Drafting and Design Presentation Standards
Volume 3: Structural Drafting Standards

Chapter 12: Abutments and Piers

January 2021

Queensland Government

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Chapter 12 Amendments

Revision register

Issue/Rev No.	Reference Section	Description of Revision	Authorised by	Date
1	–	First Issue.	Manager (Structural Drafting)	April 2011
2	–	Document name change.	Manager (Structural Drafting)	Nov 2011
	12.4	Distance from holding down bolt hole to the end of the deck unit varies when the deck unit is skewed and/or the hole is slotted.		
	12.7	Figure 12.7-1 and formula updated to allow for variable distance between abutment centreline and the ballast wall.		
	12.8	Typical end wall width increased to 300 mm.		
	12.11	Add section Thrie Beam and Conduit Treatment at Abutment Wingwalls.		
	12.12	Transition in barrier height shall be 1 on 10. Figure 12.12-3 amended accordingly.		
	12.15	Add section Alignment of Elastomeric Bearings.		
3	–	**Table of Contents** – 12.11 – Name change	Team Leader (Structural Drafting)	May 2013
	–	**List of Figures** – 12.11-1, 12.11-2 and 12.12-3 name change.		
	12.4	Holding Down Bolt Formed Hole Spacings – paragraph revised. Figure 12.4-1 updated.		
	12.5	Wording revised first paragraph. Figure 12.5-1 updated.		
	12.7	Wording revised. Figure 12.7-2 revised.		
	12.8	Whole clause revised. Figures 12.8-1 to 12.8-4, 12.8-7 and 12.7-8 revised. Figures 12.8-5, 12.8-6, 12.8-9 and 12.8-10 deleted.		
	12.9	Wording parapet replaced with traffic barrier.		
	12.10	Wording parapet replaced with concrete traffic barrier. Abutment wingwall recess wording revised. Figures 12.10-1 and 12.10-2 revised.		

Issue/Rev No.	Reference Section	Description of Revision	Authorised by	Date
	12.11	Re-name section to Thrie Beam and Electrical / Telecommunication Conduit Treatment at Abutment Wingwalls. Figures 12.11-1 and 12.11-2 revised.		
	12.12	Clause revised. Figure 12.12-3 revised.		
	12.15	Wording revised. Figures 12.15-1 and 12.15-2 revised.		
	12.16	Figure 12.16.1 revised.		
	12.17	Figures 12.17-5, 12.17-6, 12.17-10 and 12.17-12 revised.		
	12.19	Clause revised.		
	–	Appendixes A and B – updated.		
4	12.5	General review including the removal of engineering content. Deck Unit Mortar Seating thickness has been revised to alert designers to geometric considerations, so as to avoid deck soffit clashes with headstocks.	Team Leader (Structural Drafting)	Jan 2021

Contents

Figures

12 Abutments and Piers

12.1 Glossary of terms

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

12.2 Figures and examples shown in this volume

The figures and examples shown in this volume are taken from the typical details / solutions used in past Transport and Main Roads projects which for presentation purposes only and may contain some details that are now superseded. These details have been included for ease of reference, and to show the required standard of drafting presentation. The details are not to be used without an engineering check and certification by an appropriate Registered Professional Engineer of Queensland (RPEQ) to confirm that the details are appropriate for the specific project.

12.3 General

The substructures at each end of a bridge are called abutments, with the first abutment along the gazettal referred to as ABUTMENT A and the other abutment referred to as ABUTMENT B.

If the bridge has multiple spans, the intermediate substructures are called piers. For a two-span bridge the pier is shown as PIER. For bridges with spans of three or more each pier is represented by a number, for example PIER 1, PIER 2 and so on.

When designing abutments and piers for a particular bridge, consideration shall be given to rationalising sizes to ensure good economics due to the repeated use of formwork and design details.

For bridges crossing a waterway, the Plan views of the abutment and piers shall show a flow arrow. For bridges where there is no water flow, the Plan views of the abutment and piers shall show a north point arrow. Refer Chapter 2 – *Standard of Presentation, 2.10 Arrows*.

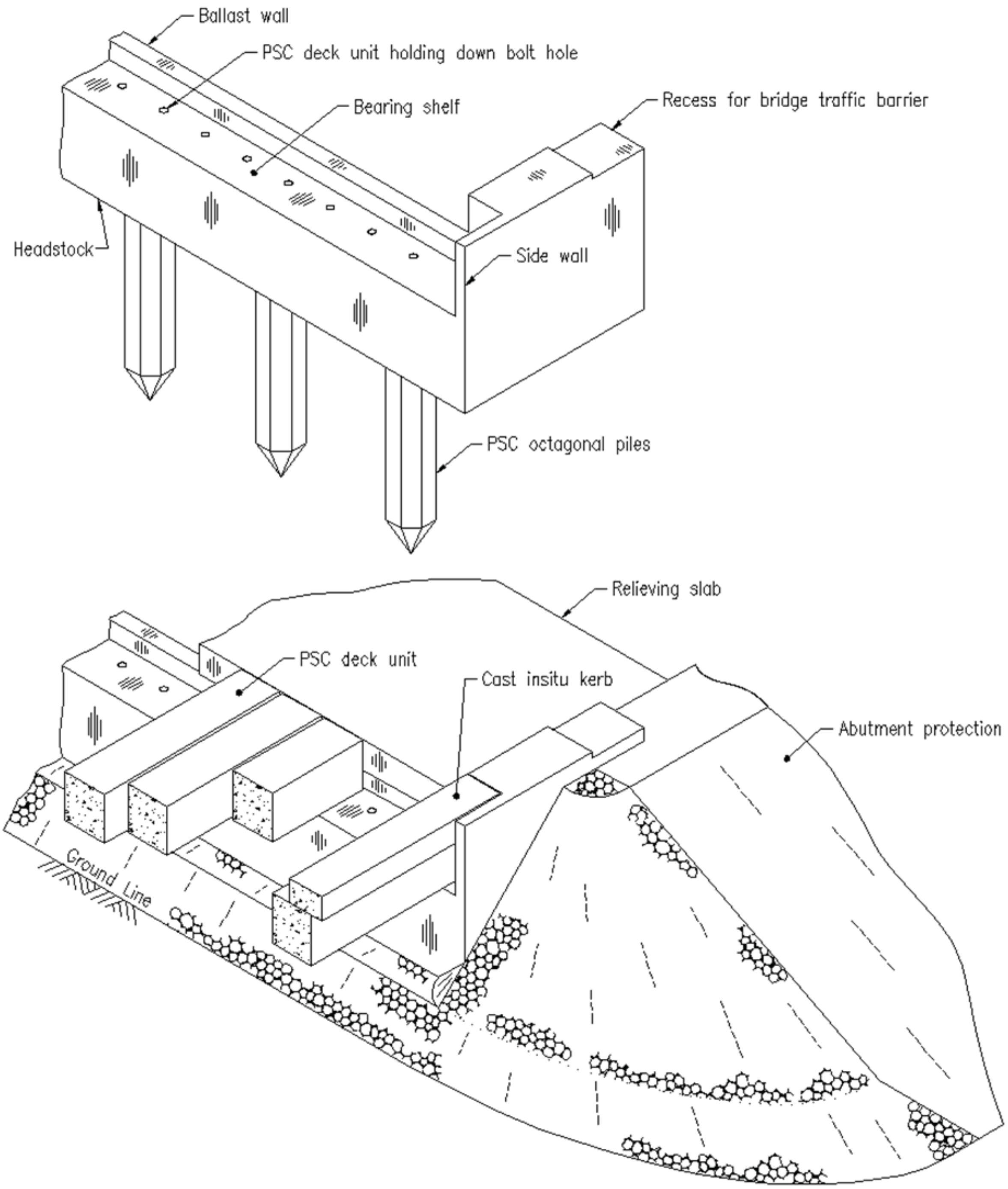
Abutments

An abutment headstock supports the superstructure, for example, deck units, girders. The ballast wall retains the embankment and supports the relieving slab. The abutment wingwalls retain the embankment and provide anchorage for the bridge barrier. The abutment sidewalls provide a separation barrier from the embankment fill and the superstructure and joints. Refer Figure 12.3(a) *Typical Abutment*.

Piers

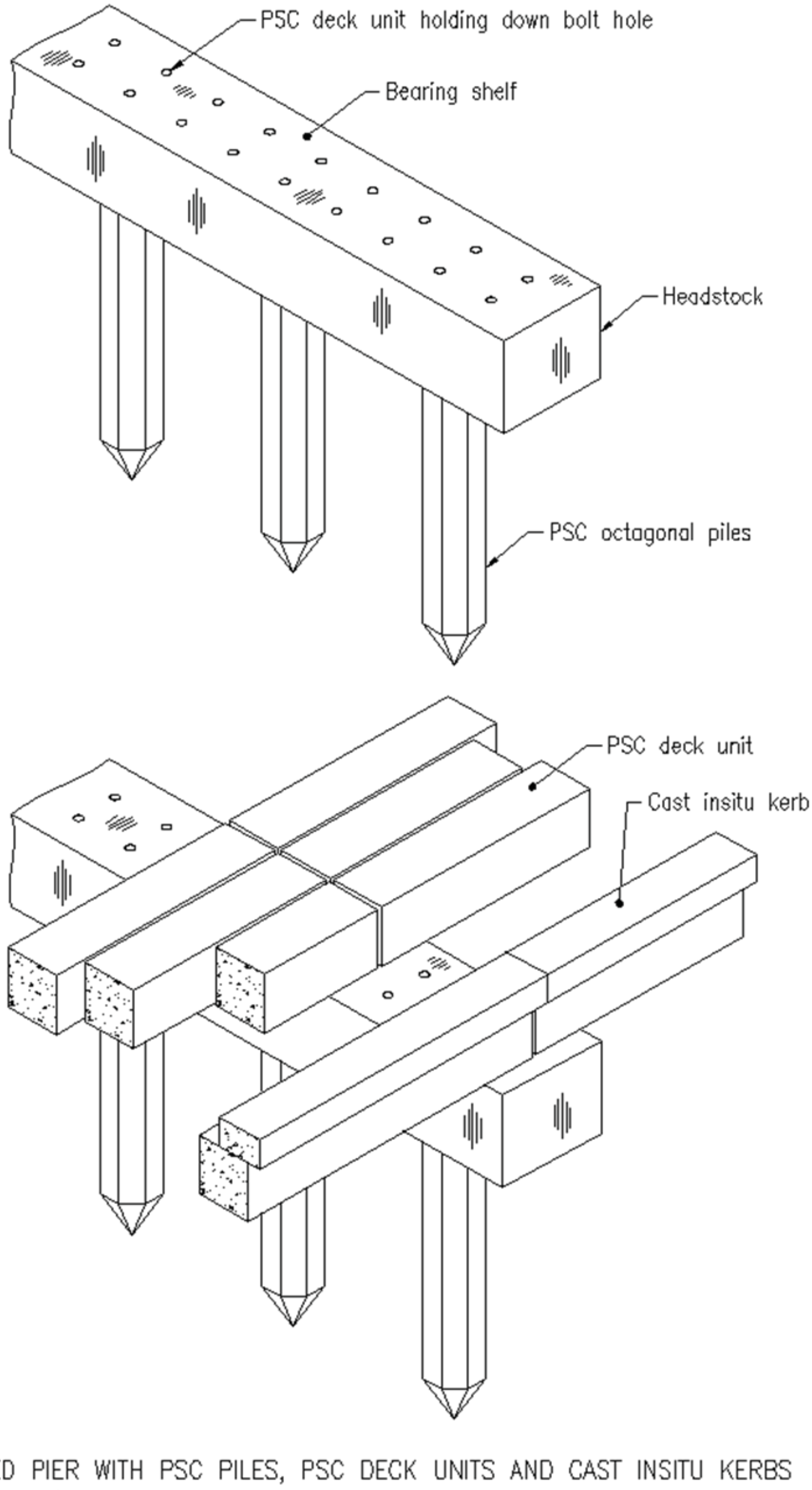
In comparison a pier is relatively simple. Like the abutment headstock, the pier headstock also supports the superstructure. Refer Figure 12.3(b) *Typical Pier*. On deck unit bridges in a highly visible area, for example an overpass on a highway or major river with significant traffic, pier sidewalls may be used to hide the bearings and improve aesthetics. Pier sidewalls may also be used as a control measure to prevent the falling of units or girders, especially for structures with superelevated headstocks.

Figure 12.3(a) - Typical abutment



FIXED ABUTMENT WITH PSC PILES, PSC DECK UNITS AND CAST INSITU KERBS
(THE ABUTMENT DOES NOT HAVE A JACKING SHELF BECAUSE
IT DOES NOT HAVE BEARINGS THAT MAY NEED REPLACING)

Figure 12.3(b) - Typical pier



FIXED PIER WITH PSC PILES, PSC DECK UNITS AND CAST INSITU KERBS
(THE PIER DOES NOT HAVE JACKING SHELVES BECAUSE
IT DOES NOT HAVE BEARINGS THAT MAY NEED REPLACING)

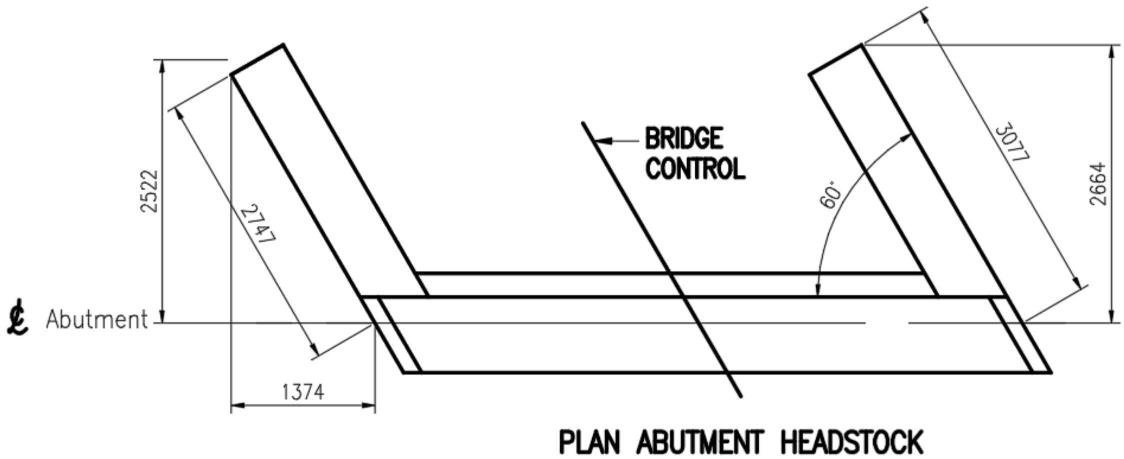
12.4 Deck Unit Bridge - Headstock layout

All headstocks are set out from a nominated point (Set Out Point) being the intersection between the Bridge Control and the headstock centreline at the road surface height. All formed holes, bearings, wingwalls etc are to be set out along a line from this point perpendicular to the headstock centreline. Due to the effects of skew and superelevation on the structure, the lateral position of the headstock shall be considered separately in each case.

> For example, a superstructure depth of 1000 mm including bearings / mortar and DWS on a 3% superelevated deck and a square bridge would result in a 30 mm offset from the bridge control to the centre of the bearing shelf, whereas the same deck with a 30 deg skew would be 26 mm.

