Ballarat Railway Station - Goods Shed

Structural Investigation

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</tbody>
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1 Introduction

Cardno was engaged by VicTrack to undertake an assessment of the representative structural condition of the concealed base of the timber internal columns, a closer inspection of the roof framing, representative sampling of timber species used in the roof framing and equivalent stress grading of the existing timber roof trusses.

Two inspections were carried out. The first inspection was carried out on 9th September 2015 and involved timber samples collection, a close up inspection of the roof and general building framing. Collection of samples was undertaken through the use of an elevated work platform. The second inspection was carried out on the 16th and 17th September 2015 as part of the column base foundation investigation. This involved the exposure of the base of the columns with the use of a mini excavator.

These proposed works followed on from the works carried out by ARUP including their “Visual Structural Inspection of the Existing Structure” report on the Goods Shed dated 31 March 2014.

The Structural Investigation sets out the methodology site works associated with the investigation and collection of samples from the existing building.

This document provides relevant information for the personnel carrying out works, remediation of goods shed, and to inform the stakeholders as to structural aspects of proposed repurposing of the Goods Shed.

The Goods Shed is part of the rail yards directly north of the Ballarat Railway Station, east of Lydiard Street and south-west of Nolan Street.

The column locations that were investigated and the roof trusses sampled were selected to be as representative of the general condition of the existing structure but also to capture additional information of any particular features.
# 2 Scope / Methodology

All works, while intrusive, were carried out so as not to affect the structural integrity of the building. The works included column base excavation, timber roof truss grading, and a general structural inspection of the condition of the building.

## 2.1 General Building Framing

Roof framing members were inspected utilising the elevated platform, as well as off the mezzanine platform located at the northeast corner of the building. General inspection of the internal and external features of the building was also carried out. The extent of the building assessment is illustrated in the Good’s Shed Inspection Boundary outlined in SK02 (Appendix B). The adjoining buildings to the southwest and northeast corner of the Goods Shed are not part of the scope of this structural investigation and have been specifically excluded from our discussions.

## 2.2 Timber Analysis

At nominated locations, using an elevated platform, off the platform level, samples of the timber of the bottom chord as well as the truss diagonals were recovered.

The samples were taken to a timber specialist for analysis and grading.

Referring to SK04 (Appendix D), SK03 (Appendix C) and SK02 (Appendix B) sampling was:

<table>
<thead>
<tr>
<th>Element</th>
<th>Location (referring to column references on SK02 and SK04)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header beam</td>
<td>Between N12 and N13 and between S7 and S8 - (2 samples).</td>
</tr>
<tr>
<td>Truss bottom chord</td>
<td>Between S5 and Southern Wall, between S7 and Southern Wall and between S10 and Southern Wall – (3 samples)</td>
</tr>
<tr>
<td>Truss diagonal</td>
<td>Between S5 and Southern Wall, between S7 and Southern Wall and between S10 and Southern Wall – (3 samples)</td>
</tr>
</tbody>
</table>

## 2.3 Column Base Investigation

The locations for the column base foundation investigation were reviewed following the timber roof truss inspection. At the nominated location, using a mini excavator, off the platform level, a trench was created to the side of the existing columns opposite the platform edge. Columns’ face was exposed down to the footings/supporting member.

The depth of excavation was targeted at approximately 1m below the level of the platform. The width of the trench was approximately 500mm to enable effective view of the side of the column. Refer to SK01, Appendix A.

Once clean of all platform backfill material, and other debris, the condition of the material of the base of the column and the top of its footing was assessed.

Following completion of Cardno’s observations, the observation trench was backfilled and carefully compacted. Concrete paving was placed returning the platform’s surface back to a temporary working condition. As the platform is a suspended slab, it will require structural replacement for full working capacity to be achieved.

The proposed locations for the investigations can be found on SK02, Appendix B.
2.4 Desktop Review

Review of other available information including survey data and historical documents was undertaken. These assist the understanding of the current conditions as well as possible reasons for the building’s current state.
3 Observations

A summary of the observations from the inspection are listed below. Observations are described in detail in Sections 4 & 5:

- While the columns were generally in good condition, some features of concern were one or more of vertical cracks, separation from the header beam, termite damage, additional installed reinforcement, absent capitals.

