

# IMPORTED STRUCTURAL STEEL ISSUES & CONSIDERATIONS

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**ABSTRACT:** *Beca Ltd (Beca) has recently been involved in a number of New Zealand based projects where imported structural steel has been used or considered for either material supply and/or fabricated sections. This paper will cover the code compliance aspects for structural steel in New Zealand for both designers and builders, as well as some of the difficulties we have encountered when alternative structural steel was proposed on a major project in New Zealand.*

## 1 Compliant Structural Steel

### 1.1 Introduction

As demand in the construction industry in New Zealand continues to grow, pressure on procurement of resources and materials is also on the rise. We have seen an increasing trend towards the desire to import commodities from non-traditional sources globally. Clients, Contractors, Fabricators and the like, are looking for ways to service the New Zealand market to minimise costs and reduce delays through providing alternative pathways for sourcing and securing construction materials. These alternative procurement methods are being used to provide a competitive advantage to secure work to improve project feasibility. As a professional services firm, Beca has been working closely with the construction industry to ascertain the viability of being able to import structural steel for use in the New Zealand market. However, there is a widespread lack of understanding in the supply chain as to our minimum standards for steel and the specifics of New Zealand regulations, as they can often be viewed as being onerous or difficult to achieve. These misconceptions need to be lifted, as it is widely known within the steel industry that not all steel is created equal.

### 1.2 The Project Participants

There are a number of parties involved in the selection and procurement of structural steel for use on New Zealand projects:

#### 1.2.1 Consulting Design Engineer

Is responsible for the production of design drawings and specifications, which comply with New Zealand regulations. Often this design will be peer reviewed by another engineer. For the purposes of achieving building consent approval, the design engineer will typically supply a producer statement for design (PS1), and the peer reviewer a producer statement for design review (PS2). These producer statements are provided to confirm design compliance with the New Zealand Building code.

#### 1.2.2 Structural Steel Contractor & Associated Supply Chain

The Contractor will typically supply, fabricate and erect the steelwork in accordance with the Design Consultant's documentation (drawings and specifications) and the approved building consent. The Contractor will typically undertake all three activities noted above, but the roles are sometimes being divided amongst a number of groups as the influence of imported materials is affecting how the structural steel is handled. The structural steel Contractor is typically engaged under the Main Construction Contractor, but again, factors such as the influence of imported materials is resulting in some Clients engaging Structural Steel Contractors direct. On completion, the various parties will typically provide a producer statement for construction (PS3). These producer statements confirm compliance of the built project with the consented plans and specifications. Other groups often involved in the supply chain include local steel merchants, steel importers, and counterpart steel merchants off shore. All these parties have a responsibility in the supply of structural steel for use in New Zealand.

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### 1.2.3 Construction Reviewer

Typically this is the same person who has carried out the design, but doesn't strictly need to be. This Engineer will carry out construction review and on satisfactory completion will provide a producer statement for construction review (PS4).

### 1.2.4 Territorial Authority

The Territorial Authorities are responsible for ensuring the various parties involved in the project provide sufficient evidence confirming that the proposed design and construction are completed to the agreed codes and standards. The Territorial Authority will issue building consents for the works based on submissions made by the Client, and will subsequently provide sign off at the completion of the project through a Code Compliance Certificate. In some regions, Territorial Authorities are taking a proactive oversight role in the importation of structural steel, and will demand that consents (or amendments to consents) are lodged for such activity.

## 1.3 Consulting Engineer – Specification of Steel

In New Zealand, all professional engineers work within the regulatory framework governed by the New Zealand Building Act (NZBA). The NZBA cites the New Zealand Building Code (NZBC), which also has the minimum standards for structural design addressed under Clause B1 of the NZBC, and durability under Clause B2.

As a means of compliance with Clause B1, the Verification Method B1/VM1 is noted, which generally states that compliance with the cited material and loadings codes is an accepted means of compliance with the provisions of the Building Code, to which the Verification Method relates.

In particular, B1/VM1 cites NZS 3404:Part 1:2009 as the applicable New Zealand standard for structural steel materials.

