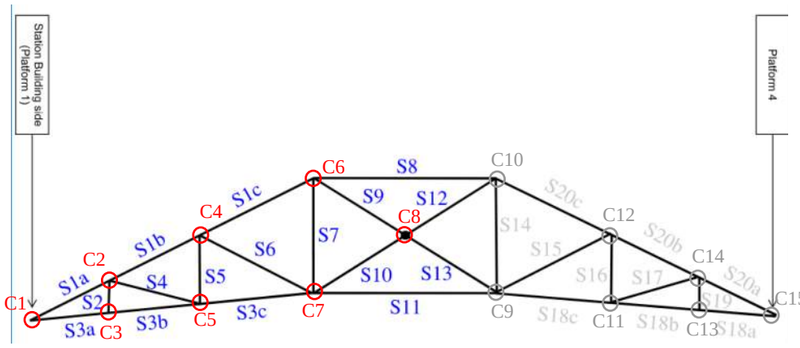
Roof A Trusses
Context

The Huddersfield station Roof A structure is a cast iron and wrought iron / early steel structure which has varying levels of corrosion across large extents of the roof due to its age and levels of exposure to the elements.

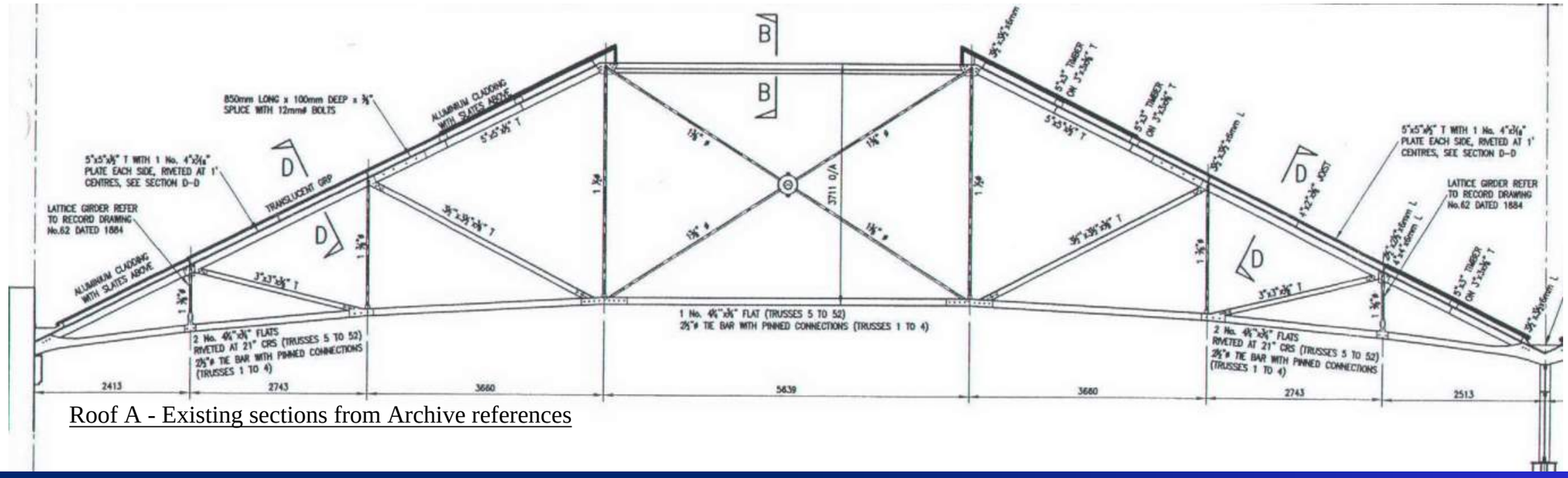
The structure is to be bast cleaned and the corrosion protection system to be reinstated in a phased nature across the roof. Alongside this, a series of pre agreed strengthening works are to be carried out which are designed against the planned change in loading conditions following refurbishment. Due to the forceful nature of the blast cleaning process, the limited knowledge of the underlying condition of the steelwork and its historical construction methods, there is potential for element cross sections, full truss elements or connection assemblies to be found to be corroded or flawed to a greater extent than could be reasonably determined from the visual and geometrical surveys which could be carried out prior to construction.

Due to the time sensitive and phased nature of the works and the potentially lengthy approval time of any remedial works, this document is set out to agree in principle the repair, strengthening or replacement methodologies across the truss. This is to enable remedial works to be carried out swiftly should any critical defects be found against pre agreed principles.



Roof A - Element and Connection references

Roof A - Typical Roof A photo from 25.07.2023



Roof A - Existing sections from Archive references

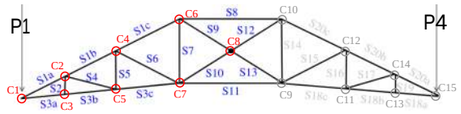
Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

151667-TSA-30-MVL3-SK-S-007 Rev P03

Grip 5 / For Information / DHx
06 October 2023

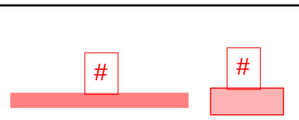
Roof A Trusses
Introduction - Intervention Likelihood



Roof A - Element and connection references

The below assessment has been carried out to determine likelihood of any intervention being required across the roof A truss. This has been done considering the following factors:
- Structural Analysis and element utilisation across each element of the truss.
- Measured geometry of remaining sections from 25% survey in 2020.
- Visual conditions survey from platform level in 2023.

The combination of these factors has been used to develop a colour coded scale of the likelihood of additional interventions across the truss in addition to the main works agreed strengthening. The scale runs from possible to highly unlikely. For possible interventions a numerical estimate, based on the survey outlines above, has been provided to identify the number of trusses which are deemed to fall into this category. This is provided on the specific intervention pages.

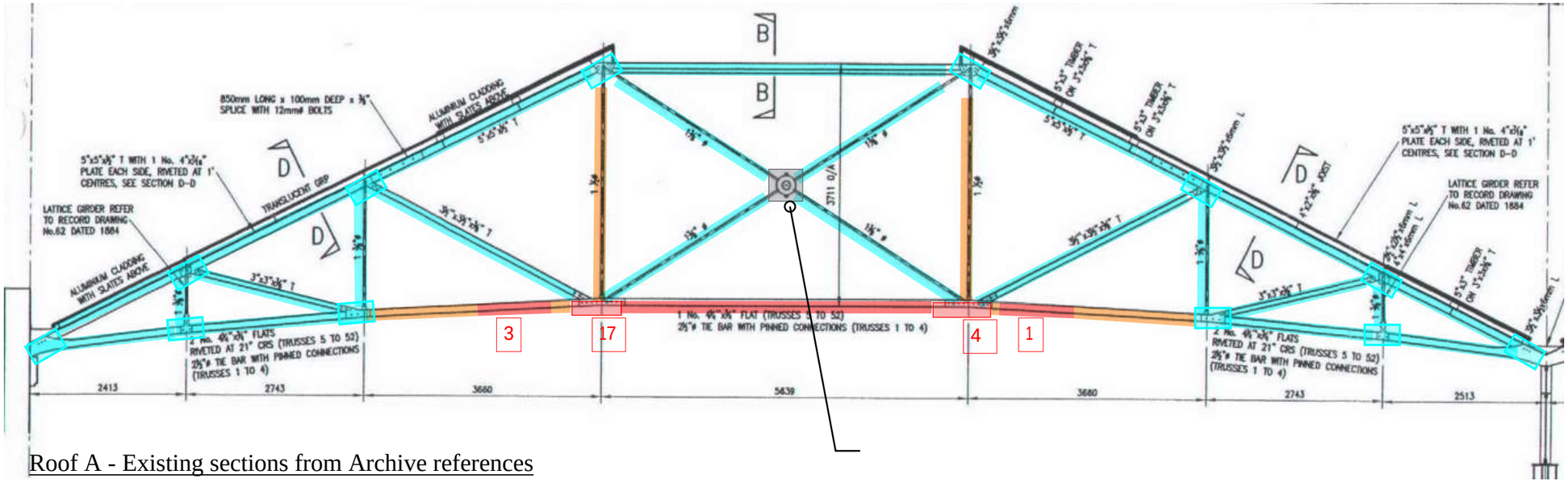


Possible Intervention required.
Element or truss with visible deterioration AND element is at or near full utilisation. Number denotes estimated likely trusses.

Unlikely Intervention is required
Element or truss with visible deterioration OR element is at or near full utilisation.

Highly Unlikely Intervention is required
Element or truss with limited or no visible deterioration and element has some residual capacity.

Intervention Likelihood Key



Roof A - Existing sections from Archive references

Intervention Page Labels

Intervention Likelihood:	Trusses in this Category
Possible Intervention required	**X out of 46**

Intervention Likelihood:
Unlikely Intervention is required

Intervention Likelihood:
Highly Unlikely Intervention is required

Huddersfield Station

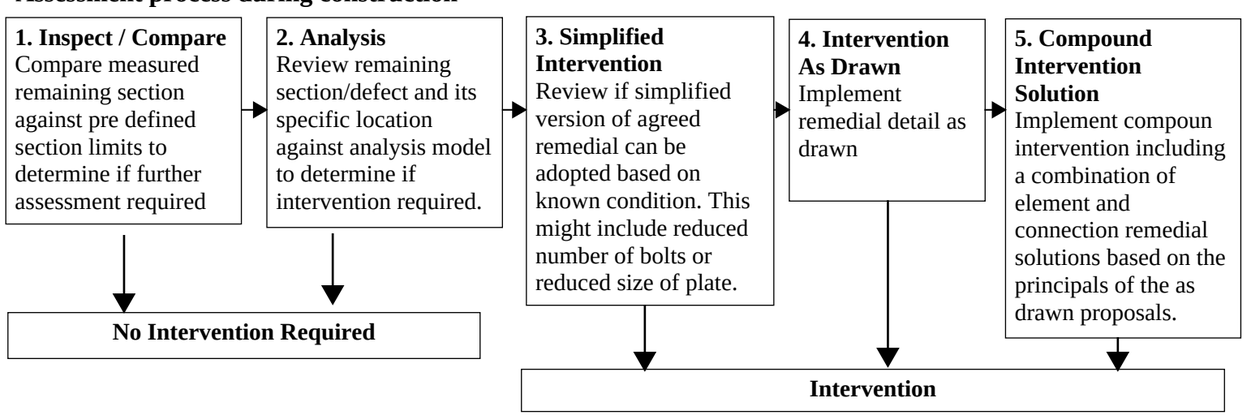
Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses
Introduction - Assessment Process

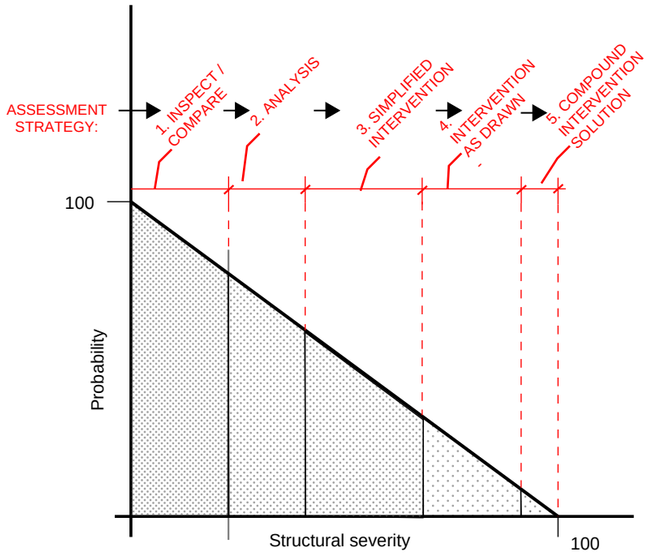
The following process is proposed to determine the most appropriate solution for identified defects across the truss:

Prior to Construction
- Determine limiting cross sections for truss elements for reference during construction
- Develop the minimal impact remedial principles for elements and connections across the truss for agreement with all concerned parties
- Put in place a workflow to capture areas of concern as they arise on site and the agreement of what remedial works if any are required.

Assessment process during construction

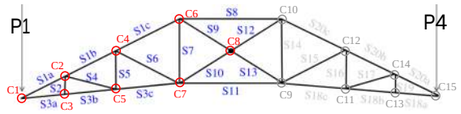


The below considers the probability of each intervention stage being required.



Roof A - Intervention assessment process and intervention stages

Roof A Trusses
Introduction - Intervention Summary



Roof A - Element and connection references

The following pages set out the principles to be adopted when the assessment of the existing structure following blast cleaning determines that an intervention is required.

For completeness, these scenarios take either an existing known defect **exaggerated to an extreme worst case** whereby an intervention needs to replace most or all of the capacity of the existing element or connection element, **or are based on notional hypothetical defects** in those cases where no evidence of deterioration is currently seen. As described in the assessment process, where possible a simplified intervention will be carried out that follow the same principles as described below but may be of a reduced plate extent or fewer bolts as applicable.

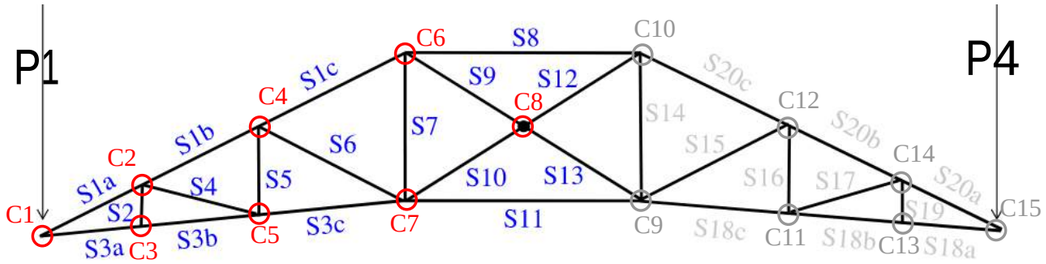
Proposal Structure

The interventions are presented in turn from the truss ends towards centre regardless of condition or intervention likelihood (denoted by colour coding). They are further categorised as follows:

* Element intervention - for section loss / damage along an element length
* Connection intervention - for section loss / damage to connection plates or parts of the truss elements within the extent of the connection.

A situation may arise whereby the area of concern is close to a connection or spans both the element and the connection. As set out in the assessment process a **compound intervention solution** will be adopted in this instance following the combined principles of the the relevant element and connection intervention details.

The below truss key plan is provided at the top of each page to assist in the identification of the location of each intervention. As the truss is mirrored, details are proposed to one half of the truss, with the same interventions to be carried out on the mirrored elements which are greyed out for clarity.



Indicates location of intervention

Roof A - Element and connection references

Scope

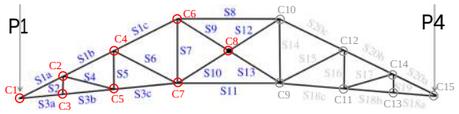
The interventions set out in this document cover the structural elements of the primary Roof A trusses. A Separate document covers the wrought iron columns to platform 4. A similar assessment process will be undertaken during construction for any other structural elements across the roof structure and the principles set out in this document and those in the accompanying columns sketch are to be applied.

General principles of Intervention proposals.

