RFCS

SAFSS

Work Package 1 End User Requirements

214265

Final | 9 April 2013

Job number 214265

Ove Arup & Partners Ltd
Level 5 Festival Walk
80 Tat Chee Avenue
Kowloon Tong
Kowloon
Hong Kong
www.arup.com

ARUP

Document Verification

ARUP

Job title	SAFSS			**Job number** 214265
Document title	Work Package 1 End User Requirements			**File reference**
Document ref	214265			
Revision	**Date**	**Filename**		
Draft 1	SAFSS	**Description**	214265 Draft 1 | November 2010	
			Prepared by	Checked by	Approved by
		Name			
		Signature			
Final	9 Apr 2013	**Filename**			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

1 Introduction

The End User requirements given in this document do not prejudge or define the outcomes of the proposed research but set out broad principles the project should satisfy. These principles are consistent with the data and methodologies for the selection and use of other materials when designing structures to the Eurocodes. The aim is to provide the End User with the information relevant to the selection of ferrtic stainless steels for use in the design of structures. These requirements are based on and derived from experience of the use of Eurocodes for the design of carbon steel and other stainless steel materials (austenitic and duplex) in structural engineering. Other approaches to defining the End User requirements (such as surveys or questionnaires) were considered inappropriate given the very low awareness and use of ferritic materials in the target markets.

In addition to the project producing the data required by the End User it is important this data is presented in a useful, usable and familiar form consistent with the approach. The presentation of data should be similar to the treatment of data for other materials within the Eurocode system

Ferrtic stainless steels are largely unknown in the construction industry and are not part of the normal palette of materials considered by designers, architects and engineers. As such, this family of steels rarely form part of the materials selection discussions for use in construction projects. Only occasionally do ferritic steels receive any consideration when offered as an alternative by a supplier usually to offer a cost saving over some other preferred material such as aluminium or austenitic stainless steels. It is extremely rare that design teams subsequently adopt ferritic steels. The End User Requirements for WP1 should address the reasons for both the lack of awareness and uptake in relation to the particular markets that are the focus of the project.

The lack of use of ferritic steels in construction also means that the supply chain infrastructure for the materials does not exist in a recognisable form that is comparable to, for example, carbon steels, aluminium and even austenitic stainless steels.

The current project cannot address all the issues relating to the design and supply of ferritic steels in construction projects. However, the project can provide the foundation for future development through the provision of base design data for use with European codes and standards. This base data can include:

Corrosion and durability data in environments relevant to buildings, particularly in relation to exposed decking and lattice roof/space frame structures

Data on the base mechanical properties for use in design

Data relating to welding procedures and joining which is particularly relevant to both fabricated elements of lattice/space frame structures and decking where through deck resistance welding is common on carbon steel products

The development of detailed design standards and codes specific to ferritic steels and the development of the supply chain infrastructure is a longer-term commitment, which is rightly the responsibility of the steel producers and other interested parties.

1 Durability of Ferritic Steels

The primary drivers for using any type of stainless steel in construction are:

- Corrosion resistance and durability in a given environment
- The quality, range and stability of any surface finish provided to the stainless steel during manufacture

A limiting factor to the use of ferritic stainless steels in construction is that these steels have always been perceived not to have comparable corrosion resistance to the more familiar austenitic stainless steels (for example 1.4307 and 1.4404). There is concern that in many environments, even those that are relatively benign, ferritic steels will rapidly tarnish or stain brown due to atmospheric corrosion and over longer periods pit or suffer corrosion that is potentially more significant.

The perception most designers have is that any corrosion is undesirable whether it affects component integrity, visual appearance or both. Currently there is no significant body of published and verified data appropriate to the construction industry that addresses this perception. If anything the reverse is true, for example Eurocode EN1996 for Masonry Design only permits the use of Ferritic steel for internal controlled environments. EN1993-1-4 is only marginally more favourable suggesting that certain grades of ferritic steel are appropriate for external environments with a low corrosion risk.

