Drafting and Design Presentation Standards
Volume 3: Structural Drafting Standards

Chapter 14: Prestressed Concrete Girders

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Queensland Government

Feedback: Please send your feedback regarding this document to: tmr.techdocs@tmr.qld.gov.au

Chapter 14 Amendments

Revision register

Issue/Rev No.	Reference Section	Description of Revision	Authorised by	Date
1	–	First Issue.	Manager (Structural Drafting)	Apr 2011
2	–	Document name change.	Manager (Structural Drafting)	Nov 2011
	14.5	The 30 mm dia drain hole shall not be positioned vertically between strands. Restraint angle fasteners shall be located above the bottom two rows of strands. Strands shall have 60 mm min cover to voids.		
	14.6	Restraint angle details vary depending on the forces they are designed to accommodate.		
	14.8	Figures amended to shown current standard reinforcement details. Fastener move upwards between 2nd and 3rd row of strands.		
	14.10	Add details on alternate cross girder design. Holes may be required if the bridge is subject to flooding.		
	14.12	Lifting Loops section added.		
	14.13	Girder erection sequence added.		
	Appendix A	1200 mm deep girder removed. 1500 mm and 1800 mm deep girders updated.		
	Appendix B	Example drawings replaced.		
3	All sections	General revisions and the inclusion of new Transport and Main Roads approved Wide Flange I-Girders.	Team Leader (Structural Drafting)	Feb 2018
	14.3.1	Figure 14.3.1 Closed Top Flange T-Girders marked 'Not Permitted'.		
	14.4	Girder drawings to include all the information required by casting yards.		
	14.5	Figures 14.5-4, 14.5-5 and 14.5-7 amended. Reference to Attachment Plate and minimum dimensions.		
	14.6	Figures 14.6-1, 14.6-2, 14.6-3 and 14.6-5.		

Issue/Rev No.	Reference Section	Description of Revision	Authorised by	Date
	14.7	Figure 14.7-1.		
	14.9	Notes added regarding the stability of girders.		
	Appendix B	Sample T-Roff girder drawings - Sheet 10. Two 10A bars deleted from end grid (1st and 3rd bar from the bottom deleted).		

Contents

Figures

14 Prestressed Concrete Girders

14.1 Glossary of terms

For a complete glossary of terms refer Chapter 1 – *Introduction.*

14.2 Figures and examples shown in this volume

The figures and examples shown in this volume are for presentation purposes only, and may contain some details that are now superseded. These details have been included for ease of reference, to illustrate typical solutions, and to show the required standard of drafting presentation. The details are not to be used without an engineering check and certification by a Structural RPEQ to confirm that the details are appropriate for the specific project.

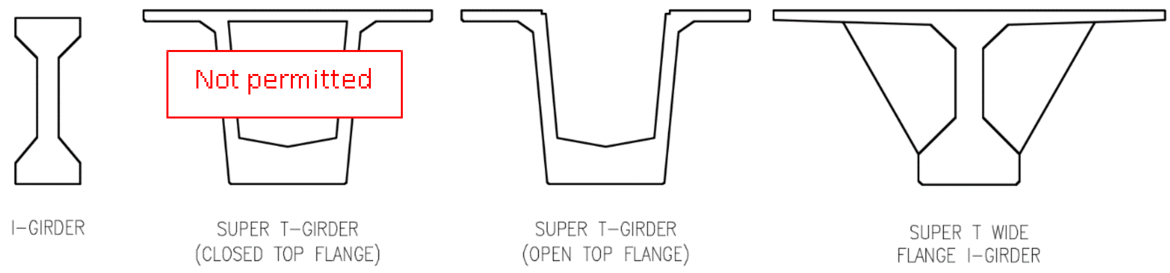
14.3 General

This chapter discusses the typical arrangement of PSC girders. PSC Super T-Girders are currently the most prevalent girder type for spans in the order of 25 – 36 m. Alternative 'Wide Flange I-Girders' now have type approval for designs where spans may be up to 46 m. Wider flanges for this girder type may also be used (shorter spans) to reduce the required number of girders. Many details shown in this chapter specifically are relevant for Super T-Girders. Most of the general parameters are applicable to the Wide Flange I-Girders also, for example, half joints (not permitted), restraints, and so on. Project specific examples of these girders may be sourced from the Lucinda Drive project on the Port Drive (Port of Brisbane) project. A design guide for the Transport and Main Roads approved 'Wide Flange I-Girders' is also available from approved suppliers as listed in the Proprietary Design Index for Bridges and Other Structures.

For Super T-Girders steel tub void formers are to be used, producing an open void which facilitates ease of inspection. Girders with closed voids are not acceptable due to casting issues related to the accurate restraint of void formers and the difficulty of verifying casting and compaction.

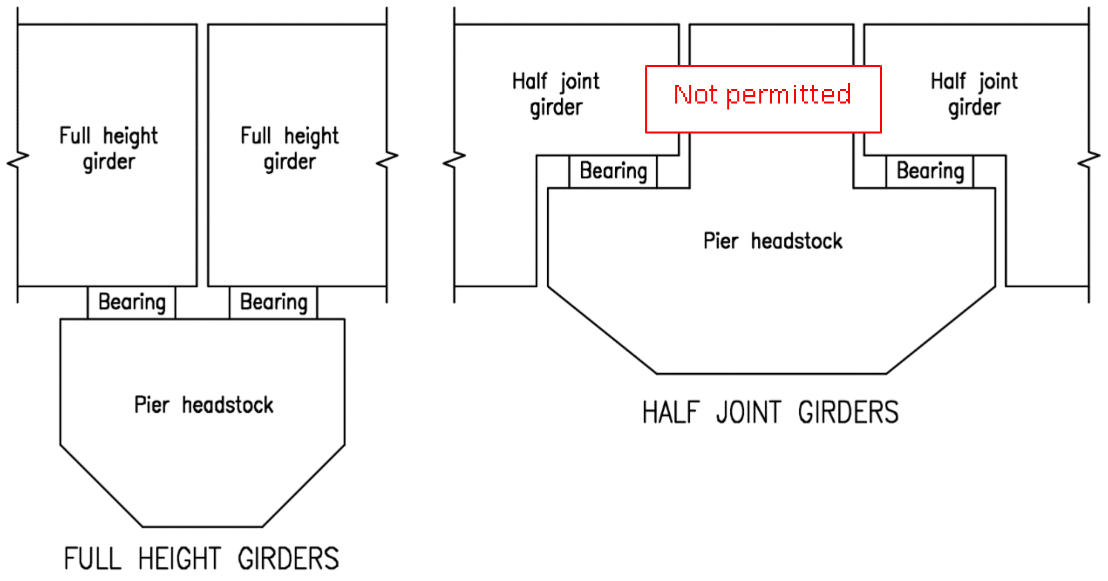
PSC girders are typically used for spans greater than 25 m long where they become more economical to use than PSC deck units. Refer example drawings in Appendix B - *Example Super T-Girder Drawings*.

Figure 14.3(a) - Girder types



Girders with half joints (shown below), are not permitted on Transport and Main Roads designs due to the issues related to shear forces at the half joints and the level of reinforcing required to overcome shear in such a compact environment.

Figure 14.3(b) - Girder joints



14.4 Standard design details

Standard Super T-girder design sheets have been developed in Structures and Marine Engineering Branch and are used as the standard for design and presentation in the production of departmental bridge drawings. For standard details for 1500 and 1800 mm deep super T-girders refer Appendix A *Super T-Girder Design Sketches*.

All departmental PSC girder drawings shall provide the casting yards with all the required project specific information in an easy to understand format on a succinct set of drawings, supplemented only by the general arrangements, general notes and specifications.

14.5 Super T-Girder profiles

T-Girder dimensions and void arrangements shall be in accordance with Chapter 4 of the *Design Criteria for Bridges and Other Structures*. Options are supplied for girder depths ranging from 1000 to 1825 mm deep.

Girder sectional properties for Super I-Girders will be project specific and within the constraints of the dedicated casting yard and subject to review by the department as per the normal design requirements of the *Design Criteria for Bridges and Other Structures*.

For girder mass calculations, the specific density of 2.7 tonnes/m^3 shall be used.

Super T-Girders - Flange widths

The outer profile of a girder must comply with AS 5100.5. Casting yard forms comply with this profile. The width of the girder flanges may vary to suit the width of the bridge deck.

Whenever possible, the flanges on outer girders are to be made the same width as those on the internal girders to keep the number of girder types to a minimum.

An example of where this is not usually possible is when a drain pipe hangs below the outer flange and this flange needs to be wider to accommodate the pipe and its expansion joints. Standard widths of girder flanges may vary from 1226 mm minimum to 2500 mm maximum.

On bridges with a horizontal curve, the outer flange of the outer girders, are to be curved to match the road alignment. When setting out the bridge, the Drafter shall ensure that the flanges are wide enough to fit holes for formwork anchors.

Super T-Girder voids

Voids shall be made from standard 5 m and 2.5 m long forms. The standard void sizes have been developed in coordination with the pre-casting industry and are designed to ensure the manufacture of PSC girders is efficient, simplified and cost effective.

Voids are separated longitudinally by a diaphragm of concrete 150 mm wide containing one set of steel reinforcement. The solid end blocks at each end of the girder will increase or decrease in size to accommodate the standard void lengths.

An end block length is measured along the centreline of the girder. On square or slightly skewed girders the end blocks may vary in length nominally from 2 m up to 3 m to avoid having a non-standard void length.

Refer to the *Design Criteria for Bridges and Other Structures* for acceptable void arrangements.

Super T-Girder void drainage

30 mm diameter drain holes are required between the voids and in the end blocks, to drain the voids prior to deck casting.

The 30 mm diameter drain holes shall not be located vertical between the strands, they must be horizontal between voids and continue horizontally through the end block of the girder each end.

If the bridge is subject to flooding, 100 mm diameter drain holes may be required at the base and top of the voids to allow the voids to fill with water to prevent the bridge from potential floatation.

Gaps between girders – All girder types

Standard practice is to space girders to allow a 30 mm gap between girder flanges, however this may vary slightly depending on the width of girder flanges and the width of bridge deck. During construction the gap is covered by approved high strength waterproof tape to prevent deck concrete from leaking between the girders.

Span lengths – All girder types

Span lengths from pier to pier are generally to be to the nearest metre, with a gap between girders of 50 mm. Thus a 27 m span utilises a girder length of 26950 mm.

In most cases end spans are to use girders with lengths matching the internal spans so the end span length is to be a resultant of the location of the bearings at the abutments.

Strands – All girder types

Strands are to have 60 mm cover to any voids and forms, minimum.

Gaps and inclined girder ends

A nominal gap of 50 mm is provided between the ends of girders on adjacent spans, and between the ends of girders and the abutment ballast wall. When girders are being placed on site they are lowered vertically into position. To provide adequate clearance it is important that the ends of the girders be vertical once placed on the structure.

Therefore, girders are to be designed to have nominally vertical ends after installation. The designer must make allowance for grades, vertical curves and rotation of the girder ends due to the effects of the 100 day design hogs so that the required vertical ends are achieved.

Worked example - bridge on a simple grade.

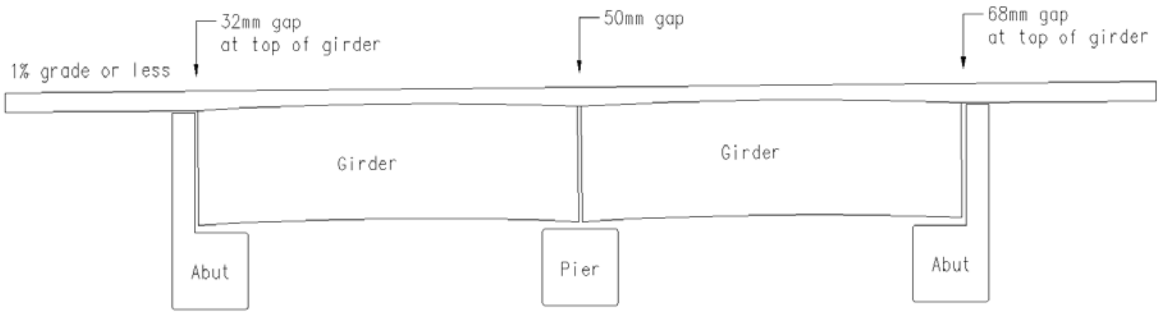
For a project with 1800 deep girders and a 1% grade: the gap between the top of the girder and the ballast wall will reduce at the low end of the bridge. At the lower abutment the gap from the ballast wall to the girder end will be 32 mm. At the high end of the bridge it will increase to 68 mm. These gaps are at the limit of what is acceptable, therefore, 1% is the steepest grade with which the girders ends can be made vertical (at 100 days after casting).

For grades greater than 1%, each end of the girder needs to be inclined to ensure that the ends will be vertical when the girder is installed.

For bridges on a vertical curve the end incline may vary on both ends of the girders on every span. These inclined dimensions may be rationalised to the nearest 5 mm to reduce the amount of variations.

Where deep girders are combined with grades and skews consideration should be given to increased clearance at the abutment ballast walls to accommodate discrepancies in the girder end kicks between designed end kicks and actual. Extra wide flanges may also create increased geometric challenges especially where a vertical curve is applied to the bridge deck. This must be taken into consideration by the designer.

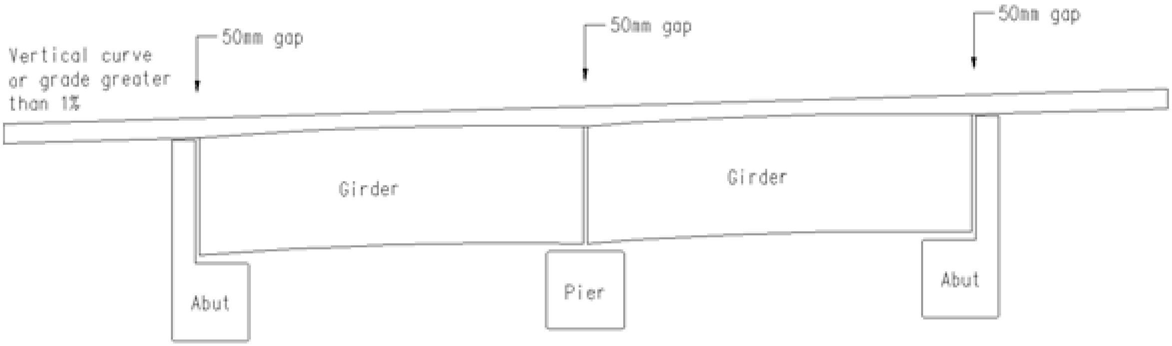
Figure 14.5(a) - Girder end incline guidelines



For bridges on a grade of 1% or less, the ends of the girders are not vertical, but are perpendicular to the bottom of the girder (after 100 days).

Note – The gaps shown are calculated using an 1800 mm deep girder on a 1% grade, the gaps will vary depending on the girder depth. The designer is to calculate the gaps and ensure sufficient clearance is achieved between the girder and the ballast wall.

Figure 14.5(b) - Girder end incline guidelines

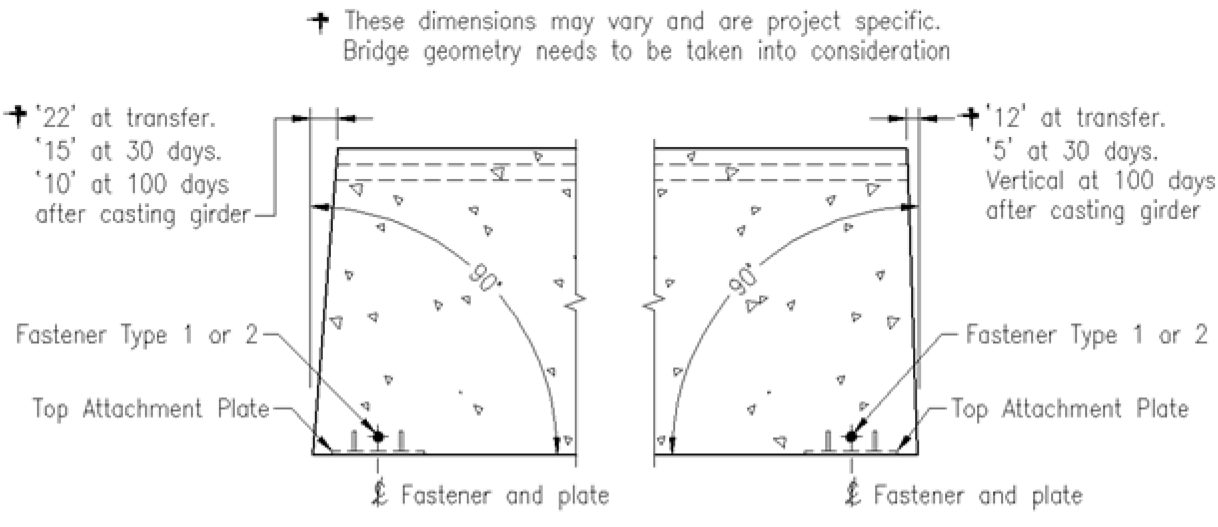


When end incline dimensions are shown on a drawing, three sets of distances are required. These are the distances at transfer, at 30 days, and at 100 days after casting. The transfer figure tells the casting yard what offsets the girder ends must have immediately after it has been cast and is leaving the form.