Within NZS 3404.1:2009, Section 2.2 sets out the types of steels which can be used for code-compliant design. By default there are only four sets of country standards which are cited: Australia/New Zealand (AS/NZS), British (EN), Japanese (JIS), and American (AISC).

Section 2.2 of NZS 3404.1:2009 (paraphrased) states: *“If structural steels or shapes other than those listed are used, they shall comply with an internationally recognised standard that is approved by a qualified metallurgist or materials engineer, as being equivalent to the listed standard. **Such an approval is outside the scope of this Standard as part of a verification method for the NZBC.**”*

Thus it can be seen from the above that the supply of steel from outside the traditional (approved) sources will require robust verification with respect to code compliance.

Within these standard steel types, there are various levels of strength, ductility and toughness. With knowledge of the seismic demand on the steel elements being designed, the engineer must specify the appropriate steel sub-type, as per Table 1 of NZS3404.1:2009 (recreated below).

**Table 1 – Steel types for seismic members (recreated from NZS3404.1)**

| Seismic member category | Conforming steel types |
|-------------------------|------------------------|
| 1 and 2                 | 2S, 3, 5S, 6           |
| 3                       | 2, 5                   |
| 4                       | 1, 4, 7A, 7B, 7C       |

Clarifying Table 1 above, seismic member categories 1 and 2 are for elements of the structure which are expected to be pushed beyond yield in an Ultimate Limit State (ULS) seismic event. Designers require this type of steel to have high levels of ductility and toughness in order to function as expected. By contrast, seismic members in category 4 are elements where little to no yielding is expected (thus can be considered to act elastically) and have less onerous performance requirements.

With the design engineer specifying the conforming steel types for the project, the supplier can then utilise Table 2 of NZS 3404.1:2009 (recreated below), in choosing steel supply options.

**Table 2 – Steel type relationship to steel grade (recreated from NZS3404.1)  
(For steels from 2.2.1)**

| Steel Type | Steel grade                    |                   |                              |                    |                       |                               |
|------------|--------------------------------|-------------------|------------------------------|--------------------|-----------------------|-------------------------------|
|            | AS 1163<br>ASTM A106<br>API 5L | AS/NZS<br>1594    | AS/NZS 3678<br>AS/NZS 3679.2 | AS/NZS<br>3679.1   | BS EN<br>10025        | JIS G 3106<br>JIS G 3136      |
| 1          | C250<br>Grade B                | 200<br>250<br>300 | 200<br>250<br>300            | 250<br>300         | S275<br>S275JR        | SM 400A<br>SN 400A            |
| 2          | C250L0                         | -                 | -                            | 250L0<br>300L0     | S275J0                | SM 400B<br>SN 400B            |
| 2S         | -                              | -                 | 250S0<br>300S0               | 250S0<br>300S0     | -                     | -                             |
| 3          | -                              | -                 | 250L 15<br>300L 15           | 250L 15<br>300L 15 | S275J2G3/<br>S275J2G4 | SM 400C                       |
| 4          | C350                           | HA350<br>HA440    | 350<br>WR350                 | 350                | S355<br>S355JR        | SM 490YA                      |
| 5          | C350L0                         | -                 | WR350L0                      | 350L0              | S355J0                | SM 490YB<br>SM 520B<br>SM490B |
| 5S         | -                              | -                 | 350S0                        | 350S0              | -                     | -                             |
| 6          | -                              | -                 | 350L15<br>400L15             | 350L15             | S355J2G3/<br>S355J2G4 | SM 520C                       |
| 7A         | C450                           | -                 | -                            | -                  | -                     | -                             |
| 7B         | C340L0                         | -                 | -                            | -                  | -                     | -                             |
| 7C         | -                              | -                 | 450L15                       | -                  | -                     | -                             |

Key points to note:

- The yield strength of the steels can range between 200MPa and 520MPa, but the most commonly specified steels in NZ are around 250MPa to 355MPa
- Steels which are required by the designer to undergo inelastic seismic action typically require satisfactory Charpy V-notch properties measured at 0° C or -15° C. These requirements may be difficult to meet for ordinary steels from alternative sources.
- The NZ Steel Code is technically advanced and allows the designer to make use of the specific properties of steel with respect to strength, ductility and toughness. However, this does mean that for seismic resisting steels in particular, there are specific material requirements that must be met. Substitution with ordinary steels will result in substandard performance and possible premature failure during a seismic event.