- Header beams displayed cracks, fungal growth, termite damage, and potential overstressing due to lack of support at locations where separation from the column and header beam occurred on the adjacent column.

- The column and truss capital displayed cracks, separation, termite damage and fungal growth. Collapse of the column capital situated on column N11 was identified.

- The roof truss members were in sound condition with some cracks. At areas where the column foundation showed settlement, deflection of the roof truss members and header beams, and loosening of truss joints occurred, following this movement. There was evidence of longitudinal rotation of a bottom chord member.

- The diagonal chords showed separation at the connection to the bottom chord members at areas where the bottom chord members had deflection associated with the settlement of column foundations. A diagonal chord had completely dislodged, coming to rest on truss bottom chord, on the truss frame that spanned between column N3 and S3.

- The header beam, which spanned from N16 to the perimeter wall, showed signs of collapse at the support. Water was present in this location from roof drainage leakage. The wall supports the bottom chord member vertically. In addition, rotation of the header beam, which spanned from S1 to the eastern wall, was observed.

- The roof truss diagonal members to bottom/top chord are joined through a combination of clamp and bolted connections. These appeared to be in sound condition. Loosened nuts were observed.

- The foundation system consisted of timber columns situated on bluestone. For columns S3 and S6, concrete was placed around the base of the timber column. These columns had previously been reinforced with additional timber posts.

- Inspection of the foundations revealed varying levels of deterioration of the column base. The base of columns N10 and N11 specifically revealed termite damage.

- The platform consisted of reinforced concrete slab, which was supported by bluestone foundation/piers. This was consistent with the Victorian Railways historical documents [3].
## 4 General Building Framing

The following section contains detailed observations of the overall building framing including condition of the columns, roof framing and walls.

### 4.1 Columns

<table>
<thead>
<tr>
<th>Observation</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column S1 had a vertical crack. Horizontal cracks observed on the column capital, which connects the column to the header beam.</td>
<td><img src="image" alt="Column S1" /></td>
</tr>
<tr>
<td>Column S2 had vertical cracks and was reinforced with a vertical timber member. The column was connected directly to the beam with no column capital.</td>
<td><img src="image" alt="Column S2" /></td>
</tr>
</tbody>
</table>
Column S3 had extensive water present from roof drainage leakage. Fungal growth observed in the region of the column capital. The column was reinforced with two vertical timber members. Settlement of the column was evident.

Column S4 was reinforced with a vertical timber member. The column showed separation from the header beam.
<table>
<thead>
<tr>
<th>Column S5 displayed a split in the column capital. The column was in sound condition.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column S6 was reinforced with a vertical timber member. The column to beam connection was reinforced with two vertical timber members. The column showed separation from the header beam.</td>
</tr>
<tr>
<td>Column S7 had vertical cracks. Cracks in the column capital were also identified.</td>
</tr>
<tr>
<td>Columns S8 and S10 were directly connected to the header beam with no column capitals. Column S9 was connected to the header beam with the presence of the column capital. The columns appeared to be in sound condition.</td>
</tr>
</tbody>
</table>
Column N1 is a timber column with an adjacent steel column. The steel column was in sound condition. Cracks in the column capital and the timber column observed.

Column N2 had vertical cracks. The column was connected directly to the header beam with no column capital.

Column N3 had extensive water presence from roof drainage leakage. Settlement of column was observed. Fungal growth observed on header beam spanning from column N3 to N2.
<table>
<thead>
<tr>
<th>Column N4 was in sound condition. The rotation of the header beam was evident relative to the column, which resulted in the separation of the connection between the column and the header beam.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column N5 appeared to be in sound condition. Cracks and separation of the column capital and the header beam was observed.</td>
</tr>
<tr>
<td>Columns N6 appeared to be in sound condition.</td>
</tr>
<tr>
<td>Column N7 was in sound condition. A split in the column capital was identified.</td>
</tr>
<tr>
<td>Column N8</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Column N9</td>
</tr>
<tr>
<td>Column N10</td>
</tr>
<tr>
<td>Column N11</td>
</tr>
<tr>
<td>Column N12 and N13</td>
</tr>
<tr>
<td>Column N14</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>Had vertical cracks and was connected directly to the header beam. Cracks were also observed in the header beam.</td>
</tr>
</tbody>
</table>
4.2 Internal Roof

Truss Bottom Chord: No significant damage observed for the bottom chord members. Rotation of member observed for the bottom chord spanning from column N14 in the central span.