Enough dimensions are to be supplied, such that a drawing may be readily understood, without the requirement of further calculation. For example, each feature shall be easily established by a longitudinal and transverse dimension parallel and normal to the abutment centreline, not solely by an offset dimension and a dimension along a bearing.

Figure 12.4(a) – Wingwall dimensioning



Holding down bolt formed holes

Both ends of a deck unit are connected to a headstock with either holding down bolts, threaded rod, or dowel bars set into formed holes in the headstocks. For typical deck unit anchorage details refer Chapter 11 – *General Arrangements*, *11.7 Detailed Design General Arrangement Drawings*. Dowel bars may only be used on overpass bridges that will not be submerged in a 2000 ARI flood.

The formed holes are 90 mm in diameter, 450 mm deep, perpendicular to the bearing shelf, and shall be shown in the headstock Elevation and Section views. Refer *Appendix A – Example Abutment Drawings – Sheet 1*.

Holding down bolt formed hole spacings

The spacing of the formed holes for holding down bolts is determined by the width of the PSC Deck Units, gaps between the deck units and the skew of the bridge. The standard nominal gap between deck units is 25 mm. This gap can vary slightly due to bowing of the deck units.

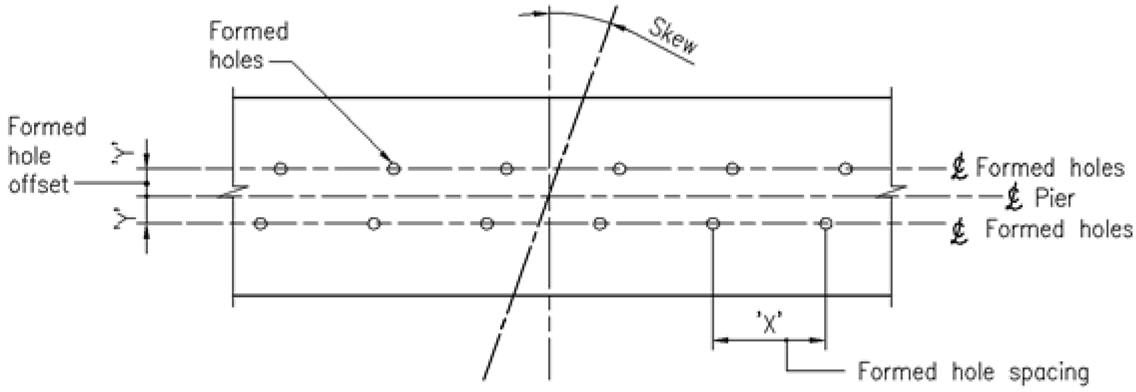
Other spacings may be used. For details refer Chapter 9 – *Bridge Types, 9.5 PSC Deck Units with Cast Insitu Kerbs*.

The following formulas were used for dimensions shown in Figure 12.4(a) *Formed Hole Spacings* and are based on deck units having square ends and at various skews to headstocks:

- On abutment and pier headstocks the formula for dimension 'x' = (width of deck unit + gap between units) ÷ cosine of skew angle.
- On pier headstocks the formula for dimension 'y' = (distance holding down bolt hole from end of unit + half gap between ends of units) x cosine of skew angle.

The dimensions shown in Figure 12.4(b) *Formed Hole Spacings* are based on 596 mm wide deck units with a distance of 220 mm from the holding down bolt hole to the end of the unit. Where the end of the deck unit is skewed and/or has a slotted holding down bolt hole for expansion joints, the end distance will usually be greater and will need to be designed to determine the distance. Also, if the bridge is on a horizontal curve, the skew angle varies between the deck units and the abutment and pier headstocks.

Figure 12.4(b) - Formed hole spacings (for deck units with fixed ends)



Formed Hole Spacing Dimension 'X'

Skew	0°	5°	10°	15°	20°	25°	30°
For 25 mm gaps between units	621	623	631	643	661	685	717

Formed Hole Offset from Pier Centreline Dimension 'Y'

Skew	0°	5°	10°	15°	20°	25°	30°
Distance	245	244	241	237	230	222	212

Square and superelevated bridges

On square and superelevated bridges, the headstock is offset to maintain the correct position of the superstructure.

The offset is calculated as follows:

- Offset = (Depth from top of DWS to the bearing shelf of the headstock) x (% of superelevation)

The offset is applied along the headstock centreline. Refer Figure 12.4(b) *Formed Hole Offset*.

Skewed and superelevated bridges

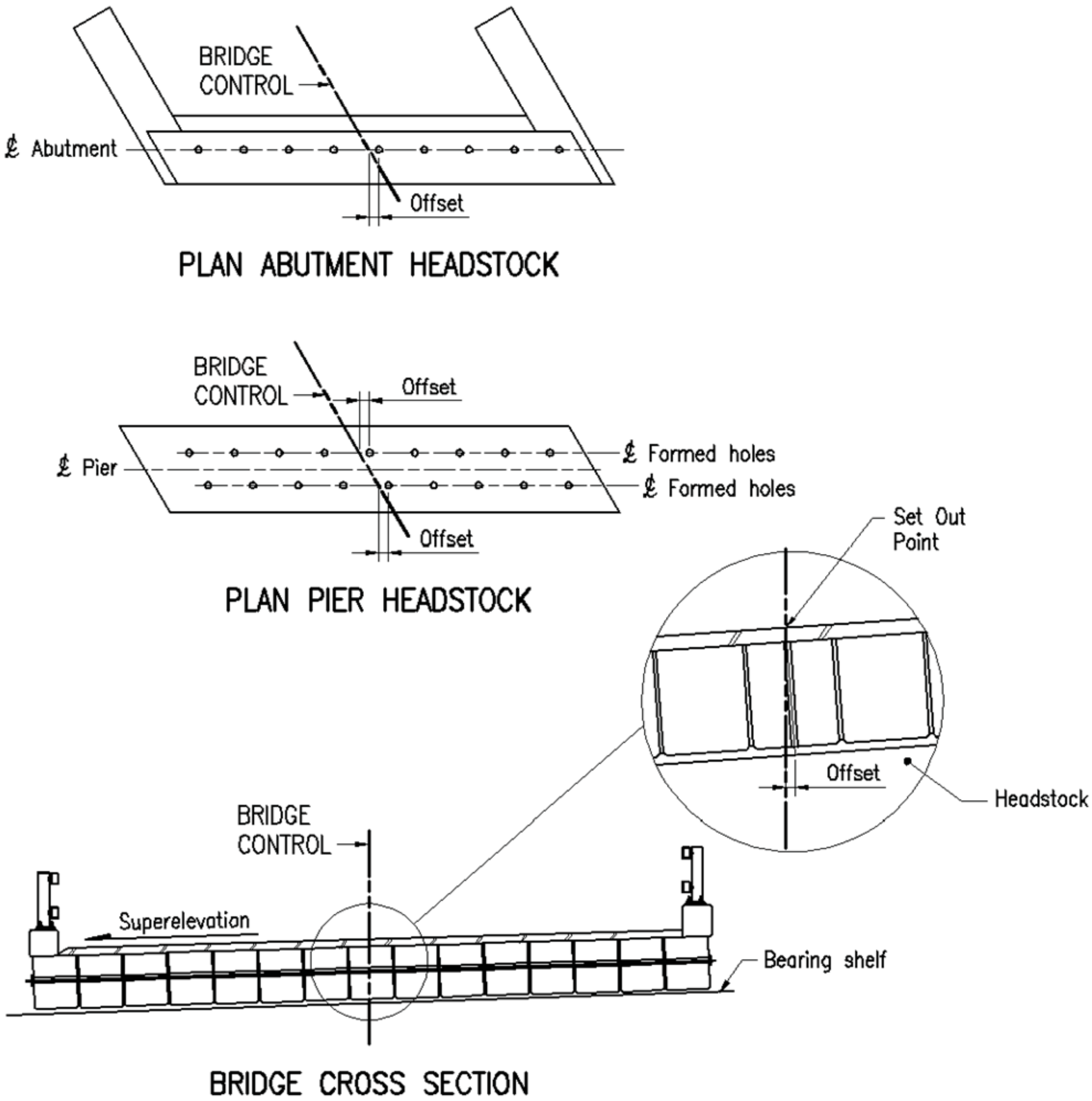
When the bridge is skewed and superelevated, the headstock is offset to maintain the correct position of the superstructure.

The offset is calculated as follows:

- Offset = (Depth from top of DWS to the bearing shelf of the headstock) x (% of superelevation) ÷ (Cosine of the angle of skew)

The offset is applied along the headstock / formed hole centreline. Refer Figure 12.4(c) *Formed Hole Offset*.

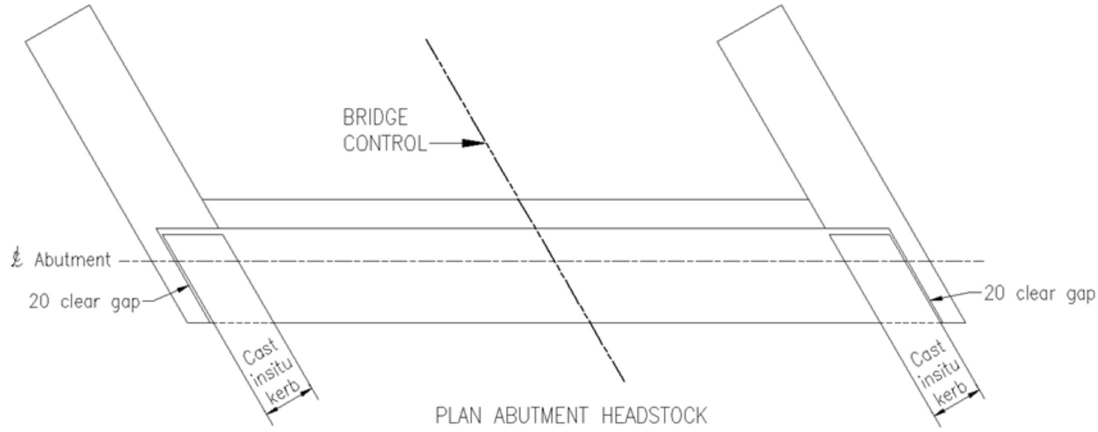
Figure 12.4(c) - Formed hole offset



Abutment sidewalls

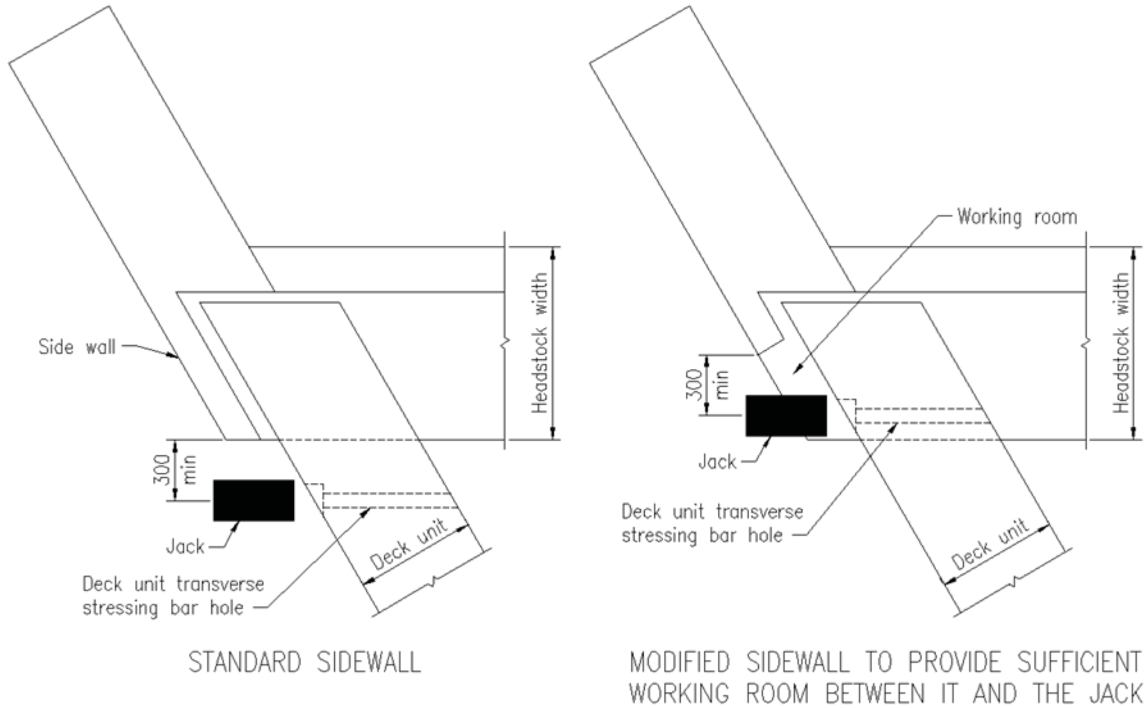
On a deck unit bridge with cast insitu kerbs there is a 20 mm gap between the cast insitu kerb and the 150 mm wide sidewall. Refer Figure 12.4(d) *Clear Gap at Abutment Sidewalls*.

Figure 12.4(d) - Clear gap at abutment sidewalls



On skewed bridges the Drafter must check that the abutment side walls will not interfere with the transverse stressing of the deck units. The side wall may need to be terminated to provide sufficient working room between it and the jack. Refer Figure 12.4(e) *Abutment Side Wall and Transverse Stressing Jack Clearance*.

Figure 12.4(e) - Abutment side wall and transverse stressing jack clearance



Length of abutment headstocks

The length of an abutment headstock is determined by allowing for the overall width of the bridge (between kerbs) plus the width of the wingwall on both sides of the bridge. For wingwall widths refer Section 12.7 *Deck Unit Bridge – Abutment* Wingwalls.

Width of abutment headstocks

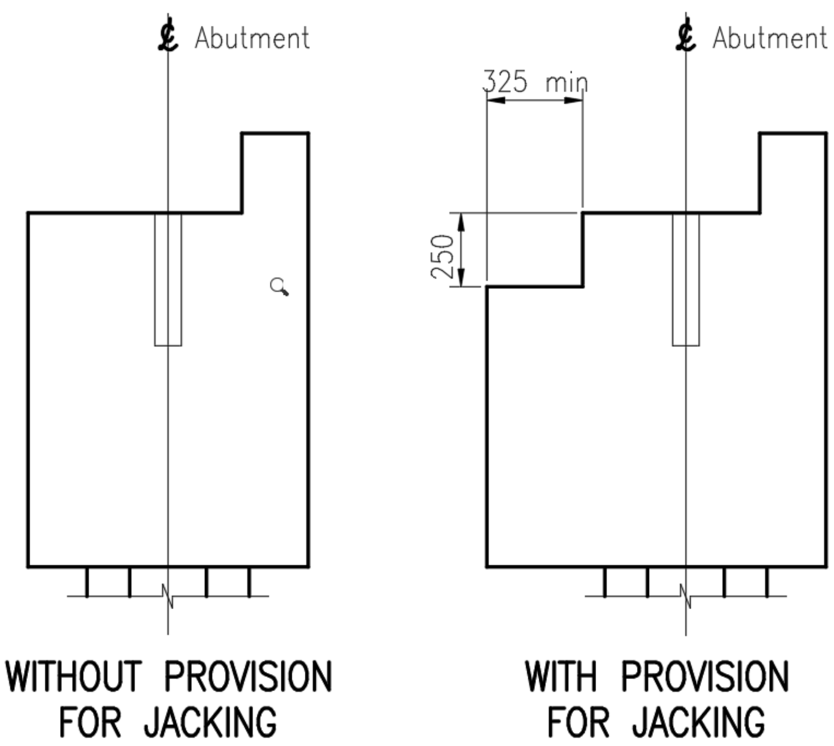
The width of an abutment headstock is determined by the design engineer according to the design loadings and may also be influenced by the extent of the cement mortar / bearings on the bearing shelf, provision for jacking, as well as the pile type and size and piling tolerances. Refer 12.5 *Deck Unit Bridge – Mortar Seating* and Chapter 13 – *Provision for Bridge Jacking Inspection and Maintenance*.

