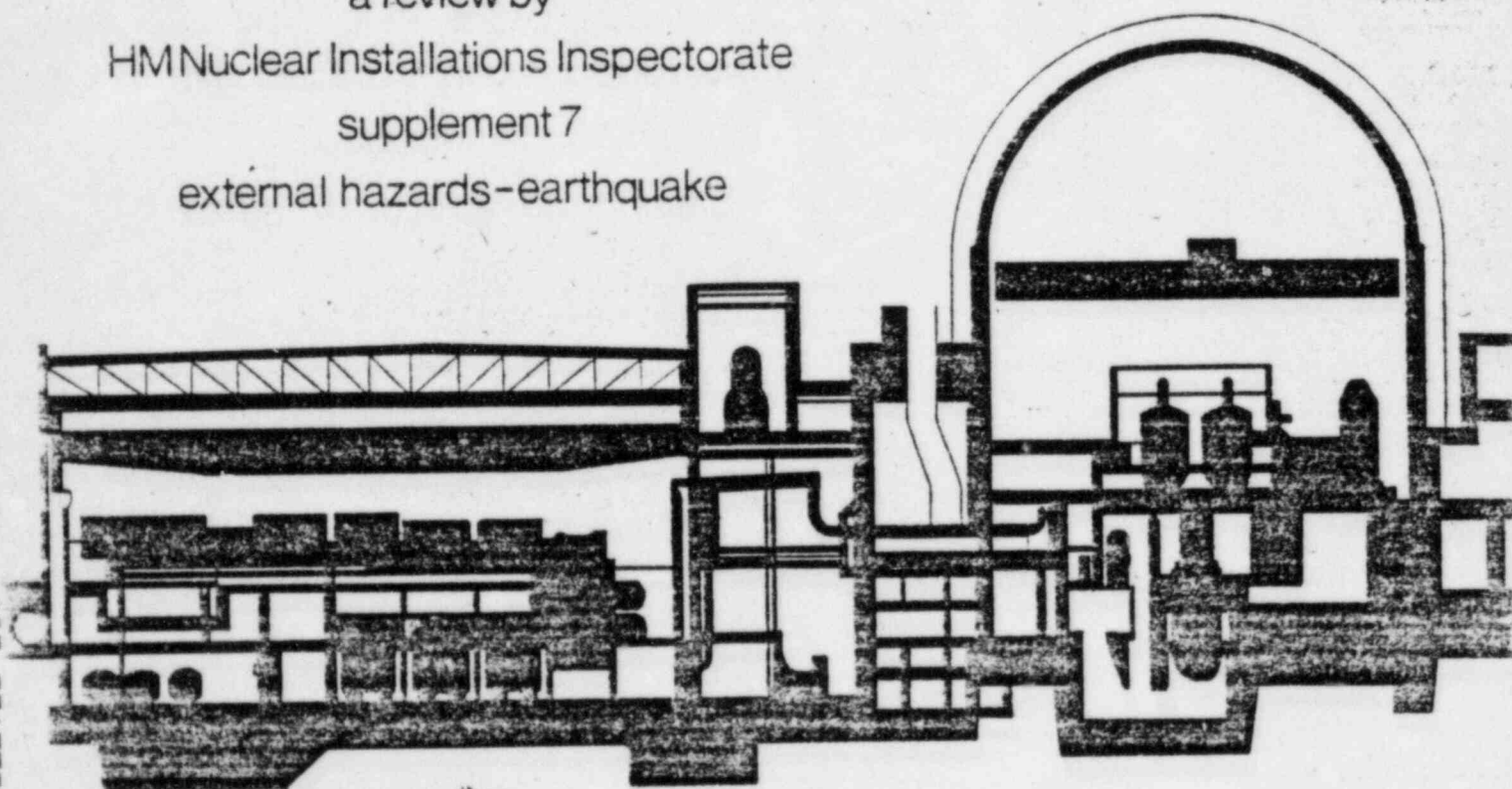


NII 01 (SUPP 7)