The presented pre-emptive intervention proposals are designed in line with the general principles of the strengthening of the main works programme. As such these details should be read in conjunction with the specification and project notes of these works which are outline in the steelwork spec and on drawing 151667-TSA-30-MVL3-DRG-S-ST-180000 and those on 151667-TSA-30-MVL3-DRG-S-ST-180027 . In particular attention should be paid to:

1. Proposal and testing of blast cleaning technique and subsequent corrosion protection systems which are set out in 151667-TSA-30-MVL3-DRG-S-ST-180014
2. Removal of any existing rivets and replacement by bolts or temporary pins is to be done strictly one at a time
3. Any works to structure which result in reduction in capacity such as rivet removal or hole drilling are to be done under limited loading conditions including wind speed limits and live load control to surrounding roof and are to be replaced / made good in the same working day
4. Existing holes from which rivets are removed shall be reamed to remove any cracks or other fatigue details which may be present. In all cases, reaming shall enlarge the diameter of the hole by a minimum of 2mm.
5. Any temporary pins used prior to TCB's to be snug fit in holes where possible. Consideration to be given to tapered pins to ensure good fit.
6. All replacement bolts to be TCBs with regular hex heads
7. Bolt edge distances all TBC pending further assessment and to satisfy code requirements of project.
8. Bolt sizes + setting out TBC when at construction - the relationship between reamed hole diameters and bolt diameters to be be in accordance with BS 5400: Part 6 or BS 5950: Part 1 or Part 2 as applicable to the design.
9. Cheese plates to be provided where required within connection assembly to ensure physical connection between new and existing structural elements and efficacy of TCB's. Cheese plates to be tack welded to new plates to avoid slippage.
10. All new plates and fixtures to be site measured prior to fabrication. New holes to match locations of existing rivet holes as required.
11. All new elements to be site measured prior to final fabrication including in relation to any new connection plates elements installed.
12. Provision for non-structural items are not considered as part of this review.
13. These proposals are to be reviewed with the design team following the dismantling and testing of the 6No Manchester end trusses. The specification of this works is noted on drawing 151667-TSA-30-MVL3-DRG-S-ST-180007
14. Temporary works to facilitate these proposals are to be developed by the contractor.
15. Due to the material properties of the existing steel structure determined from testing (likely early steel) **Welding of the existing structure is not permitted.**

Roof A Trusses
Introduction - Heritage



Roof A - Element and connection references

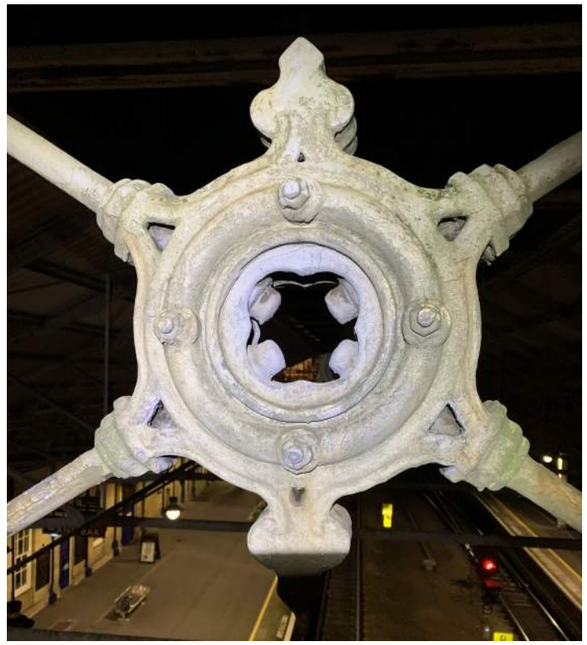
Heritage & Aesthetic principles

The conservation objectives of this project are to make interventions to the roof structure **only when necessary** and for those interventions to be in keeping with the language of the original truss, as minimal in extent as possible and to be consistent in detail both across the truss and along the length of the 46 retained trusses of Roof A.

Further to this where possible the interventions are designed to retain the existing elements in place and be reversible such that the original arrangement could be restored in future.

These guiding principles have been adopted across the proposed intervention to the greatest extent possible. Where deviations from these principle are presented, this is done primarily on the basis that no feasible alternative has been identified which would allow the truss to continue to be fit for purpose under the design loadings and against the worst-case possible section loss or damage presented. **As noted elsewhere, it is anticipated that many of the presented details will not be required in practice during this project.**

In regard to the overall effect of this works on the visual appearance of the roof truss attention is drawn to the opening image of this report on page 1 and that adjacent. This shows that the overwhelming impression of the roof is the number of elements and their complexity, as well as the overall truss shape - a Euston truss. As such the impact of the proposed interventions is not expected to impact this wider impression. The distance to many of the elements and connections from platform level is also such that the details may be not easily identified and interventions are proposed to have as minimal impact on the wider visual impression as practically possible.



Roof A - Central Rose Detail

Roof A - Perspective Photo

Huddersfield Station

Roof A - Truss Pre-emptive
Interventions Proposals Sketchbook

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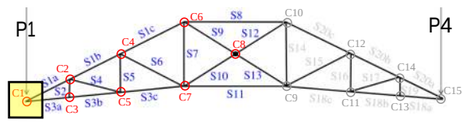
06 October 2023

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

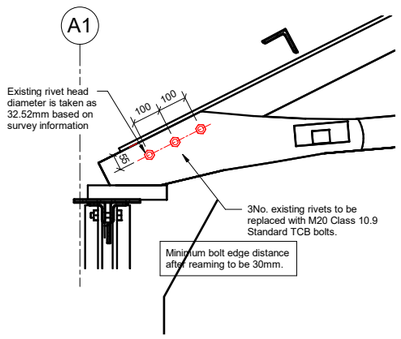
Connection C1

C1 is understood to be in reasonable condition.

This connection is formed of the following components:
- on the bottom chord (S3a), a 'gib and cotter' through pin to connect the outer plates of the truss end into the assembly of S3a inner plates. The gib and cotter act like folding wedges to be driven into place to securely wedge into the hole.
- on the top chord (S1a), 3No. rivets to transfer thrust forces (compression) into the bottom chord outer plates. The vertical component of the thrust is carried into the supporting column/truss under; the horizontal component balances the tension or tie force in the bottom chord.

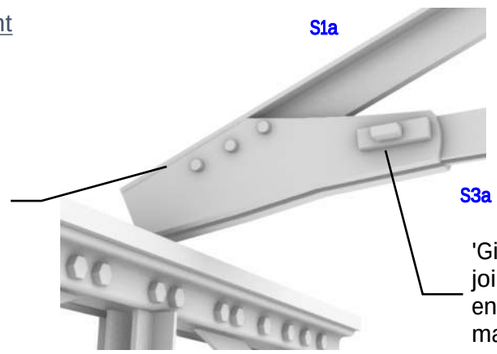
The following proposals aim to maintain these load paths under an assumed deterioration scenario within the inner plates of S1a, whilst also satisfying the requirements of the main works scheme (replacement top chord bolts required for strength).

Deterioration to the outer plates is not considered: there is no evidence to suggest that damage has occurred.



Main works proposals from drawing 151667-TSA-30-MVL3-DRG-S-ST-180027

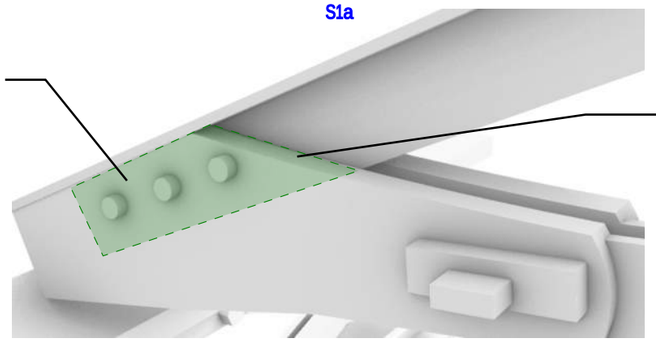
Schematic arrangement



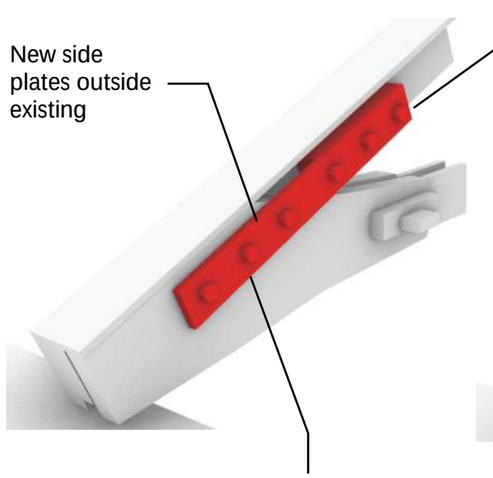
3No. rivets assumed in load transfer - i.e. no end bearing assumed for S1a

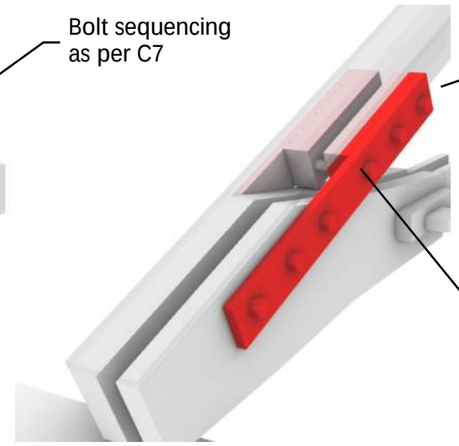
'Gib + cotter' jointing of bottom end side plates into main S3a assembly

Scenario A



Scenario A - Proposal





Bottom bolts
- through over-reamed existing rivets as per main works proposals
- loads transferred out of new side plates as per existing load path

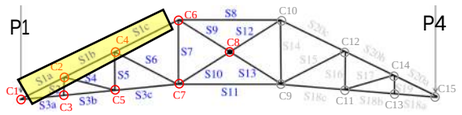
Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

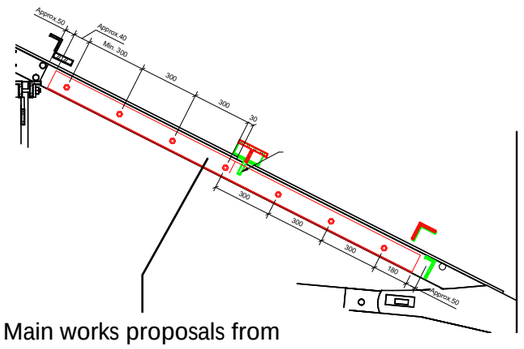
Elements S1a, S1b and Slc

The top boom T sections of the Roof A truss are identified separately as elements S1a, S1b & S1c but are assumed to be a single continuous structural member.

These elements have been strengthened historically and in some locations are being further strengthened as part of the main works package. The sections appear to be in reasonable condition given their sheltered nature directly under the existing roof finishes and therefore the likelihood of significant corrosion or section loss being identified during the blast cleaning process is deemed to be low.

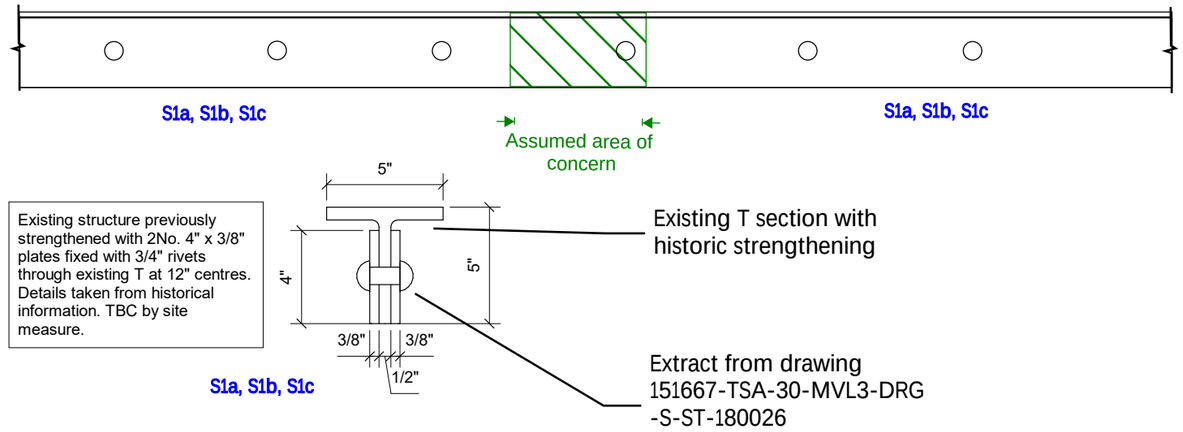
Should remedial works be identified as required during the works a notional deterioration scenario is shown opposite, conservatively assuming full plate section loss. The remedial proposal is to strengthen the sections in a complementary fashion with the strengthening proposals already agreed in discrete locations (see drawing extract below). No temporary works are assumed to facilitate this remedial: the existing elements are being supplemented by additional structure and the temporary case does not make the condition weaker than existing.

Historic side plate strengthening

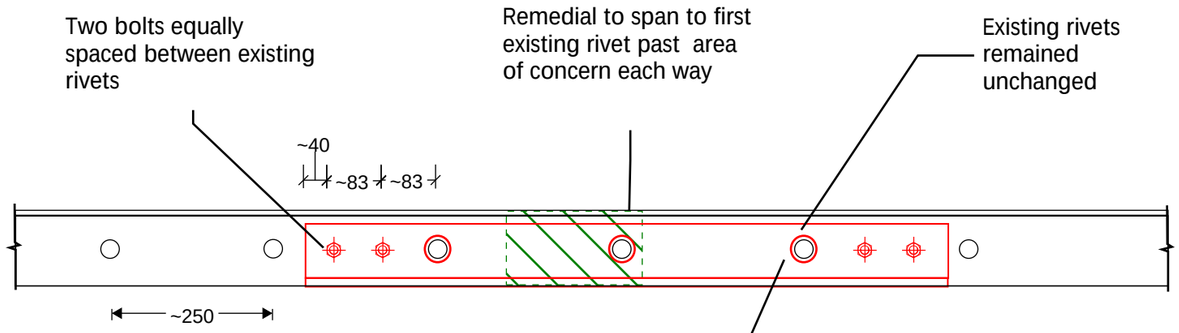


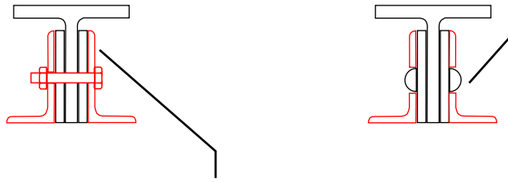
Main works proposals from drawing
151667-TSA-30-MVL3-DRG
-S-ST-180026

Scenario A



Scenario A - Proposal




New angles bolted to existing sections. Angles to match strengthening proposals elsewhere in structure. Bolts to be sized to suit damage or section loss identified.

S1a, S1b & S1c:

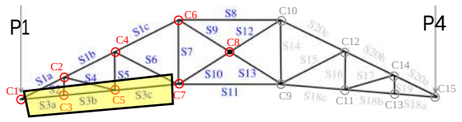
Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

Elements S3a, S3b and S3c

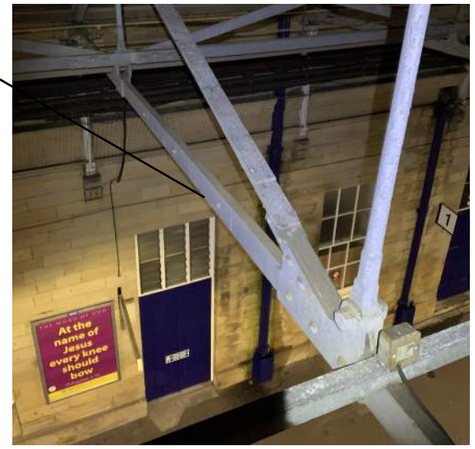
The bottom boom plates of the Roof A truss are as per the original construction. They are identified separately as elements S3a, S3b & S3c but are assumed to be a single continuous structural member up to the middle braced bay (where there's a joint into bottom boom element S11).

The sections appear to be in generally reasonable condition with the exception of a small number of locations where water has penetrated between the riveted sections causing corrosion between the plates forcing them apart, commonly referred to as birds mouthing. Away from these isolated details, it is anticipated that the likelihood of excessive corrosion or other defects including cracking is low.

Should remedial works be identified as required during the works a notional deterioration scenario is shown opposite, conservatively assuming full plate section loss.