Typically abutment headstocks are 950 mm wide when the deck units they support are on mortar seating, square ended, and the joint is fixed. If the deck units are skewed and/or have a slotted holding down bolt hole, the distance from the holding down bolt hole in the deck unit to the end of the deck unit is increased from the typical dimension of 200 mm. Consequently the abutment width shall be increased.

Where jacking shelves are required for bearing replacement the jacking shelves are to be 325 mm wide (minimum). Depending on the jack size required the jacking shelves may be wider, so it is important to determine the jack size early. Jacking shelves are typically 250 mm deep.

The centreline of the abutment is through the piles and through the deck unit holding down bolt. Refer Figure 12.4(f) Example *Fixed and Square Abutment Headstocks*.

Figure 12.4(f) - Example Fixed and Square Abutment Headstocks



Length of pier headstocks

The length of a pier headstock is determined by the extent of the cement mortar or bearings on top of the headstock. When dimensioned from the Set Out Point the headstock length shall be rounded up to the nearest 50 mm on each side. Refer PIERS – PLAN in Figure 12.5(a) *Mortar Seating Limits*.

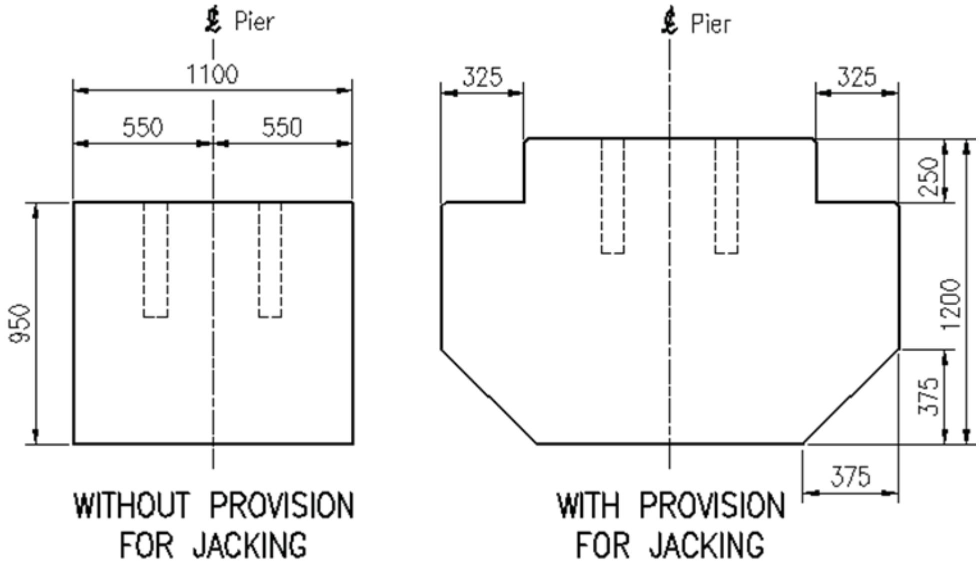
Width of pier headstocks

The width of a pier headstock is determined by the extent of the cement mortar or bearings on the bearing shelf, as well as the pile size and piling tolerances. Refer 12.5 *Deck Unit Bridge – Mortar Seating* and Chapter 13 – *Provision for Bridge Jacking, Inspection and Maintenance*.

Typically, pier headstocks are 1100 mm wide when the deck units they support are on mortar seating, square ended, and the joint is fixed. If the deck units are skewed and/or have a slotted holding down bolt hole, the distance from the holding down bolt hole in the deck unit to the end of the deck unit is increased from the typical dimension of 200 mm. Consequently, the pier width shall be increased.

If the deck units are supported on laminated or single layer elastomeric bearings, a jacking shelf is required. Typically, this is 325 mm wide (or greater, depending on jack size) and 250 mm deep. Refer Figure 12.4(g) *Typical Fixed and Square Pier Headstock Dimensions*.

Figure 12.4(g) - Typical fixed and square pier headstock dimensions



Depth of abutment and pier headstocks

The bridge designer is to determine the project headstock depths based on the specific project requirements. It is to be noted that a headstock designed to incorporate jacking will be typically 250 or more deeper than a headstock which does not include provision for jacking. Refer Figure 12.4(g) *Typical Pier Headstocks*.

12.5 Deck unit bridge - Mortar seating

Mortar seating thickness – Abutments and piers

Transport and Main Roads has experienced insufficient clearance being allowed for in the design of projects where expensive repairs / modifications were required on site. This includes projects designed using 3d software.

Care is to be taken by the designer in the detailing of the bridge to ensure adequate clearance, 15 mm or greater, is achieved at the minimum clearance point between the soffit of the deck units and any point on the abutment and pier headstocks, usually the front edges, taking into account, but not limited to the following factors:

1. hog of deck units (design hog, tolerance - actual hog at installation, final hog after casting of deck or final hog after achieving 100 days cure)
2. skew
3. grade
4. vertical curve
5. horizontal curve
6. fanning of deck units either for curves or for road geometry requirements such as merging lanes or exit ramps
7. slope of headstock, and
8. change in deck profile (design live and dead loads, creep and shrinkage).

The resultant grade of the deck unit soffit will be determined by the approach and departing seating heights and the curve of the deck unit hogs. The pinch points for the least clearance will often be at the higher side of the deck units on the front face of the superelevated headstocks.

NOTE: Any proposal to set Deck Units vertical will complicate the situation further.

Refer Figure 12.5(a) *Mortar Seating Limits*.

With respect to headstock clearance, the following shall apply:

- mortar seating depth may be varied to a maximum thickness of 30 mm to accommodate geometric issues on less complex designs, and
- in cases where a greater thickness of mortar seating would be required to achieve minimum clearance, the bearing shelf (top of the headstock) must be sloped to match the resultant grade.

With respect to abutment ballast wall clearance, the following shall apply:

- Ballast walls are generally designed with a nominal clearance of 50 mm from the end of the deck units to the front face of the wall. Where extreme geometry applies, such as large grades and deeper units, the gap may be increased to achieve a minimum gap of 20 mm.

Mortar seating limits – Abutments

The extent of the mortar seating bed placed under deck units shall extend 200 mm from the formed holes towards the front face of the headstock.

Mortar seating shall not be placed any closer than 175 mm to the front of the headstock in any application. Refer Figure 12.5(a) *Mortar Seating Limits*.

When the width of the headstock exceeds the standard 950 mm, the clear distance to the front of the headstock shall increase to maintain the 200 mm dimension.

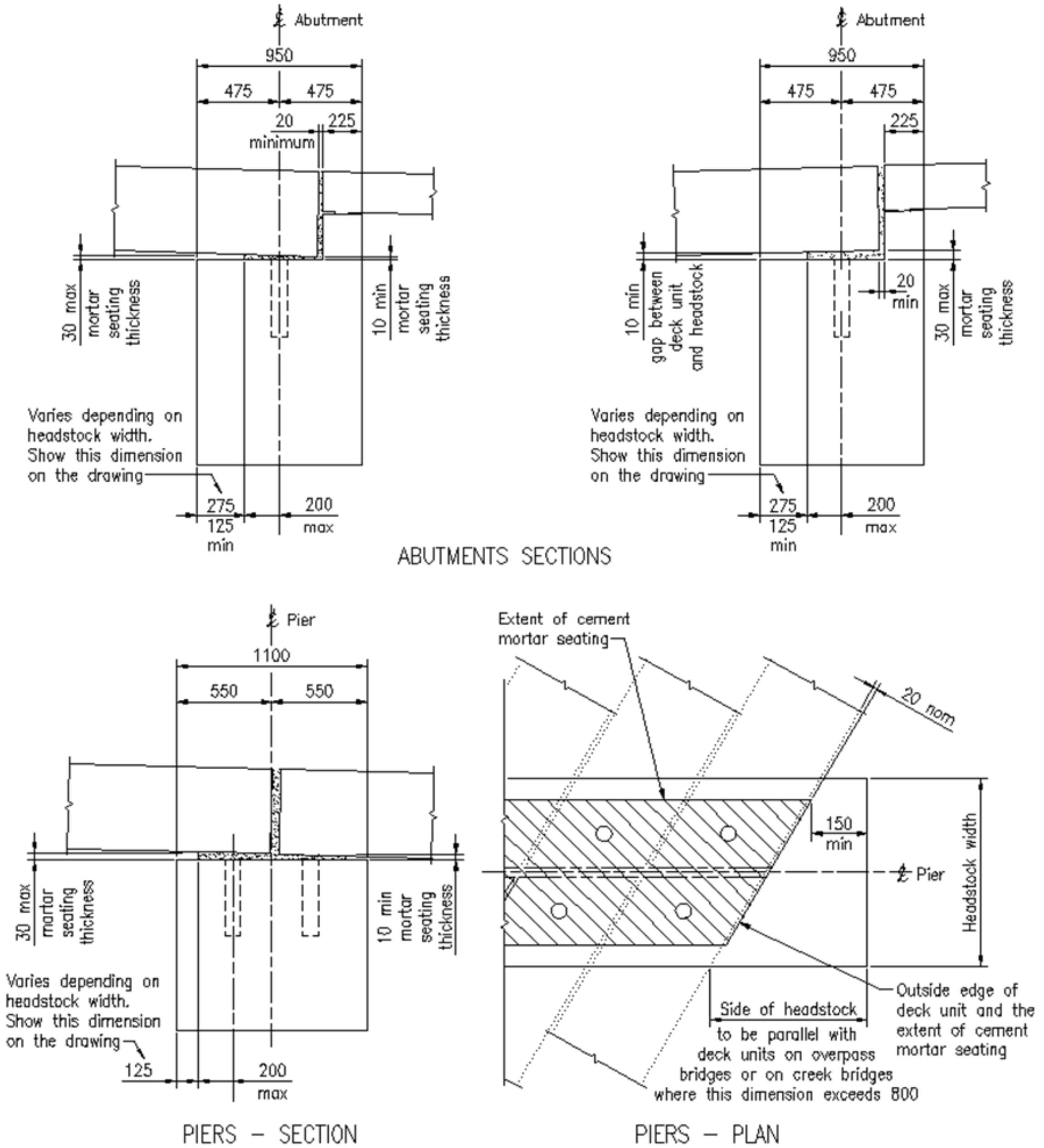
Mortar seating limits – Piers

The extent of the mortar seating bed placed under deck units shall extend 200 mm from the formed holes towards the front face of the headstock.

Mortar seating shall not be placed any closer than 125 mm to the front of the headstock in any application. Refer Figure 12.5(a) *Mortar Seating Limits*.

When the width of the headstock exceeds the standard 1100 mm, the clear distance to the front of the headstock shall increase to maintain the 200 mm dimension.

Figure 12.5(a) - Mortar seating limits



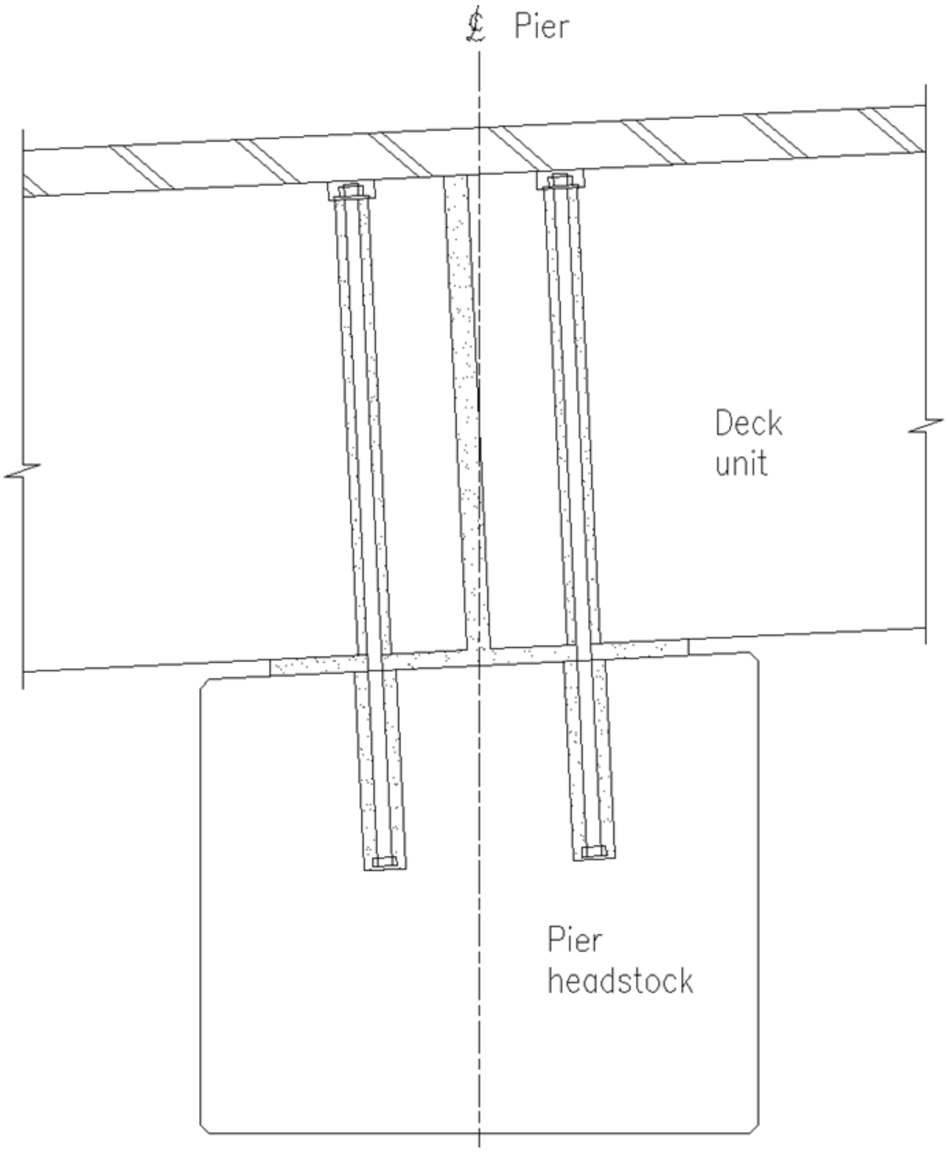
12.6 Deck unit bridge - Sloped headstock bearing shelves

Headstocks with mortar seating

As explained in 12.5 *Deck Unit Bridge – Mortar Seating*, the bearing shelf may need to be sloped to ensure that the mortar seating thickness does not exceed 30 mm. Even when the bearing shelf complies with these guidelines for mortar seating, it may still need to be sloped to allow the deck unit holding down bolts to fit inside the deck unit holding down bolt holes. The 75 x 75 x 6 thick washer for the holding down bolt must be able to sit inside the 100 x 100 x 55 deep recess in the top of the deck unit. Therefore, the bolt can only be off centre a maximum of 12 mm at the top. If the bolt is closer than this the formed hole in the headstock shall be made perpendicular to the deck unit. Consequently, the bearing shelf will be sloped parallel with the grade of the bridge at that particular point.

