ENGINEERING (AND OTHER) CHALLENGES WITH OFFSHORE FABRICATION

Hawkes D

ABSTRACT

Offshore steelwork fabrication presents many challenges, including the tyranny of distance, variation in country design and fabrication standards, language (both written and verbal), cultural differences, contract and legal implications and of course budget, schedule and quality outcomes.

This paper explores a variety of issues that are likely to be encountered, both of a technical and non-technical nature, when steelwork fabrication is conducted in a location other than where the final product will be located for use.

Infrastructure Owners and their project personnel need to develop strategies for tendering, bid/tender evaluation, procurement, quality control, transport, delivery, erection, use and maintenance of structural steel that are different from those conventionally employed when design, materials, fabrication and erection all occur in the same jurisdiction.

These strategies need to address each phase of procurement and use, including the correlation between the standards used for design, fabrication and use.

KEYWORDS

Structural, Steel, Welding, Fabrication, Offshore, Standards, Engineering

AUTHOR DETAILS

Mr Doug Hawkes, Director and Principal Structural Engineer, Structural Integrity Engineering Pty Ltd, Queensland, Australia.

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1. INTRODUCTION

‘Offshore’ steelwork fabrication presents many challenges, including the tyranny of distance, variation in country design and fabrication standards, language (both written and verbal), cultural differences, contract and legal implications and of course budget, schedule and quality outcomes.

This paper explores a variety of issues that are likely to be encountered, both of a technical and non-technical nature, when steelwork fabrication is conducted in a location other than where the final product will be located for use.

The modern world of ‘free trade’ and minimising trade barriers is perceived to be made very simple by Politicians with the release of a policy, all with the best intentions of working together across a variety of borders. The reality however is somewhat different, particularly when the industries affected by these particular policies are governed by local regulations and by extensive interrelated technical requirements, also particular and possibly peculiar to the local environment.

Technical requirements are often governed by dozens of standards, all of which are potentially localised and may even be referenced as mandatory in statutory regulations. Whilst the ‘ISO’ suite of standards is an attempt by some parts of the world’s technical population to create a ‘standardised’ planet, there is by no means a set of ‘world standards’ that govern even the most simple of structures.

Infrastructure Owners and their project personnel need to develop strategies for tendering, bid/tender evaluation, procurement, quality control, transport, delivery, erection, use and maintenance of structural steel that are different from those conventionally employed when design, materials, fabrication and erection all occur in the same jurisdiction.

These strategies need to address each phase of procurement and use, including the correlation between the standards used for design, fabrication and use.

This paper will describe what many will consider obvious. However, the application of management strategies to deal with the issues identified, including their interrelationships, is generally far less obvious to see in action.

2. ‘LOCAL’ VERSUS ‘OFFSHORE’ FABRICATION

2.1 ‘Local’ Fabrication

‘Local’ fabrication can be described as the situation where the design, materials, fabrication, transport, erection and use, plus all the standards applicable to these phases of the project lie *within the one jurisdiction*.

This generally implies that the technical issues associated with standards differences are relatively minor. The non-technical issues, particularly those to do with language and culture, also may not be of particular importance with regards to management and control.

‘Local’ fabrication can still have many of the issues raised in this paper.

2.2 'Offshore' Fabrication

'Offshore' fabrication may include a variety of situations where the design, materials, location of fabrication, construction and erection location and the final use location may all be in different jurisdictions. This in turn could result in a wide variety of available or applied standards, regulations, expectations and issues across different jurisdictions.

The below table provides a simplistic example of the variety of situations that could be experienced in the modern world of 'free trade', considering that the place of design and use is the same.

Table 1
Variety of Standards Issues possible for 'Offshore' fabrication

Fabrication Scenario	Location of Design and Use	Materials	Fabrication
'Local'	Location/Jurisdiction 1	Location/Jurisdiction 1	Location/Jurisdiction 1
'Offshore' Type 1	Location/Jurisdiction 1	Location/Jurisdiction 1	Location/Jurisdiction 2
'Offshore' Type 2	Location/Jurisdiction 1	Location/Jurisdiction 2	Location/Jurisdiction 2
'Offshore' Type 3	Location/Jurisdiction 1	Location/Jurisdiction 2	Location/Jurisdiction 3

The above table considers that the location for design and the location for use is the same, yet results in four different possible scenarios. If the location of design or use changes, an added multiple of possible scenarios is now present.