The SAFSS project will consider corrosion aspects of ferritic steels in Work Package 7 (WP7). The end user requirements for the output from WP7 are:

- Review and collate existing published and unpublished data on corrosion of ferritic stainless steels.
- Provision of corrosion rate data for different ferritic steels in naturally occurring environments
- Provision of corrosion rate data for different environments typical of construction applications
- The data and guidance shall make a distinction between corrosion rates and/or types of corrosion that may over the long term cause integrity concerns and those that may impact only on visual quality
- Relate the data for ferritic steels to data for other commonly used metals in construction i.e. painted steel, galvanized steel, weathering steels

The challenge in the project is to meet the last two objectives in a way that can provide end users with robust data to allow confidence in the use of ferritic steels in a given application.

For structural and galvanized steels ISO12944-2, Table 1, gives an estimation of corrosion risk. The risks are based on rates for different environments; for these qualitative environments the rate data is presented as a range. This is a convenient way to assess risk for these materials where there is a perception that corrosion protection is required (structural steel) or that there is a finite life for the component (galvanized steel).

Presenting corrosion data in a similar manner to that in Table 1 may be useful to the user assessing integrity risk. The data will show annualised section loss due to corrosion and pit data presented in several ways that might be useful. For example, pit density (pits per unit area of surface) and pit penetration rate (mm per unit of time) for each steel grade studied.

However, this may not always be helpful to the end user concerned with appearance; it implies corrosion and therefore requirements for protection, which is not expected for any stainless steel. Where visual requirements are important the data needs to show that neither staining nor pitting occur for a given surface finish and grade of steel. When assessing corrosion risks and visual quality the key period may be exposure of the steel during the construction, for example metal decking exposed in the finished building. The corrosion risks during this period maybe greater than in the finished structure and any corrosion during this, relatively, short period would be unacceptable in the longer term. Therefore the evaluation of risk has to consider both the short (construction period) and the long-term exposure.

Further complications, for both visual and none visual applications may arise at welded connections. If corrosion performance is different at welded connections, these may represent the limiting corrosion conditions particularly if the surface finish differs from the parent material.

1.1 Variables

Therefore the variables a designer needs to consider in assessing corrosion are:

The material grade

The surface finish quality

The service environment

Is there a visual requirement?

What degree of general corrosion is tolerable?

What degree of pitting is tolerable?

Is performance at welds the limiting factor?

Data from the exposure trials and the literature should be presented in a manner that allows the user to select a material grade that satisfies these criteria.

For steels in applications where appearance is important a simple table of the form given in Table 2 may suffice. In which “Yes” implies the material can be used and “No” that it cannot be used in that environment.

Corrosivity category	Mass loss per unit surface/thickness loss (after first year of exposure)				Examples of typical environments in a temperate climate (informative only)	
	Low-carbon steel		Zinc		Exterior	Interior
	Mass loss g/m^2	Thickness loss µm	Mass loss g/m^2	Thickness loss µm		
C1 very low	⩽ 10	⩽ 1,3	⩽ 0,7	⩽ 0,1	—	Heated buildings with clean atmospheres, e.g. offices, shops, schools, hotels.
C2 low	> 10 to 200	> 1,3 to 25	> 0,7 to 5	> 0,1 to 0,7	Atmospheres with low level of pollution. Mostly rural areas.	Unheated buildings where condensation may occur, e.g. depots, sports halls.
C3 medium	> 200 to 400	> 25 to 50	> 5 to 15	> 0,7 to 2,1	Urban and industrial atmospheres, moderate sulfur dioxide pollution. Coastal areas with low salinity.	Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries, dairies.
C4 high	> 400 to 650	> 50 to 80	> 15 to 30	> 2,1 to 4,2	Industrial areas and coastal areas with moderate salinity.	Chemical plants, swimming pools, coastal ship- and boatyards.
C5-1 very high (industrial)	> 650 to 1 500	> 80 to 200	> 30 to 60	> 4,2 to 8,4	Industrial areas with high humidity and aggressive atmosphere.	Buildings or areas with almost permanent condensation and with high pollution.
C5-M very high (marine)	> 650 to 1 500	> 80 to 200	> 30 to 60	> 4,2 to 8,4	Coastal and offshore areas with high salinity	Buildings or areas with almost permanent condensation and with high pollution.

