The transient nature of occupant loads

The transient nature of occupant loads: a case study for a small UK office

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Background to office occupant loads

In the fire safety design of offices in the UK it is common for the number of potential occupants within the building to be estimated through the application of an 'occupant load factor' (sometimes referred to as a 'floor space factor'). This estimation of the occupant load is necessary to determine stair and exit capacities, support egress calculations, etc.

Spearpoint and Hopkin [1] note that the definition of occupant load is not universal, with NFPA 1 [2] describing it as *"the total number of persons that might occupy a building or portion thereof at any one time"*, the New Zealand Acceptable Solutions [3] as *"the greatest number of people likely to occupy a particular space within a building"*, and the Scottish Technical Handbook [4] as *"…the appropriate number of occupants in each space for normal circumstances"*.

Guidance in the UK, including Approved Document B (ADB) vol. 2 [5], BS 9999:2008 [6], and the Scottish Technical Handbook [4], recommends that an occupant load factor of 6 m^2/person be applied for offices. ADB [5] suggests that, as an alternative to using occupant load factors, the occupancy *"may be determined by reference to actual data taken from similar premises. Where appropriate, the data should reflect the average occupant density at a peak trading time of year"*. However, the public availability of this type of data, specifically for UK occupancies, appears to be somewhat limited.

To estimate a probabilistic distribution for the occupant load of a representative UK office building, Hopkin et al. [7] have previously applied US data from the studies of Milke and Caro [8] and Thackeray et al. [9]. A truncated normal distribution was proposed with a mean of 24.6 m^2/person, a standard deviation of 14.1 m^2/person, a minimum (i.e., highest density) of 0.5 m^2/person and a maximum (i.e., lowest density) of 101.5 m^2/person. However, Hopkin et al. acknowledged that office occupant loads, and associated design guidance for offices, will differ between the US and the UK.

In the absence of relevant data for UK offices, an alternative approach commonly taken is to utilise the number of desks / workstations / seats which the building occupier intends to place in the premises, considering that each desk is representative of a single occupant. A limitation of this approach is that it assumes all available desks will be occupied simultaneously, and that no additional occupants other than those assigned to desks will be present within the building at the time of evacuation. In practice, occupancies within the building may be far more transient. Some desks may not be occupied should staff be on leave, only working part-time, working from home, or attending external meetings. It is also possible that occupants other than those assigned to desks could be in the office temporarily for meetings, special events, etc.

The purpose of this article is to use an exemplar to briefly explore the variable nature of office occupant loads and thus provide some high-level context on common design approaches and assumptions. To achieve this, the article details a case study for a single UK office, in which occupancy data was recorded for an eight-week period.

Case study methodology

The case study office is based in Manchester, comprises a single level, and accommodates the staff of a fire engineering consultancy firm. A summary of the office details is presented in Table 1.

To determine the number of occupants in the office, a 'headcount' was taken on each hour between 07:00 AM and 06:00 PM (07:00 to 18:00) on weekdays (the range of typical office working hours for the consultancy). The data was recorded for an eight-week period in January and February 2020, prior to any then unforeseen lockdown impacts of the Covid-19 pandemic. In some instances, a headcount

was not taken due to the individual responsible for counting being unavailable or otherwise occupied at the time.

Table 1. Summary of office used for the case study.

Item	Value	Additional comments
Office floor area	~200 m^2	The floor area includes an area for desks, an open plan kitchen and dining space, but excludes a separate meeting room.
Number of permanent staff	21-24	Staff numbers increased by three across the eight-week period that the study was undertaken. Most staff were full-time employees, with a few staff working part-time, two to three days a week.
Number of fixed desks	28	A greater number of fixed desks were available than permanent staff to accommodate for potential company growth, additional visitors, etc.
Available floor area per staff member	8.3-9.5 m^2/person	For this specific office, the floor area available per staff member was shown to be greater than the 6 m^2/person occupant load factor recommended in ADB. To achieve a value $\approx$ 6 m^2/person, nine visitors would need to be present in addition to the 24 staff.
Available floor area per desk	7.1 m^2/desk	As above, the available floor area per desk is greater than the 6 m^2/person ADB occupant load factor. To achieve 6 m^2/desk, an additional six desks would be needed.

