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Rethinking Industrial Shed Construction - Consider Timber

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1

Introduction

Timber's sustainability credentials are attracting world-wide interest and advancements in timber engineering have made timber an increasingly cost-competitive proposition.

Encouraging the construction industry to adopt innovative approaches needs information and evidence. Attention to technical design, construction costs and site processes is critical to show the value proposition of timber construction to customers and optimise its use.

This Guide aims to help those involved in the decision chain (such as cost managers, estimators, design professionals, building developers and project managers) gain a better understanding of the value that timber construction systems offer industrial shed projects.

The Guide is based on a research project that developed a model shed building with a timber solution, and compared it with conventional steel portal construction. The timber solution was designed to optimise functional performance, constructability and cost effectiveness and provides guidance for compliance under the National Construction Code (NCC). This Guide provides an explanatory understanding of decision making issues when developing timber solutions.

2

What Drives Decisions When Choosing Industrial Shed Construction Systems?

A key objective of the project was to provide an understanding of the decision drivers along the customer/supply chain for the selection of industrial construction systems. Key areas of exploration included:

- Benchmarking against existing industrial shed construction systems, especially steel portal frame constructions. A steel solution for the model building is provided in Section 5.3 for comparative purposes.
- Understanding the nature of the overall delivery supply chain and related work flows – especially construction scheduling, productivity and prefabrication issues.
- Optimising the regulatory framework where it affects the viability of timber solutions.

3

Project Development

The research project was developed by a series of expert/stakeholder meetings, interviews, concept development sessions, design charrettes, cost planning studies, construction programming studies and detailed design studies aimed at developing the model shed building and a cost-effective timber solution for it.

A team of experts worked together to provide input to the development process.
Core collaborators included:

- **The Timber Development Association (TDA)**: A market development association for the timber industry and the project leader for this work, on behalf of the timber industry.
- **The University of Technology Sydney (UTS)**: A technology-driven university with an integrated understanding of the building industry and specific expertise in timber construction. The university co-developed the research method and mediated the strategic direction of the timber solutions in terms of detailed design, cost and site productivity issues.
- **Arup Ltd:** A global multi-disciplinary engineering firm with expertise spanning structural, acoustic, fire and services engineering. Arup Ltd provided design and engineering input into the timber solution and the corresponding steel solution.
- **Taylor Thompson Whitting Consulting Engineers:** An engineering firm with specialised services in structural, civil and facade engineering who provided the structural design for the re-engineered steel solution.
- **BCIS**: A global subsidiary of the Royal Institute of Chartered Surveyors who specialise in gathering building cost data used for reporting on cost trends for a variety building forms. BCIS provided quantity surveying, cost estimating and cost planning input for both the timber solution and the corresponding concrete solution.
- **Engineered timber manufacturers, suppliers and industry associations** (including Tilling Timber, Hyne Timber, Meyer Timber, Nelson Pine Industries, Carter Holt Harvey Wood Products, MiTek): Their input helped ensure the practical viability, design properties and availability of appropriate timber componentry.

Using the above team, two timber portal concept designs were developed (revolving around different portal, girt and purlin assemblies). Both were debated, tested against construction logistics and rationalised for cost, construction flow, structural performance and services integration. These design concepts were then tested more broadly on a cross section of building owners, developers, designers and contractors for critical feedback.

The designs considered included:

- Version 1: Timber Portals based on 6.7 m bay spacing (as detailed in Timber Solution 1)
- Version 2: Timber Portals based on 10.0 m bay spacing (as detailed in Timber Solution 2)

These were compared against a typical steel portal design utilising an 8.0 m spacing bay spacing (as detailed in Steel Solution).

Different bay spaces were used to test the robustness of the timber solution, relative to the steel option. In each case, the spacing was selected by the design engineer based on common scenarios faced in practice.

4

The Model Industrial Shed – the Basis for Comparison and Solution Development

The model shed is shown Figure 1. The model demonstrates a prototypical situation for modelling spatial, loading and fire resistance conditions, providing a neutral base for creating both the timber and competing steel solutions. The basic spatial characteristics of the model are provided in Table 1.

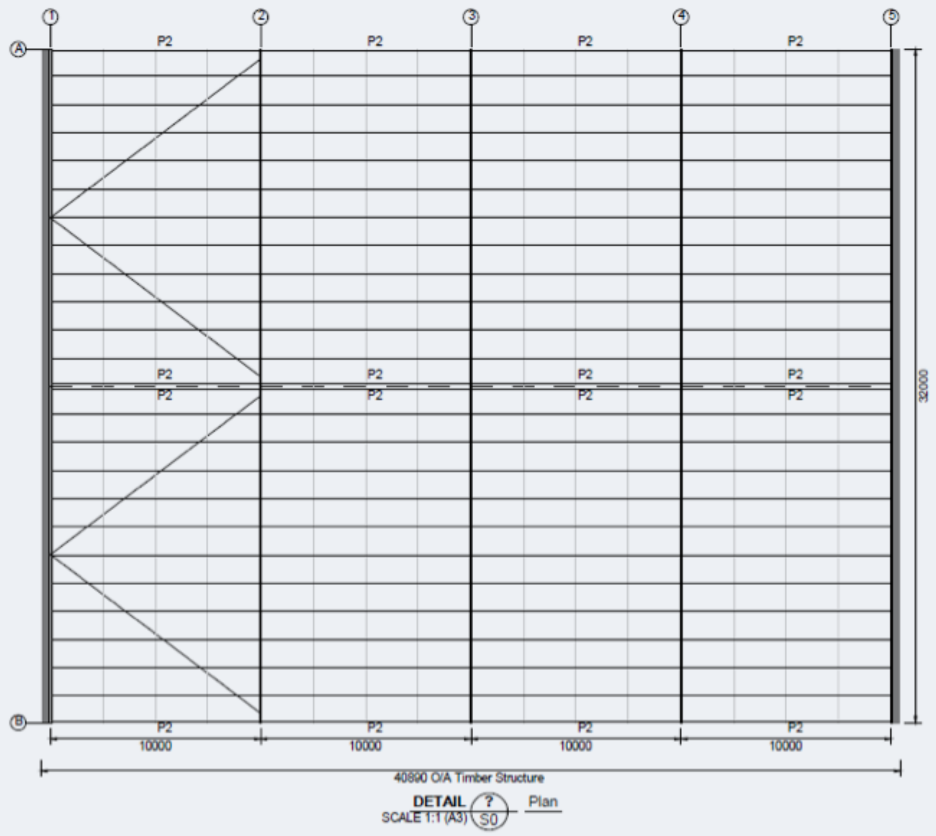


Figure 1: Plan of the industrial building (10 m timber bay shown).

Item	What was used in the model	Relevance and Reasons
Height	• Single storey construction • 8.0 m overall height • 5.0 m to underside of eaves	• This represents a typical height for buildings of this style
Area	• 32.0 m span x 40.0 m length • 1,200 m² footprint/GFA	• The area and length to width ratio are a common size for industrial sheds
Setbacks	• External wall distances are at least 3.0 m from property boundaries	• The location of the building relative to other buildings/properties affects façade fire resistance requirements
NCC Building classification	• Class 7b building i.e. a wholesale distribution shed	• The classification influences performance and compliance requirements

Table 1: Key spatial characteristics of the model shed building.

In considering information about the model shed, it is important to realise that the only differences between the timber solution(s) and competing steel solution concern the footing, portal, purlins and girts construction. Other aspects are the same. Even so, discussion that clarifies NCC performance requirements and design settings (as relevant to the competing solutions) can be found under the dedicated sub-headings below.

4.1 Key Structural Parameters

Parameters applied to the model:

- Wind speed: Region A and Terrain Category 2 exposure.
  - wind direction, Shielding multiplier and Topographic multiplier all set as 1.
- Foundation: Moderately reactive clay soil conditions applied to footing design.

Reasons:

- The selected wind speed deals with typical conditions the model building would likely face in real world conditions.
- The selected foundation is common in large parts of the greater Sydney basin and other parts of Australia where these buildings would often be found. If poorer foundations were encountered, then this would likely favour the timber solution(s), i.e. using larger bay spacings and lighter construction.

4.2 Fire Resistance (based on NCC requirements)

Parameters applied to the model:

- The Type of construction used was Type C, therefore:
  - external walls: no fire resistance requirements as they are more than 3.0 m from the boundary
  - external columns: not applicable
  - common or fire wall: not applicable
  - internal wall: not applicable (no internal walls are present in the design)
  - roof: no fire resistance requirement under the stated Building classification.

