BLIGH
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GREAT OCEAN ROAD COASTAL TRAIL SUSPENSION BRIDGES

STRUCTURAL CONCEPT DESIGN REPORT

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Great Ocean Road Coastal Trail
Suspension Bridges

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APPENDICES

1.0 GENERAL

1.1 Introduction

To activate tourism in the areas of the Great Ocean Road including Fairhaven to Skenes Creek, Victoria State Government Department of Environment, Land, Water and Planning (DELWP) commissioned World Trail Pty Ltd to develop a finalised trail route and Trail Master Plan for the region that delivers a world-class coastal walk connecting towns as well as providing several short two to four-hour walking loops. World Trail Pty Ltd is also to provide a Trail Planning and Design Report that will be utilised in the planning and approvals and construction stage of the project.

The proposed walking trail is to include signature eye-catching suspension bridges providing spectacular views, and up to six pedestrian suspension bridges are possible as follows:

0. Grassy Creek (Bridge 0)
1. Big Hill (Bridge 1)
2. Reedy Creek (Bridge 2)
3. Cumberland River (Bridge 3)
4. Winterbrook Falls (Bridge 4)
5. Mt. Defiance (Bridge 5)

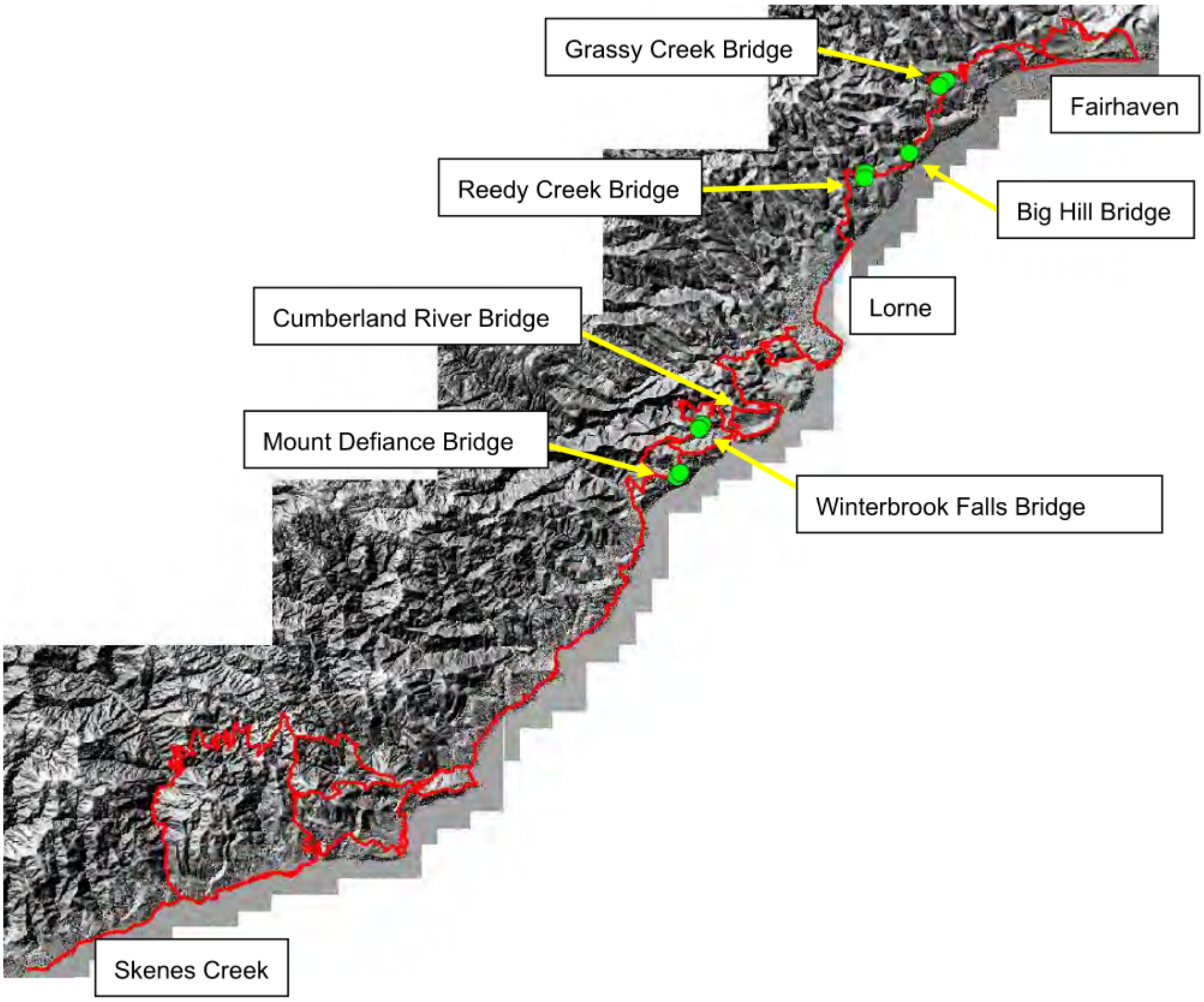


Figure 1, Locations of proposed bridge sites (green dots show proposed abutment locations)

Bligh Tanner has been commissioned by World Trail Pty Ltd to:

- Review geotechnical advice and comment on proposed abutment locations for the above suspension bridges based on available ground conditions;
- Provide input into the nature, feasible engineering requirements and structural form of the suspension bridges; and
- Provide concept structural design of the pedestrian suspension bridges.

1.2 Report content

This report provides guidance on loading assumptions for:

- Dead loads;
- Live loads on the footbridge;
- Wind loads;
- Earthquake loads; and
- Load combinations.

The report also summarises design approaches to:

- Stability design;
- Serviceability acceptance criteria;
- Geotechnical / foundation design;
- Choice of materials;
- Fire resistance;
- Sustainability; and
- Inspection and maintenance.

1.3 Design Objectives

Structural design objectives

- Produce a cost-effective structure capable of resisting all applied loads without failure during its intended life;
- Comply with all relevant and current design standards and best construction practices;
- Design structures that are safe to construct, operate, inspect and maintain;
- Design shall achieve the necessary approvals, compliance with environmental requirements;
- Minimise long-term maintenance.