3. STRUCTURAL RELIABILITY

It is important to start at a base position of structural reliability, before independent consideration of many of the individual factors that can affect overall reliability.

This is aptly described in ISO 2394 *General principles on reliability of structures* [1]:

"It is important to recognize that structural reliability is an overall concept comprising models for describing actions, design rules, reliability elements, structural response and resistance, workmanship, quality control procedures and national requirements, all of which are mutually dependent. The modification of one factor in isolation could therefore disturb the balance of reliability inherent in the overall concept"

The alignment of what occurs in any workshop (either 'local' or 'offshore') to the original design requirements and design intentions is of vital importance.

With regards to fabrication and welding, ISO 3834 *Quality requirements for fusion welding of metallic materials* [2] states:

"For products to be free from serious problems in production and in service, it is necessary to provide controls, from the design phase, through material selection, into manufacture and subsequent inspection. For example, poor design may create serious and costly difficulties in the workshop, on site, or in service. Incorrect material selection may result in problems, such as cracking in welded joints.

To ensure sound and effective manufacturing, management needs to understand and appreciate the sources of potential trouble and to implement appropriate procedures for their control."

4. CHALLENGES TO BE MANAGED

4.1 Technical Challenges

Technical challenges can be described as topics specific to the specification and production of the end product.

4.1.1 Basis of Design

The basis of design is the most commonly overlooked principle when undertaking procurement works in a location other than where the design was carried out. The basis for design is the platform from which all decisions should be made. This may (and most probably should) require access to the Designer and/or their calculations.

The ability of Design Engineers to be able to assess their existing design against different standards is a key capability that will be required in the future.

4.1.2 Documented Design

The 'documented design' is the compilation of the drawings, the Specifications and their referenced standards that describe the end product and how the Designer intended to achieve that end product.

These documents need to be clear on the requirements of the design, the standards applicable to the works and describe how substitutions of materials, standards and processes from that specified will be managed.

The documented design is required to be complied with, as deviation from that prescription implies a non-compliant product, unless authorised.

Further, all personnel involved with the project fabrication, including the Designer need to have an intimate understanding of the specifications and standards applicable. This includes reading them, as i*t is impossible to know what is in a document without actually reading it.*