Sizewell B

a review by
HM Nuclear Installations Inspectorate
supplement 7
external hazards - earthquake



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Supplement 7: External hazards – earthquake NII 01 (SUPP 7)

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INTRODUCTION

1. In its Review of the CEBG's Pre-Construction Safety Report (PCSR) for Sizewell 'B' (ref 1), published in July 1982, The Inspectorate commented upon a number of aspects of the design against external hazards. In particular, in paragraphs 4.10 to 4.24, 5.23 and 8.6, comment was made on the safety case in relation to earthquakes. It was concluded, in paragraph 19.5, that the case presented was not yet satisfactory and that design changes might be required.

2. In December 1982 the CEBG replied to these comments, with a paragraph by paragraph response, in a report R018 (ref 2). This report was supported by other reports both by CEBG and their consultants. The Inspectorate has examined R018 and its supporting reports, and has discussed them with CEBG. Its current views on the safety case relating to protection against the effects of earthquakes are given in this supplementary report. For convenience, this report follows the format of R018, the CEBG's response being examined against each relevant paragraph of the Review.

EARTHQUAKES BEYOND THE SAFE SHUTDOWN EARTHQUAKE (SSE) LEVEL (4.11)

3. The Inspectorate has expressed a number of reservations relating to the CEBG's response to its request for sensitivity studies of system response to events greater than the safe shutdown earthquake (SSE) level. The Inspectorate does not share the CEBG's view that the claimed conservatisms are universally available or that they could be readily quantified. It was therefore concerned that, in R018, the CEBG undertook sensitivity studies only in the band immediately above the SSE level without specifying the level proposed.

4. As a result of further discussion, the CEBG has undertaken that its studies will extend to a zero period acceleration (ZPA) of 0.35g (ie 40% above the SSE level) for components qualified by analysis. The Inspectorate will require that, for those components qualified by test, the tests levels will be set sufficiently above 0.35 as to ensure an appropriate survival rate at 0.35g. The Inspectorate considers that these would provide an acceptable basis for licensing.

5. The Inspectorate considers these sensitivity studies to be both important and urgent because achievement of the required level of reliability may be more difficult to demonstrate for events above the SSE level, and because it may be reasonably practicable to make certain design modifications, for example, to provide additional bonded reinforcement in the critical areas of the containment. Hence the Inspectorate will require at least preliminary results of sensitivity studies on the major components qualified by analysis to be available prior to licensing.

PERMISSIBLE STRESSES IN THE SSE (4.12, 4.13)

6. At the time of the Review the CEGB had given an undertaking that stresses under the action of the SSE will be shown to be within ASME Service Level B limits for active components required to function during or after an earthquake, and within Service Level D limits for all other Seismic Category 1 components and structures. This was generally acceptable but the Inspectorate had two reservations on the details of these proposals as it understood them. The first was that all active components (as defined, for example, in the US Code of Federal Regulations) should be covered by the Service Level B limits. This would include, for example, the supports of the reactor pressure vessel, of the steam generators and of the reactor coolant pumps. The CEGBs intentions were not clear with regard to these components. The second was that the Inspectorate is not yet satisfied that the Service Level D limits on stresses are adequate for assuring the integrity of the structures unless these stress limits are applied to the combined SSE and loss of coolant accident (LOCA), or SSE and steam line break (SLB), load cases. This is discussed later in paragraph 9 and 10.

7. It is considered that the CEGB response in R018 does not take account of the concerns in the Review in a sufficiently comprehensive way. In this context the most important criticisms are:

- (a) The steam generator support columns, the steam generator snubbers, and the reactor coolant pump support columns and tie bars are required to function as active components during an earthquake. Measurement of the potentially

increased bending stress in the columns is now proposed by the CEEB as a means of monitoring the support column friction forces (ref 3). Hence, loss of functional integrity of these bearings will enhance column/bending stresses compared to those calculated by the proposed models. Functional integrity of all of these components after the earthquake is also required to ensure safe shutdown (and that is required for all seismic events greater than Operational Shutdown* level).