Results

A total of 293 data points were recorded out of a potential 480 across the eight-week period, with Figure 1 providing a summary of the key results. Figure 1a and Figure 1b present the cumulative distribution functions (CDFs) for the occupant density and the occupants present per total office staff, respectively. The latter represents the number of occupants present (including any visitors) divided by the total office staff employed at the time the headcount was taken. The distribution function in Figure 1a has a mean of 21.8 m^2/person, similar to 24.6 m^2/person from the distribution of Hopkin et al. [7], discussed previously. The medians are less similar, with 16.0 m^2/person for the office distribution and 24.9 m^2/person from Hopkin et al. The standard deviation of the distribution is 26.6 m^2/person, presenting a greater extent of spread when compared to 14.1 m^2/person from Hopkin et al. From Figure 1b, it can be observed that at no stage within the eight-week period was the office at its full staff capacity, with the maximum being 85% of the staff in the office at a given instance in time. The overall median of occupants present per total office staff was 53%.

Figure 1c and Figure 1d provides the average (mean) values for occupants per total office staff by the time of day and the day of the week, respectively. The dashed grey lines indicate two standard deviations (s) above and below the average values (i.e., the 5^{th} and 95^{th} percentiles when assuming a normal distribution). These figures highlight the general variability of the number of occupants in the office over time. Between 07:00 and 09:00, the number of occupants increases, subsequently maintaining an average in the region of 54% to 64% (per total office staff) up to 16:00 before decreasing after this time. In the 09:00 to 16:00 period, two standard deviations, above and below the average value, range from 23% ($-2s$) up to 86% ($+2s$). For the day of the week, there is less of a clear trend, although it appears

that more people were in the office on Tuesdays (an average of 58%) compared to other days (e.g., 52% on Mondays). Again, the two standard deviations above / below the average is wide ranging, from 15% (−2*s*) up to 90% (+2*s*).

The results provided are for the occupants present per total staff. However, it is important to highlight that the total number of staff (21-24) is fewer than the number of desks available within the office (28), and thus the proportions would be lower if the number of desks were instead used as the point of reference.