4.1.3 Specifications and Standards

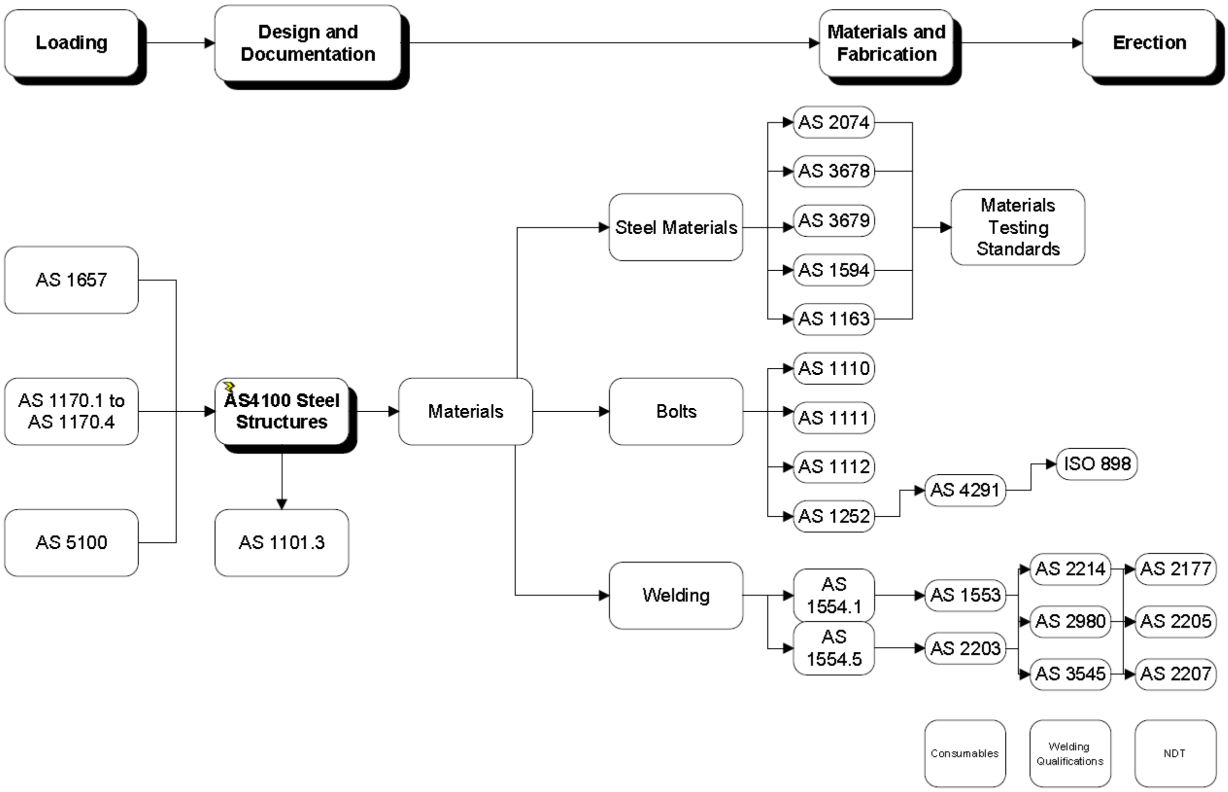
In an Australian context, the design of structural steelwork is generally addressed by the use of AS4100 *Steel structures* [3]. This standard makes reference to a wide variety of standards, which also refer to subsequent standards for execution of the works. Figure 1 illustrates the relationships between standards that are referenced directly by AS4100 or subsequently via the standards that AS4100 refers to.

Substitution of standards may need to be assessed not only for materials, but also welding, inspection (including NDT) and acceptance criteria.

The majority of welding standards around the world have an origin from either Europe or America. In general they are similar with different detail requirements. Therefore, while it may be necessary to assess some of those detail differences, it is more important that the standard to which the workshop wishes to work is a recognised standard and that the workshop actually uses it effectively. Imposition of an unfamiliar standard upon a workshop can cause more problems that it will solve. The piece of steel or the weldment does not know what standard it is being manufactured to.

The involvement of the Design Engineer may also be required (including approval of use of an alternative standard). The choice of welding standard can also affect the methods and acceptance criteria for NDT.

Figure 1
Australian Standards Relationships



There is a significant level of linking of numerous standards, over many fields.

4.1.4 Materials

Steel materials are manufactured to an enormous number of worldwide standards. In the Australian and Asian regions, these could include Australian Standards, such as AS 3678 [4], AS 3679 [5] and AS 1163 [6], Euronorm Standards such as EN 10025 [7] and EN 10219 [8], Chinese Standards such as GB/T 1591 [9], GB 700 [10] and GB/T 8162 [11], or American Standards ASTM A36 [12], A572 [13] or A500 [14]. BS, JIS or DIN standards materials may also be available as well.

Some of these standards will cover dimensions only, some will cover material properties only, and some will cover both.

In an Australian context, a key difference between most other international standards and the structural steel Australian Standards AS 3678, AS 3679 and AS 1163 is that the international standards yield strengths are generally lower for the nominal and industry common, but poorly termed, 'Grade 350' type steel. The grade designation of steels (i.e. Grade 350, S355, Q345 etc) is *generally* defined as the yield strength for up to 16mm thickness. As thickness increases, yield strength generally decreases *for the same grade.* Take the following examples of 20mm and 50mm plate for the relevant Australian Standards and for two other standards.