Project objectives

The following Guiding and Supporting Principles of the Project apply to the design of the suspension bridges.

Conserving and protecting the Otway Coast

- The Great Ocean Road Coastal Trail (GORCT) will be designed and constructed in a manner that is sympathetic and respectful of the landscape; and
- The trail will be environmentally sustainable, constructed utilising durable local materials where possible. In particular, materials that can blend with the landscape and will withstand weather and natural events will be prioritised.

Encouraging all to be active

- The GORCT will include features and experiences that can't be experienced by simply driving along the Great Ocean Road.

Showcasing the landscape

- The GORCT will provide iconic walking experiences, showcasing the grandeur and diversity of the Great Ocean Road's natural and cultural landscapes;
- The trail design process will recognise that the landscape and geology of the region is the defining feature of the walking experience;
- The trail will aim to provide unique experiences, through lookouts and bridges, based on the unique coastal geology and views that becomes destinations within their own right; and
- The trail experiences will be benchmarked against similar iconic trails both in Australia and overseas.

Providing economic benefits

- The whole of life cost of the GORCT will be acknowledged throughout its design, construction and operation.

Creating a unique visitor experience

- The GORCT will create lifelong memories, through a walking experience that captures the essence of the Great Ocean Road through the seasons – the solitude, amazing views and scenery, connection to cultural heritage, varied flora and fauna and the breathtaking wildness of the Southern Ocean;
- The trail design will create an immersive landscape experience for a wide variety of users;
- The GORCT will be a Nationally Significant trail, ranked within the top 10 trail experiences in Australia; and
- The GORCT will be an iconic long distance walking trail, known internationally and capable of attracting visitors from overseas. It will also comprise shorter walks and loops, allowing people to experience enjoy shorter sections of the landscape.

2.0 REFERENCES

2.1 Australian Standards

The design of the structure is to comply with the requirements of the current versions of the following building codes and standards:

- AS/NZS 1170.0 Structural design actions Part 0: General principles
- AS/NZS 1170.1 Structural design actions Part 1: Permanent, imposed and other actions
- AS/NZS 1170.2 Structural design actions Part 2: Wind actions
- AS 1170.4 Structural design actions Part 4: Earthquake actions in Australia
- AS 1720.1 Timber structures Design methods
- AS 2156.1 Walking tracks: Classification and signage
- AS 2156.2 Walking tracks: Infrastructure design
- AS 2159 Piling – Design and installation
- AS 3600 Concrete structures
- AS 4100 Steel structures

The bridges will be designed to AS 2156.2 instead of AS 5100 Bridge design as they are classified as walking track structures. AS 5100 specifications are considered typically in excess of what's required to deliver access structures for walkers in remote areas, away from roads and railway lines.

2.2 Geotechnical Investigation

Golder has undertaken a preliminary geotechnical review of six proposed bridge sites and made recommendations of likely siting locations for bridge abutments based on a geohazard assessment including slope stability/landslide potential and erosion potential.

The Golder report (21468192-001-R-Rev0) includes hazard maps and concludes that portions have lower hazard risks. For the bridges over valleys, the abutments/anchors are to be founded sufficiently upslope to avoid landslides.

The geotechnical conditions at each bridge site are described in Section 5 of the Golder report. In summary, each site has been assessed and a preferred location for abutments has been identified based on a visual assessment of slope stability. The preferred abutment locations define the span of the bridge and height above valley. These are summarised in Figure 2:

Bridge	Span	Height above valley (approx.)
Grassy Creek (Bridge 0)	132m	30m
Big Hill (Bridge 1)	141m	30m
Reedy Creek (Bridge 2)	71m	20m
Cumberland River (Bridge 3)	450m	150m
Winterbrook Falls (Bridge 4)	164m	75m
Mt. Defiance (Bridge 5)	165m	45m

Figure 2, Bridge spans and height above valley

All bridge locations nominated are underlain by sandstone/siltstone rock with overlying soils that should be suitable for shallow or deep foundations and anchors. Detailed investigation will occur later in the detailed design project phase.

The Golder report also provides indicative engineering parameters and preliminary commentary on geotechnical aspects for bridge abutment and anchor design.

2.3 Fairhaven to Skenes Creek Coastal Trail Feasibility Study

Previous similar project

The lower-bound budget cost for the suspension bridges on the Great Ocean Road Coastal Trail project as stated in Fairhaven to Skenes Creek Coastal Trail Feasibility Study (Table 15 Note 18) is extrapolated from the cost of the 141m span Maramataha Bridge built in 2011 on the Timber Trail in New Zealand.

As such, the 141m span Maramataha Bridge was used as a reference for our approach to the nature, form and constructability of the proposed suspension bridges on the Great Ocean Road Trail. A photo of that bridge is shown in Figure 3.

Figure 3, Photo of 141m span Maramataha Bridge

Major features of the 141m span Maramataha Bridge and its construction are:

- The main wire rope cables are supported on elevated towers with the deck walkway being horizontal;
- The towers consist of two legs interconnected by lateral bracing for stability;
- The lengths of the hangers vary with the variation in the sag of the main cables along the span;
- Wind stabilisation is provided by wind guy systems;
- The bridge has a 10-person weight limit;
- A lot of timber was used, including timber decking, timber walkway joists and cross bracing and Glulam in the towers;
- The remote aspect of the bridge location meant it was not possible to get a crane or trucks to the site, so everything had to be erected with light weight equipment or flown in by helicopter;
- The foundations had to be constructed without heavy machinery and anchored to rock; and
- Prefabrication was maximised because of the isolated location, e.g., wire ropes were ordered at their exact lengths, the hangers were attached to the cables and then the assembly flown in as a big string by helicopter.

Classification of the walking track

The design live load specified for structures covered by AS 2156.2 depends on the Classification of the walking track that includes the structure.

The Fairhaven to Skenes Creek Coastal Trail Feasibility Study states: ‘The trail is proposed to be designed to meet the Australian Walking Track Grading System between Level 2 and 3, meaning that no bushwalking experience is required. The trail may include some steps or a gentle gradient increasing to short steep sections.’