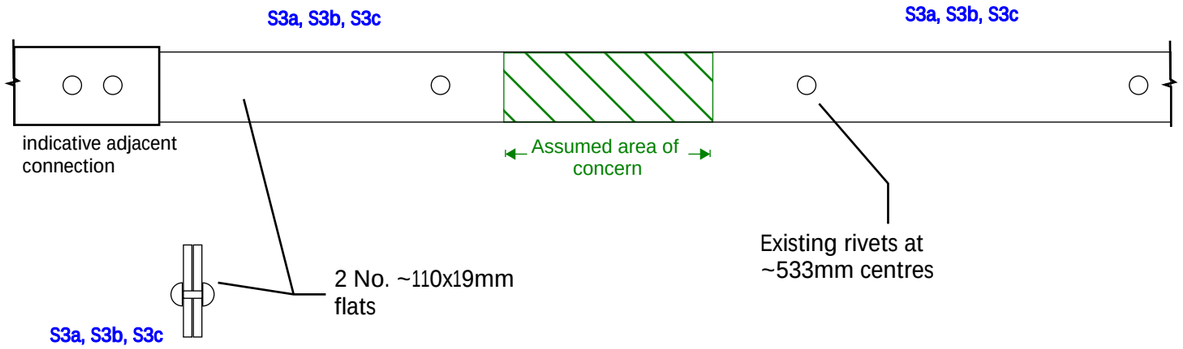
The proposal is to remediate in a similar manner to the existing compound section of flat plates. This will be done by drilled through existing rivets and fixing an additional flat side plate of matching depth to the affected lengths.

Bottom boom riveted plates



Bird mouthing of riveted plates

Scenario A

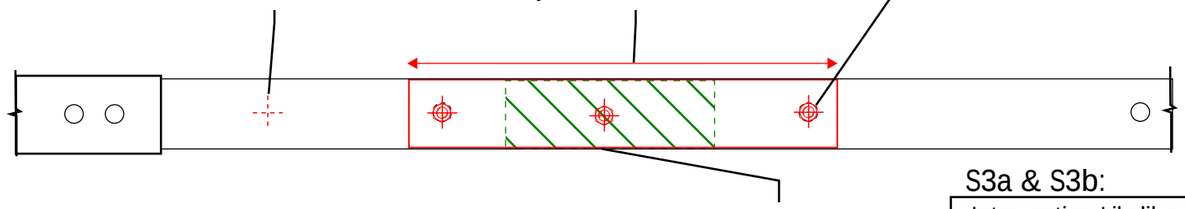


Scenario A - Proposal

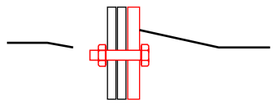
If defect extends beyond final rivet before connection, new hole for bolt connection to be formed.

Remedial to span to nearest existing unaffected rivet past area of concern each way

Existing rivets to be drilled out. Holes to be overreamed to suit new bolt diameter



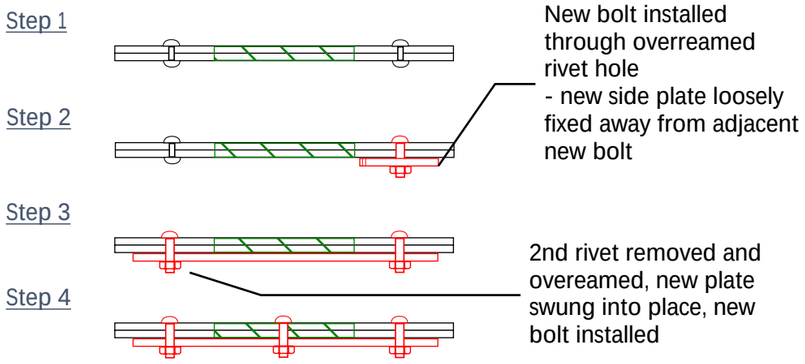
Bolts to be fixed through existing rivet holes. Plate thickness and bolt sizing to suit extent of defect.



New flat plate bolted to existing plates (to one face only).

Potential additional bolt within area of concern - torqued to bring birds mouthed plates together

The suggested sequencing has been developed to satisfy the following criteria:
- only 1No. rivet removed at a time
- TCBs in place in permanent works



New bolt installed through overreamed rivet hole
- new side plate loosely fixed away from adjacent new bolt

2nd rivet removed and overeamed, new plate swung into place, new bolt installed

S3a & S3b:

Intervention Likelihood:

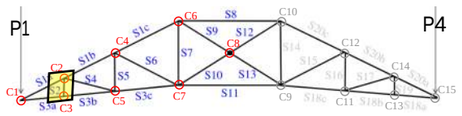
Highly Unlikely Intervention is required

S3c:

Intervention Likelihood:	Trusses in this Category
Possible Intervention required	**4 out of 46**

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook



Roof A - Element and connection references

Element S2

The vertical S2 element is as per the original construction which is tied into both the Roof A truss and the longitudinal braced truss.

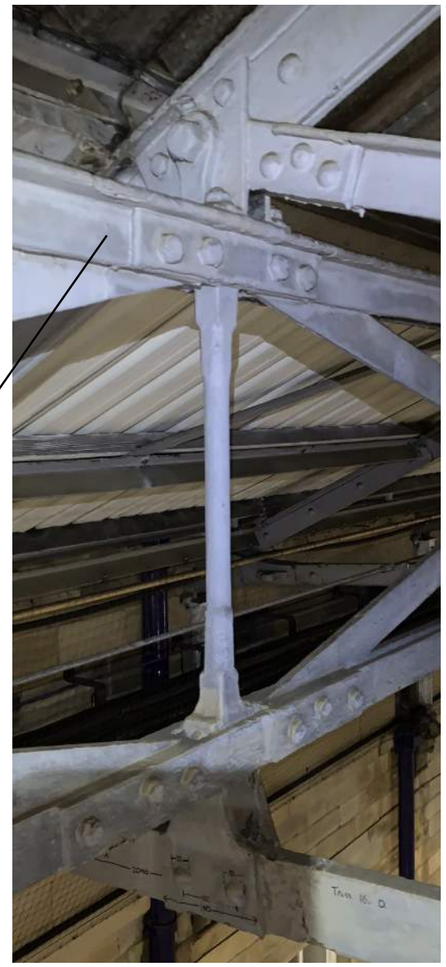
The elements are generally in good condition and the design forces sufficiently low that there is very minimal risk that section loss through corrosion will cause the elements to be under design capacity.

In the notional deterioration scenario of a cracked cross section with zero capacity, S2 is to be left in place and four angles bolted around the tie element through new and existing holes. The alternative strategy of replacing S2 like-for-like has been deemed impractical given the difficulties of removing the hanger fork ends from the existing connection assemblies at C2 and C3.

No temporary works are assumed to facilitate this remedial: the existing elements are being supplemented by additional structure and the temporary case does not make the condition weaker than existing.

Top connection C2
- with fork ends and additional brackets from S2

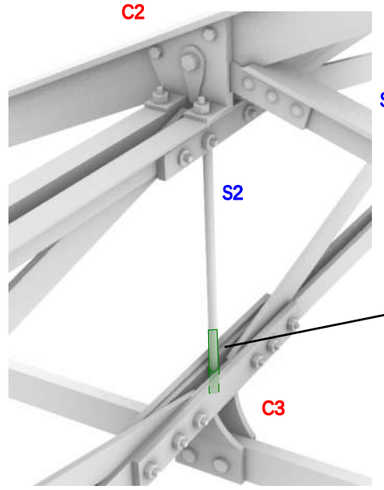
Longitudinal truss



Existing vertical S2

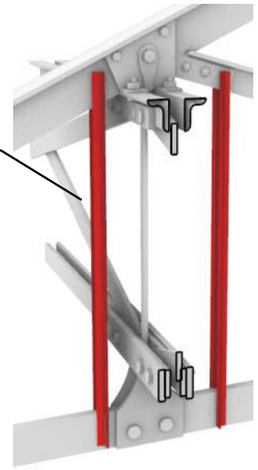
Bottom connection C2
- with fork ends from S2

Scenario A

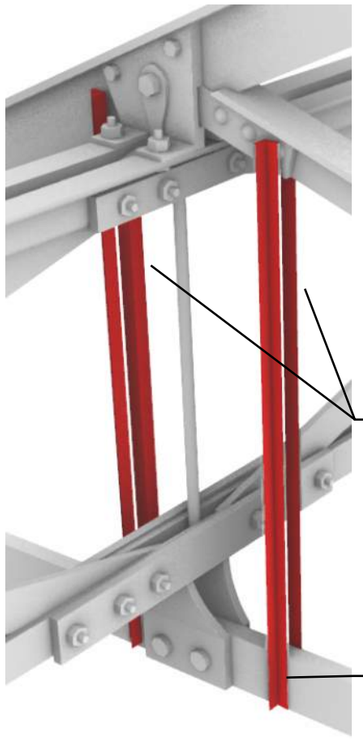


Assumed area of concern
- positioned within area inaccessible to other remedial approaches

Scenario A - Proposal



New angles set outwith longitudinal truss elements + S2 fork ends (top and bottom)



4 No. new vertical steel angles
- installed around tie rod element
- bolted into new holes in surrounding elements

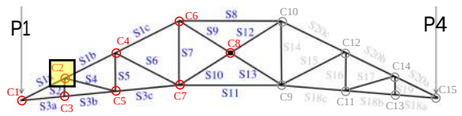
New bolts into bottom boom (S3a & S3b)

Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook



Roof A - Element and connection references

Connection C2

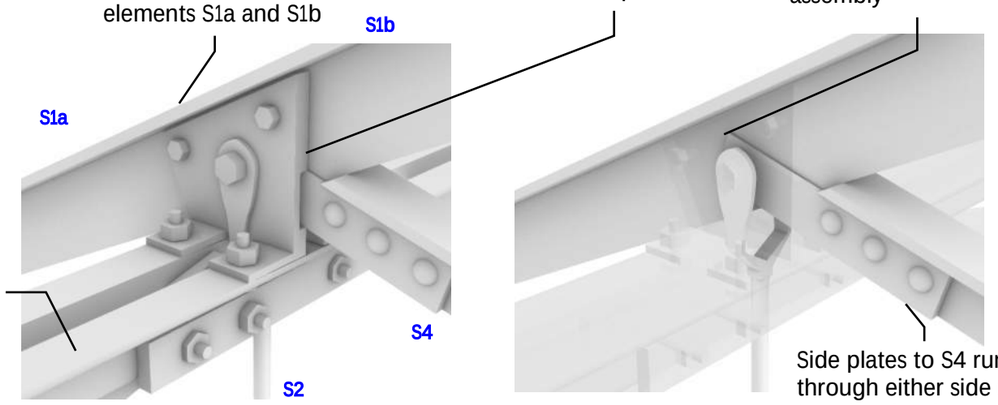
C2 is understood to be in reasonable condition.

Similar to C3, connection C2 is made complex by the interface with the perpendicular longitudinal truss. C2 would be very similar to C4 if it weren't for the longitudinal truss brackets which force the S2 fork ends even wider to accommodate the entire assembly of plates (see photos).

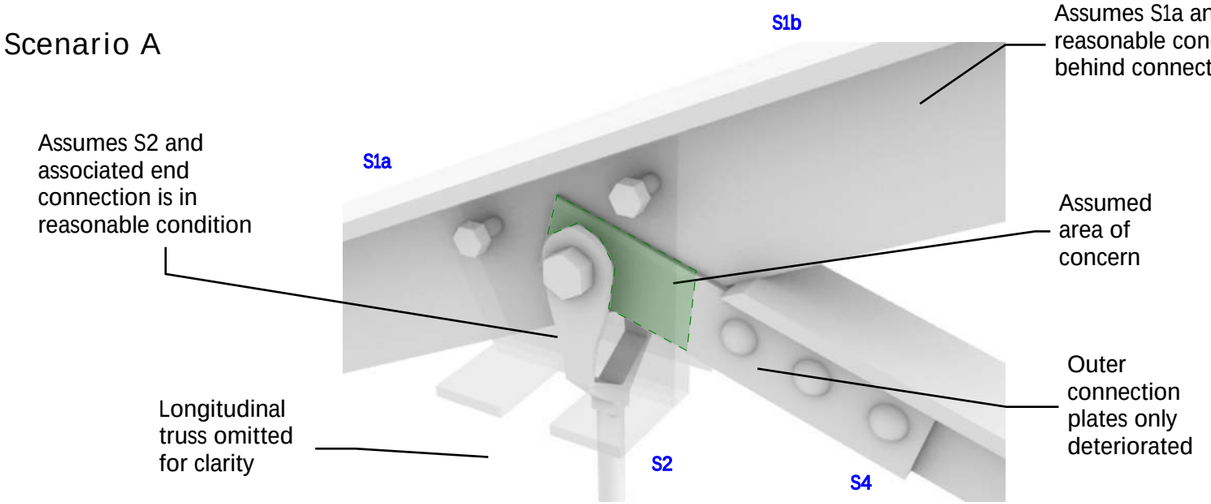
An assumed deterioration scenario is similar to C4 however the area of concern (S4 connection plates) are now positioned within the longitudinal truss brackets and replacement of these plates is not possible without removal of not just the S2 hanger but also the longitudinal truss elements.

A different strategy is required which aims to keep as many existing elements in place and to install supplementary side plates outside the existing assembly. This is facilitated by temporary works to hold elements in place while the single through pin is replaced and made longer.

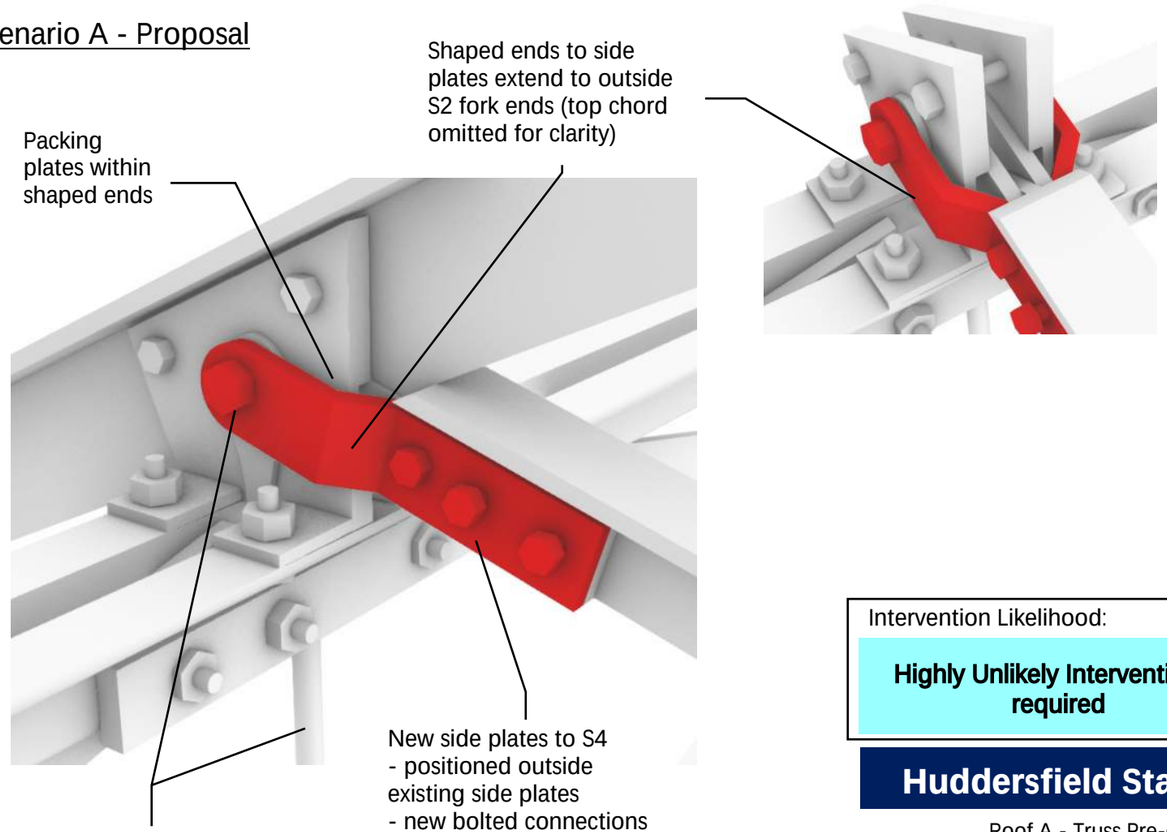
Schematic arrangements



Scenario A



Scenario A - Proposal

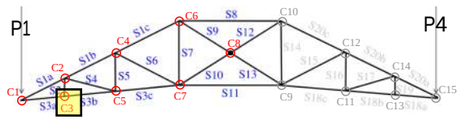


Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

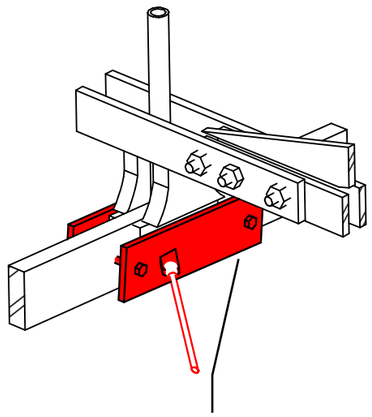
Connection C3

C3 is understood to be in reasonable condition.

