Corus Construction & Industrial

Weathering steel

Connecting with the environment

Contents

Steel strong by nature

Self-protecting, durable and attractive, weathering steel is ideal for a whole range of outdoor structures in exposed locations.

Weathering steel is a high strength, low alloy steel that protects itself from corrosion by forming a protective oxide patina eliminating the need for paint or other protective coatings.

Weathering steel offers an attractive and economic solution for many structures, including bridges, buildings and sculptures.

The steel's corrosion rate is so low that structures fabricated from unpainted weathering steel can achieve long lifespans with only minimal maintenance.

Through our technical advisory services, we offer extensive metallurgical and technical expertise on all aspects of weathering steel, its properties and applications.

Extensive appeal
The atmospheric corrosion resistance of weather resistant steel enables it to be used unpainted in many structural and architectural applications for structures such as bridges, open-frame buildings, transmission towers and sculptures. There are also high temperature benefits which make weathering steel suitable for flues, chimneys and ducting.

Practical benefits
Weathering steel offers significant advantages over other metals for structures that are exposed to the elements. These include:

• *Very low maintenance*
Periodic inspection and cleaning should be the only maintenance required to ensure the structure continues to perform well. Weathering steel is ideal for bridges and other structures where access is difficult or dangerous, and where future disruption needs to be minimised.

• *Initial cost benefits*
Cost savings from the elimination of any protective paint system may outweigh the additional material costs. For example, the cost of weathering steel has been shown to be approximately five per cent lower than conventional painted steel alternatives in bridges using a HA Type 2 paint system.

• *Whole-life cost benefits*
The minimal maintenance requirements of weathering steel structures greatly reduce both the direct costs of maintenance operations, and the indirect costs of traffic delays or rail possessions.

• *Speed of construction*
Overall construction times are reduced as both shop and site painting operations are eliminated.

• *Attractive appearance*
The attractive appearance of mature weathering steel often blends pleasingly with the environment. Its appearance changes and improves with age.

• *Environmental benefits*
The environmental problems associated with volatile organic compounds (VOC's) from paint and the disposal of blast-cleaning debris from future maintenance work are avoided.

• *Safety benefits*
Health and safety issues relating to initial painting are eliminated, and the risks associated with future maintenance are minimised.

• *High temperature benefits*
Oxidation loss of steel at temperatures above 400°C can be decreased by using weathering steels. At these temperatures a patina forms even in the absence of water. The precise performance improvement is dependent on the heating cycle and environmental conditions. A typical improvement would be an increase of 50°C over equivalent loss in carbon manganese steels.

Please note, weathering steels are not suitable for use in significant load-bearing members above 450°C.

Strength and protection

Self defence

In weathering steel, Corus has a smart metal that forms its own protective barrier under normal atmospheric conditions.

Natural reaction

In the presence of moisture and air, all low alloy steels have a tendency to rust. The rate of rusting depends on the level of oxygen, moisture and atmospheric contaminants that can access the metal's surface. As the process progresses, the layer of rust forms a barrier against the corrosive elements, slowing down the rate of rusting.

In time, the rust layers formed on most conventional structural steels detach from the metal surface, allowing the corrosion cycle to be repeated.

With weathering steel the oxidisation process is initiated in the same way. However, the steel's specific alloying elements produce a stable oxide layer that adheres to the base metal and is much less porous than the rust on other metals. This oxide patina develops under conditions of alternate wetting and drying to produce a protective barrier, impeding the access of further moisture, oxygen and contaminants.

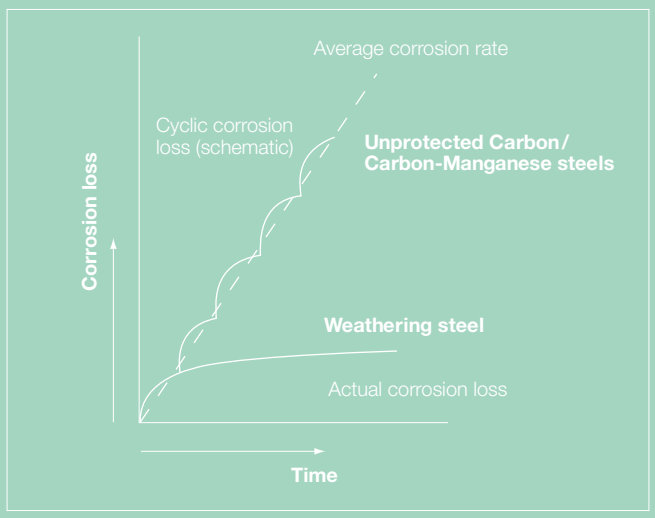


Figure 1
Schematic comparison graph

Durable and adaptable

The appearance of weathering steel changes with time and climatic conditions to provide structures that blend with their environment.