Truss Diagonal member: Dislodged diagonal member on truss frame spanning from Column N3 to S3.
4.3 Header Beams

Header Beam: Termite damage was present on header beam located between column N12 and N13. Fungal growth was observed on header beams situated on columns N3 and S3. The header beam which spans from column S1 to eastern wall displayed collapse at the support. Rotation of header beam, which spans from N16 to the western wall, was identified.

The header beams are double span continuous members with half joints at the ends of each member. Header beams receive partial support at intermediate locations and full support at the ends where column capitals exist. Separation of the header beam to column was identified at columns S4 and S6, which coincide as intermediate support locations. Potential overstressing of the beams due to the lack of support at these locations.
### 4.4 Connections

<table>
<thead>
<tr>
<th>Connections</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Truss to Wall Connection: No significant damage was observed in the roof truss to wall connections. Tie down was not visible. Isolation of timber to bluestone seamers through the use of a lead platform. The extent of the roof truss to wall support is unknown.</td>
<td><img src="image1.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Header Beam to Wall Connection: Evidence of water from roof drainage leakage observed on the header beam spanning from column N16 to the western wall. The evident collapse at the support is likely to have been a result of the water in this region.</td>
<td><img src="image2.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Header Beam to Wall Connection: Water observed on the header beam that spanned from column S1 to the eastern wall. Rotation of the beam was evident</td>
<td><img src="image3.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Diagonal member to Truss Connection:</td>
<td><img src="image1.jpg" alt="Image" /></td>
</tr>
<tr>
<td>------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>The diagonal member on truss frame</td>
<td>The diagonal member on truss frame spanning from column N2 to the perimeter wall had separation at the connection to the bottom chord.</td>
</tr>
<tr>
<td>spanning from column N2 to the perimeter wall had separation at the connection to the bottom chord.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Truss Capital: The truss capital members appeared to be in sound condition</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Steel Connections: The steel connections, which connected the diagonal roof truss members to the top and bottom chords, displayed minor surface corrosion but overall in sound condition. The bolts were unfastened to a small degree.</th>
<th><img src="image2.jpg" alt="Image" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Connections: The steel connections, which connected the diagonal roof truss members to the top and bottom chords, displayed minor surface corrosion but overall in sound condition. The bolts were unfastened to a small degree.</td>
<td>Steel Connections: The steel connections, which connected the diagonal roof truss members to the top and bottom chords, displayed minor surface corrosion but overall in sound condition. The bolts were unfastened to a small degree.</td>
</tr>
</tbody>
</table>
4.5 **External Roof**

The settlement of columns N3 and S3 was evident in the varying ridge of the roof.
Cracks identified in the bluestone on the western wall. Protrusion of the bluestone in this area was also observed.

4.6 Mezzanine

A steel framed mezzanine was present which spanned from column N1 to the northern and eastern wall. The steel beams connected to the bluestone walls through cast in concrete. The condition of the mezzanine platform and the connections were sound.
4.7 **Office Work Room**

| Cracks observed in the columns, header beams and the column capital in the work room. |
|---|---|---|---|
| ![Image 1](image1.jpg) | ![Image 2](image2.jpg) | ![Image 3](image3.jpg) |
### 4.8 External Walls

<table>
<thead>
<tr>
<th>Northern Wall: The northern wall was in sound condition. The platform situated along the northern wall showed signs of deterioration from possible vehicle impact.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Wall: The eastern wall consisted of a combination of bluestone and brickwork.</td>
</tr>
<tr>
<td>Southern Wall: The southern wall was in sound condition. The platform situated along the southern wall showed signs of deterioration.</td>
</tr>
</tbody>
</table>
### Western Wall:
The western wall was in sound condition. Water leakage from the gutters is consistent with the water damage present on the internal header beam, which spanned from Column N16 to western wall.