The casting yard will calculate and make an allowance for the amount of incline required in the form to achieve the designed incline at transfer.

About 30 days after casting, the girder may leave the casting yard, therefore an incline distance is provided to let the precast inspector check that the girder is hogging as designed. The incline distance at 100 days is the amount that the girder end is inclined when it is erected on the bridge. Refer *Figure 14.5(c) - Girder end incline details.*

Figure 14.5(c) - Girder end incline details



Girder anchorage details

Girders and or decks may be anchored by a number of systems.

The department accepts RPEQ certified designs for either:

1. Restraint angles connecting the girders to the headstocks, or
2. Restraint blocks with dowels into cross girders. The dowel caps placed in the cross girders are designed to restrain transversely and manage either expansion or fixed longitudinal restraints.

Pot bearings shall be used, as appropriate, for the larger loads and movements associated with longer spans and or wider flange girders.

A construction sequence for the bearing installation and girder erection is required to detail the proposed sequence and method of bearing and girder installation including the epoxy mortar.

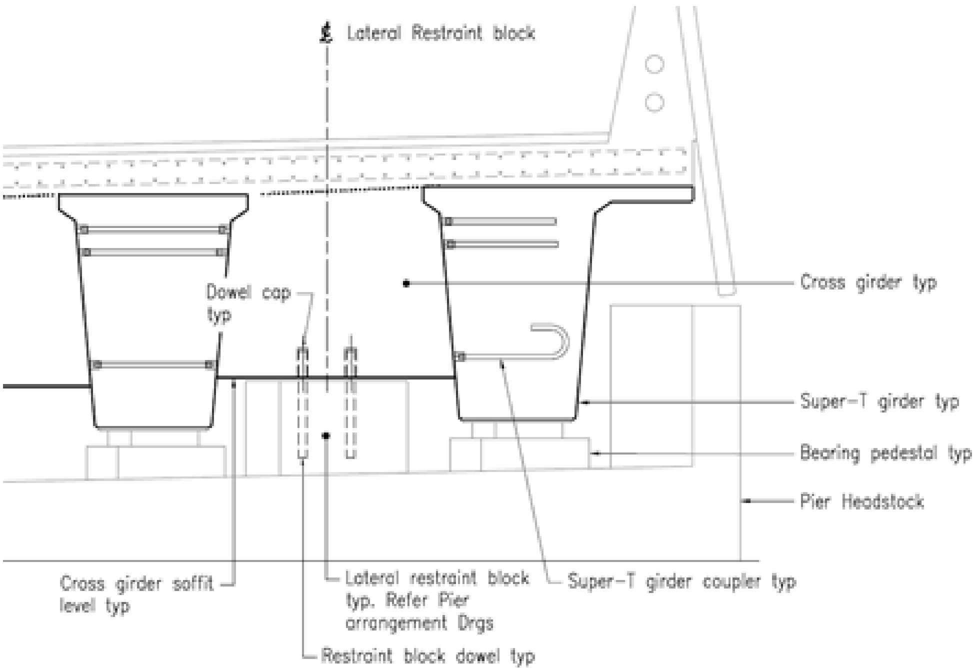
Restraint blocks

Where restraint blocks are used the number and sizes of dowels and restraint blocks are to be determined by the designer to accommodate the required loads. Typically it is expected that cross girders will be deeper than the restraint blocks and dowels will be cast into the restraint blocks deeper than they project into the cross girders. No proprietary products for dowels are approved for use in restraint blocks.

Sufficient details are to be shown for orientation, sizing, reinforcing, dowel caps, dowels, locations and correct installation dimensions and orientation.

Restraint blocks are to be supplied on both ends of each span so that the deck infill pour is not engaged to carry larger loads than otherwise required.

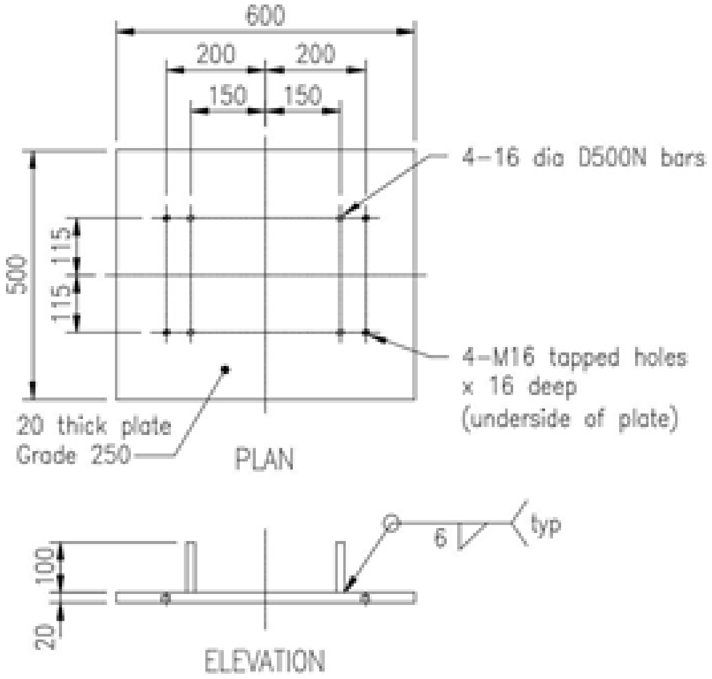
Figure 14.5(d) - Typical restraint block



Top attachment plates

A top attachment plate is cast into the underside of the girder and a bearing restraint plate is then screwed to this before the girder is lifted onto the bridge. The top attachment plate shall be larger in length and width than the bearing restraint plate to ensure plates fully engage after casting. The plate is to be 600 mm minimum width. Four dowel bars welded to the plate hold it in place in the girder.

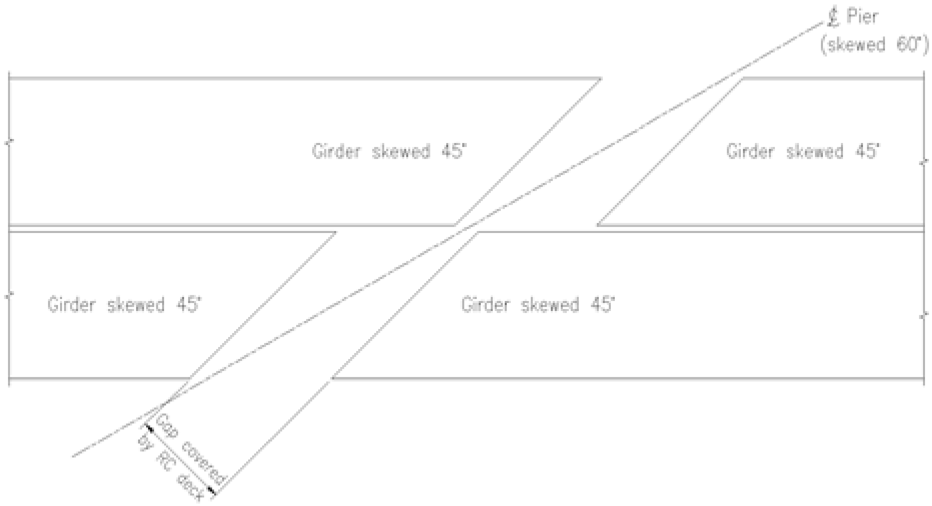
Figure 14.5(e) - Top attachment plate



Skew

Girders should not be skewed more than 45º. When the road and bridge geometry is being designed, every effort should be made to avoid skews larger than this. Due to constraints, skews larger than 45º are sometimes unavoidable. The department does not have a policy or standard details on how girders / decks skewed more than 45º are to be designed. One possible option is to increase the gap between girders of adjacent spans and cover the gap with a reinforced concrete deck. Refer Figure 14.5(f) - *Bridges skewed > 45º*.

Figure 14.5(f) - Bridges skewed > 45º

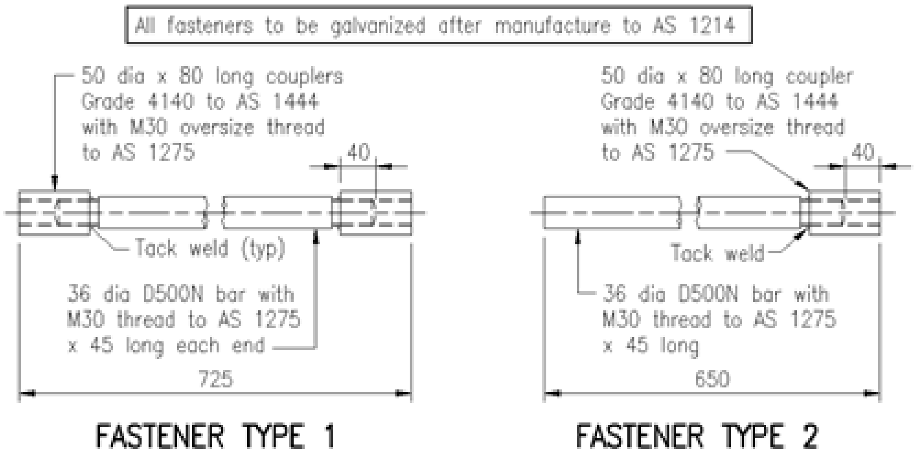


Fasteners

Fasteners are cast into the girder to allow cross girder reinforcement to be attached. These fasteners must be galvanised even though they are encased with cross girder concrete. This is to prevent corrosion caused by steam curing during casting.

Where fasteners are used for restraint brackets the fasteners shall be located above the bottom two rows of strands. To prevent the fasteners being hidden beneath the surface of the concrete a note on the girder drawings shall read '*Fasteners shall be exposed prior to delivery to site*'. For an example of the details required on the girder drawings, refer Figure 14.5(g) - *Girder fasteners*.

Figure 14.5(g) - Girder fasteners

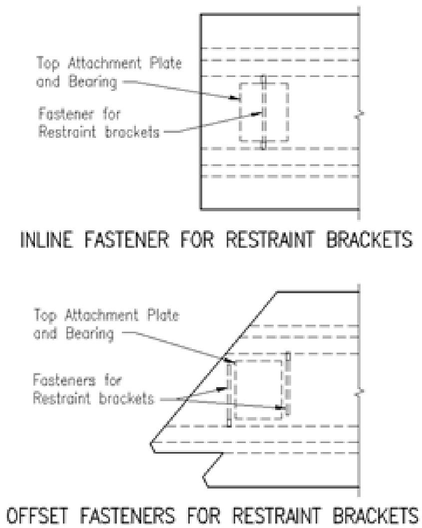


A detailed view (minimum scale of 1:10 on an A1 drawing) shall show how the fasteners, top attachment plate and reinforcing steel fit together in the end block.

Fasteners in skewed girders

On bridges with skews >10º, the restraint bracket fasteners may need to be offset to prevent the headstock widths becoming un-proportionally wide. Chapter 12 – *Abutments and Piers, 12.8 Girder bridge headstock layout* explains the method required to determine if the fasteners need to be offset. Refer Figure 14.5(h) - *Fasteners for restraint brackets*.

Figure 14.5(h) - Fasteners for restraint brackets



14.6 Miscellaneous girder components

Casting yards that manufacture girders require drawings that succinctly detail the components that are cast into the girders i.e. the top attachment plate and the fasteners. Details for the following girder related items are to be shown on the *Miscellaneous Details* drawing.

Bearing restraint plates

Girders supported on elastomeric bearings require a bearing restraint plate above each bearing to stop the bearing moving from its designed position. Because the vertical load from the girder must be applied evenly across the bearing, the plate is tapered to nullify the effect of the girder hogging. The minimum thickness of the plate is 16 mm. For an example of the required bearing restraint plate details refer *Figure 14.6(b) - Bearing restraint plates*. These details shall not be shown on the girder drawing because the casting yard manufacturing the girders will not be fabricating the steelwork. Rather, the details shall be shown on the *Miscellaneous Details* drawing, refer Chapter 18 - *Expansion joints and miscellaneous details.*

If a bridge has different types of plates, a layout diagram is required to show the orientation of the plates, refer *Figure 14.6(a) - Layout diagram for bearing restraint plates*.