Table 2
Yield strength comparison for various steel standards

Standard and Grade	Yield strength (MPa)	
	20mm	50mm
AS 3678 Grade 350	350	340
EN 10025 Grade S355	345	335
GB/T 1591-1994 Grade Q345	325	295
GB/T 1591-2008 Grade Q345	335	295
Variation	25 MPa	45 MPa

There is a variation of up to 45 MPa, or a 13% difference between standards for the same plate thickness. Another comparison is that for the 50mm plate, Grade '350' has become Grade '295' with use of an overseas standard material. It also highlights that the year of the standard of use for plate manufacture is also important, with yield strength specified varying between two different versions of GB/T 1591 [9].

However, some design standards require consideration of yield and ultimate tensile strength, and conduct design on what is called a 'modified' yield. This highlights the importance of understanding the design basis for a structure as well.

Table 3
'Modified Yield' strength comparison for various steel standards according to AS4324.1 [15] Clause 5.3

Standard and Grade	Yield strength (MPa)	Ultimate tensile strength (MPa)	'Modified Yield' strength (MPa)
AS 3678 Grade 350 – 20mm plate	350	450	332.5
EN 10025 Grade S355 – 20mm plate	345	470-630	337-345
GB/T 1591-1994 Grade Q345 – 20mm plate	325	470-630	325
GB/T 1591-2008 Grade Q345 – 20mm plate	335	470-630	332

Strategies to manage materials issues can include:

a) Where possible, the Design Engineer may obtain guidance from the Owner or Contractor on where the fabrication is likely to be carried out, and what materials are likely to be used. If this is possible, once the likely materials of construction are known, undertake the design to the relevant mechanical properties of the materials.

b) Ensure that materials substitution processes include the Design Engineer, as there may be a design basis, and additional design requirements that are 'implied' by use of the design material, but may require design review for a material substitution.

c) Whatever the materials used in design, it is imperative to state in the steelwork specifications, on drawings and in drawing notes the *Standard and the Grade* of steel specified, plus include a note that material substitution is permissible only with the approval of the *Design Engineer*.

A subsequent consequence of using a substitute materials standard is that the original design thickness may require substitution with a thicker plate. This may result in weight changes, drawn details no longer being accurate and potential cost penalties with these issues.

4.1.5 Pre-fabrication requirements

The works specification should contain a tollgate for approval of pre-fabrication requirements, such as welding procedure qualifications and welder qualifications. Works related to the qualifications necessary should not be permitted to commence until the requirements of the relevant standard are completed.

4.1.6 The works and acceptance criteria

Establishment and policing of acceptance criteria is essential. Establishment of acceptance criteria will need to include design, pre-fabrication requirements, fabrication quality, documentation, defect corrective actions, signoff and approvals, acceptance, etc. In the majority of cases the acceptance criteria is defined by established standards, and therefore there is little justification for works that do not comply.

The Fabricator is responsible for producing a product that achieves the acceptance criteria. These criteria should not be viewed as ‘stretch targets’ (irrespective of where in the world the works are being done) but as the absolute minimum criteria to be achieved.

Acceptance criteria should be relaxed only in the most extenuating circumstances, and with sufficient engineering assessment. Direct or ‘implied’ acceptance of works outside of the acceptance criteria can result in creation of new ‘pseudo’ acceptance criteria that can outlast this current project and affect others.

If it is defective, fix it.

4.1.7 Inspection (NDT)

Inspection forms an important part of assessing the product against the established acceptance criteria. The first responsibility for inspection lies with the Fabricator. Substituting the Fabricators responsibilities to present a compliant product with Owner financed third party inspection and detection of defects is an undesirable situation. Should this be permitted or even tolerated, the Fabricator is likely to form a reactive attitude to defects (where only those identified by the third party Inspector are rectified) rather than have procedures in place that actively control and manage their fabrication process to minimise the possibility of defects.

Non-destructive testing should not be seen as the great saviour for poor quality fabrication. ISO 3834 *Quality requirements for fusion welding of metallic materials* [2] gives the following guidance:

“Quality cannot be inspected into a product, it has to be built in. Even the most extensive and sophisticated non-destructive testing does not improve the quality of the product”

4.1.8 Third party auditing

Owners may need to establish strategies to undertake third party auditing of all phases of a project. This may require the involvement of Design Engineers, specific quality inspection personnel (both full time and intermittently), and management.