Reasons:

- The chosen parameters require no fire rating, which therefore removes the complexity that fire resistant construction can have on each material.
- Timber fire resistance is easier to achieve than steel construction fire resistance, due to timber's charring[1] capacity. Consideration of a fire rating would have skewed the result towards a timber outcome.

4.3 Sound Resistance (based on NCC requirements)

Parameters applied to the model:

- Not applicable. No sound resistance is required for 7B building classifications.

[1] Further information on Timber char capacity can be found in WoodSolution Guide No 3 - Timber-framed Construction for Commercial Buildings Class 5, 6, 9a & 9b - Design & construction guide for BCA compliant fire-rated construction

5

The Timber Solution

The following section presents core design information for the two timber solutions and the competing steel solution (see Figure 2 for a section through timber solution).

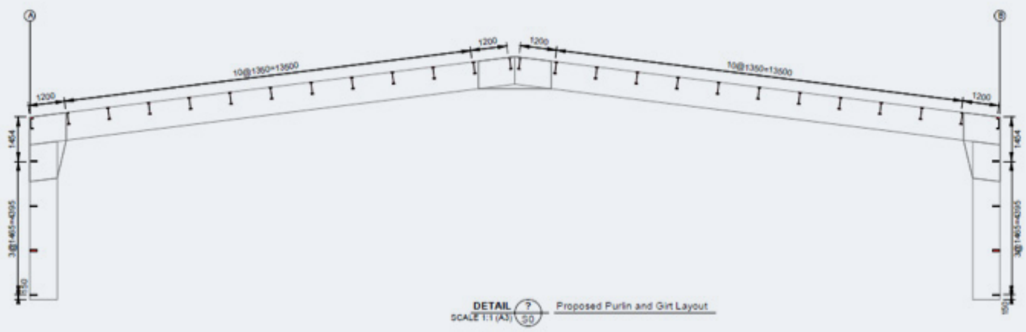


Figure 2: Section of Timber Portal Frame (10.0 m portal spacing shown).

5.1 Timber Solution 1 (6.7 m portal spacing) details

Refer to Appendix A for the structural drawing of Timber solution 1. All timber elements are termite treated to H2S.

- Columns:
  - Main – 1100 x 110 LVL13
  - End Bay – 800 x 110 LVL 13
- Rafter:
  - Main – 1100 x 110 mm LVL13
  - End bay – 800 x 110 LVL13
- Eave Rafter: 400 x 110 LVL13
- Purlins: 300 x 45 and 240 x 45 I-beam
- Girts: 300 x 45 and 240 x 45 I-beam
- Girt support columns: 400 x 63 LVL13
- Bracing: 24 mm diameter galvanised rod
- Flybrace: 90 x 45 LVL 11

5.2 Timber Solution 2 (10.0 m portal spacing) details

Refer to Appendix B for the structural drawing of Timber solution 2. All timber elements are termite treated to H2S.

- Columns:
  - Main – 1050 x 105 LVL16
  - End Bay – 800 x 110 LVL13
- Rafter:
  - Main – 1050 x 105 LVL16
  - End bay – 800 x 110 LVL13
- Eave Rafter: 400 x 63 LVL13
- Purlins: 400 x 90 I-beam
- Girts:
  - Side Wall – 200 x 45 LVL13 @ 1465 cs
  - End Wall – 240 x 45 LVL13@ 1550 cs
- Girt support columns:
  - Side Wall – 300 x 63 LVL13
  - End Wall – 400 x 63 LVL13
- Bracing: 24 mm diameter galvanised rod
- Flybrace: 90 x 45 LVL 11

5.3 Steel Solution (8.0 m portal spacing) details

Refer to Appendix C for the structural drawing of the steel solution. All steel zinc is silicate treated.

- Columns:
  - Main – 530UB82
  - End Bay – 460 UB67
- Rafter:
  - Main – 530UB82
  - End Bay – 460UB67
- Purlin: 200Z24
- Girts: 200Z24 & one row of bridging
- Girt support columns: 250UB31
- Flybrace @ 3 per Rafter
- Bracing: 24 mm diameter galvanised rod

6

Cost Plan Results - Comparing the Timber and Concrete Solutions

Using the model industrial building described in Section 4, and the two timber solutions and the corresponding steel solution described in Section 5, a cost estimate and cost planning comparison was undertaken to help determine the potential benefits of the timber solution.

The cost comparison was only undertaken for the parts of the building that were considered to have different costs under the competing scenarios (therefore excluding items such as concrete slab, roof and wall sheeting, mechanical electrical and plumbing). In order to create stable costing conditions, it was assumed that the building would be constructed in suburban Sydney.

The Cost Plan was developed by the Building Cost Information Service (BCIS), (refer to Appendix D for full Cost Plan results). Quantities were independently measured off supplied drawings and quotes obtained from the market where needed. The steel price was developed from information within the BCIS data base. As the timber solution is a relatively new construction system, a price from the marketplace was obtained. A quote was attained from Meyer Timber.

A basic comparison of each model cost plan is shown in Table 1. Detailed results can be found in Appendix D.

Element	Timber Portal Solution 1 6.67 m Bay Spacing	Steel Timber Portal Solution 2 10 m Bay Spacing	Steel Portal Solution 8.0 m Bay Spacing
Purlin	$39,483	$74,595	$46,190
Girts and Girt support columns	$20,761	$28,247	$60,496
Portal Frame	$147,310	$91,500	$98,635
Footings	$19,480	$22,000	$33,540
Total	**$227,034**	**$809,620.00**	**$238,861**

Table 1: Comparison of material cost used in all three solutions.

Table 1 compares key cost items that differentiate the competing timber and steel solutions. The timber solution with the 10.0 m portal spacing is by far the cheapest of the three options (9.4% cheaper than steel), followed by the timber solution with the 6.67 m portal spacing (5.0% cheaper than steel).

Portal bay spacing is a cost-sensitive issue. For instance, when considering the two timber solutions, the 10.0 m spacing results in a lower proportional portal frame cost (42.2% of total cost) compared to the 6.67 m solution (64.9% of total cost). Clearly, this is because fewer portals are required in the 10.0 m spacing.

The 10.0 m portal spacing also means larger purlins are required to span the longer distance, which results in a higher proportional cost for this item (34.5% of total cost) compared to the 6.67 m solution (17.4% of total cost).

Even though girt and purlin costs are higher for the larger portal spacing, it is still the portal frame costs that dominate the overall cost profile for shed construction, and so where all other variable are equal, the larger bay spacing offers the lowest cost option.

Table 1 shows a breakdown of the key cost areas, which are discussed further under dedicated subheadings below.

It was found that girt costs for the two timber solutions contributed only a minor proportion to overall costs and also remained relatively stable, irrespective of portal bay spacings. For instance, with the 10.0 m bay spacing, girts only contributed 13.1% of the total cost; and 9.1% for the 6.67 m bay spacing. The inclusion of intermediate support columns means that the load on girts is less sensitive to changes in bay spacings. Further, girts can be cost effectively increased in span by simply increasing the depth of the plywood web of the 'I' beams used (i.e. by an extra 100 mm). As such, timber girts offer a cost-effective and relatively cost-stable proposition, even as portal bay spacings

7

Factors Affecting the Cost Competitiveness of Timber

7.1 Erection Onsite

For productivity and process improvement, an increasingly popular technique for the erection of timber portal buildings is to fabricate certain assemblies off the slab and then crane them into position. For instance, the rafter and purlin assemblies are typically fabricated off the deck for every second portal bay. These bay assemblies are then craned into place (see Figure 3), by sitting the rafters into the pre-made pockets of the pre-positioned columns. Once these assemblies are in place, the purlins for the neighbouring bays are placed in a more conventional manner.

Overall, this approach improves cost and – to some extent – safety, as the amount of work undertaken at height is substantially reduced.

Figure 3: Timber portal roof structure constructed on the ground. *Image: Timberbuilt*

7.2 Timber Connectors

Most timber connectors are designed to mimic steel connection systems, so that the approach to fabrication is similar for the two competing systems. Details on specific joints are provided below.