Figure 14.6(a) - Layout diagram for bearing restraint plates

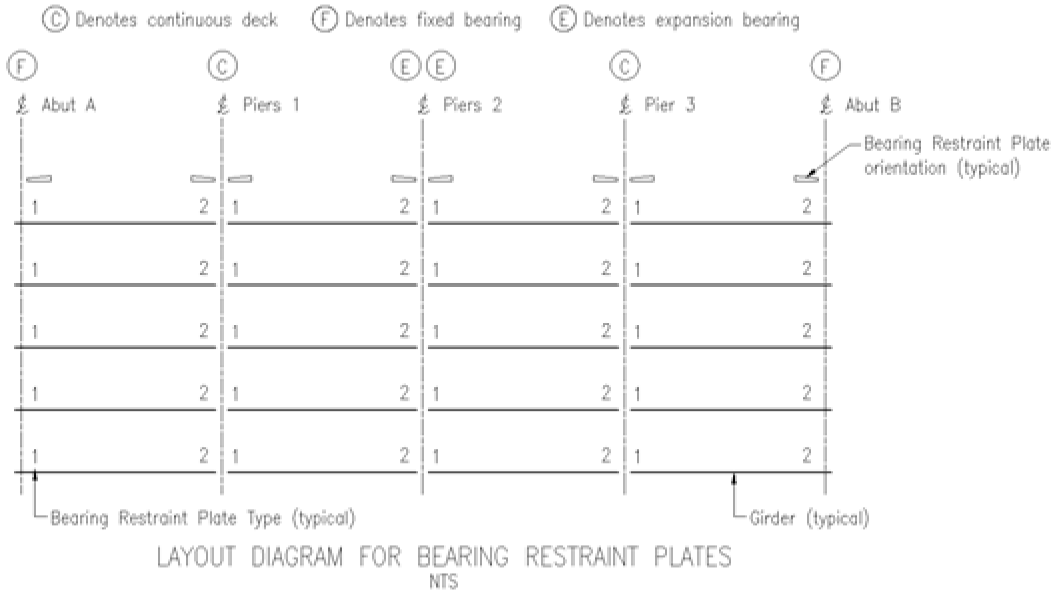


Figure 14.6(b) - Bearing restraint plates

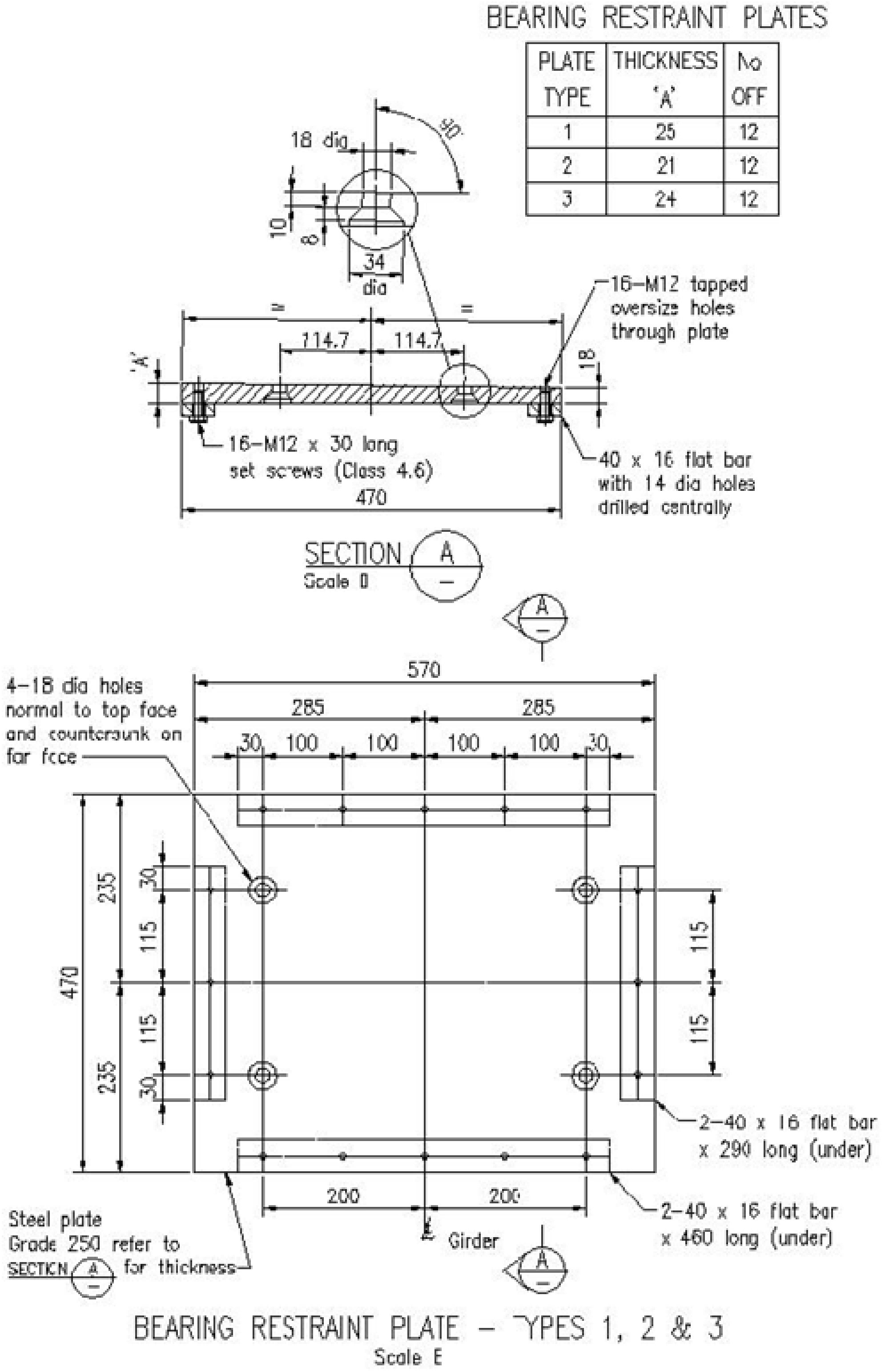


PLATE TYPE	THICKNESS 'A'	No OFF
1	25	12
2	21	12
3	24	12

14.7 Reinforcement

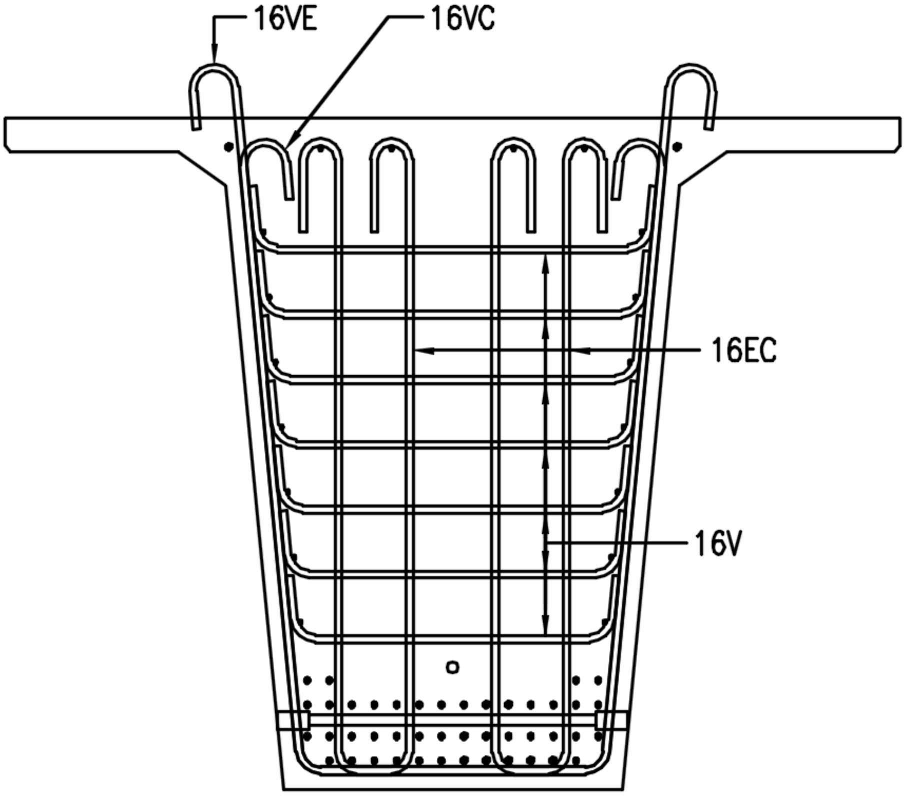
For reinforcing details regarding proprietary Wide Flange I Girders refer to the technical manual produced by the girder supplier. The remaining details in this chapter apply to Super T-Girders.

Most Super T-Girder reinforcing details have been standardised and are shown on the departmental standard design sheets. The Design Engineer should use these details and only calculate the reinforcement set spacing and wall thickness of the girders.

Reinforcing set spacing

Typically there is congestion in the end block due to closely spaced reinforcing. The absolute minimum spacing for reinforcing in the end blocks is 90 mm. In the end blocks the 16V bars shall be placed inside the 16VE and 16VC bars to provide extra clearance between sets. Refer *Figure 14.7(a) - Typical reinforcing set – end blocks.*

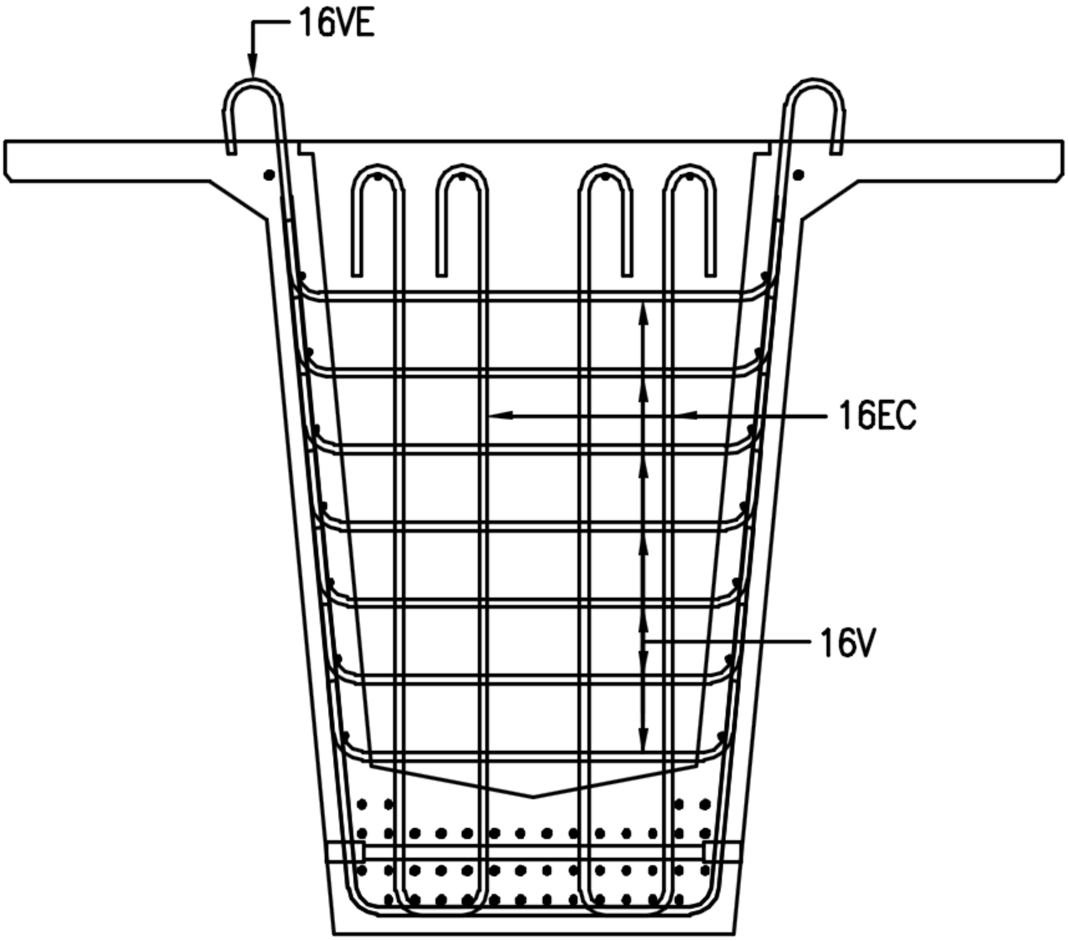
Figure 14.7(a) - Typical reinforcing set - end blocks



Note: The 16V bars sit inside the 16VE bars so that the set is only two bars wide (16EC + 16VE + 16VC) and not three (16EC + 16V + 16VE or 16VC).

Along the voided section of 1500 mm deep girders where the walls are typically 100 mm thick, the 16VE and 16V bars are located side by side to maintain cover to the void. Refer Figure 14.7(b).

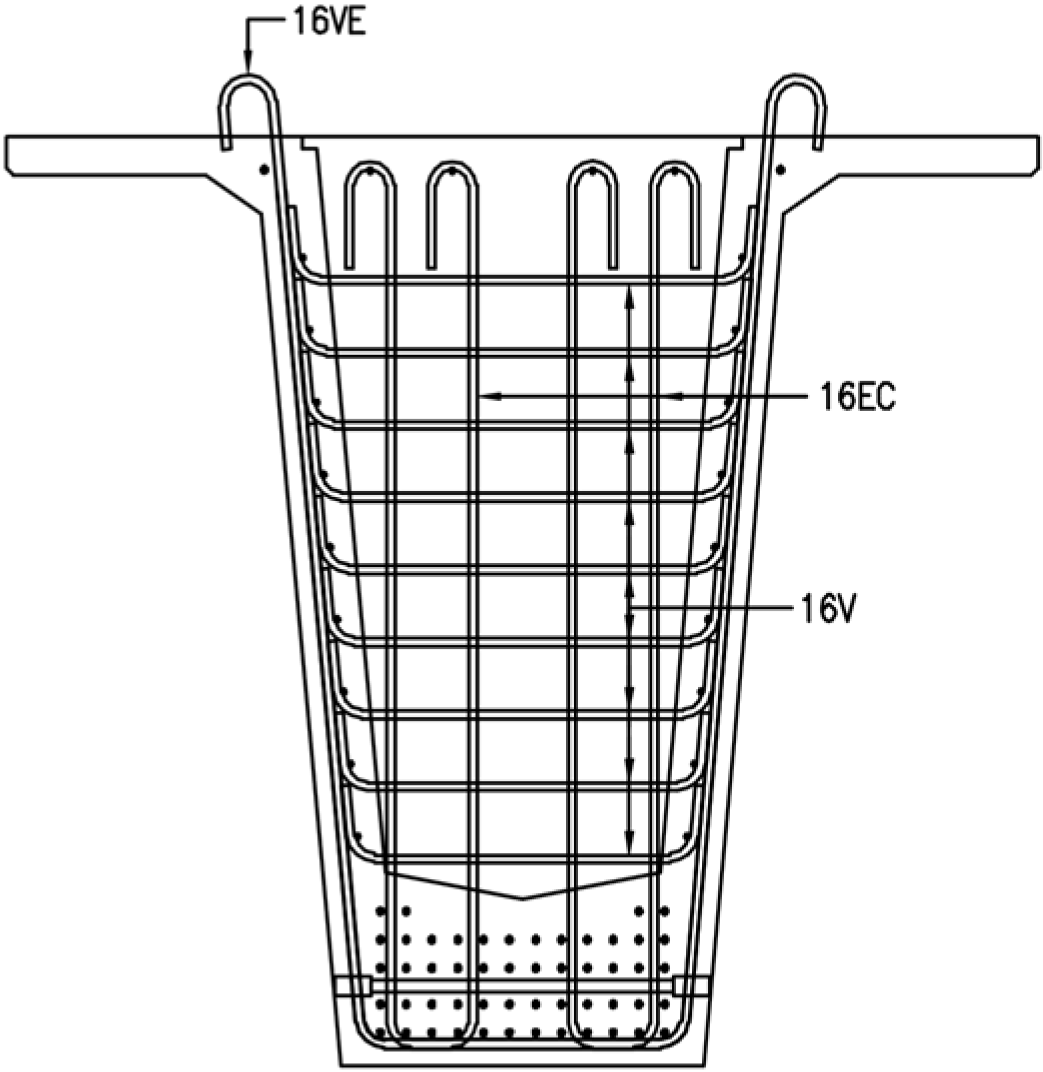
Figure 14.7(b) - Typical reinforcing set in diaphragms and around voids (1500 deep girders)



Note: The 16V bars sit beside the 16VE and 16EC bars so that the 12A longitudinal bars have sufficient cover to the void. The reinforcing set is three bars wide, however the sets are not spaced as closely as they may be in the end block.

Because the walls of 1800 mm deep girders are typically 120 mm thick, maintaining cover is not a problem. Therefore the 16V bars shall be placed inside the 16VE bars. Refer *Figure 14.7(b) - Typical reinforcing set in diaphragms and around voids (1500 deep girders)*.

Figure 14.7(c) - Typical reinforcing set in diaphragms and around voids (1800 deep girders)



Note: The 16V bars sit inside the 16VE and 16EC bars so that the set is only two bars wide (16EC and 16VE) and not three (16EC and 16V and 16VE).

Skewed girders

Some casting yards prefer to tack weld the fasteners into the form and lower the prefabricated reinforcement cage into the form.

To enable them to do this the reinforcement must be parallel to the fastener at the bottom of the cage.

Refer *Figure 14.7(d) - Girder Reinforcement around Fastener (1)* and *Figure 14.7(e) - Girder Reinforcement around Fastener (2)* for an example of how the reinforcing steel may be set out.