Changing hues

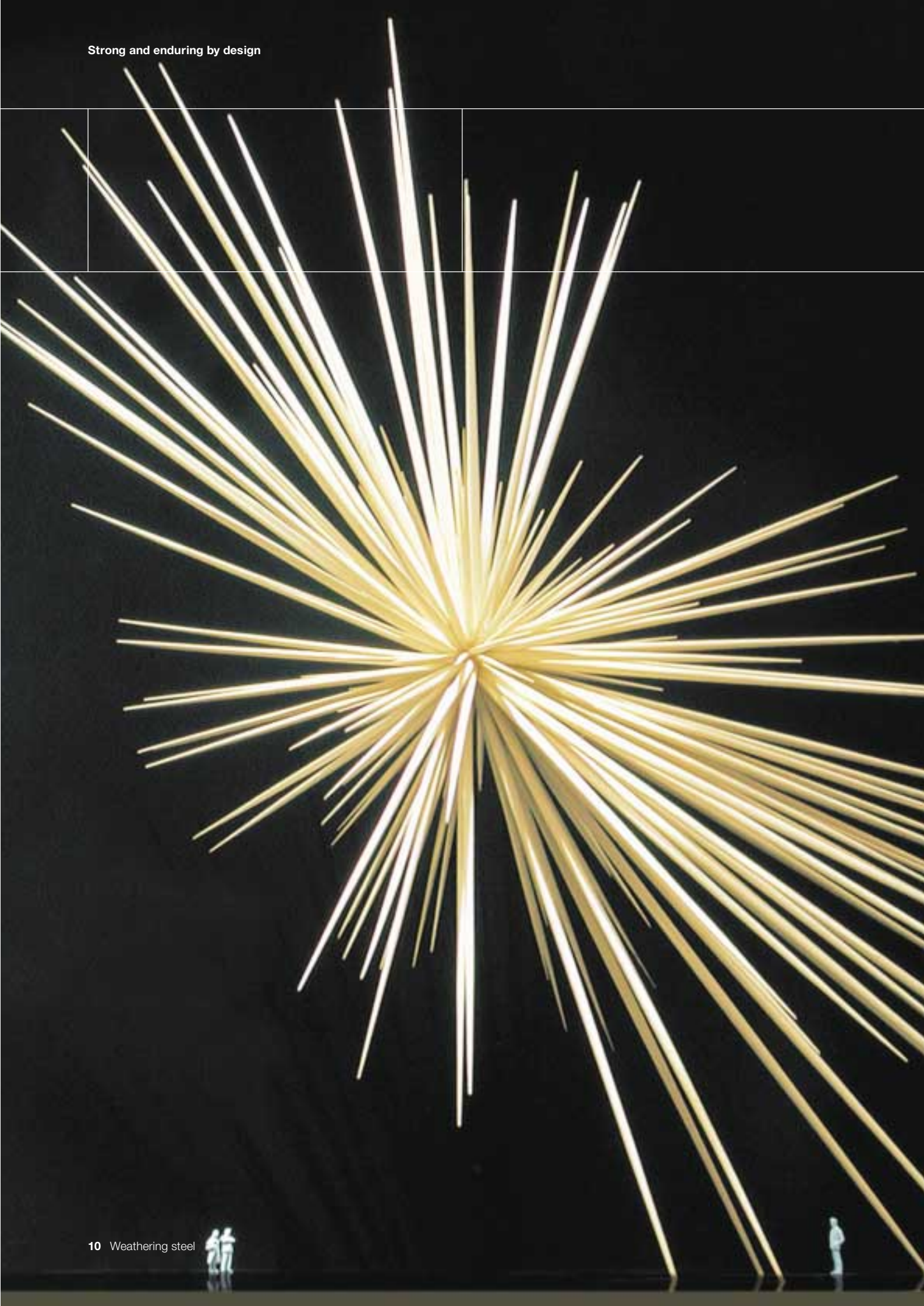
The colour of weathering steel varies over time and with exposure to different conditions. Initially, structures appear orange-brown as the protective layer begins to form. The steel often darkens during construction and, within two to five years, attains its characteristic dark brown, sometimes slightly purple, colouration.