7.2.1 Portal Frame Knee Connector

The connection between the main rafter column and the rafter is designed to transfer bending loads at this point and provides a complex connection for both timber and steel. In the two timber options, different approaches were taken to the key joints in the portal frames that aim to simplify fabrication onsite, using prepared components, including:

- **Timber Solution 1 (6.7 m portal spacing)** – QuickConnect[2] a system developed by the Structural Timber Innovation company and Auckland University. The Quick-Connect moment connection is a moment resisting joint for timber portal frame buildings. It is based on a system of pre-tensioned rods which are placed at the upper and lower extremities of the portal frame members. Bending moment is transferred across the joint by means of a moment couple carried by steel rods. The rods are housed in U-shaped timber sleeves attached to the sides of the portal frame members.
- **Timber Solution 2 (10.0 m portal spacing)** – LVL Gusset is more traditional moment connector used for timber portal frames. The gussets are nailed onto the rafter and column in lines at the edge of gusset.

[2] Further information can be found Quick Connect moment joints from the Design Guide Australia Timber Portal Frame EXPAN Quick-Connect Extract - www.expan.co.nz/

7.2.2 Purlin and Girt Connection

In both timber solutions 1 and 2, the I-beam purlins are connected to the main rafter through a block fixed to the side of the portal rafters (fixed prior to purlin placement). The block is screw fixed to the web I-beam purlins such that it fits between the two flanges of the I-beam and sits directly under the top flange of the I-beam. This provides a convenient means of locating the purlin, which is also able to rest on the block. The I-beam purlin is then screwed or nailed fixed through the web, into the block (see Figure 4).

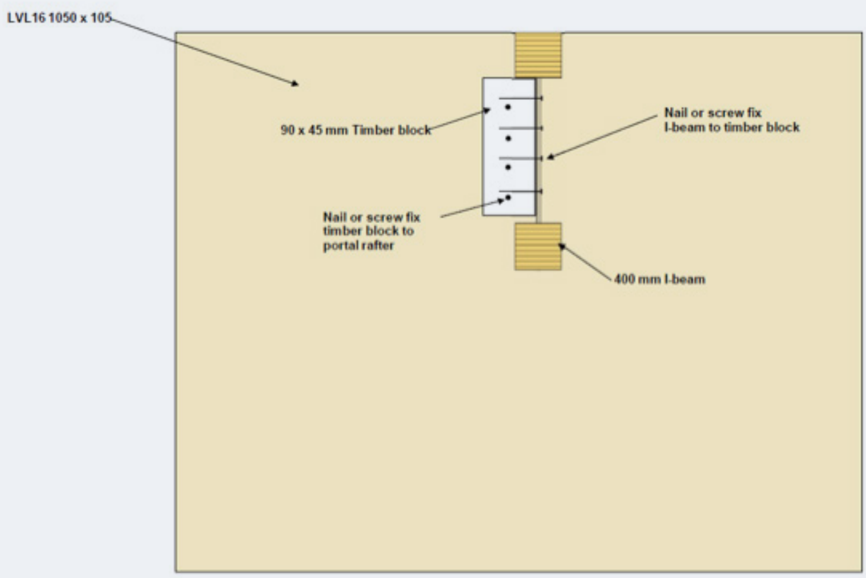


Figure 4: I-beam purling connection via timber block to rafter.

7.3 Timber Portal Frame Member Sizes

One aspect that differentiates the two timber solutions from the steel solution is the need for deeper rafter elements. To reduce the impact of the deeper rafters, purlins and girts are mounted on the side of the column or rafter, resulting in only 220 mm impact overall. For instance:

- Steel solution: 610 UB with 200Z24 over purlins (830 mm overall depth)
- Timber Solution 2: 1050 mm rafter (1050 mm overall depth)

Further, the timber purlins and girts are designed as simply supported beams. This is driven primarily because the I-beams used for this purpose are not long enough to span continuously over multiple portal bay spacings, i.e. I-beam maximum length is 12 m while a double span purlin would require 20.0 m length I-beams. Even so, the side mounting of the purlins and girts (mentioned above) does serve to assist in providing lateral stability to the portal rafters.

[2] Further information can be found Quick Connect moment joints from the Design Guide Australia Timber Portal Frame EXPAN Quick-Connect Extract - www.expan.co.nz/