However, the strategy must ensure that the third party auditing does not become the Fabricators quality control process.

4.1.9 Erection

The flow on effects of poor work practices and acceptance of works with defects can cause issues at the erection location. This may include interface fit-up, but also attitude that if defective works are acceptable at the workshop then they are acceptable at the worksite.

This can result not only in direct costs due to rectification works, but long term costs associated with defective product.

4.1.10 Future use and maintenance

The use of offshore materials and offshore fabrication standards and practices can potentially lead to increased costs during use and maintenance of structures. Owners will need to develop strategies to ensure that materials of construction (as opposed to materials of design) are accurately recorded and retrievable, plus documentation relating to weld procedures from manufacture are available for maintenance.

4.1.11 Statutory obligations

Statutory obligations, except those specifically required to obtain permits or registrations, are seldom reviewed in detail. As an example in the Australian mining industry context, the *Western Australian Mines Safety and Inspection Regulations 1995* [16] contain very specific duties with regards to Designers, Manufacturers and Importers. This includes the allocation of legal duties when items of plant are designed and manufactured outside the jurisdiction of the state. This is most clearly seen in part 6.9 of the regulations, which states:

"*If the designer and the manufacturer of plant are both outside the jurisdiction of the State, the importer of the plant must carry out the designer's duties, and the manufacturer's duties under regulations 6.3, 6.4, 6.7 and 6.8*"

This clearly places a responsibility on the 'Importer' (which may be a Contractor, or potentially the Owner themselves) to manage risks associated with the design and the manufacture of an item. This effectively excludes a defence based on fault by an offshore Supplier.

4.2 Non-Technical Challenges

Non-technical challenges can be described as topics that are not directly related to the specification and production of the end product, but can have a significant influence on the product and/or the project.

4.2.1 Safety

In an Australian context, some of the workshops in different areas of the world have totally different safety standards to what would be expected in Australia. This may result in expatriate Employees being exposed to additional risks at the offshore workshops due to the work site, travel for business, and out of hours activities.

This requires an additional set of management strategies which may need to cover Employees direct safety risks at workshops, global and local travel, including Employees inexperienced with overseas exposures.

It can also have a 'cultural' effect on expatriate Employees when they return to their normal place of work – the mindset of a certain safety standard that their Employer would apparently accept at an 'offshore' location can be transferred to the local location that may affect both the Employers worksite and the Employees ability to retain employment.

4.2.2 The perception of advantage

It is not uncommon for decisions to be made very early in a project for 'offshore' procurement due to the perceived advantages of schedule and/or cost. These decisions are often made without any appreciable assessment of the technical and non-technical issues that will require management during procurement and during use of the structure.

The decision may also be made with absolutely no knowledge of the specific location or workshop where the fabrication may be procured. Subsequently, the decision to select and use a particular 'offshore' fabrication shop may be made personnel who are unskilled in assessment of that workshops capabilities and quality processes.

An example of this is management selection of an inadequate workshop that then requires the QA personnel to attempt to resolve all the issues present and entrenched at that workshop due to that single poor decision.

The perception of advantage can rapidly change to a reality of disadvantage.

4.2.3 Language and Interpretation

The issue of language and interpretation can be significantly underestimated. The issue of language is compounded when both verbal and written communications require translation/interpretation. The common misconception is that all is required is an interpreter/translator.

It needs to be recognised that interpretation and translation is a two-way process.

To highlight potential issues, some examples are provided:

a) 'Literal' interpretation – The English language can cause many issues with 'literal' interpretation. There is often a need to provide context when using certain words in the English language. As an example, using word recognition software rapidly identifies the necessity of context, and the confirmation that by increasing the volume of your voice, the level of understanding does not increase!

   When there is an intention to issue documents to countries whose primary language is different, documents need to be read and reviewed with an entirely different mental approach, including reading every single word 'literally'.