Figure 14.7(d) - Girder reinforcement around fastener (1)

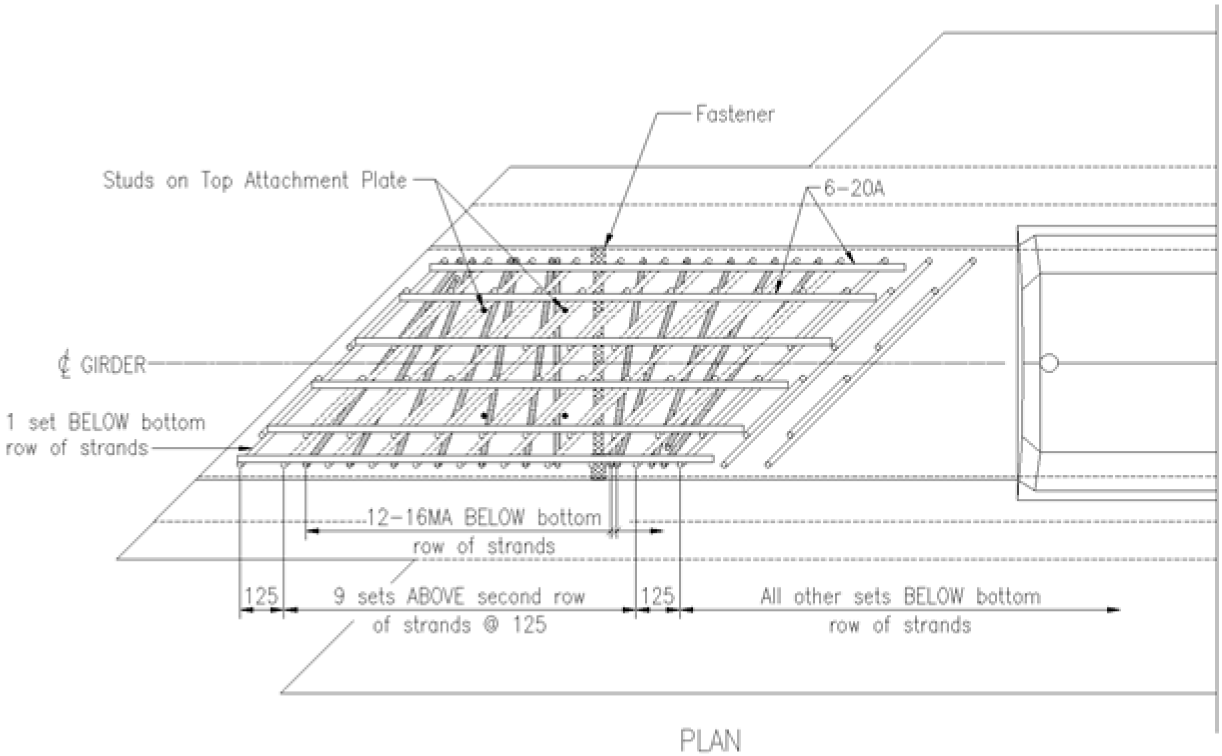
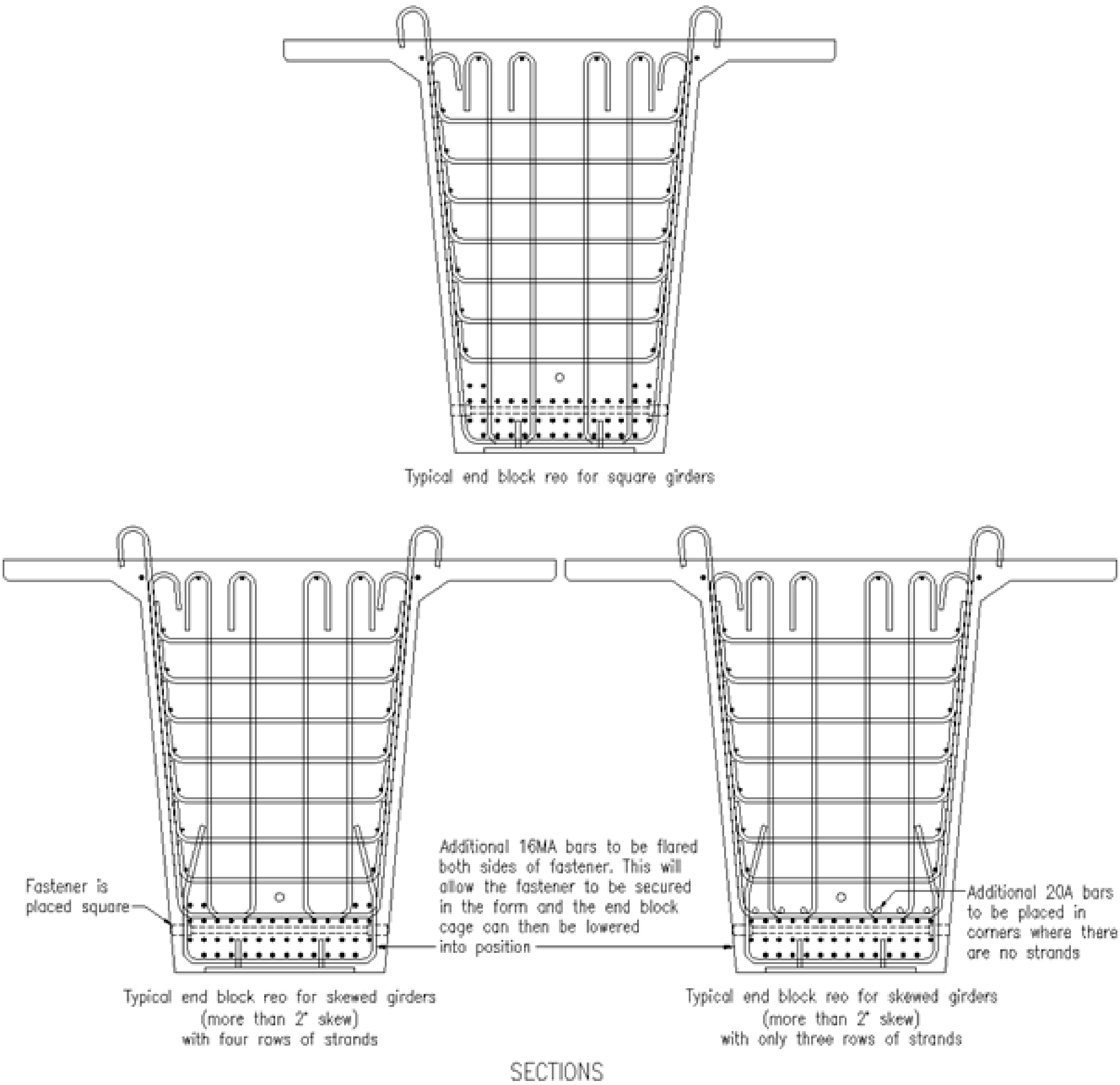


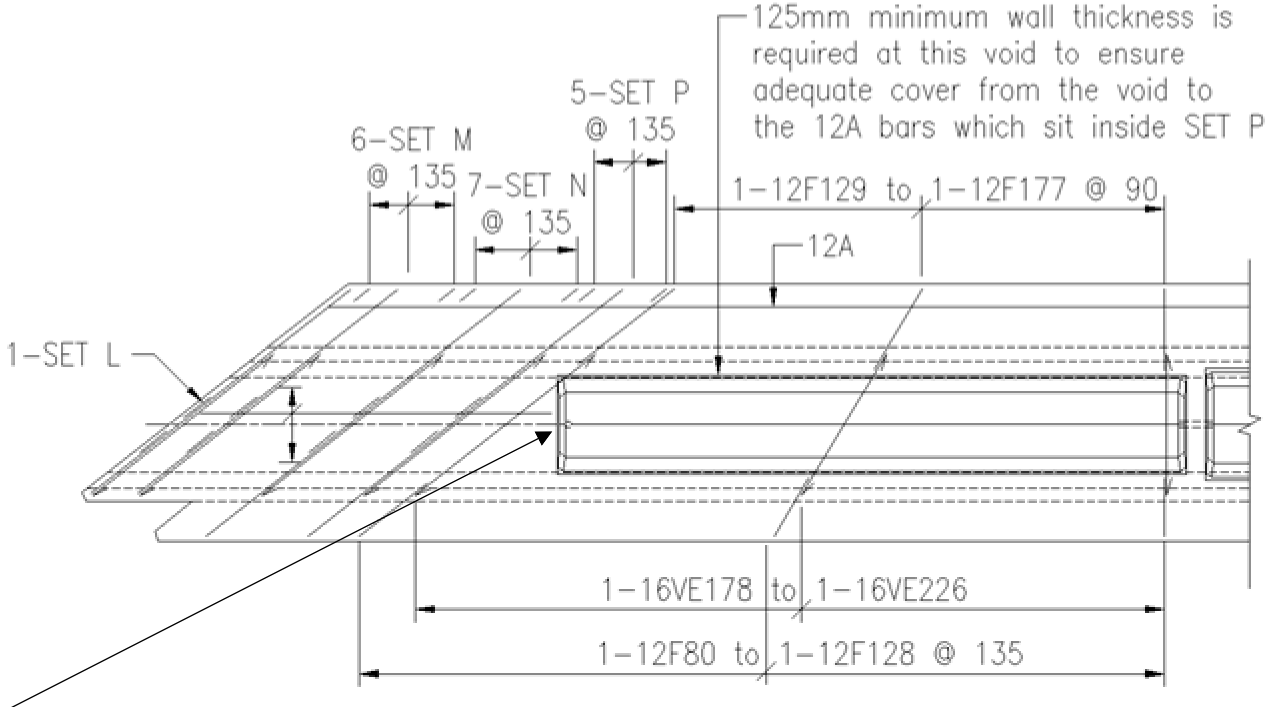
Figure 14.7(e) - Girder reinforcement around fastener (2)



Fanned reinforcement

In skewed girders the reinforcement is fanned about the voids at each end of the girders. Refer *Figure 14.7(f) - Variable bars*. Because the reinforcing sets in the end block encroach into the wall of the girder at the adjacent void, the wall thickness of this void must be at least 125 mm thick to maintain cover to the 12A bars.

Figure 14.7(f) - Variable bars



To reduce the chance of cracking, additional reinforcement is required near this face of the void at both ends of the girder.

14.8 Drilling holes into girders

Drilling holes into girders is not permitted. The following text shall be shown on the general arrangement drawing beside the section deck detail 'DRILLING INTO THE GIRDERS IS NOT PERMITTED. ALL FERRULES / ATTACHMENTS MUST BE CAST-IN'.

14.9 Cross girders

All girder bridges are to have cross girders cast at the ends of each span.

Some of the benefits of cross girders are as follows:

- to strengthen the structure
- to provide a location for the temporary packers required during bearing installation
- to provide jacking points for bridge maintenance, and
- to provide stability of the girders prior to and during casting and curing of the deck.

For Wide Flange I-Girders extra considerations will be required for girder stability prior to casting and curing of the deck. Potentially this may have impacts on the casting of the girders where cast in ferrules are required as was the case on the Lucinda Drive, Port of Brisbane project.

It is good practice to space girders as far apart as possible to reduce reinforcement congestion in the cross girders, and to facilitate easier inspection and maintenance of the bearings. This may require reducing the number of girders by increasing the girder depth.

At fixed and expansion joints the cross girder reinforcement bonds into the concrete deck. At continuous deck joints the cross girder reinforcement cannot do this as the deck is de-bonded with sheets of closed cell expanded polyethylene. For an example of the typical details required, refer *Figure 14.9(a) - Typical cross girder design*.

The ends of the girders may be cut out to allow the top reinforcing steel to continue over the girder. The main advantages of this design are that it reduces / eliminates the laps in the top cross girder reinforcement and also the top girder couplers that this reinforcement would typically screw into. The main disadvantages are that construction and detailing of the girders drawings are both more complicated. Refer *Figure 14.9(b) - Alternate cross girder design*.

The reinforcement details and the width and depth of cross girders are project specific and are largely dependent on the span length and girder width. The examples shown may have less reinforcement that is required to comply with current standards.

If the bridge is subject to flooding, holes may be required near the top of the cross girders so that as the bridge is submerged, air between the girders can be released to prevent the bridge from potentially floating away.

Figure 14.9(a) - Typical cross girder design

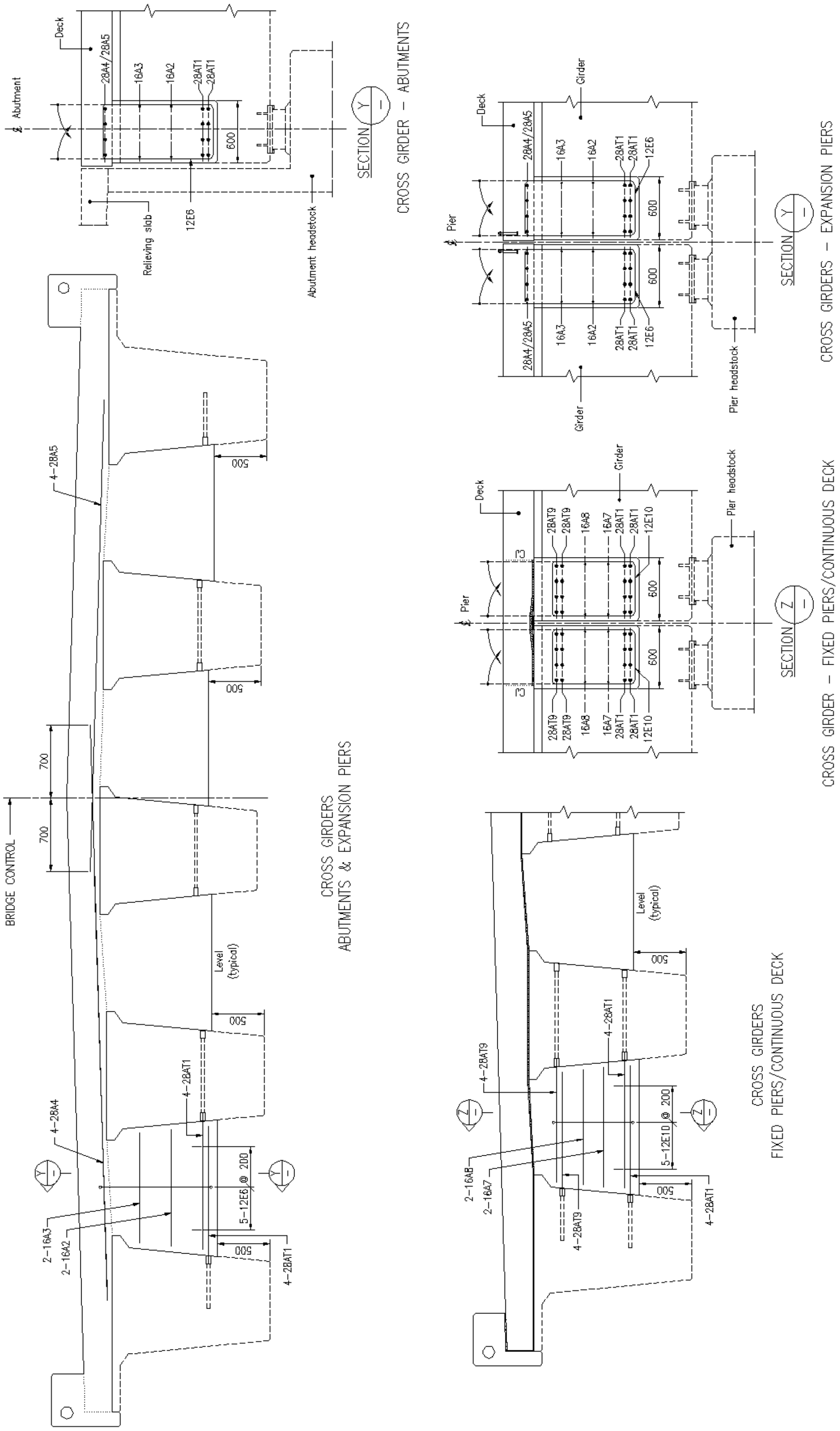
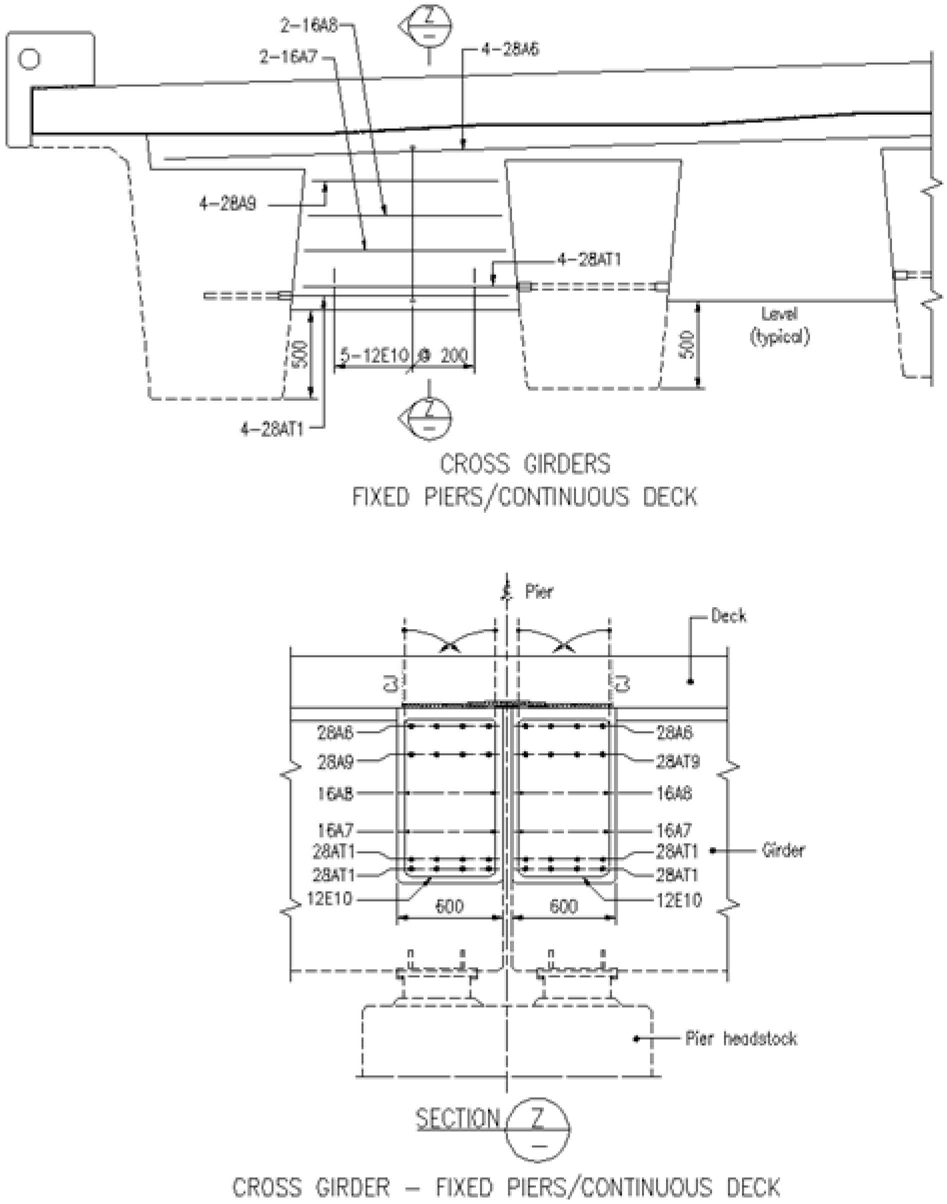


Figure 14.9(b) - Alternate cross girder design



14.10 Holes in girder flanges for road drainage

The department's typical deck drainage design for a girder bridge is to use a steel drain pipes to carry the water to the end(s) of the bridge. Refer Chapter 18 - *Expansion Joints and Miscellaneous Details, Appendix C - Example Drain Drawings*.