8

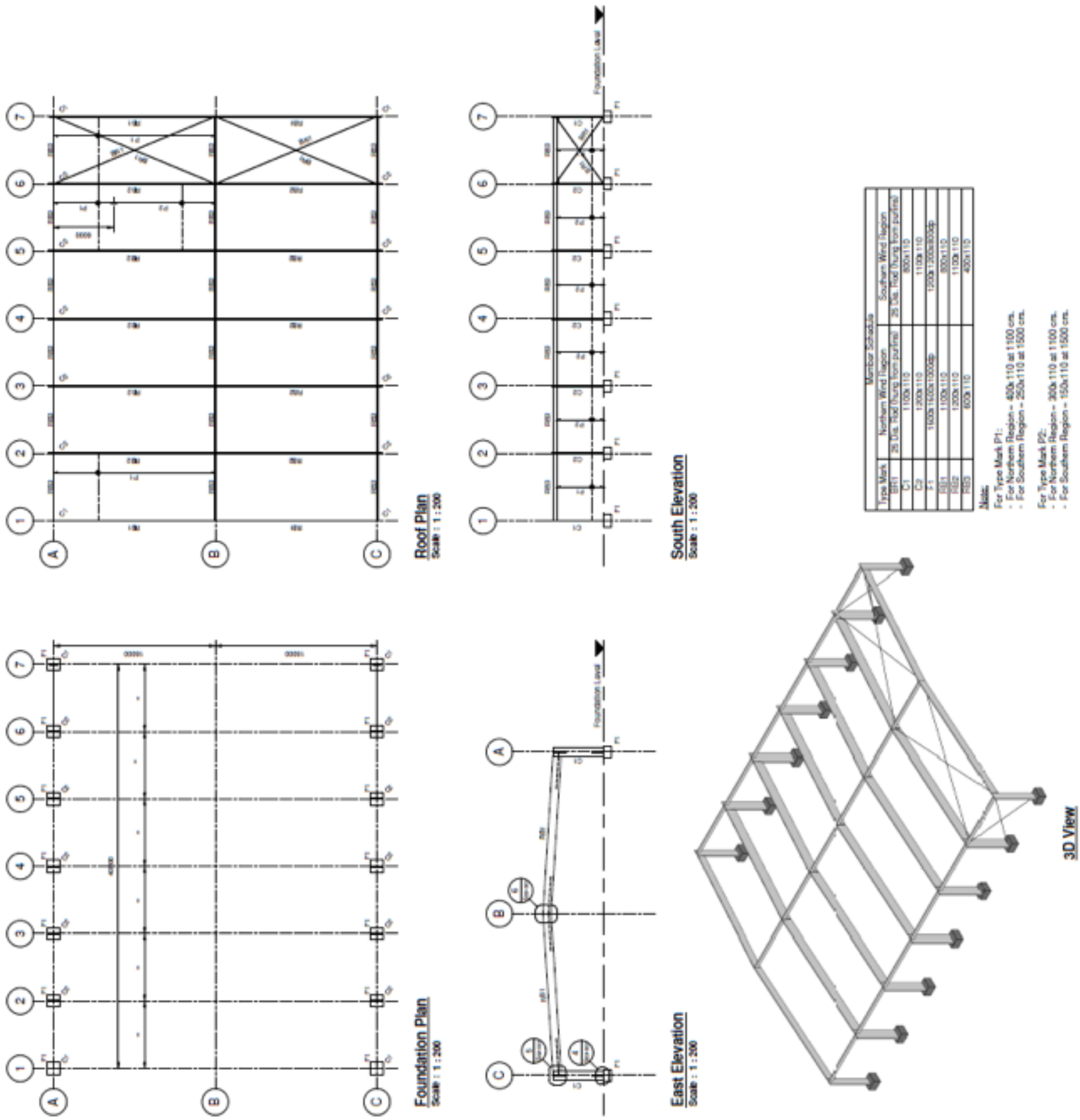
Conclusion

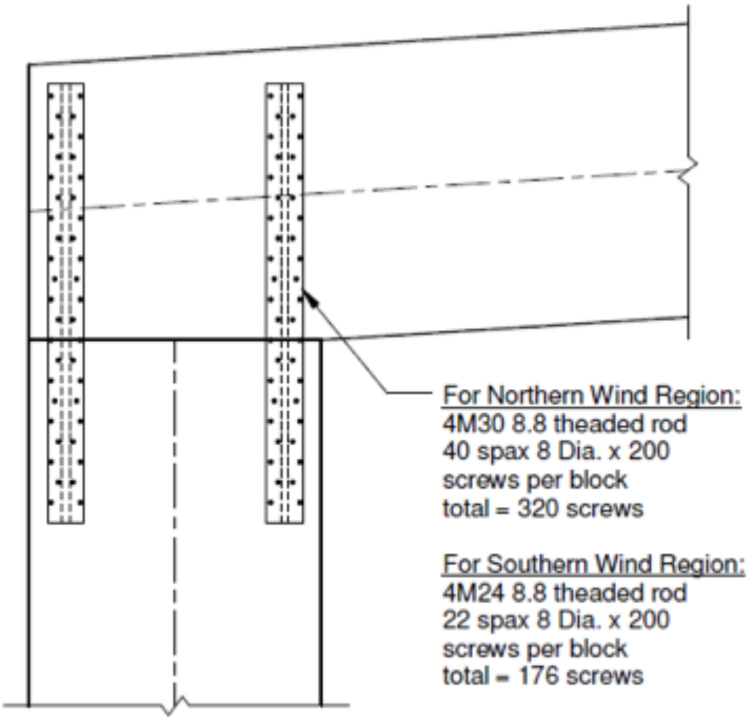
A model single-storey industrial shed was designed and costed using a timber solution, with two portal bay spacings considered, and a more conventional steel-framed solution for a theoretical location in suburban Sydney. The site was assumed to have no significant cost implications concerning site access, ground conditions or neighbouring properties.

Timber Solution 2 (10.0 m portal bay) was found to cost $22,519 or 9.4% less than the steel solution. The girts and purlins were found to be cheaper in timber while the steel solution portal frame was overall cheaper. As girts and purlins contribute about half of the overall costs, this made the result better for both timber solutions.

It is recommended that timber industrial sheds be considered as a viable alternative to traditional steel frames. Importantly, the level of cost comparison with concrete must go beyond a basic comparison of material costs, and must instead weigh up the full range of cost-sensitive issues affecting the construction process.

Appendix A: Timber Solution 1 – 6.7 m bay spacing





Detail 5

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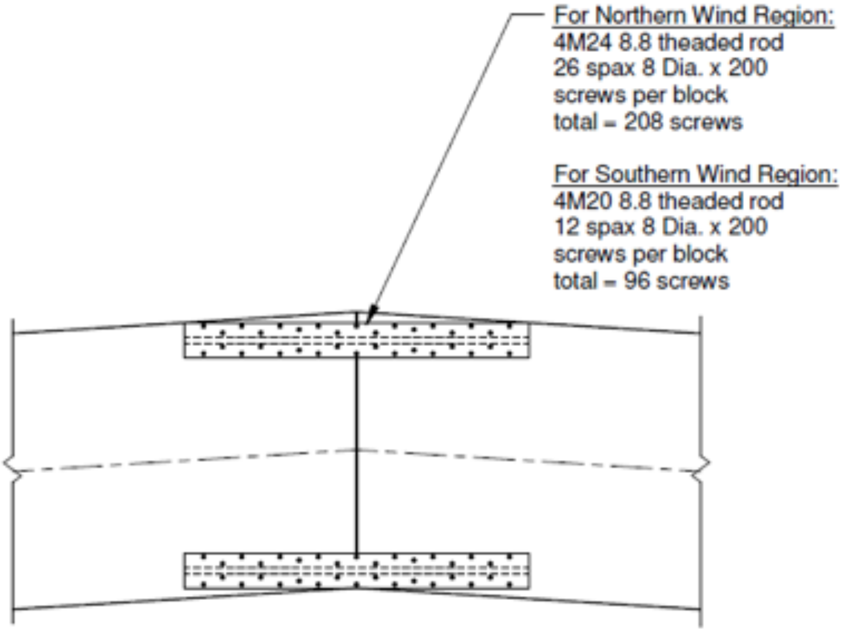
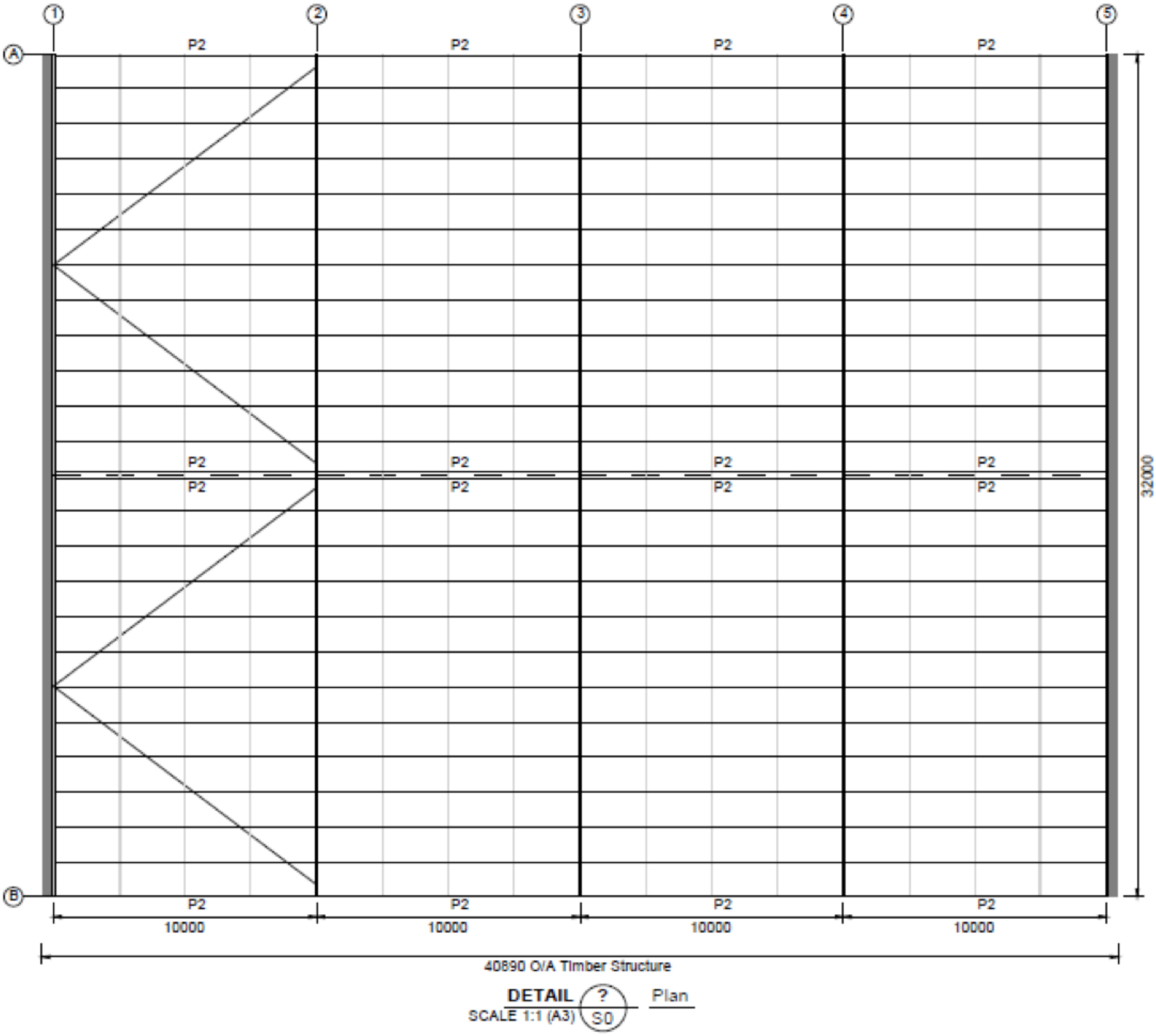
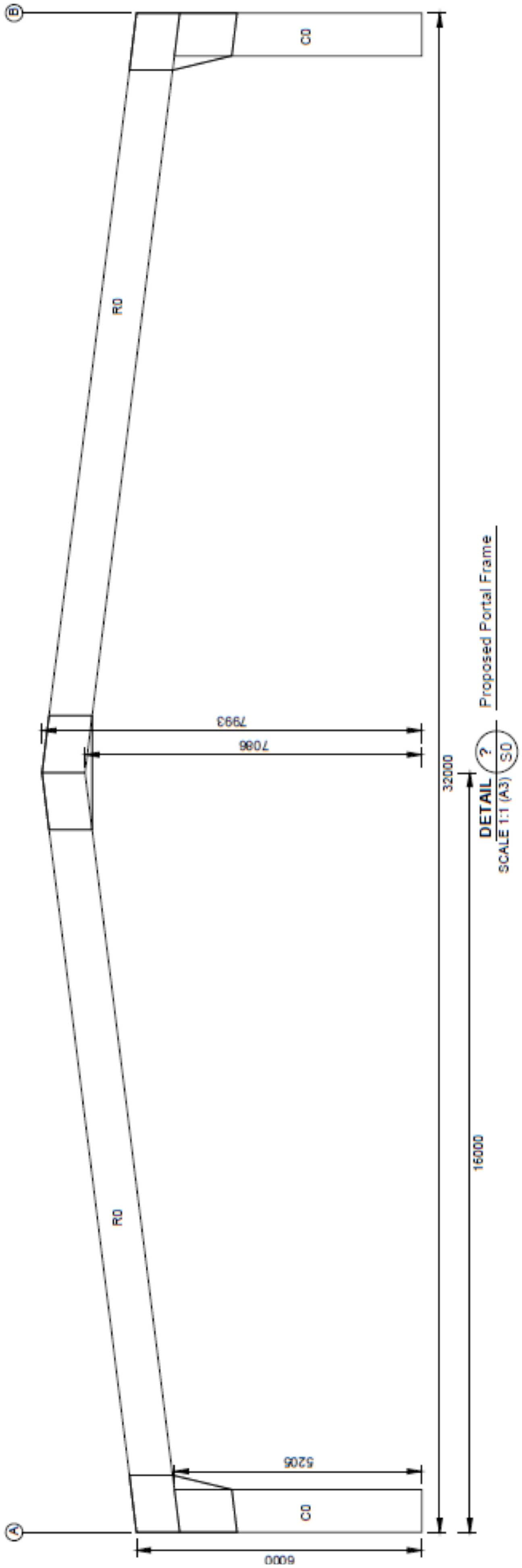