- (b) No demonstration has yet been provided for bearing integrity under fluctuating lateral loads.
- (c) There is no reliable experimental data which allows direct correlation between stress level and probability of failure; this weakness is especially significant for those components whose failure is deemed to be incredible.

8. After exchange of correspondence and further discussion, the CEEB has given a commitment to adopt permissible levels of stress, appropriate to SSE loading, which provide an acceptable basis for licensing. This includes meeting ASME Service Level B stress limits for all supports and restraints for components such as the reactor pressure vessel, the steam generators and the reactor coolant pumps, and not only for those assigned as "active" components in ROL8.

LOAD COMBINATIONS (4.14)

9. For reasons that are partly explained above, the Inspectorate is not convinced that ASME stress limits either guarantee functional integrity and operability when many components and structures may fail on account of excessive displacements, or guarantee against failures of components susceptible to fracture mechanisms if defects are

* Operational Shutdown Earthquake (OSE) level is effectively synonymous with Operating Basis earthquake (OBE) but there is no fixed relationship between OSE and SSE, whereas in the USA the OBE is set at a minimum level of half that of the SSE level).

postulated, or provide assurance against common cause effects. These concerns are the more crucial for those components whose failure is deemed to be "incredible". Furthermore, ASME requires the designer to apply Service Level D limits to all credible faulted load combinations. Additionally, the considerations of relative importance of seismic stresses discussed in the CEGB's response is valid for parts of the loop pipework, but is not valid for primary component supports and restraints.

10. The Inspectorate has advised the CEGB that the position advanced in the report R018 does not provide an satisfactory basis for licensing on four main grounds:

- (a) It is reasonably practicable to design for the load combination of safe-shutdown earthquake (SSE) plus loss-of-coolant accident (LOCA) loads. This load combination is a design load case in the majority of Westinghouse PWR plants, including the SNUPPS Units.
- (b) Considerable additional confidence, in terms of safety, is provided by SSE and LOCA load combination and it is difficult to see how this confidence could be achieved otherwise.
- (c) The main argument of the CEGB case in R018 depends upon the Load Combination Project, originally part of the Seismic Safety Margins Review Programme (SSMRP), conducted by the Lawrence Livermore National Laboratories for the USNRC. It is the Inspectorate's view that much of the data, assumptions and methodology used in this project are not yet sufficiently well validated to provide an acceptable basis for regulatory purposes.
- (d) The Inspectorate considers that there would be a worthwhile increase in confidence if the load combinations SSE and LOCA, and SSE and SLB (main steam line break) were factored into the design, particularly that of the containment.

11. The position adopted by the CEBG in R018 is not presently acceptable, and the Inspectorate requires that this issue be resolved to its satisfaction prior to licensing.

OPERATIONAL SHUTDOWN EARTHQUAKE (OSE)

12. The CEBG's response in R018 does not make proper allowance for the fact that earthquakes do not occur as single events widely spaced in time, but usually occur as a series of shocks; nor does the response recognise that pre-cursors and aftershocks frequently approach the severity of the main shock. Such allowance would require that all pressure-bearing components have multiple OSE events factored with all the Design Specification loads into their fatigue analysis, and all components seismically qualified by test must have multiple OSE events included in their test programme before the SSE test in order to satisfactorily pre-qualify for continued operation for events at or below OSE level.

13. The Inspectorate would expect such pre-qualification to be on the basis of an appropriate demonstration either by analysis or test. Mere inspection of stress levels, as proposed in the CEBG's response, is insufficient to give the pre-qualification sought.