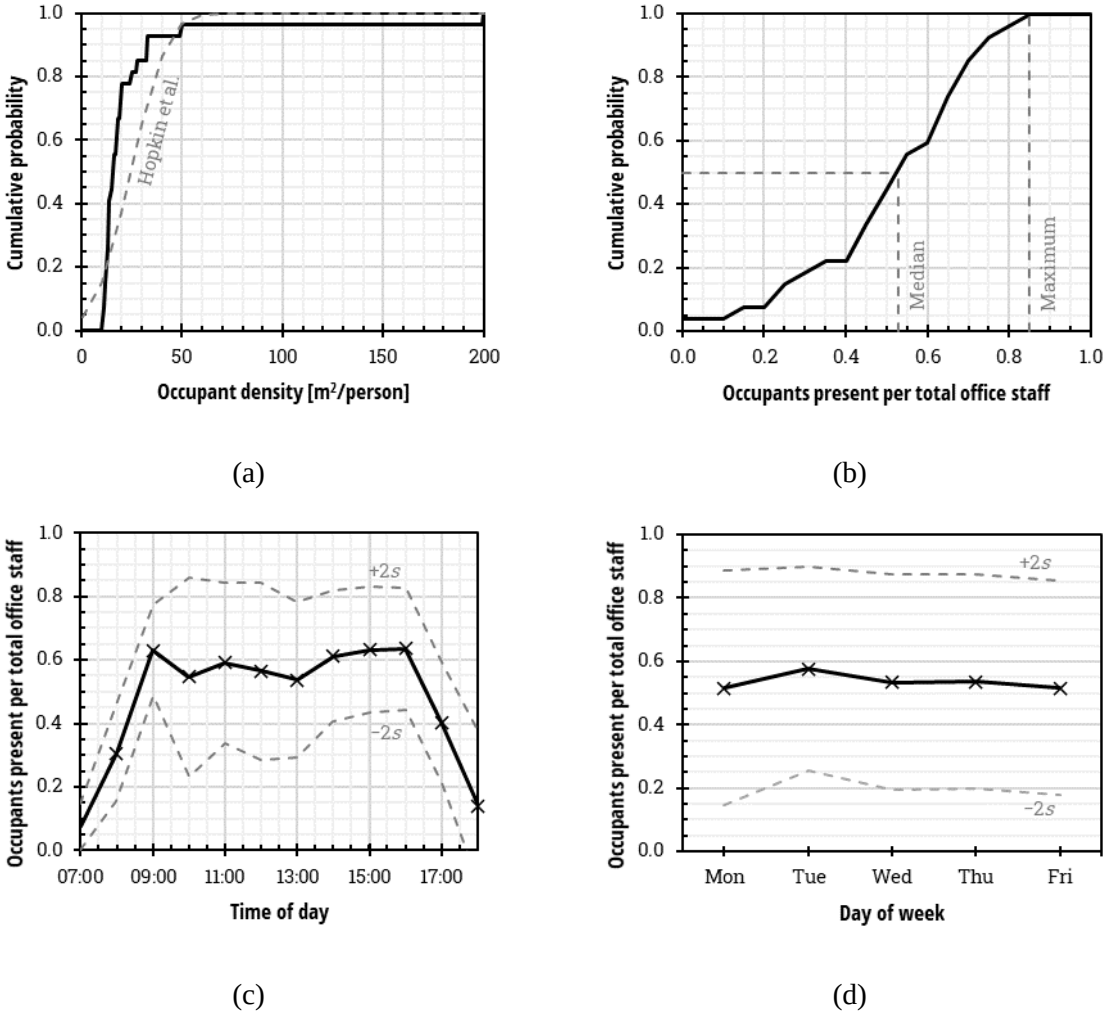

Figure 1. (a) CDF for the occupant density; (b) CDF for the occupants present per total office staff; (c) average occupants per total office staff by the time of day; and (d) average occupants per total office staff by the day of the week.

Discussion and conclusions

This article briefly summarises a case study of the single storey office of a fire engineering consultancy firm, where the number of occupants in the office was recorded for an eight-week period. The results of the study highlight the variability in the occupancy by the time of day and the day of the week, as well as indicating that the office was never fully occupied to either its full staff numbers or desk capacity. A median of 53% of occupants per the total staff were present in the office at a given time, with a maximum of 85%.

A potential implication of the data presented in this article is that the common UK practice of utilising the number of desks or seats as a representation of the occupant load is a 'conservative' design approach. However, it is important to recognise that this single office is by no means representative of the wide-

ranging behaviours which could be observed across different offices in the UK, and its observations should not be applied to design without very careful consideration. The observations in this article could be unique to the office in question, and the transience of an office occupant load will be dependent on several factors, including seasonal variations, the office culture, and the type of work that is being delivered. For example, it may be hypothesised that a call centre is likely to have a greater number of occupants remaining in the office and at their desks than an engineering consultancy, where the staff are regularly outside of the office, such as on site or attending external meetings.

It would be beneficial to collate more data on office attendance in the UK (and elsewhere), by the time of the day, the day of the week, etc. This would help to develop a greater understanding on the transience of office occupant loads for different office practices and cultures. This topic has become even more pertinent with the ongoing debate around the likelihood of offices returning to previous working conditions post-pandemic, or whether hybrid working, working from home, flexible working, etc., could become the 'new normal' [10]. Such changes to working practices could substantially alter the utilisation of office footprints and the associated occupant loads. With the collection of more data across the coming years, it is possible that existing assumptions around fire safety design of offices could be revisited.

References

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