Detail 6

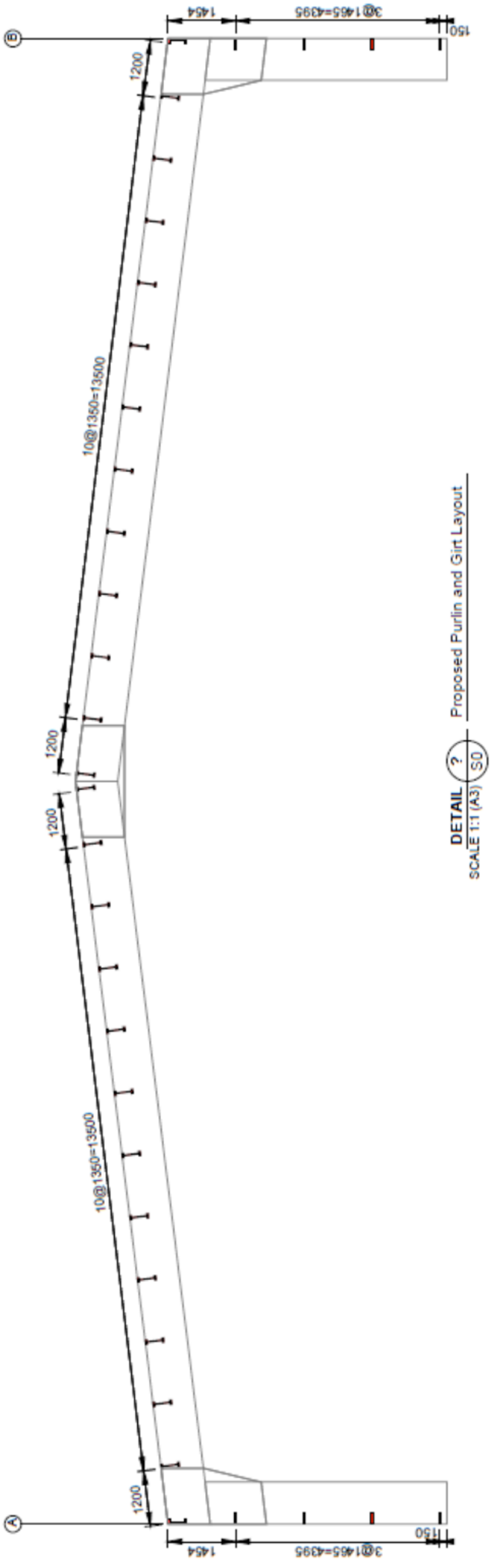
Scale : 1 : 20

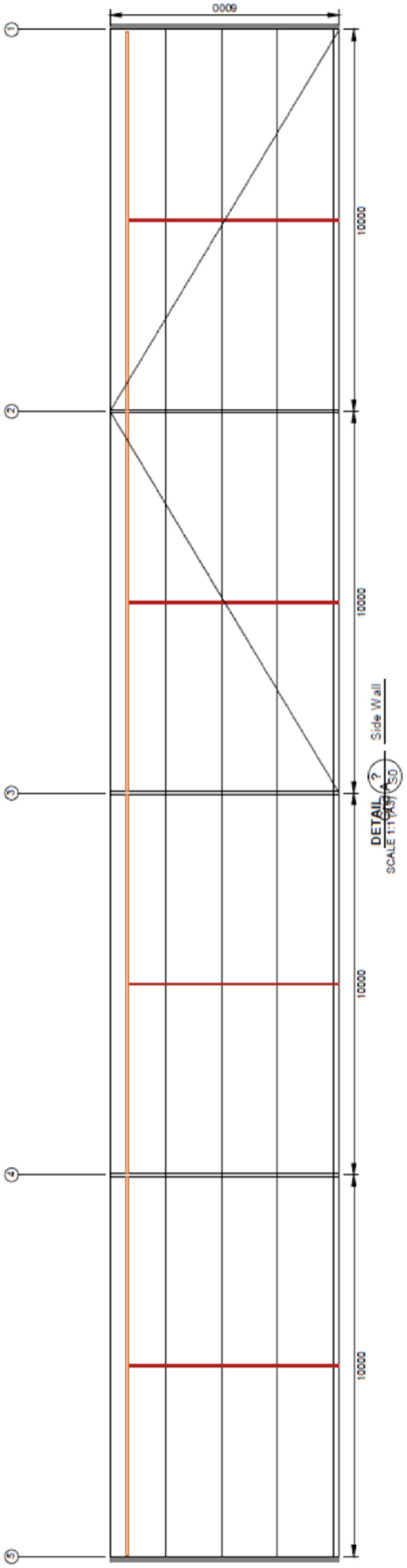
Appendix B: Timber Solution 2 – 10 m bay spacing

