THE HIGHWAYS AGENCY

BD 7/81

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT
FOR NORTHERN IRELAND

Weathering Steel for Highway Structures

Summary: This Standard gives the requirements for the use of 'Weathering Steel' in highway structures.

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VOLUME 2	HIGHWAY STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES), MATERIALS
SECTION 3	MATERIALS AND COMPONENTS

BD 7/81

WEATHERING STEEL FOR HIGHWAY STRUCTURES

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1. INTRODUCTION

1.1 'Weathering Steels' generally corrode more slowly than normal structural steels, and where the steel is used in the appropriate environment, advantage can be taken of this property to eliminate painting. The economic advantage to be gained by the use of 'Weathering Steel' as an alternative to ordinary steel is greatly reduced if painting is necessary; paint does not have an increased life on 'Weathering Steel'.

1.2 The rate of corrosion of 'Weathering Steel' is dependent upon the alloy content, the degree of contamination in the atmosphere, and the frequency with which the surface is wetted and dried.

2. SCOPE

2.1 This Departmental Standard specifies requirements for the use of 'Weathering Steel' for the construction of highway structures. Appendix C contains a supplementary specification clause for construction in weathering steel which will be incorporated in the Department's Specification for Road and Bridge Works at the next revision. Notes for Guidance on the specification clause are given in Advice Note BA/7/81.

3. MATERIALS

The 'Weathering Steel' for use in highway structure shall comply with BS 4360:1979.

4. GENERAL REQUIREMENTS

4.1 'Weathering Steel' bridges shall be designed to ensure that all parts of the structure dry out in dry weather conditions. Reinforcement of weld profiles which may cause water traps shall be specified to be ground flush. Particular attention shall be given to the detailing of all deck joints, the provision of adequate ventilation at and around abutment areas, and the avoidance of undrained overlaps, pockets and crevices. The possibility of leakage at 'fixed' and 'expansion' joints shall be allowed for in the design by providing positive drainage systems, and joints shall be located away from structural steelwork to ensure that water does not run on or down the steel. The outlet pipes of deck drainage systems shall be of sufficient length to ensure that the discharged water does not spray onto the adjacent steelwork in any wind condition. The use of drainage goods of non-metallic type is recommended.

4.2 Bridges shall have access for monitoring and close examination of critical areas particularly near 'fixed' and 'expansion' joints.

4.3 Bi-metallic joints may promote corrosion in local areas and shall be avoided or insulated from the environment.

4.4 Surface contamination from concrete, mortar, asphalt, paint, oil and grease shall be prevented, as these have an adverse effect on the formation of a uniform coating. Blast cleaning the surface assists the formation of a uniform coating and should be specified for permanent visible surfaces where good aesthetic appearance is required. Where shedding of mill scale would be a hazard, removal by blast cleaning shall be specified.

4.5 Adequate protection shall be specified both during construction and in service, against rust staining of the piers and abutments.

4.6 Removal of graffiti from 'Weathering Steel' is difficult. Blast cleaning provides one solution, but is costly; any other method is unlikely to be visually satisfactory. Suitable provision should be made in the design to prevent or reduce such incidence as far as possible.

4.7 Unless otherwise specified in this Departmental Standard, design and construction in 'Weathering Steel' shall conform to the current departmental requirements for design and construction in steel.

5. LIMITATION OF USE

5.1 'Weathering Steel' shall not be used in the following situations:-

a. In a marine environment where the structure would be affected by salt. To measure the chloride content in the atmosphere, chloride tests may be undertaken as described in Appendix A. An average value of more than 0.10mg C1/100 cm^2/day, based on monthly test results over at least one year, shall be taken as indicating a marine environment.

b. For bridges over roads subjected to de-icing salt spray, where the headroom for the road below the structure is less than 7.5m.

c. For parts of structures subjected to de-icing salt spray.

d. Where the steel would be continuously wet or damp.

e. Where the steel would be buried in soil.

f. In an atmosphere containing concentrated corrosive industrial fumes. An average sulphur content in the atmosphere exceeding 2.1mg SO^3/100cm^2/day shall be taken as indicating a concentrated corrosive environment.
The sulphur content shall be measured in accordance with British Standard 1747 Part 4: 1969 - 'Methods for the Measurement of Air Pollution - The Lead Dioxide Method', and the average figure shall be based on at least one year's findings.

5.2 In the first instance, advice on the atmospheric chloride and sulphur levels present at any particular location may be sought from the Transport and Road Research Laboratory, Structures Department. Where the precise environmental classification remains in doubt, the appropriate measurements described above shall be taken.

6. ALLOWANCES FOR LOSS OF THICKNESS

6.1 To cater for the loss of thickness due to slow rusting during the life of the bridge, an allowance of extra thickness specified in Table 1 shall be provided on each exposed surface in addition to the minimum design thickness required for structural purposes. For applying Table 1, the category of the environment in which the structure is located shall be taken in accordance with clause 6.2.

