Guidance Note 8.01

Preparing for effective corrosion protection

Scope

This Guidance Note covers some of the considerations that are needed in the design, detailing, fabrication and assembly of new bridge steelwork to ensure that the protection against corrosion is not compromised by inadequate preparation, damage, or an unnecessarily severe local environment.

The selection of a protective coating system is outside the scope of the Note - see References [1], [2] & [3] for guidance on that aspect. The recommendations in this Guidance Note can also be used for local application of corrosion protection systems on weathering steel bridges. Refer to GN 1.07 for further discussion of rare situations where there may be a need to paint weathering steel

General information on each of the alternative protective treatments, which can be combined to provide a 'duplex' system, is given in the following Guidance Notes:

- GN 8.03 Hot dip galvanizing
- GN 8.04 Thermally sprayed metal coatings
- GN 8.05 High performance paint coatings

General

The application of a protective coating system is the most common way of controlling corrosion. However, the effectiveness of the system depends not just on the coating materials and specified application procedures, but also on the initial surface condition, the access for application and the environment under which the work is done.

Initial surface condition

For new works, it is necessary to specify that the surfaces shall comply with rust grades A or B according to BS EN ISO 8501-1 [4]. Material that is pitted, i.e. rust grades C or D, should be rejected, since it is difficult and uneconomic to prepare such material sufficiently to clean all the corrosion products from the pits in the surface.

Surface preparation

General surfaces

The presence of even small amounts of surface contaminants, oil, grease etc. can physically impair and reduce coating adhesion and these contaminants should be removed by detergent washing before abrasive blast cleaning or mechanical preparation. It is erroneous to think that subsequent blast cleaning operations will remove such contaminants and it also risks contaminating the abrasive if it is recycled. It is bad practice to permit them to remain on the surface.

Similarly, mill scale on new steelwork is unsuitable for modern high performance coatings and must be removed. This is usually achieved by abrasive blast cleaning to visual cleanliness Grade Sa 2½ or Sa 3 as defined in BS EN ISO 8501-1, depending on the exposure, the coating system and the requirements of the designer. Note most high build new works paint systems require the higher Sa3 class of cleanliness.

In addition to the degree of visual cleanliness, surface preparation also needs to consider the 'roughness' appropriate to the coating to be applied. For example, shot abrasives produce a rounded surface profile and are used for thin film paint coatings (rarely used on bridges), whereas thick or high build paint coatings need a coarse angular surface with a higher profile, as provided by grit abrasives, to give a mechanical key.

The surface treatment specification therefore should describe the abrasives that can be used and the roughness required, usually as an indication of the average amplitude achieved by the blast cleaning process, and state a method of measurement e.g. comparator panels, special dial gauges or replica tapes. Usually, comparators or replica tapes are used. The comparators are covered by BS EN ISO 8503-1 [5].

The replica tape method, which is more widely used, is covered by BS EN ISO 8503-5 [6].

It is necessary to remove general surface imperfections on welds and cut edges to produce an acceptable surface condition for coating. These are described below, and preparation grades are described in detail in BS EN ISO 8501-3 [7]. In general, P2 grade should be used as a minimum standard, though external edges and corners should be treated as described below.

Weldments

Weldments on fabricated structural steelwork represent a relatively small but important part of the structure and can produce variable surface profile and uneven surfaces or sharp projections that can cause premature failure of the coating. Although welded areas are inspected, the requirements for weld quality do not always coincide with the requirements for successful application of a coating system. Welds must generally be continuous and always free from pin holes, sharp projections, excessive or sharp undercutting and weld spatter. Any sprayed coatings or gels used in non-destructive testing (e.g. those used in MPI or UT) need to be removed as well.

Removal of surface imperfections such as undercut should be by dressing the profile using grinding disks. Spatter can be removed using abrasive 'flap' disks.

Particular attention needs to be paid to the blast cleaned profile, because weld metal is harder and site blast cleaning is more difficult than shop blasting.

Edges, Corners and cut faces

Sawn and thermally-cut ends and edges need similar treatment to ensure that the coating adheres and is of sufficient thickness.

At outside arrises (i.e. the meeting between two surfaces), there is a potential problem when there is a sharp (i.e. 90°) edge, because the surface tension in the fluid coating acts to pull the fluid away from the arris.

Consequently, edges and other arrises should be smoothed by grinding or filing. It is generally considered sufficient to smooth the corner to a radius of about 2 mm. For highway bridges, this minimum radius is specified in the SHW, Clause 1810.2 [12].

Note in addition to the requirement for smoothing arrises, the NGSHW, Clause NG1914(13) [1], describes the requirements for application of one or more stripe coats (an extra coat applied only locally) for all external corners, edges (and for welds and fasteners, to counteract this effect even when the edge has been prepared).