The water is drained from the deck with 150 mm diameter PVC scuppers that pass through 200 mm diameter holes in the girder flange. Refer *Figure 14.10(a) - Plan view of hole layout* and *Figure 14.10(b) - 200 mm diameter holes in girder flange for scuppers*.

Figure 14.10(a) - Plan view of hole layout

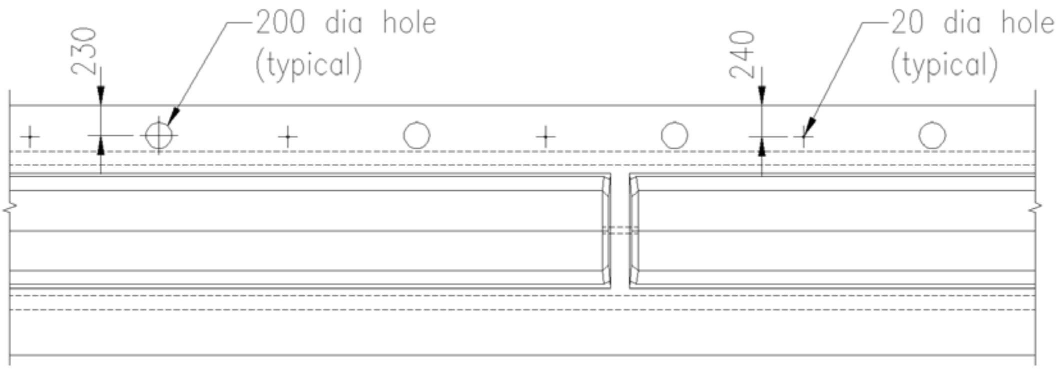
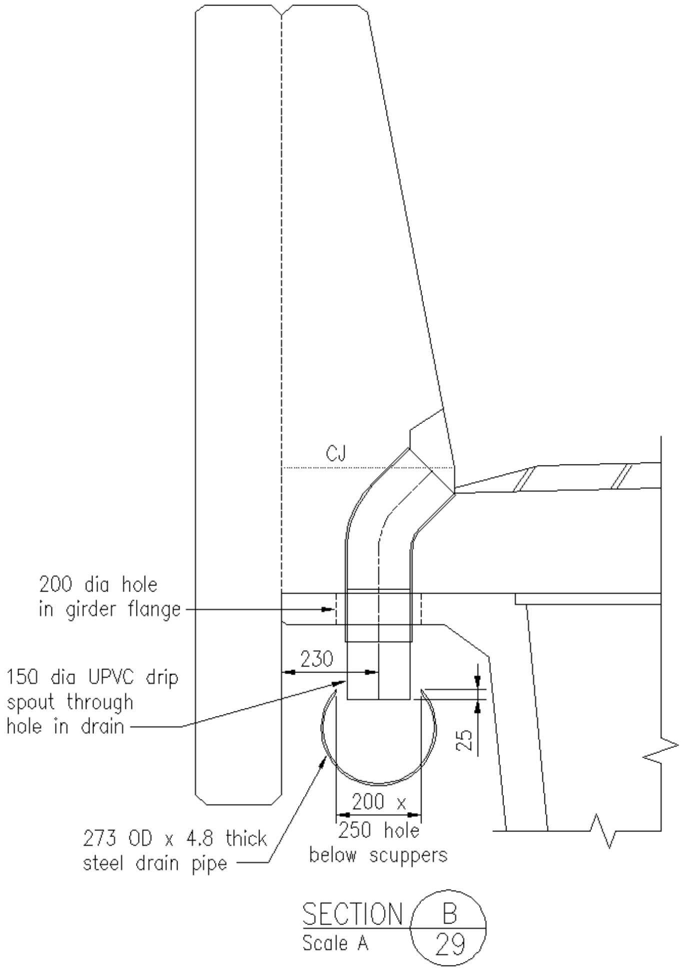
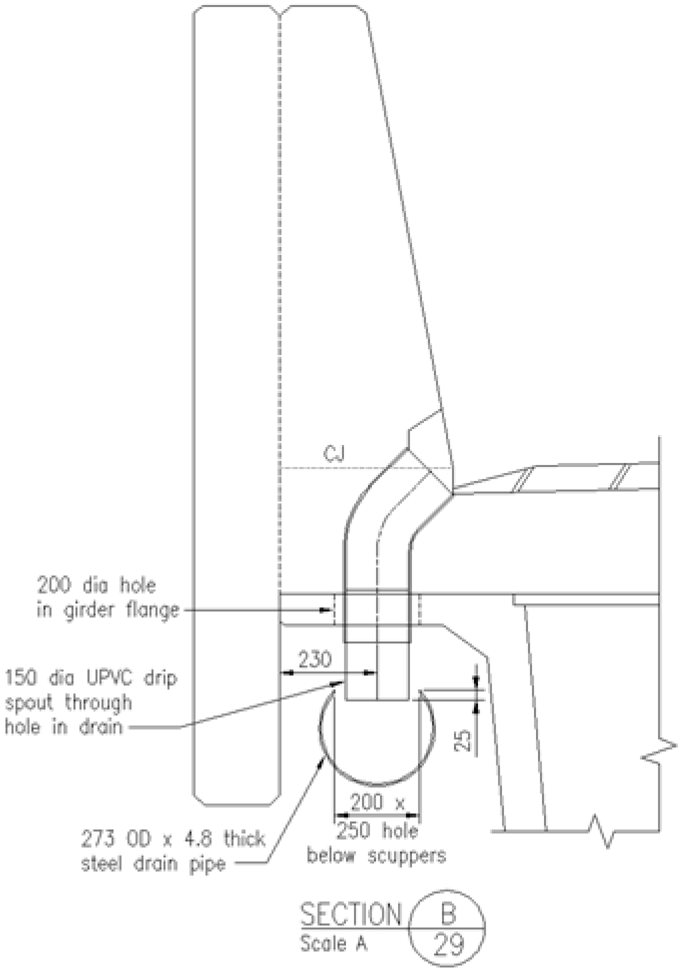


Figure 14.10(b) - 200 mm diameter holes in girder flange for scuppers



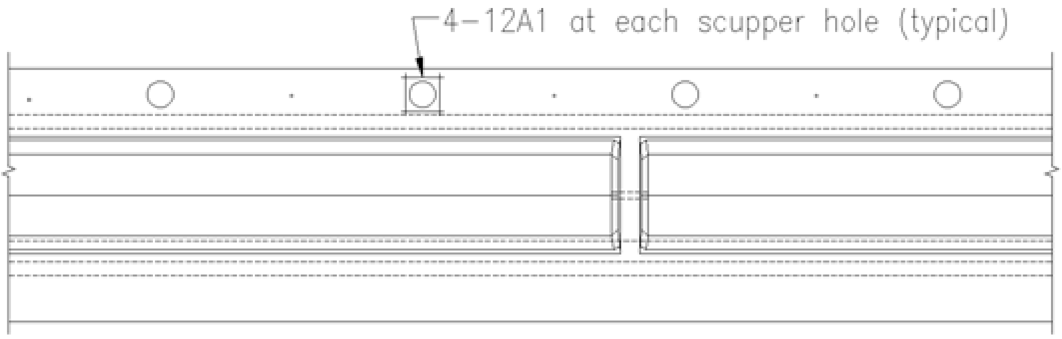
The drain pipe is supported by a steel drain bracket which passes through 20 mm diameter holes in the girder flange. Refer *Figure 14.10(a) - Plan view of hole layout* and *Figure 14.10(c) - 200 mm diameter holes in girder flange drain bracket*.

Figure 14.10(c) - 200 mm diameter holes in girder flange drain bracket



To reduce the chance of cracking around the 200 mm diameter holes, four trimmer bars shall be placed around each hole. Refer *Figure 14.10(d) - Trimmer reinforcement bars*.

Figure 14.10(d) - Trimmer reinforcement bars



14.11 Lifting loops

Lifting loops shall have a factor of safety of 5. The department does not have standard lifting loop details. The details are dependant on the mass of the girder.

The following examples are from a 77 tonne girder, refer *Figure 14.11(a) - Lifting diagram* and *Figure 14.11(b) - Lifting loop details*.

Figure 14.11(a) - Lifting diagram

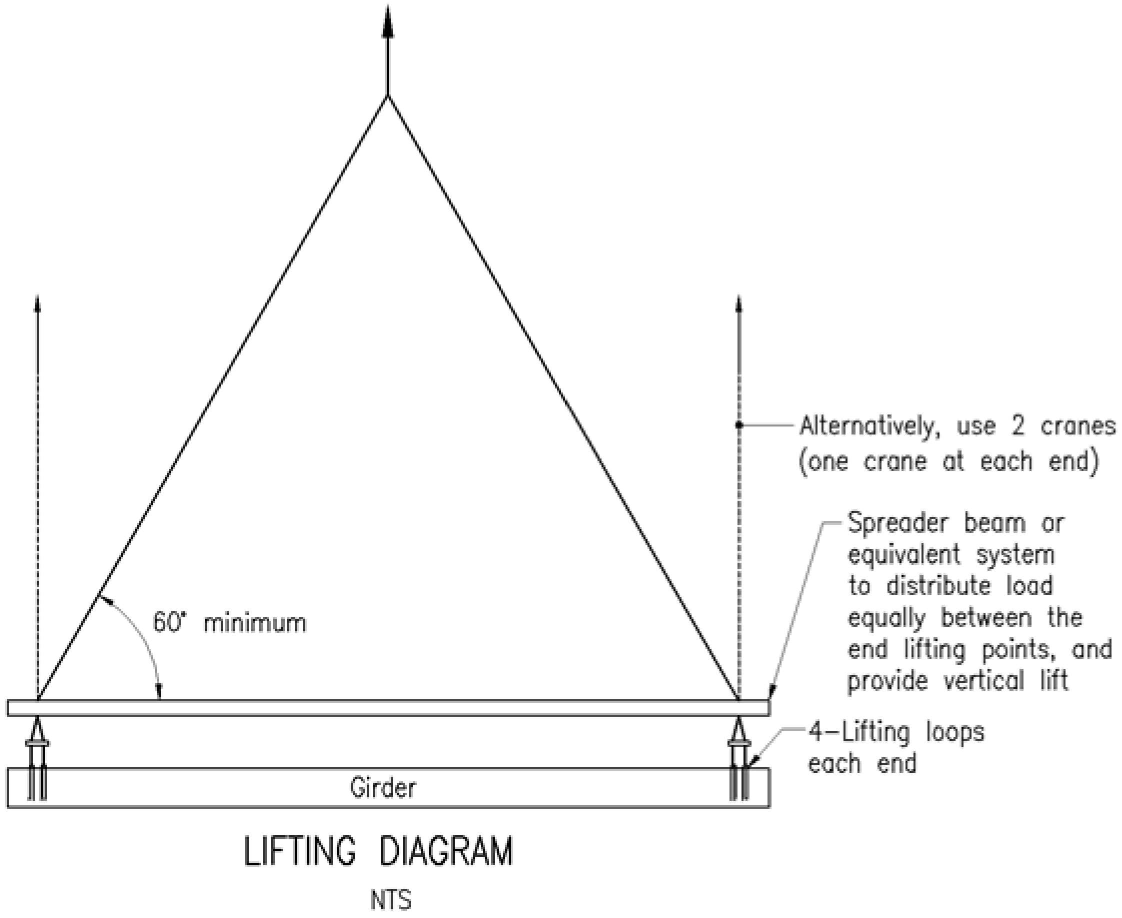
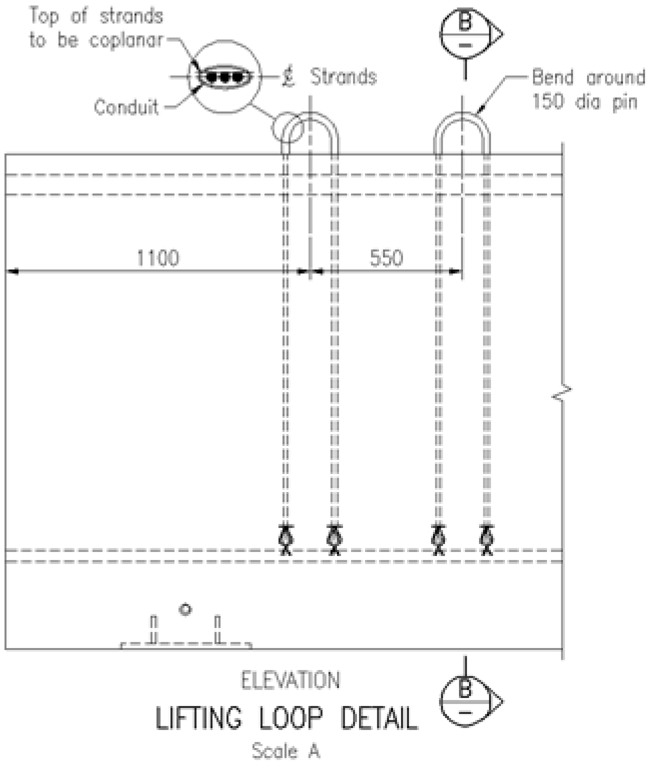
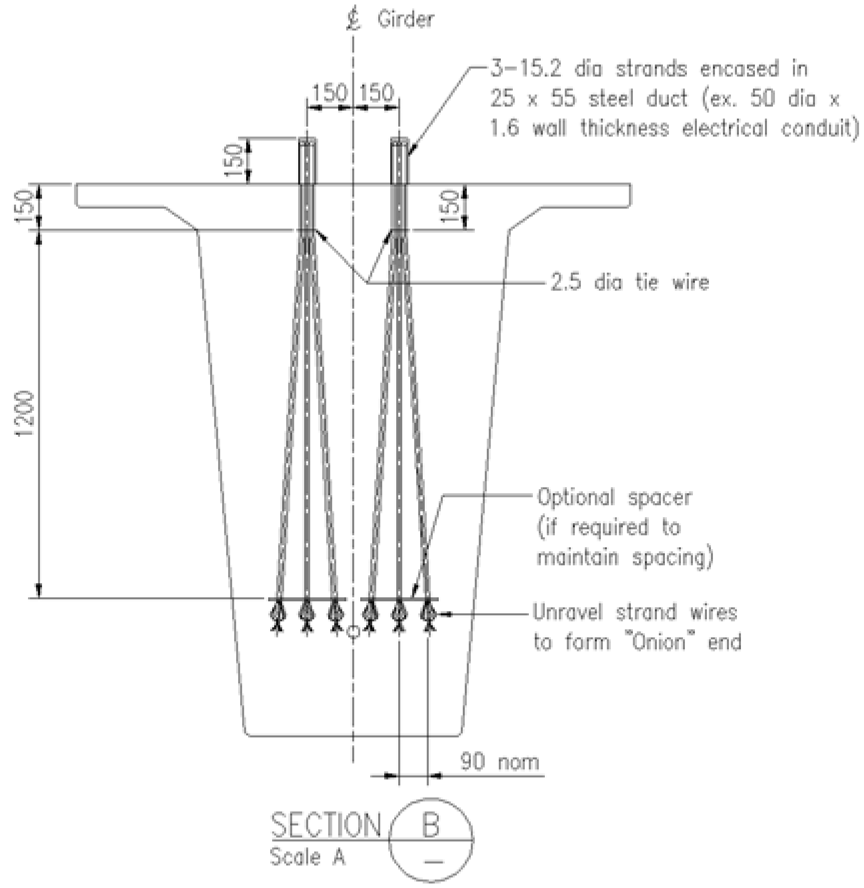