6.2 The environment surrounding the structure shall be classified as either:-

i. 'Severe', or

ii. 'Mild'.

The environment shall be deemed to be 'severe' if the average sulphur content in the atmosphere exceeds 1.0mg $SO^3/100cm^2$/day; all other environments may be deemed 'mild' for this purpose (see clauses 5.1f and 5.2 above).

TABLE 1: ALLOWANCES OF EXTRA THICKNESS

ENVIRONMENT (see clause 6.2)	THICKNESS ALLOWANCE ON EACH SURFACE
Severe	2mm
Mild	1mm

6.3 The interior surfaces of ventilated box-sections shall be provided with an extra thickness of 0.5m. However no allowance is necessary if the interior of the box section is nominally sealed against ingress of water by means of continuous welding, gasketed manholes etc.

6.4 All fillet welds and partial penetration butt welds are to be increased in size above the minimum design requirements so as to provide an allowance of extra thickness given in Table 1. Full penetration butt welds need not be increased in size, as the thicknesses of the parent plates already include an allowance.

7. DESIGN CRITERIA

7.1 Global analysis of the structure may be done on the basis of the inertias appropriate to either the required design thicknesses without any allowance or the total thicknesses initially provided. Stresses on all sections and connections shall be checked after deducting the allowance of extra thickness prescribed in Clause 6.

8. MONITORING OF STRUCTURES

8.1 Immediately after construction, at locations specified by the Engineer as critical for strength or vulnerability to joint leakage or condensation, measurements of actual steel thicknesses shall be carried out.

8.2 The exact locations of the measurement points shall be marked on the 'as built' drawings, and these drawings and the records of the first set of measurements shall be sent by the Engineer to the appropriate RC(R&T) in duplicate - one copy being for onward transmission to the Maintenance Authority.

8.3 Additionally, the Engineer shall provide the appropriate RC(R&T) with details of the chemical composition (ie ladle analysis) of the steel.

(Note: This is required for long term feedback so that in the event of an excessive corrosion rate, correlation with the chemical composition of the steel may be investigated).

8.4 Visual examination of the structure at critical areas, particularly in the vicinity of 'fixed' and 'expansion' joints shall be carried out at intervals not exceeding 2 years.

8.5 Any indication of leakage or wet patches shall be thoroughly examined and the cause of such leakage remedied.

8.6 The actual steel thicknesses at the critical locations shall be measured and recorded at intervals of approximately 6 years during the life of the structure.

8.7 If projections from such measurements over a period of at least 18 years indicate that the likely total loss of thickness over the design life of the structure (ie 120 years for highway bridges) would be more than the allowances provided in the design in accordance with Table 1, then consideration shall be given to provide a suitable protective system for the steel at an appropriate time.

8.8 All the information required under this Clause shall be incorporated in an inspection and maintenance manual for the structure. (See clause 3.1.4 of BE4/77).

8.9 Appendix B describes an instrument, called 'EMA 1 Induction Ultrasonic Thickness Tester' that has been found satisfactory for the purpose of measuring sound steel thickness.

9. REFERENCES

9.1 The following documents are referred to in the text:

1. BS 4232: 1967 Surface finish of Blast-Cleaned Steel for Painting.

2. BS 4360: 1979 Weldable Structural Steels.

3. BS 1747: Part 4: 1969 Methods for the Measurement of Air Pollution - the Lead Dioxide Method.

4. BE 4/77 The Inspection of Highway Structures.

5. ASTM A 325 High Strength Bolts for Structural Steel Joints.

6. Specification for Road and Bridge Works fifth edition 1976 and supplement No 1 1978.

10. ENQUIRIES

Technical enquiries arising from the application for this Advice Note to a particular project should be addressed to the appropriate Technical Approval Authority.

All other technical enquiries or comments should be addressed to:

Head of Bridges Engineering Division
Department of Transport
St Christopher House
Southwark Street
LONDON
SE1 0TE

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MEASUREMENT OF ATMOSPHERIC CHLORIDES

Chloride Candle Method

The 'Chloride Candle' consists of a constant area of moist filter paper wound round a glass cylinder partially immersed in a reservoir of distilled water containing 20% glycerol (see diagram).

The candle is exposed inside a louvred box in a similar manner to the 'Lead dioxide Candle'. Atmospheric chlorides are deposited on the moist filter paper protruding above the bottle.

