BUILDING PERFORMANCE

Practice Advisory 14: Long span steel roof trusses - welding and section checks

This Practice Advisory was issued in response to concerns about the collapse of the Stadium Southland roof in Invercargill during a snow storm on 18 September 2010. It provides guidance for owners, territorial authorities and practising structural engineers.

This information was confirmed as current in December 2016.

Published on 1 June 2012 1st edition

Of interest to Chartered professional engineers

This Practice Advisory is issued as guidance information in accordance with section 175 of the Building Act 2004 and, if used, does not relieve any person of the obligation to consider any matter to which the information relates according to the circumstances of the particular case. This document is not a compliance document in terms of the Act and not a substitute for professional advice.

Background

A snow storm on 17 to 19 September 2010 caused damage to, or the collapse of, a number of buildings in and around Invercargill, including the roof of Stadium Southland. The report we commissioned on the Stadium Southland roof collapse found, however, that the snow loading would not have been sufficient to cause the collapse of Stadium Southland roof if its trusses had been fabricated to comply with the standards of the day.

Technical investigation into the collapse of the Stadium Southland roof (http://www.mbie.govt.nz/publications-research/research/building-and-construction/southland-stadium-technical-investigation.pdf) [PDF 2 MB]

MBIE considers it important that the circumstances of this failure are fully understood by building owners, territorial authorities and practising structural engineers and the implications for similar buildings around New Zealand examined and acted upon. Defects in the construction of the steel tube truss roof, particularly those portions that involved late design changes and welding on site, appear to have significantly reduced the ability of the roof to sustain the intended design loads and the snow load experienced at the time of the collapse.

Purpose and scope of advisory

This Practice Advisory is to:

- alert building owners to the issues that the report has identified with this long span truss steel construction
- provide advice to building owners to enable them to instruct Chartered Professional Engineers to review their buildings
- alert practising structural engineers assessing existing long span roof trusses in buildings throughout New Zealand
- provide advice to territorial authorities.

It applies to all existing buildings throughout New Zealand:

- that have long span roof trusses (over 20 metres) fabricated from welded closed steel hollow sections such as circular and rectangular tubes

- and to which members of the public have access.

The presence of weld defects and undersize structural members may adversely affect the performance of buildings and it is important that these are identified and repaired. It is particularly important that building owners have confidence in the integrity of their buildings in areas where snow build up may overload the structure.

Actions to be taken

MBIE advises the following actions from the various parties:

- Building owners with concerns: Owners should contact a Chartered Professional Engineer with suitable qualifications and experience to review the construction of the roof trusses in conjunction with a suitably qualified welding inspector.
- Structural engineers: Recommend to clients that construction records of existing roof structures are reviewed to ascertain that inspection reports are available confirming that welding complies with requirements of the standard of the day, for example, AS/NZS 1554.1 or NZS 4701 for structures built before 1994. If inspection reports do not comply then recommend identification of collapse critical connections and a programme of inspection following the guidelines set out in the flowchart in Figure 2.
- Territorial authorities: When advising owners of the need to renew their annual Building Warrant of Fitness, territorial authorities are advised to bring this Practice Advisory to the attention of owners.
- Building consent authorities: When building consent applications are made for any work on a building with long span steel roof trusses, building consent authorities are advised to bring this Practice Advisory to the attention of owners.
- Building owners of large span public buildings in snow-prone regions are advised to develop snow load monitoring, mitigation and evacuation procedures where there is a risk of snowfall exceeding design specification. Owners may also consider installing snow load alarms, possibly in conjunction with the security monitoring system.

Roof truss inspection

Inspection steps

A flowchart identifying appropriate inspection steps to take is shown in Figure 2 and described as follows. Where non-compliance is found, appropriate remedial work will need to be agreed with the Chartered Professional Engineer (structural). The inspection regime shown in the flowchart is hierarchical in that satisfaction of one level of testing should be completed before proceeding to the next level of more detailed checks. If instances of non-compliance are found at one level, then further testing should be undertaken at that level, at the direction of the engineer, until satisfactory compliance is achieved.

Adequacy of welding quality assurance records

- The structural engineer should check whether welding records for the roof trusses complying with requirements of the standard of the day, for example, NZS 3404.1 and AS/NZ 1554.1, have been kept, and whether they cover the collapse critical joints.
- If appropriate welding quality assurance records exist, then no further action is required.

Selection of a sample of collapse critical roof trusses for examination

- The structural engineer should use appropriate judgement to select 10 percent and no less than three roof trusses for further inspection.

