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Email: CountryBridgeSolutions@rms.nsw.gov.au

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Foreword:

Roads and Maritime Services has prepared this document as a guide for producing a complete Country Bridge Solutions (CBS) modular bridge design for a site. It provides technical data pertaining to standard CBS components and practical guidance for procuring or carrying out the design.
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# 1. Common terms used in this guide

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<th>Term</th>
<th>Definition</th>
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<tr>
<td>AADT</td>
<td>Annual Average Daily Traffic, determined by measuring the number of axle pairs crossing at a specific site per year and dividing this number by 365</td>
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<tr>
<td>Abutment sill beam</td>
<td>Horizontal precast concrete member that supports the deck modules at the end of the bridge deck and retains earth fill at the abutments</td>
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<td>Alignment</td>
<td>The geometrical form of the centreline of a carriageway in both the horizontal and vertical directions</td>
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<tr>
<td>AS 5100 Set</td>
<td>Australian Standard for bridge design that sets out the requirements for the design, using limit states principles, of bridges and other structures</td>
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<tr>
<td>Asset</td>
<td>An item of economic value owned by a person or organisation</td>
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<tr>
<td>Australian Height Datum (AHD)</td>
<td>A common national surface level datum approximately corresponding to mean sea level</td>
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<td>Australian standard</td>
<td>Standards prepared, adopted or approved by Standards Australia</td>
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<tr>
<td>Blockout</td>
<td>A void in the abutment sill beam or pier headstock to accommodate the pile starter bars</td>
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<tr>
<td>Carriageway</td>
<td>That portion of a road or bridge used by vehicles, including shoulders.</td>
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<tr>
<td>Cast-in-situ</td>
<td>Concrete that must be poured on site at a particular stage of construction, rather than precast and transported to site</td>
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<tr>
<td>CBS</td>
<td>Country Bridge Solutions</td>
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<tr>
<td>Certification</td>
<td>Document issued by the designer certifying that reasonable professional skill and care has been used in the preparation of the design, with a view to securing that it has been checked for compliance with the relevant standards, and has been accurately translated into construction drawings.</td>
</tr>
<tr>
<td>Concrete closure strip</td>
<td>Cast-in-situ concrete that connects neighbouring deck modules and provides transverse structural continuity</td>
</tr>
<tr>
<td>Component</td>
<td>Any discrete part of the bridge brought to site for assembly</td>
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<tr>
<td>Contractor</td>
<td>Organisation or individual that has been engaged to construct the bridge</td>
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<tr>
<td>Term</td>
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<tr>
<td>Cross fall</td>
<td>The carriageway slope at right angles to the alignment, expressed as a percentage</td>
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<tr>
<td>Deck module</td>
<td>CBS prestressed concrete double-T superstructure element</td>
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<tr>
<td>Design criteria</td>
<td>The particular requirements specified by Australian standards and other technical documents that the design must satisfy</td>
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<tr>
<td>Designer</td>
<td>Organisation responsible for the design and certification of the bridge</td>
</tr>
<tr>
<td>Design flood</td>
<td>A flood of known magnitude or average recurrence interval, or a historic event which is selected for bridge design purposes</td>
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<tr>
<td>Driven pile</td>
<td>Precast reinforced concrete pile, installed by driving</td>
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<tr>
<td>Environmental impact assessment</td>
<td>The process by which information about the potential environmental effects of a development proposal are collected, assessed and taken into account</td>
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<tr>
<td>General arrangement</td>
<td>Drawing sheet that gives an overall view of the bridge as it will appear once constructed, including a plan, elevation, typical cross section, site plan and vertical alignment diagram (as appropriate), and general notes pertaining to the whole drawing set.</td>
</tr>
<tr>
<td>Grade</td>
<td>The rate of longitudinal rise or fall of a carriageway with respect to the horizontal, expressed as a percentage</td>
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<tr>
<td>Holding down and restraint bracket</td>
<td>Galvanised steel bracket assembly that provides lateral, longitudinal and or vertical restraint to the superstructure</td>
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<tr>
<td>Hydraulics</td>
<td>The study of water flow in waterways, in particular the evaluation of flow parameters such as water level and velocity</td>
</tr>
<tr>
<td>Hydrology</td>
<td>The study of the rainfall and runoff process including the evaluation of peak flows</td>
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<tr>
<td>Laminated elastomeric bearing</td>
<td>A bearing made from natural rubber that has two or more metal plates bonded into it</td>
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<tr>
<td>Low performance level traffic barrier</td>
<td>Twin rail steel traffic barrier designed to meet low performance level criteria in accordance with AS5100</td>
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<tr>
<td>Pier headstock</td>
<td>Horizontal precast concrete member that supports the deck modules at the piers</td>
</tr>
<tr>
<td>Pile</td>
<td>Fully or partially buried bridge element arranged vertically and providing bridge foundation</td>
</tr>
<tr>
<td>Scour</td>
<td>The erosion of material by the action of flowing water</td>
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<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>Scour protection</td>
<td>Measures taken to reduce the effects of scour around bridge foundations and road embankments, such as large loose stones (rip rap) or gabions.</td>
</tr>
<tr>
<td>Skew</td>
<td>The angle between a line at right angles to the alignment and the centreline of the abutment sill beam or pier headstock</td>
</tr>
<tr>
<td>SM1600</td>
<td>Traffic loading model defined in AS5100, Part 2: Design loads</td>
</tr>
<tr>
<td>Soffit</td>
<td>Downward facing surface of any bridge component</td>
</tr>
<tr>
<td>Span</td>
<td>The horizontal distance between supports of a member</td>
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<tr>
<td>Timber beam bridge</td>
<td>Bridge in which the principal means of spanning between piers/abutments is longitudinal timber members, typically round undressed hardwood</td>
</tr>
<tr>
<td>Waterway opening</td>
<td>The area in the vertical plane of the alignment bounded by the natural ground surface and the design flood level, minus the area of piers, abutments and other permanent obstructions to flood flows</td>
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2. Introduction