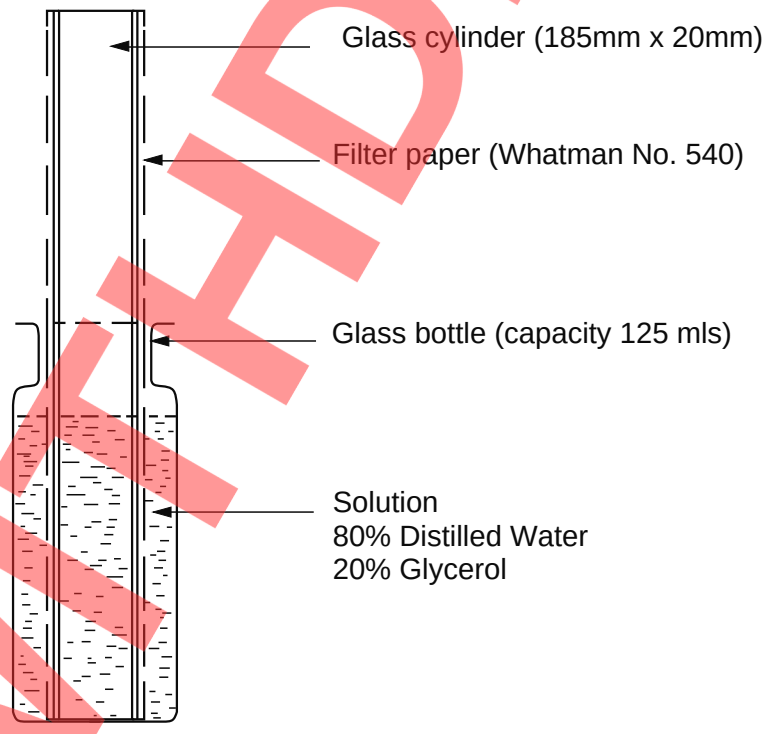
At the end of each exposure period, the filter paper is pushed into the bottle and the paper and liquid analysed for total chloride content.

Calculation of results

If m = Total chloride content (mg)
d = Number of days exposure
A = Area of exposed filter paper (cm^2)

The chloride content is expressed as:-

$$\frac{m \ . \ 100}{A \ . \ d} \quad mg \ c1^- / 100 \ cm^2 /day$$



CHLORIDE CANDLE

MEASUREMENT OF RESIDUAL STEEL THICKNESS

EMA 1 Induction Ultrasonic Thickness Tester

This instrument has been developed by the Unit Inspection Company, a subsidiary of the British Steel Corporation, and is manufactured under licence by Wells Krautkramer. It measures the residual steel thickness with sufficient accuracy - ignoring any rust which may have formed on the steel surfaces - provided the rust thickness does not exceed 1.5mm.

The instrument consists of three parts, viz:

a. a Control and Power Unit (EMAC1)

b. a Transducer, which is the probe itself (EMAT1)

c. an Ultrasonic Instrument (USM2).

All 3 units are portable and are battery operated; a battery charger EMAD1 is included in the package.

The basic principle of operation of this ultrasonic gauge is that high frequency eddy currents are generated in the surface layer of the steel and momentarily a powerful magnetic field is induced normal to the eddy currents. This produces an ultrasonic shear wave, the reflection of which from the opposite surface is displayed on an oscilloscope screen. The time interval between the echoes is directly related to the thickness of sound steel. As this method does not require any contact between the probe and the test material, it is suitable for measuring the residual steel thickness covered by a layer of rust; and because the ultra sound is only induced in the sound metal, any rust layer is ignored and only the sound metal thickness is measured. The instrument is calibrated to give direct readings of thickness by using standard thickness blocks.

Further details of the instrument and the techniques for its use may be obtained from the transport and Road Research Laboratory, Structures Department.

SUPPLEMENTARY SPECIFICATION CLAUSE FOR WEATHERING STEEL

Material and Workmanship for Construction in 'Weathering Steel'

1. Weathering steel shall comply with BS 4360:1979 to the grade indicated on the drawings. The maximum carbon equivalent value shall be 0.54%.

2. The chemical composition of bolts, nuts and washers, including high strength friction grip bolts, for weathering steel shall comply with ASTM A325 Type 3 Grade A or equivalent. Load indicating bolt heads or washers shall not be used with High Strength Friction Grip bolts.

3. Electrodes of matching chemical composition to the parent metal shall be used for butt welds and for the capping runs of multi-run fillet welds except that, where agreed by the Engineer, basic covered hydrogen controlled electrodes without weather resisting properties may be used for butt welds in material 12mm thick or less.

4. The top surfaces of all butt welds on bottom flanges of beams shall be ground flush.

5. All surfaces shall be maintained free from contamination by concrete, mortar, asphalt, paint, oil, grease and any other undesirable contaminants, and, where specified, shall be blast cleaned to assist the formation of a uniform coating. The quality of surface finish shall be to 3rd quality BS 4232.

6. The method of protection of concrete piers and abutments against rust staining during construction shall be agreed with the Engineer.