Identification of collapse critical joints

- From each of the selected sample of trusses, the structural engineer should identify for the inspectors three collapse critical joints, using the construction drawings if available.
- The critical regions of a typical truss have been identified in Figure 1 as an aid to selecting critical joints. This guidance does not relieve the structural engineers of their responsibility to exercise judgement in selecting collapse critical joints, particularly for complex truss configurations.

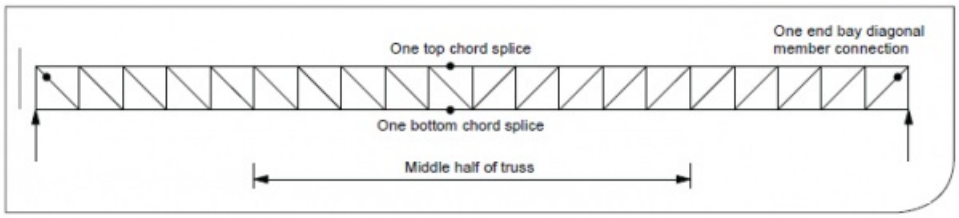


Figure 1: Critical truss weld connection locations (Field welded splices are the most critical connections)

Weld visual examination

- Undertake 100 percent visual examination of the selected collapse critical welds in accordance with the requirements of AS/NZS 1554.1: 2011 for Structural Purpose (SP) welds.
- If welds, bolts, packing plates, movement joints have been omitted or there are gross defects, then a full inspection of all collapse critical trusses in accordance with the requirements of NZS 3404.1: 2009 Section 8 will need to be undertaken.

Weld ultrasonic or radiographic examination

- Undertake ultrasonic or radiographic examination of collapse critical welds in accordance with the requirements of AS/NZS 1554.1: 2004 for Structural Purpose (SP) welds.
- If weld quality has not been achieved, then a full inspection of all collapse critical trusses in accordance with the requirements of NZS 3404.1: 2009 Section 8 will need to be undertaken.

Section geometry checks

- The structural engineer should select three collapse critical sections for each of the sampled trusses to determine that member sizes are correct.
- To determine that wall thicknesses of closed steel hollow sections are correct, undertake ultrasonic wall thickness checks of each selected section.

When reviewing new construction:
Do • Engage a Chartered Professional Engineer • Ensure a qualified welding inspector is used. • Identify collapse critical welds and members for examination. • If using closed hollow sections as structural members, make sure to check the wall thickness supplied matches the specification. Don't • Assume welds fabricated on site are as likely to comply as shop welds.

Main points

- If adequate records of inspection by qualified welding inspectors of roof trusses during their construction or subsequent modification are not available, then section sizes and welds, particularly in closed hollow section tubes, may not be sufficient to meet the required design demands.
- Closed hollow sections may not have the specified wall thickness.
- Complete penetration welds in closed hollow sections may not have achieved full penetration and strength. This is particularly likely if backing strips have not been used in preparing the welds in accordance with the welding standard AS/NZS 1554.1.
- Site welding of trusses, particularly where accessibility is difficult due to height or confined spaces, may not have been completed or achieved the specified quality.
- Compression splices without full contact on bearing plates or abutting sections may significantly reduce truss capacity.
- Packer plates at bolted connections between trusses and supports may reduce connection capacity if they are not adequately fitted.
- Designated slotted connections in the roof structure that have been prevented from moving may cause additional loads on other parts of the structure.
- Connections of steel roof trusses into concrete or masonry pilasters using cast in inserts may not have adequate ductility to cope with roof overload.

Further advice and information

The NZ Heavy Engineering Research Association (HERA) and Steel Construction NZ (SCNZ) are supporting this MBIE Practice Advisory with targeted seminars and advice with the aim to inform on the requirements and provide a deeper understanding of the identification of critical members and critical joints and the associated inspection and fabrication procedures.

Visit the HERA website (http://www.hera.org.nz/) and SCNZ website (http://www.scnz.org/) for more information.