The Australian Walking Track Grading System is aligned with AS 2156.1, which includes descriptions of the various walking track classes. The descriptions point towards a Class 3 track leading to suspension bridge sites, where short steep sections may be encountered.

3.0 DESIGN CONSTRAINTS

3.1 Site Access

Limitations on construction access and construction equipment affect the design options and the cost of construction.

Information re access to the proposed bridge abutment locations is as follows.

3.1.1 Grassy Creek (Bridge 0)

There is no vehicle access to either abutment. The nearest vehicle access point is about 800m SE on private property (St Bernards College Santa Monica campus). If a temporary vehicle access were to be constructed, it would need to come upstream along the banks of Grassy Creek.

3.1.2 Big Hill (Bridge 1)

Vehicle access is possible to the northern abutment via a management vehicle track. There is no vehicle access to the southern abutment.

3.1.3 Reedy Creek (Bridge 2)

There is no vehicle access to either abutment. The nearest vehicle access point is about 250m SE of the eastern abutment along the outside of a private property boundary.

3.1.4 Cumberland River (Bridge 3)

There is no vehicle access directly to either abutment. The nearest vehicle access point (only suitable for 4WD vehicles) is about 250m N of the eastern abutment uphill along a narrow, steep walking track.

3.1.5 Winterbrook Falls (Bridge 4)

There is no vehicle access to either abutment. Both abutments are located at the end of long spurs or ridge lines, which appear to have had old logging tracks on them in the past. It may be possible to open temporary vehicle access tracks along these spurs / ridge lines, as minimal benching/earthworks would be required. If so, the access track to the northern abutment would be about 3km long and the access track to the southern abutment would be about 1.7km long.

3.1.6 Mt. Defiance (Bridge 5)

There is no vehicle access to either abutment. Both abutments are located at the end of long spurs or ridge lines. It may be possible to open temporary vehicle access tracks along these spurs / ridge lines, as minimal benching/earthworks would be required. If so, the access track to the northern abutment would be about 500m long and the access track to the southern abutment would be about 1.6km long.

3.2 Geotechnical Constraints

As noted in Section 2.2, the preferred abutment locations that define the span of the bridges are located sufficiently upslope to avoid landslides.

Where rock can be encountered at reasonable depths, tower foundations will be founded on top of this rock and back stay foundations will be anchored into the rock. Deep foundations are more expensive though stability of anchor blocks may require deep foundations for stability against sliding.

4.0 DESIGN LIFE

The intended design life of a structure is the period during which the structure is assumed to perform its intended purpose with expected maintenance but without major structural repair being necessary. It is related to the level of loading expected during the design life, the environment to which the structure is exposed, the durability of materials used in its construction, the method of detailing and the inspection and maintenance regimes.

The suspension bridges will be designed to achieve a minimum expected working life of 50 years without major structural repair or replacement of the foundations, towers or cables being necessary.

Hangers, deck bearers, joists and decking are more easily replaced and may have a lower design life.

5.0 DESIGN LOADS

5.1 Dead Loads

The dead load is the total weight of all the permanent components of the footbridge structure. That includes self-weight of the main cables, decking, deck framing, cross bracings, side mesh, hangers, handrail cables, wind guy cables, connections, etc.

The dead load of the components is calculated from the material properties of the constituent elements or from data provided by the suppliers or fabricators of the elements. Where a choice exists, it is prudent to choose light but safe building materials to increase the live load carrying capacity of the footbridge.

5.2 Live Loads

5.2.1 Deck

The number of people allowed on the footbridge at any one time determines the live load on the deck.

Given that the suspension bridges are in remote locations, an argument could be made for basing the design live loading on an assessment of crowd density, as was likely done for the Maramataha Bridge.

In the case of the Maramataha Bridge, we understand that the designers adopted a design live load of ten people at any one time, or approximately 1.2 tonnes. A similar rational approach could be applied to the GORCT suspension bridges where an assessment of the likely peak loading on a bridge at any one time could be made by the designers. Whilst this could be argued as a realistic approach for most of the bridge life in this remote location resulting in some more economical outcomes, such an assumption carries some risk as pedestrian traffic would need to be controlled at peak times (e.g., the bridge opening).

The alternative approach of referencing a design live load from an Australian Standard for pedestrian bridges (including bridges in an urban setting) would result in a bridge design that carries live load (pedestrian numbers) that could be considered unrealistic for this remote site, but this approach of designing to a nationally accepted Standard incorporates a risk-averse assumption that may be preferred by DELWP, approving authorities and insurers.

Our concept work is based on this more conservative assessment of live load intensities, a sensitivity analysis of the live load effects determined an increase in structure requirement, but the margin of increase was not considered excessive and therefore was a recommended approach based on a risk vs cost consideration.

Suspension bridge design often includes consideration of collapse risk following from possible cable or hanger failure. The adopted conservative bridge live load compared to likely actual loads implies that subject to inspections and maintenance during the bridge life, the risk of main cable breakage is considered extremely low.

AS 2156.2 ‘Walking tracks: Infrastructure design’ covers pedestrian bridges. The design live load specified for structures covered by AS 2156.2 depends on the Classification of the walking track that includes the structure, adopted as Class 3 in this case (see Section 2.3 above).

The live loads on the deck tabulated in Figure 4 have been adopted for the concept design.

Source Document & Section	Uniformly Distributed Load	Concentrated Live Load
Walking tracks Class 3 AS2156.2 access way, Section 2.3 (b)	3.0 kPa over 1.2m width = 3.6kN/m	1.4 kN over 75mm x 75mm

Figure 4, Live Loads on Deck

The suspension bridges will not be designed for maintenance vehicles.

5.2.2 Barriers

The design live loads on the barriers are tabulated in Figure 5.

Source Document & Section	**Top rail**		**Infill**	
	Horizontal kN/m	Vertical kN/m	Horizontal kPa	Any direction kN
Walking tracks Class 3 AS2156.2 access way Table 1	0.36	0.36	0.75	0.25

Figure 5, Live Loads on Barriers

5.3 Wind Loads

The wind load is calculated from the assumed wind velocity in AS/NZS 1170.2 and is taken as a uniformly distributed load with a horizontal component. The vertical component is neglected for footbridge analysis.