The possibility of this becoming an issue will increase as the deck units get deeper on bridges with a vertical grade / curve. Refer Figure 12.6(a) *Sloped Bearing Shelf for Mortar Seating*.

Figure 12.6(a) - Sloped bearing shelf for mortar seating (pier shown - abutment similar)



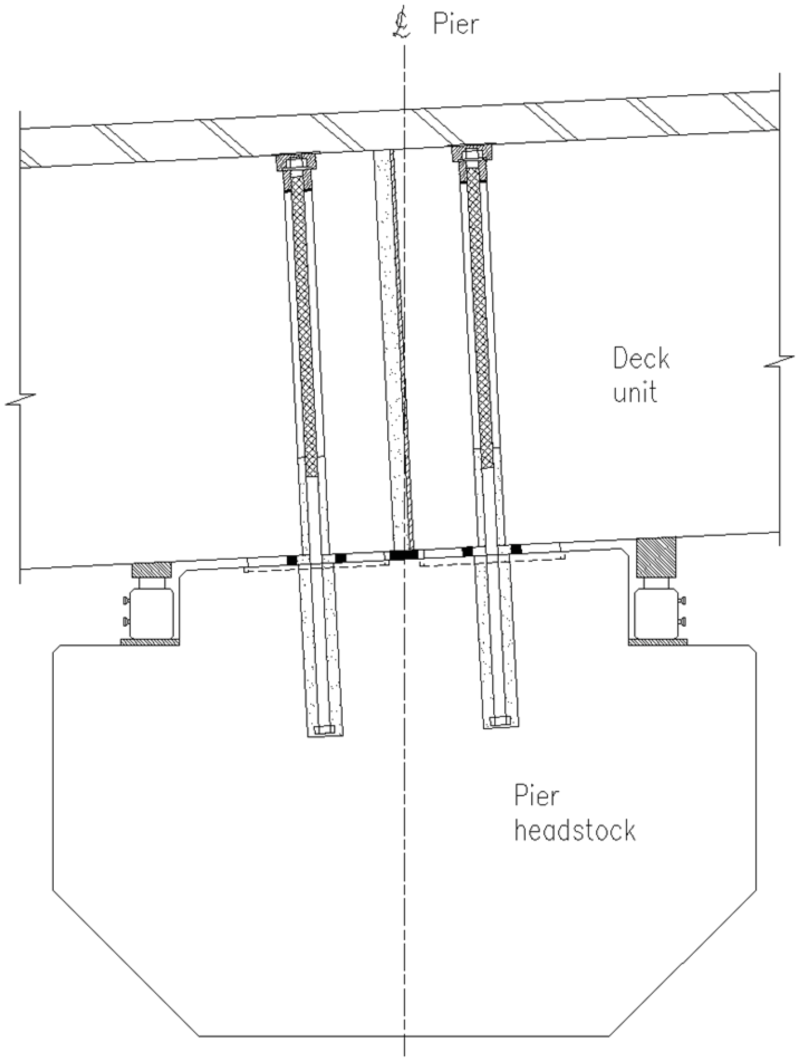
Headstocks with elastomeric bearings

Clause 4.7 of the *Design Criteria for Bridges and Other Structures* defines the circumstances where elastomeric bearings must be used. On bridges with elastomeric bearings, the bearing shelf shall be sloped parallel with the grade of the bridge at that particular point. This is because the holding down bolts must sit centrally in the deck unit holding down bolt holes to suit future jacking requirements of the deck units. This design works for grades up to 5%. For grades in excess of 5%, the design shall be amended to ensure that the bearing sits horizontally. Refer MRTS74 *Supply and Erection of Prestressed Concrete Deck and Kerb Units*. Alternatively, PSC girders may be required when the effects of excessive grade are experienced.

Depending on the required jack size for bearing replacement the jacking shelf widths may be required to be wider than the minimum detailed in Chapter 13, hence it is advisable to discover the jack size early in the abutment and piers detailing process.

Refer Figure 12.6(b) *Sloped Bearing Shelf for Elastomeric Bearings* and Chapter 13 – *Provision for Bridge Jacking Inspection and Maintenance*.

Figure 12.6(b) - Sloped bearing shelf for elastomeric bearings (pier shown - abutment similar)



12.7 Deck unit bridge - Abutment wingwalls

Wingwall widths are typically the width of the cast insitu or precast kerb width + 20 nominal gap + 150 sidewall width. Standard cast insitu kerb widths are specified on Transport and Main Road's Standard Drawing No. 2045.

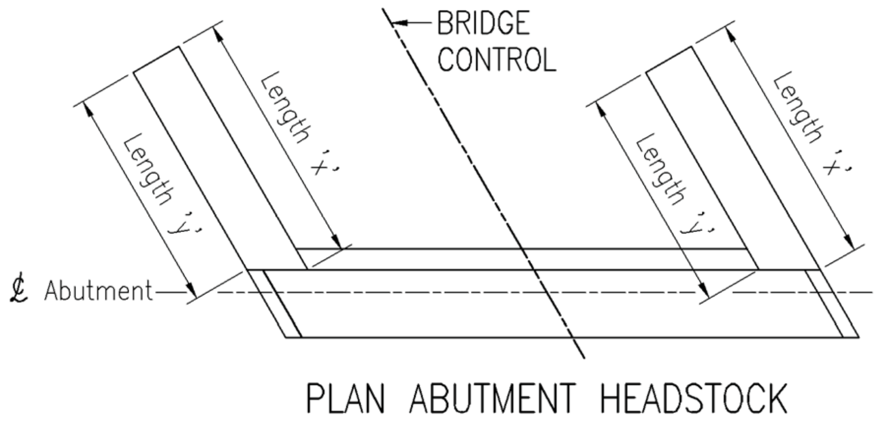
The top of the wingwalls are designed to be flush with the top of the kerbs.

The criteria for conduits in wingwalls are as follows:

- Conduits on bridges are allowed a maximum elbow bend of 22.5° so that the services can be easily pulled through the conduit, and
- Conduits must exit the back of the wingwall 600 mm minimum below ground. This distance may be reduced to 300 mm if the conduits are covered with a concrete protective strip.

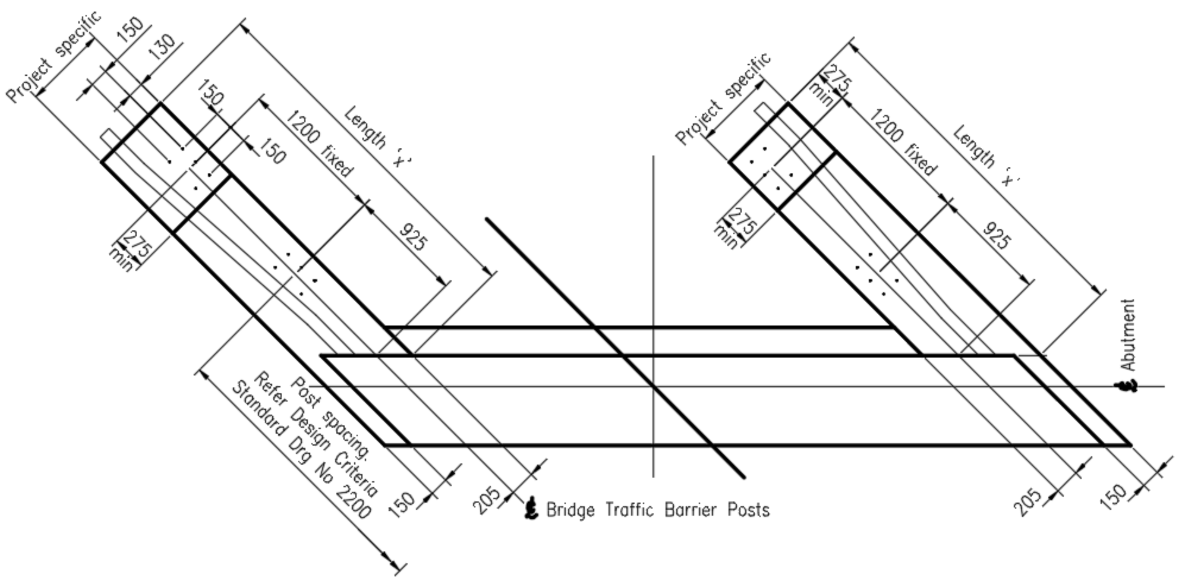
To simplify reinforcing bars, the profile of the wingwalls (in Plan view) shall be the same if possible. Refer Figure 12.7(a) *Wingwall Lengths*.

Figure 12.7(a) - Wingwall lengths



Refer to Design Criteria on Transport and Main Road's Standard Drawing No. 2200 for bridge traffic barrier post spacings and recess depth to be provided at the end of the wingwalls.

Figure 12.7(b) – Deck unit bridge wingwall dimensions



12.8 Girder bridge - Headstock layout

This content is written based on departmental experience with Super T-girders. It is not the intent of this chapter to exclude alternative approved girder types.

All headstocks are set out from a nominated point (Set Out Point) being the intersection between the Bridge Control and the headstock centreline at the road surface Height. All bearings, wingwalls etc are to be set out along a line from this point perpendicular to the headstock centreline.

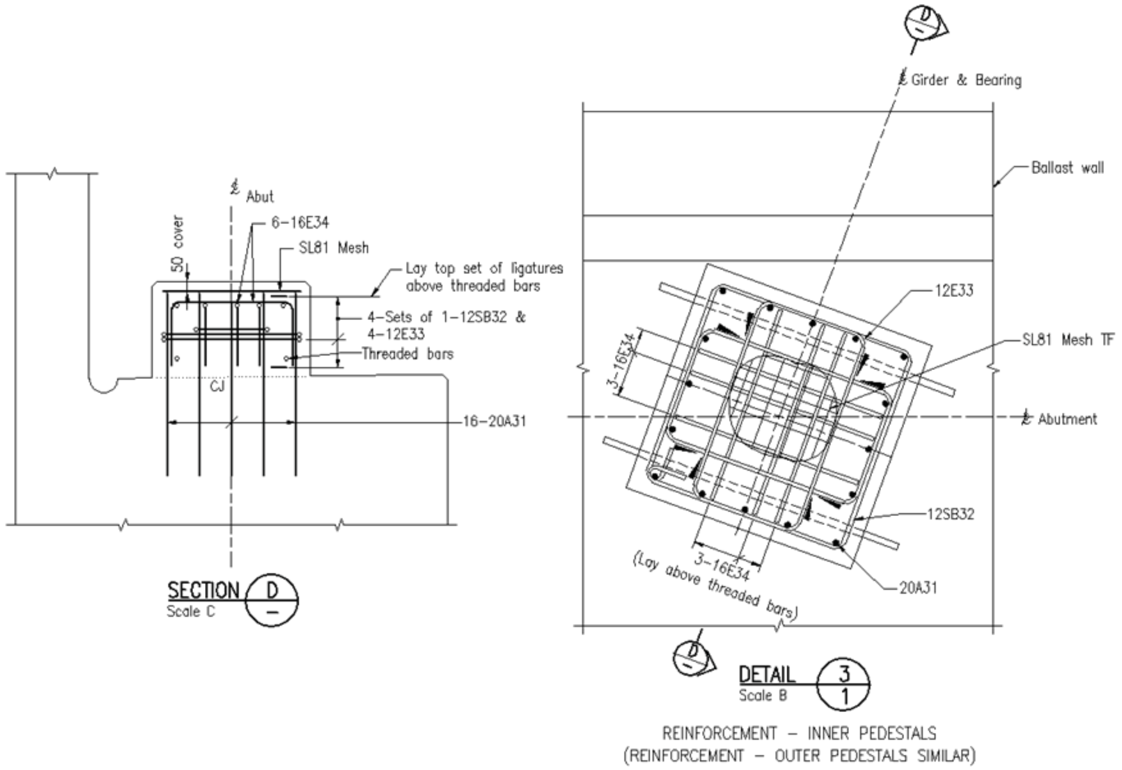
Unlike deck unit bridges, there is no offset to calculate for girder bridge headstock. Super T-girders are placed vertically in all situations so headstocks are not offset in any way at the bearing surface level.

Elastomeric and pot bearings are installed on a reinforced concrete pedestal. The top of the pedestal, and consequently the bearings, shall be level in all directions. Refer Figure 12.8(a) *Pedestal Details* for further details.

Note:

- Girders are placed vertically in all situations.
- Girders are typically placed with a 30 mm gap between top flanges longitudinally Tapered steel plate between the bearing and the girder allows for vertical grade and hog A Height shall be shown at the top of every pedestal.
- Pedestals are typically made from S50/10 reinforced concrete.
- Cover to reinforcing in pedestals shall typically be in accordance with AS 5100 for appropriate exposure classification.
- Heights of pedestals vary and therefore shall be designed individually.

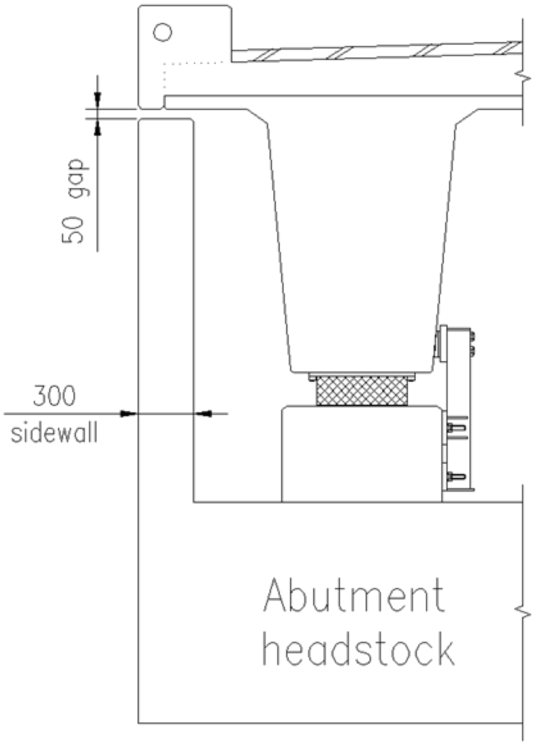
Figure 12.8(a) - Pedestal details



Abutment sidewalls

On girder bridges, sidewalls shall be designed to withstand impact loads during installation of the girders. Typically the sidewalls are 300 mm wide and should finish flush with the outside of the concrete kerb. Refer Figure 12.8(b) *Girder Bridge Abutment Sidewalls*.

Figure 12.8(b) - Girder bridge abutment sidewalls



Length of abutment headstocks

The length of an abutment headstock is determined by allowing for the overall width of the bridge (between kerbs) plus the width of the wingwall on both sides of the bridge. On girder bridges the wingwalls are the same width as the kerb/concrete traffic barrier adjoining it. Refer 12.9 *Girder Bridge – Abutment Wingwalls* and Figure 12.8(b) *Girder Bridge Abutment Sidewalls*.

Width of abutment headstocks

Ballast walls are generally to be 225 mm or greater in width. The width of the bearing shelf is determined by the width of the pedestals plus adequate clearance between the front face of the headstock and the pedestals. There must be at least 250 mm between the bearing and the front face of the pedestal for the placement of non-compressible temporary packers during girder erection.