The time taken for the patina to form and the characteristic colour to develop depends mainly on the environment and exposure conditions. In an industrial atmosphere the weathering process is generally more rapid, and the final colour darker, than in a rural setting.

Varying textures

The texture of weathering steel is influenced by the orientation of the structure and the degree of shelter it provides. Surfaces facing south and west, and those subject to frequent wet and dry cycles, develop a smoother fine-grained texture. Sheltered structures, and surfaces facing north and east, tend to develop a coarse granular texture.

The images below show the typical appearance of weathering steel after 12 years in rural and urban environments.



Strong and enduring by design

By following good design practice you can ensure that weathering steel provides long-term high performance for your structure.

Consider the conditions

In continuously wet situations weathering steels will corrode at the same rate as carbon manganese steels. The detailing of beams, columns, exterior wall systems and other elements should therefore avoid pockets, crevices and other locations where water can collect.

Where such conditions are not possible, provision should be made for drainage and ventilation to allow the steel to dry. Damp debris and dense vegetation growing around the steel structure will also prolong surface moisture retention in the metal, causing accelerated corrosion. In such cases, the steel must be protected using a high-quality paint system from its base to above the maximum vegetation growth level.

Compatibility with other materials

It is important to be aware of the issues that arise when weathering steel comes into contact with other materials, and the measures you should take to protect your structure. Here are a few points to bear in mind:

- Elements in contact with, or buried in, soil should be painted.
- Interfaces between steel and concrete should be treated with an appropriate sealant.
- Elements encased in concrete need not be painted.
- Connections to galvanically dissimilar materials, such as zinc or cadmium plated bolts, should be avoided.

Concrete, stone and unglazed brick may suffer from oxide staining when in contact with weathering steel. We recommend that such substructures are sealed with washable organic coatings to facilitate cleaning.

Treating existing structures

Where there has been an unforeseen change in environmental conditions, or where design features have caused excessive corrosion, it may be necessary to paint existing weathering steel structures.

The quality of the surface preparation will influence the durability of any applied paint coating. A very high integrity coating will need a surface treatment, such as wet abrasive blast cleaning, to completely clean the metal and remove corrosive contaminants. Following cleaning, weathering steel can be treated as any other structural steel.

Robust options

It is vital to choose the most appropriate construction metal for your structure, taking account of local environmental and climatic conditions.

Extreme conditions

In some extreme environments the long-term durability of weathering steel may be compromised, making it unsuitable for certain structures. In marine environments for example, exposure to high concentrations of chloride ions in seawater spray, salt fogs or airborne salts are detrimental to the metal. Therefore, as a general rule, weathering steel should not be used within 2km of the coast line.

The use of de-icing salt on roads over and under weathering steel bridges can also lead to problems in extreme cases. It is unlikely to be a problem for most bridges, but in tunnel-like conditions around enclosed, narrow roadways an excessive build up of salt may occur.

Estimating corrosion rates

The procedure for measuring corrosion rates, set out in ISO 9226, is carried out on standard metal specimens exposed for a year in the required location. Corrosion measurements are taken over this period to obtain representative average values.

In most cases, such information is not available at the design stage, which means a judgement needs to be made about the suitability of weathering steel for any given project. ISO 12944: Part 2 relates the classifications C1 to C5 to descriptions of typical environments (see Table 1), and is a good starting point.

Table 1

Environmental category	Typical environment
C1	Interior environments only.
C2	Atmospheres with low levels of pollution. Mostly rural areas.
C3	Urban and industrial atmospheres with moderate sulphur dioxide pollution. Coastal areas with low salinity.
C4	Industrial areas and coastal areas with moderate salinity.
C5-I	Industrial areas with high humidity and aggressive atmospheres.
C5-M	Coastal and offshore areas with high salinity.

A site visit will help to assess the nature of the environment for the proposed structure and the suitability for weathering steel. Local authorities can provide information about future development plans in the area that may affect the local environment. Information about the levels of sulphur dioxide pollution can be obtained from the UK National Air Quality Environment Centre of AEA Technology.

Broad range of products

Weathering steel is available from Corus in plates and sections in a range of sizes to suit many applications.