Figure 14.11(b) - Lifting loop details





14.12 Girder erection sequence

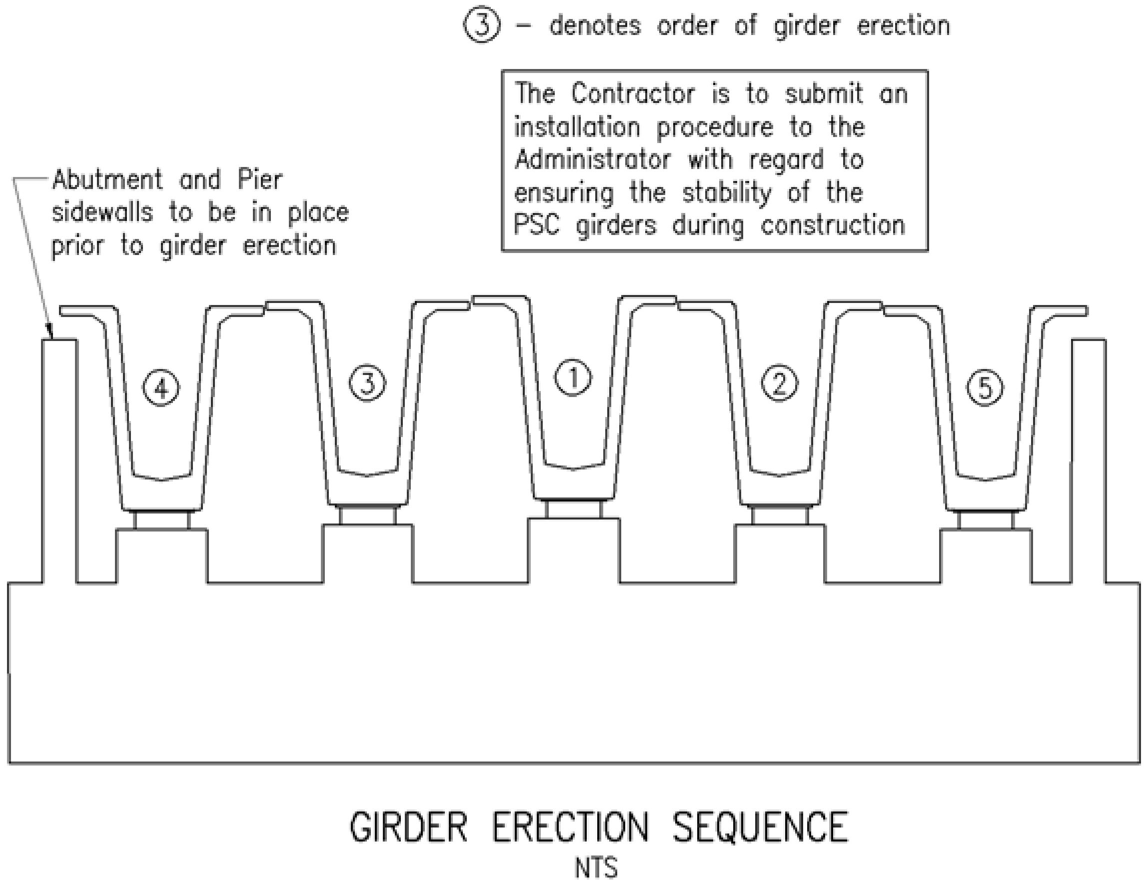
One of the greatest safety risks during bridge construction is an unsecured girder toppling over, and worst still, falling off the bridge altogether. By erecting the girders from the centre of the bridge first and then working outwards, the risk of a girder falling off the bridge is reduced.

If headstock sidewalls are required, they shall be constructed before the girders are erected. These walls improve aesthetics and safety. The walls shall be strong enough to resist impact loads during installation of the girders.

The Contractor is responsible for ensuring the stability of the girders during construction. This usually involves temporary bracing between the girders, or temporary propping of the girders.

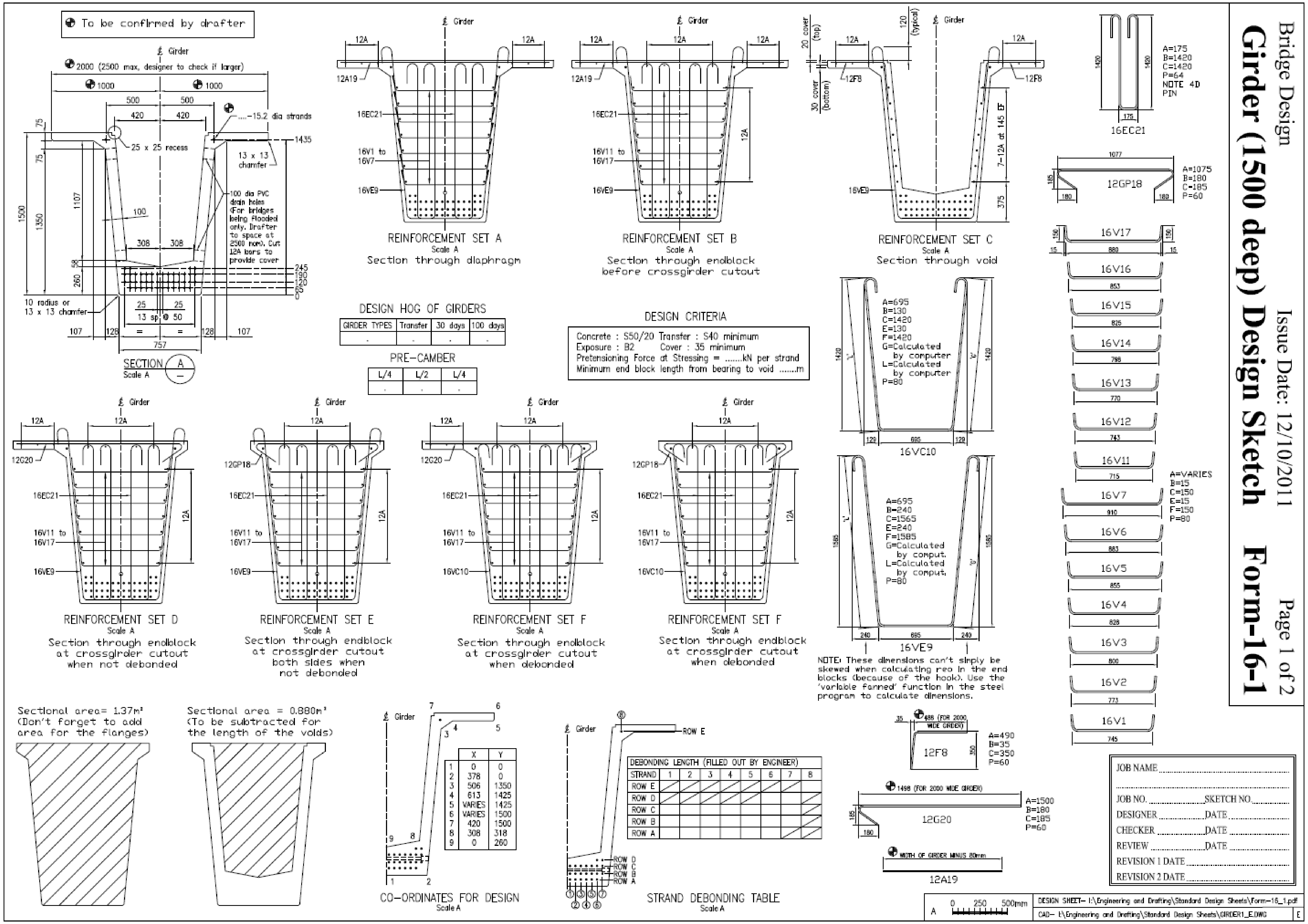
For an example of the required details, refer Figure 14.12(a) *Girder erection sequence detail*.

