Date: 06/09/01
Ref: 45/1/191

Note: The following letter was issued by our former department, the Department for Transport, Local Government and the Regions Department for Environment, Transport and the Regions (DTLR). DTLR is now Communities and Local Government - all references in the text to DTLR now refer to Communities and Local Government.

Building Act 1984 - Section 16(10)(a)

Determination of compliance with Requirement B3 (Internal fire spread (structure)) of the *Building Regulations 1991 (as amended)* in respect of the period of fire resistance of a major element of the structure of a building

The proposed work

4.The proposed building occupies a densely populated and busy city centre site. The building work comprises the erection of a 179.8m high free standing, steel framed tower with 39 storeys plus mezzanine above ground, and one basement level. The tower will be circular in plan, and its diameter will vary with height, with the maximum diameter of 53.8m occurring at level 16.

5.The steel framed structure will include the central core and on the perimeter a geodesic lattice framework, referred to as the diagrid, with horizontal beams which will act as circumferential hoop ties. Steel hollow sections will form the main members of the diagrid lattice which will support the outer edges of the floor plates and provide a stability system for the building. The diagrid will be based on two storey modular segments which repeat every 20° on plan.

6. The floors will be of composite metal deck and concrete construction. The external facade of the building will be almost entirely formed of glass. The plans and details do not specify the type of passive fire protection which will be used on the steel frame.

7.The building will be put mainly to office use (levels 2 to 28) and is designed for multi-tenancy. There will be some retail space at ground and first floor level. Ancillary facilities will be included, such as staff dining at the top of the building. Goods handling facilities and a small amount of car parking are to be provided in the basement.

8. Between levels 2 and 28 the office storeys will be linked, six stories at a time, by six triangular atria (as seen in plan) equally spaced around the perimeter. This pattern will be interrupted between levels 10 and 15, where there will be three pairs of two storey atria. Each floor plan will be rotated by 5 degrees with respect to the next storey. The effect of this will be to slant the atria.

9.The Fire Strategy for the building suggests that a system of phased evacuation will be adopted. There will be two protected stairways of 1.3m width positioned within the central core of the building.

10.The building is to be fitted with an automatic sprinkler system which will be generally in accordance with BS 5306: Part 2: Specifications for sprinkler systems, together with the additional requirements for life safety. A fire detection and directive voice alarm system designed to facilitate the phased evacuation strategy and a smoke management system will also be incorporated into an extensive package of fire safety measures.

11.Given the high ratio of glazing in the facade of this building you consider that a fully developed fire on one of the storeys would be well ventilated. However, the provisions for structural fire protection in the guidance in *Approved Document B (Fire safety)* do not vary with the degree of anticipated ventilation. Therefore in order to take advantage of this feature of the building you elected to adopt the equivalent time of fire exposure method for design given in the *Structural Eurocode 1 - Basis of design and actions on structures - Part 2-2: Actions on structures exposed to fire ENV 1991-2-2:1995*.

12.The period of fire resistance for the elements of structure of this building using the guidance given in *Approved Document B* would be 120 minutes. However, using the equivalent time of exposure method you produced calculations which showed that the period of fire resistance necessary for the diagrid would be 60 minutes.

13.These proposals were the subject of a full plans application which was rejected by the Council on the grounds of non-compliance with Requirement B3 of the Building Regulations. The Council was not prepared to accept that your proposed level of protection of 60 minutes for the diagrid would ensure that stability would be maintained for a reasonable period in the event of a fire. They have raised a number of concerns in respect to the methodology used, and the factors and coefficients selected for the calculations, and have suggested that in their view a minimum fire resistance period of 90 minutes would be required to satisfy Requirement B3.

14.However, you believe that your proposed period of fire resistance of 60 minutes will be capable of withstanding a fully developed fire which results in the burn-out of a compartment. On this basis you have argued that your proposed fire resistance period is therefore adequate. Accordingly, in your view this proposal would be in compliance with Requirement B3 and it is in respect of this question that you applied for a determination. The material date for your determination is the date your full plans application was deposited

with the Council and it therefore falls to be considered in respect of the *Building Regulations 1991* (as amended up to and including SI 1999/77).

The applicant's case

15. You consider that the proposed period of fire resistance for the diagrid structure is such that it will survive a burn-out of the fire compartment and as such Requirement B3 will be satisfied. This view is based on an analysis which follows a method given in the recommendations of Eurocode 1 (ENV 1991-2-2:1995).