The complexity of C3 arises from the interface with the perpendicular longitudinal truss. The incoming hanger S2 pass through a gap in the bottom boom of the longitudinal truss, at which point the hanger bifurcates into fork ends either side of its connection into the truss bottom chord. The S2 fork ends flare on elevation and in section, making side plates more difficult than other connections.

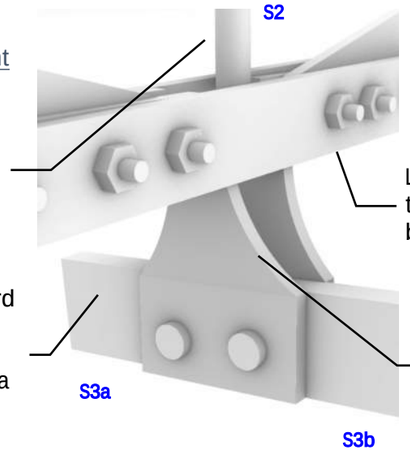
Other than these interfaces the connection itself is relatively simple: a hanger connection into a continuous bottom chord (elements S3a and S3b).

Two notional deterioration scenarios are considered. Each of the associated proposals could be easily modified to accommodate the main works proposals for new plan bracing connections at the southernmost trusses.



Main works proposals from drawing
151667-TSA-30-MVL3-DRG-S-ST-180022

Schematic arrangement



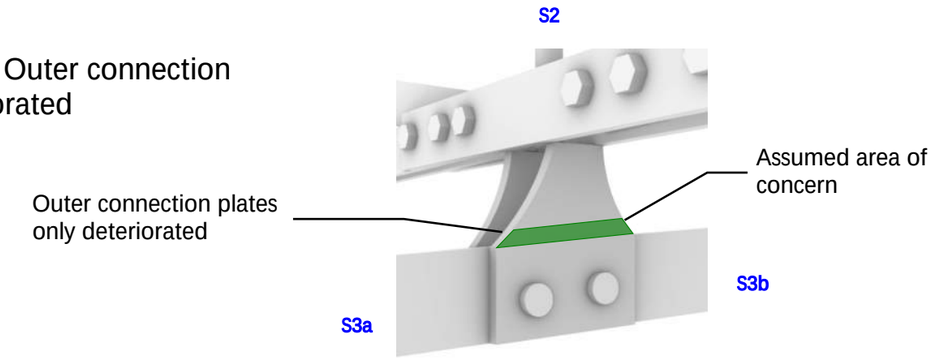
S2 passes through gap between flats

Longitudinal truss - bottom boom

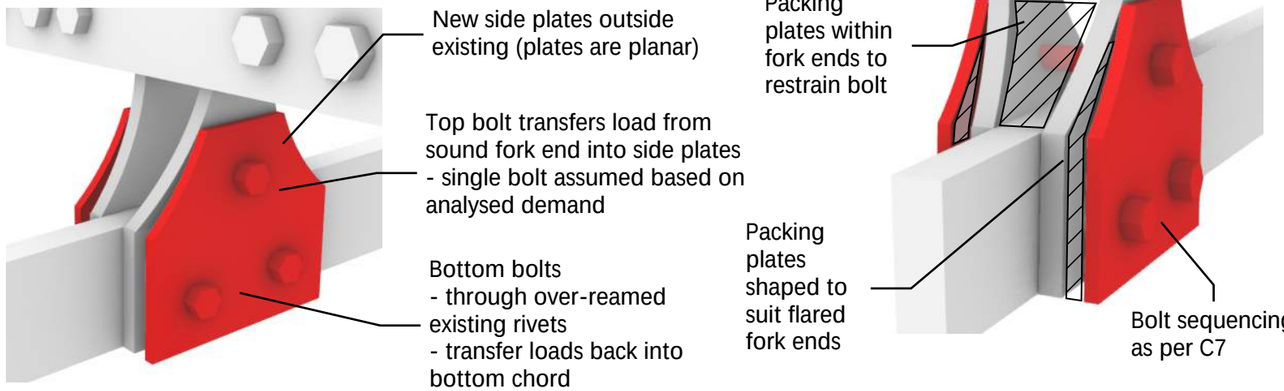
Bottom chord continuous between elements S3a and S3b

Sculpted fork end with flared plates

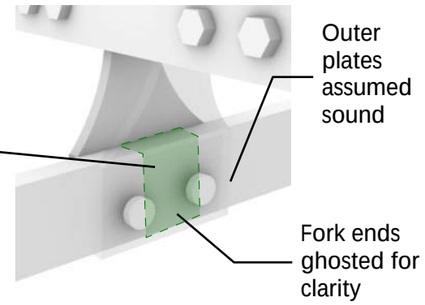
Scenario A: Outer connection plates deteriorated



Scenario A - Proposal



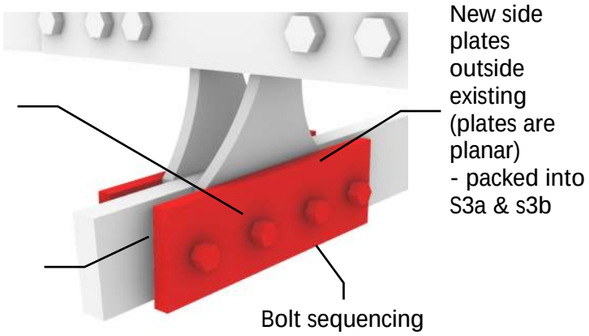
Scenario B: Inner connection plates deteriorated



Scenario B - Proposal

Internal bolts
- through over-reamed existing rivets
- transfer S2 loads into new side plates

External bolts
- transfers S2 loads into sound bottom chord
- transfers S3a loads into S3b via side plates



Scenarios A&B:

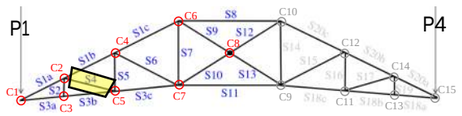
Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

Element S4

The outer diagonals of the Roof A trusses are as per the original construction on the platform 4 ends (S17) but have been previously strengthened using flat plates bolted to the top surface on the platform 1 end (S4).

The sections appear to be in reasonable condition given their sheltered nature directly under the existing roof finishes and therefore the likelihood of significant corrosion or section loss being identified during the blast cleaning process is deemed to be low.

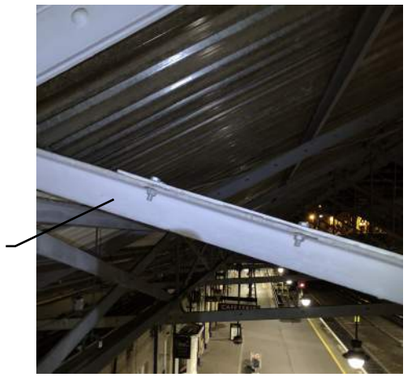
Should remedial works be identified as required during the works a notional deterioration scenario is shown opposite, conservatively assuming full plate section loss.

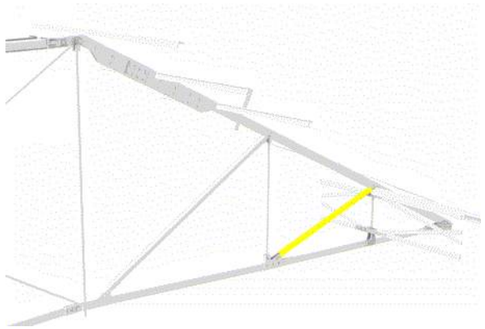
The proposal is to remediate the sections in a complementary fashion with the existing strengthening works utilising either:

- Proposal 1 - flat plates bolted to the top flanges

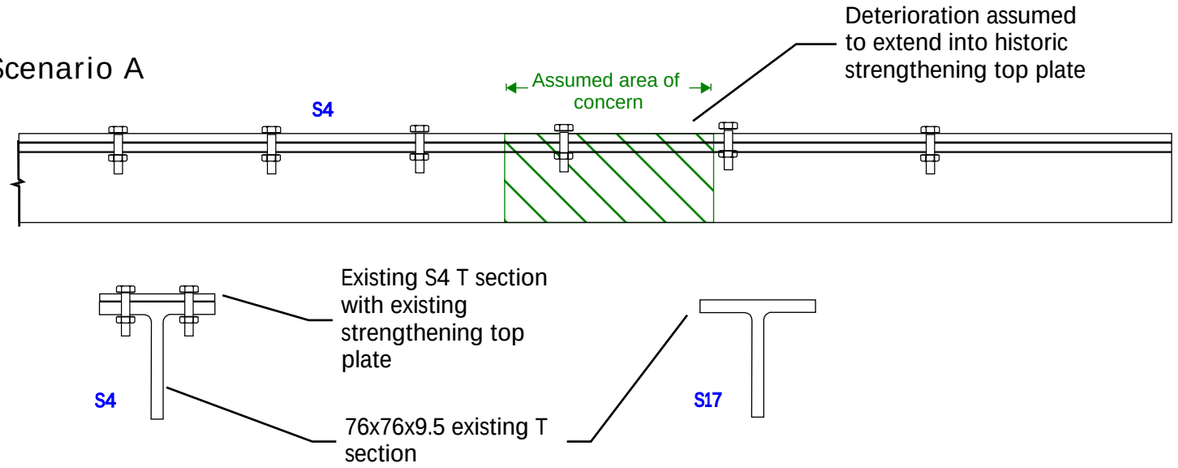
- Proposal 2 - for the case of significant section loss or damage, using upturned T sections bolted to the top flange. This follows the proposed strengthening works outline for element S6 on drawing 151667-TSA-30-MVL3-DRG-S-ST-180025.

S4 T section with strengthening
- S17 (on mirrored side of truss) is similar without strengthening plate

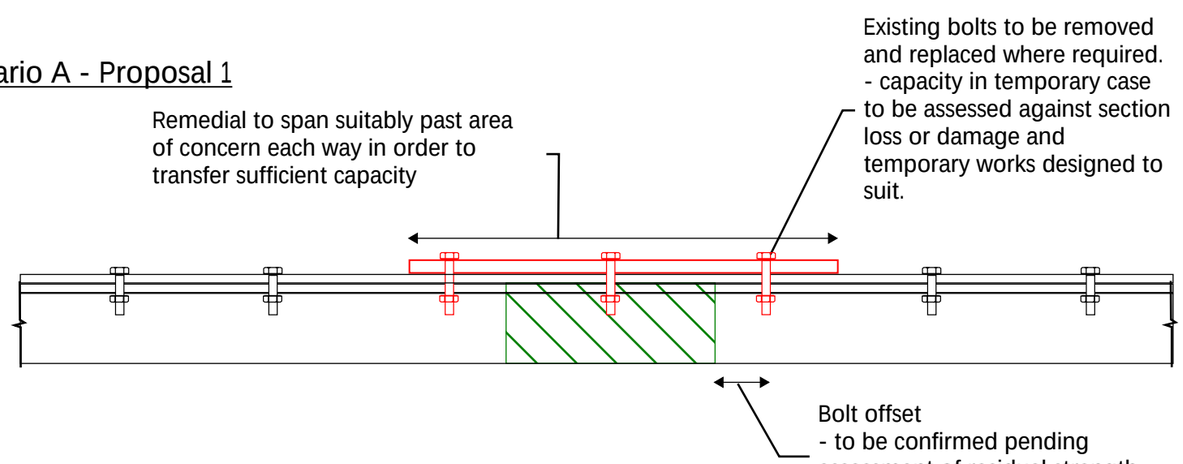




Scenario A



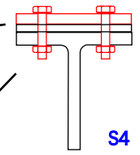
Scenario A - Proposal 1



Scenario A - Proposal 2

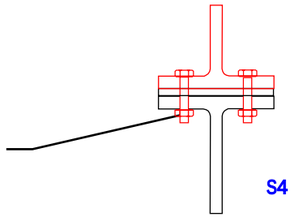
Provide second top plate (S4) or install new top plate (S17) to top face of T section.

Plate and bolts sized in relation to section loss or damage extent.



Scenario A - Proposal 3

For significant section loss or damage provide strengthening T similar to S6 strengthening proposal as show on 151667-TSA-30-MVL3-DRG-S-ST-180025



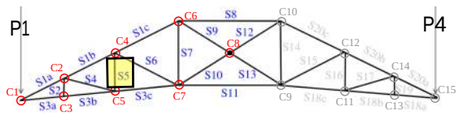
Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses Intervention Proposals



Roof A - Element and connection references

Element S5

The vertical S5 element is as per the original construction. The elements are generally in good condition and the design forces sufficiently low that there is minimal risk that section loss through corrosion will cause the elements to be under design capacity.

In the notional deterioration scenario of a cracked cross section with zero capacity, two proposals are suggested:

- **Proposal 1** - supplementary new steel angle section added each side of existing S5 hanger, with top and bottom gusset plates to connect back into the truss. The gusset plates require shaping around existing plates/bolts to facilitate their positioning as tight into the connection as possible. No temporary works are assumed in this proposal: the existing elements are being left in place and supplemented by additional structure and the temporary case does not make the condition weaker than existing.

- **Proposal 2** - proposes a like-for-like replacement for S5, potentially using an equivalent salvaged element from the dismantled end trusses. The drawback of this proposal is that temporary works are required to tie together the top/bottom booms whilst S5 is replaced, plus propping the compressive force from diagonal S6 whilst a new top pin is installed.

