EDICT OF GOVERNMENT

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MAGNA CARTA (1297)
NATIONAL ANNEX

UK National Annex to Eurocode 3: Design of steel structures –
Part 1-9: Fatigue

ICS 91.010.30
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Introduction
This National Annex has been prepared by BSI Subcommittee B/525/10, Bridges, in consultation with B/525/31, Structural use of steel. In the UK it is to be used in conjunction with BS EN 1993-1-9:2005.

NA.1 Scope
This National Annex gives:

a) the UK decisions for the Nationally Determined Parameters described in the following clauses and subclauses of BS EN 1993-1-9:2005:

- Clause 2(2)
- Clause 2(4)
- Clause 3(2)
- Clause 3(7)
- Clause 5(2)
- 6.1(1)
- 6.2(2)
- 7.1(3)
- 7.1(5)
- Clause B(4)

b) references to non-contradictory complementary information.

NA.2 Nationally Determined Parameters

NA.2.1 Material and execution tolerances and information on inspection requirements for fabrication [BS EN 1993-1-9:2005, 1.1(2)]

NA.2.1.1 Material and execution tolerances
Until such time as BS EN 1090-2 is published, the rules are applicable to structures where execution conforms to either BS 5400-6:1999 for bridges or BS 5950-2:2001 for buildings. Note that, where BS 5400-6:1999 makes reference to minimum class requirements D, E and F, Unspecified, these may be taken to refer to a minimum requirement for the value of $\Delta \sigma_r = 91 \text{ N/mm}^2$, $80 \text{ N/mm}^2$, $63 \text{ N/mm}^2$ and $56 \text{ N/mm}^2$ respectively. For additional guidance see NA.3.
NA.2.1.2 Information on inspection requirements for fabrication

For the safe life method of assessment, special inspection and testing requirements for welds, cut edges and plain surfaces should be provided on drawings for all applications where the minimum required fatigue strength exceeds the relevant value of $\Delta \sigma_c$ in Table NA.1.

Table NA.1 Minimum required fatigue strength

<table>
<thead>
<tr>
<th>Detail type according to BS EN 1993-1-9</th>
<th>Fatigue strength levels, $\Delta \sigma_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 8.1</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Table 8.2</td>
<td>1, 2, 3, 4, 5, 6, 7, 10, 11</td>
</tr>
<tr>
<td></td>
<td>1, 2, 4, 5, 7, 19</td>
</tr>
<tr>
<td>Table 8.3</td>
<td>8, 10</td>
</tr>
<tr>
<td></td>
<td>3, 6</td>
</tr>
<tr>
<td>Table 8.4</td>
<td>4</td>
</tr>
<tr>
<td>Table 8.8</td>
<td>5</td>
</tr>
</tbody>
</table>

NOTE Minimum required fatigue strength is the value of $\Delta \sigma_c$ that would just achieve compliance with BS EN 1993-1-9:2005, Clause 8.

For additional guidance see NA.3.

NA.2.2 Fatigue loading models

[BS EN 1993-1-9:2005, Clause 2(2)]

NA.2.2.1 Sources of fatigue loading

All sources of fluctuating stress in the structure should be identified and should be obtained from the relevant parts of BS EN 1991. For fatigue loading not covered in BS EN 1991 the following should receive particular attention:

a) superimposed moving loads, including vibrations from machinery in stationary structures;

b) environmental loads such as wind, waves, etc.;

c) acceleration forces in moving structures;

d) temperature changes.

Where no published data for live loading exist, the partial safety factors for fatigue load intensity for safe life design should take into account the degree of confidence in the prediction of the design load spectrum from the available data. Recommended values of $\gamma_{f1}$ are given in Table NA.2.
Recommended $\gamma_{fl}$ for safe life design

<table>
<thead>
<tr>
<th>Number of standard deviations on load intensity</th>
<th>Value of $\gamma_{fl}$</th>
<th>$\pm 0$ standard deviations $^{A)}$</th>
<th>$\pm 2$ standard deviations $^{A)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.5</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>+1</td>
<td>1.3</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>+2</td>
<td>1.1</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

$^{A)}$ Number of standard deviations on number of cycles.

Reference to guidance on determination of specific fatigue loading models is given in NA.3.

**NA.2.3 Determination of fatigue strength from tests**

[BS EN 1993-1-9:2005, Clause 2(4)]

Reference to guidance on determination of specific fatigue strength data from tests is given in NA.3.