<table>
<thead>
<tr>
<th>4.9</th>
<th><strong>Internal Walls</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The internal walls were cladded and existed to separate the work room to the remainder of the building</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4.10</th>
<th><strong>Gutters</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The gutters from inspection were riveted steel plate. A damaged gutter was identified at the header beam support which spanned from column N1 to the eastern wall.</td>
</tr>
</tbody>
</table>
### 4.11 Adjoining Buildings

<table>
<thead>
<tr>
<th>North Western Goods Building:</th>
<th><img src="image1" alt="Image 1" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>The adjoining goods building appeared to be a timber framed structure. Damage to the supports observed from an external inspection indicate possible vehicle impact.</td>
<td><img src="image2" alt="Image 2" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>North Eastern Building:</th>
<th><img src="image3" alt="Image 3" /></th>
</tr>
</thead>
<tbody>
<tr>
<td>The adjoining building appeared to be a steel framed structure. Damage was observed to the roof.</td>
<td><img src="image4" alt="Image 4" /></td>
</tr>
</tbody>
</table>
5 Column Base Investigation

5.1 Column S3

- **Structure:** The column appeared to have been previously supported on the bluestone. It is at present reinforced with two additional timber posts. The concrete encasement around the base of the column could be a recent addition to rectify the loss of strength due to the deterioration of the column. The column deterioration beneath the soffit of the 130 mm thick slab was 300mm. Remains of the deteriorated timber column were uncovered on the surface of the lead plate situated on the bluestone. Water was present from roof drainage leakage.

- **Moisture Condition:** damp/wet soil
- **Column Base Condition:** Excessive deterioration
- **Moisture Barrier:** Lead plate
- **Restraint:** No pin was observed to hold the column in place from lateral movement. The concrete slab appears to provide the only form of lateral restraint.
- **Platform Slab Backfill:** soil & terracotta
5.2 Column S4

- Structure: separation of column from the header beam observed. The column extended 300 mm beneath the soffit of the 130mm thick concrete slab and was situated on bluestone. The column was reinforced with an additional timber post.

- Moisture Condition: damp/dry soil
- Column Base Condition: some deterioration
- Moisture Barrier: None observed
- Restraint: Concrete slab provided some form of lateral restraint.
- Platform Slab Backfill: crushed rock (aggregate), soil & terracotta
5.3 Column S6

- Structure: Separation of column to header beam connection reinforced with timber posts. The column extended 350mm beneath the soffit of the 130mm thick concrete slab and supported by bluestone. The column was reinforced with an additional timber post. Concrete identified around the perimeter of the timber column separated in lumps during excavation.

- Moisture Condition: dry soil
- Column Base Condition: some deterioration
- Moisture Barrier: None observed
- Restraint: Concrete slab provided some form of lateral restraint.
- Platform Slab Backfill: soil & crushed rock (aggregate)
5.4 Column N3

- Structure: The column extended 300 mm beneath the soffit of the 130 mm thick concrete slab and supported by the bluestone. Water from roof drainage leakage was evident.
- Moisture Condition: damp crushed rock
- Column Base Condition: some deterioration
- Moisture Barrier: None observed
- Restraint: Concrete slab provides some form of lateral restraint.
- Platform Slab Backfill: soil and crushed rock (aggregate)
5.5 Column N10

- Structure: The column extended 300 mm beneath the soffit of the 130 mm thick concrete slab and supported by the bluestone. Moderate deterioration of the base observed. Termite damage observed in the timber remains.

- Moisture Condition: dry crushed rock
- Column Base Condition: moderate deterioration
- Moisture Barrier: None observed
- Restraint: Concrete slab provided some form of lateral restraint.

- Platform Slab Backfill: soil and crushed rock (aggregate)
5.6 Column N11

- **Structure:** The column extended 300 mm beneath the soffit of the 130 mm thick concrete slab and supported by the bluestone. Moderate deterioration of the base observed. Termite damage observed in the timber remains.