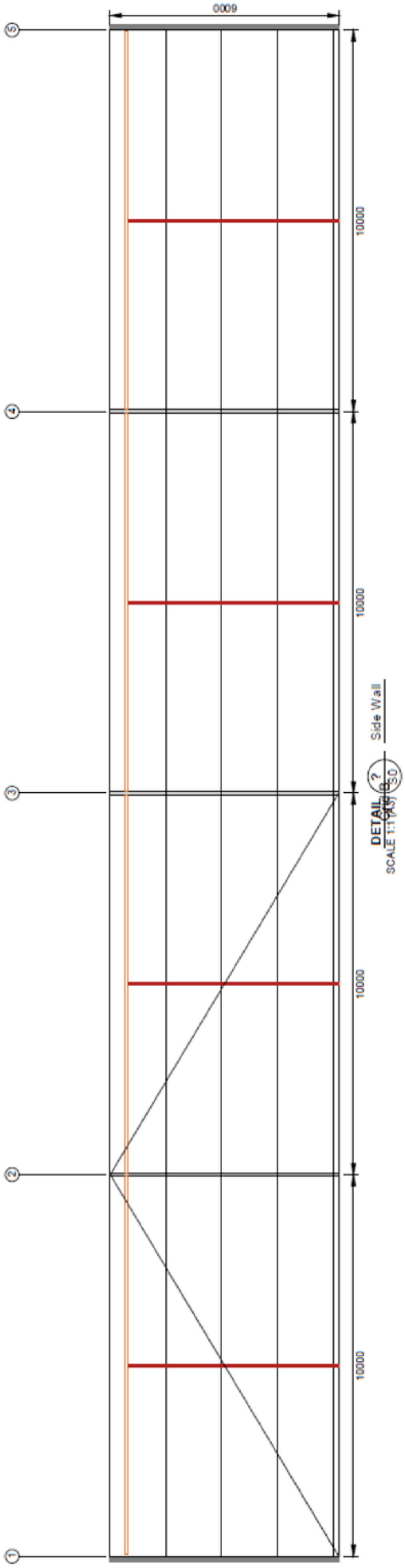


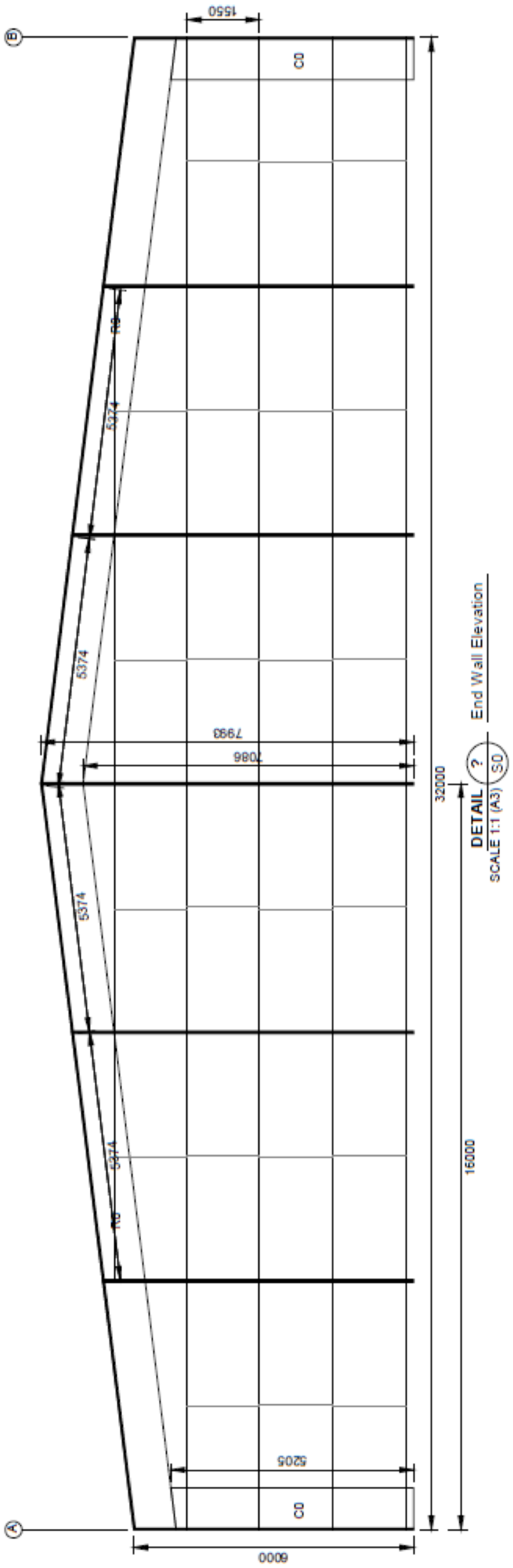


Proposed Portal Frame
DETAIL
SCALE 1:1 (A3)
?
S0
A
B
C0
C0
R0
R0
32000
16000
7993
7086
5206
6000


Proposed Purlin and Girt Layout
DETAIL
SCALE 1:1 (A3)
S0
10@1350=13500
10@1350=13500
1200
1200
1200
1200
3@1465=4395
3@1465=4395
1454
1454
150
150
A
B


6000
10000
10000
10000
10000
Side Wall
DETAIL


6000
10000
10000
10000
10000
Side Wall
DETAIL


End Wall Elevation
DETAIL
SCALE 1:1 (A3)
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1550
C0
5374
5374
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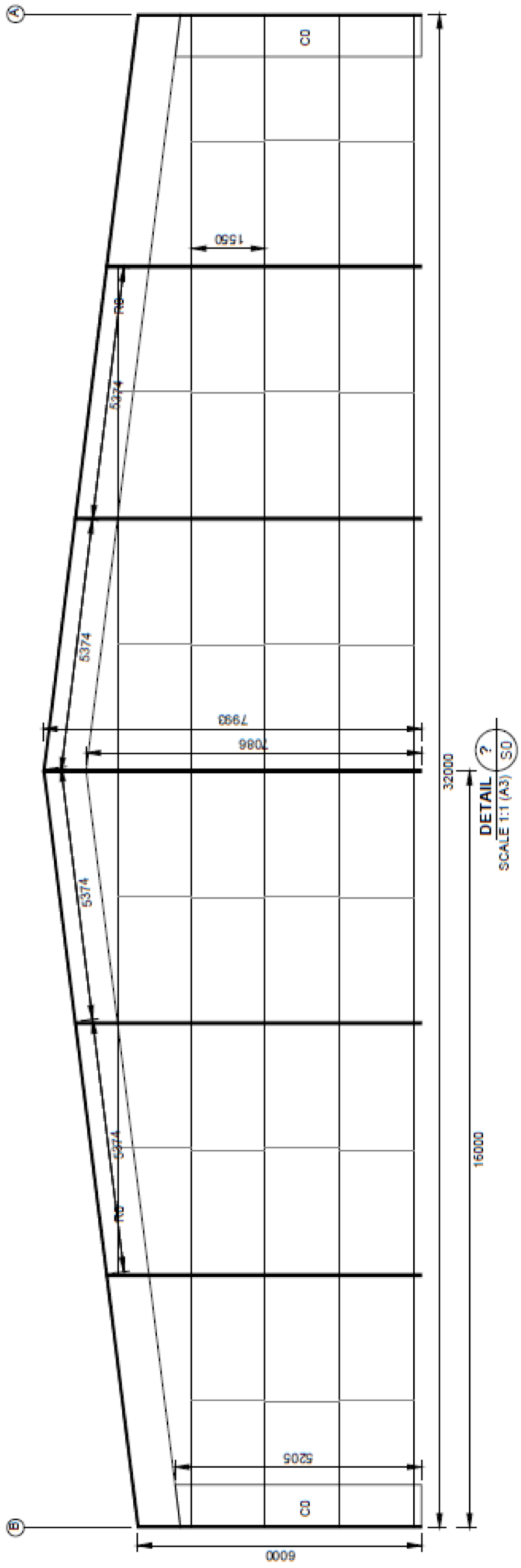
6000
32000
16000
A
B


DETAIL
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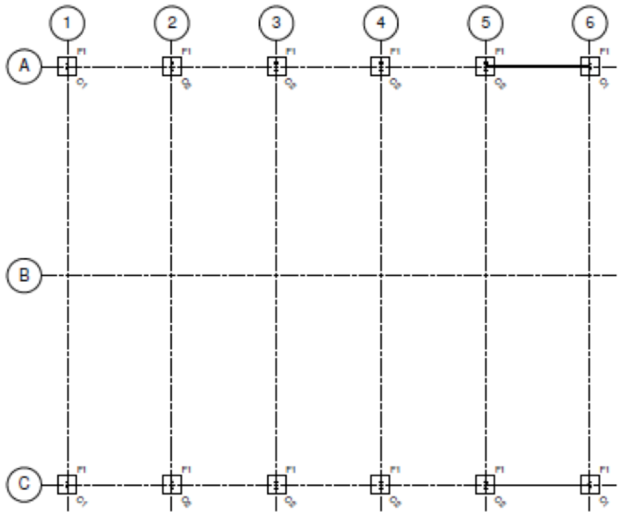
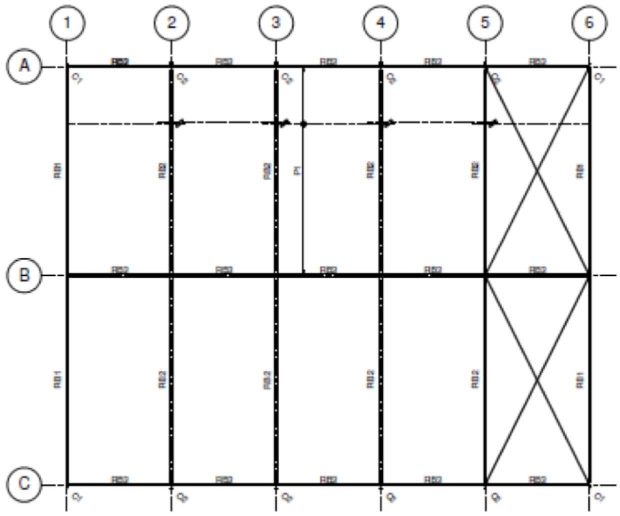
C0
1550
5374
5374
5374
5374
7993
7086
5205
C0
6000
32000
16000
A
B