Wind loads are to be derived in accordance with AS/NZS 1170.2 and based on the following design parameters:

- Wind Region A5
- Terrain Category 2.5
- SLS wind speed V_{20} = 37 m/s
- ULS wind speed V_{500} = 45 m/s

5.4 Earthquake Loads

The earthquake loading is calculated in accordance with AS1170.4 Structural design actions Part 4: Earthquake actions in Australia.

The following design parameters are to be adopted:

- Hazard Factor Z = 0.10
- Annual Probability of Exceedance = 1/500
- Probability factor = 1.0
- Sub Soil Class = Be (Rock) for Bridge 1 southeast abutment, Bridge 2 southwest abutment, Bridge 3 southern abutment, Bridge 4 both abutments and Bridge 5 both abutments
- Sub Soil Class = Ce (Shallow soil) for other abutments

5.5 Temperature Effects

A change in temperature will cause a change in the main cable length and hence a change in the cable tension and walkway profile.

5.6 Load combinations

The structure as a whole and all its members will be designed to support the combinations of factored loads and forces given in AS/NZS 1170.1 for strength and stability limit states. To calculate the accumulative effective load, each possible load combination will be checked to find the maximum controlling case.

6.0 EXPOSURE ENVIRONMENT

The GORCT bridge locations are within 1 km of the shoreline where the rate of corrosion is increased by the presence of soluble chlorides in the atmosphere. The bridges are also exposed to the full ravages of weather and UV.

From AS 4312, the best source of Australian data for corrosivity of steel in the local environment, the GORCT bridges are likely to be Corrosivity Category C3 ‘Coastal or light industrial’.

From AS 3600, the concrete exposure classification of B2 will be adopted for above-ground surfaces of concrete elements, based on the bridges being in a 'Coastal' environment.

7.0 BRIDGE DESIGN

7.1 Deck cross section

Bridge widths are not specified in AS 2156.2. The outline of a Class 3 track in Table 3 of AS 2156.1 describes the width as ‘variable and generally less than 1200mm’. A width of 1.2m is considered adequate for a walkway with low pedestrian volume and has been adopted as the width of the deck between handrails.

Widening the deck up to 1.5m was considered but the potential loading on a 1.5m wide bridge is 25% greater than on a 1.2m wide bridge and it therefore has to be made stronger, increasing cost in about the same proportion. Widening the deck up to 1.5m also encourages risky activities such as running on the bridge or pedestrians congregating.

Barriers will be 1100mm high with mesh infill.

7.2 Choice of Materials

The choice of materials to use for the footbridge elements will affect the final project cost and construction methodology. The choice of materials is governed by local availability, the cost and ease of transportation to the site, the degree of workmanship to be employed, the degree of supervision (quality control) available, safety, durability (maintenance), and funding available.

7.2.1 Foundations

The foundations will be reinforced concrete.

7.2.2 Towers

Structural steel has been adopted for the towers due to its high strength/weight ratio, adaptation to prefabrication and speed of erection.

To address the durability of steel in the coastal environment, it is proposed to adopt Hot dip galvanising Coating System HDG900 in accordance with AS/NZS 4680 as the protective system. According to AS/NZS 2312.2:2014 Table 6.2, HDG900 will give 60 years minimum life to first maintenance of coating in Corrosivity Category C3.

7.2.3 Cables

General Purpose 6x36 IWRC Galvanised 1960 Grade wire ropes, obtained from specialist suppliers, has been adopted for all cables.

The 6x36 construction provides an excellent balance of flexibility and durability. Likewise, the 1960 grade tensile ensures high breaking loads but a very good balance of strength and fatigue resistance for the longest possible service life.

7.2.4 Hangers

Galvanised Reidbar (continuously threaded steel reinforcing bar) has been adopted for the hangers as it is compatible with Reidbar components that can be screwed onto the bar, including couplers, nuts and spherical washers, simplifying connections.

7.2.5 Deck Bearers and Deck Bracing

Grade 1 Timber (Red Ironbark or Turpentine) has been adopted for the deck bearers and deck bracing. Grade 1 Timber has been specified as it is the most naturally durable timber and bearers and deck bracing are the most difficult deck components to replace. From AS 5604 Timber—Natural durability ratings, Grade 1 Timber has a minimum above-ground life expectancy of 40 years.

Red Ironbark and Turpentine are also sustainably grown, stable, resistant to UV degrade and bushfire-resisting timbers. While most timbers ignite with about the same degree of difficulty, flame spreads slower on dense hardwood timbers including Red Ironbark, Turpentine, Spotted Gum and Blackbutt, allowing more time to extinguish it. It also chars slower so it often has a better chance of survival than other timbers.

Structural steel with Hot dip galvanising Coating System HDG900 could also be considered for the Deck Bearers and Deck Bracing.

7.2.6 Deck Joists

Grade 2 Timber (Spotted Gum) has been adopted for the deck joists. Grade 2 Timber has been specified as it is more readily available and less expensive than Grade 1 Timber and deck joists are easier to replace than bearers or deck bracing. From AS 5604 Timber - Natural durability ratings, Grade 2 Timber has an above-ground life expectancy of 15-40 years.

Spotted Gum is also sustainably grown, stable, resistant to UV degrade and bushfire-resisting.

Structural steel with Hot dip galvanising Coating System HDG900 could also be considered for the Deck Joists.

7.2.7 Decking

Slip resistant (Reeded top) 'Deckwood', quality hardwood decking developed specifically by Outdoor Structures Australia for external structures and used on boardwalks and foreshores all around Australia, has been adopted for the walkway decking.

Deckwood is selected from Spotted Gum, Ironbark or Tallowwood species. Boards are scalloped on the underside to prevent cupping and the sides of boards are tapered for self-cleaning of litter.

Fibreglass Reinforced Plastic (FRP) mesh could also be considered for the walkway decking. FRP products are corrosion resistant and require little or no maintenance.

7.3 Bridges 0, 1, 2, 4 and 5

Suspension bridges are one of the most cost-effective ways to create a long-span bridge to cross a large area without intermediate supports.

We have undertaken a high-level concept design for the suspension bridges excluding Cumberland River Bridge. Refer to Appendix A for an indicative general arrangement sketch, included for the purpose of communicating that concept. The concept design is subject to detailed design in a future project phase.

