Office floor loading in historic buildings

ENGLISH HERITAGE

Introduction

Apart from mills and warehouses, few historic buildings are capable of carrying massive imposed floor loadings. However, the need to design for high floor loadings in offices is often put forward by those responsible for the refurbishment of historic buildings as the reason for draconian alterations. The claim is made that high loadings are needed to give the client flexibility in the way that the building is to be used and to ensure that overloading cannot occur accidentally, causing excessive deflections or either partial or complete collapse. This leaflet explains why it should never be necessary to apply such high loadings in historic buildings which are to be used as offices.

Past history and future use

Office loadings have not changed over the years; office equipment has usually been restricted to the weight which one person can carry. Modern office furniture is lighter, for instance, than its Victorian counterpart, whilst stored material such as paper and books weigh just the same. Far from there being a risk that floor loadings will increase in future years, it is clear that the opposite will be true. The days of heavy computing equipment are gone, and modern desk-top computers are often lighter than manual typewriters. All the indications are that as well as becoming more powerful, they will become even smaller and lighter: fixed computers in offices are a thing of the past. As material can easily be stored on disc, paper storage is likely to decrease as computers become more widely used. Heavier items such as filing cabinets are always stored against walls where their effect on the floor is much less, while the lighter desks are sited in the open spaces in the centre of rooms. It is difficult to draw a great distinction between some domestic loading and office loading. Whether the people sitting around the table are eating a meal together or discussing business clearly does not affect the floor loading.

Why then are offices often designed for such heavy floor loading?

British Standard requirements

The most recent British Standard on the subject, BS 6399: Part 1: 1984, gives values for 'the load assumed to be produced by the intended occupancy or use, including the weight of movable partitions, distributed, concentrated, impact, inertia, and snow loads but excluding wind loads', more simply known as live loads. Table 8 of this BS refers to offices and banks, and suggests that offices for general use should be designed to carry 2.5 kN/m^2. However it also suggests that areas designated for other uses should be designed for higher loadings. For example offices with fixed computers should be designed for 3.5 kN/m^2, whilst file rooms, filing, and storage space should be as high as 5.0 kN/m^2. Corridors, it proposes, should be designed for 4.0 kN/m^2. By comparison, domestic floor loading is designated as 1.5 kN/m^2.

Conversions

1.5 kN/m^2 = 30 lb/sq ft
2.5 kN/m^2 = 50 lb/sq ft
3.5 kN/m^2 = 70 lb/sq ft
4.0 kN/m^2 = 80 lb/sq ft
5.0 kN/m^2 = 100 lb/sq ft

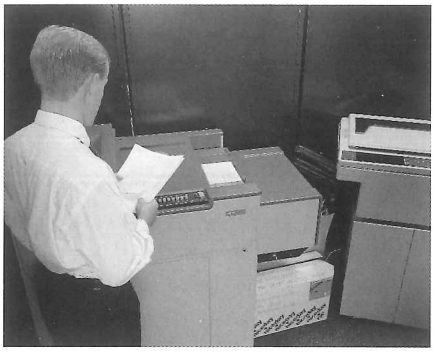
While these requirements are applicable to 'alterations and additions to existing buildings' and 'to existing construction on change of use', they do not apply to 'the maintenance of, or the replacement of parts of, existing buildings where there is no change of use'. To give full flexibility to the user of the building it could therefore be concluded (and to the detriment of many historic buildings, often is concluded) that the value of 5.0 kN/m^2 as suggested by the British Standard should be used throughout the building.

Lower design loads

The paper produced for Stanhope Properties plc in March 1992, An assessment of the imposed loading needs for current commercial office buildings in Great Britain, relates to floor loadings in new development and concludes that the blanket use of the value of 5.0 kN/m^2 results in a lack of economy in the design of new buildings. It suggests the use of 2.5 kN/m^2 except in certain isolated areas which should be designed to the higher value of 7.5 kN/m^2. The document comments that the lower value is more than adequate for 99% of all office use but points out that the value of 5.0 kN/m^2 is completely inadequate for the heavy rolling filing systems used today, many of which apply a load well in excess of 5.0 kN/m^2.

The Stanhope Properties plc paper confirms and updates the huge amount of research carried out by the then Building Research Station, the results of which were published, *Floor loadings in office buildings the results of a survey*, CP 3/71, in January 1971. Thirty two buildings and a total floor area of 160,000 sq m (1.75 million sq feet) were investigated in this 1971 survey and the BRS report concluded that, except in very small areas, usually rooms more like cupboards than offices, floor loadings were always below 2.5 kN/m^2.