The edges of rolled sections generally do not require grinding, as they are usually smooth as a result of the rolling process.

Thermally cut edges should be ground smooth and free of 'drag lines'. Note that thermally-cut surfaces, if left untreated, will be harder than the rolled surface, refer to GN 5.06. These, if left untreated, also make it more difficult to produce the profile required using the blast cleaning process.

Post-blasting inspection

After abrasive blast cleaning, it is necessary to examine the prepared surfaces for imperfections and changes to surface conditions caused during fabrication processes, e.g. by welding. Such areas should be treated as the specification requires and blasted again if necessary.

After the preparation of the surface to an acceptable standard of cleanliness and profile, it is important that the steelwork has no residual dust or particulate matter on the surface and is not allowed to deteriorate.

Re-rusting can occur very quickly in a damp environment and unless the steel is maintained in a dry condition coating of the surface should proceed as soon as possible. Any significant re-rusting of the surface should be considered as a contaminant and be removed by re-blasting.

Site connections and splices

Splices general

Unless thermal metal spray is used (see GN 8.04), girder splices and connection details are often not given full protection in the shops, leaving the connection zones to be made good on site. A frequent consequence is that these zones are the least well prepared and protected, and are the first to show signs of breakdown.

Paint coats should always be stepped back at joints. This means that the coating applied after the structural joint is made has staggered joints between the shop and site applied coats. This avoids the coating system having one plane of weakness.

Welded connections

At welded connections, the key factors in ensuring the effectiveness of the coating system are the effectiveness of the protection before final coating. The areas locally to welds are usually masked, to prevent them being coated. The masking stays in place until the joint is welded; this is not an ideal protection if there is prolonged exposure before welding.

After welding, it is essential that the joint surfaces, including the weld itself, are prepared to the specified standard of cleanliness and profile. Because of the contamination that can occur from the welding flux / slag, particular attention needs to be paid to cleaning off all residues.

The surfaces of welds themselves should not need any grinding if they comply with the requirements of BS EN 1011-2: 2001 [7] for smoothness and blending into the parent metal. Rough profiles, badly formed start-stops, sharp undercut and other defects such as adherent weld spatter should be removed by careful grinding or use of flap disks as above, such that that the strength of the weld is not compromised.

Bolted connections

Bolted connections, which are almost always preloaded slip-resistant connections, merit particular consideration, both of the surfaces that will remain exposed and of those that will not (i.e. the faying surfaces).

Faying surfaces are usually either left blasted and unpainted or metal sprayed without sealer.

Thermal metal sprayed coatings do not need as much protection as bare steel connections. Their use is mandatory for Network Rail bridges [3].

Surfaces need to be protected (usually by masking tape) until the parts are finally bolted together (see GN 7.05). Some slight 'gingering' of bare steel or discoloration of thermally metal sprayed coatings is not detrimental. Wire brushing or grinding is likely to polish such material, reducing the slip factor and should not be permitted.

Attention should be paid to the removal of any adhesive used on the protective films for the faying surfaces, and to the removal of any lubricants used on the threads of bolts. Care should be taken to avoid contamination of surfaces during bolting up, for example, older air-power wrenches tend to produce a fine oily/misty exhaust that may settle on the surface.

Refer also to GN 8.02 for more information on the corrosion protection systems for bolts.

Damage during handling and transport

During handling, turning and assembly, damage to edges and to surfaces by the use of sharp-toothed clamps must be avoided by taking precautionary measures, such as the use of properly designed lifting cleats. If damage does occur, it must by carefully blended out by grinding (and the full protective treatment restored, with specified overlaps between coats).

Cleanliness at site

Just as surface cleanliness before first coating is fundamental to performance of the system, so is the cleanliness of painted surfaces prior to the application of subsequent coats. On site, thorough cleaning shortly before painting is always necessary to remove contamination accumulated over time and from construction activities including dust, grout leaks from concreting, and the products of blast-cleaning, bolting and welding. Advice should be sought from the paint manufacturer before using detergents or other chemicals as cleaning agents.

Access for application of paint and thermally sprayed coatings

Since the effectiveness of a coating depends on the preparation and the proper application of the coating, it is essential that the preparation, application and inspection are straightforward. Narrow gaps, difficult to reach corners, and hidden surfaces should therefore be avoided wherever possible.

Components to be galvanized require particular attention. Refer to GN 8.03.

Cope holes

A typical detail that is difficult to protect on painted structures is a cope hole in a web stiffener. Unless the hole is very large, it is virtually impossible to blast clean the surface properly, and to apply a protective treatment to the surface. (A fluid coating can only be applied by brush or when using airless spray by 'bouncing off' other surfaces, and it is totally impossible to apply metal spray.)