- **Moisture Condition:** dry soil
- **Column Base Condition:** moderate deterioration
- **Moisture Barrier:** None observed
- **Restraint:** Concrete slab provided some form of lateral restraint.
- **Platform Slab Backfill:** soil
6 Timber Analysis

Samples of the timber of the bottom chord, truss diagonal, and header beams were recovered in a number of locations. The samples were taken to a timber specialist for analysis and grading. The sample locations are detailed in SK03. Refer to Appendix D for the detailed timber analysis report.

6.1 Timber Species
The diagonal chord was identified as Baltic/Scots Pine and the truss bottom chord was identified as Shortleaf Pine. The diagonal chord members are a strength group of SD6 whilst the Southern Yellow Pine group would be a minimum strength group of SD7. The columns from inspection were identified as Victorian Hardwood, most likely locally sourced.

6.2 Timber Grade
The timber grade for all roof truss members, not damaged due to water, fungi or termites is Grade F11 which is seasoned timber of Structural Grade No 1. The timber grade for the columns, not damaged due to water, fungi or termites, is F17.

6.3 Moisture Content
The moisture content of the timber samples were within the 15% maximum allowed in AS2858. The moisture content ranged from 10.1 to 12.3%.
7 Discussion

7.1 Fungal Growth
Fungal growth was present on the column capitals and header beams situated on columns S3 and N3. This coincided with the leaking roof drainage locations present at columns N3, S3 and the wall adjacent to column N16.

7.2 Termite Damage
Termite damage was observed in columns N10 and N11 from the column base foundation investigation. Further, from the timber grading assessment, termite damage was identified in the header beam located between columns N12 and N13.

7.3 Bluestone Wall Condition
The external bluestone wall measured a minimum thickness of 650 mm. The condition of the walls was sound. Patched up brickwork was observed on the eastern wall. The erosion of mortar was identified. The walls have to be refilled with mortar.

7.4 Platform Condition
The platform consisted of a 130mm slab supported by bluestone foundations. The depth of the platform was 900mm. The edge of the platform consisted of bluestone with a timber edge beam. Slight deterioration observed where the bluestones were absent. Furthermore, cracks observed in the slab located near column N4.
7.5 Roof Condition

Internal inspection of the roof trusses displayed a varying elevation at their ends where supported on header beams. Refer to SK05 (Appendix E) for the elevation profile. The deflection in the truss supports coincided with the roof drainage leakage positions at columns N3 and S3. The deflection is associated with the settlement of these columns. The header beams appear to be double span continuous members with the column capitals as end supports.

The separation of columns from the header beams occurred at the central support. There are a number of possible scenarios that could have caused this to occur. The settlement of the column S3 caused the header beam to rotate following the deflection. This resulted in separation of the connection from the header beam at column S4. The separation at column S6 is also present with no observed settlement of the adjacent column S6.

The change in the roof load could be a significant contributing factor. The existing roof had cement sheeting. The original roof cladding of the goods shed has been identified [4] as being is slate. The Northern Station Building and the adjacent Train Hall were originally slate roofs [2]. The current corrugated asbestos cement cladded roof is lighter than the original slate roof, with a decrease in overall loads of the roof. The results is smaller forces acting on the supporting framing and leading to relaxation at intermediate supports such as column S4 and S6 and thus results in separation of the header beams from the columns.
8 Structural Advice

8.1 Foundation System
The foundation system consisted of timber columns situated on bluestone. We presume lead sheeting provided a moisture barrier from the ground between the bluestone and the timber columns. The bluestone appeared to be in sound condition. For columns S3 and S6, concrete was placed around the base of the timber column. The concrete surrounding column S6 disintegrated during excavation. The concrete placed around column S3 did not provide any structural benefit due to the decomposed column. The condition of the foundations for all the columns needs to be assessed.

8.2 Platform System
Cracks in the slab were observed near column N4 that will require rectification. The remaining areas of the platform appeared to be in sound condition.

8.3 Columns
Columns with termite damage or water damage are required to be replaced. The foundation investigation revealed deterioration at the base of all the columns inspected. Although the level of deterioration varied, the base will have to be replaced. An effective moisture barrier system is required to be installed in all the columns if not present. During the replacement of the column bases, lateral restraint to be provided at the base through the possible use of a shear pin.