   Translators/Interpreters have the same issue – they must have sufficient experience in context and the process of communication must be slowed down, simplified and a process of confirmation of understanding both ways must be undertaken.

   This is just as important with technical and/or contractual documentation, including standards. Many technical standards have been written by people whose basis for writing the standards was that a person of the same language would read them.

b) 'Convenient' interpretation – Situations can arise when there is no corresponding word/phrase for the relevant word/phrase requiring translation. This may be due to there being no equivalent word or due to the interpreter not having the vocabulary to achieve an accurate translation.

   In this situation, many translators will default to what they 'think' it means, or what they think needs to be communicated. Sometimes they will get it right and sometimes it will be out of context.

c) Interpreters/translators – Many interpreters/translators have been trained in the 'conversational' form of the language that they are interpreting, as this is the most common and the most used. Unfortunately this does not assist greatly when technical language is being used.

d) Slang/Dialects/Accent – Use of slang or a strong accent can also result in misunderstanding. A conscience change of one's common language characteristics may be needed to assist interpretation.

To be able to resolve many issues with language requires time, patience and understanding (literally!). It also requires training of personnel to be able to maximise the efficiency of their communications and establish that both parties understand and have correctly communicated and understood the requirements. Remember, difficulty in understanding may be mutual.

4.2.4 Culture

Cultural differences can be behavioural, technical, procedural and bureaucratic.

There is no shortage of advice on general behavioural cultural differences across different countries, but issues associated with a technical environment are rarely dealt with.

For example, some cultures have a very well established hierarchy when technical meetings are being held. Open criticism or comment of a projects outcomes or schedule or cost could cause offence, or create barriers to progressing resolution of an issue.

Procedural culture may be so strong within an organisation that no matter how inefficient it appears to an observer, the ability to change that process or culture is likely to be minimal. It may therefore be necessary to work around it.

The ability to read and balance cultural happenings with resolution of technical issues is a skill well worth investing in, to be able to satisfactorily achieve compliant works offshore.

4.2.5 The tyranny of distance

For 'local' fabrication it is generally a minor cost and a minor inconvenience to attend a workshop and resolve issues, either of a technical or non-technical nature.

Transferring the location of fabrication to thousands of kilometres away introduces all sorts of schedule, cost, communication and technical issues that now require an entirely different strategy to 'hop in the car and attend the workshop'.

Therefore, resourcing and budgeting needs to be allowed for both what is planned, and also contingency to manage what is unplanned.

4.2.6 Base level of knowledge/education

The base level of education and knowledge of fabrication personnel can vary significantly, and must be appreciated. For example, workshop floor employees in lower cost countries may not have a basic education, and may not be able to read. They may rely on verbal instruction from Supervision to achieve their daily tasks. They may have learnt their trade by observing others, rather than by any formal training.

This must be recognised, as communication of problems that need to be resolved may be about 'showing' as much as 'saying' or 'writing' about the issue.

4.2.7 Relationship of designer to end product

The modern structural steelwork procurement process often creates a separation of the Design Engineer from the end product by distance, contracts and care. Many Design Engineers do not get to see the fruits of their design effort, therefore do not develop an appreciation for size, or the difficulties in producing their designs.

Similarly, many Design Engineers are not aware of the substitutions that their designs may be subjected to. They are not familiar with 'common' worldwide design, steel or fabrication standards. For example, Australian standard materials may not be used for a particular design, even if it is being fabricated in Australia.

This separation will need to change, to ensure that Design personnel not only remain responsible for their designs, but also have the ability to control how their design is implemented.

4.2.8 Contract/legal recourse

Purchasing offshore can result in a significantly reduced ability for any contractual/legal recourse should these avenues be required to be pursued.

4.2.9 End user attitude effects

Should substandard work practices, acceptance criteria and products be permitted (either directly or by lack of action) in an offshore location, the flow on effects to the local environment can include:

a) An attitude that reduced quality is acceptable.
b) An approach to rectification of defects that is substandard, because we are fixing someone else's problem.

This can further exacerbate an already defective situation.