If cope holes are used, they should be circular and of at least 40 mm radius, preferably more. (If the cope hole were formed by a 45° snipe, the weld would not be returned through the hole and there will be the additional problem of a narrow crevice - such a detail should not be used at all.)

There is an argument for using a cope hole in a web stiffener that is fitted to the bottom flange, to provide a drainage path along the flange. The benefits in painted structures are, in most cases, marginal, and the action of channelling water past surfaces that have probably been less well protected than they should have been is questionable.

The best detail at the inside corner of a web stiffener is a small snipe, just sufficient to clear the web/flange weld, so that the stiffener fillet weld can be continued round the corner, completely sealing the junction.

Interfaces

A common interface in steel composite bridges is between a steel flange and a concrete deck slab.

Surfaces in contact with concrete are usually (with the exception of a marginal strip at the edges of the interface) blast cleaned and left as bare steel. The marginal strip should be treated as for the external surfaces, except that only the shop coats need be applied. It is recommended that the width of the marginal strip should be at least equal to the required cover to the reinforcement, for the same exposure condition. A width of 50 mm is common. Any aluminium metal spray on surfaces in contact with concrete needs to receive at least one coat of paint, to prevent the reaction that may occur between concrete and aluminium. It is recommended that any shear connectors be positioned such that they (and their welds) do not lie within the marginal strip; they should also be protected against overspray of the coating. Refer to GN 2.11 for further details.

In both cases, the perimeter of the interface needs to be considered carefully, since water may penetrate through capillary action. It is usual to specify that a margin inside the interface is also coated; this does not compromise the bonding of the concrete or the friction capacity of the joint. Joints may also be sealed with a suitable high quality alkali resistant mastic.

Narrow gaps

Gaps of less than 1 mm width should be able to be sealed by flooding the gap with paint.

Sometimes wider but narrow gaps are created between two steel elements. These will be very difficult to maintain properly and should be avoided if at all possible. If there are narrow gaps, they should be sealed, either by welding or by proprietary sealants approved by the paint manufacturer, and covered by the protective coating.

Bolts, nuts and washers

The exposed surfaces of bolted fasteners need to be protected to at least the same level as the rest of the steelwork. Indeed the crevices associated with these fasteners are particularly vulnerable. Short-term protection of the fastener can be obtained by the specification of a sherardized or electroplated coating, but the full coating system should be applied after assembly. Hot dip galvanized fasteners are commonly specified; they should be overcoated after assembly. The SHW requires stripe coats to be applied to all fasteners, including washers. See GN 8.02 for further details on protective treatment of bolts.

Moisture and dirt traps

In detailing the steelwork, avoid any features that would hold or trap water and dirt. For example: avoid arranging channels with toes upward; arrange angles so that the vertical leg is below the horizontal. As a last resort, if features that trap water or dirt cannot be avoided, provide drainage holes, but ensure that they are large enough to be coated properly and kept clean, and that they do not discharge onto other vulnerable areas.

Access for maintenance

Remember that the bridge will have to be maintained and that the coating will need to be renewed during the life of the bridge. This can only be done effectively if there is good access, both for personnel and for the process of cleaning and recoating. Avoid creating

details where this would be difficult or impossible in the assembled configuration.

Further advice on design considerations is given in References [8] and [9].

References

[1] Manual of Contract Documents for Highway Works: Specification for Highway Works, Series 1900; Notes for Guidance on the Specification for Highway Works, series NG1900, TSO, 2014.

[2] Network Rail Standard NR/GN/CIV/002, Guidance Note. The use of protective coatings and sealants, Issue 6, June 2023 and associated briefing document.

[3] Steel Construction website: https://www.steelconstruction.info/Corrosion_protection, BCSA, Tata Steel, SCI

[4] BS EN ISO 8501-1:2007 Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.

[5] BS EN ISO 8503-1:2012, Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces.

[6] BS EN ISO 8503-5:2004, (BS 7079-C5:2004) Preparation of steel substrates before application of paints and related products. Surface roughness characteristics of blast-cleaned steel substrates. Replica tape method for the determination of the surface profile.

[7] BS EN ISO 8501-3:2007 (BS 7079-A3:2006) Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness. Preparation grades of welds, edges and other areas with surface imperfections

[8] BS EN 1011-`2: 2001, Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels.

[9] BS EN ISO 12944-1:2017 Paints and varnishes. Corrosion protection of steel structures by protective paint systems - General introduction

[10] BS EN ISO 12944-3:2017 Paints and varnishes. Corrosion protection of steel structures by protective paint systems – Design considerations

[11] BS EN ISO 12944-5:2019 Paints and varnishes. Corrosion protection of steel structures by protective paint systems – protective paint systems.

[12] Manual of Contract Documents for Highway Works, Volume 1, Specification for Highway Works, Series 1800; Structural Steelwork, TSO, April 2021