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PUBLISHED DOCUMENT

Recommendations for the design of structures for earthquake resistance to BS EN 1998

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Foreword

Publishing information

This Published Document is published by BSI and came into effect on 31 July 2009. It was prepared by Subcommittee B/525/8, *Structures in seismic regions*, under the authority of Technical Committee B/525, *Building and civil engineering structures*. A list of organizations represented on these committees can be obtained on request to their secretary.

Information about this document

This Published Document is a background paper that gives non-contradictory complementary information for use in the UK with the following parts of BS EN 1998, *Design of structures for earthquake resistance*, and their UK National Annexes:

- *Part 1: General rules, seismic actions and rules for buildings;*
- *Part 2: Bridges;*
- *Part 4: Silos, tanks and pipelines;*
- *Part 5: Foundations, retaining walls and geotechnical considerations;*
- *Part 6: Towers, masts and chimneys.*

It is not planned to issue a UK National Annex or Published Document to BS EN 1998-3, *Assessment and retrofitting of existing buildings*, because it is considered that little use will be made of this part for buildings in the UK.

Presentational conventions

The word “should” is used to express recommendations of this Published Document. The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Contractual and legal considerations

This publication does not purport to include all necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a Published Document cannot confer immunity from legal obligations.

Introduction

When there is a need for guidance on a subject that is not covered by the Eurocode, a country can publish documents containing non-contradictory complementary information that supports the Eurocode. This Published Document provides just such information and has been cited as a reference in the UK National Annexes to BS EN 1998-1:2004, BS EN 1998-2:2005, BS EN 1998-4:2006, BS EN 1998-5:2004 and BS EN 1998-6:2005.

1 Scope

This Published Document provides non-contradictory complementary information for use in the UK with BS EN 1998-1:2004, BS EN 1998-2:2005, BS EN 1998-4:2006, BS EN 1998-5:2004 and BS EN 1998-6:2005, and their UK National Annexes.

This Published Document gives background information and some additional guidance on the clauses subject to National Choice in these parts of BS EN 1998.

This document only covers the United Kingdom and does not consider conditions applicable to British Overseas Territories, where seismological and other aspects might be very different. It is restricted to considerations for the design of new structures within the scope of BS EN 1998-1, BS EN 1998-2, BS EN 1998-4, BS EN 1998-5 and BS EN 1998-6 to resist seismic actions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 1990:2002, *Eurocode – Basis of structural design*

BS EN 1991-1-5:2003, *Eurocode 1: Actions on structures – Part 1-5: General actions – Thermal actions*

BS EN 1998-1:2004, *Eurocode 8 – Design of structures for earthquake resistance – Part 1 General rules, seismic actions and rules for buildings*

BS EN 1998-2:2005, *Eurocode 8 – Design of structures for earthquake resistance – Part 2 Bridges*

BS EN 1998-4:2006, *Eurocode 8 – Design of structures for earthquake resistance – Part 4 Silos, tanks and pipelines*

BS EN 1998-5:2004, *Eurocode 8 – Design of structures for earthquake resistance – Part 5 Foundations, retaining walls and geotechnical considerations*

BS EN 1998-6:2005, *Eurocode 8 – Design of structures for earthquake resistance – Part 6 Towers, masts and chimneys*

3 Assessing the need for seismic design of structures within the UK

3.1 Function, location and form of structure

The UK National Forewords to BS EN 1998-1 and BS EN 1998-5 state the following:

“There are generally no requirements in the UK to consider seismic loading, and the whole of the UK may be considered an area of very low seismicity in which the provisions of EN 1998 need not apply. However, certain types of structure, by reason of their function, location or form, may warrant an explicit consideration of seismic actions.”

3.2 to 3.4 discuss in turn how the *function*, *location* and *form* of a structure in the UK affect the need for seismic design.

3.2 Influence of function

For most engineered and non-engineered structures in the UK, natural hazards, such as wind, flood, ground movements due to moisture change, and extreme temperatures, pose a substantially higher risk of injury and economic loss over the lifetime of a structure than the risk posed by earthquakes. However, in some cases the function of a structure is such that failure due to very low probability events, including earthquakes, might need to be considered. At least four such categories of structure can be distinguished, as follows.

