STEEL INDUSTRY GUIDANCE NOTES

Corrosion Protection

Durability is an important issue to consider when designing and detailing steel structures. Various protection systems are currently available, and paint technology is advancing at a rapid pace. Consequently, cost effective corrosion protection of structural steelwork should present little difficulty for common applications and environments if the factors that affect durability are recognised at the outset. The key to success lies in recognising the corrosivity of the environment to which the structure will be exposed, in defining clear and appropriate coating specifications, and in ensuring the correct application of coatings by trained operatives.

Corrosion Process

The corrosion of steel is an electrochemical process that requires the simultaneous presence of water and oxygen. In the absence of either, corrosion does not occur. Hence, for unprotected steel in dry environments (e.g. internal steelwork), corrosion will be minimal. The principle factors that determine the rate of corrosion of steel in air are the proportion of total time during which the surface is wet, due to rainfall, condensation etc, and the type and amount of atmospheric pollution (e.g. sulphates, chlorides, etc.)

Within a given local environment, corrosion rates can vary markedly, due to effects of sheltering and prevailing winds etc. Consequently, corrosion rate data cannot be generalised. However, environments can be broadly classified according to BS EN ISO 12944-2, which describes categories from C1 (heated interiors) through to C5 (Aggressive marine or industrial).

Influence of Design on Corrosion

The design of a structure can affect the durability of any protective coating applied to it. Detailing is important to ensure that the protective treatment can be applied to all surfaces. Narrow gaps, difficult to reach corners, and hidden surfaces should be avoided wherever possible. Details that could potentially trap moisture and debris, which would accelerate corrosion, should also be avoided. Measures that can be taken include:

- Ensure weld profiles are not excessive
- Avoid using channels with toes upward
- Arrange angles with the vertical leg below the horizontal
- Avoid crevices that attract and retain water through capillary action

Guidance for the prevention of corrosion by good design detailing can be found in BS EN ISO 12944-3.

Surface Preparation

Surface preparation is the essential first stage treatment of a steel substrate before the application of any coating, and is generally accepted as being the most important factor affecting the total success of a corrosion protection system. The surface preparation process not only cleans the steel, but also introduces a suitable profile to receive the protective coating. Various methods and grades of cleanliness are presented in BS EN ISO 8501-1 and the standard grades of cleanliness for abrasive blast cleaning are:

Sa 1 – Light blast cleaning
Sa 2 – Thorough blast cleaning
Sa 2½ – Very thorough blast cleaning
Sa 3 – Blast cleaning to visually clean steel

The type and size of the abrasive used in blast cleaning have a significant effect on the profile and amplitude produced. Grit abrasives are used for high build paint coatings and thermally sprayed metal coatings, which need a coarse angular surface profile to provide a mechanical key. Shot abrasives produce more rounded profiles and are used for thin film paint coatings such as pre-fabrication primers.

Paint Coatings

Modern specifications usually comprise a sequential coating application of paints or alternatively paints applied over metal coatings to form a 'duplex' coating system. Protective paint systems usually consist of a primer, followed by intermediate / build coats applied in the shop, and finally the finish coat, which is usually applied on site.

The primer wets the steel surface and provides good adhesion for subsequently applied coats. Intermediate coats are applied to 'build' the total film thickness of the system. Generally, the thicker the coating, the longer the life. The finish coat provides the required appearance and surface resistance of the system against weather, sunlight, and condensation.

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Details of standard paint systems suitable for a range of different environments are given in the Corus Corrosion Protection Guide, 2004.

With modern high performance coatings, correct application has become increasingly important to achieve the intended performance. Industry has recognised this and established a training and certification scheme for paint applicators (ICATS – Industrial Coating Applicator Training Scheme). ICATS registration has subsequently become a mandatory requirement for work on Highways Agency and Network Rail bridges.

Metallic Coatings

The two most commonly used methods of applying metallic coatings to structural steel are thermal (metal) spraying and hot-dip galvanizing.

Thermally Sprayed Metal Coatings

Thermally sprayed coatings of zinc, aluminium, and zinc-aluminium alloys provide long-term corrosion protection to steel structures exposed to aggressive environments. They are also an important component of many 'duplex' coating systems. The metal, in powder or wire form, is fed through a special spray gun containing a heat source, which can be either an oxygas flame or an electric arc. Molten globules of the metal are blown by a compressed air jet onto the previously grit blast cleaned steel surface. No alloying occurs and the coating consists of overlapping platelets of metal and is porous, so requires sealing after application.

Hot-dip Galvanizing

Hot-dip galvanizing is a process that involves immersing the steel component to be coated in a bath of molten zinc (at about 450°C) after pickling and fluxing, and then withdrawing it. The immersed surfaces are uniformly coated with zinc alloy and zinc layers that form a metallurgical bond with the substrate. The resulting coating is durable, tough, abrasion resistant, and provides cathodic (sacrificial) protection to any small damaged areas where the steel substrate is exposed.

Appropriate Specifications

The overall success of a protective coating scheme starts with a well-prepared specification. It is an essential document that is intended to provide clear and precise instructions to the contractor on what is to be done, and how it is to be done. The specification should be drafted by someone with appropriate technical expertise, and it should be clear as to what is required, and what is practical and achievable. In detail the specification needs to consider the following aspects:

- Environment and access for future maintenance
- Design of the structure
- Surface preparation
- Coating system and application
- Handling and transportation
- Inspection and quality control.
- Health and safety

Inspection and Quality Control

Inspection forms an integral part of quality control. Its purpose is to check that the requirements of the specification are being complied with and to provide a report with proper records to the client. One of the greatest assets to the coating inspector is a clear written specification that he can refer to without doubt.

The appointment of an appropriately qualified third party inspector should be seen as an investment in quality and not just an additional cost. Inspection of the processes, procedures and materials required for the protective coating of steel structures is vital, since a major error in one operation cannot be easily detected after the next operation has been carried out, and if not rectified immediately can significantly reduce the expected life to first maintenance.

Key Points

1. Correctly establish the corrosivity of the environment.
2. Define clear and appropriate coating specifications.
3. Carry out thorough surface preparation to the required standard.
4. Ensure the correct application of coatings by trained operatives.
5. Implement a rigorous regime of inspection and quality control.

Further Sources of Information

1. A Corrosion Protection Guide, Corus Construction & Industrial, 2004.

2. Steel Bridges – Material Matters - Corrosion Protection, Corus, 2009.

3. Steel Designers' Manual (6th Edition), Chapter 35, The Steel Construction Institute, 2003.

4. Steel Bridge Group: Guidance notes on best practice in steel bridge construction (Issue 5) – Section 8, The Steel Construction Institute, 2009.

5. BS EN ISO 12944, Paints and varnishes, Corrosion protection of steel structures by protective paint systems, British Standards Institution, 1998.