Plates

Plates can be obtained direct from the mill in minimum quantities of five tonnes per width and thickness. Corus supplies S355J0W, S355J2W and S355K2W weathering steel grades to BS EN 10155 within the following parameters.

Table 2

Parameter	Delivery Condition Normalised	Normalised rolled
Max. plate width*	3.75m	3.9m
Max. plate length*	17.0m	18.3m
Max. gauge	100mm	65mm
Max. plate weight*	14.5 tonnes	14.5 tonnes
CEV** (Max./typical)	0.52/0.50	0.47/0.44

* For a full range of sizes please refer to our brochure 'Plate products range of sizes'
** Carbon Equivalent Value

To discuss your specific requirements please contact your account manager or telephone the plates technical advisory service +44 (0) 1724 402106.

Sections

The typical minimum quantity available for sections direct from the mill is 50 tonnes per size and weight. This includes universal beams (UBs), universal columns (UCs), channels and angles. It may be possible to order smaller quantities, depending on the availability of suitable feedstock and gaps in the rolling programme. To discuss your specific requirements please contact our sales office.

Hollow sections

Special casts need to be made to produce hollow sections specified to BS 7668: 2004, which means the minimum order quantity is 150 tonnes. Within this quantity, a variety of section sizes can be ordered, with minimum quantities depending on the section size.

High strength friction grip (HSFG) bolts

Weather resistant HSFG bolts are stocked in the UK by Cooper and Turner, with chemical compositions complying with ASTM A325, Type 3, Grade A and in metric sizes (M20, M24 and M30).


The Open
University

Sound and solid construction methods

Corus can advise on the preparation and installation of weathering steel to create structures that will stand the test of time.

Cutting

Oxy-fuel gas, plasma or laser cutting processes can be used to cut weathering steel, using a procedure similar to the one used for cutting high strength carbon-manganese steels of similar CEV (Carbon Equivalent Value) and thickness.

Standards such as BS 5400 : Part 6 : 1999 specify a maximum allowable thermally-cut edge hardness of 350 Hv30, and cutting procedures should be adopted to ensure this is not exceeded. Cracking should not occur when the surface hardness is below this level. However, care should be taken when a cut edge is incorporated into a bend. It is advisable to remove the cut edge by grinding or linishing, prior to bending.

Welding

Weather resistant steels can have higher carbon equivalents values (CEVs) than most other high yield structural steels. This is important to remember when defining pre-heat levels for welding, which should be based on the actual steel CEV where possible. If the CEV is unknown, the maximum permissible CEV for that steel thickness should be used. To determine the appropriate welding parameters, refer to BS EN 1011-2: 2001 “Welding – Recommendations for welding of metallic materials. Part 2: Arc welding of ferritic steels”. Consumables that weather in a similar manner to the parent steel are readily available for all common welding processes. There are three types of welding electrodes typically available: 0·5% Cu and other elements, 1Cr0·5Mo or 2·5%Ni. The latter has been shown to have the added advantage of giving good levels of notch toughness. However, as with the parent steel, weathering characteristics depend on external conditions, and you should seek advice from a consumable supplier for the most suitable electrode.

If you do not require weld metals with similar colouring to the parent steel, you can use a welding consumable with the appropriate strength for your steel.

Bolting

All bolted joints should use weathering grade HSFG bolts, nuts and washers with chemical compositions that comply with ASTM A325, Type 3, Grade A, or equivalent. For bolted connections the slip factor is the same as for conventional steel. Such connections inevitably result in overlapping plates, with the potential problem of crevices and the associated corrosion risk. However, careful detailing of the joint can avoid these problems.

Corus supplies weathering steel to Cooper and Turner who manufacture high strength friction grip (HSFG) bolts, nuts and hardened washers for use in steel structures. These are made to the dimensions and mechanical properties of BS4395 Part 1, General Grade and ASTM A325 Type 3, Grade A. Available manufactured sizes are M20, M24 and M30.

Surface preparation

To aid the formation of a uniform oxide patina, abrasive blast cleaning (up to a minimum standard of Sa2 to BS EN ISO 8501.1) should be carried out after fabrication and before delivery to site. Paint, wax or crayon marks on the steelwork should be avoided if possible, since they interfere with the weathering process and are difficult to remove.