Although both documents relate to new development they have much to say about historic and other existing buildings which are being refurbished. Floor loads in excess of 2.5 kN/m^2 are not necessary in refurbishment work for



Even allowing for some paper storage, it is difficult to see how this small room could ever reach even the lower value of 2.5kN^2 required for office design

the same reasons that they are not necessary in new development. Apart from the rolling filing systems it is not possible to get a normal office floor loading greater than 2.5 kN/m^2.

Even heavy office equipment does not impose a great load on the floor. In one English Heritage building, two typical modern photocopiers occupy a small room which has only space for the machines, for the people using them, and for one or two others waiting their turn. One machine weighs 65 kg (143 lb) whilst the other weighs 320 kg (704 lb), and the floor area is approximately 3 m by 2 m. The resulting floor load is 0.64 kN/m^2 (13 lb/sq ft), less than half the design load for domestic accommodation.

File storage

There always has been, and may always be to a degree, a need for storage of paper in the form of files, drawings, ledgers, and so on. In rooms used as offices this will be close to walls but heavy concentrations of files should be restricted to areas suitable for absorbing heavy loading such as basement rooms or other areas agreed with the engineer. This might be seen as an unacceptable limitation but in practice is often no real problem demanding at most a little forethought.

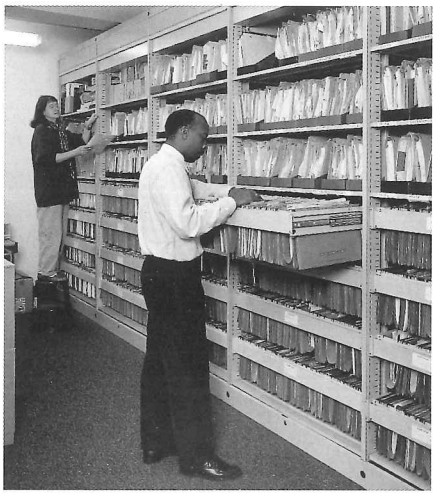
To give another example from an English Heritage office, there is a modern shelving system installed in the offices of the Conservation Engineering Branch. This system is 2.3 m high and covers a floor area of 5.1 m by 1.03 m. It is virtually full of files and its weight is estimated at 3,000 kg (about 3 tons). The floor loading directly beneath this is 5.7 kN/m^2 but when minimal circulation space of 700mm on either side is taken into account this value drops to just within the 2.5 kN/m^2 requirement of the British Standard.

Partitions

Where partitions might be used, the codes of practice suggest the use of 1.0 kN/m^2 in addition to the previously agreed floor loading. In the case of historic buildings which often have relatively small rooms, the need for this extra loading should be examined closely. Generally, it is only necessary to use this additional loading in large open areas which might be planned in new build and where the exact location of the partitions is not known at the time of construction.

Crowd loading

The BRS survey assumed (quite rightly) that crowd loading might occur during fire alarms. It refers to work carried out by the London Transport Board which reports that when packing of personnel takes place to the point where shuffling ceases the imposed floor loading is 2.4 kN/m^2. In panic situations where people run, this close spacing of people will not occur and the unit load will be lower, although there will be some dynamic forces set up. It is suggested that the value of 2.5 kn/m^2 will be adequate even for corridor and staircase areas. In a small building occupied by only a few office staff, such a loading will never be reached.



The imposed floor loading in this file storage system is less than 2.5 kN^2

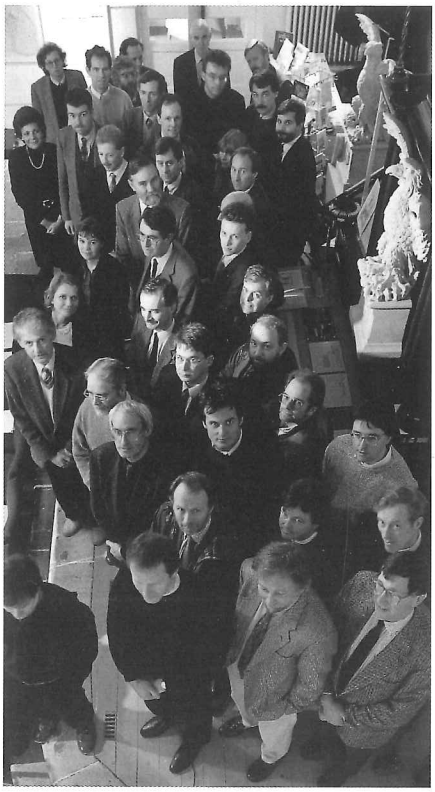
Loadings in historic buildings
The use of the higher value as suggested by the British Standard, is uneconomic in new developments both in financial terms and environmentally. It is invariably disastrous when used in the refurbishment of historic buildings. Not only does it cost considerably more and uses scarce natural resources unnecessarily, it destroys valuable historic fabric. The use of the higher loads might mean that nothing of the interior structure of the building can be retained as there is rarely any way in which an existing building can satisfactorily be strengthened to carry 5.0 kN/m^2. The historical integrity of an important building may be lost or made less by needlessly upgrading its floors. There is also the consideration of the 'value added' to the building for the client by retaining a truly historic building instead of having a sham, an historic facade with a modern core but that is, perhaps, another matter altogether.