Appendix C: Steel Solution – 8 m bay spacing



Foundation Plan
Scale : 1 : 200



Roof Plan
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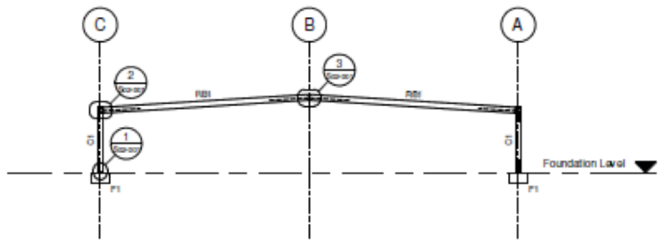
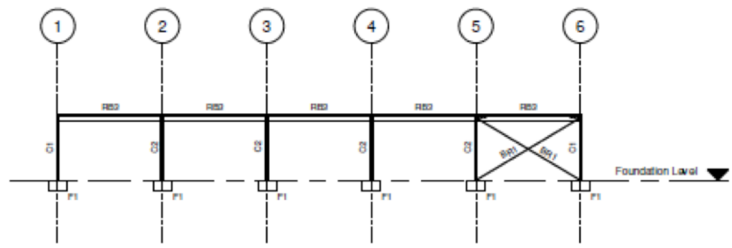


East Elevation
Scale : 1 : 200



South Elevation
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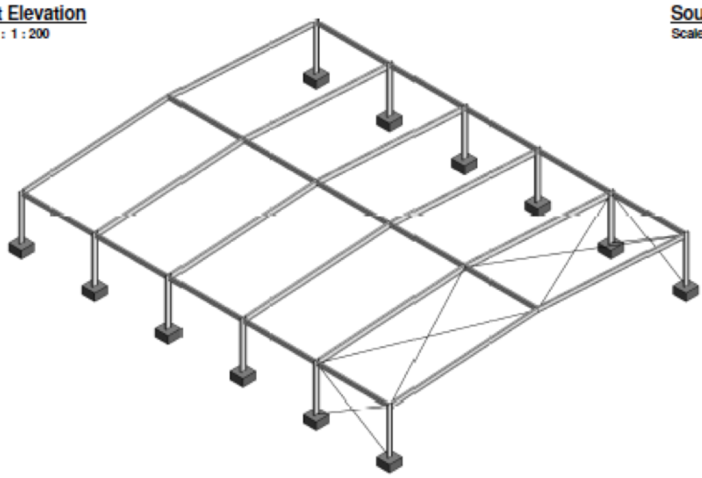
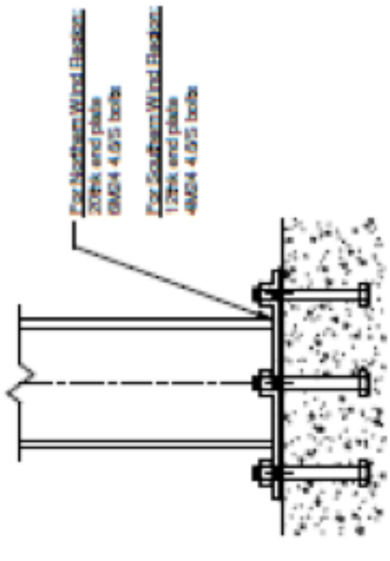


3D View

Member Schedule		
Type Mark	Northern Wind Region	Southern Wind Region
BR1	25 Dia. Rod (hung from purlins)	25 Dia. Rod (hung from purlins)
C1	460UB67	610UB101
C2	530UB82	610UB125
F1	1400x1400x800dp	1750x1750x1000dp
RB1	460UB67 x 3 rows of fly bracing	610UB101 x 3 rows of fly bracing
RB2	530UB82 x 3 rows of fly bracing	610UB125 x 3 rows of fly bracing
RB3	410UB54 x 3 rows of fly bracing	530UB82 x 3 rows of fly bracing

Note:

For Type Mark P1:
- For Northern Region = 250Z24/19 Purlins at 1800 crs. plus 1 row of bridging
- For Southern Region = 200Z24/19 Purlins at 1600 crs. plus 1 row of bridging



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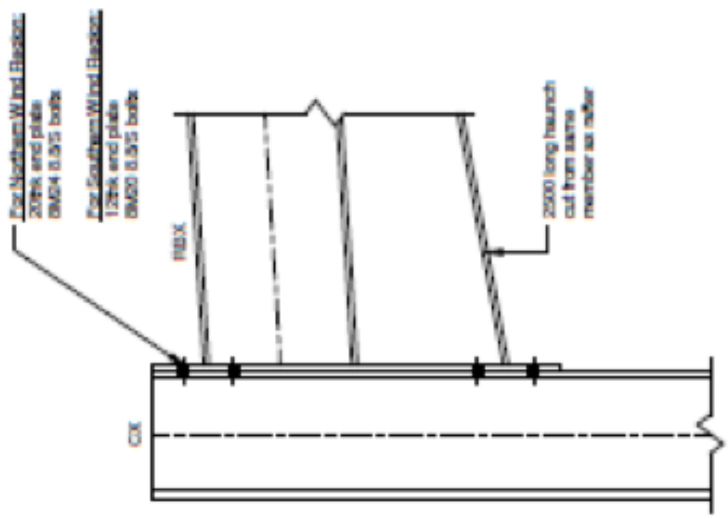
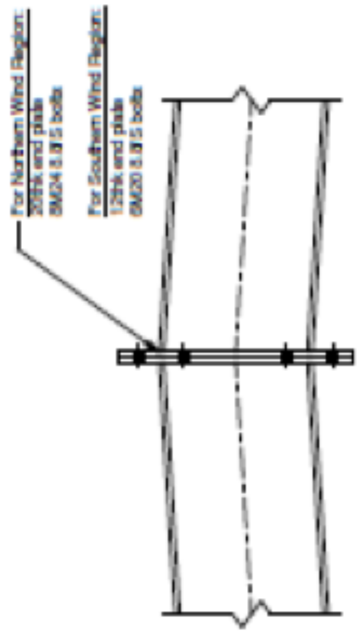
Scale : 1 : 10



Detail 2
Scale : 1 : 10



Detail 3
Scale : 1 : 10

Appendix D: Detailed Cost Information

Project Name: **Industrial Building – Timber Frame 6.67 m Bays - Timber Solution 1**

Client Name: Timber Development Association for Forest and Wood Products Australia

Element		$/m² GFA	Quantity	Unit	Unit Rate ($)	Cost ($)
Industrial Timber 6667 mm			**1,280**	**m²**	**$177.37**	**$227,035**
Substructure		**$15.22**				**$19,480**
1	1200 x 1200 x 800 Column base, including excavation, concrete, reinforcement.	$13.13	14	No.	$1,200	$16,800
2	Holding down bolt assembly comprising 4M24 bolts cast into concrete with cages.	$1.31	14	No.	$120	$1,680
3	20 mm grout under base plates	$0.78	20	m²	$50	$1,000
Columns		**$22.55**				**$28,870**
1	1220 x 135 Laminated Veneered Lumber columns; 10No.	$17.77	50	m	$455	$22,750
2	800 x 135 Laminated Veneered Lumber columns; 4No.	$4.78	20	m	$306	$6,120
Roof		**$123.38**				**$157,923**
1	1200 x 135 Laminated Veneered Lumber roof beams; 10No.	$60.12	162	m	$475	$76,950
2	800 x 135 Laminated Veneered Lumber roof beams; 4No.	$16.05	65	m	$316	$20,540
3	400 x 135 Laminated Veneered Lumber roof beams; 18No.	$15	120	m	$160	$19,200
4	25 diameter galvanised roof bracing	$1.37	70	m	$25	$1,750
5	Purlins; 300 x 45 HySPan; 32No.	$6.85	214	m	$41	$8,774
6	Purlins; 300 x 45 HySPan; 112No.	$23.99	749	m	$41	$30,709
External Walls		**$16.22**				**$20,762**
1	Mullions; 400 x 63 hySPAN LVL13; 7993 long.	$0.74	2	No.	$473	$946
2	Mullions; 400 x 63 hySPAN LVL13; 7329 long.	$1.36	4	No.	$434	$1,736
3	Mullions; 400 x 63 hySPAN LVL13; 6665 long.	$1.23	4	No.	$395	$1,580
4	Girts; HJ 300 x 45 HyJoist; 40No.	$3.76	256	m	$18.80	$4,813
5	Girts; HJ 240 x 45 HyJoist; 8No.	$0.60	43	m	$17.90	$770
6	Girts; 300 x 45 HySPan; including protective treatment; 8No.	$1.65	54	m	$39	$2,106
7	Girts; 300 x 45 HySPan; including protective treatment; 40No.	$6.88	267	m	$33	$8,811
Preliminaries Adjustment		**$0**				**$0**
	Provision of time related preliminaries based on the duration of structure construction time.					
1	Preliminaries based on reduced Construction duration of:	$0	0	Weeks		$0
Total Cost		**$177.37**				**$227,035**