The major features of the concept design for Bridges 0, 1, 2, 4 and 5 are:

- The main cables are 52mm (32mm for Bridge 2) diameter galvanised 6-strand wire rope manufactured in accordance with AS 3569;

- The main cables are supported on structural steel towers consist of two I-beam (UB) legs interconnected by angle section lateral bracing for stability. A H-beam (UC or WC section) tower headstock supports the main cables. The tower will be fully shop welded into modules weighing less than helicopter lift capacity. Tower modules will be connected on site with bolted splices;
- The main towers are constructed on simple reinforced concrete foundations socketed into intact weathered rock at a depth of 1.5m. Holding down bolts cast into the tower foundation fix the tower to the foundation;
- The backstay cables comprise two 44mm (one 40mm for Bridge 2) diameter galvanised 6-strand wire rope manufactured in accordance with AS 3569;
- All backstay cables each end of Bridges 0, 1, 4 and 5 are anchored in a 3.2m x 4m footing socketed 900mm into intact weathered rock found at a depth of 1.5m. The foundation includes two 152mm diameter x 5.2m long grouted passive anchors drilled into the rock to carry tension loads.
- The backstay foundations will most likely be more expensive than the foundations for Maramataha Bridge where we understand that rock anchors were directly attached to the rock face;
- Galvanised Reidbar (continuously threaded steel reinforcing bar) hangers spaced at 2m attached to the main cables with special fittings are bolted to Structural Grade 1 Timber deck bearers. Detailing of the deck framing will ensure that failure of any hanger will not result in collapse. The lengths of the hangers vary with the variation in the sag of the main cables along the span to achieve a horizontal deck profile;
- The bearers in turn support three Structural Grade 2 Timber joists that run in the direction of the bridge. Structural Grade 1 Timber Plan bracing is provided on the underside of the joists to provide plan stiffness.
- Slip resistant (Reeded top) Deckwood, quality hardwood decking developed specifically for external structures and used on boardwalks and foreshores all around Australia, is fixed to the joists with 304 stainless steel batten screws;
- Wind stabilisation is provided by wind guy systems.

7.4 Bridge 3 Cumberland River

The span of Bridge 3 Cumberland River is estimated to be 450m and may be greater (500-600m) to be sufficiently upslope to avoid landslides.

The forces in the main cables and footings of a 450m span suspension bridge are significantly larger than those in the main cables and footings of Bridges 0, 1, 2, 4 and 5. If the sag to span ratio for Bridge 3 and Bridge 4 was kept the same, the increase in main cable and backstay forces for Bridge 3 would be proportional to the square of the ratio of the spans of the two bridges, i.e. main cable and backstay forces for 450m span Bridge 3 = 7.5 x main cable and backstay forces for Bridge 4. To reduce the force in the main cables as much as possible, the 450m span deck walkway could sag about 10m. In this case, there would be 33m sag in the main cables and the towers would reduce in height to 24.3m. However, the main cable and backstay forces are still very high.

A 450m span suspension bridge requires a different design philosophy to that adopted for the design of the other five suspension bridges, where spans don't exceed 165m. Other structural solutions are possible and probably more suitable, but the rates used for suspension bridges in the cost estimate would not apply to Bridge 3; they would be significantly higher.

Bridge 3 is not considered feasible for this project from a cost perspective.

7.5 Dynamic response

Excitation due to pedestrians and wind is a significant consideration and it is important that this risk is adequately addressed. The potential issues can result in significant discomfort and complaints from users or in extreme cases, structural failure.

Detailed modelling of the bridges will be required to determine the susceptibility to dynamic excitation. In particular, the modelling will establish whether the deck level wind guys can be configured to provide a high degree of effective dynamic damping to the structure.

Response to pedestrian loads can be modelled and analysed on computer with a reasonable level of confidence.

Computer modelling for wind dynamic response has lower reliability and wind tunnel testing of physical models is often necessary to determine performance of this type of structure. Detailed discussions with wind engineering specialists will be required as the design is progressed to the next phase.

8.0 CONSTRUCTION

As design progresses, input from suitable contractors will be sought to ensure that details are consistent with the most efficient and safe construction processes recognizing the restricted access for construction vehicles. At this stage the design has been based on the general construction process described below:

8.1 Site preparation

- Prepare bridge site with removal of identified fauna, trees, boulders, etc.

8.2 Foundations

- Excavation using small excavator, where necessary delivered by helicopter (with other materials such as reinforcement, formwork etc.);
- Excavator equipped with drilling rig for ground anchors;
- Concrete mixed at site in mobile batching plant or delivered using helicopter.

8.3 Towers

- Delivered by helicopter, installed on packers over the cast-in holding down bolts and inclined towards main span, with temporary adjustable cables tied back to backstay foundations. Tower inclination is for stability (avoids temporary propping) and to reduce main cable tension at time of installation;
- Only grout tower base plates at the end of construction.

8.4 Main cables

- Install guide wire between tops of both towers using helicopter;
- Deliver main cables with hangers attached, at one tower (helicopter). Secure to tower;
- Feed main cable along guide wire by winching from opposite tower. Secure to opposite tower;
- Winch towers to vertical position and install backstay cables.

8.5 Deck

- Preferably fabricate deck in modules at tower locations;
- Deck built progressively from towers towards midspan by rolling out along completed deck, then cantilevering from last deck unit. Individual member weights to be kept below 50kg to simplify lifting on site to two-man lifts;
- Once the deck is completed, add handrail and mesh balustrade to complete the structure.

8.6 Wind Guy cables

- Installed hung under completed deck, with ends winched across to anchor blocks.

9.0 INSPECTIONS

9.1 Purpose

The general purpose of inspections is to:

- Check the general serviceability of the structure for obvious signs of defects which might affect the immediate safety of users;
- Identify maintenance items that require immediate action and/or to schedule routine maintenance for completion at a later date;
- Identify and prioritise maintenance needs including monitoring, maintenance and/or repair or further investigation;
- Assess the effectiveness of past maintenance treatments;
- Model and forecast changes in condition (deterioration modelling) and residual life; and
- Estimate future requirements for maintenance budgets.