Communications
It is often suggested that structural engineers use higher floor loadings in their designs because they are following their clients' instructions on flexibility, whilst clients frequently say that the higher loadings are necessary because their structural engineering advisers recommend it. Clearly closer liaison is necessary between clients and their advisers on what the clients' requirements are and what loadings the standards suggest may be used in complete safety.

Appraisal
In order to assess the loading a building can carry it is necessary to understand fully how it works, what its defects are, and how they might be overcome. A thorough understanding of the building and its structure is more important than ensuring that beams and joists fully comply with current regulations on permissable stresses and allowable deflections.

A well-constructed domestic building or one which has been brought up to a good standard by some very basic improvements will be capable of carrying office loadings even if calculations show that there is some overstress and some deflections which are higher than the permissible. It is more important to ensure that joints are tight and capable of doing their job (or that they are strengthened to do just that) rather than ensuring that there is no overstress. There will always be plenty of warning of problems with an overloaded floor; deflections will become visibly excessive and ceilings will begin to crack.

Calculations of stresses and deflections often seem to show that timber floors are capable of carrying little more than their own weight. Even where the building has been functioning quite satisfactorily over many years whilst carrying a substantial load this is frequently the case. Calculations giving such



People standing close together impose a loading of about 2.5 kN/m^2.

results should be closely questioned. Since load tests are an accepted method of proving the adequacy of a structure, the past history of a satisfactory performance should be enough to attest to the future structural adequacy of the building.

The effects of excessively high floor loading
In order to make sure that the floors in an historic building are capable of carrying the supposedly necessary floor load of 5 kN/m^2 there is likely to be considerable disturbance of their historic fabric. Joists may need to be doubled up or replaced and beams will need to be strengthened either by reinforcing with channels or by replacing them with new steel beams. It will probably be impossible to strengthen the floors to this extent and still retain any of the historic fabric.

The basic wall structure of the building may well then be found to be incapable of supporting all the extra load and new columns will have to be introduced. It is never possible to hide these extra elements. New columns will need new foundations and existing walls will have to be underpinned. Taken to its logical conclusion, such strengthening will mean that much of the building will be condemned as being useless and demolition will be recommended. In historic terms, saving the facade, which is about as much as might be hoped for in such a scenario, is a very poor option.

Stiffening
One problem with timber floors is that they sometimes feel springy and bouncy. This can often be overcome by stiffening joints with steel brackets and by screwing plywood sheets on top of the joists. Basic improvements of this type are often all that is needed to enable a floor to behave satisfactorily as an office floor.

Safety and long useful life
It is clear that office loadings rarely, if ever, reach 2.5 kN/m^2. Even moderately dense filing only just exceeds the value of 2.5 kN/m^2. So-called 'hard spots', areas of the building which are capable of carrying very heavy loads from file storage systems etc, are worthy of investigation early in the design of a refurbishment scheme. Files are rarely, if ever, stored close to windows or in the centre of rooms, being put close to walls where they are out of the way and do not obstruct the brighter parts of the rooms where desks are sited. Therefore they are usually stored in the best place for the structure, close to the supports of beams and joists.

This typical office results in a loading of 1.6 kN/m²

In historic office refurbishment any very heavy storage, which is usually referred to less frequently, can be put in the basement where any weight problems can be overcome without damage to the building's historic fabric. If very heavy storage is required on other floors, it may be necessary to strengthen that part of the building to the required level, and retain the remainder at the lower, but adequate, general office-use level of loading.

If the rooms in an historic building are only to be used as offices without file storage then clearly a floor loading of 1.5 kN/m² will be perfectly adequate.

Conclusions

The floor loadings for office buildings, whether new development or refurbished existing buildings, should be no higher than 2.5 kN/m², except in certain localised areas agreed with the client and then only if modern rolling filing systems are planned. In the interests of conserving the building such areas should be located in basements, or on other solid floors, or in the stronger areas of the buildings. This should not cause practical problems as these areas are often not suitable for normal use by the occupants.

The actual loading which the occupants of offices, their furniture, and storage put upon the floor will rarely exceed the loading from domestic occupation. Proper examination and stiffening of the floor should be carefully considered rather than ensuring that it can be justified by calculation to carry 2.5 kN/m². There should never be a need to justify a floor in an historic building to carry 5.0 kN/m².

References

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