What is Country Bridge Solutions?

CBS is a modular bridge system developed by Roads and Maritime Services (Roads and Maritime) to assist councils in replacing bridges on regional and local road networks. The system delivers an innovative and reliable standard bridge design and construction sequence consistent with both Australian Standards and Roads and Maritime technical documents.

Conceived for the replacement of ageing timber beam road bridges in regional NSW, the CBS system has two key strengths:

1. It provides a suite of standardised solutions that can be constructed under various site conditions with minimal variation to the design of the bridge components.
2. Its designs are supported by a set of best practice guides that clearly explain the processes that need to be followed throughout the entire asset life cycle in order to ensure a high quality, durable, safe and fit-for-purpose bridge solution for each site.

Key features of CBS include:

- A suite of standard bridge drawings for a modular bridge solution.
- Guidance on solution selection, site investigation, detailed design, construction, operation and maintenance management provided in a set of four best practice guides.
- A fully certified bridge deck system, incorporating prestressed concrete double-T deck modules.
- Standardised substructure components that can be easily adapted to suit a range of site conditions.
- Three standard bridge configurations to suit different future traffic demands and site constraints, including a two-lane and a single-lane ‘stitched’ solution, as well as a simplified ‘butted’ solution for single lane remote sites with very low expected heavy vehicle traffic volumes.

Why CBS?

The CBS system provides councils with:

1. High quality, durable and easy to build structural solutions developed by technical experts in bridge infrastructure and explained in guides written in plain language.
2. New bridges designed to current Australian bridge design standard traffic loading.
3. Opportunity to improve access for heavy vehicles and agricultural equipment through an enhanced standard carriageway width.
4. Opportunities to use local labour resources and regional manufacturing capability.
5. Transportability of precast components on standard General Access trucks.
6. Minimised on-site concrete requirements, especially for remote lightly trafficked sites.
7. Low performance level barriers suitable for submergence.
8. “Cradle to grave” guidance on bridge asset management.
9. Reduced maintenance requirements resulting from a 100 year design life.
10. Increased capacity of regional transport networks to the benefit of community and commerce.

Responsibilities

Roads and Maritime has standard drawings for the components of a modular bridge solution, as well as guides covering solution selection, site investigation, detailed design, construction, operation and maintenance management.