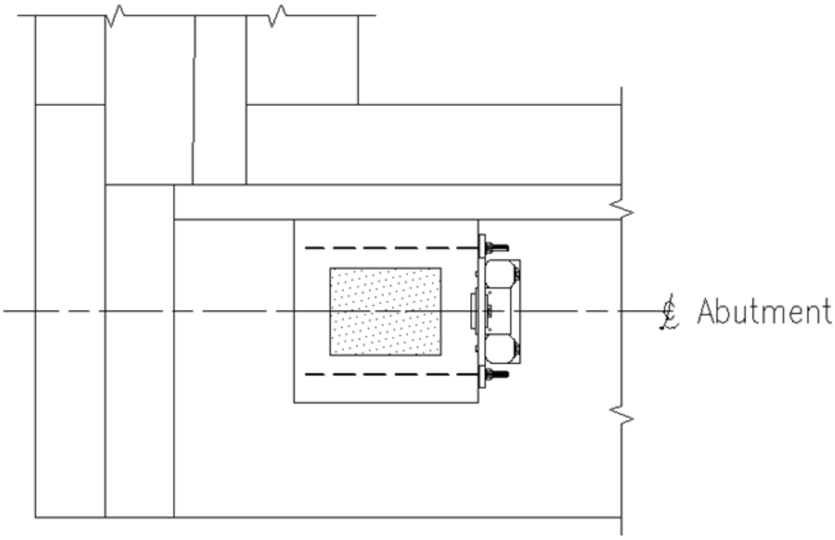
When determining headstock width, the pile size and piling tolerances must also be considered.

The headstock width shall be rounded up to the nearest 25 mm each side when dimensioned from the Set Out Point. When a ballast wall is very tall, for example on a 1800 mm deep super T-girder bridge, the width of the wall may need to be larger than 225 mm.

Square abutment headstocks

Refer Figure 12.8(c) *Abutment Pedestal Profile (Square)*.

Figure 12.8(c) - Abutment pedestal profile (Square)

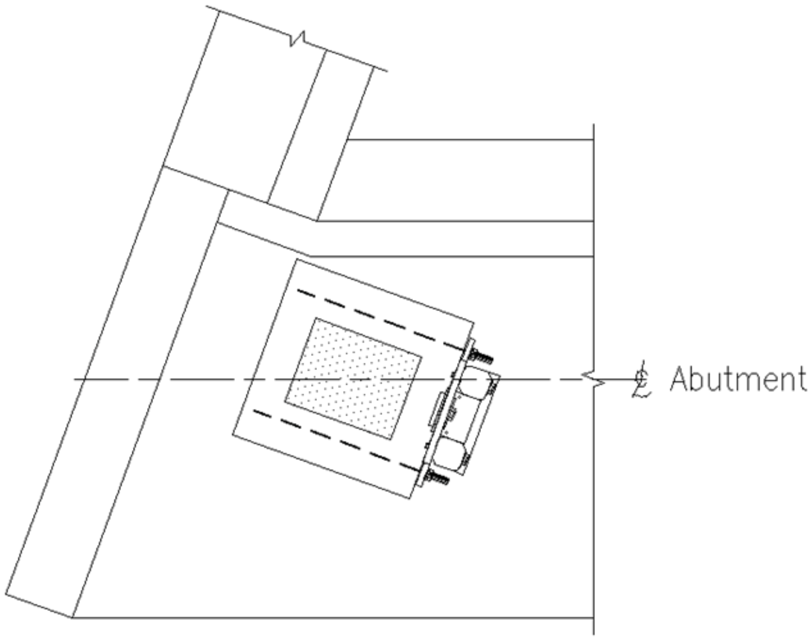


Skewed abutment headstocks

Calculating abutment headstock widths becomes more difficult for skews. Depending on variables such as the bearing and pedestal size and the skew angle, the headstock width may become unproportionally wide.

Refer Figure 12.8(d) *Abutment Pedestal Profile (Skewed).*

Figure 12.8(d) - Abutment pedestal profile (Skewed)



Length of pier headstocks

Depending on the width of the headstock, the skew angle and the importance of aesthetics, the ends of the headstock will be either square or skewed. The headstock length shall be rounded up to the nearest 25 mm each end when dimensioned from the Set Out Point.

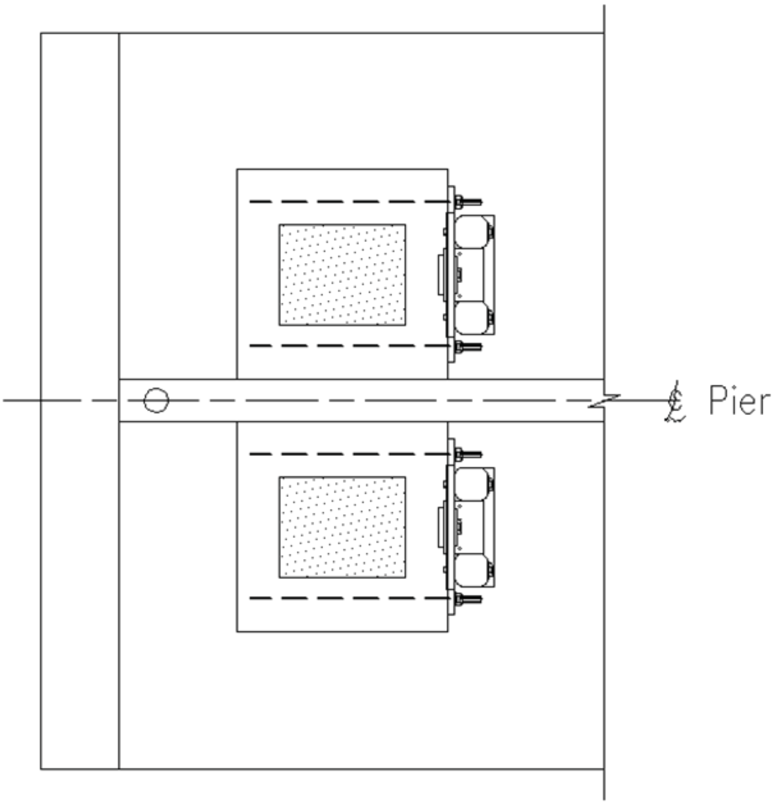
Width of pier headstocks

There must be at least 250 mm between the bearing and the front face of the pedestal for the placement of non-compressible temporary packers during girder erection. The headstock width shall be rounded up to the nearest 25 mm each side when dimensioned from the Set Out Point.

Square pier headstocks

Refer Figure 12.8(e) *Pier Pedestal Profile (Square)*.

Figure 12.8(e) - Pier pedestal profile (Square)

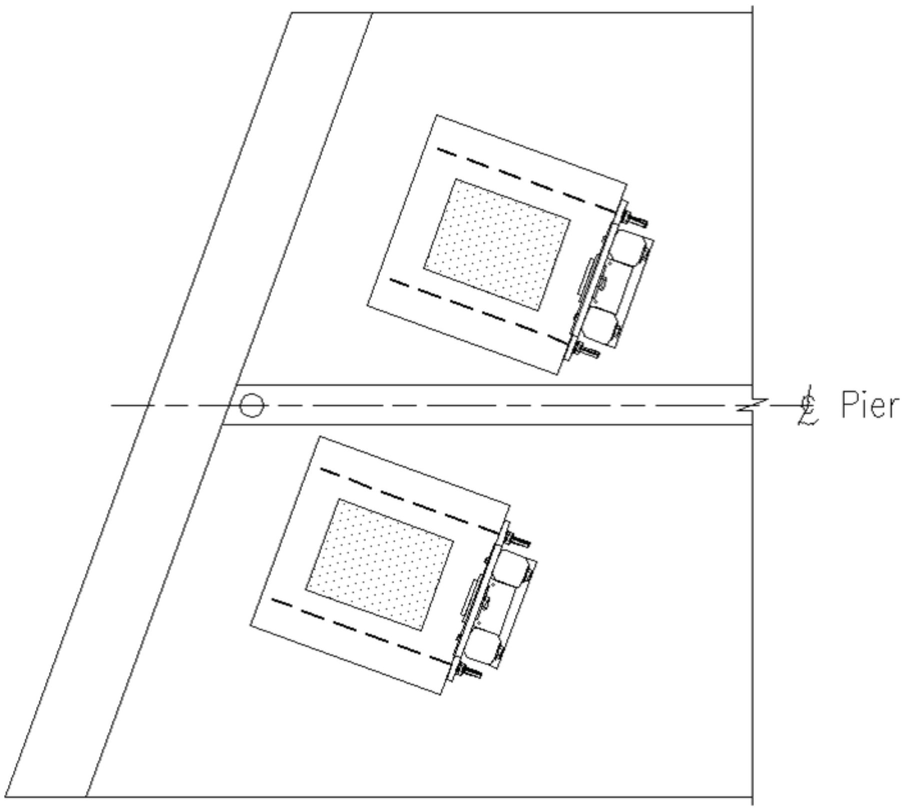


Skewed pier headstocks

Calculating pier headstock widths becomes more difficult for skews. Depending on variables such as the bearing and pedestal size and the skew angle, the headstock width may become unproportionally wide.

Refer Figure 12.8(f) *Pier Pedestal Profile (Skewed).*

Figure 12.8(f) - Pier pedestal profile (Skewed)



12.9 Girder bridge - Abutment wingwalls

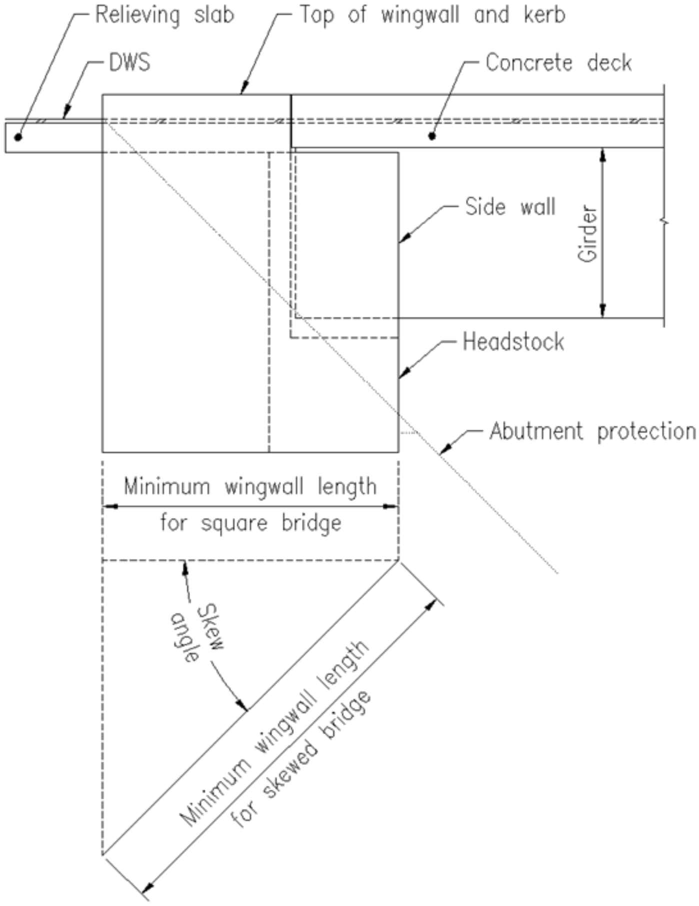
To match the top of the cast insitu kerb, the top of the wingwall is 275 mm above the road running surface. Because the abutment sidewall is located below the kerb/traffic barrier girder bridge abutment wingwalls are the same width as the kerb/traffic barrier adjoining them. Girder bridges cannot use the standard wingwall size tables and therefore shall be designed individually. Points to consider when designing the length of a wingwall include:

- Conduits on bridges are allowed a maximum elbow bend of 22.5° so that the services can be easily pulled through the conduit. By placing conduits as close as possible to the bottom of the traffic barrier unnecessarily long wingwalls can be avoided.
- Conduits must exit the back of the wingwall 600 mm minimum below ground. This distance may be reduced to 300 mm if the conduits are covered with a concrete protective strip.

These two criteria result in a wingwall that is longer than it would be without a conduit.

The wingwalls must be long enough to contain the road embankment. Bridges with deep girders and large skews will need extra length wingwalls. Figure 12.9(a) *Calculating Non-Standard Wingwall Lengths* demonstrates the effect a deep superstructure and a large skew have on the wingwall length.

Figure 12.9(a) - Calculating non-standard wingwall lengths



12.10 Abutment headstock profiles

Top of abutment wingwalls

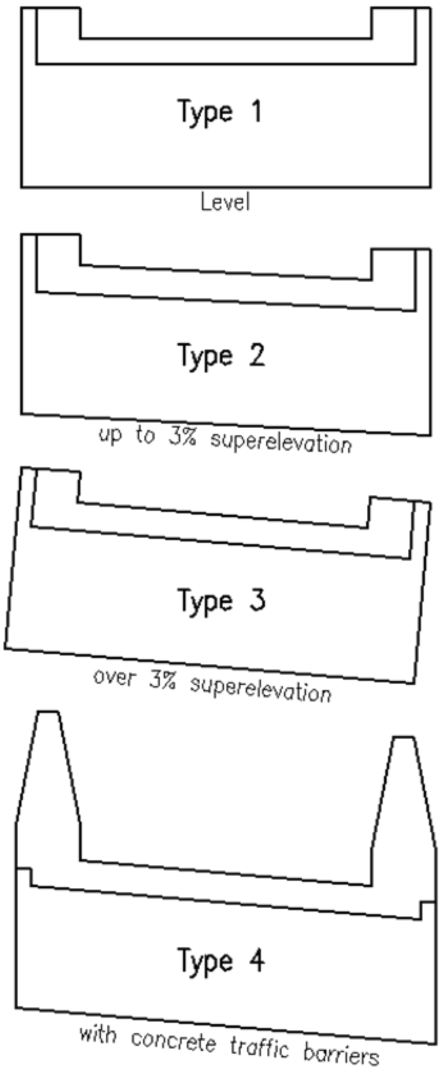
Bridges with cast insitu kerbs: The top face of the kerbs and abutment wingwalls are level on bridges with a crossfall or superelevation up to and including 3% (Type 1 or 2).

Bridges with a superelevation greater than 3%, the top face of the wingwalls follows the superelevation (Type 3).

Bridges with concrete traffic barriers: Regardless of the amount of crossfall or superelevation the concrete traffic barriers shall be vertical and the top face shall be level (Type 4).

The end slope of abutment headstocks shall be perpendicular to the top face of the kerb or wingwall. Refer Figure 12.10(a) *Abutment Headstock Elevation Options*.

