Research Fund for Coal and Steel

SAFSS: Structural Applications of Ferritic Stainless Steels

Design Guidance - Alloy Selection

Report Ref

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This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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1 Introduction

The selection of stainless steels for a particular application is dependent on the exposure condition and service environment. The more severe the environment the more highly alloyed stainless steel that is required to provide corrosion free performance. For stainless steels, corrosion resistance in naturally occurring atmospheres is generally good but specific exposure conditions can result in poor performance with respect to corrosion. In particular, chlorides from the sea, road de-icing salts or other sources can result in general staining or pitting of exposed surfaces.

For structural components, structural integrity is rarely affected by staining and pitting but it is unsightly when appearance is important. The selection of an alloy appropriate for the service environment can avoid the risk of staining or pitting. Generally the higher the alloy content of Chromium and Molybdenum the better the corrosion resistance.

The corrosion performance may also be affected by the quality of the surface finish to the stainless steel. Generally the higher the quality of surface the less rough it is and therefore the less risk of staining and pitting corrosion.

There is no accepted or standardised method of classifying the environments and corrosion performance of stainless steels used in construction. Guidance for using austenitic and duplex stainless steels is based on experience, both good and bad, built up over many years. Such experience does not exist for most ferritic stainless steels.

For carbon steels and galvanized steels the most widely used classification method is that given in ISO 9223[1]. This method links the corrosion rate of the metal to three measurable environmental parameters, Time of Wetness (TOW), Chloride Deposition rate and Sulphur Dioxide deposition rate.

2 Environment Classification

For the SAFSS project, the environmental variables given in ISO 9223 were measured at four locations for a period of 18 months. Samples of ferritic steels were also exposed at the same sites for the same length of time and the results qualitatively analysed at the end of the project. The test sites all used standard panels fully exposed at an angle of 45°, other orientations which are likely on real structures may give different performance.

The ISO 9223 method was used because it is established and provides well known classifications, C1 to C5 plus CX, which are used in the construction industry for corrosion evaluation and protection methods for carbon steels.

[1] ISO 9223:2012 Corrosion of metals and alloys -- Corrosivity of atmospheres -- Classification, determination and estimation

The environmental data obtained in the research can be used to calculate a predicted corrosion rate of **carbon steel** using the dose response function given in ISO9223. This corrosion rate can then be related back to the environment category also given in ISO9223. The resulting environment categories for the four test locations are given in Table 1.

The original site selection intended to cover rural, industrial/urban and coastal locations. However, the actual data gathered for the assumed coastal site (Tornio, Finland) recorded very low chloride deposition rates and is not considered representative of European coastal locations generally which are characterised by higher chloride deposition rates.

Location	Environment Classification to ISO 9223
Tornio	C2
Isbergues	C3
Ljubjiana	C2
Seville	C2

Table 1 Environment classes to ISO 9223

Based on the qualitative assessment of the extent of corrosion on sample panels of various ferritic steel grades, a correlation between the environment category and appropriate use of the different alloys was assumed.

3 Design Guidance – Alloy Selection

Tables 2 and 3 provide guidance on the selection of alloys for the different environments tested based on the performance of test coupon exposures in this project.

Table 2 provides guidance on alloy selection with no tolerance of visible staining on the exposed surface.

Table 3 provides guidance where cosmetic corrosion, staining and minor pitting may occur but corrosion will not affect the integrity of the component.

Alloy Designation	**C1**	**C2**	**C3**	**C4**	**C5**	**CX**
1.4003						
1.4509						
1.4621						
1.4521						

Table 2 – Alloy selection for high quality finish

Alloy Designation	**C1**	**C2**	**C3**	**C4**	**C5**	**CX**
1.4003						
1.4509						
1.4621						
1.4521						

Table 3 Alloy selection with tolerance of cosmetic corrosion

Notes to Tables

1) Green cells indicate the alloy is appropriate for the environment classification.
2) Red cells indicate the alloy is inappropriate for the service environment.
3) Yellow cells indicate that caution is required for these combinations of alloy and environment. There is a risk of staining and localised corrosion at exposed welds and fixings. This risk is greatest where standing water and/or atmospheric pollutants (particularly chlorides) may accumulate.
4) None of the test locations were classified as C4, C5 or CX so it is not possible to provide guidance for these environments based on the SAFSS research.
5) The C1 classification assumes the service condition is an internal environment with no direct exposure to the weather or chlorides. This would include unheated areas of building such as roof spaces, perimeter walls and steel behind cladding.
6) Welds and mechanical fixings through stainless steels may produce crevices which are more susceptible to corrosion on exposed panels. This risk is greatest where the surfaces allow accumulation of water or atmospheric pollutants.
7) There are variations in the performance of steels from different producers at the same test site due to differences in surface condition and whether the steel is hot or cold rolled: the guidance is based on the worst case performance of a given alloy at the test sites.
8) None of the test sites showed significant chloride deposition rates on the sample panels. The user should take this into account when considering applications close to roads where de-icing salts may be used or where wind-blown chlorides from the sea may contaminate surfaces of the structure.