The bridges should be subject to regular inspections with a maximum interval between successive inspections. The bridges should also be subject to an inspection after extreme events such as an extreme wind, earthquake, landslide / rock fall or bushfire.

The bridges will require a maintenance manual, the prescribes the inspections, the frequency of inspections and maintenance required to achieve the design life.

Inspections would be expected to involve the items described below.

9.2 Foundations

Foundations should be checked for the following:

- Cracks in the concrete surfaces, spalling of concrete, exposure of steel reinforcement and chemical attack.
- Pulling out of the footings or anchor blocks, evidenced by ground heave around the anchor blocks.
- Tilting of the footings or anchor blocks, evidenced by loss of straightness to the concrete surfaces.

9.3 Anchorages

The anchorages are easy to inspect because they are exposed above the ground. The anchorages must be inspected for rusting of the turnbuckles and hooks, functionality of the threads and integrity of the individual members. The anchorages are exposed to vandalism and may be adversely affected by misuse.

9.4 Steel Cables

The steel cables, especially the main cables, may not be easy to inspect particularly between the towers. The cables should be checked for rusting, spalling of the steel threads and general loss of tension. The loss of tension is not easily quantifiable but should be apparent from loss of structural integrity or deformation of the footbridge.

Subject to inspections and maintenance during the bridge life, the risk of main cable breakage is considered extremely low.

9.5 Cable Connections

The live load from pedestrian traffic and wind effects tends to impose stresses on the connections. The connections may lose functionality because of shearing of bolts and rivets, unscrewing of nuts or slackness in grips and studs. Each joint should be examined visually for any such failures and the defects repaired.

9.6 Vertical Hangers

The vertical hangers are subject to vertical and horizontal oscillations as well as to human activity at the supports and may be displaced from their vertical orientation. It is easy to recognise a malfunctioning hanger by the loss of straightness and alignment. In exceptional circumstances, the hangers may be bent from vandalism.

9.7 Deck

The deck is exposed to live loads from pedestrian activity. The deck may be subjected to unusual loads leading to localised failure of the deck walkway. The deck may fail if concentrated live loads are imposed. The deck is also prone to weathering and normal wear and tear from human activity leading to the wearing of the deck connections as well as the general deterioration of the components.

9.8 Side Mesh

The side mesh is the most vulnerable component of the deck due to the flexibility of the construction materials. The mesh may be vandalised by pedestrians.

10.0 MAINTENANCE

The primary objective of maintenance activities should be preventative to avoid the need for member replacement or other major repairs.

Should degradation/damage be observed, the concept allows for the following potential methods of maintenance.

10.1 Foundations

- Cracks in concrete shall be made good by sealing.
- If steel reinforcement is exposed from spalling, the rust should be cleaned from the steel surface and the surface thoroughly cleaned before sealing with cement mortar.
- Efflorescence resulting from chemical attack should ideally be washed by water jetting or scrubbing the concrete surface.
- Heaving or shifting of the footings shows a major failure of the footbridge and ordinary remedial works are not adequate to redress the problem. The engineer may have to re-design the footings to add stability to failed components.

10.2 Anchorages, Steel Cables and Cable Connections

Those steel components showing advanced rusting should be repaired by painting the parts with approved weather-resistant paint or bitumen seal. The connections should be retightened where they are loose. The sag may be monitored as a check for the main cables.

In cases where the components are no longer functional, the connections should be replaced completely by new parts.

The detailed design phase should consider how key components such as cables can be replaced, if necessary, without having to deconstruct/reconstruct the bridge.

10.3 Vertical Hangers

The hangers should be realigned and fixed into place by securing the joints and connections. The steel should also be repainted if rusting has been observed. If the hanger has deteriorated beyond functionality, then that hanger should be replaced. Care should be taken to ensure that the hanger is of the right length and that the hanger is in tension to operate in tandem with the rest of the hangers.

10.4 Deck

If an individual panel has deteriorated to such an extent that it is now unsafe, then the panel should be removed and be replaced by a new one. Take care not to weaken the adjoining panels and to secure the panel correctly.

10.5 Side Mesh

The mesh will be in panels which can be replaced if necessary. Alternatively, the mesh may be patched by fixing a piece over any deteriorated section.

11.0 PRELIMINARY COST ESTIMATE

The Fairhaven to Skenes Creek Coastal Trail Feasibility Study (Table 15) used lower and upper bound rates for the suspension bridges of $2,695 and $4,600 respectively, per metre length. The lower bound rate was based on the cost of the Maramataha Bridge built in 2011, extrapolated to 2019 dollars (Table 15 Note 18). No basis is provided for the upper bound rate.

Multiplying the 2019 rates by 1.1 for 2022 dollars and adding 30% contingency, given the early stage of the project, gives lower and upper bound rates of approximately $3,900 and $6,500, respectively.

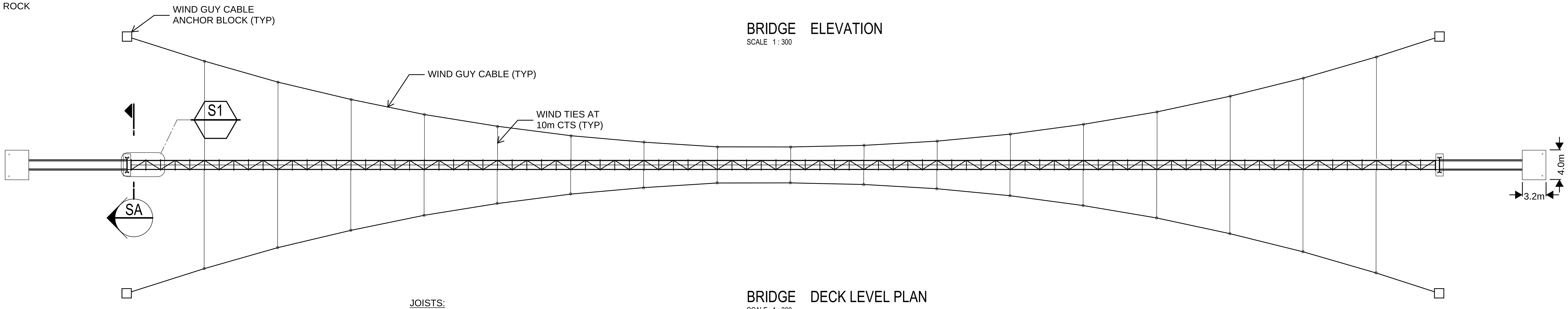
Proposed Bridges 0, 1, 2, 4 and 5 are similar in form to the Maramataha Bridge except that they are designed for a higher live load and foundations are likely to be more expensive. Given that, as well as the escalation on building materials post COVID-19 and the current surge in construction, we consider that the upper bound rate is more realistic.