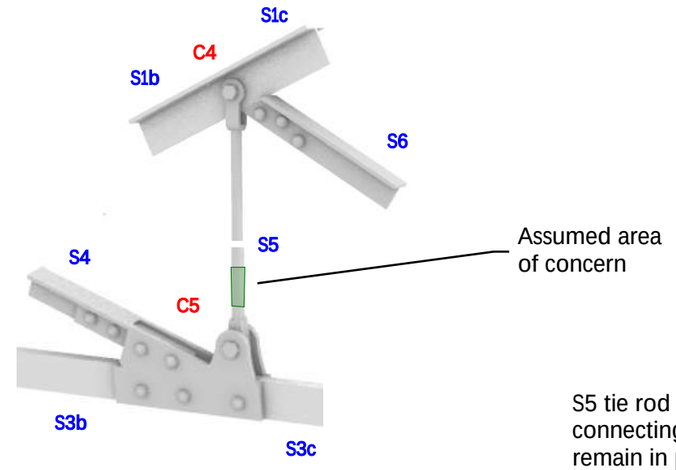
Top connection C4
- with S5 fixed by through bolt/pin into top boom (with connecting plates from S6 sandwiched within)

Existing vertical S5

(Non-structural fixings spanning between trusses)

Bottom connection C5
- with S5 fixed by through bolt/pin into side plates of C5

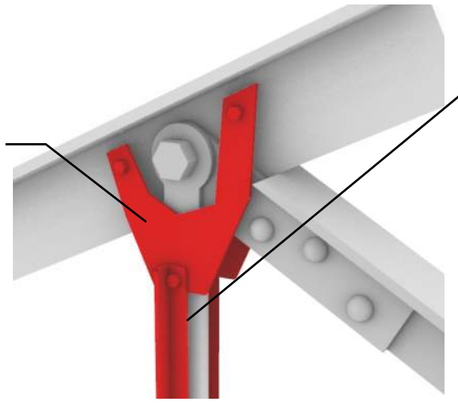
Scenario A



Assumed area of concern

Scenario A - Proposal 1

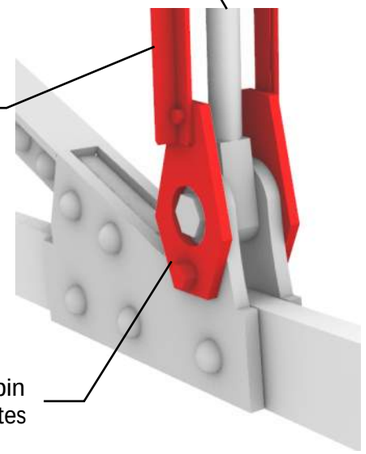
Top gusset plate
- bolted connection packed off top boom
- shaped around S6 diagonal top flange
- shaped around existing S5 pin



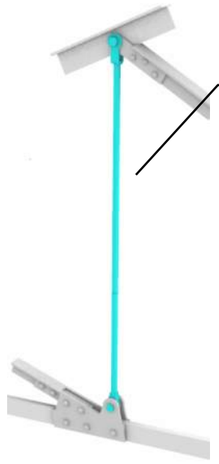
2 No. new angles installed to each face of tie rod
- bolted into new top and bottom gusset plates

Bottom gusset plate
- shaped around existing S5 pin
- set outside existing side plates

S5 tie rod and connecting pins to remain in place.

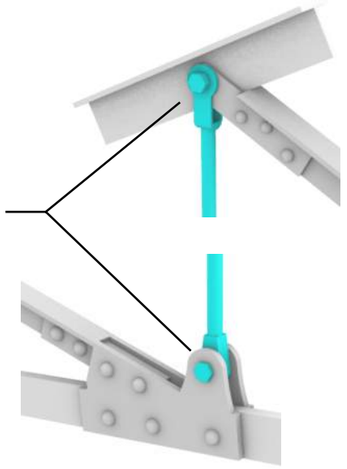


Scenario A - Proposal 2



S5 replaced with like-for-like hanger

New pins for top and bottom connection

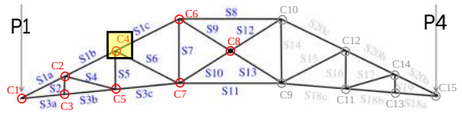


Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook



Roof A - Element and connection references

Connection C4

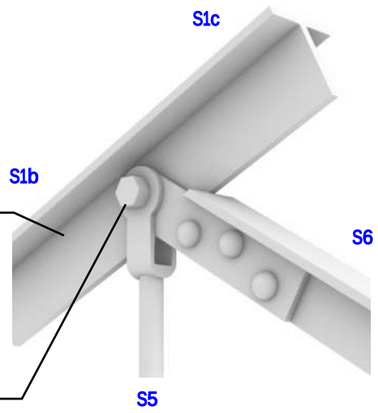
C4 is understood to be in reasonable condition.

The geometry at C4 includes:
- continuous top chord running through the connection (S1b and S1c)
- internal connection plates extending from incoming diagonal Tee S6
- external fork ends from vertical tie S5

The notional deterioration scenario presumes damage to the internal plates from S6 - to reiterate no evidence of deterioration has been identified at this position but this is the assumption to allow potential options to be considered.

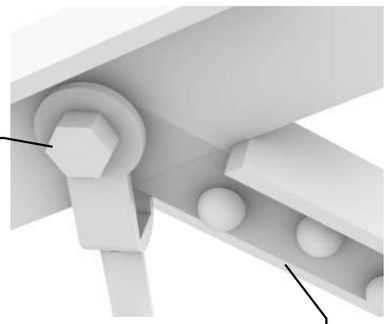
The proposal assumes temporary works are in place, necessary due to difficulty of over-reaming the existing bolt at the S5 tie rod connection (i.e. large bolt size, small edge distances, no redundancy for single bolt fixing).

Schematic arrangement



S1b and S1c assumed as a single continuous top chord through connection

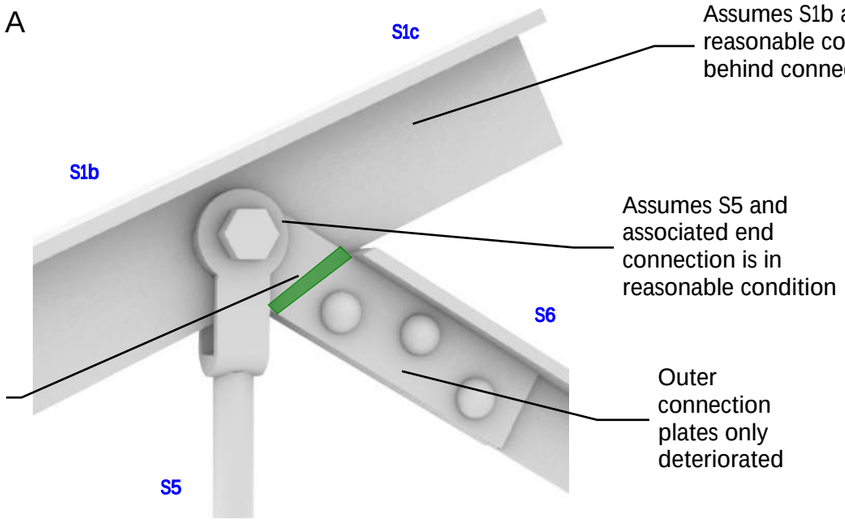
Bolt as pin, not rivet



Single bolt through assembly

Web of S6 in same plane at S1b/S1c
- only side plates extend to form connection

Scenario A



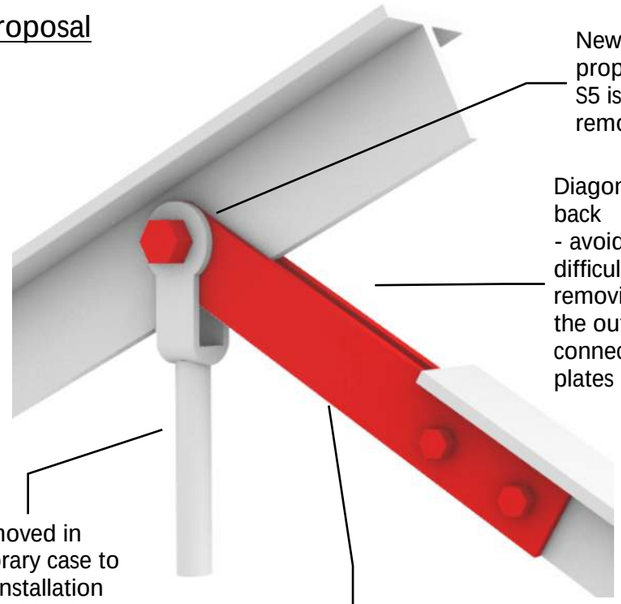
Assumes S1b and S1c in reasonable condition behind connection

Assumes S5 and associated end connection is in reasonable condition

Assumed area of concern

Outer connection plates only deteriorated

Scenario A - Proposal



New pin proposed whilst S5 is temporarily removed

Diagonal S6 cut back
- avoids difficulties of removing only the outer connection plates

S5 removed in temporary case to allow installation of new side plates
- temporary works required

New side plates in same plane as existing
- bolted connection into S6 which is assumed sound

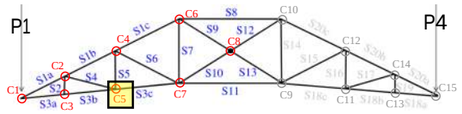
Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses Intervention Proposals



Roof A - Element and connection references

Connection C5

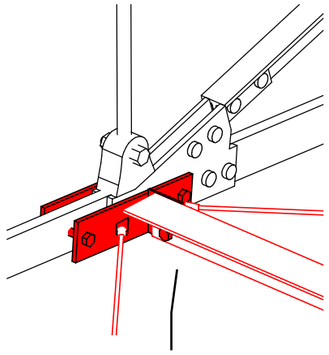
C5 is understood to be in reasonable condition. Associated main works proposals involve additional side plates to receive new plan bracing on the southernmost trusses. These side plates are affixed into the existing connection via new bolts through over-reamed existing rivets.

The following series of notional deterioration scenarios consider increasing severity of damage, with remedial proposals mainly adopting the same strategies already outlined for C7. Differences particular to C5 include: the bottom chord elements S3b and S3c are assumed continuous through the connection; tie rod S5 is connected directly into the C5 connection plates.

Each scenario has an equivalent proposal. Accompanying notes for the proposals are given below:
- **Proposal A** - with new bridging plates as per C7 but requires temporary works to support S5 whilst a new pin is installed (which transfers loads into the new plates)

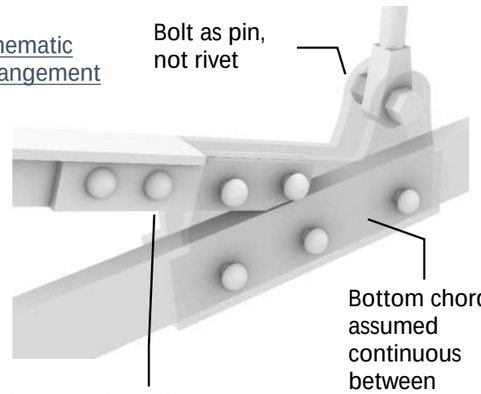
- **Proposal B** - if the end of S5 has deteriorated then replacement structure rather supplementary structure is recommended, since the assumed new bridging plates would imply temporary works are already in place to bypass S5. the replacement S5 could be an equivalent salvaged element from the dismantled end trusses.

- **Proposal C** - as proposal B but requires wider new bridging plates to extend further to sound material at incoming elements.

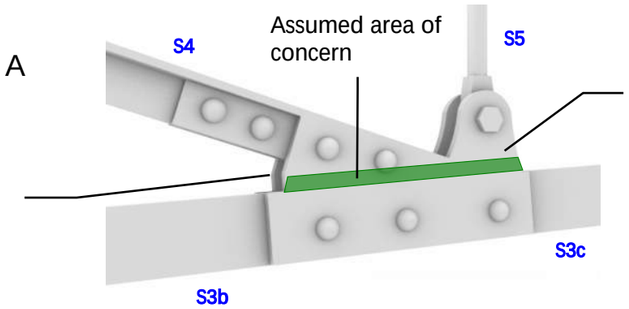


Main works proposals from drawing 151667-TSA-30-MVL3-DRG-S-ST-180022

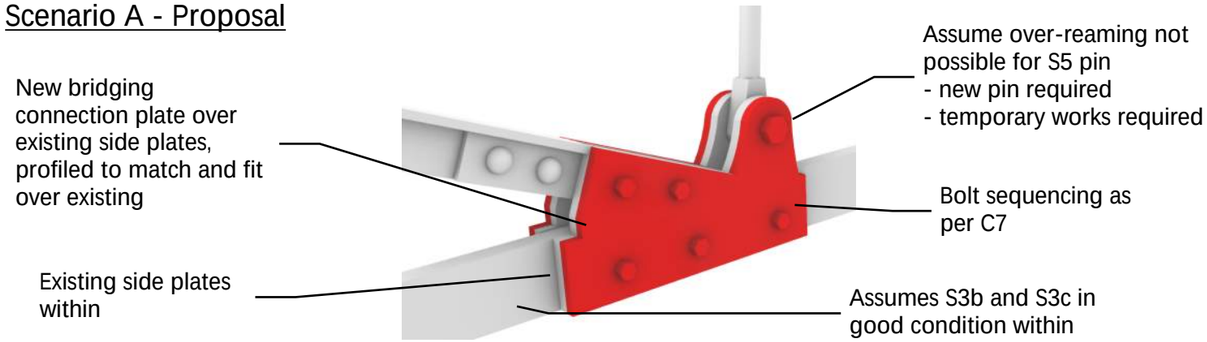
Schematic arrangement



Scenario A

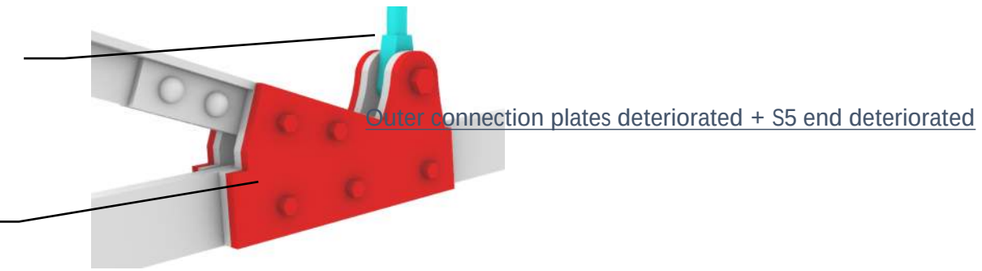


Scenario A - Proposal



Scenario B: Outer connection plates deteriorated + S5 end deteriorated

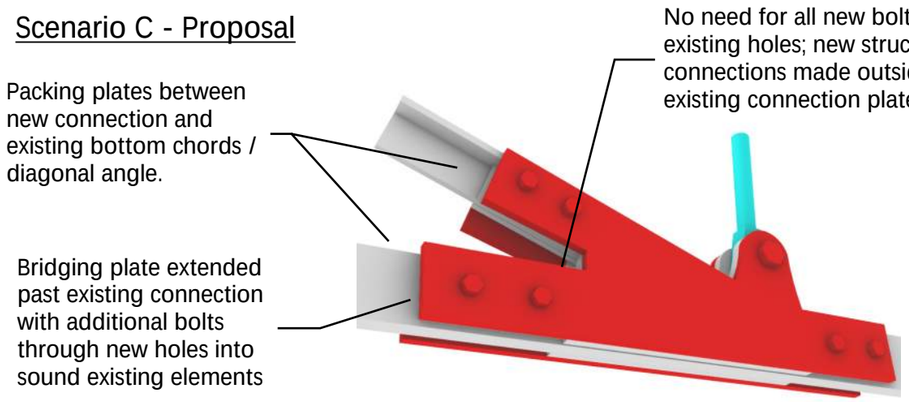
Scenario B - Proposal



Outer connection plates deteriorated + S5 end deteriorated

Scenario C: Outer connection plates deteriorated + S5 end deteriorated + S3b & S3c deteriorated within connection

Scenario C - Proposal



Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

151667-TSA-30-MVL3-SK-S-007 Rev P03
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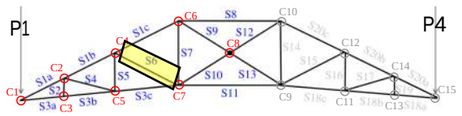
Grip 5 / For Information / DHx
06 October 2023

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

Element S6

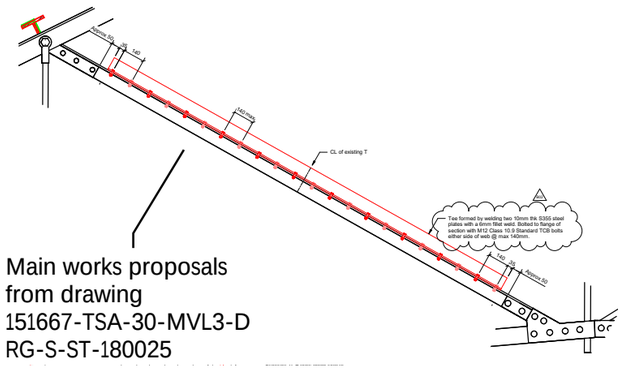
The inner diagonals of the Roof A trusses are currently as per the original construction however strengthening has been specified as part of the main works to all inner diagonal elements (S6 and S15) as per 151667-TSA-30-MVL3-DRG-S-ST-180025.