8.4 Bluestone Walls
Mortar restoration, and repointing, of the external bluestone walls will be required.

8.5 Roof Trusses

Header Beams
Minor rectifications to the header beams. The header beam which spans from column N16 to the western wall and from column S1 to the eastern wall required to be repaired or replaced.

Diagonal Members
The diagonal member dislodged on the truss frame, which spanned from column S3 to N3 will have to be reinstalled.

Truss Chord Members
Rotation of the bottom chord member of the truss spanning from N13 to the column situated along the office workroom is required to be repaired.

8.6 Steelwork
Minor rectifications to the steelwork and retightening of the bolts are required.

8.7 Additional Work
The leaking roof drainage is a significant contributing factor to the deterioration of the structure. A roof plumber is to inspect and repair the guttering system taking due regard to any heritage requirements.
9 Remedial Works

A summary of the remedial works required to be undertaken are listed below. Commentary is limited to the main platforms and roof framing. The remedial works proposed are targeted to bring the building back to a sound functioning state without accelerated deterioration due to rain water egress. The adjoining building to the southwest corner of the goods shed is not part of the scope of this structural investigation and has been specifically excluded from discussions. Refer to the inspection boundary in SK02 (Appendix B).

- The leaking roof drainage system is to be addressed immediately to minimise the rate of deterioration of the building framing.
- Comprehensive inspection, assessment and treatment of termites for the entire building.
- Inspection and assessment of all column base foundations to be undertaken. Requires installation of an effective moisture barrier system and lateral restraint at each column base.
- Rectification of platform slab, specifically in areas where cracks were observed. Long term works will require complete replacement of the platform slab.
- An estimated total timber replacement of 50% for columns. The base of all the columns will have to be replaced. For the area of columns above ground level, an estimated replacement of 30% of all the columns. This value is subject to change based on a detailed termite assessment.
- An estimated 80% of timber replacement for column capitals.
- Minor rectifications to 30% of header beams. Timber replacement for 10% of header beams.
- An estimated 50% of roof trusses will require minor repairs and straightening to correct alignment.
- Minor restoration to 70% of steel work.
- Mortar restoration required for all the external bluestone walls. Allow 100% of walls to undergo repointing to a depth of 50mm.

Note: Many of the items listed must carried out at the same time and may be incorporated with future repurposing works.
10 Conclusions

The Goods Shed is in good sound structural condition. Considering its age, function modification, and previous repairs, it is in good serviceable overall condition.

There has been neglect in isolated areas of the building that led to localised deterioration of the building cladding that now has impacted on also on the Goods Shed’s structure. It seems similar issues may have occurred in the past, with some repairs evident, however a more rigorous investigation need to be carried out, a permanent solution found and a repair must carried out.

As a minimum, keeping the weather out of the building’s interior is the priority, and we suggest remedial work be carried out, ahead of any repurposing of the building.

The Goods Shed can then remain a useful and important building for many years.
11 References

2. Ballarat Station Precinct Master Plan “Investigation and Analysis Report” December 2013
APPENDIX A

COLUMN BASE INVESTIGATION ~ SK01
APPENDIX

B

INVESTIGATION LOCATIONS ~ SK02
APPENDIX C

DESCRIPTORS ~ SK03
Ballarat Goods Shed – Descriptors – SK03
All measurements shown have been obtained using indirect measurement by laser scanning from external ground and internal floor levels. 3D Revit Model 3091500BA.rvt and elements shown within consist of linear Revit elements applied to a best fit of laser scan data of features that are visible and safely accessible from external ground level and internal floor levels. All data contained within 3D Revit model 3091500BA.rvt should be verified/confirmed by all contractors & consultants prior to any future construction & site works.

Revit Project 3091500BA.rvt has been set up on a Shared MGA Coordinate System based on information provided by Cardno.

Any materials shown are indicative only. Floor, ceiling and roof thicknesses are indicative only. Levels shown are to Australian Height Datum vide PM 604 with a stated value of 430.057. Roof details are for reference only and may not depict current site conditions.
Attn John Rouvalis
Cardno
Level 4, 501 Swanston St
Melbourne Victoria 3000

22 September 2015

John

Re: Structural Investigation of Ballarat Railway Station Goods Shed

I attended the above location on September 9 for the purpose of taking samples for species and moisture content identification, and assessing the structural grade of the truss timbers by visual stress grading.