APPENDIX A
STRUCTURAL SKETCHES

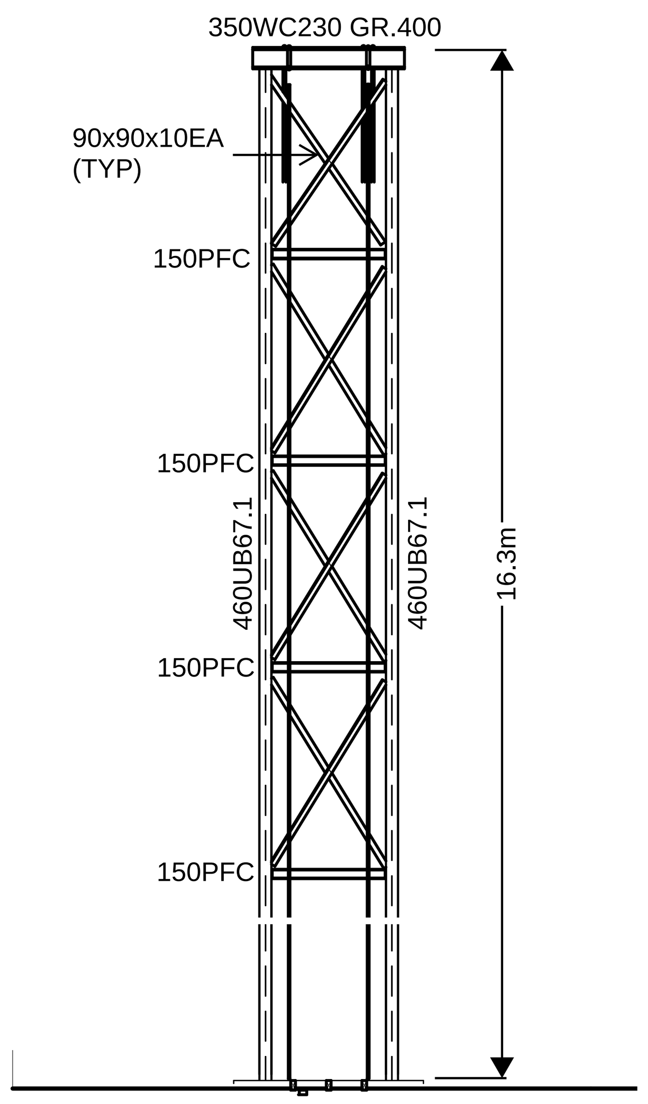
SKETCHES INDICATE A HIGH LEVEL CONCEPT DESIGN ONLY. THIS INDICATIVE SKETCH IS FOR THE PURPOSES OF COMMUNICATING A CONCEPT ONLY AND IS SUBJECT TO DETAILED DESIGN IN A FUTURE PROJECT PHASE.

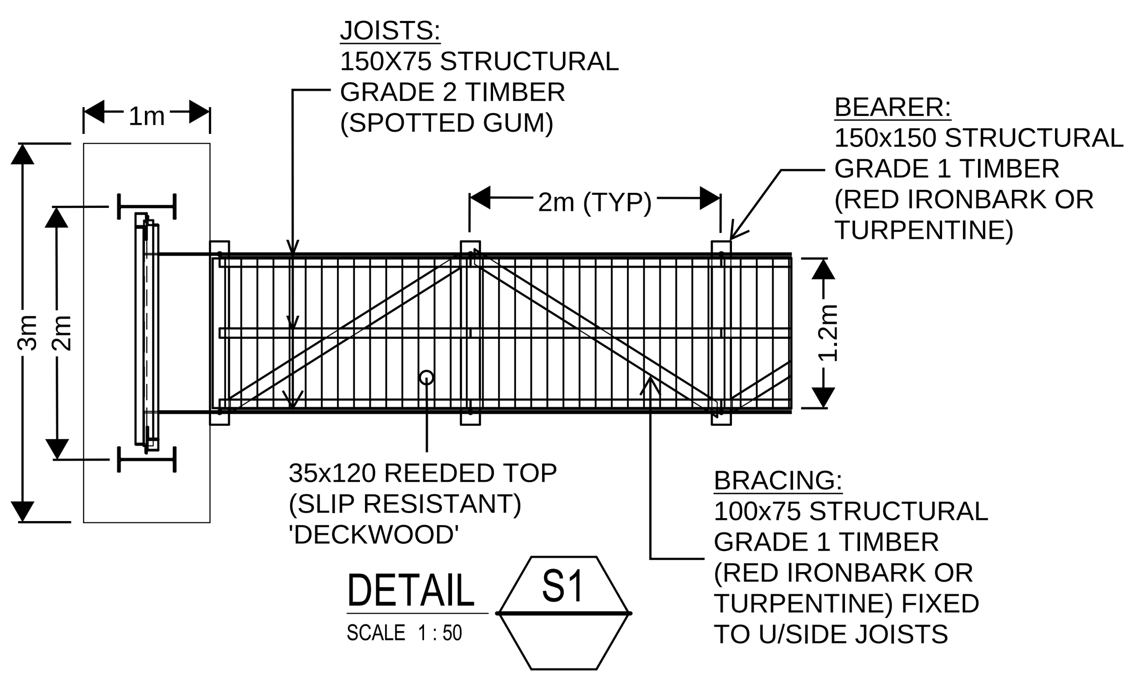
BRIDGE	SPAN (m)	SAG (m)
0 Grassy Creek	132	12
1 Big Hill	141	12
2 Reedy Creek	71	6
4 Winterbrook Falls	164	15
5 Mt. Defiance	165	15