16. In response to the Councils concerns with regard to the appropriateness of this method, and some of the factors and coefficients used in the calculations, you have argued that the method has only been applied where you consider it to be appropriate and that it has been applied using factors and coefficients given in the *National Application Document (NAD) BS DD ENV 1991-2-2:1996.* The Eurocode was developed by an international committee of leaders in the field of fire engineering, including representatives from the UK. It is your understanding that Eurocode 1 and the NAD will be formally adopted within the UK in due course. In particular you state the following:

(i)The values of fire load density used in your calculations were selected for consistency, in that these values were listed in Table 7 of the NAD, i.e. they were specifically defined as part of the method.

(ii)The fire loads in the Eurocode are not as high as those in *BS DD 240 Fire safety engineering in buildings: Part 1: Guide to the application of fire safety engineering principles: 1997*, but still represent substantial fire loads for office accommodation. The fire loads in DD 240 are 80 per cent fractile values. The fire load modification factors for consequence, risk and sprinkler protection have also all been taken from the NAD.

(iii) The NAD indicates that a value for kb of 0.09 should be used where no assessment of the lining materials is undertaken. The thermal inertias for the materials (plaster and block work) to be used in the proposed building are given in the Eurocode and elsewhere, and using these you have adopted a value of 0.07 for kb (as given in Table 8 of the NAD) for the values of inertia.

The Council's case

17.The Council takes the view that the proposed 60 minute period of fire resistance for the diagrid is not adequate. They point out that the fire engineering solutions given in the codes of practice which have been used have yet to be ratified by any recognised authority and that the guidance contained in DD 240 suggests that care should be taken in the use of time equivalence type formula.

18.The Council therefore takes the view that the figures selected by you are not sufficiently robust when considering such a large building, and the fact that the internal arrangements and fire loads could vary significantly with time. They consider that the consequences of failure are considerable given the large number of people which would be required to remain in the building awaiting evacuation, and the potential need to evacuate a large part of the surrounding area.

19.The Council has also raised the following concerns with regard to the factors and coefficients used in the design calculations:

(i)The base values for fire load density given in the Eurocode are lower than those used in DD 240 and may not reflect actual fire load particularly on dealing floors where a higher level of plastics from computer equipment will be present.

(ii)The height of the building makes fire fighting operations extremely difficult and requires large numbers of people to remain in the building awaiting evacuation. The fire load modification factor for consequence recognises this by multiplying the fire load density by a factor of 2.2 but this is negated by the factor for sprinklers (0.75) and in the case of retail areas a factor for the probability of a fire occurring (0.8).

(iii) The Council is concerned that fire protection should not be over-dependant on the successful operation of the sprinkler system. There will be times when the sprinkler system will be inoperative such as during alteration work. It is at these times that the probability of a fire occurring will also increase.

(iv) As the Building Regulations assume a fire will occur the probability factor used in a supporting formula should perhaps be unity.

(v)The thermal property conversion factor (0.07) adopted in the calculations assumes that the thermal inertia of the floor, wall and ceiling linings will never fall below 720 jms 1/2k. This is based on the figures contained in Table 8 of the NAD. However, the speculative nature of this building is likely to see the introduction of linings having a lower value. As a consequence the Council believes that the default value of 0.09 given in the NAD would offer greater comfort.

(vi) Sub-division of the floors by partitioning will delay the introduction of ventilation which will result in higher fire temperatures.

(vii) The temperatures which can be expected in a real fire may be higher locally than those specified in the standard fire resistance test. The ability of the fire protection to withstand these temperatures has not been established.

The Secretary of State's consideration

20.The Secretary of State takes the view that he is being asked to decide whether the proposed level of fire protection to the diagrid structure will be sufficient to ensure that the loadbearing elements of structure of the building will be capable of withstanding the effects of fire for an appropriate period without loss of stability.

21.The purpose in providing a structure with fire resistance is threefold, namely:

(i)to minimise the risk to the occupants, some of whom may have to remain in thebuilding for some time while evacuation proceeds if the building is a large one;

(ii)to reduce the risk to fire fighters, who may be engaged on search or rescue operations; and

(iii) to reduce the danger to people in the vicinity of the building, who might be hurt by falling debris or as a result of the impact of the collapsing structure on to other buildings.

22.In making this determination it is important not to confuse the period of fire resistance specified for the structure with the actual time it may take for a fire to cause a loss of stability in the building. This actual time will be dependent on the nature and location of the fire and the properties of the environment in which it occurs. In most cases, where the elements of structure in the building are adequately protected premature catastrophic failure is unlikely to occur.