Figure 14.12(a) - Girder erection sequence detail

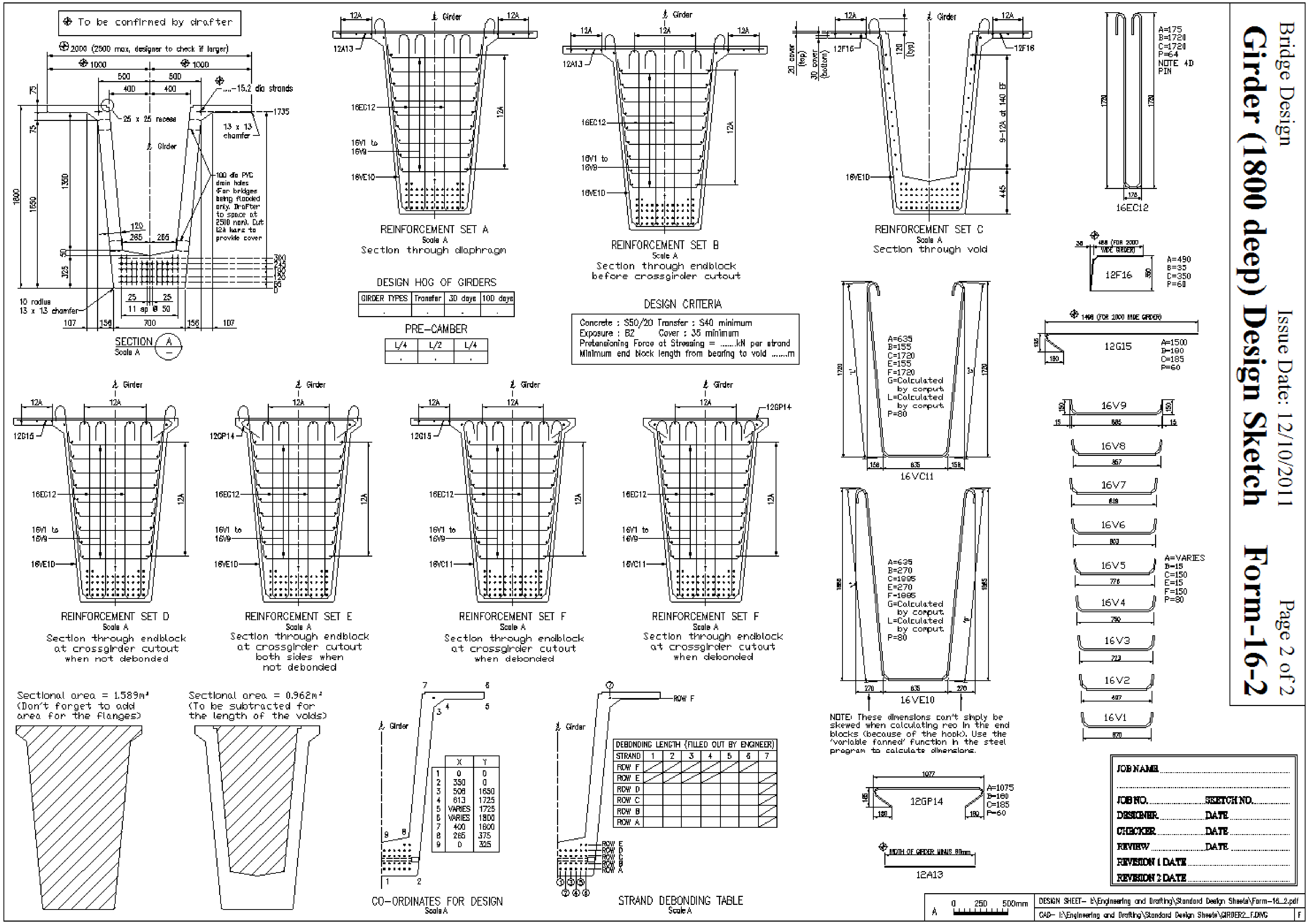


Appendix A – Super T-Girder design sketches

Appendix A – Super T-Girder Design Sketches – Sheet 1

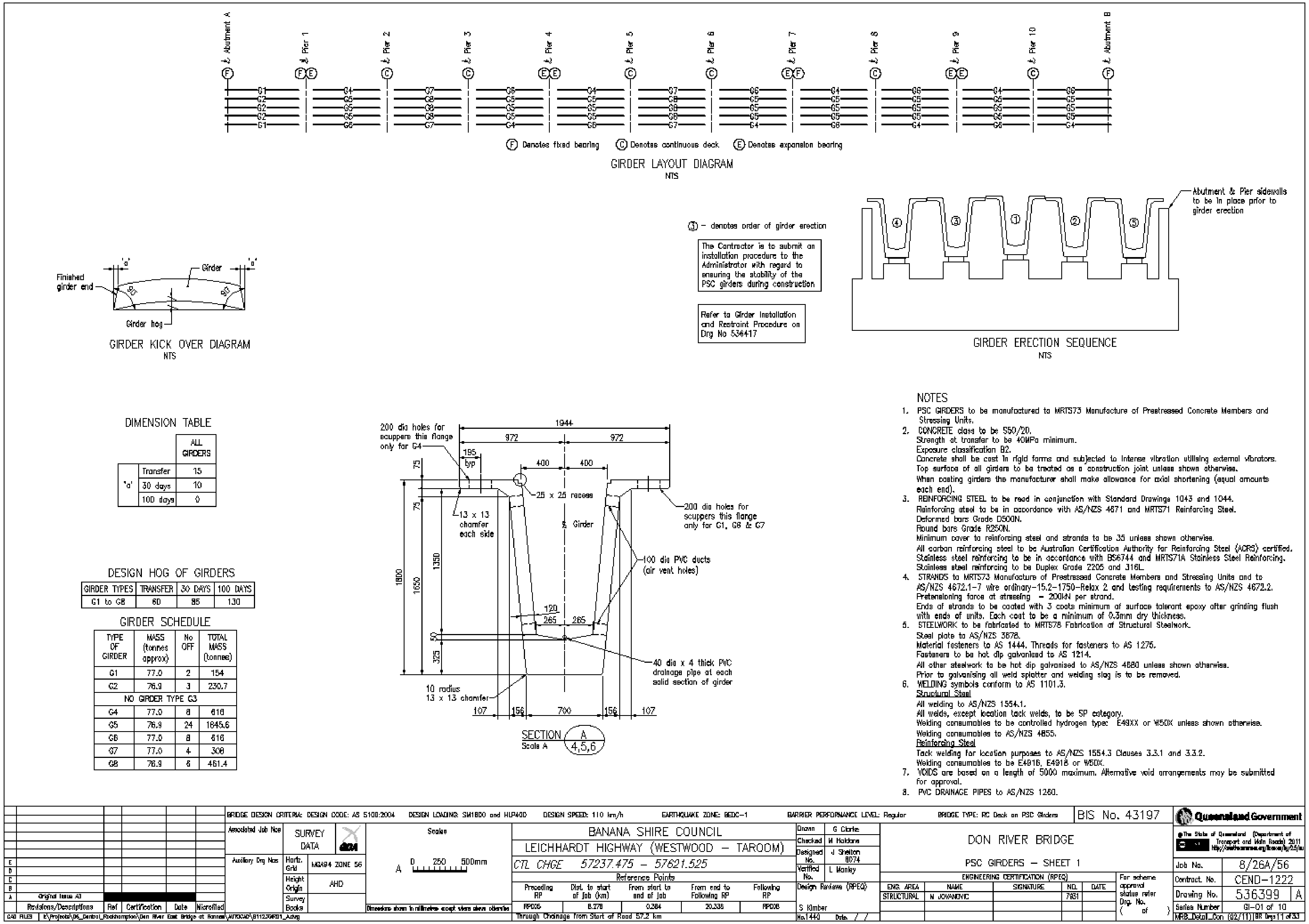


Appendix A – Super T-Girder Design Sketches – Sheet 2

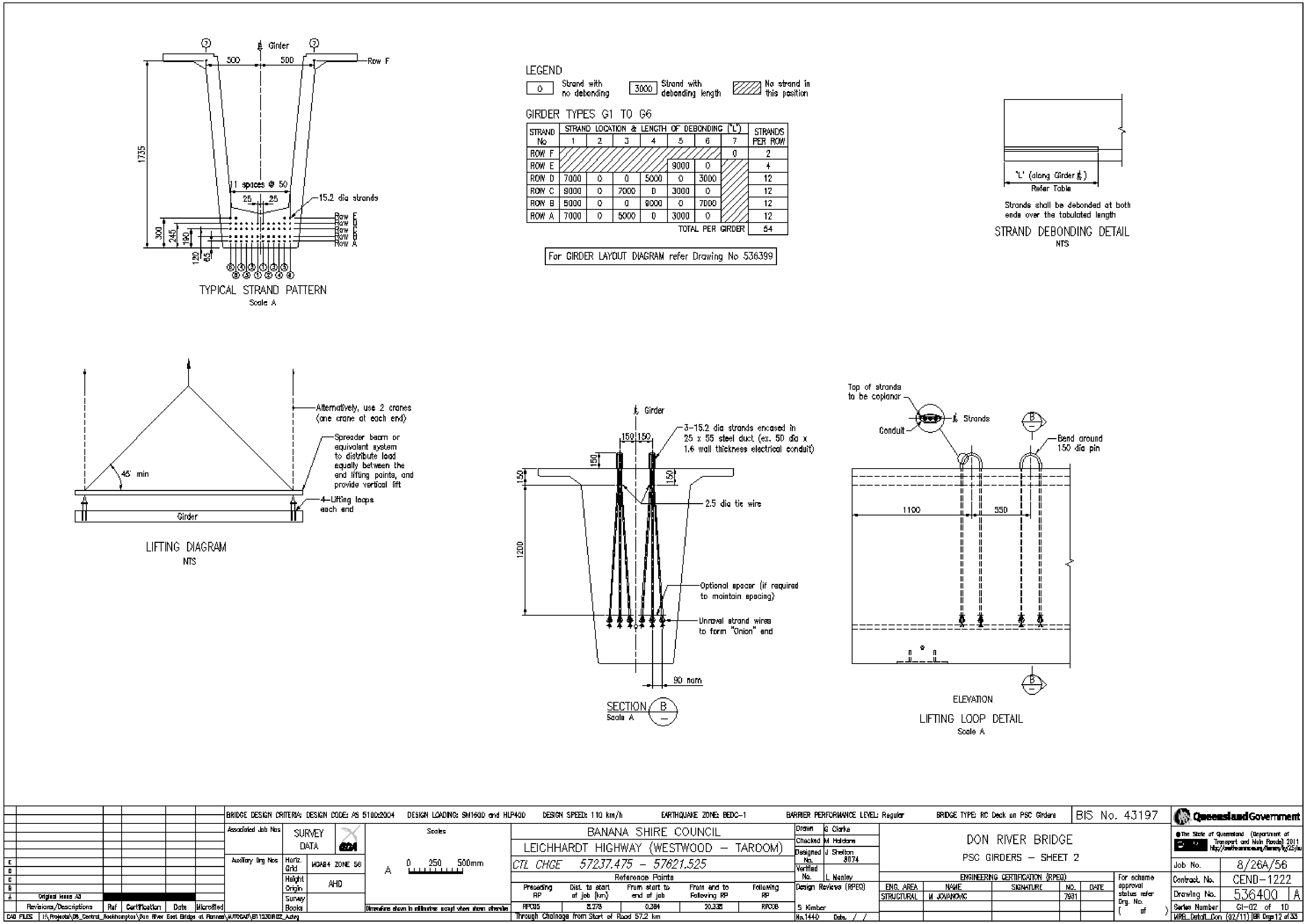


Appendix B – Example Super T-Girder Drawings

Appendix B – Example Super T-Girder Drawings – Sheet 1



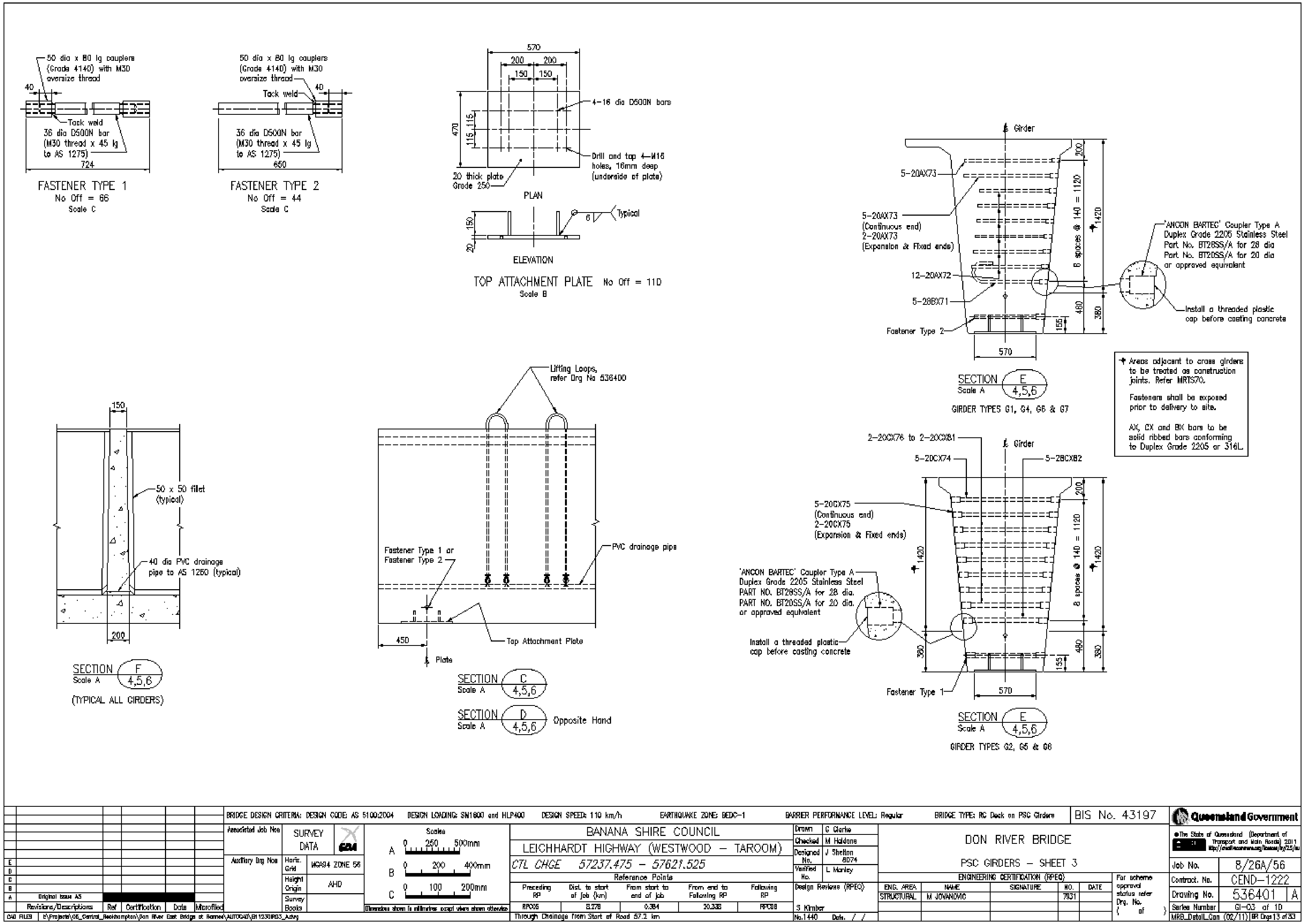
Appendix B – Example Super T-girder Drawings – Sheet 2



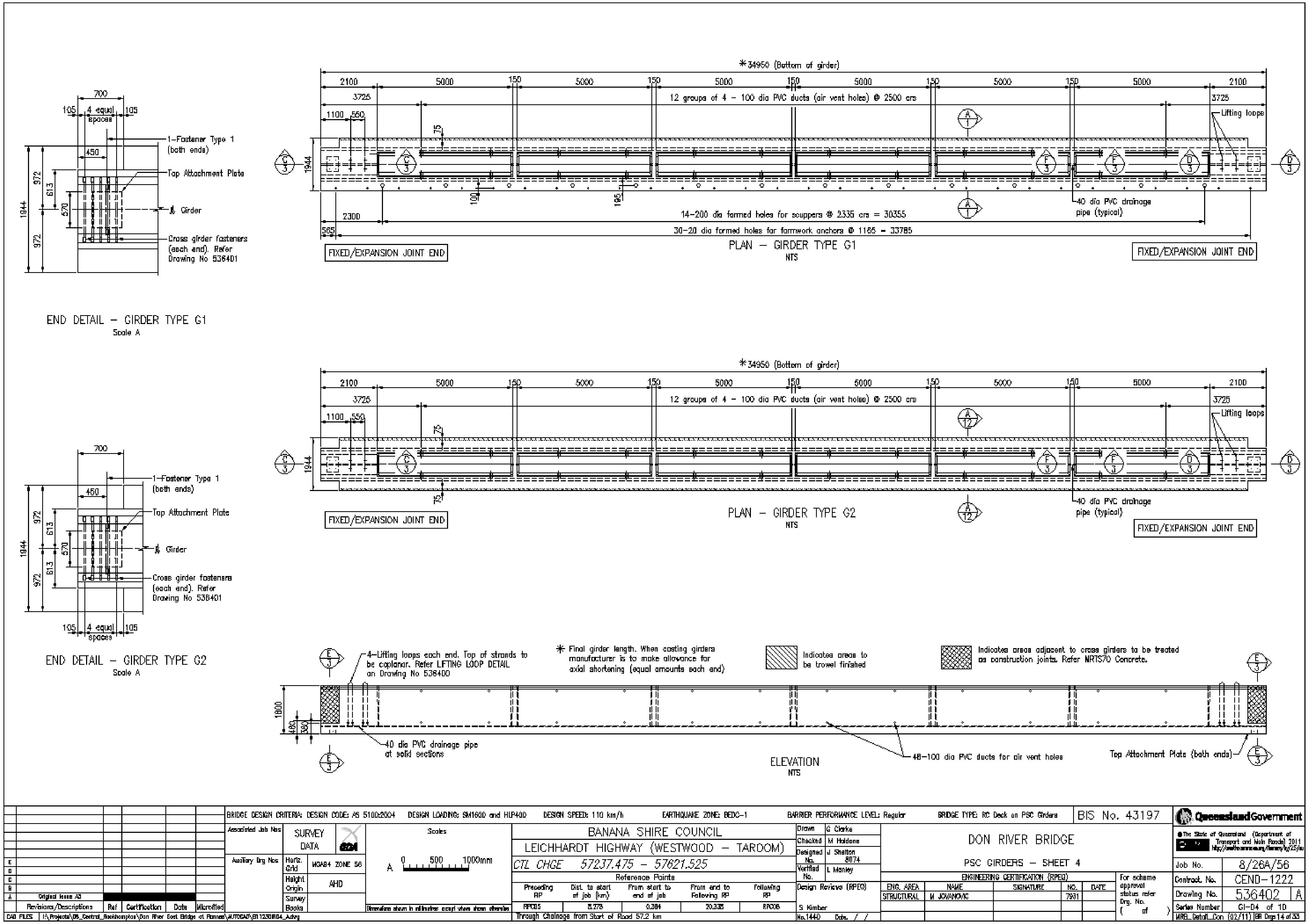
GIRDER TYPES G1 TO G6

STRAND No	STRAND LOCATION & LENGTH OF DEBONDING ("L")							STRANDS PER ROW
	1	2	3	4	5	6	7	
ROW F							0	2
ROW E					9000	0		4
ROW D	7000	0	0	5000	0	3000		12
ROW C	9000	0	7000	0	3000	0		12
ROW B	5000	0	0	9000	0	7000		12
ROW A	7000	0	5000	0	3000	0		12
							TOTAL PER GIRDER	54

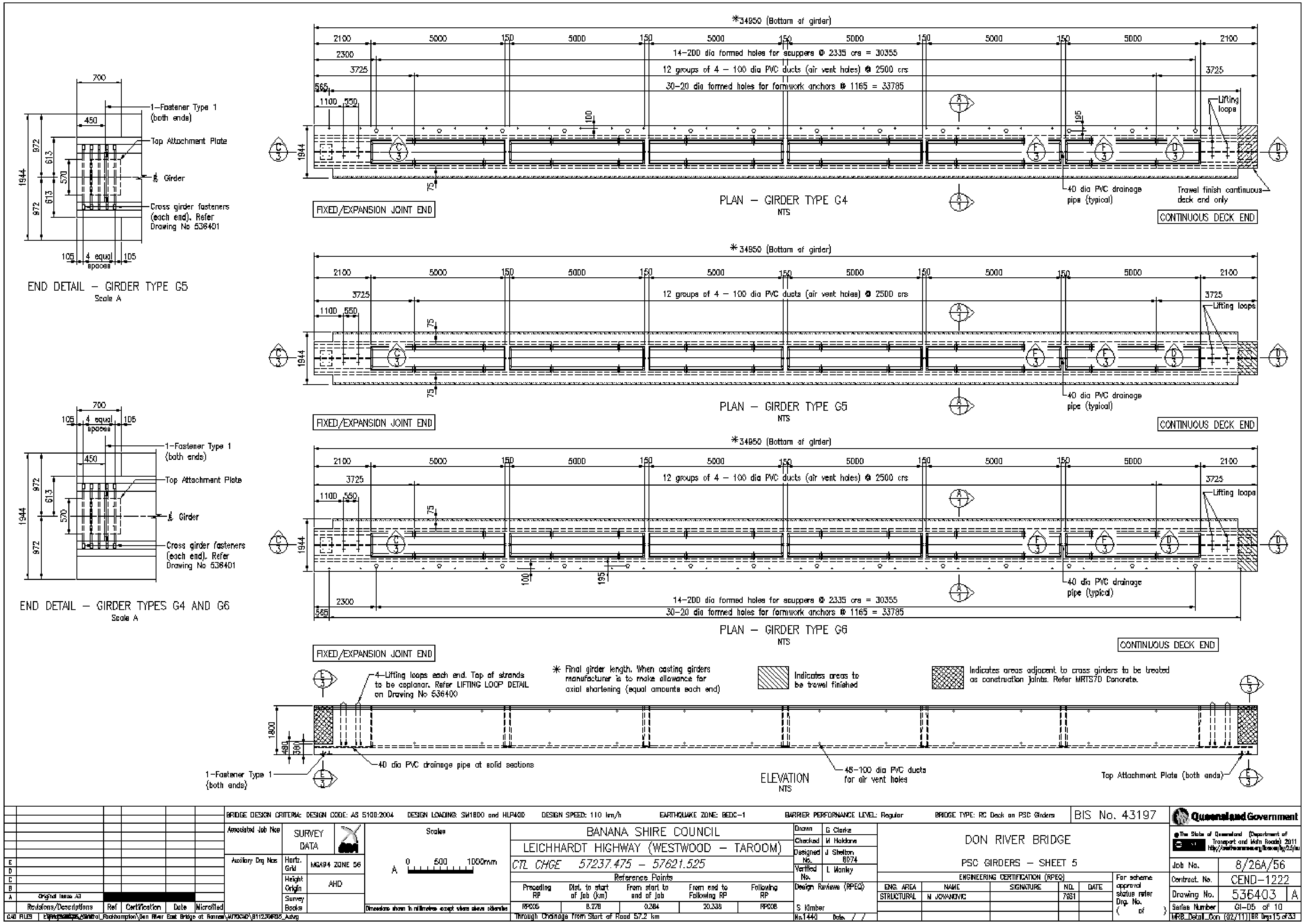
Appendix B – Example Super T-girder Drawings – Sheet 3