14. In recent correspondence the CEBG has undertaken to include multiple OSE events in the fatigue analysis of all those components whose failure is deemed "incredible". Other components qualified by analysis will be pre-qualified for multiple OSE events on a sampling basis. In addition, the test programmes of those components qualified by test will include multiple shocks at a level corresponding to the maximum OSE floor response prior to test at a level corresponding to SSE excitation. (For the reasons advanced in paragraph 4, this latter test may well be at levels above that corresponding to 0.35g ZPA). In discussion, the Inspectorate has indicated that 6 OSE events factored into the analysis or tests should give a sufficient level of pre-qualification for continued operation.

EXTERNAL HAZARDS TRIP (4.17)

15. The Inspectorate would wish to see consideration given to a trip, controlled by excitation from external hazards, to provide automatic shut-down of the reactor in the event that the external hazard exceeds that level against which the plant is pre-qualified (for example, the OSE level). Following tripping because of an external hazard it would then be necessary for the CEBG to revalidate the plant for further service before plant start-up would be permitted. The CEBG has not yet put forward such a provision nor proposed any alternative philosophy of recovery from external hazard events.

16. In the light of criticism, by the Inspectorate, of the response in R018, the CEBG has undertaken to re-examine the question. The Inspectorate has required that assurance be given either that an external hazard trip will be implemented or else that such a trip could be implemented during the design stage without serious cost or programme implications, prior to licensing.

SAFE SHUTDOWN EARTHQUAKE (5.23)

17. The Inspectorate accepted in the Review the zero period acceleration of 0.25g assigned to the safe shutdown earthquake (SSE) corresponds approximately to the expected excitation at the 10^{-4} events/year level, based on mean UK seismicity. However it noted that the two largest earthquakes in the past century have occurred in the East Anglia region (Colchester and Dogger Bank) and both appeared to have offshore epicentres. Accordingly, it looked for assurance that no offshore tectonic features (faults) exist, which might render inappropriate the assumption of mean seismicity.

18. In addressing the Inspectorate's concern for potential offshore faults that might influence seismicity CEBG present the results of offshore and onshore studies. (ref 7) By virtue of the survey data presented the Inspectorate accept the CEBG's view that none of the evidence suggests the existence of any capable fault offshore such as to risk the site being in the epicentral region of a tremor on such a

fault. Of the faults that have been revealed by the extensive surveys, conducted in the main by the Institute of Geological Sciences (IGS) and the Oil Companies, only the Hewitt Fault (which we previously postulated as part of a Dowsing/Hewitt/Rhine Graben tectonic structure) would appear capable. Irving (Ref 4) has shown that if Rhine Graben seismicity (which is higher than UK mean seismicity) is postulated on the Hewitt fault and attenuated through the substantial distance to the site, the result is to predict a lower zero period acceleration (ZPA) versus frequency than is predicted by assuming mean UK seismicity. The CEEB has indicated its intention to follow up several other surveys of the Southern North Sea for which tectonic interpretation is not yet available, and this should provide further corroboration of its view.

19. In regard to on-shore faulting the CEEB has addressed the broad spread of available information which includes satellite photographs. In the particular case of the so-called "Mid Essex Fault" the CEEB judgement is based predominantly on negative information (ref 7). Nonetheless it does not seem reasonable to categorise this as a potentially active fault since there does not appear any evidence of movement in the ice-age deposits. Some specific questions still remain to be addressed in the context of on-shore tectonics, but at this time the Inspectorate considers that its questions in the Review about offshore tectonics have been satisfactorily addressed, and the reservation about the level of excitation assigned to the SSE is accordingly removed.

20. In the further work provided in support of the CEEB's case (refs 5, 6) the additional studies of historical seismicity have refined and extended the catalogue of British earthquakes in an important degree. However, in processing the catalogue information from assigned intensities through deduced magnitudes to reassessment of British seismicity, several unvalidated methodologies are employed and many unsubstantiated assumptions are made. In such circumstances, prudence dictates the adoption of the most conservative of the results, providing always that it is reasonably practicable to do so. Thus, the Inspectorate accepts that 0.25g ZPA assigned to the SSE corresponds to

about 10^{-4} /yr frequency for a plant located in an area where no evidence exists to indicate seismicity above mean UK seismicity.