References

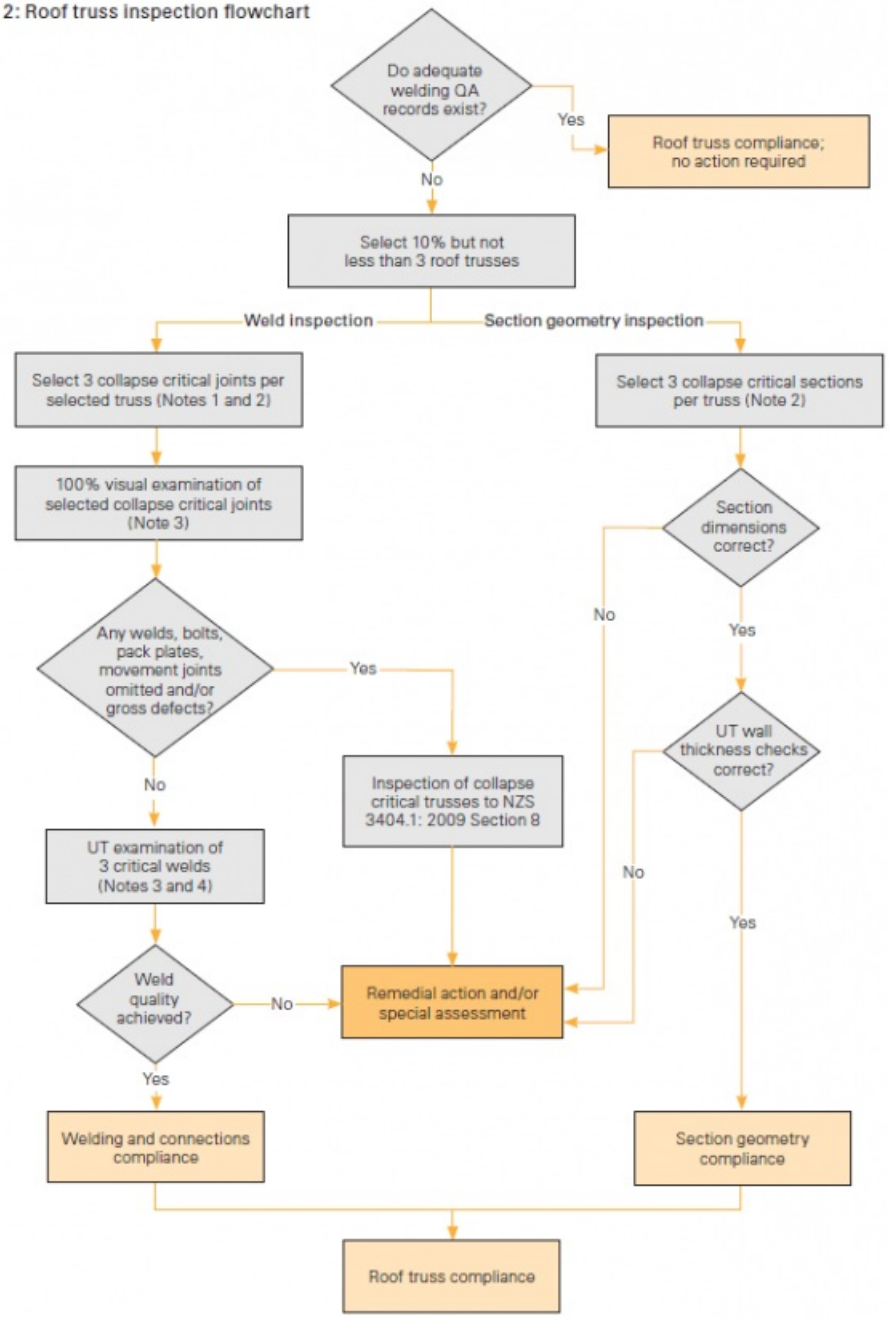
Department of Building and Housing, Technical investigation into the collapse of the Stadium Southland roof, May 2012 (http://www.mbie.govt.nz/publications-research/research/building-and-construction/southland-stadium-technical-investigation.pdf) [PDF 2 MB]

StructureSmith Ltd, Hyland Consultants Ltd, Structural Engineering Report on the Collapse of Stadium Southland Roof. May 2012.

NZS 3404.1: 2009 Steel structures Standard – Materials, fabrication, and construction.

AS/NZS 1554.1: 2011 Structural steel welding – Part 1: Welding of steel structures.

Figure 2: Roof truss inspection flowchart



Notes:

Collapse critical trusses and collapse critical joints are to be identified by suitably qualified and experienced Chartered Professional Structural Engineers.

The guideline on the selection of typical critical locations is given in Figure 1.

Personnel responsible for the examination, interpretation and reporting of non-destructive examination shall have adequate qualifications according to AS/NZS 1554.1.

UT examination to be performed on butt welds identified as critical by visual examination to determine whether a complete penetration has been achieved according to AS/NZS 1554.1 UT examination shall be performed according to an approved procedure that takes into account joint design and material thickness. UT can be replaced by radiographic examination.

All guidance related to B1 Structure (https://www.building.govt.nz/building-code-compliance/b-stability/b1-structure/)

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government