Though not an exhaustive list, the responsibilities of the council, should they choose to use CBS, include the following:

- Produce or procure a set of detailed drawings for each site, incorporating the standard deck modular system and adapting the substructure components to the site conditions
- Certify the final bridge design for the site
- Meet all WHS obligations during investigation, design, construction and maintenance operations
- Meet all environment and heritage obligations during investigation, design, construction and maintenance operations.

2.1. This Guide

This guide has been developed to assist NSW councils with producing detailed design drawings for a CBS bridge and associated documentation. Guidance has been provided based on Roads and Maritime policies and typical practices. As a road authority, the council may adopt different practices in accordance with its own policies and procedures in some instances. Where decisions to deviate from the content of this guide are taken, care should be taken to ensure that the quality of the product is not compromised.

The information in this guide is necessarily general in nature, and council should seek specialist advice where recommended in order to successfully develop a bridge solution for their site. The guide follows on from the CBS Suitability and Investigation Guide, and assumes that the appropriate CBS bridge type has been selected for the site, and all the necessary investigations have been undertaken. Refer back to the Suitability and Investigation Guide if information requires for any design task is not yet available.

The design stage utilises data gathered during the investigation stage to incorporate the standard CBS components into a site-specific design. The guide outlines the design criteria for the CBS system as a whole, as well as for individual bridge components.

The diagram below shows how this guide sits within the overall sequence of the CBS process.

![Diagram of the CBS process](image-url)

Figure 2-1: The Country Bridge Solutions process
2.2. Country Bridge Solutions delivery process

The following information provides a brief outline of the CBS delivery process to assist the reader during the design phase.

The CBS system delivers a set of standard components that can be combined and used for specific bridge sites with a minimum amount of design work required to complete a drawing set for a new bridge.

The whole CBS delivery process, and how the four guides combine with the CBS standard drawings and council requirements to inform that process, is shown below.

![Country Bridge Solutions delivery process diagram](image-url)

Figure 2-2: Country Bridge Solutions delivery process
3. **CBS Design Process**

The outcome of this phase will be a complete set of detailed design drawings for the construction of a new bridge at the selected site. These drawings need to be produced by an experienced bridge designer, who can provide certification for the design. However, this designer does not need to start from scratch as standard drawings for many of the CBS bridge components are available. The designer must ensure that design criteria listed in the notes of these standard drawings have been satisfied in their overall design.

For each CBS bridge type and span length, there is a standard drawing set available that includes all the superstructure components, and some substructure components. These components are certified by Roads and Maritime engineers, as long as they are constructed in accordance with the drawings and referenced specifications. It is up to the designer to complete the design of the substructure in order that all loads from the superstructure are adequately transmitted to the foundations.

The designer is responsible for certifying the overall bridge design.

### 3.1. Design development

The CBS system provides drawings for a selection of modular bridge components that can form part of a completed drawing set. The development of the completed design and its drawings must be carried out by a suitably qualified bridge designer. It is vital that such a design is carried out by designers with experience and expertise in bridge design in order to ensure a quality product fit for council’s purposes.

The tasks that the designer will need to carry out include:

- Obtain traffic, road design, waterway and geotechnical information for the specific site.
- Confirm that the CBS modular bridge system is suitable for the site
- Select the appropriate CBS standard drawing set for the proposed CBS modular bridge type and span length
- Determine and provide all the information required on the cover sheet and general arrangement drawings for the specific site.
- Carry out the structural design of the bridge to incorporate the standard CBS elements, utilising the information provided by council that it gathered during the investigation phase.
- Design any modification to the standard drawings required to suit specific site conditions
- Design the substructure and foundations, and produce relevant drawings
- Design any remaining bridge elements not covered by the CBS standard drawing details
- Certify the complete bridge design
- Issue a set of drawings for construction, as well as a design report outlining design assumptions made, load combinations designed for, and explaining how the design meets council’s requirements.
The design development process is illustrated below:

Figure 3-1: Country Bridge Solutions design development
To assist council in ensuring that the designer provides a value-for-money service, council should request that the designer provide a design program, to which they must commit. This should show how they plan to meet at least the following critical milestones:

- Confirmation that the selected bridge type, span lengths, carriageway width and bridge general arrangement are appropriate for the site
- Submission of a 20% concept design, showing completed general arrangements and all the selected standard drawings
- Submission of an 80% detailed design showing a substantially completed bridge design, with all dimensions and notes included
- Submission of a 100% design, demonstrating that all council's comments on the 80% submission have been addressed and is suitable for tender documents and/or council use for construction.
- Submission of Issued for Construction (IFC) drawings and a completed design report, including certification of the design and a list of specifications for construction

### 3.2. Design review

The milestones in the previous section give opportunities for council to provide feedback to the designer. If refinements to the design that will provide substantial benefits to any stakeholder are desired, it is more cost-effective to incorporate them as early as possible in the design development. For example, council staff responsible for maintenance may have particular suggestions that will make access to the structure safer or less costly.

The best way to provide for these refinements, as well as to check that the designer is meeting their obligations, is to maintain a register of design comments. This could be a simple spreadsheet or table that collates comments from all relevant stakeholders, and logs the designer's responses to each one. It should be a requirement on the designer that all comments have been closed out to the satisfaction of council before the design can move on to the next milestone. Stakeholders can be invited to make comments at the 20%, 80%, and 100% stages. It is useful to hold a close-out meeting with the designer after the 100% stage, to ensure that all comments have been addressed.

To keep this process manageable, council may wish to limit the number of stakeholders who provide comment. The council’s staff directly involved with the bridge delivery should be included as a minimum, and other staff such as those responsible for managing safety and environmental obligations and community consultation could also be involved, as deemed appropriate.

### 3.3. Proof checking and verification

The design and drawings should be checked by a proof checking team (verifier) that may be from the same organisation, however should be independent of the design team proposed by the designer.

The proof checker should carry out an independent design check of the detailed design and any proposed departures, including specification clauses that affect structural integrity (e.g. new materials), and should ensure that it complies with council requirements. The checker (verifier) should ensure that the calculations are translated accurately into the design details, drawings and specification clauses.

The proof checker’s analytical works should be independent of those of the designer and carried out without exchange of calculation sheets or similar information between the designer and the proof checker. The method of analysis employed by the respective teams need not be the same.
The proof checker must prepare a report listing his assumptions, methodology and summary of the structural capacity and confirm the suitability of the design. The designer and the proof checker should consult with each other if the results they are obtaining are not comparable and resolve the differences prior to the issue of IFC drawings.

4. CBS Bridge Design

4.1. CBS Design Criteria

The CBS system is designed for application in its entirety and comprises an assembly of precast concrete modular components, prepared by experienced bridge engineers. The designs maximise the use of pre-cast elements and brings innovation to component installation methods.

The CBS system has been designed and developed in accordance with AS 5100 Set 2007- Bridge Design Set, particularly for the following loadings:

1. SM1600 road traffic loading including braking forces.
2. Water flow forces including scour and submergence.
3. Earthquake
4. Barrier impact

The conditions typically encountered in the remote rural road network have been taken into account in arriving at a Low Performance Level for the design of traffic barriers in the documentation of standard drawings. Low performance barriers are provided for the effective containment of light vehicles. These barriers shall be used for low risk sites, taking into consideration the speed, environment, when all of the following provisions apply:

a. Bridges on roads with low traffic volumes.
b. Bridges with low to medium height above ground or water.
c. Bridges with an essentially straight alignment.
d. Bridges with a width between barriers of not less than 6.5 m for a 2 lane bridge or 4.2 m for a single lane bridge.

The standard design must be adjusted to suit to any deviation from the above design assumptions.

The following structural elements are not covered in the CBS standard design and shall be designed, verified and certified in accordance with AS 5100 and RMS reference documents (namely Bridge Technical Directions, Standard Bridge Drawings, Waterway manual and Structural Drafting and Detailing Manual) by suitably qualified engineers experienced in bridge design with a level of experience determined by the council:

- Piles, pile caps footings, columns, and where required wall under sill beam...
- Anchorage reinforcement from piles, columns, footings or pile caps into pier headstocks and sill beam recesses.
- Deck module holding down brackets for bridges where the ultimate water flow velocity exceeds 4m/s and where the overtopping exceeds 5m.
- The pier headstock supporting unequal spans on each side
• Traffic barrier, railing, attachments, reinforcements in the precast modules and wingwalls for barriers for any other performance level other than Low performance...

