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ISSUES WITH TEMPORARY BRACING OF STEEL STRUCTURES

BACKGROUND

It was reported in Civil Engineers Australia September 2009 page 25 that "a lack of temporary bracing led to the collapse of a steel frame for a Victorian warehouse during strong winds". As a consequence, the structural engineering firm, the steel erection company and the developer were all fined by the Court as a result of action brought by the Victorian workplace safety agency WorkSafe.

The structural engineer in this case "produced the structural steel drawings for the project and included a note on the drawings to the effect that the contractor should provide the bracing necessary to stabilise the structure, but did not make provision for temporary bracing." It was found by the Court that the structural engineer "needed to make the need for temporary bracing explicit in its drawings" and that the steelwork erector "should have been aware of the need to brace against wind loads". [All the above statements in quotation marks " " are taken directly from the Civil Engineers Australia article.]

THE ISSUE

It is required by law under the Occupational Health and Safety Acts in the various Australian States that steel erectors are to be provided with a safe place to work in. Failures of temporary bracing or the absence of temporary bracing leading to failure can not only lead to prosecution by WorkSafe/WorkCover authorities of a number of parties involved with a steel structure but can lead to claims on professional indemnity or other insurance. If a death results from failure of a steel structure during erection, manslaughter charges are a possibility for all parties. The outcome of the above case would indicate the need for all parties to consider the implications of the need to provide temporary bracing.

This Technical Note addresses only the issue of temporary bracing of steel structures during erection, leaving aside the many other issues related to the erection of steel structures.

RELEVANT DOCUMENTS

Relevant Australian Standards are AS 4100 [Ref. 1] and AS 3828 [Ref. 2]. American Code SEI/ACSE [Ref.3] covers construction loading, including wind loading.

AS 3828 was published in 1998 and states in its preface that it was based on the Queensland Advisory Standard for steel construction of the time. Workplace Health and Safety Queensland has published in 2004 an updated document [Ref. 4] which contains some information similar to that in AS 3828.

WorkSafe Victoria has also published a document specifically on steel erection [Ref. 5], while New South Wales [Ref. 6] and Western Australia [Ref. 7] have published more general documents on "safe design", neither of which cite AS 3828. References [4] and [5] cite AS 4100 and AS 3828 as relevant standards.

This Technical Note distills the information on temporary bracing from these references.

THE STRUCTURAL ENGINEERS RESPONSIBILITY

(a) Design phase

AS 4100 Clause 1.6.2 requires that the drawings or specification or both for a steel structure shall contain details of "(e) the location and details of planned joints, connections and splices; (f) any constraint on construction assumed in design and (h) any requirements for fabrication, erection and operation". Clearly, these requirements in AS 4100 put the onus on the structural engineer to document all the information under items (e), (f) and (h) and the result of the above Court case reinforces that view. AS 4100 however does not state that the design engineer is responsible for the erection design nor does it specifically state that temporary erection bracing be shown on the drawings, only that erection requirements be indicated.

AS 4100 Clause 3.1.1 requires that the structure "is stable if it does not overturn, tilt or slide throughout its intended life" which would be expected to include during erection, while Clause 3.2.2 requires that "any action which may significantly affect the stability, strength ... shall be taken into account" including under item (e) construction loading.

AS 3828 states in Clause 2.2 that the designer should take into account "(b) the stability of the assembled portions and single components at all stages of the erection", "(c) the effects of the erection sequence on stability" and "(g) clear instructions for the requirements of temporary bracing" including that it be "detailed on the drawings". Reference [4] contains the same wording.

AS 3828 Appendix B Clause B1.2 recommends that "the designer should design all bracing members to cater for all load conditions including wind load during frame erection ... If cold-formed purlins are required to act as struts, the designer should specifically endorse these procedures ... or replace them with an alternative detailed erection procedure."

AS 3828 Appendix B Clause B1.4 recommends that "the designer should endorse the drawing that the building is suitable to be erected by the erection procedure .... If this is not the case, then the designer should ensure that a clear and detailed alternative procedure is adopted."

The Victorian document [Ref.5] cites both AS 4100 and AS 3828 for detailed technical guidance with any conflict between the publication and the Australian Standards being resolved by following the provisions in the Australian Standard. Hence, the above requirements also apply in Victoria.

The Victorian document introduces the "erection engineer" into the process and states that design for erection may be produced independently of the structural design for the building in Clause 3.1. The erection engineer approves the sequential erection procedure and prepares associated erection drawings and approves the stability of the structure during erection. It would therefore appear that, in Victoria, the erection engineer is responsible for compliance with the AS 4100 and AS 3828 requirements noted above. It would be a contractual arrangement as to who employs the erection engineer.