- 1) Structures where failure poses a large threat of death or injury to the population. Examples include nuclear power plants and major dams (both of which are explicitly outside the scope of BS EN 1998) and certain petrochemical installations, such as liquid natural gas (LNG) storage tanks and high pressure gas pipelines (which are within the scope of BS EN 1998).
- 2) Structures which form part of the national infrastructure and the loss of which would have large economic consequences. An example is a major bridge forming a transportation link vital to the national economy.
- 3) Structures whose failure would impede the regional and national ability to deal with a disaster caused by a major damaging earthquake.
- 4) Strengthening or upgrading of historic structures forming an important part of the national heritage.

In many cases, structures could fall into more than one category; for example, the seismic failure of a busy estuarial bridge might cause extensive human casualties, affect the regional or national economy and also impede the flow of disaster relief into the area affected by the earthquake.

In some cases, UK legislation requires an explicit consideration of seismic design for certain types of infrastructure. In other cases, seismic considerations have been widely applied, even in the absence of legislation, for example in the assessment of major dams and in the contractual specifications for the design of major bridges. There might be other cases where the owner of a structure decides that an explicit seismic design is required for economic or other reasons; the local

level of seismic hazard and the particular sensitivity of the structure to seismic excitation (as discussed in 3.3 and 3.4) are likely to influence that decision.

3.3 Influence of location

The location of a structure affects the regional seismic hazard, which varies significantly across the UK, as discussed in Clause 4; that is, the earthquake ground motions for a given annual probability of exceedence are significantly greater in some parts of the UK than others, although everywhere the hazard is very low by international standards.

Location also affects the local influences on seismic hazard; in particular, the effect of superficial soil deposits in modifying seismic ground motions.

3.4 Influence of structural form

All structures possess some degree of earthquake resistance, and this is greatly enhanced by regulatory requirements to provide measures enhancing robustness, such as peripheral ties in buildings and detailing to increase ductility, and by the provision of wind resistance. In many cases, these are considered to provide sufficient protection against seismic actions in the UK. However, certain features might result in designs that are satisfactory for resisting wind but are vulnerable to seismic loading. Examples of such seismically unsatisfactory features in building structures are open and relatively weak ground storeys, very heavy roof masses and large eccentricities between centres of mass and stiffness. Examples for bridges are bridge decks on bearings which provide poor lateral restraint, and concrete bridge piers which are poorly confined by transverse reinforcement.