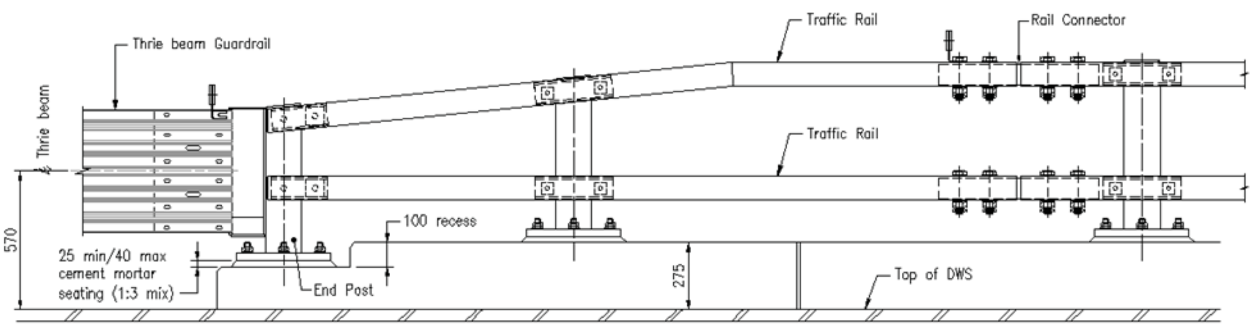
Figure 12.10(a) - Abutment headstock elevation options



Abutment wingwall recess for regular performance level bridge steel traffic barrier connecting to thrie beam guardrail

To suit the end post of a bridge steel traffic barrier a 100 mm deep recess shall be cast into the top of the wingwall. The recess length varies on skewed bridges. Refer Figure 12.7(b) *Deck Unit Bridge Wingwall Dimensions*. Refer Figure 12.10(b) *Abutment Wingwall Recess*.

Figure 12.10(b) - Abutment wingwall recess



Bridge steel traffic barrier connecting to W beam guardrail

W beam guardrail may only be used in low speed environments.

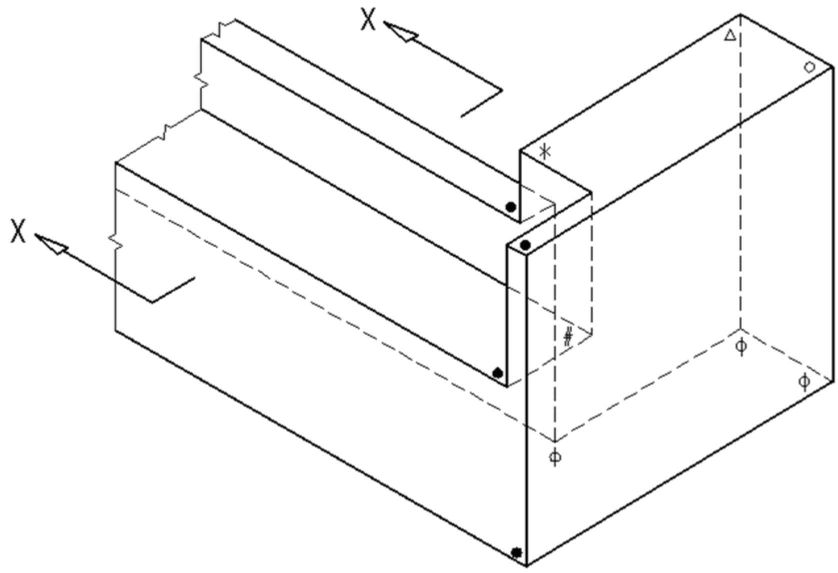
Abutment headstock heights

Variations in geometric conditions (grade, superelevation, skew and so on) on an abutment require Heights to be shown to specific points to clearly define the headstock. Figure 12.10(c) *Abutment Height Notation* defines these points and indicates where Heights are required to be shown.

Note the following:

- Conditions 1, 4 and 7 require Heights to be shown on one side of the abutment only. All other conditions require Heights to be shown on both sides of each abutment.
- The soffit of all headstocks is to be horizontal through Section X-X, and set to the resultant crossfall.
- The soffit of wings to be coplanar with the soffit of the headstock.
- Conditions 4 to 6 will require a Height at a point marked thus '#' when the bearing shelf needs to be sloped due to grade – refer to Figure 12.5(a) *Mortar Seating Limits* for further details.
- A headstock with a jacking shelf requires additional Height(s) to be shown '#' is only needed on a girder bridge when the bridge is skewed.

Figure 12.10(c) - Abutment Height notation



BRIDGE WITH CAST INSITU KERBS

1.	Square on level grade – no superelevation	●					
2.	Square on level grade – with superelevation ≤3%	●					
3.	Square on level grade – with superelevation >3%	●		∗			
4.	Square on longitudinal grade – no superelevation	●	○	∗			
5.	Square on longitudinal grade – with superelevation ≤3%	●	○	∗			
6.	Square on longitudinal grade – with superelevation >3%	●	○	∗	△		
7.	Skewed on level grade – no superelevation	●					
8.	Skewed on level grade – with superelevation ≤3%	●				ϕ	#
9.	Skewed on level grade – with superelevation >3%	●		∗		ϕ	#
10.	Skewed on longitudinal grade – no superelevation	●	○	∗		ϕ	#
11.	Skewed on longitudinal grade – with superelevation ≤3%	●	○	∗		ϕ	#
12.	Skewed on longitudinal grade – with superelevation >3%	●	○	∗	△	ϕ	#

Vertical curves

Abutments within the limits of a vertical curve will require special consideration in determining Heights, while at the same time ensuring that the DWS thickness is not reduced below the minimum allowed either at the ends or at the centre of the span.

12.11 Thrie beam, pit, and electrical / telecommunication conduit treatment at abutment wingwalls

The designer is to consider the interaction and fitment of Guardrails including post positions, conduits and cable joining pits to avoid site clashes.

Figure 12.11(a) *Thrie Beam Connecting to Bridge Concrete Traffic Barrier* and Figure 12.11(b) *Thrie Beam Connecting to Bridge Steel Traffic Barrier* provide samples for consideration.

Figure 12.11(a) - Thrie beam connecting to bridge concrete traffic barrier

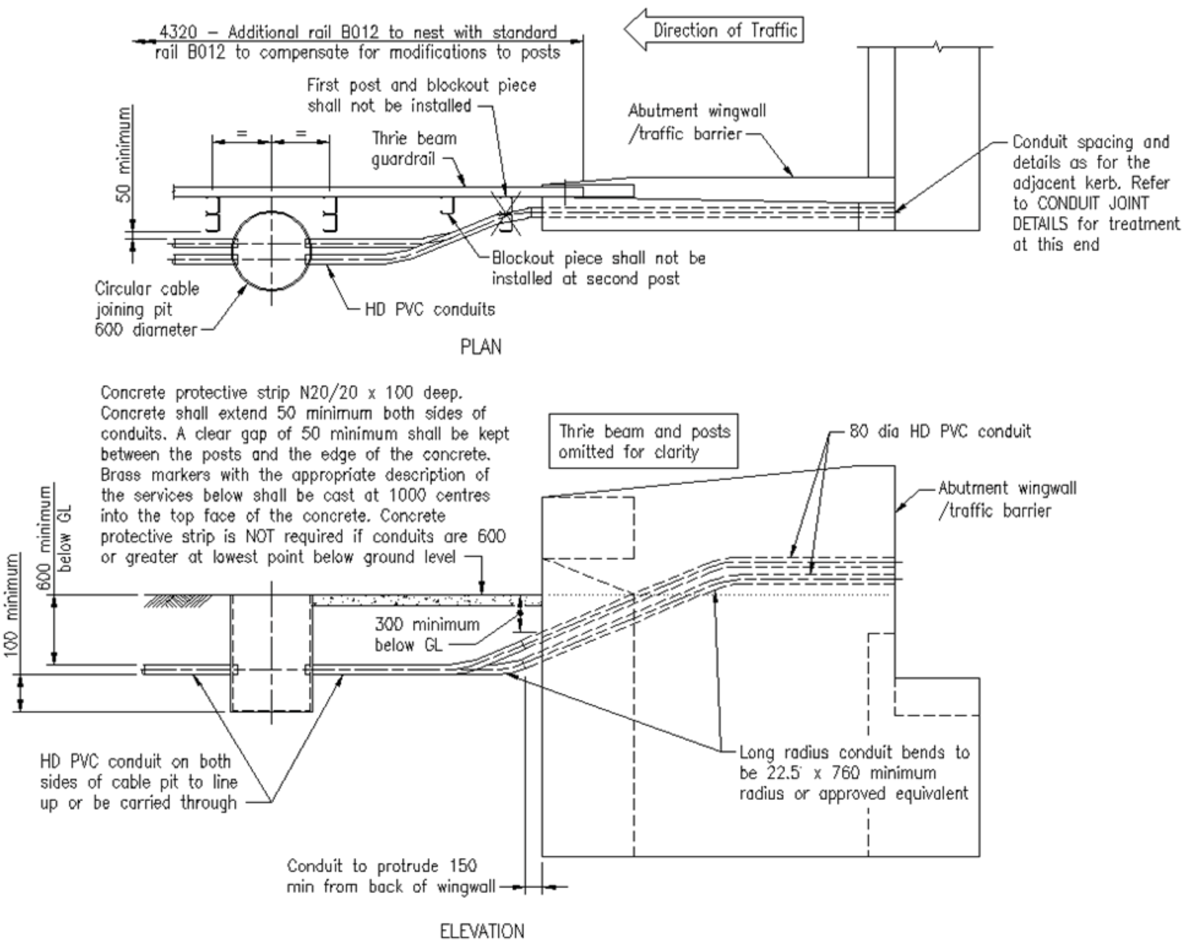
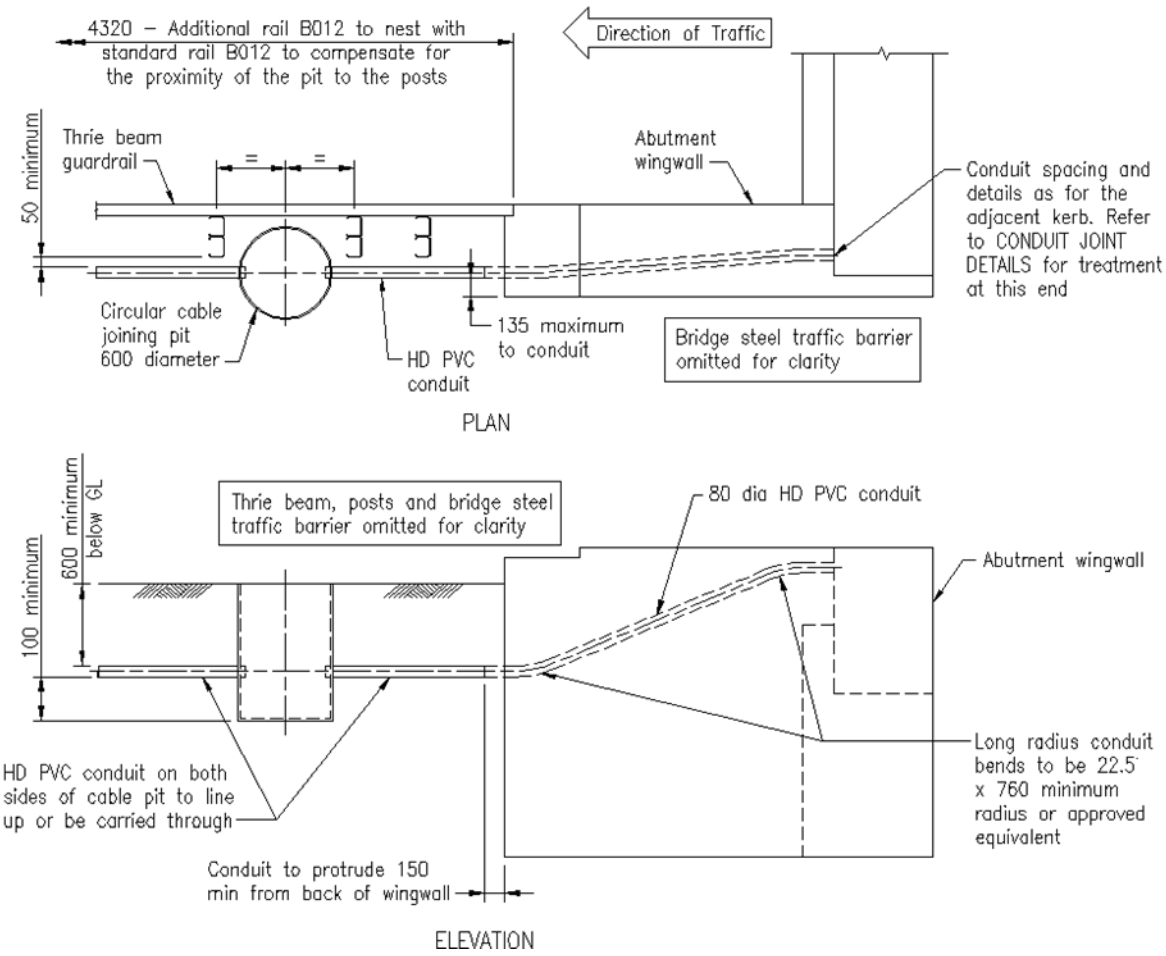


Figure 12.11(b) - Thrie beam connecting to bridge steel traffic barrier



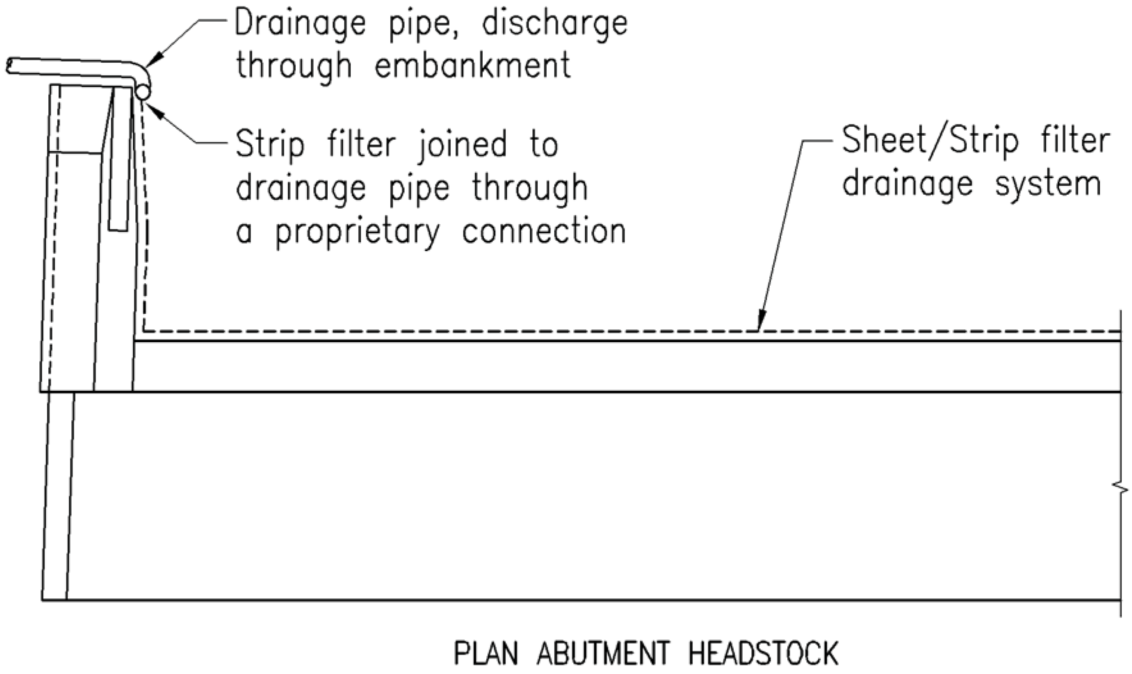
12.12 Abutment headstock additional details

Abutment headstock drainage

The embankment behind an abutment headstock must be drained to prevent hydrostatic pressure being applied to the abutment. A sheet filter placed above a strip filter shall be placed behind the headstock and wingwalls. Drainage pipes are to be connected to strip drains through proprietary connections and shall be drained through the embankment either side of the headstock.