The sections appear to be in reasonable condition therefore the likelihood of significant corrosion or section loss being identified during the blast cleaning process is deemed to be low.

Should additional interventions be identified as required during the works, the proposal is to increase the thickness or fixing sizing of the current specified strengthening works as required to account for any loss of section or element damage.

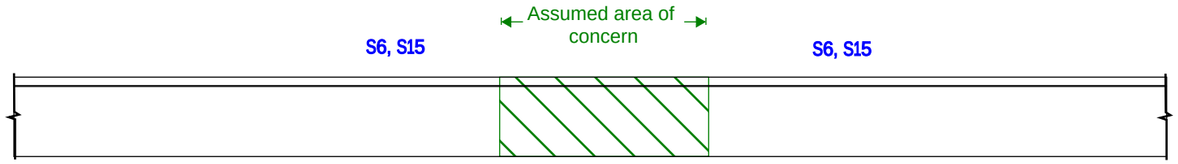
No temporary works are assumed to facilitate this remedial: the existing elements are being supplemented by additional structure and the temporary case does not make the condition weaker than existing.


Existing S6 element



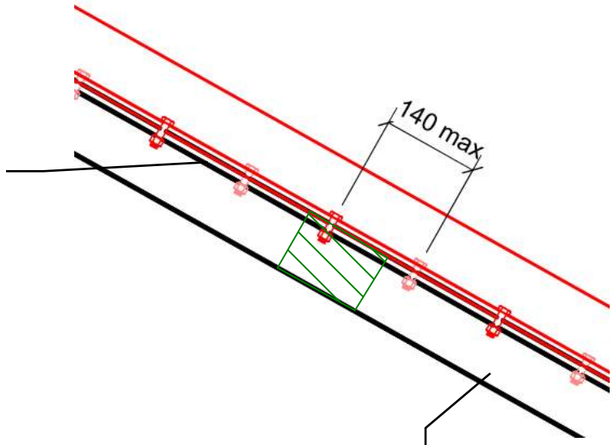
Main works proposals from drawing 151667-TSA-30-MVL3-DRG-S-ST-180025

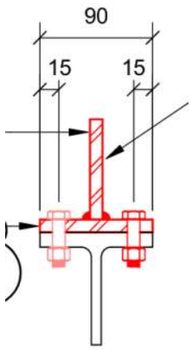
Scenario A



Scenario A - Proposal

New strengthening section to be increased in section thickness as required to account for identified section loss or damage.





Existing Tee section under

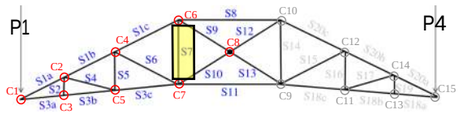
Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses Intervention Proposals



Roof A - Element and connection references

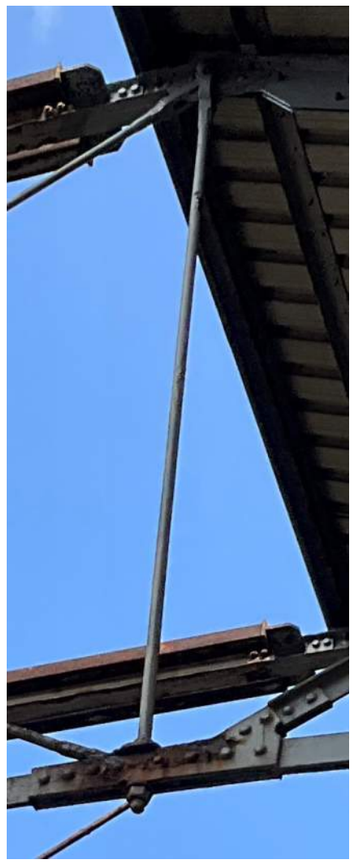
Element S7

The vertical S7 element is as per the original construction. The elements are generally in good condition with the exception of a small number of cases which show signs of pitting which may be historical i.e. below existing paint system. The utilisations of these elements are relatively low when design forces are compared against surveyed section dimensions. There is therefore a low risk that section loss through corrosion will cause the elements to be under design capacity.

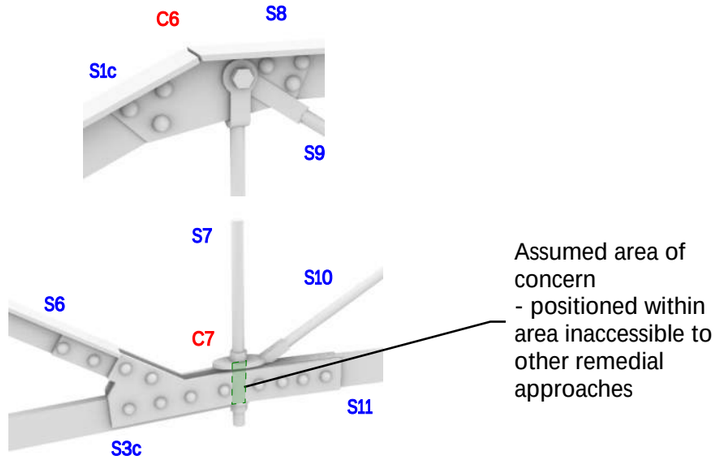
In the notional deterioration scenario of a cracked cross section with zero capacity, two proposals are suggested:

- **Proposal 1** - supplementary new steel flat or angle sections added each side of existing S7 hanger, with top and bottom gusset plates to connect back into the truss. The gusset plates require shaping around existing plates/bolts to facilitate their positioning as tight into the connection as possible. No temporary works are assumed in this proposal: the existing elements are being left in place and supplemented by additional structure and the temporary case does not make the condition weaker than existing.

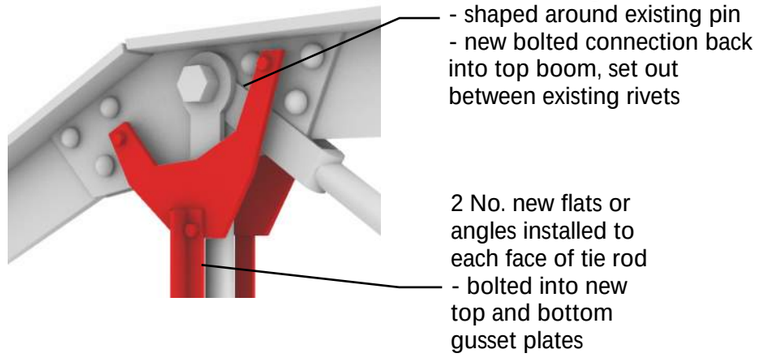
- **Proposal 2** - proposes a like-for-like replacement for S7, potentially using an equivalent salvaged element from the dismantled end trusses. The drawback of this proposal is that temporary works are required to tie together the top/bottom booms whilst S7 is replaced, plus propping the incoming forces from incoming diagonals whilst new top and bottom pins are installed.

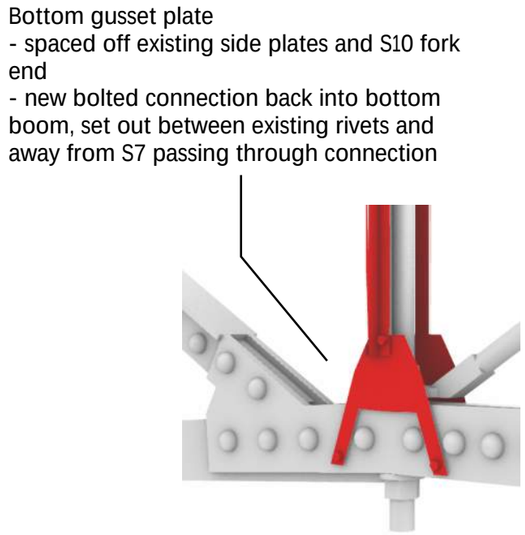


Scenario A

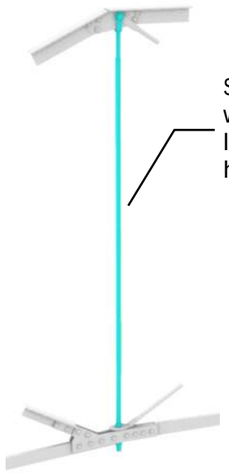


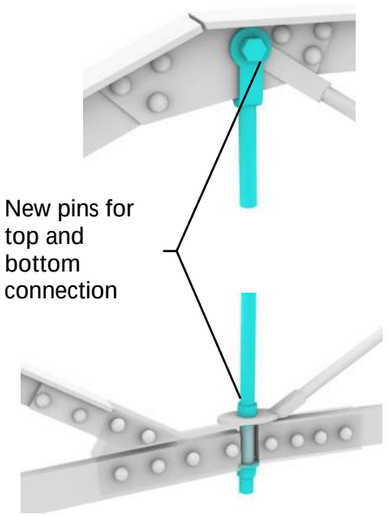
Scenario A - Proposal 1





Scenario A - Proposal 2





Intervention Likelihood:

Unlikely Intervention is required

Huddersfield Station

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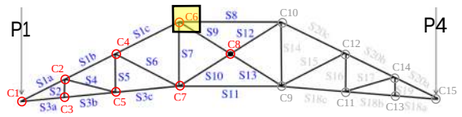
Intervention Proposals



Roof A - Element and connection references

Connection C6

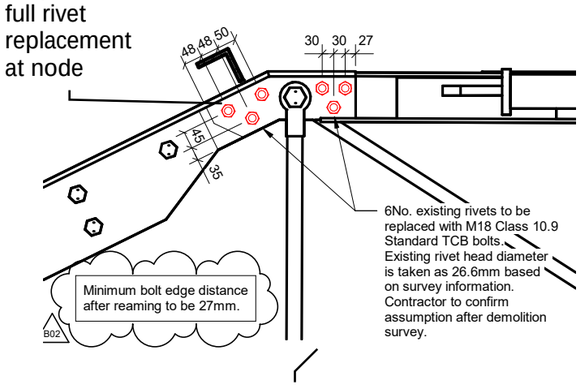
C6 is largely understood to be in reasonable condition and strengthening works through rivet replacement with new bolts is already proposed as part of the main works package. A notional deterioration scenario assumes damage to the outer plates at the connection of incoming ties.

C6 presents similar issues to those discussed in C7 except that the current S7 & S9 tie rods forked end fixings prevents the installation of a new bridging plate over existing.

Two proposals are presented in response to the deterioration scenario:
- **Proposal 1** is in line with those presented for C7 with supplementary bridging plate over existing, excepting that (i) S7 & S9 ties need to be removed in the temporary case (ii) S7 & S9 ties now have a wider connection to be fixed back into. There may be a potential to re-use tie rod S7 and its wider fork end (now adopted as the inner fork end), then with a new tie rod S9 with a wider end as the outer fork.

- **Proposal 2** avoids the need for replacement tie rods S7 & S9 by requiring more extensive temporary works to support all 4 incoming members (S1c, S8, S7, S9). This facilitates full removal of the existing connection plates and therefore new bridging plates can be used in the same plane as existing. The benefit is that existing tie rods S7 & S9 can be re-used.

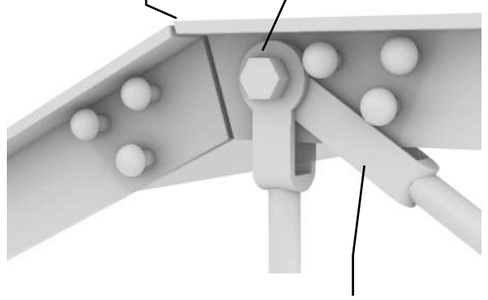
Proposed full rivet replacement at node



Main works proposals from drawing 151667-TSA-30-MVL3-DRG-S-ST-180027

Break in top chord (between S1c and S8) shown indicatively

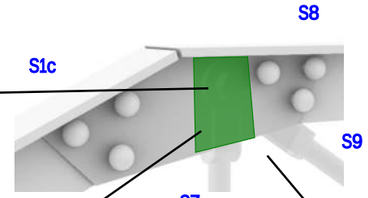
Single pin through S7, S9, cover plates and S8



Schematic arrangement

Inner S9 fork end within S7 fork outer end

Scenario A



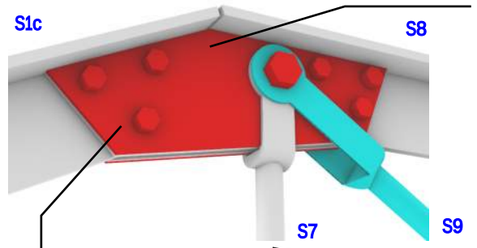
Assumed area of concern

Assumes S7 and S9 and associated end connections are in reasonable condition

Outer connection plates only deteriorated

Fork ends ghosted for clarity

Scenario A - Proposal 1

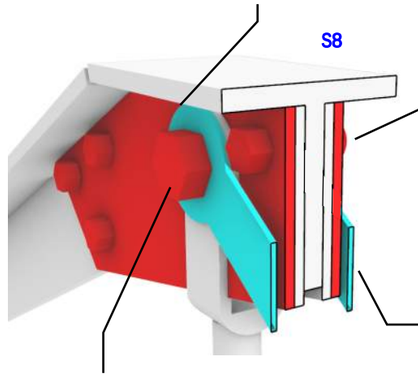


New bridging connection plate over existing side plates, profiled to match and fit over existing.

Bolts as per main works proposals with sequencing as per C7

Potentially re-used S7 becomes inner fork end

Temporary works installed in place of S7 and S9 to allow bridging plate installation



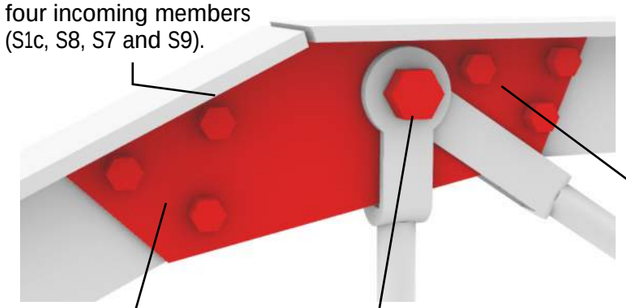
Existing side plates within

New S9 with wider fork end to become outer fork

New through pin

Scenario A - Proposal 2

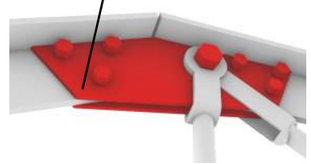
Temporary works installed in place of all four incoming members (S1c, S8, S7 and S9).



Bolts as per main works proposals with sequencing as per C7

Tie rod pin removed; new pin after re-installation of tie rods

New connection plate in same plane as removed existing plate



Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

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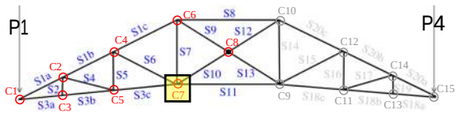
Roof A Trusses
Intervention Proposals



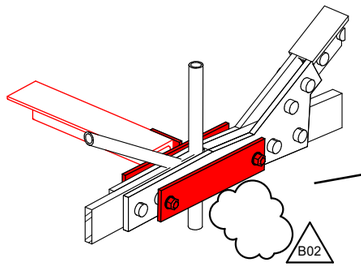
Roof A - Element and connection references

Connection C7

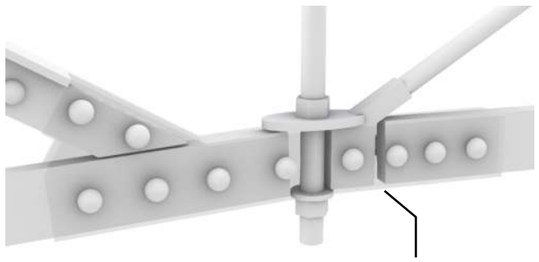
C7 has been identified as having corrosion present which appears to have progressed between the initial survey in 2019 and the latest in 2023. The corrosion appears most significant in the bolts and connection plates around the base of the diagonal members and particularly on the central side of the truss (towards member S11). It unclear from the photos to what extent the corrosion and water ingress has penetrated to the inner plates of the connection and what condition they may be in. The vertical tie rod S7 and associated washers and bolts appear generally to be in good condition as do the incoming diagonal angle S6 and its associated bolts.