• Verify that all the requirements of AS 5100 are met for specific sites where barriers are omitted

• Temporary support and bracing for all precast elements.

• Any required embankment/scour protection

• The substructures where maximum out of position of piles measured at cut off levels of piles exceed 75mm.

The structure has been designed for the weight of waterproof membrane which is required to be installed in accordance with RMS QA specification B344 if cracks wider than 0.2mm develop on the deck surface or along the construction joints.

4.2. Components

The design of the following CBS components have been standardised in accordance with the design criteria in Section 4.1 and certified documentation is included in the set of standard drawings:

1) deck module including traffic barriers
2) bearings
3) holding down and restraint bracket
4) pier headstock
5) abutment sill beam
6) wing walls.

The design of the foundations cannot be standardised due to the varying conditions from bridge site to site. However suggested design options for the foundations are captured in the sets of standard drawings.

Figure 4-1: Design of components covered by CBS and components that needs to be designed by the designer
4.2.1. CBS Standard Components

**Deck Modules:** The superstructure comprises 600mm deep precast prestressed concrete double-T deck modules complete with low performance level traffic barriers. For each type and span length the deck modules are fully detailed so that the same base deck module mould could be utilised by adjusting to suit the specific width and span length. This must be used in strict adherence to the design criteria and notes shown on the cover sheet of the drawing set to retain certification.

**Traffic Barriers:** The bridge traffic barrier is designed for low performance level. If any other performance level is required for a specific site, the design shall be adjusted in accordance with AS 5100. Where providing the barrier constitutes a higher risk such as frequent structural damage during flooding, the traffic barriers may be omitted provided all the requirements of clause 13.5.2 of AS 5100.1 are met.

**Bearings:** Laminated elastomeric bearings mounted on grout pads to suit each type are designed and detailed in the corresponding standard drawing set. The standard drawing set also includes the installation procedure to facilitate accurate setting out and levelling of the bearings.

**Holding Down and Restraint Brackets:** The restraint brackets are fabricated from steel sections, galvanised and anchored into the headstock and deck using couplers and bolts. They are designed to provide vertical restraint (holding down) for Types 1 and 2 and both vertical, lateral and longitudinal restraint for Type 3. The lateral and longitudinal restraint for Type 1 and 2 are provided by the shear keys with dowels.

**Precast headstocks:** The pier headstocks are 900mm wide and either minimum 750mm or 900mm deep depending on the number of pile/column supports. The headstocks are detailed with block outs to accommodate the required number of pile/column supports. The concrete and reinforcement details are provided.

**Precast abutment sill beam:** The abutment sill beam is fully detailed. They are 900mm wide and minimum 900mm deep and the appropriate type to suit the number of block outs needed to suit the pile/column support must be selected by the designer.

**Precast Wingwall:** Precast reinforced concrete wing walls mounted with Low performance barrier have been designed for cantilever lengths of 3.7m and 4.6m. They are detailed with a void at the interface with the curtain wall so that it can be made integral with the abutment sill beam via cast in situ stitch pour.

4.2.2. Substructure

Substructure drawings are provided as non-certified templates and contain various options for the foundations with design criteria and suggested notes for use by the design engineer. These need to be selected to suit site specific foundation, water flow, articulation and earthquake conditions and designed accordingly. The precast headstocks and abutment sill beams corresponding to each option are fully detailed.

**Cast-in-situ columns / precast piles / footings:** The columns, footings and piles are not detailed. They shall be designed and detailed by the design engineer to suit the foundation conditions. It should be noted that the substructure with 800mm diameter columns can directly support the precast headstock. All others require temporary supports.
4.3. CBS bridge types

There are three CBS bridge types, as outlined below and for each type, standard drawings for span lengths of 8m, 10m and 12m have been published.

- **TYPE 1** – Two Lanes with Closure pour (8.5m carriageway)
- **TYPE 2** – Single Lanes with Closure Pour (8.5m carriageway)
- **TYPE 3** – Single Lanes without Closure Pour (4.2m carriageway)

The standard design drawings of CBS bridges contain details and information for the whole structure with suggested options for various combinations of components listed below:
TYPE 1: Two Lanes with Closure pour (8.5m carriageway)
The deck module type comprises four precast prestressed concrete double-T modules placed side-by-side and stitched together with cast-in-situ concrete closure pour strips. This provides an 8.5m carriageway width with a two-way cross fall, to carry two lanes of traffic. It has a 150mm high kerb with an 800mm high low performance level steel traffic barrier. (Figure 4-2).