**NA.2.4 Provisions for in-service inspection programmes**

[BS EN 1993-1-9:2005, Clause 3(2)]

In the event that the damage tolerant assessment method is to be used, the following provisions apply.

a) The designer should be satisfied that the Maintaining Authority for the structure is aware of the practical requirements and the likely costs of provision of access, the inspection itself, possible repair and temporary loss of service, prior to approval being given.

b) Any potential fatigue crack initiation sites should be on or close to a surface which will be readily accessible in service.

c) The method or methods of inspection should be specified for each potential fatigue initiation site. Inspection for fatigue cracking requires more sophisticated techniques than are used for normal principal inspections.

d) The minimum size of detectable fatigue crack should be specified for each initiation site, taking into account the capability of the methods in c).

e) The maximum tolerable size of fatigue crack (using fracture mechanics) for fracture under ULS loading should be calculated.

f) The time taken for the fatigue crack to grow from the minimum detectable size in d) to the fracture tolerable size in e) should be calculated by fracture mechanics using upper bound crack growth data and the upper bound fatigue loading.

g) The maximum interval between inspections should be not more than half the time calculated in f). This may be less than the interval between principal inspections.

h) Guidance should be given on any requirements for taking the structure out of service or increasing the inspection frequency in the event that cracks are detected.
i) Viable schemes should be drawn up for repair, strengthening or replacement of the member where fatigue cracks have been detected.

j) A maintenance manual should be provided to the maintaining authority at the time of commissioning of the structure, giving details of the items in c), g), h) and i).

NA.2.5 Assessment method, definition of class of consequence and partial factor for fatigue strength [BS EN 1993-1-9:2005, Clause 3(7)]

NA.2.5.1 Assessment method
Steel structures subject to fatigue loading should be assessed using the safe life method, unless otherwise agreed with the Maintaining Authority.

NA.2.5.2 Classes of consequences
Unless otherwise specified in the project specification, all steel structures subjected to fatigue should be consequence class CC2 according to BS EN 1990:2002, Annex B. If consequence class CC1 or CC3 is specified, the appropriate $K_{Fi}$ factors should also be applied. The values in BS EN 1990:2002, Annex B are recommended.

NA.2.5.3 Partial factor for fatigue strength
For steel structures assessed for safe life using the detail categories given in BS EN 1993-1-9:2005, Tables 8.1 to 8.10, and the fatigue loading in BS EN 1991-2, a value of $\gamma_{Mf} = 1.1$ should be used irrespective of consequence class in BS EN 1990:2002. For additional guidance see NA.3.

NA.2.6 Stress limitations for Class 4 sections [BS EN 1993-1-9:2005, Clause 5(2)]
The effects of excessive repeated non-linear out of plane deflection in flat panels might be neglected if the slenderness of plates meets criterion (2) of BS EN 1993-2:2006, 7.4.

NA.2.7 Use of nominal, modified nominal and geometric stress ranges [BS EN 1993-1-9:2005, Clause 6.1(1)]
Reference to guidance on determination of stress ranges is given in NA.3.
NA.2.8 Design value of nominal stress range
[BS EN 1993-1-9:2005, Clause 6.2(2)]
Where no $\lambda_i$ values are given it is not possible to calculate the value of $\Delta \sigma_{E,2}$. In such cases the verification format should be based on damage accumulation equation A.1, given in BS EN 1993-1-9:2005, A.5(1), and damage accumulation expression A.2, given in BS EN 1993-1-9:2005, A.6(1), using the most comprehensive load model available. For additional guidance see NA.3.

NA.2.9 Verification of fatigue strength category
[BS EN 1993-1-9:2005, Clause 7.1(3)]
Verification of a fatigue strength category for a particular application by testing is permitted provided that it is evaluated in accordance with BS EN 1993-1-9:2005, 7.1(3), Note 1. For additional guidance see NA.3.

NA.2.10 Fatigue strength categories for details not covered by Tables 8.1 to 8.10 or Annex B
[BS EN 1993-1-9:2005, Clause 7.1(5)]
Fatigue strength categories for details not covered by BS EN 1993-1-9 should be given for individual projects.

NA.2.11 Use of Annex A
[BS EN 1993-1-9:2005, Clause 8(4)]

NA.2.11.1 Loading events
Reference to guidance on determining fatigue loading models is given in NA.3.

NA.2.11.2 Cycle counting
Reference to guidance on the procedure for cycle counting by the reservoir method is given in NA.3.

NA.3 References to non-contradictory complementary information
Complementary guidance on fatigue is given in PD 6695-1-9.
For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 5400-6:1999, Steel, concrete and composite bridges – Part 6: Specification for materials and workmanship, steel


PD 6695-1-9, Recommendations for the design of structures to BS EN 1993-1-9

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

BS EN 1991, Eurocode 1 – Actions on structures