For an example of the details required on the abutment drawings refer Figure 12.12(a) *Abutment Headstock Drainage*. For examples of the details required on the General Arrangement drawings refer Chapter 11 – *General Arrangements*, Figure 11.7(a) *Deck Unit Anchorage Detail – No Provision for Jacking*.

Figure 12.12(a) - Abutment headstock drainage



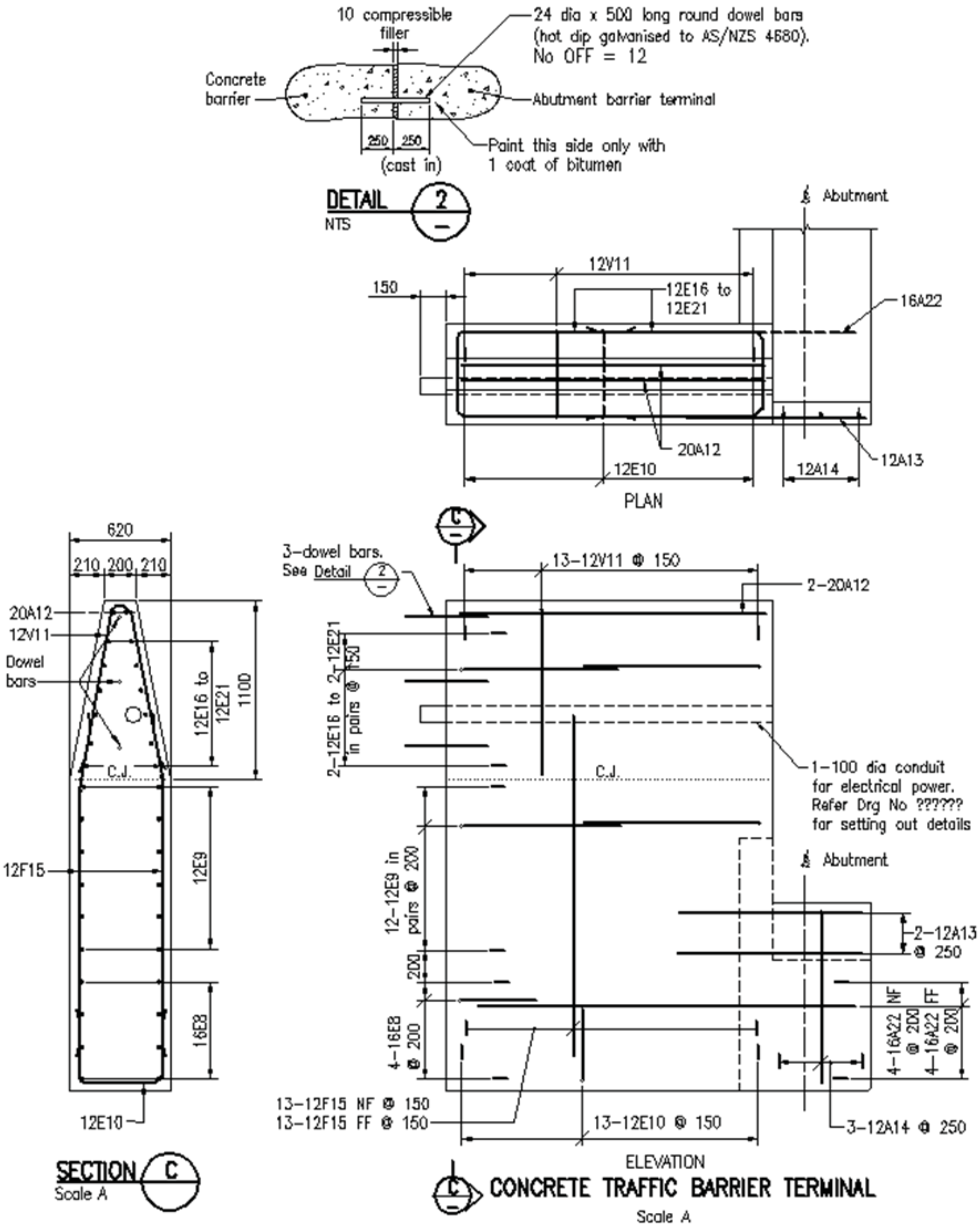
Wingwall (concrete traffic barrier type) connection to extruded barrier

Bridges with concrete traffic barriers can connect to a concrete median barrier rather than guardrail. In this case the back of the wingwall will finish vertically and have dowel bars protruding for the median barrier to connect to.

Dowelled joints are not to be used at abutment barriers or pier barrier joints where they may interfere with future jacking operations.

Refer Figure 12.12(b) *Wingwall Connection to Extruded Barrier*.

Figure 12.12(b) - Wingwall connection to extruded barrier



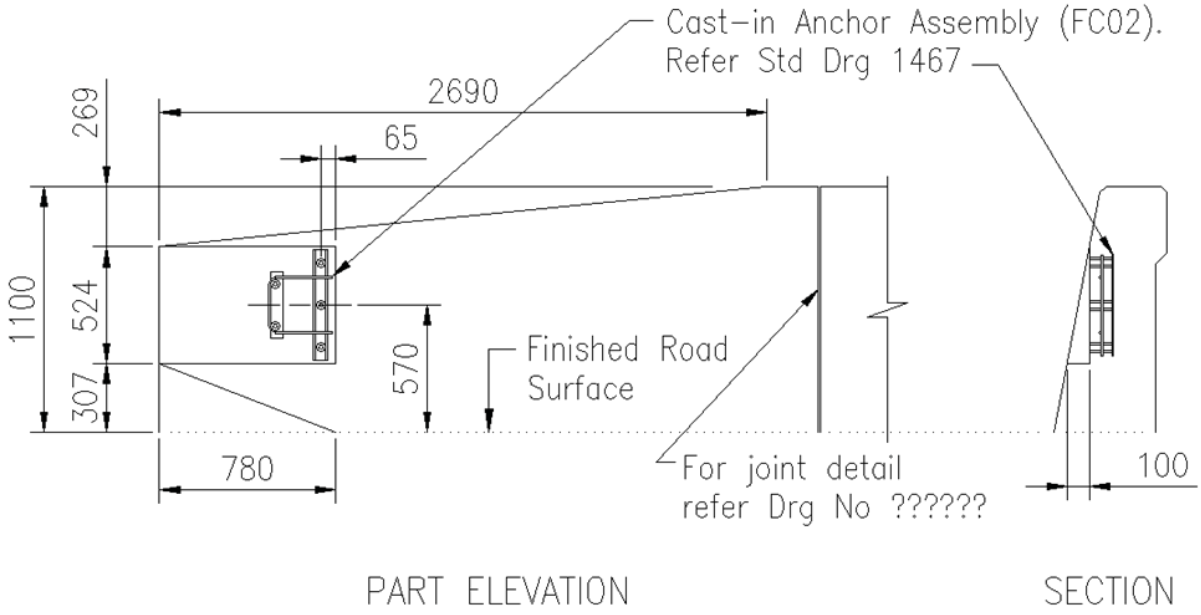
Wingwall (concrete traffic barrier type) connection to guardrail

On bridges with concrete traffic barriers, an anchor is to be cast into each wingwall to accommodate guardrail connection.

Thrie beam guardrail connects to cast-in anchor assembly (part number FC02).

For anchor details refer to Transport and Main Road's Standard Drawing 1467 *Cast in Anchor Assembly for W and Thrie Beam Guardrail Connection*. For an example of the details required on the abutment drawings refer Figure 12.12(c) *Wingwall Connection to Thrie Beam Guardrail*. Note that the transition in barrier shall be one on ten (1 on 10). This results in a relatively long wingwall which may need to be supported by a pile.

Figure 12.12(c) - Wingwall connection to thrie beam guardrail



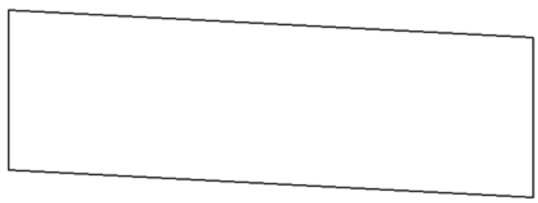
12.13 Pier headstock profiles

End slope of pier headstocks

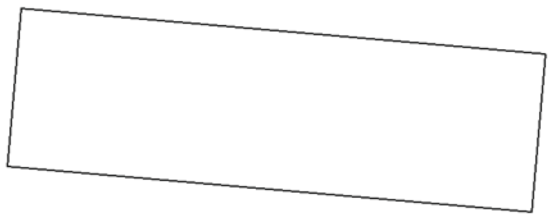
Resultant superelevation is the slope of the headstock after superelevation, vertical grade and skew are accounted for.

Pier headstocks with a resultant superelevation up to and including 3% have vertical ends. Pier headstocks with a superelevation greater than 3% have ends sloped perpendicular to the top of headstock. Refer Figure 12.13(a) *End Slope of Pier Headstocks*.

Figure 12.13(a) - End slope of pier headstocks



Pier headstocks with resultant superelevation up to and including 3%



Pier headstocks with resultant superelevation greater than 3%

Pier headstock Heights

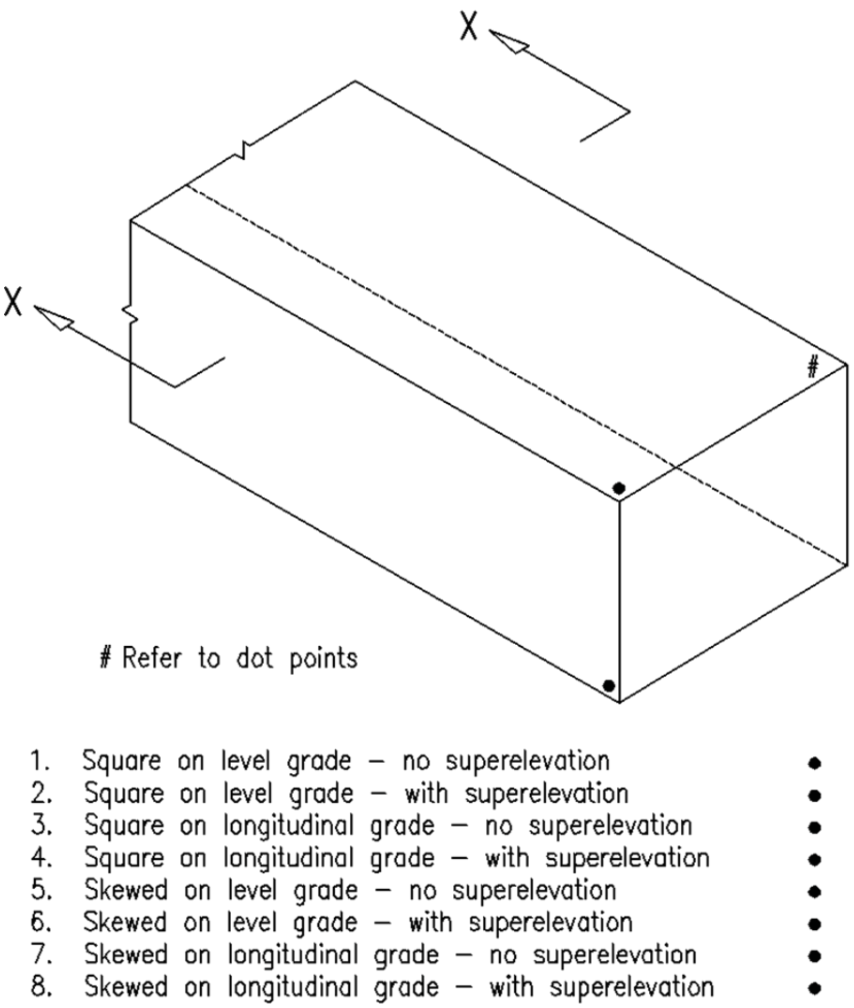
Variations in geometric conditions (grade, superelevation, skew and so on) on a pier require Heights to be shown to specific points to clearly define the headstock.

Figure 12.13(b) *Pier Height Notation* defines these points and indicates where Heights are required to be shown. The points indicated are based on a simple headstock that is rectangular in Plan view. Headstocks that are not rectangular require separate consideration.

Note the following:

- Conditions 1, 3 and 5 require Heights to be shown on one side of the pier only.
- The soffit of all headstocks is to be horizontal through Section X-X, and set to the resultant crossfall.
- Conditions 3, 4, 7 and 8 will require a Height at a point marked thus '#' when the bearing shelf needs to be sloped due to grade – refer to Figure 12.5(a) *Mortar Seating Limits* for further details.
- '#' is only needed on a girder bridge when the bridge is skewed.
- A headstock with a jacking shelves requires additional Height(s) to be shown.

Figure 12.13(b) - Pier Height notation



Vertical curves

Piers within the limits of a vertical curve will require special consideration in determining Heights, while at the same time ensuring that the DWS thickness is not reduced below the minimum allowed either at the ends or at the centre of the span.

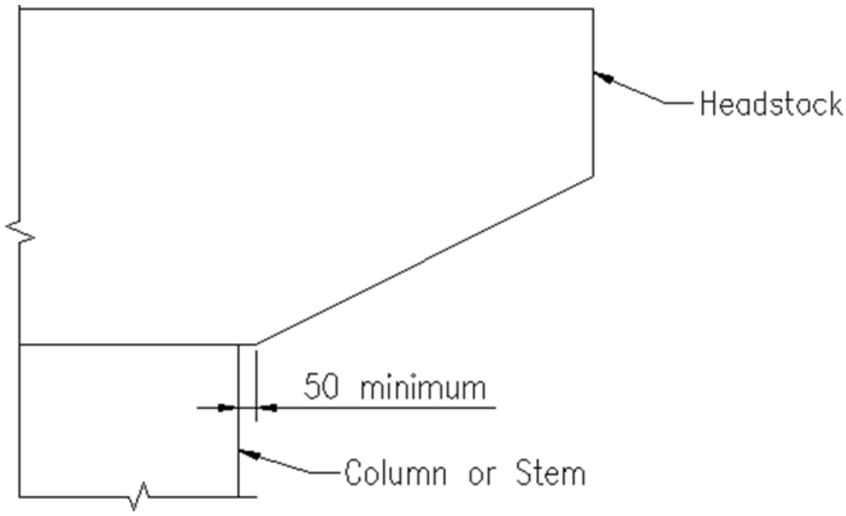
12.14 Tapering of pier headstocks

Tapered pier headstocks – Profile

Pier headstocks that are supported by columns or a solid blade stem are often tapered from the outer column or stem to the end of the headstock.

A 50 mm minimum clearance is required from the column or stem before the taper commences. Refer Figure 12.14(a) *Tapered Pier Headstocks – Profile* for details.