3.5 Decision on seismic design

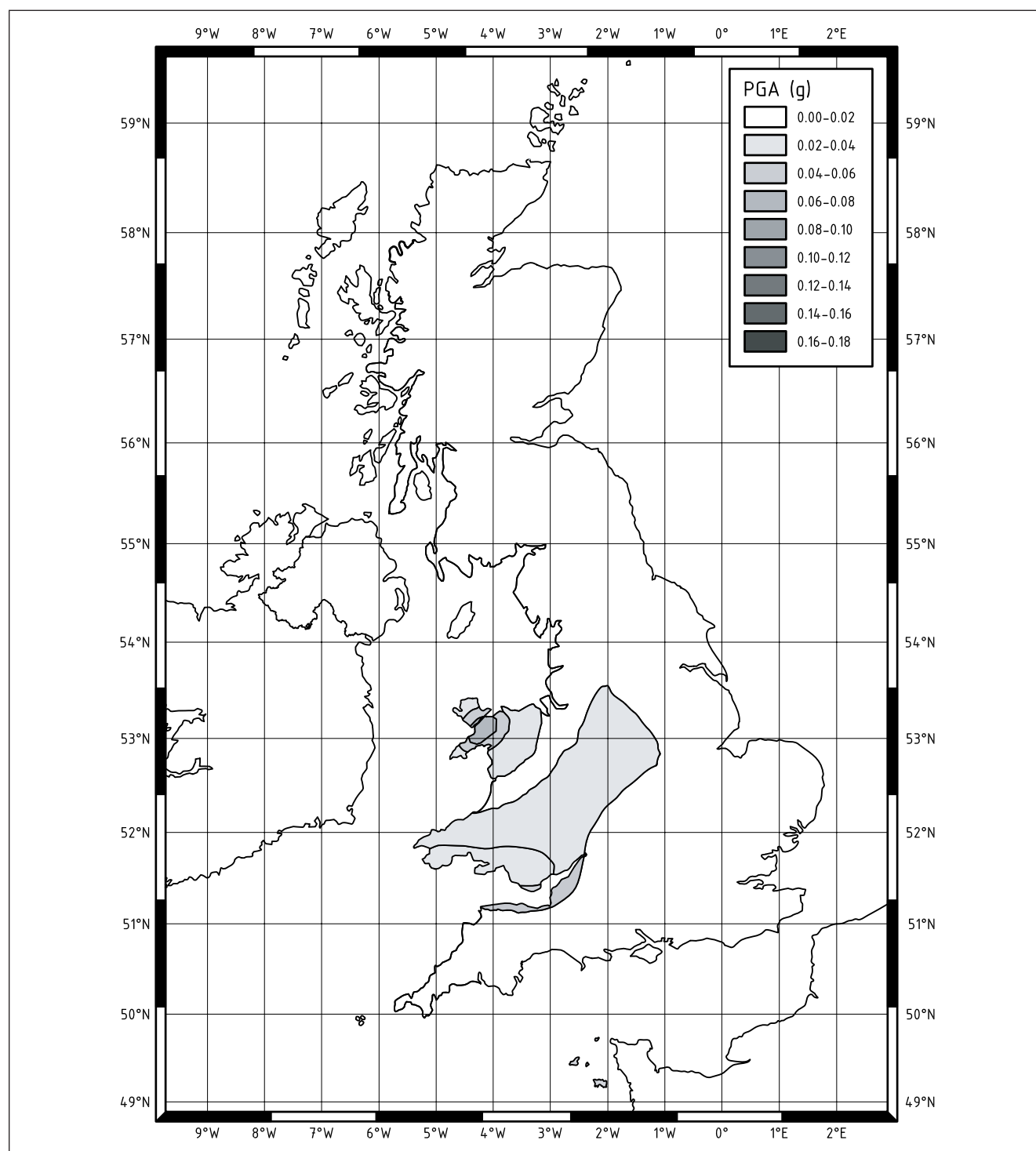
It is the responsibility of the designer to establish whether statutory or other considerations require an explicit seismic design. In the absence of statutory requirements or contractual specifications, structures classified by BS EN 1990:2002, Table B1, as being in consequence classes CC1 or CC2 are unlikely to warrant seismic design, provided they are adequately designed for non-seismic design conditions.

For structures in consequence class CC3, the need for an explicit seismic design should be considered, although in many cases examination of the consequences of failure, location and structural form will indicate that an explicit seismic design is not warranted. Specific advice for the design of buildings, bridges, and silos, tanks and pipelines is given in Clauses 7, 8 and 9 respectively.

4 Seismic hazard in the UK

An assessment of the seismic hazard in the UK was carried out at the British Geological Survey by Musson and Sargeant [1], for the purposes of preparing the UK National Annex to BS EN 1998-1 and this Published Document. Figure 1 and Figure 2 show the seismic hazard maps that resulted from this exercise. Note that Figure 1 corresponds to the definition of a_{gR} in BS EN 1998-1 for the recommended reference return period of 475 years.

Figure 1 Seismic hazard map of 475 year return period Peak Ground Acceleration (PGA) on rock (redrawn from Musson and Sargeant [1])



Comparison of the peak ground acceleration (PGA) values shown in Figure 1 with PGA values found worldwide (see, for example, GSHAP [2]) shows that seismic hazard in the UK is very low by international standards. The recommended definition of a very low seismicity region in BS EN 1998-1 is an a_{gR} value of less than 0.04 g for a 475 year return period; application of the Eurocode is not required in such regions. It can be seen from Figure 1 that only a very small part of Wales exceeds this recommended value and Musson and Sargeant's study [1] found no values exceeding 0.08 g. The zoning of the whole

of the UK as an area of very low seismicity given in the UK National Forewords to BS EN 1998-1 and BS EN 1998-5 therefore essentially accords with the definition of very low seismicity recommended by the Eurocode. It may be observed, however, that the Eurocode provides an alternative definition of very low seismicity regions as those where the product a_{gRS} (i.e. the design PGA on soil) exceeds 0.05 g; this represents the PGA at the reference return period after allowing for the amplifying effects of soil on the bedrock motions. It is likely that a rather larger area of the UK would exceed the "very low" seismicity threshold on this definition, but the area would still be relatively small.

Figure 2 Seismic hazard map of 2500 year return period Peak Ground Acceleration (PGA) on rock (redrawn from Musson and Sargeant [1])