Any intervention will need to be considerate of the part of the connection which is identified as deteriorated. Given the current condition, the most likely elements to be identified as understrength is the central section of the outer connection plates and the associated inner plates of the corresponding connecting elements. Scenarios are presented to account for increasing deterioration.

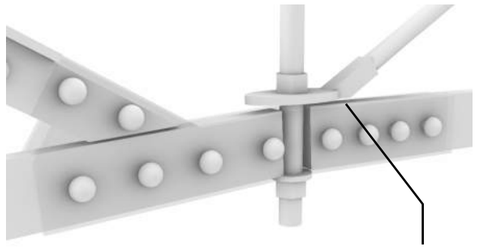
Precedent for the rivet replacement with bolts has been set in the proposed intervention drawing 151667-TSA-30-MVL3-DRG-S-ST-180022 as already agreed.



Main works proposals from drawing 151667-TSA-30-MVL3-DRG-S-ST-180022

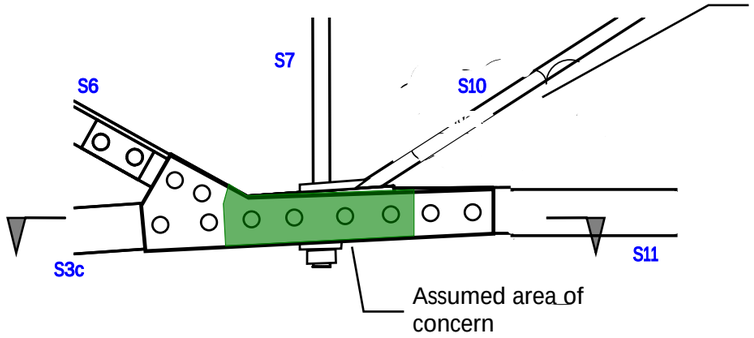

Schematic arrangement #1

S10 has fork end within and behind side plates - less likely

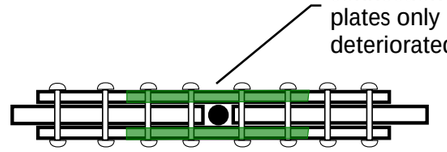

Schematic arrangement #2

S10 terminates only with bracket connecting into S7 - more likely: proposals assume this arrangement

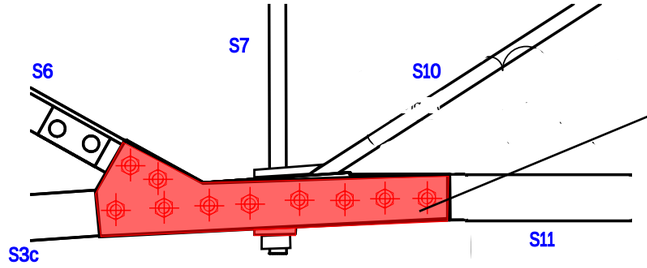
Scenario A



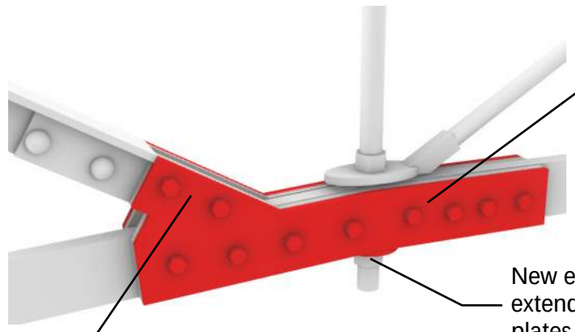
Assumes S7 and S10 and associated end connections are in reasonable condition


Outer connection plates only deteriorated

Scenario A - Proposal

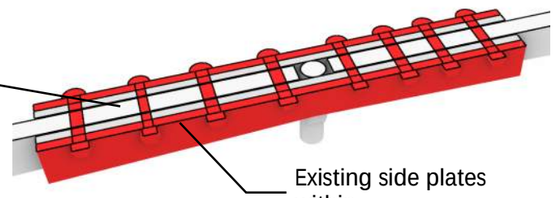


New bridging connection plate over existing side plates, profiled to match and fit over existing.
- Existing rivets to be drilled and reamed one at a time to allow for replacement new bolts: see following sheet for assumed sequence.


Proposal also accommodates potential schematic arrangement #1

New enlarged washer to extend to new bridging plates

Assumes S6 / S3c / S11 elements are in reasonable condition sufficient to connect to


Existing side plates within

Scenario A:

Intervention Likelihood:	Trusses in this Category
Possible Intervention required	**4 out of 46**

Scenario B&C:

Intervention Likelihood:
Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

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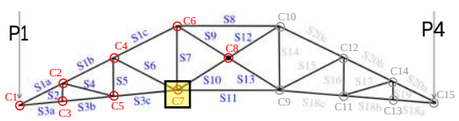
Roof A Trusses Intervention Proposals

Connection C7 (continued)

Scenario A (continued)

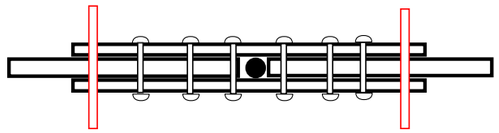


Roof A - Element and connection references

Scenario A - assumed sequencing

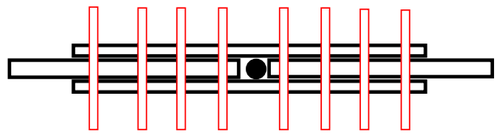
The following sequencing has been developed to satisfy the following criteria:
- only 1No. rivet removed at a time
- TCBs in place in permanent works
- principle of using supplementary (as opposed to replacement) plates, which avoids requiring temporary works
- consideration of tolerance, aesthetics and ease of installation to new steelwork

Step 1



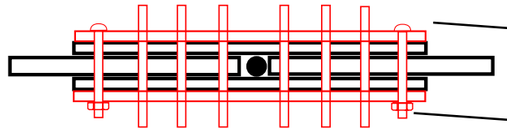
Ream out and replace outer rivets with close-fitting temporary pin / bar

Step 2



Sequentially replace all rivets, one by one, with temporary pins

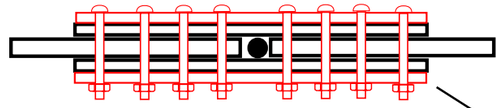
Step 3



New bridging plate site-measured to fit over temporary pins.

Pins replaced by TCBs one-by one

Step 4

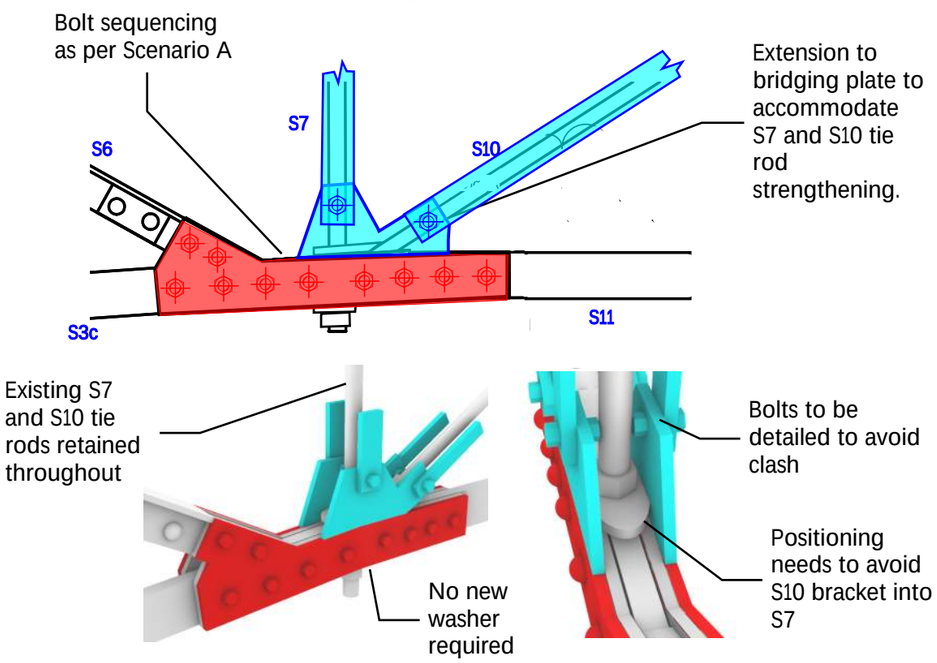


Permanent arrangement

Scenario B: Outer connection plates deteriorated + S7 / S10 ends deteriorated

Scenario B - Proposal

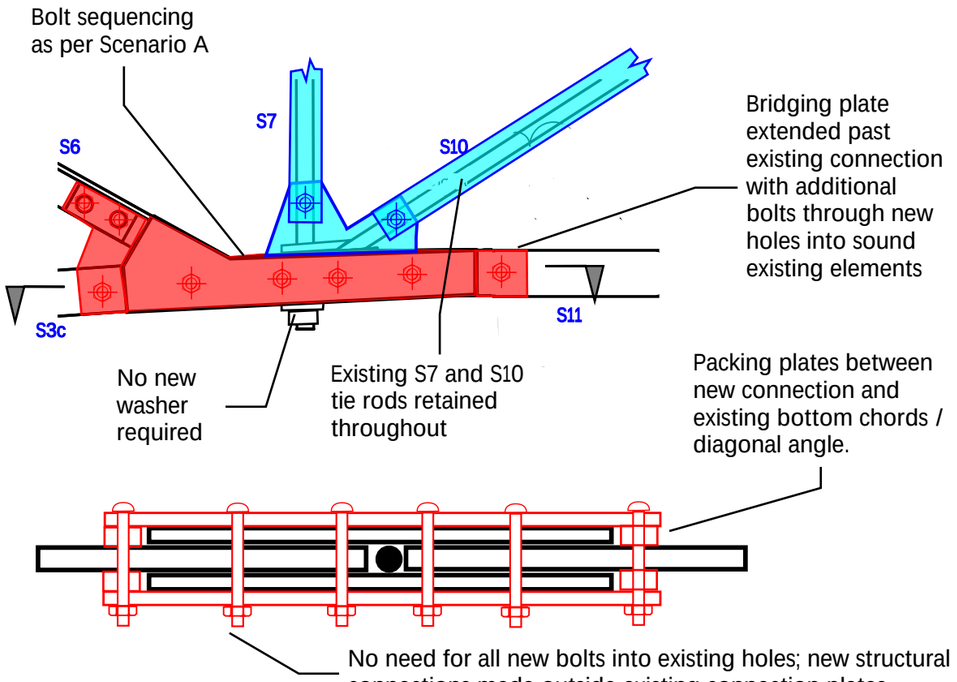
-Low likelihood of requirement due to generally good condition of S7 and S10 connection elements
-Requires full strengthening / capacity matching of elements S7, S10 which in turn requires interaction detail with central rose.
- Detail assumes some capacity of existing tie rod and connections subject to wider design checks. Proposal C may be more suitable to allow for complete redundancy of existing connection elements.



Scenario C: Outer connection plates deteriorated + S7 / S10 ends deteriorated + S6 / S3c / S11 ends deteriorated

Scenario C - Proposal

-Detail to be designed to make existing connection redundant.
-Requires full strengthening of elements S7, S10 which in turn required the full extent of central rose and associated tie rod strengthening. See associated element replacement page.
- Detail assumes some capacity of existing tie rod and connections subject to wider design checks. Proposal C may be more suitable to allow for complete redundancy of existing connection elements.



Scenario A:

Intervention Likelihood:	Trusses in this Category
Possible Intervention required	**4 out of 46**

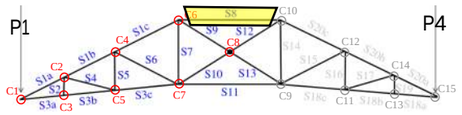
Scenario B&C:

Intervention Likelihood:
Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

S8

The top boom central elements of the Roof A truss consist of an original I sections which has been previously strengthened by two SHS box sections either side.

Whilst the corrosion protection system of the elements appears in a generally poor condition, the nature of the closed box sections, their more recent installation in modern materials and their original design capacity means that the risk of interventions being required is very low. In the unlikely event of intervention being required, the strengthening elements are proposed to be replaced like for like.

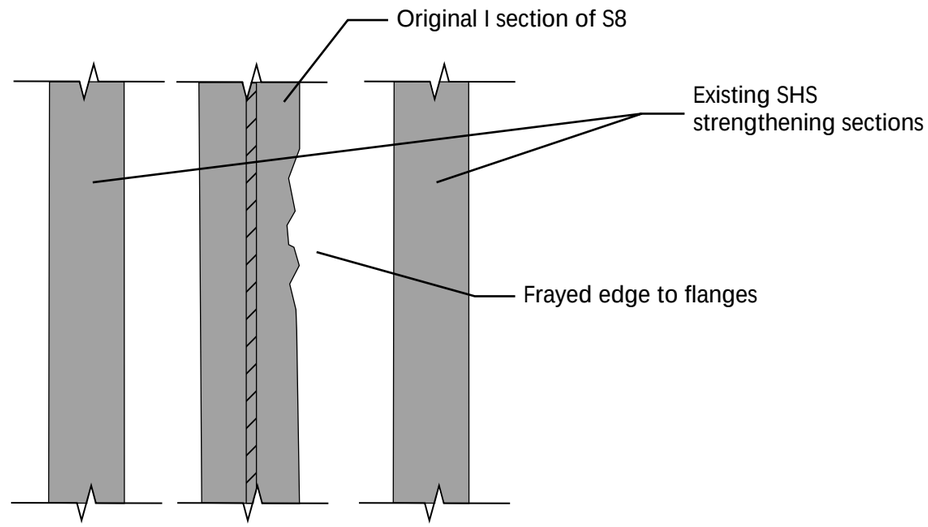
Works are to be undertaken to restore the corrosion protection of both the original and strengthened sections as per the rest of the structure.

The remedial opposite assumes a known deterioration scenario where the edges of the I section are ragged and frayed due to corrosion. The flanges are to be ground back to a minimum thickness in line with Network Rail Guidance NR/L3/CIV/040 (Specification for the Use of Protective Coating Systems) and should be ground back to a consistent line where possible to reduce the visual impact of the section loss when viewed from platform level.

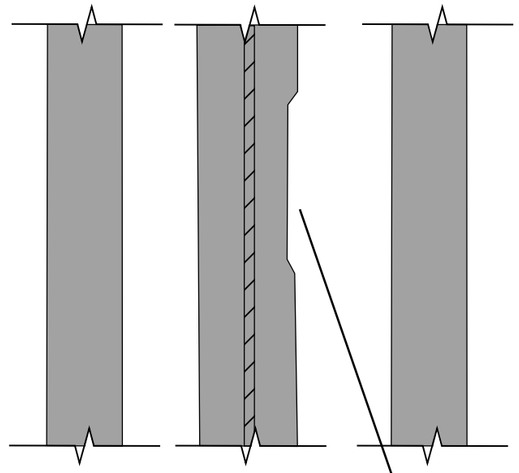

Original I section of S8

Supplementary box sections from historic strengthening

Scenario A



Scenario A - Proposal



Original I section to be blast cleaned and ground back to minimum allowable thickness for coating as per NR/L3/CIV/040. Section to be ground back to consistent line where possible for aesthetics

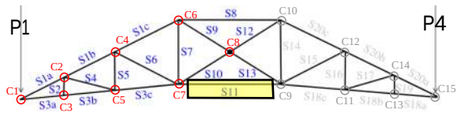
Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

S11

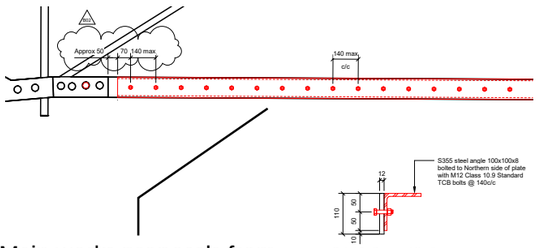
The bottom boom central elements of the Roof A truss are single flat plates as per the original construction (i.e. historically unstrengthened).