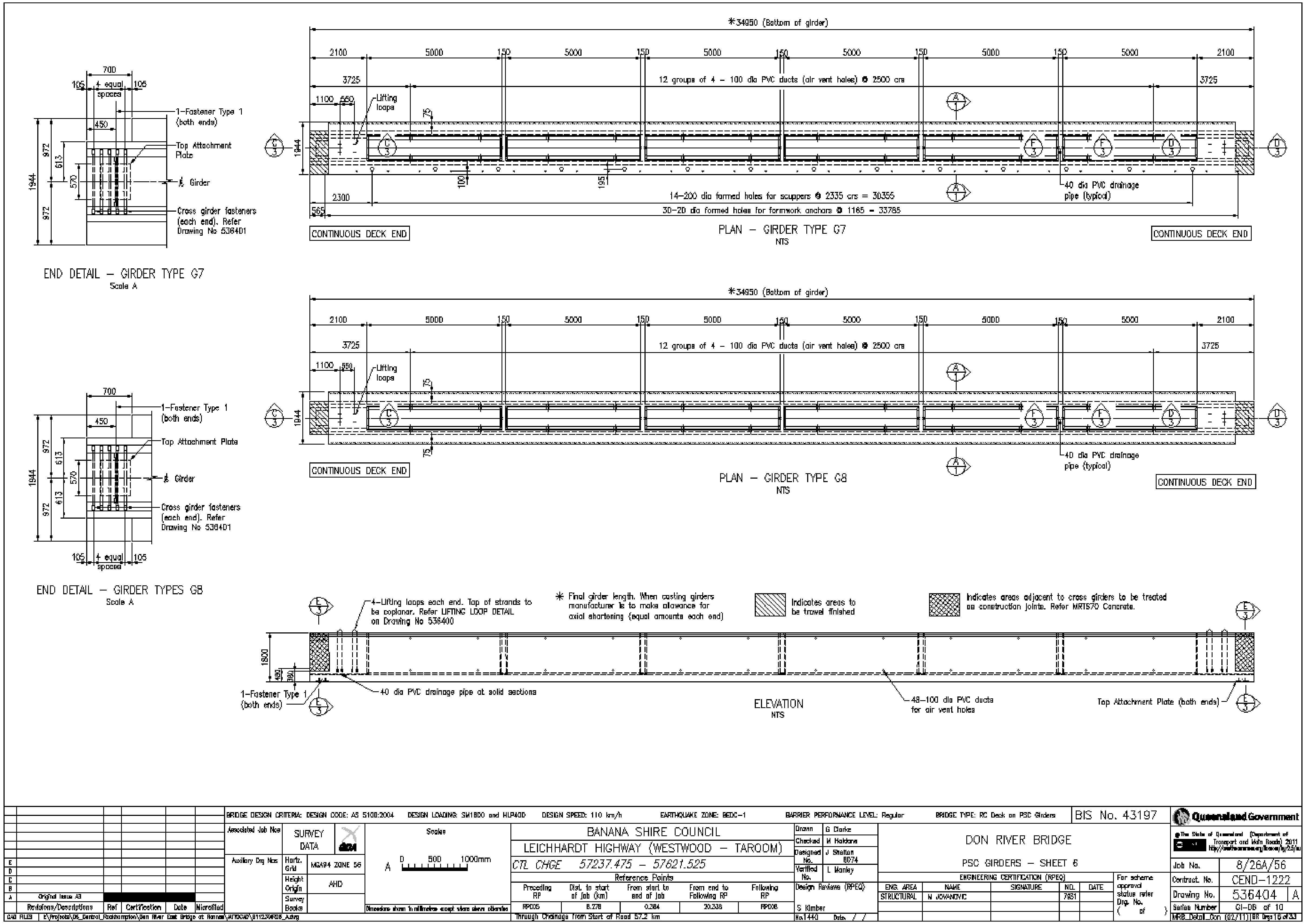
Appendix B - Example Super T-girder Drawings – Sheet 4



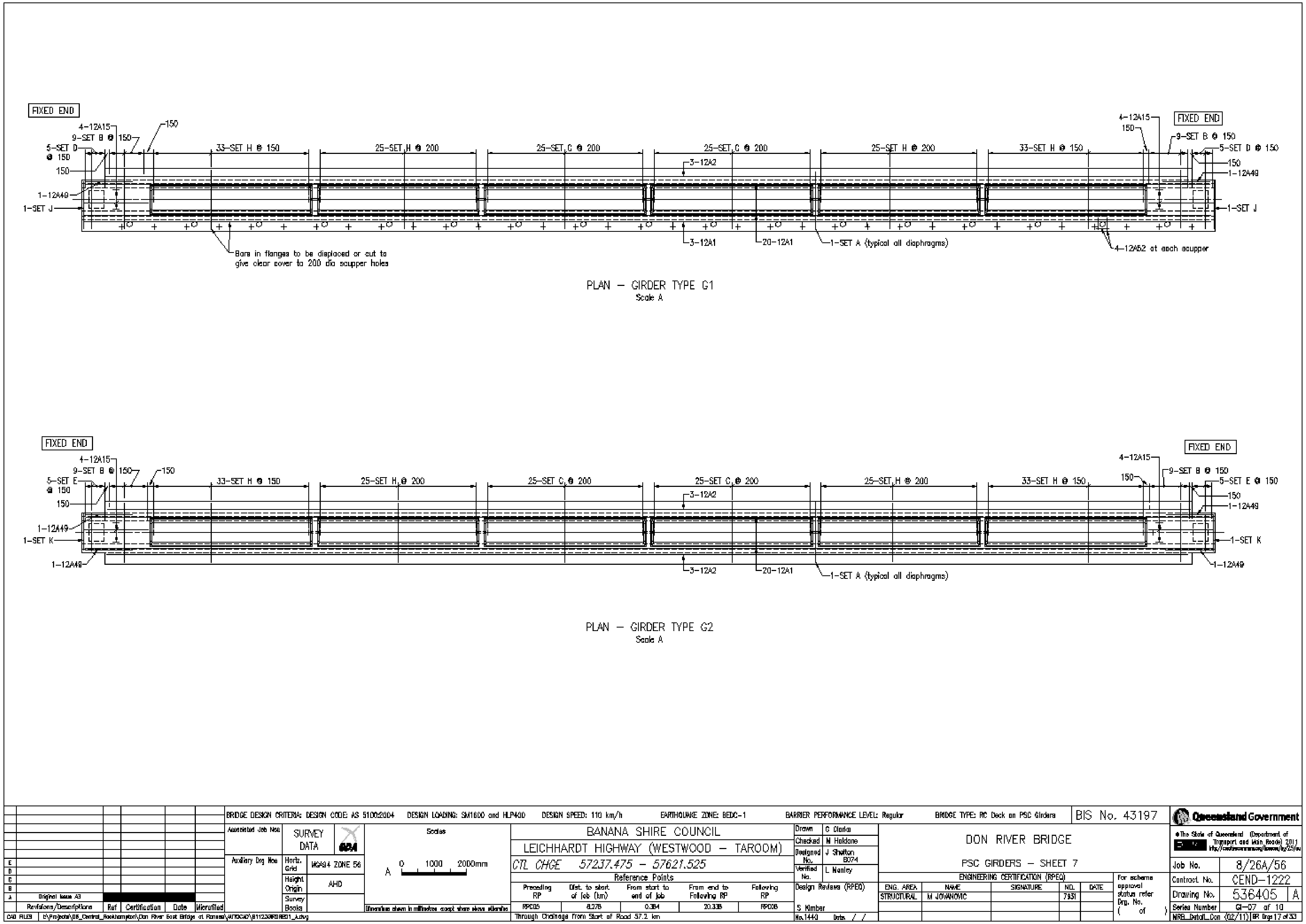
Appendix B – Example Super T-girder Drawings – Sheet 5



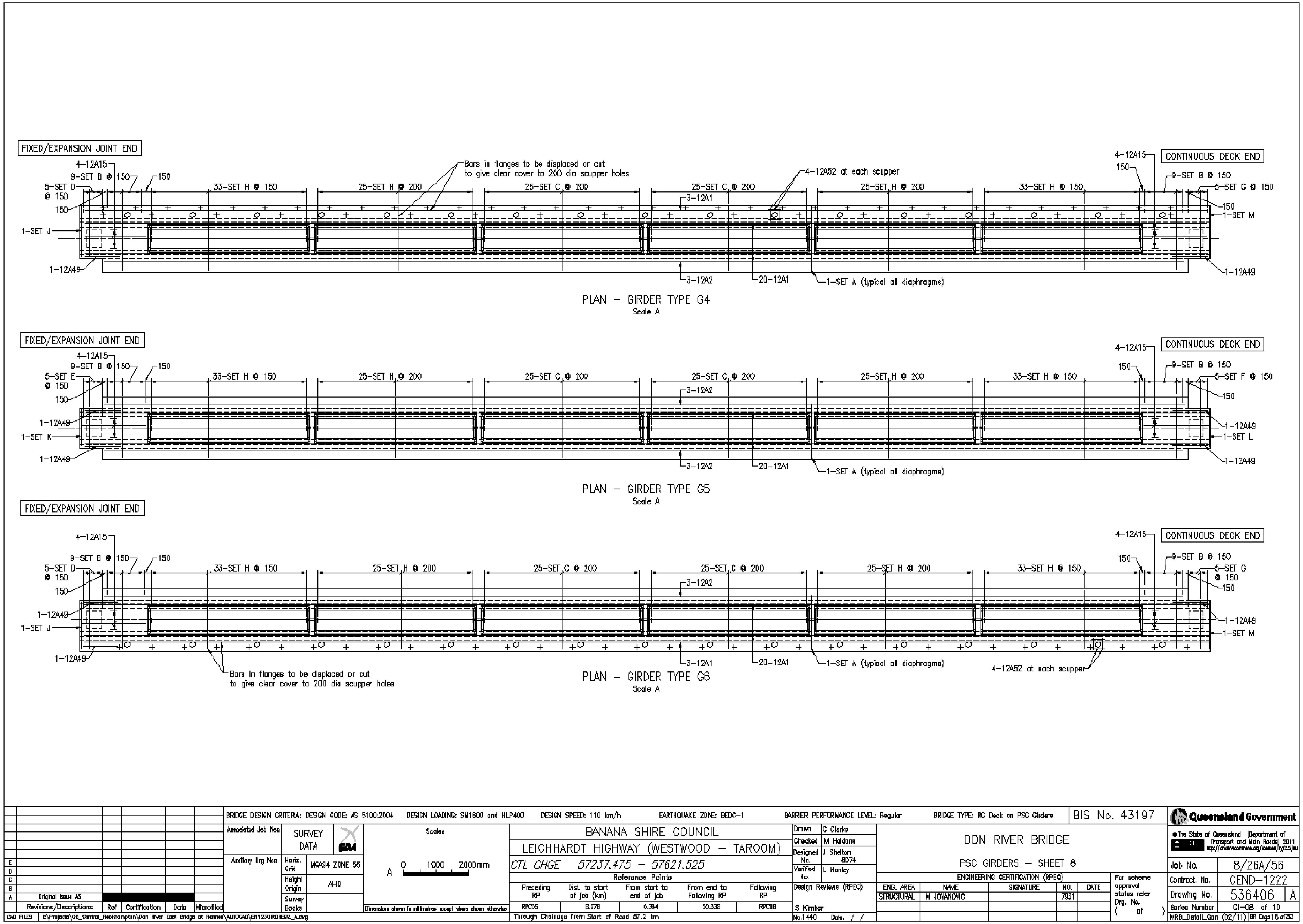
Appendix B – Example Super T-girder Drawings – Sheet 6



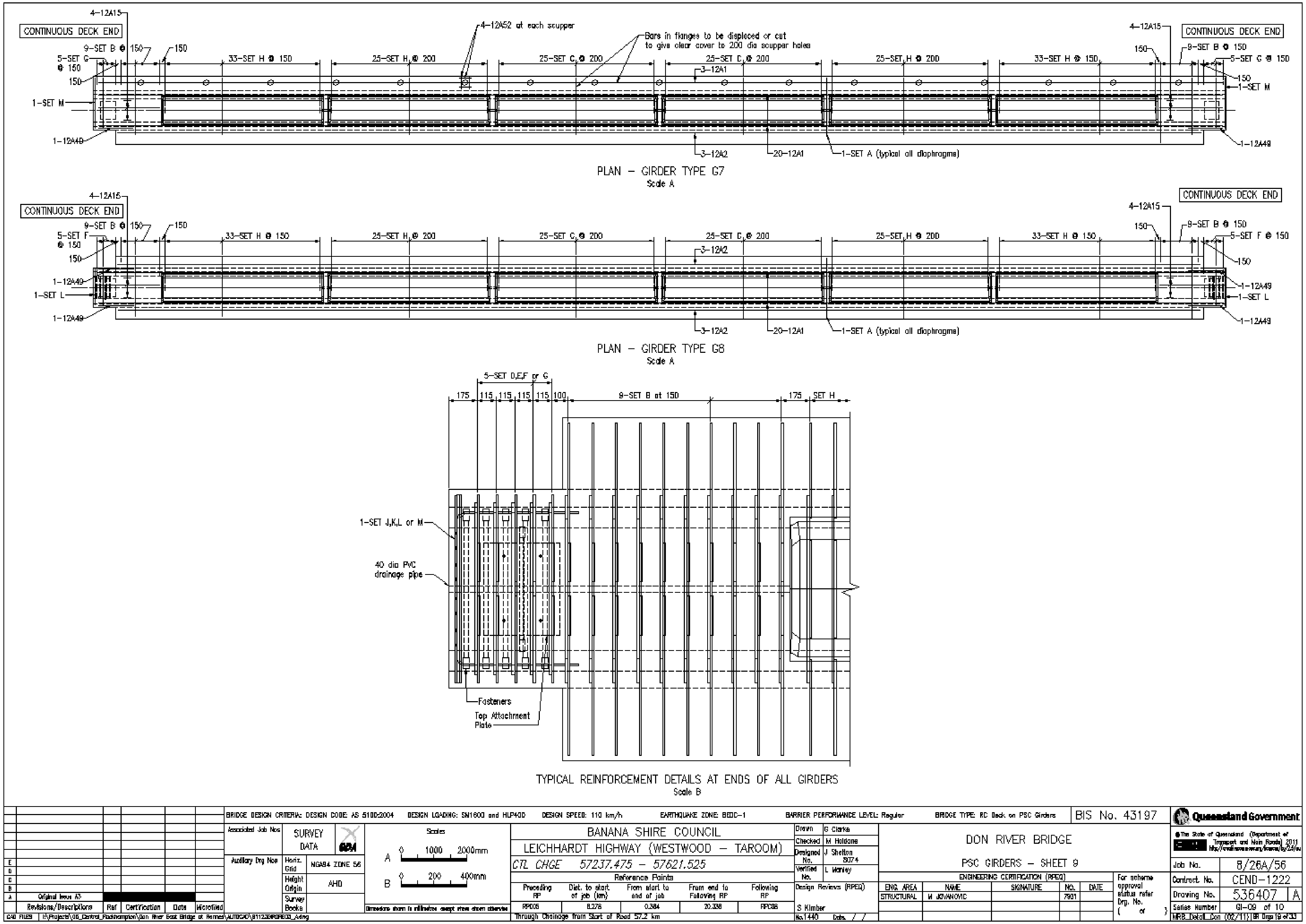
Appendix B – Example Super T-girder Drawings – Sheet 7



Appendix B – Example Super T-girder Drawings – Sheet 8



Appendix B – Example Super T-girder Drawings – Sheet 9



Appendix B – Example Super T-girder Drawings – Sheet 10