#### 1.4 The Supply Chain

When steel is procured that does not conform to the options listed in Table 2 above, there will be inherent uncertainties in the proposed material that will be supplied, and confirmation and verification will be required to ensure that the material is suitable as a substitution to the specified material. The issue is not necessarily that the steel is imported, it is that it is being imported from non-traditional locations, supplied from unknown mills, produced to a different standard, with an unknown or unproven production testing regime.

For steel material supply, there are two main issues that Engineers are conscious of:

- 1 – Steel which is purported to be manufactured to one of the accepted standards mentioned above, but the provenance and compliance is uncertain.
- 2 – Steel which is manufactured to some other standard, and is claimed to be “equivalent”

For fabricated steel, there are further potential problems with quality control and fabrication processes and testing. Compliance cannot be fully assessed from a post fabricated inspection. Quality can only be assured from quality controls or checks through the whole process.

## **2 Project Example**

The following are learnings and experience gained from a change in the steel procurement process for a sizeable newly-constructed building recently completed, designed by Beca.

### **2.1 Introduction**

The building comprises five storeys at and above ground with a full basement over the entire building footprint. The building is base isolated at ground floor level and covers the entire basement footprint. The building houses mostly office space, with retail on the ground floor and car parking in the basement.

The majority of the building superstructure is designed as a steel gravity frame - being a series of steel beams spanning onto concrete filled steel tubular (CFT) columns, with the basement constructed out of reinforced concrete. Lateral resistance of the superstructure is provided through a series of steel CHS braces located around the perimeter of the building. As the building is base isolated, the superstructure is designed to behave in an elastic manner. This enables simple construction and uncomplicated detailing, as most elements are predominantly designed for gravity demands only. As a result, most of the steel is Category 4, with the CFT columns being classed as Category 3.

Both the design and initial tendering process was based on the general assumption that structural steel members for the building would be NZ sourced, or NZ code compliant material. However, this all changed when the contract was awarded to a contractor where substantial savings were offered, with a significant proportion of the saving arising due to substitution with alternative imported materials.

At the time of tender, the drawings and structural specification were issued based on SCNZ connection detailing, standard clauses within the Beca Steel Specification (modified as appropriate), and all steel members aligning with the AISC design capacity tables and Fletcher Steel, Steelpipe and Steltech catalogues.

### **2.2 Tender Process**

During tender review, the ultimately successful tenderer made an offer based on the importation of both supplied and fabricated steel elements, being procured from China. This presented the project with a significant saving, which was attractive to the Client.

During the tender interview, the Contractor noted that steel supply was based on:

- Third party accreditation to ensure mill steel supply would meet New Zealand standards
- Independent certification that the fabrication would meet New Zealand standards
- The whole process being overseen by a dedicated Contractor's Quality Manager
- The provision of fully detailed shop drawings
- The appointment of a dedicated Contractor's Logistics Manager to ensure coordinated delivery and erection
- Erection by a local specialist firm.

Based on the above, and the fact that much of the steel was expected to have low seismic demand as a result of the building being base isolated, the offer was accepted by the Client.

### **2.3 Shop Drawings and Fabrication**

At the start of construction, the Contractor appointed a Chinese-speaking dedicated steel procurement manager, who immediately commenced with the shop drawing process and provided "examples" of steel mill certification, fabrication observation QA checklists, and welding procedure certification for approval. This led to a series of meetings to resolve what was required from the contractor to meet their obligations. It became clear that the Contractor:

- Did not understand or appreciate the difference in steel metallurgical properties;
- Did not fully understand the implications of CharpyV-notch testing at 0°C (Chinese steel is typically tested at 20°C);
- Incorrectly assumed Beca would "approve and certify" all submissions;
- Would deliver 80% of all shop drawings in a short period of time (made possible with a large off-shore shop detailing force) and expect immediate turn around;
- Did not appreciate that fabrication (welding) in China was not in general alignment with the procedures in NZ. However, because they were using a large fabricator who supplied steelwork around the world, incorrectly assumed Beca would accept their work without question (as it was "internationally acceptable").