4.3 Combining The Technical With The Non-Technical

Many of the above topics merge to create a symbiotic relationship between the technical and the non-technical aspects. Failure to address a non-technical issue may affect a technical outcome, and vice versa. Many technical and non-technical topics are interrelated.

An example is the 'perception of priorities'. A recent example included a situation where a significant steel item was being assembled. Unfortunately the priority communicated at the time to the work crew was schedule – the assembly had to be complete by a certain date. However, the sub-assemblies were not completely painted, and once assembled, it would be very difficult to achieve a quality protective coating application. This was brought to the attention of the work crew's supervision. Overnight, the items had their protective coating applied. There was no technical thought given to the quality requirements for the protective coating, but it was completed so as not to affect schedule.

5. CONCLUSIONS

Many of the challenges experienced during 'offshore' fabrication are caused by:

a) Lack of a thorough enough evaluation process on an 'offshore' fabrication/procurement decision, including how risks will be managed.

b) Lack of planning or strategy for execution of the necessary tasks from project conception to completion.

c) Ignorance or lack of knowledge of the issues likely to be encountered.

d) Driving the issue to the point of 'duress' – that is by either ignorance, or intentionally deferring any kind of action until the latest possible point in the schedule. This often places the issue at the feet of the person who should be least responsible for managing it.

All levels of personnel responsible for a project, including Management (even at the corporate level) need to adequately evaluate, plan and set strategy for the issues that are likely to arise with ‘offshore’ fabrication.

The perceived advantages of executing fabrication ‘offshore’ can rapidly disappear with a failure to actively provide a strategy, skilled resources, budget and time for management of issues from project conception to project conclusion. A strategy for ‘offshore’ fabrication needs to be a formal plan to be able to identify risks with various topics and assign controls for those risks.

In some instances, if all the necessary considerations are dealt with in project development stages, the choice to procure ‘offshore’ may be determined to be detrimental to an overall project rather than beneficial.

Many of the above topics are applicable to ‘local’ fabrication as well. ‘Local’ fabrication should not be considered immune from problems.

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REFERENCES

[1]. ISO 2394:1998 General principles on reliability for structures.

[2]. ISO 3834-1:2005 Quality requirements for fusion welding of metallic materials

[3]. AS 4100:1998 Steel Structures

[4]. AS/NZS 3678:2011 Structural steel – Hot-rolled plates, floorplates and slabs

[5]. AS/NZS 3679.1:2010 Structural steel – Hot-rolled bars and sections

[6]. AS/NZS 1163:2009 Cold-formed structural steel hollow sections

[7]. EN 10025-1:2004 to EN 10025-3:2004 Hot rolled products of structural steels

[8]. EN 10219-1:2006 to EN 10219-2:2006 Cold formed welded structural hollow sections of non-alloy and fine grain steels

[9]. GB/T 1591:1994 and GB/T 1591:2008 High strength low alloy structural steels

[10]. GB 700:1988 Carbon structural steels

[11]. GB/T 8162:1999 Seamless steel tubes for structural purposes

[12]. ASTM A36-08 Standard specification for carbon structural steel

[13]. ASTM A572 Specification for high strength low-alloy columbium-vanadium structural steel

[14]. ASTM A500-10a Standard specification for cold formed welded and seamless carbon steel structural tubing in rounds and shapes

[15]. AS 4324.1:1995 Mobile equipment for continuous handling of bulk materials, Part 1: General requirements for steel structures

[16]. Western Australian Mines Safety and Inspection Regulations 1995

[17]. Hawkes D 2009. Offshore steelwork fabrication – An engineering perspective. Australasian Welding Journal Volume 54, First Quarter, 2009, p6-8.

[18]. Hawkes D 2011. High(er) strength steels in structures – Engineering and welding considerations. Australasian Welding Journal Volume 56, First Quarter, 2011, p17-18.

[19]. Australian Steel Institute ASI Technical Note TN005 V2 June 2011, Guidelines for designing to AS4100 when imported materials are involved.

[20]. Australian Steel Institute ASI Technical Note TN007 V1 July 2011, Compliance issues and steel structures