21. The CEBB has conducted a further study which responds to a question which the Inspectorate raised about the long-period low amplitude motion following an earthquake, which is not usually recorded by a seismograph (since it is usually switched on and off by a threshold amplitude of motion) but which could represent a particular problem if resonance with sloshing fluids occurred. This study has led CEBB to conclude that it would be desirable to enhance the low-frequency end of the Design Response Spectra compared with that previously reported. (ref 8).

FOUNDATIONS (8.6)

22. In the light of the Inspectorate's acceptance of the CEBB's response to its paragraph 5.23 concern for offshore tectonics, the the Inspectorate accepts the CEBB view that there appears to exist no potential for soil fluidisation even at events of greater severity than SSE. However, a few reservations remain to be addressed in terms of local variation in soil properties, before licensing.

CONCLUSIONS

23. The CEBB response in R108 to the Inspectorate's concern for conduct of sensitivity studies discussed in paragraph 4.11 of the Review, was not considered to be adequate. As a result of further discussion with CEBB a basis for these sensitivity studies has been agreed which should be acceptable as a basis for licensing. The Inspectorate will require at least preliminary results of sensitivity studies on major components qualified by analysis to be available prior to licensing.

24. The CEBB's response in R108, supplemented by correspondence in which the CEBB undertakes that all primary component supports and restraints will meet ASME Service Level B stress limits under SSE .

loading, adequately responds to the Inspectorate's concern, expressed in paragraphs 4.12 and 4.13 of the Review, with the exception of load combination, (further discussed below).

25. The CEBG's response in R108 to the Inspectorate's concern for load combinations, expressed in paragraphs 4.13 and 4.14 of the Review, is not judged to provide an acceptable basis for licensing. Although further correspondence has passed between the Inspectorate and the CEBG and several discussions have been held since receipt of R108, no substantial progress has been made towards resolution. The Inspectorate will require satisfactory resolution of this issue prior to licensing.

26. The CEBG's response in R108 to the Inspectorate's concern for pre-qualification of the plant for continuance of operation following events up to OBE or OSE level, discussed in paragraphs 4.15 and 4.16 of the Review, was not judged to be sufficient. As a result of further correspondence and discussion, however, a basis has been agreed that is likely to be acceptable for licensing.

27. The CEBG's response in R108 to the Inspectorate's concern for an external hazard trip, expressed in paragraph 4.17 of the review, is not judged to provide an adequate basis for licensing. Following further discussions the CEBG has undertaken to review its position. The Inspectorate will require either an undertaking that an external hazard trip will be implemented or else an assurance that such a trip could be implemented during the design phase without significant programme or cost impact, prior to licensing.

28. The CEBG's response in R108, and its supporting document, adequately responds to the Inspectorate's concern for the possible existence of offshore tectonic features that might have invalidated the CEBG assumption of mean UK seismicity, expressed in paragraph 5.23 of the Review. This reservation is therefore withdrawn. As a consequence, the major reservation expressed in paragraph 8.6 of the Review, in terms of the potential for soil fluidisation is also withdrawn.

29. In response to the conclusions expressed in the Review in the area of design against earthquakes, CECB and its consultants have provided a substantial body of new material. As a result of this material, and subsequent correspondence and discussions, agreement has been reached on a basis, acceptable for licensing, on sensitivity studies of events beyond the SSE level, on the level of permissible stresses arising from SSE loads, on the pre-qualification approach to OBE or OSE loads, and on the absence of offshore tectonic features that might influence the seismicity of the Sizewell site. No agreement has yet been reached on load combinations, or on the provision of an external hazards trip. On both of these issues the Inspectorate will seek a basis which satisfies its concern prior to licensing.

HMNII

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