Figure 4-2: Country Bridge Solutions Type 1
The layout of the substructure has been developed for the following options and shall be selected to suit the foundation conditions Site specific substructure designs shall be carried out for the selected option:

- **Option 1**: 3 Nos dia 800mm dia or 4 Nos dia 600mm circular columns and cast-in-situ footings
- **Option 2**: 4 Nos or 5 Nos 450mm square precast reinforced concrete driven piles.

TYPE 2: Single Lane with Closure Pour (4.2m carriageway)
Comprises two prestressed concrete double-T modules placed side-by-side and stitched together with a single central cast-in-situ concrete closure pour strip. This provides a 4.2m carriageway width with a one-way cross fall, to carry only one lane of traffic. It also has a 150mm high kerb with an 800mm high low performance level steel traffic barrier. (Figure 4-3)

Figure 4-3: Country Bridge Solutions Type 2
The layout of the substructure has been developed for the following options and shall be selected to suit the foundation conditions. Site specific substructure designs shall be carried out for the selected option:

- **Option 1:** 2 Nos dia 800mm dia or 4 Nos dia 600mm circular columns and cast-in situ footings
- **Option 2:** 4 Nos 450mm square precast driven piles.

**TYPE 3: Single Lane without Closure Pour (4.2m carriageway)**

Comprises two prestressed concrete double-T modules placed side-by-side with a central longitudinal deck joint in lieu of a cast-in-situ concrete closure strip. This also provides a 4.2m carriageway width for one lane of traffic, but is limited only for very remote site locations where it is impossible to obtain a supply of high quality concrete, and where the traffic volumes of heavy vehicle will be very low (below 20). (Figure 4-4).

![Figure 4-4: Country Bridge Solutions Type 3](image)

Figure 4-4: Country Bridge Solutions Type 3

The layout of the substructure has been developed for the following options and shall be selected to suit the foundation conditions. Site specific substructure designs shall be carried out for the selected option:

- **Option 1:** 2 Nos dia 800mm dia or 4 Nos dia 600mm circular columns and cast-in situ footings
- **Option 2:** 4 Nos 450mm square precast reinforced concrete driven piles
5. Design certification

The CBS components are certified to be used in accordance with the design criteria shown on the relevant cover sheet. Where detailed design requires modifications to these components, re-certification due to modifications of the component for the specific application will be required.

Once the designer has completed the full set of drawings for the bridge, the designer must certify that the full set as a complete design solution for the site.

6. Safety in Design

Safety in design (SID) considers the risks associated with choices made in design and construction of the bridge and how design can be modified to eliminate or minimise their effects. The standard design assumes the asset owner, designer and contractor are familiar and aware of the risks associated with structural work. The work will require a site specific risk assessment process.

To comply with the NSW Work Health and Safety Act and Regulation 2011 and the Safe design of structures Code of Practice, SID is a key process required when designing the new bridge. The aim of SID is to ensure, so far as is reasonably practicable, that the designed structure minimises risks to the health and safety of people who construct, use, maintain or demolish them.

The process is carried out at the beginning of the design and at key stages throughout the development of the design. SID reviews are usually carried out using the Construction Hazard Assessment Implication Review (CHAIR) process and consider all hazards relating to construction, commissioning, operation, maintenance and decommissioning of the work. The intention is to ensure that hazards relating to design are identified at an early stage and that systems are established to control these issues and hazards.
7. References

The following publications were referred to in this guide:

- Austroads Bridge Design Code (1992)
- NSW Work Health and Safety Act and Regulation 2011

7.1. Country Bridges Solutions materials

- Country Bridges Solutions: Overarching guide
- Country Bridges Solutions: Suitability and investigation guide
- Country Bridges Solutions: Design guide
- Country Bridges Solutions: Construction guide
- Country Bridges Solutions: Operation and maintenance guide