Timber samples were collected from identified bottom chords, truss diagonals and header beams in such a way as to not exceed current grade limitations for want. These timber samples were taken back to the Timber Training Centre at Creswick for moisture content analysis, and two samples forwarded for expert examination of the wood structure to enable scientific species identification.

**Species**

One truss diagonal, sample D5 was identified as *Pinus sylvestris* (Baltic Pine, Scots Pine) and one truss bottom chord was identified as *Pinus echinata* (Shortleaf Pine) from the Southern Yellow Pine group.

**Strength Group Determination**

Australian Standard AS 2858 gives the strength group of Scots Pine as SD6, but does not specify a strength group of the Southern Yellow Pine group. The group is similar to Western Yellow Pine, which has a strength grouping of SD7. It would be reasonable therefore to apply a strength group determination to the timbers used in the trusses as being at least SD7 based on this comparison.

**Timber Grade**

The timbers inspected met the requirements of structural grade 1 with the exception of timbers located around columns S2, which showed extensive water damage and are likely severely degraded by fungal attack, and the timbers around columns N16-14 which have been attacked by termites and collapsed as a result.
Applying the strength grouping and the timber grade according to table B1 of AS2858 gives an assumed stress grade of F11 for the timber which remains undamaged by fungal and termite attack.

**Moisture Content**

Eight samples of the timber were tested for moisture content and all were below the 15% maximum allowed in AS 2858.

The table below shows the actual results:

<table>
<thead>
<tr>
<th>Sample Id</th>
<th>Start Weight</th>
<th>Oven Dry Weight</th>
<th>MC%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>15.55</td>
<td>13.90</td>
<td>11.9</td>
</tr>
<tr>
<td>D7</td>
<td>13.48</td>
<td>12.17</td>
<td>10.8</td>
</tr>
<tr>
<td>H7-8</td>
<td>6.56</td>
<td>5.88</td>
<td>11.6</td>
</tr>
<tr>
<td>D10</td>
<td>15.40</td>
<td>13.71</td>
<td>12.3</td>
</tr>
<tr>
<td>B12-13</td>
<td>27.14</td>
<td>24.24</td>
<td>12.0</td>
</tr>
<tr>
<td>7</td>
<td>16.09</td>
<td>14.61</td>
<td>10.1</td>
</tr>
</tbody>
</table>

**Conclusion**

With the exception of the timbers affected by fungal attack (evidenced by fungal fruiting bodies on the surface) and those with termite attack the timbers in the trusses would be graded at structural grade number one, giving an F rating of the weakest of these species of F11.

Rob Rule
Manager/ Company Secretary
Timber Training Creswick Ltd
WOOD IDENTIFICATION RESULTS

Mr Rob Rule
Manager / Company Secretary
Timber Training Creswick Ltd.
Moore Street, Creswick, VIC 3363

Dear Rob,

Re: Assessment of two wood specimens as supplied: Your request – 9th September, 2015

Following microscopic examination, in my opinion the structure of the wood specimens is consistent with¹:

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Scientific name</th>
<th>Commercial or Trade name + Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td><em>Pinus sylvestris</em></td>
<td>BALTIC PINE</td>
</tr>
<tr>
<td>10</td>
<td><em>Pinus ?<em>²</em>echinata</em></td>
<td>SHORTLEAF PINE [SOUTHERN YELLOW PINE GROUP]</td>
</tr>
</tbody>
</table>

I hope the information will help with your research and evaluation process.

Best regards,

*Jugo Ilic*

Jugo Ilic  MSc, Dr(Forest)Sc, FIAWSc

¹ Disclaimer: The content of this letter is provided in good faith and whilst Dr Jugo Ilic has endeavoured to ensure that the information contained in it is correct and accurate at the time of preparation, he does not accept any liability arising from its use whether provided directly by the above named client or indirectly from the client providing it to a third party in this or any other format.

² "?" indicates that there are other similar species which cannot be differentiated on the basis of wood structure.