The Victorian document Clause 3.3 deals with managing risk at the design stage and requires that:

—stability should be checked by the erection engineer;

—structural design engineer to provide sufficient details to allow the shop detailer to prepare shop drawings and to allow the erection engineer to prepare the erection design;

—shop drawings and the erection design should be submitted to the structural design engineer for review;

—design drawings should include structural design criteria affecting construction.

Consequently, there is a considerable amount of consensus as to what should be included in the structural documentation in references [1],[2],[4] and [5].

A reasonable conclusion from the above is that the structural design engineer designs and documents the permanent work but is also responsible for providing sufficient information on the structure to enable the steelwork fabricator and erector to form a view as to how the structure can be safely erected. As part of this responsibility, the structural engineer cannot ignore the safety-related issues that may result from the part-erected structure. The structural design engineer should have conceived at least one safe method of erection as part of the overall structural concept [see SN21 Reference [8]]. Some suggested erection schemes for portal frame buildings are found in Appendix B to AS 3828 and in Reference [4], which can be used for guidance.

One approach is that the structural design engineer identify on the structural drawings an outline of the method of safe erection upon which he has relied in the design. For example, this could be done by identifying braced bays which must be erected first and members that tie frames together (be they struts or purlins at nominated centres) and that these ties must be in place before the next frame is erected. The structural design engineer might identify where temporary bracing is required in order to provide stability, even if the design of that temporary bracing is left to the steelwork fabricator/erector. The stage at which any temporary bracing can be safely removed might also be identified.

(b) Construction phase

The structural design engineer is no longer always involved in the construction phase as the builder or client may not engage the engineer for such services. If this is the case, the structural design engineer needs to get such arrangements clearly in writing and will have no involvement in reviewing erection drawings or work method statements.

If the structural design engineer is engaged to supply construction services, then the above suggests that the engineer would review the shop drawings and any erection drawings and work method statement produced by others, unless specifically excluded from the agreed scope of work. A work method statement should include a hold point where it is reviewed by nominated persons, who might include the structural design engineer.

STEELWORK ERECTOR'S RESPONSIBILITY

Reference [8] notes that four factors are required to be achieved if a safe workplace is to be achieved during steelwork erection, namely:

(1) a sound plan set out in a written erection statement;

(2) adequate resources in terms of people and equipment;

(3) competent individuals, suitably trained and experienced;

(4) a chain of command to enable clear instructions to be given.

It is the steelwork erector who employs the steel riggers and support staff and dictates their method of carrying out the erection. Consequently, the steelwork erector is responsible for producing a safe work method statement which should ideally be submitted for review at least by the builder and possibly the structural design engineer (if so engaged for this work). The steelwork fabricator or erector is also responsible for designing any additional temporary bracing that is required by the proposed sequence of erection and submitting the design and details for review by the structural design engineer (if so engaged for the work). In Victoria, Reference [5] would suggest that the erection engineer prepare this information for review by the structural design engineer.

AS 3828 Clause 2.7 suggests that the steel erector prepare a documented work method statement and lists 28 matters that should be addressed, including item “(w) stability of structural members during the erection process” and item (x) “stability of partially erected structures when left unattended (e.g. overnight)”.

AS 3828 Clause 3.4.2 contains detailed requirements on stability including the requirement that the stability of the structure should be verified by persons nominated in the workplace health and safety plan at four nominated hold points.

The Victorian document (Ref [5]) requires a safe work method statement wherein the erection engineer should provide clear advice on how to achieve stability for each stage of the erection of the structure.

In order to produce the steelwork erection method statement, the contractor is partially reliant upon the drawings and specification produced by the structural engineer. Any omissions or questions arising from the documentation should be referred to the structural engineer for clarification through the builder.

ACKNOWLEDGEMENT

This Technical Note is partly based on SN21 Reference [8]. The contribution of engineers who reviewed Version 1 of this Technical Note is gratefully acknowledged.

REFERENCES

[1] Standards Australia, AS 4100—1998 “Steel structures”.

[2] Standards Australia, AS 3828—1998 “Guidelines for the erection of building steelwork”.

[3] American Society of Civil Engineers, SEI/ACSE 37-02, “Design loads on structures during construction”.

[4] Queensland Workplace Health and Safety, “Steel construction code of practice', 2004.

[5] WorkSafe Victoria, “Safe erection of structural steel buildings', Edition No 1, May 2009.

[6] WorkCover New South Wales, “Safe design of buildings and structures', August 2009.

[7] Western Australia Commission for Occupational Safety and Health, “Code of practice for safe design of buildings and structures', 2008.

[8] British Constructional Steelwork Association/Corus/Steel Construction Institute, Steel Industry Guidance Note SN 21 “Stability of temporary bracing”.