Installation

Care should be taken not to damage the developing oxide patina when storing or handling the steel. Although the coating will re-form, it will appear uneven until the coating is restored. Grout running onto the steel from concrete deck operations will also adversely affect the steelwork, and may necessitate a final blast cleaning once the structure has been erected. During bridge construction, piers and abutments can be wrapped in protective sheeting to protect them from oxide staining.

Painting

The requirements for paint systems are the same as those for carbon/carbon manganese steel. Painting of weathering steel does not prolong the life of the paint material, although the self-stifling properties of the oxide tend to reduce under-creep if the paint film is damaged or degraded. This means that areas requiring repainting will not expand significantly, even after a long period of time. Any damaged areas that expose the underlying metal will be protected by the formation of the protective oxide coating.

Maintenance routines

Regular inspection, monitoring and occasional maintenance will ensure your weathering steel structure achieves optimum performance.

Routine maintenance

Any surfaces contaminated with dirt or debris should be cleaned by low pressure clean water washing, where practical. In the case of bridges, such cleaning should also be carried out annually at the end of the de-icing period, if it is found that chlorides are adversely affecting the formation of a stable oxide patina.

Overhanging vegetation that causes continuous dampness should be removed and drainage channels cleared regularly. Any leaks in the drainage system should be traced and repaired. If there is evidence of excessive crevice corrosion at bolted joints, the edges should be sealed with an appropriate sealant.

Bridge inspections

Visual inspections of weathering steel bridges should be carried out by experienced inspectors at least every two years. The surface condition of the oxide patina is a good indicator of performance. Adherent, fine-grained oxide indicates that corrosion is progressing as expected, while coarse, flaking layers of oxide suggest excessive corrosion.

Visual inspections should also look for:

- Leaking expansion joints.
- Accumulations of dirt or debris.
- Moisture retention due to overgrown vegetation.
- Faulty drainage systems.
- Deterioration of sealants at concrete/steel interfaces.
- Excessive corrosion at bolted joints.

Any serious problems should be traced and rectified as soon as possible, to ensure the steel maintains its performance for the life of the structure.

References

1 BS EN 10025: 2004, Hot rolled products of structural steels – Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance, British Standards Institution.
(Supersedes BS EN 10155: 1993)

BS EN 10155: 1993, Structural steels with improved atmospheric corrosion resistance. Technical delivery conditions, British Standards Institution.

2 BS EN 10025: 2004, Hot rolled products of structural steels – Part 2: Technical delivery conditions for non-alloy structural steels, British Standards Institution.
(Supersedes BS EN 10025: 1993)

BS EN 10025: 1993, Hot rolled products of non-alloy structural steels. Technical delivery conditions, British Standards Institution.

3 BS 7668: 2004, Specification for weldable structural steels. Hot finished structural hollow sections in weather resistant steels, British Standards Institution.

4 Bridges in steel – The use of weathering steel in bridges, ECCS (No.81), 2001.

5 BD 7 / 01 Weathering steel for highway structures, Design manual for roads & bridges, Volume 2, Section 3, London, 2001, The Stationery Office.

6 BS EN 1011, Part 2, 2001, Welding recommendations for the welding of metallic materials, arc welding of ferritic steels, British Standards Institution.

7 BS 5400: Part 6: 1999, Steel, concrete and composite bridges, Specification for materials and workmanship of steel, British Standards Institution.

8 Manual of contract documents for highway works, Volume 1, Specification for highway works, Series 1800, Structural steelwork, London, 2004, The Stationery Office.

9 ISO 9223: 1992, Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, International Standards Organisation.

10 ISO 12944-2: 1998, Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Classification of environments, International Standards Organisation.

11 BS EN ISO 8501-1: 1988, Preparation of steel substrates before application of paint and related products, International Standards Organisation.

12 ISO 9226: 1992, Corrosion of metals and alloys – Corrosivity of atmospheres – Determination of corrosion rate of standard specimens for evaluation of corrosivity.

Note

References 5 & 8 are jointly published by:

- The Highways Agency
- Scottish Executive
- Welsh Assembly Government
- The Department for Regional Development (NI)

www.corusgroup.com

Designed and produced by
Orchard Corporate Ltd.

Corus Construction & Industrial
PO Box 1
Brigg Road
Scunthorpe
North Lincolnshire
T +44 (0) 1724 404040
F +44 (0) 1724 405600
E corusplates@corusgroup.com
www.corusconstructionandindustrial.com

English language version

NB:1000:UK:11/2004