- Expected Beca to review and sign off all alternative member sizes, thereby alleviating the Contractor's responsibility for coordinating and resolving the changes with all other disciplines.
- Did not understand their obligations to fully coordinate their submission to comply with the tender (submissions were made ad-hoc, incomplete, and through multiple methods of delivery).
- Incorrectly assumed it was the design engineer's responsibility to accommodate all design changes made by the Contractor, and that these changes would be checked by the design engineer along with documentation amendments needed; with payment for any changes made not being on the Contractor's account.

These meetings enabled both parties to understand what was needed to ensure the work met both the Beca Specification and New Zealand Standards. Unfortunately, the effort required to resolve the process become extensively drawn out (impacting on costs and time), required significant input by the design team (requiring an increase in resources), and necessitated complete re-documentation of all drawings to align with the alternative steel sections, to comply with Council consenting processes. These ramifications were not fully appreciated by Beca and the wider project team at the time of tender acceptance.

## **2.4 Project Coordination**

Many steel sections sourced from the Chinese market are welded sections of similar size to the AISC sections, and are not hot rolled sections such as those commonly sourced from New Zealand's traditional market suppliers. The Contractor therefore tabled member size substitutions that "generally" aligned with the rolled sections specified in the design documentation. However, as the actual fabricated beam sizes differed to the section sizes commonly used in NZ, additional effort from the Beca design team was required in determining if the alternative members met the minimum stiffness values, provided the same stability for unsupported elements, or were of similar or greater strength to those selected as part of the original design.

This review process was meant to be undertaken by the Contractor, but it was found to be easier for Beca to undertake the work, as the Contractor did not have an engineer who fully understood the design requirements of the code, or the structural demands of the actual building; in fact, the Contractor expected that this would be Beca's responsibility as they were not responsible for the design of the building.

In addition to the structural design requirements, drawing coordination was required between the various design disciplines as the actual substituted beam widths caused clashes with openings, partition wall thickness, stair widths, etc. The changes to beam depths resulted in clashes with ceilings, brackets, services, whereas web thickness changes impacted on connection detailing. This again was not fully realised at the start of the project, and required significant input by Beca's structural team as well as the architects and services engineers.

## **2.5 Meeting NZ Steel Qualification**

A review of the NZ and Chinese codes showed that substituted steel was to be classed as "unidentified" under Section 2.2 of AS/NZS 3404.1 until its chemical and mechanical properties had been tested (and shown to comply) by a laboratory holding an International Accreditation for testing to:

- AS 1391 for tensile testing at ambient temperature
- AS 1544.2 Part 2 for Charpy V-notch testing
- AS/NZS 1050.1:1996 for chemical composition.

In developing a procedure to ensure the imported steel met NZ Standards, the Contractor appointed a Chartered Professional Engineer (CPEng) qualified engineer to compare differences between the Chinese and NZ Standards, and a specialist metallurgist to review the physical properties. These appointments were only initiated when Beca insisted they employ specialists to provide qualified input and sign off that the submissions met the NZ Standards.

For this project the Contractor commissioned A Testing Centre in Shanghai to independently verify the tests on the steel being carried out firstly as the steel was being made (mill certificates), then again when the steel was received and tested by the fabricator's certifiers. A spreadsheet capturing all mill certification data and independent testing was developed, allowing immediate identification of steel elements not complying with NZ Standards.

What is of note is that the Chinese Standards only require Charpy testing at 20°C as this is a general requirement for steel internationally. Although it is generally accepted that all steel is tested in NZ at 0°C, the code does not specifically set a temperature for steel not specifically specified as L0 or S0.