NOTE 1 The loss values used for the corrosivity categories are identical to those given in ISO 9223.
NOTE 2 In coastal areas in hot, humid zones, the mass or thickness losses can exceed the limits of category C5-M. Special precautions must therefore be taken when selecting protective paint systems for structures in such areas.

Table 1 Extract from ISO12944-2

Ferritic steels are different in two respects; the steels do not corrode in the same manner and should not require additional protection if correctly selected for a given environment. The severity of corrosion risk is also related to chloride concentration or deposition on the steel surface. Where degradation of ferritic steels occurs it is likely to be by localised pitting corrosion, rather than the uniform or general section loss more typically associated with structural steel or galvanized steels. Pitting may result in significant areas of staining over the surface that may be visually unacceptable and on thin materials (<5mm thick) may result in perforation within normal building design lives.

For ferritic steels, the end user needs to be able to identify and evaluate the risks of:

- Corrosion that may affect component integrity
- Corrosion but may affect appearance but does not affect integrity

Steel/Environment	**C1**	**C2**	**C3**	**C4**
1.4003	Yes	No	No	No
1.4016				
1.4509				

1.4521				
1.4621				

For steels where visual appearance is less important the output is more complicated. The user needs to assess two aspects of corrosion namely the rate of any general section loss and the risk of pitting causing perforation within a defined life for each environment. Table 3 shows an example of the data for a C2 Environment and each environment would have a similar table.

	General Loss (mm/year)	Pit Density (Number/unit area)	Characteristic Pit Depth (mm/year)
1.4003	<0.02	5	0.02
1.4016	<0.01	3	0.01
1.4509			
1.4521			
1.4621			

Table 3 Corrosion rates for C2 Environment

The data allows the user to assess the risk of corrosion loss and perforation for any combination of environment and material grade.

2 Design Data

The project shall deliver data, guidance on design methodologies to allow designers to use ferritic steels with confidence. Ultimately, inclusion of data in EN1993-1-4 provides this confidence and to achieve this

- There must be adequate validated data to allow structural design in accordance with all the requirements of EC3
- The number of grades from EN10088 should be limited or the steels grouped to simplify selection and avoid confusion.
- Any section of EC3 that are not relevant to design with ferritic stainless should be identified and the reasons why they don't apply given, for example through thickness ductility for lamellar tearing or lamination of the steel may not be required for thin section considered in this project.

This design data includes both mechanical and physical property data used as basic input into design calculations; this data includes:

- Mechanical properties: yield and ultimate strength, elongation at failure and toughness, elastic modulus
- Physical properties: Density, thermal co-efficient of expansion, thermal conductivity

3 Availability and Supply Chain

Design Codes such as the Eurocodes provide guidance in the form of Informative Annexes but this is usually quite limited in scope and content. However guidance on the selection and use of ferritic steels, beyond the limited scope of EC3, is required to address issues not directly covered in the Design Code, for example the corrosion performance and durability of the steels. The project should provide additional, detailed guidance on such aspects.

The successful development of ferritic steels also includes guidance on:

- On the materials available and appropriate for use in construction
- The selection of an appropriate grade from a relevant standard for a given application
- How the chosen material is specified for a given project
- The product form available
- How to procure chosen material

These significant issues should not be underestimated; they are fundamental to how materials are used to translate a design into something that is built. Other materials groups, particularly austenitic stainless steels, have not always dealt with the issues in a very satisfactory manner and although now quite well established continue to struggle with many of the above points. The Project provides an opportunity to recognise these issues and provide clear guidance to the end user.

4 Joining

- Weldability of ferritic steels and the need to demonstrate that welding doesn't have a detrimental impact on the properties of the steel, particularly toughness, elongation and corrosion performance. These factors may vary with ferritic grade used.

Needs to include stud welding for decking applications.

- Threaded fasteners - types, availability and design procedures

5 Sustainability

Increasingly end users require data on sustainability aspects of materials used in construction. Typically, this will include:

- The recycled content of the materials
- The embodied energy of the materials
- The ease of re-use or recycling at the end of life