BRIDGE ELEVATION
SCALE 1 : 300

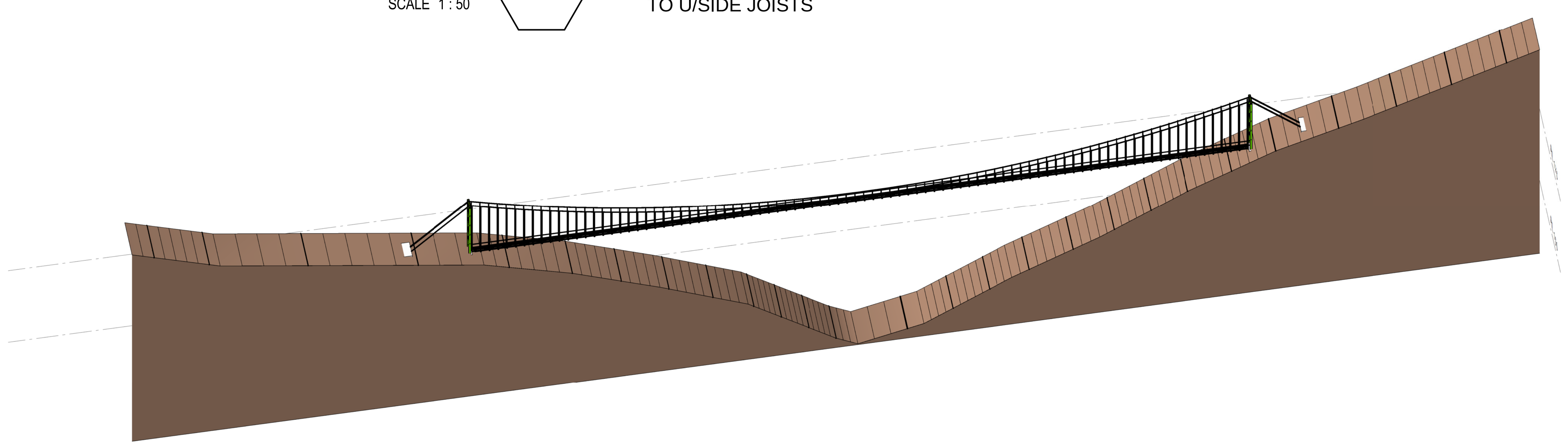


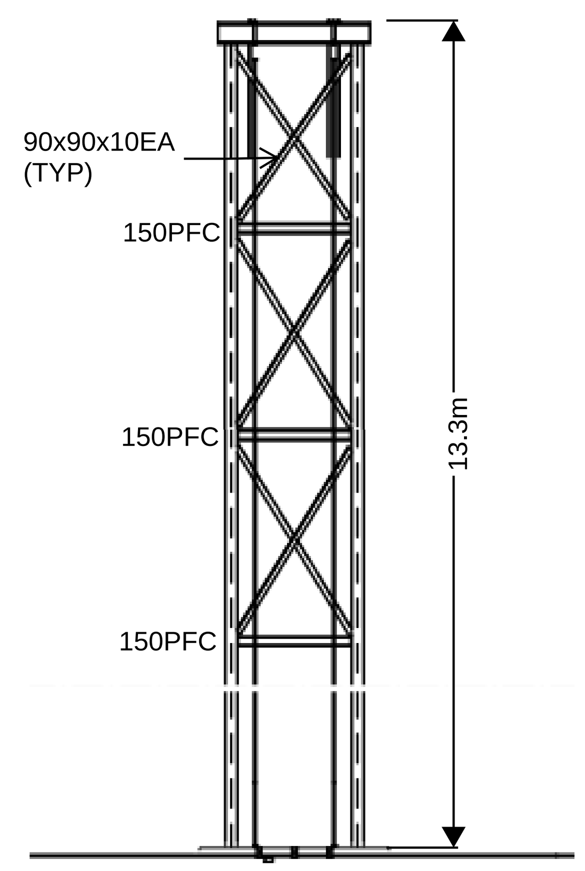
BRIDGE DECK LEVEL PLAN
SCALE 1 : 300

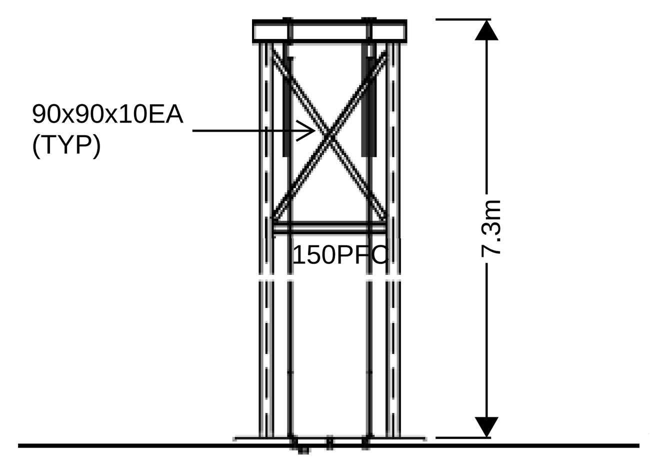




DETAIL S1
SCALE 1 : 50







SECTION SA BRIDGES 4 & 5
SCALE 1 : 100

3D PERSPECTIVE VIEW - BRIDGES 4 & 5
WIND GUY CABLES AND WIND TIES NOT SHOWN

SECTION SA BRIDGES 0 & 1
SCALE 1 : 100

SECTION SA BRIDGE 2
SCALE 1 : 100

BLIGH TANNER

REV	DATE	DESCRIPTION
A	16/03/2022	
B	25/03/2022	
C	14/04/2022	
D	06/05/2022	

DRAWN | DESIGN | APPROVED
CHECKED | CHECKED | R.P.E.Q
DATE | DATE | DATE

PROJECT: GREAT OCEAN ROAD TRAIL
LOCATION
CLIENT: WORLD TRAIL

DRAWING TITLE: SUSPENSION BRIDGE GENERAL ARRANGEMENT
ARCHITECT
ASSOCIATE CONSULTANT

SCALES
JOB NO
DRAWING NO
REVISION: D

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