23.In this case you have elected to adopt the equivalent time of fire exposure method for design given in the *Structural Eurocode 1 - Basis of design and actions on structures - Part 2-2: Actions on structures exposed to fire ENV 1991-2-2 :1995* which is in effect only in a trial format. This methodology is based on an innovative approach to establishing the necessary level of fire resistance required. In cases where such an innovative approach is adopted extra care must be taken to ensure that the approach used will satisfy the functional requirements of the Building Regulations as they apply to the specific building in question.

24.The Secretary of State therefore considers that two questions arise in this case:

(i) is the time equivalent method given in the Eurocode appropriate in the circumstances of this case to demonstrate compliance with Requirement B3?;

and if it is

(ii) are the factors and coefficients used in your calculations appropriate?

25.Compliance with a British Standard, or any similar guidance document, does not by itself indicate that the Building Regulations have been satisfied. Whilst it may be possible to use a draft standard as a means of demonstrating compliance, its use must be justified in terms of the particular circumstances of the building to be designed in relation to the scope of application of the design method. In the absence of specific guidance, reference needs to be made to the supporting documents used to develop and validate the design method. It is also necessary to explore the sensitivity of the method selected and to adopt reasonably pessimistic and robust design values.

26.The time equivalent method takes account of the fire load, thermal properties and in particular the ventilation conditions for the fire compartment. There have been some experimental validations of this method however these may not adequately reflect the complexity and scale of this particular building. For example, the area of ventilation used in the calculations is taken as the total area of glazing. Although this may be a reasonable assumption in many cases, in this case the Secretary of State takes the view that this assumption should have been addressed in more detail and other scenarios considered. It follows that he also takes the view that whilst the time equivalent method may be a means of demonstrating compliance with Requirement B3, in the circumstance of this case the method could be considered to be unreliable.

27.With respect to the thermal properties of the enclosure you have selected a conversion factor of 0.07 for use in the calculations. The Council, however, has suggested that the default value given in the NAD of 0.09 would be more appropriate. You have argued that the default value is only recommended where no assessment of lining materials has been undertaken and that you have selected 0.07 based on the thermal inertia values given in Table 8 of the NAD. The Secretary of State takes the view that the assessment you have made of the thermal properties of the enclosure are not sufficiently detailed to justify the conversion factor that you have selected.

28.With respect to the fire load density you have selected a value of 500MJ/square metres which is given in the NAD. However, the Council has referred you to other data given in BS DD 240 which suggests a higher value of 570MJ/square metres should be used for calculation purposes. You have argued that this higher 570 fire load is an 80 per cent fractile value and that the value you have selected (500) is specified as part of the method given in the draft NAD. Whilst it would not be normal practice to mix design values from different codes the Secretary of State accepts that there is merit in adopting a value which is more statistically robust. Using values lower than the 80 per cent fractile could result in an unacceptable probability of underestimation of the actual fire load. It would therefore have been appropriate to examine the sensitivity of your calculations to variations in this value.

29.Finally, you will wish to be aware that the Secretary of State has noted that work on the development of the Eurocodes, including Eurocode 1, is still in progress. The most recent version of the draft Eurocode (*prEN 1991-1-2:*

March 2001) now includes the 80 per cent fractile figure of 511 MJ/square metres for fire load in offices.

The determination

30.The Secretary of State considers that compliance with the requirements of Part B of the Building Regulations is a life safety matter. He has given careful consideration to the particular circumstances of this case and the arguments presented by both parties.

31.The Secretary of State has considered, in particular, the arguments presented in respect of both the appropriateness of the methodology adopted and the appropriateness of the coefficients and calculations applied. Whilst he does not seek to question the validity of the time equivalence methodology, he is not satisfied that all possible limitations of this method of calculation have been fully addressed. In particular, he considers that the factors and coefficients used in the calculations are insufficiently robust and pessimistic to ensure a reasonable level of safety having regard to the height, design, level of occupancy, and city centre location of the building with all the implications which this carries for public and fire fighter safety.

32.Having taken all the above matters into account, and the particular need to ensure the safety of persons in and about the proposed building, the Secretary of State has concluded, and hereby determines, that your proposals do not comply with Requirement B3 (Internal fire spread (Structure)) of Schedule 1 to the Building Regulations 1991 (as amended up to and including SI 1999/77).