This was also not appreciated by the specialist metallurgist appointed to review the chemical properties who noted: *Steel manufactured to Chinese Code GB/T1591 for grades Q345B and Q345C complies with Section 2.2 of AS/NZS 3404.1 for the project in terms of its chemical and mechanical properties EXCEPT the Charpy test for Q245B steel which must exceed 27 Joules at 0°C.*

In our research it would appear that the requirement for testing to 0°C for L0 and S0 only, used to be included as part of the milling and fabrication standards, but over the years the actual requirement was dropped or omitted based on the findings that the steel produced in NZ generally had the minimum ductility required for non-seismic elements. This can't be categorically stated, as most people spoken to during our investigation had varying reasons or statements as to the omission or lack of detailed clarification, depending on their position in the market. In the end, the design team concluded that for all non-seismic (Category 4) elements, Charpy testing to 20°C could be accepted. It is also important to note that a wide range in energy readings could be obtained during testing. Therefore having readings of 50, 92 and 80kJ is not uncommon for a test, so careful consideration and judgement is required when reviewing these test results.

Although most members were shown to comply, there were a few identified as having either lower strengths (245MPa) or large variances in the Charpy test results (results were only available after the steel arrived in NZ). Fortunately these issues were confined to localised members, being either roof trimmers or short span rafters bolted at close centres to concrete members. However, time and effort was required to review and determine whether these elements could be accepted.

Some points that were also not fully appreciated at the time were:

- The need to carefully review the  $f_y/f_u$  ratio. This is almost taken for granted when reviewing NZ compliant steel, but with imported steel and particularly from China,  $f_u$  values can be exceptionally high
- This is commonly achieved through the addition of minerals that would not be part of the normal reporting table for elements in NZ; one example of these elements is Boron.
- The potential impact on the phi factor used for materials. The phi factor in NZS3404.1:2009 is 0.9, and has been established over an extensive period of time through testing of milled steel; which is lacking quantification from imported material sourced from overseas mills. Consideration should be made to potentially reduce the phi factor to account for the unknown variability in material properties that exists with steel received from unknown origins.

## **2.6 Meeting NZ Fabrication Standards**

Due to the Chinese members being fabricated as opposed to being hot rolled, there was considerably more fabrication involved relative to standard rolled sections. This again required significantly more input in terms of checking, verification and QA documentation not foreseen at the time the tender was received and awarded.

To ensure fabrication met New Zealand Standards, the Contractor established the following procedure:

- The main fabricator would test the steel from the mills to verify the steel properties, and would secure all the steel plates in one area of the fabrication yard. This meant all plates used for the project would not be mixed with the general plate runs during fabrication. They in turn also employed an independent testing agency for testing and monitoring to ensure the steel complied with the required standards and that only the compliant steel was used on the project.
- As the fabricator's independent testing agency was not ISO accredited, SGS were appointed by the Contractor to provide independent inspection, verification, testing and certification services of the work undertaken by the fabricator (SGS has ISO 17025:2005 certification).
- In New Zealand, Southern QA Ltd was appointed to provide an independent review of all weld testing procedures put forward by the fabricator. They visited the fabrication facility in China to inspect procedures and QA systems being followed. A report setting out their general acceptance of the process was presented along with a few recommendations.

Most reports, certification and inspection logs issued through the project were found to meet the minimum project standards. Where issues were raised, these were referred to Southern QA for comment, and in all cases the discrepancies were found to be due to language used (conversion of Chinese to English) and not due to actual fabrication practice.

## 2.7 Learnings

At the completion of the design period, there may be a need to review and revise the design further to accommodate Contractor and/or Client requests, if it is seen to be in the best interests of the project. This project example outlines the agreements and concessions to ensure the structural Specification was met, and demonstrates the additional effort required to achieve a successful outcome for the Client. The main learnings from this project are considered to be:

- The Client is reliant on the experience and input of the design team when accepting a tender. In this case we did not anticipate the extent of additional work required, and overestimated the Contractor's understanding of roles and responsibilities.
- Not all re-design costs are recoverable, and sometimes it can take considerable efforts to get these costs reimbursed. In this case, the Contractor paid for most of the effort required by Beca, but not all the cost was recoverable.
- Visiting overseas mills and fabrication workshops is an important step to break down language and communication barriers, and providing confidence in the processes that are employed overseas. It also demonstrates to the overseas fabricators that the Client is serious in confirming the quality of their produce. We did not visit the fabrication shop for this project, and in retrospect this may have resolved a number of communication issues along with providing a better level of confidence in fabrication.
- If steel sections are being substituted, a Building Consent amendment (along with a revised PS2) is required.
- Chinese companies employ large workforces, thus be prepared to receive the entire project's shop drawings within days of them starting. This will also mean that RFI's will be raised in numbers demanding significant resource increases. This needs to be controlled and appropriate steps taken to meet both party's expectations.
- When weighing up the financial benefit, all costs and savings should be aggregated as savings can be eroded by the additional time and costs incurred.
- Get input from the industry. Local bodies such as SCNZ and HERA are there to help, and are currently doing a lot of work in this space.
- Be aware of the limitations of designers and contractors regarding the finer points of the NZ Standards. SCNZ and HERA are a very valuable source of advice in this regard.
- Consider the seismic category of the structural steel being proposed, and the more stringent requirements for Category 1 and 2 steel members. It was fortunate that in this case the steel only needed to be Category 4.
- There were significant delays involved in the process. It was fortunate that this did not affect the overall critical path.

## 2.8 Summary

On this project the Contractor was eventually able to deliver Chinese manufactured steel member substitutions that we were able to accept and the resulting quality was reasonable. However, there was considerable additional time and cost for Beca and the other project participants to reach this point. This was not appreciated when the tender was received and awarded.

What initially appeared as a substantial saving in steel cost was reduced due to professional and consenting fees. Had there not been delays on site caused by other construction issues, the time taken to resolve the steel supply may have impacted heavily on programme.

If using unidentified steel, it is essential that a Contractor employs specialist Consultants with suitable qualifications and experience to sign off the material, and also appoint a key person with experience in China to manage the process.

We would recommend caution to any Client considering this option, and would challenge the Contractor to clarify key issues about delivery noted above. On future occasions we would apply much more scrutiny and insist on a better delivery plan as part of the tender.

If the project has low seismic demand for the steel, you get the process right, ensure adequate QA checks are in place, allocate sufficient time and effort, and appoint suitably qualified specialists to provide guidance and sign-off, the possibility of using steel from China can offer a saving that may be worth pursuing.

### **3 Recommendations**

#### **3.1 Recommendations for Consulting Engineers**

Based on experience gained on this and other similar projects, Beca is considering to adopt the following position for future steel structure design and specification:

- 1 – All steel is to be selected in compliance with NZS 3404 part 1, Tables 1 and 2.
- 2 – All fabricators shall be NZ based and accredited to the Steel Fabricator Certification (SFC) scheme.
- 3 – All structural steel shall be sourced from an ACRS accredited mill.

This position is not intended to be anti-competitive, but more to clearly set the bar for the acceptance standards required. Use of alternative procurement will need to meet the same standards of steel properties and metallurgy, fabricator competence and quality systems, and overall 3<sup>rd</sup> party quality assurance and chain of custody for the steel materials.

In our consulting engagements, we will make it clear that this is the basis of our design. This then allows us to clarify our scope, and make clear to Clients and Contractors alike that departures from these fundamentals will incur further cost and time in order to achieve an acceptable outcome. Sufficient time will need to be allowed in the program to instigate any substitutions.

#### **3.2 Recommendations for Contractors, Fabricators and Steel Suppliers**

It is important that all parts of the supply chain appreciate that all steels are not created equal. The surest path is to source steels from accredited mills that produce steel to the standards which are cited by New Zealand codes. Care should be taken to ensure that the correct subtypes are used as well.

If pursuing cost savings which may be achieved from non-traditional steel supply, it is very important that the time and cost of the additional effort to demonstrate compliance is factored in to any bid. This is likely to include additional costs for the consulting team, 3<sup>rd</sup> party testing at the mill, workshop, and in NZ as well as employing specialist metallurgists. Potential programme delays with this process also need to be factored in.

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