Notes

1. The cost estimates are at September 2014 prices and based on construction in the Sydney area.
2. The timber frame rates are based on feedback from the Sydney market.
3. The cost comparison of Steel and Timber Frames uses the Steel Frame program duration as the base; and subsequently there is no adjustment to the preliminaries above.
4. All Product H2-S treated and unpainted.
5. No protective coating used as Industrial building. This reduces cost in visual non-critical applications.

Project Name: **Industrial Building – Timber Frame 10 m Bays - Timber Solution 2**

Client Name: Timber Development Association for Forest and Wood Products Australia

Element		$/m² GFA	Quantity	Unit	Unit Rate ($)	Cost ($)
Industrial Timber 10 m Bay			**1,280**	**m²**	**$169.02**	**$216,342**
Substructure		**$17.19**				**$22,000**
1	1600 x 1600 x 800 Column base, including excavation, concrete, reinforcement.	$15.23	10	No.	$1,950	$19,500
2	Holding down bolt assembly comprising 4M24 bolts cast into concrete with cages.	$0.94	10	No.	$120	$1,200
3	20 mm grout under base plates	$1.02	26	m²	$50	$1,300
Columns		**$15.31**				**$19,600**
1	1050 x 105 hyOne Laminated Veneered Lumber column; 5205 long	$15.31	10	No.	$1,960	$19,600
Roof		**$123.38**				**$157,923**
1	1050 x 105 hyOne Laminated Veneered Lumber rafter, 16124 long	$47.27	10	No.	$6,050	$60,500
2	Knee gusset; 63 4x-band hySPAN (LVL13)	$4.22	20	No.	$270	$5,400
3	Knee gusset; stiffener fillet (LVL13)	$1.72	10	No.	$220	$2,200
4	Ridge gusset; 63 4x-band hySPAN (LVL13); including protective treatment	$2.11	10	No.	$270	$2,700
5	Ridge gusset; stiffener fillet (LVL13)	$0.86	5	No.	$220	$1,100
6	Purlins; HJ400 90 hyJOIST	$34.13	1040	m	$42	$43,680
7	Eaves beam; 400 x 63 hySPAN (LVL13) (8No.)	$4.16	82	m	$65	$5,330
8	Flybraces; 90 x 45 LVL11 screwed to rafter and purlin	$4.88	80	No.	$78	$6,240
9	Lateral restraint; 90 x 45 LVL nailed to underside of purlins	$9.37	387	m	$31	$11,997
10	Lateral restraint; 90 x 45 LVL blocking piece 1350 long	$4.73	144	No.	$42	$6,048
11	25 mm diameter galvanised roof bracing	$1.02	52	m	$25	$1,300
External Walls		**$22.07**				**$28,247**
1	Girts; 240 x 45 hySPAN (10No.)	$9.34	299	m	$40	$11,960
2	Girts; 200 x 45 hySPAN (32No.)	$6.75	320	m	$27	$8,640
3	Mullions; 400 x 63 hySPAN LVL13; 7993 long	$0.75	2	No	$480	$960
4	Mullions; 400 x 63 hySPAN LVL13; 7329 long	$1.38	4	No	$440	$1,760
5	Mullions; 400 x 63 hySPAN LVL13; 6665 long	$1.25	4	No	$400	$1,600
6	Mullions; 300 x 63 hySPAN LVL13; 5600 long	$1.68	8	No	$269	$2,152
7	25 mm diameter galvanised wall bracing	$0.92	47	m	$25	$1,175
Preliminaries Adjustment		**$0**				**$0**
	Provision of time related preliminaries based on the duration of structure construction time.					
1	Preliminaries based on reduced Construction duration of:	$0	0	Weeks		$0
Total Cost		**$169.02**				**$216,342**

Notes

1. The cost estimates are at September 2014 prices and based on construction in the Sydney region.
2. The timber frame rates are based on feedback from the Sydney market.
3. The cost comparison of Steel and Timber Frames uses the Steel Frame program duration as the base; and subsequently there is no adjustment to the preliminaries above.
4. All Product H2-S treated and unpainted.
5. No protective coating used as Industrial building. This reduces cost in visual non-critical applications.

Project Name: Industrial Building – Steel Frame 8 m Bays - Steel Solution

Client Name: Timber Development Association for Forest and Wood Products Australia

Element		$/m² GFA	Quantity	Unit	Unit Rate ($)	Cost ($)
Industrial Steel Frame 8 m Bays		**$186.61**	**1,280**	**m²**	**$186.61**	**$238,861**
Substructure		**$26.20**				**$33,540**
1	1750 x 1750 x 1000 Column base, including excavation, concrete, reinforcement.	$24.84	12	No.	$2,650	$31,800
2	Holding down bolt assembly comprising 4M24 bolts cast into concrete with cages.	$1.13	12	No.	$120	$1,440
3	20 mm grout under base plates	$0.23	6	m²	$50	$300
Columns		**$28.85**				**$36,925**
1	460UB67 Column including zinc silicate treatment; (4No.)	$6.92	1.61	t	$5,500	$8,855
2	530UB82 Column including zinc silicate treatment; (8No.)	$16.93	3.94	t	$5,500	$21,670
3	165 x 5 CHS bracing	$3.50	40	m	$112	$4,480
4	Allowance for steel plates and bolts fittings of 5% on structural steelwork	$1.50	0.32	t	$6,000	$1,920
Roof		**$105.20**				**$134,656**
1	310UB40 Roof beam including zinc silicate treatment; (4No.)	$11.09	2.58	t	$5,500	$14,190
2	460UB67 Roof beam including zinc silicate treatment; (8No.)	$37.13	8.64	t	$5,500	$47,520
3	165 x 5 CHS Roof beam including zinc silicate treatment; (15 No.)	$10.14	2.36	t	$5,500	$12,980
4	50 x 50 x 5 steel angle in fly bracing, including zinc silicate treatment	$3.81	122	No	$40	$4,880
5	165 x 5 CHS bracing	$10.76	123	m	$112	$13,776
6	Allowance for plates bolts and connections 5%.	$3.75	0.80	t	$6,000	$4,800
7	200Z24/19 Galvanised purlins	$24.75	1056	m	$30	$31,680
8	Bridging between 200Z24/19 Galvanised purlins	$3.77	161	m	$30	$4,830
External Walls		**$26.36**				**$33,740**
1	200Z24/19 Galvanised girts	$16.69	712	m	$30	$21,360
2	Sag rod between 200Z24/19 Galvanised girts	$3.50	112	m	$40	$4,480
3	250UB31 Mullion including zinc silicate treatment; 6No.	$5.84	1.36	t	$5,500	$7,480
4	Allowance for plates bolts and connections 5%.	$0.33	0.07	t	$6,000	$420
Preliminaries Adjustment		**$0**				**$0**
	Provision of time related preliminaries based on the duration of structure construction time.					
1	Preliminaries based on reduced Construction duration of:	$0	0	Weeks		$0
Total Cost						**$238,861**

Notes

1. The cost estimates are at September 2014 prices and based on construction in the Sydney region.
2. The cost comparison of Steel and Timber Frames uses the Steel Frame program duration as the base; and subsequently there is no adjustment to the preliminaries above.
3. The steelwork is assumed to be pre-fabricated and bolted together on site with minimum welding required.
4. Provision has been included for 5% steelwork fittings.

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