The sections appear to be in mixed condition due to being exposed to the elements due to the missing lanterns above, with some elements showing significant rust staining and coating failure (identified during the 2023 visual inspection from platform level). The condition of the existing steel will be assessed following blast cleaning and compared against predefined section limits to determine if strengthening is required. It is anticipated this may occur at multiple trusses across the roof structure particularly at trusses on columns lines which have a higher design load requirement.

Should remedial works be identified as required during the works a notional deterioration scenario is shown opposite, conservatively assuming full plate section loss.

The remedial proposal is to strengthen the sections with a new flat plate bolted to the existing section at regular intervals in a similar detail to the adjacent bottom boom sections S3aS3b/S3c. This proposal adopts a similar strategy to the strategy already agreed for strengthening S11, which has a partnered new angle section for those trusses on end bays (as identified on drawing 151667-TSA-30-MVL3-DRG-S-ST-180015 and as per drawing extract below). The assumption is that should S11 be deteriorated on these end bay trusses, the proposed main works strengthening will be sufficient in lieu of the side plate strengthening shown here.

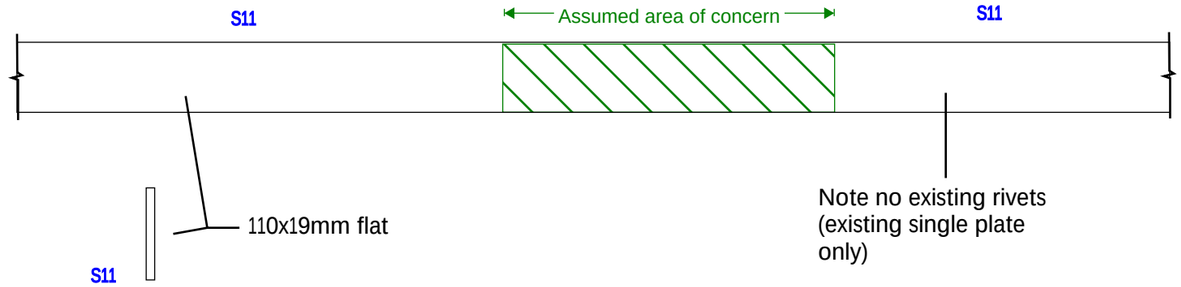
No temporary works are assumed to facilitate this remedial: the existing elements are being supplemented by additional structure and the temporary case does not make the condition weaker than existing.



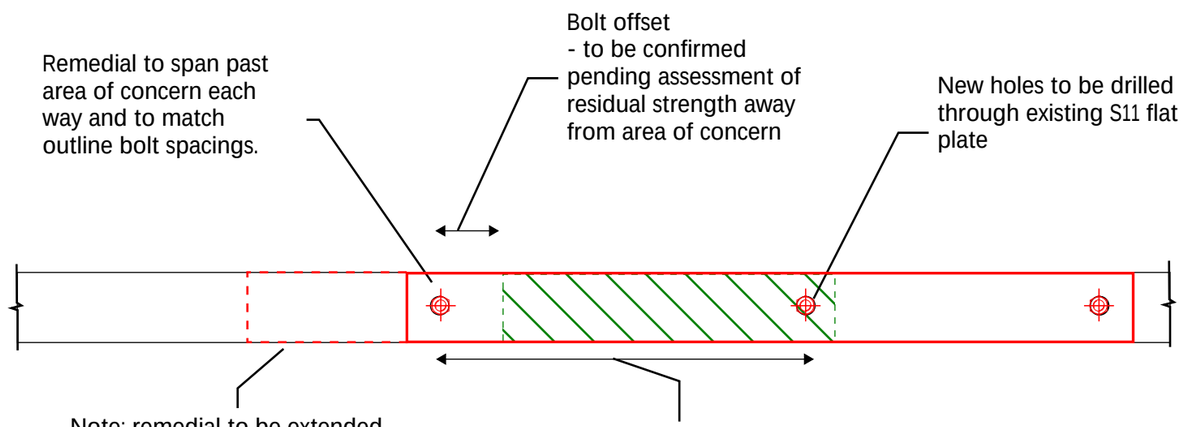
Detail 2 - Proposed Section
1:5

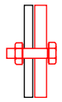
Main works proposals from drawing 151667-TSA-30-MVL3-DRG-S-ST-180025

Scenario A



Scenario A - Proposal





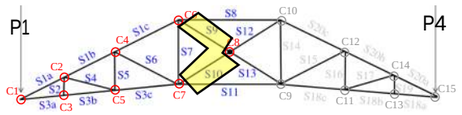
New flat plate bolted to existing plate along one face. Plate thickness and bolt sizing to suit extent of defect.

Intervention Likelihood:	Trusses in this Category
Possible Intervention required	**4 out of 46**

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook

Roof A Trusses
Intervention Proposals



Roof A - Element and connection references

Elements S9 & S10

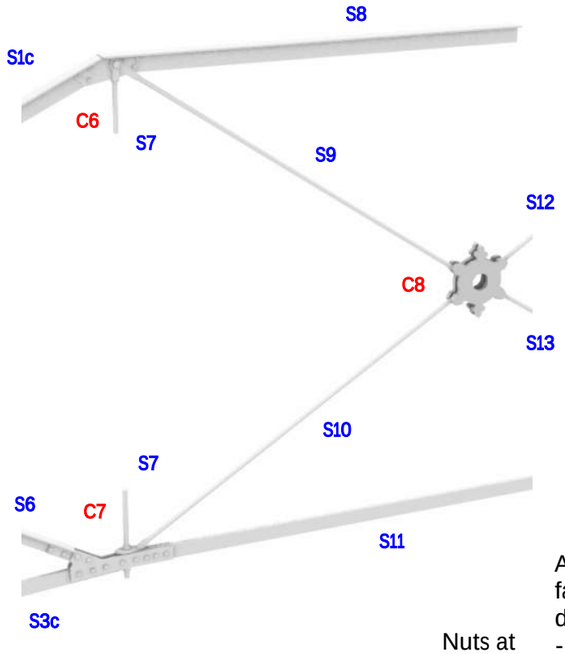
S9 and S10 are the diagonal rods in the central braced truss bay, which together with their mirrored equivalents (S12 + S13) meet at the central node connection (C8, also known as the 'rose' connection).

The nature of the C8 node connection is unclear but is suspected to consist of a pair of ornamental non-structural fascia plates which conceal a structural 'ring' connection. It is likely the incoming diagonals S9 and S10 pass through the ring to receive a nut onto a threaded end. The other ends of diagonals S9 and S10 connect into complex multi-element connections C6 and C7.

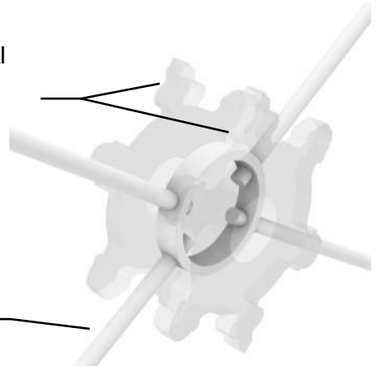
The elements are generally in good condition and the design forces sufficiently low that there is minimal risk that section loss through corrosion will cause the elements to be under design capacity.

As a conservative consideration, the notional deterioration considers a serious structural failure within the inaccessible area within C8. A pair of failed incoming rods are considered.

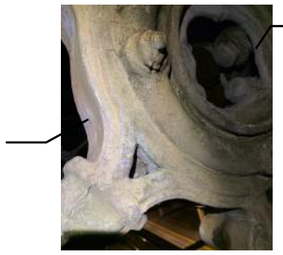
Given the aesthetic sensitivity of the rose connection and the complications of connecting supplementary new steelwork, the remedial proposal is for element replacement. This could be with an equivalent member from the dismantled end trusses or by a newly forged section. Significant temporary works would be required to support this central bay whilst these elements were replaced.



Assumed two-piece fascia with ornamental detailing
- bolted together to conceal structural connection within



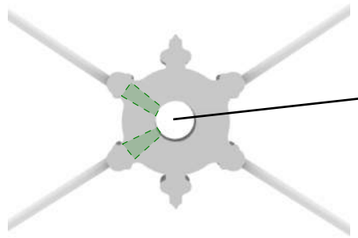
Diagonal rods assumed to connect into single circular ring



Assumed painted over joint between fascia pieces

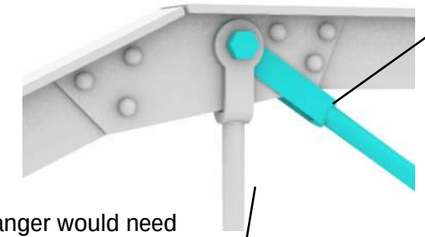
Nuts at ends of diagonal rods

Scenario A



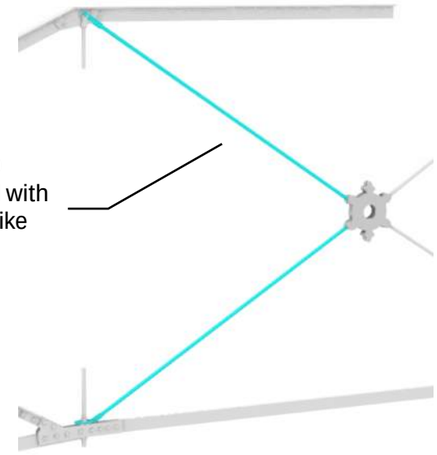
Assumed area of concern
- positioned within area inaccessible to other remedial approaches

Scenario A - Proposal

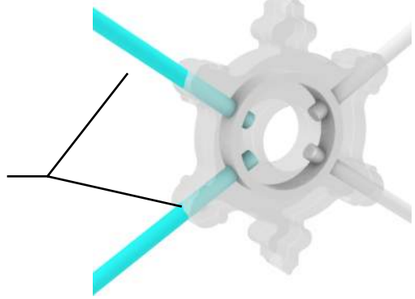


New S9 forged fork end to match existing

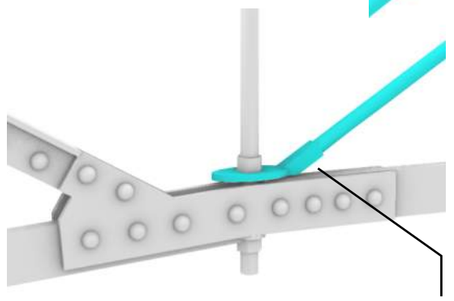
S7 hanger would need to be temporarily removed for new S9 installation
- temporary works required



S9 & S10 replaced with like-for-like rods



Straight shaft of replacement rods to pass through retained structural ring
- threaded ends to receive nut



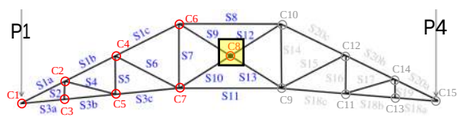
New S10 fork end to match existing
- detail complicated since vertical rod S7 passes through S10 fork end, which implies S7 would need to be temporarily removed
- temporary works required

Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook



Roof A - Element and connection references

Connection C8

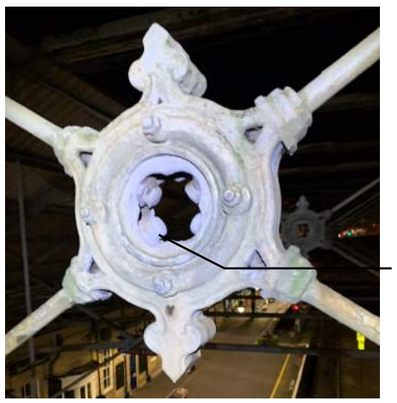
Connection C8 is the central node of the middle braced bay, and is alternatively known as the 'rose' connection. It ties together the end of the incoming tension rods S9, S10, S12 and S13.

The nature of the C8 node connection is unclear but is suspected to consist of a pair of ornamental non-structural fascia plates which conceal a structural 'ring' connection. It is likely the incoming diagonals pass through the ring to receive a nut onto a threaded end.

The condition of the inner structural ring is currently unknown, given its inaccessibility within the suspected non-structural fascias. As a positive there aren't any indications of excessive corrosion to the fascia plates, which could otherwise be interpreted as a sign of hidden ongoing deterioration. However it could equally be the case that corrosion of the ring is simply hidden behind the fascias and has not reached the position where the fascias are affected. Given the position of the rose directly under the open roof, and the potential for trapped water within the connection, the risk of corrosion cannot be ruled out.

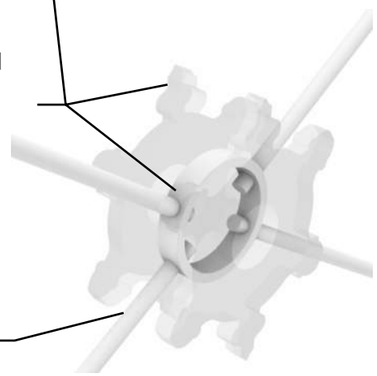
For the purposes of this assessment, a notional deterioration scenario considers full failure of a part of the structural ring. The remedial proposal is constrained by the architectural sensitivity of the rose, its central aspect on the truss, and the difficulty of using supplementary steelwork when it would have to interface with the non-structural fascias. For this reason a simple new replacement structural ring is proposed, like-for-like, which can again be concealed within the fascias. The significant temporary works to facilitate this proposal - temporarily replacing the action of the cross bracing- should be recognised.

Assumed painted over joint between fascia pieces



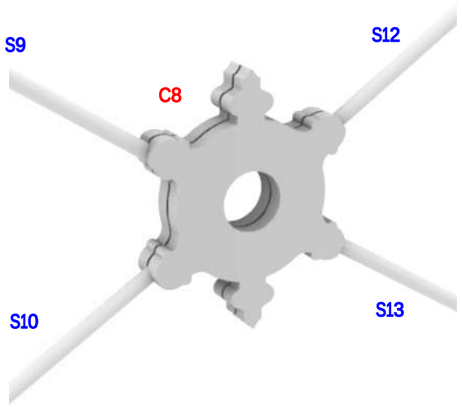
Nuts at ends of diagonal rods

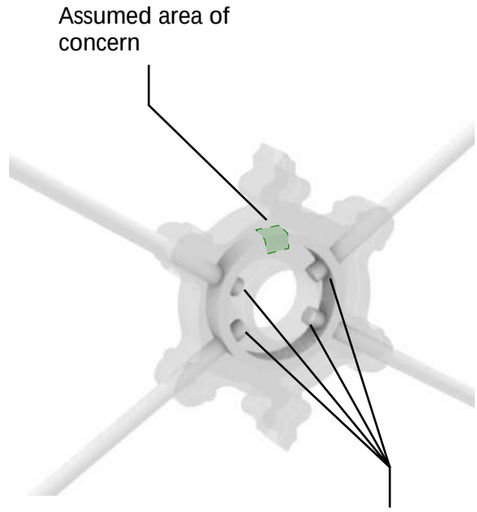
Assumed two-piece fascia with ornamental detailing
- bolted together to conceal structural connection within



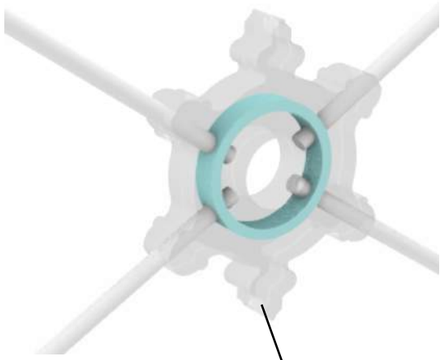
Diagonal rods assumed to connect into single circular ring

Scenario A





Scenario A - Proposal



Non-structural fascias removed and re-bolted around replacement structural 'ring'

Intervention Likelihood:

Highly Unlikely Intervention is required

Huddersfield Station

Roof A - Truss Pre-emptive Interventions Proposals Sketchbook