FOCUS Public buildings

glass, this greatly increases the opening factor above the upper limit and reduces the thermal inertia below the lower limit.

The rooms/enclosures that were out of range with the Eurocode limitations were atriums open between floors, laboratories or workshops with skylights in the roof, larger lecture theatres where the height was over 4m, and floor areas over 500m².

Figure 1 shows the results in terms of the total volume in the KB campus buildings. The enclosures inside the Eurocode's applicability represent 66% of the total volume and, on average, each of the limitation groups take 5%.

Figure 1: Results in terms of % of total volume of enclosures in KB, split by Eurocode limitations

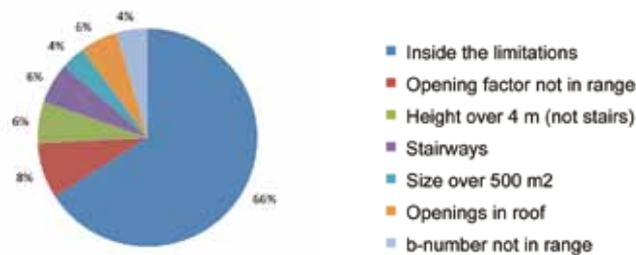


Table 1: Number of rooms out of range in KB

Total number of rooms	3,055
Inside the limitations	2,909
Opening factor not in range	32
Height over 4m (excluding stairways)	13
Stairways	78
Size over 500m ²	8
Openings in roof	22
b-number not in range	33

Informatics Forum

The Informatics Forum at the University of Edinburgh has just been built and taken into use. This building was chosen for the survey because of its unique nature and architectural traits, which are representative of complex, modern buildings. Built over six floors around a central glass atrium, with 12,000m² of floor area, the Informatics Forum has an open design that is beyond the range of applicability of traditional design methods.

Table 2 shows the results in terms of number of rooms in the Informatics Forum. Figure 2 shows the results in terms of the total volume in the building. It is interesting to see how evenly the volume distribution is between those limitation groups (15% each on average) and how small is the volume inside the Eurocode limitations (8%). This is largely due to the glass walls and the large atrium.

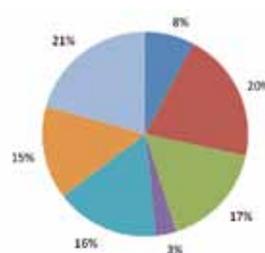


Figure 2: Results in terms of % of total volume of enclosures in Informatics Forum, split by Eurocode limitations

Table 2: Number of rooms out of range in the Informatics Forum

Total number of rooms	30
Inside the limitations	19
Opening factor not in range	2
Height over 4m (excluding stairways)	2
Stairways	3
Size over 500m ²	4
Openings in roof	1
b-number not in range	2

Built over six floors around a central glass atrium, the Forum has an open design beyond the range of applicability of traditional design methods



Conclusions

Comparing the two surveys, the results are rather different, although the same parameters were used in both. In King's Buildings, 66% of the total volume of those buildings is inside the limitations of the Eurocode. Most of the enclosures out of the applicability of the code are small atria with staircases between two or three floors, lecture theatres and workshops, along with some hallways or open spaces. In the Informatics Forum, 8% of the total volume is inside the limitations. The enclosures that are out of the applicability of the code include the Forum (atrium) and a workshop, as well as some open areas.

The difference could be due to the construction times. King's Buildings were built over a long period of time, with many of them from the early 20th century. They feature different sizes and styles but none of them has a high atrium that makes up a large portion of the building, as does the Informatics Forum – a brand new modern building with lots of open spaces and glass facades. One could say that modern building trends are once more moving out of the limits of our current understanding in fire dynamics.

In order to expand the narrow range of applicability in the Eurocode, new methods aimed at developing a better understanding of both fire dynamics and structural behaviour are needed. Such a methodology is currently being developed at the University of Edinburgh^{1,2,3}. The key aspect of this new methodology is to account for the fire dynamics specific to the building, including a wide range of possible fires. This methodology spans over a very wide range of building types, sizes and shapes by accounting for travelling fires that propagate across the floor plate ■

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References

1. Rein, G., Zhang, X., Williams, P., Hume, B., Heise, A., Jousey, A., Lane, B., and Torero, J., *Multi-Story Fire Analysis for High-Rise Buildings*, 11th Interflam, pp.605-616, September 2007.
2. Stern-Gottfried, J., Rein, G., Lane, B., and Torero, J., *An innovative approach to design fires for structural analysis of non-conventional buildings*, Application of Structural Fire Engineering, Prague 2009.
3. Stern-Gottfried, J., Rein, G., and Torero, J., 'Travel guide', *Fire Risk Management*, November 2009, pp.12-16.

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