Figure 12.14(a) - Tapered pier headstocks – Profile



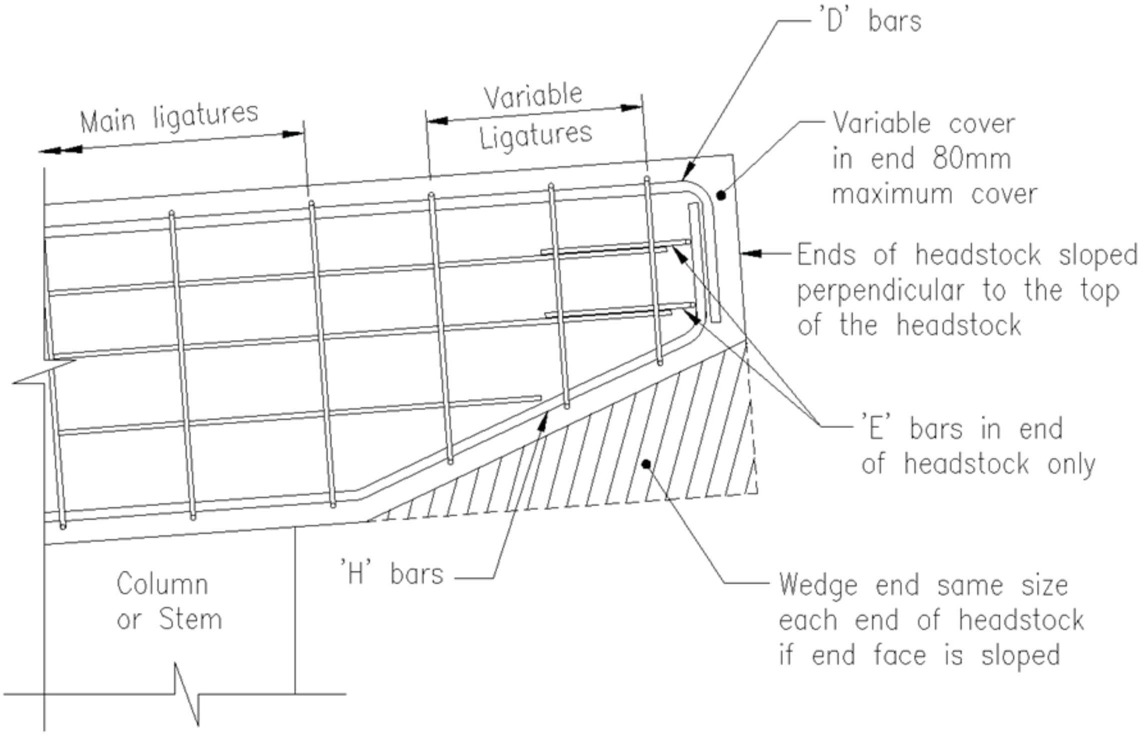
Tapered pier headstocks – Reinforcement

The arrangement of reinforcing steel in tapered pier headstock should be as follows:

- Main headstock bars should assume H or D shape; that is, legs bent at right angles to longitudinal direction of the bar – refer Transport and Main Road's Standard Drawing 1043 *Standard Bar Shapes.*
- Cover may vary at ends up to a maximum of 80 mm.
- Ends of headstock shall be sloped perpendicular to the top of the headstock. This is done so that both tapered ends contain the same shaped reinforcement.

Refer Figure 12.14(b) *Tapered Pier Headstocks – Reinforcement* for details.

Figure 12.14(b) - Tapered pier headstocks – Reinforcement



Stepped pier headstocks

A pier headstock will be stepped when it supports PSC deck units or PSC girders of different depths on adjacent spans. The depth of the step shall be calculated to ensure that the top of the PSC components align. Refer Appendix B *Example Pier Drawings – Sheet 1*.

12.15 Alignment of elastomeric bearings

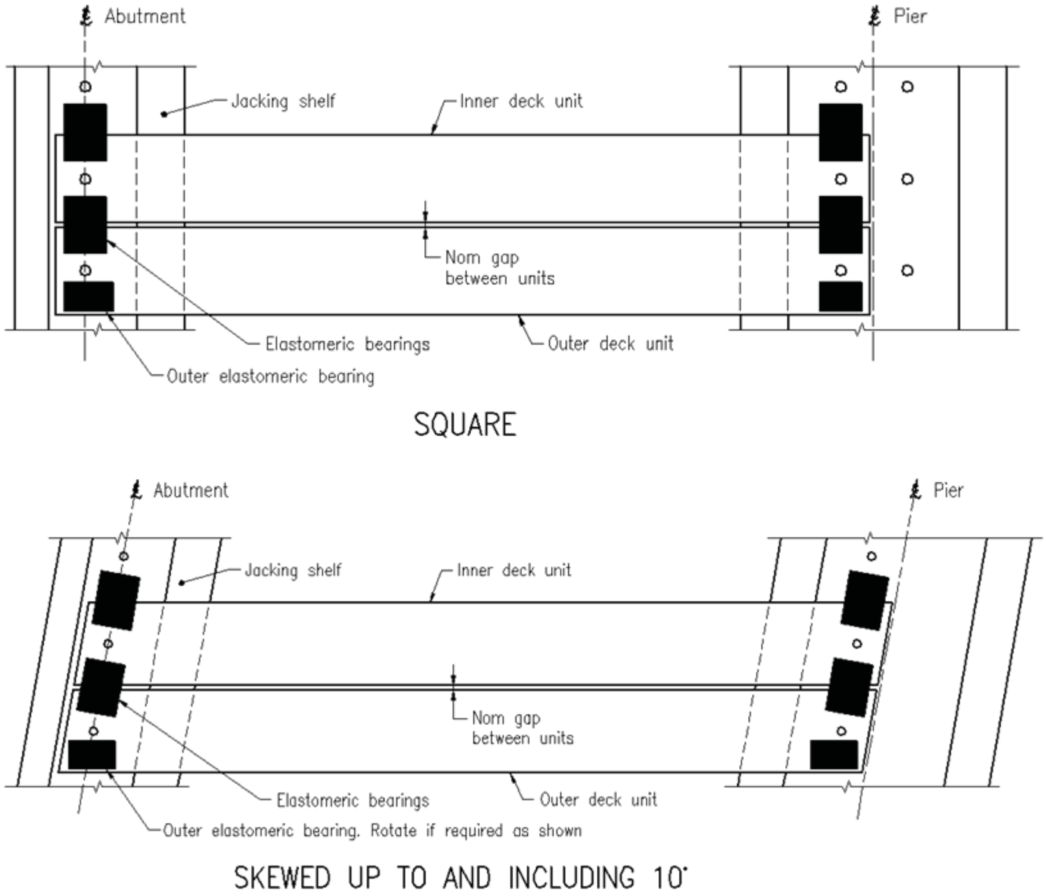
Alignment of bearings on deck unit bridges

On square bridges, and those skewed up to and including 10° and have a maximum nominal gap of 40 mm between each deck unit, bearings shall be positioned parallel to the headstock. Refer Figure 12.15(a) *Alignment of Bearings on Deck Unit Bridges Skewed ≤10°*.

The bearings shall also be positioned between the deck unit holding down bolts so that the bearings are loaded by the two adjacent deck units. Placing the bearings between the holding down bolts rather than in front of them allows for a substantial reduction of the headstock width.

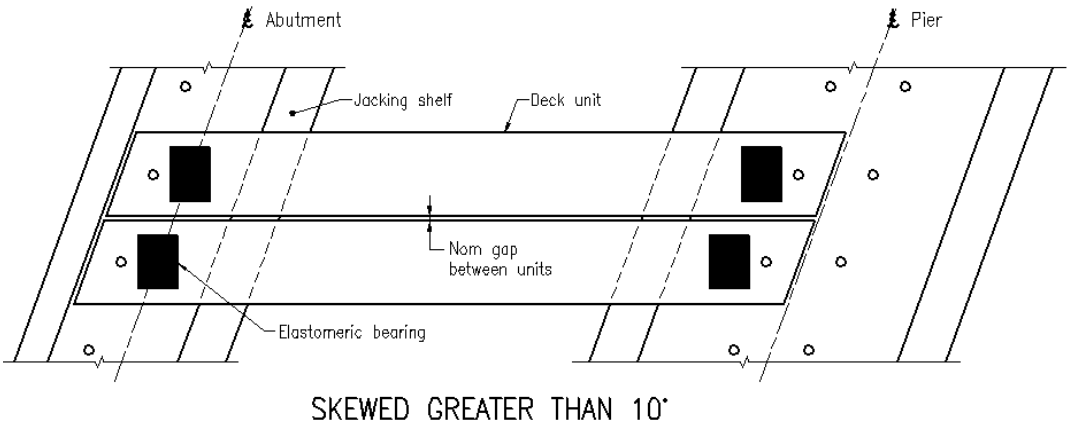
Smaller bearings (typically a non-standard size), are placed under the outer deck units. Because of the limited space available to position these bearings, they need not be parallel with the headstock. If the small outer bearings cannot accommodate the forces applied by a composite deck and/or long span lengths, the method of positioning all of the bearings for a bridge skewed more than 10° should be used.

Figure 12.15(a) - Alignment of bearings on deck unit bridges skewed ≤10°



On bridges skewed more than 10° or bridges that have a nominal gap between the deck units greater than 40 mm, the bearings shall be positioned in front of the deck unit holding down bolt holes, and square to the longitudinal axis of the deck unit. They are positioned in this manner to avoid unequal loading of each half of the bearing which would happen if it was positioned between the deck units. Refer Figure 12.15(b) *Alignment of Bearings on Deck Unit Bridges Skewed >10°*.

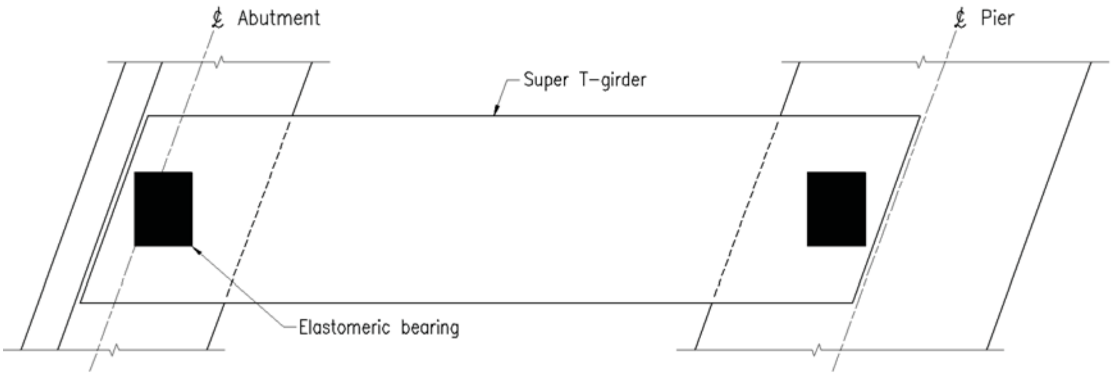
Figure 12.15(b) - Alignment of bearings on deck unit bridges skewed >10°



Alignment of bearings on Super T-girder bridges

At all joints, elastomeric bearings shall be parallel with the girders. This allows for rationalisation of both the drawings and construction of the girders. Refer Figure 12.15(c) *Alignment of Bearings on Girder Bridges*.

Figure 12.15(c) - Alignment of bearings on girder bridges



12.16 Provision for bridge jacking

Deck unit bridges

Abutment and pier headstocks of a deck unit bridge must incorporate jacking shelves wherever there are elastomeric bearings or bearing strips. Provision must be made to jack the span and replace the bearings. The shelf will also be used to support temporary packers when the bearings are being installed.

Typically the shelf shall be 250 mm deep and 325 mm wide. To stop the edge of the jacking shelf from breaking away during jacking, the jack must sit at least 175 mm from the side of the headstock.

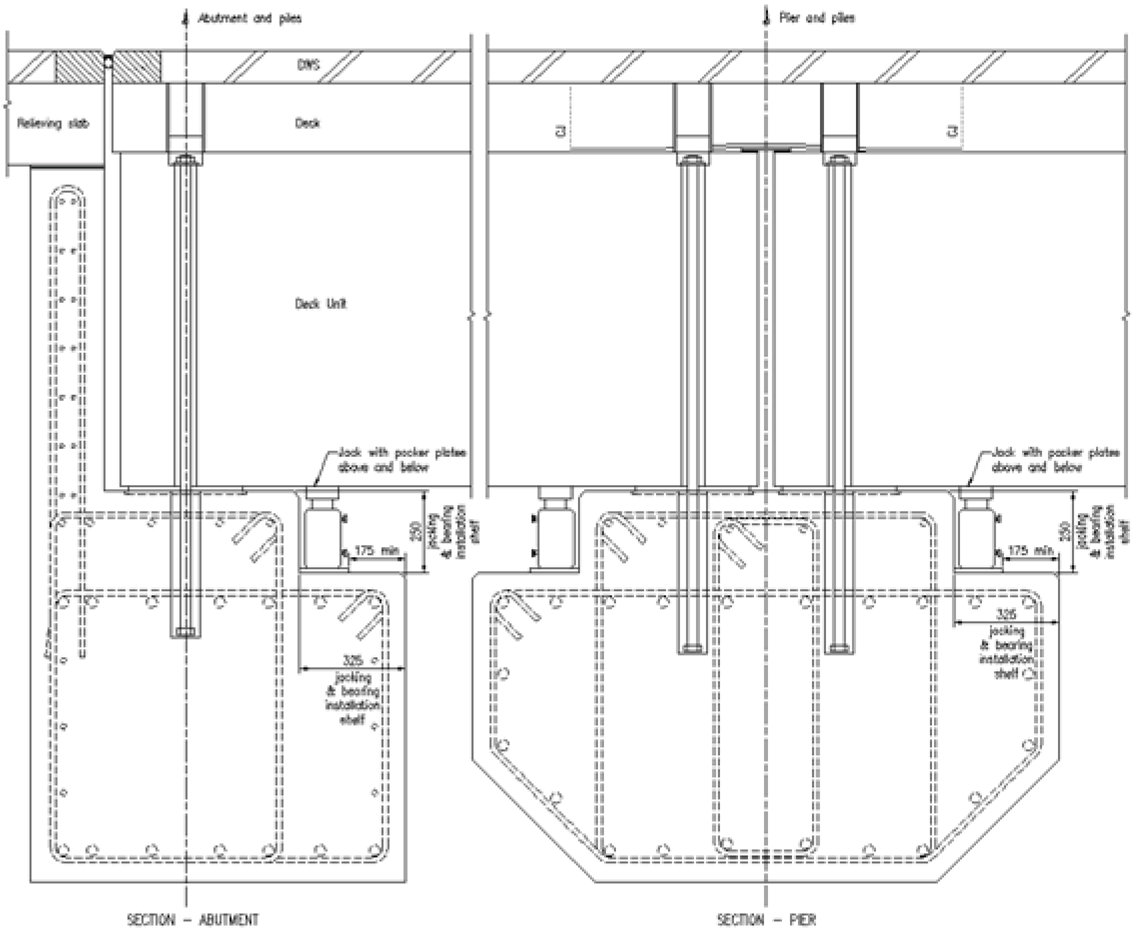
Similarly, the bearing must sit at least 175 mm from the edge of the bearing shelf on a square bridge. On a skewed bridge this distance may be reduced because only one corner of the bearing is not within tolerance.

Elastomeric bearings are used on a headstock in following instances:

- bridges with an insitu reinforced concrete deck always sit on elastomeric bearings; the expansion joint end of a span always sits on elastomeric bearings
- deck units 21 m long or greater always sit on elastomeric bearings, even if there is no concrete deck and/or expansion joint.

For further details refer Figure 12.16(a) *Headstock Jacking Shelf Details* and Chapter 13 *Provision for Bridge Jacking, Inspection and Maintenance*.

Figure 12.16(a) - Headstock jacking shelf details



Girder bridges

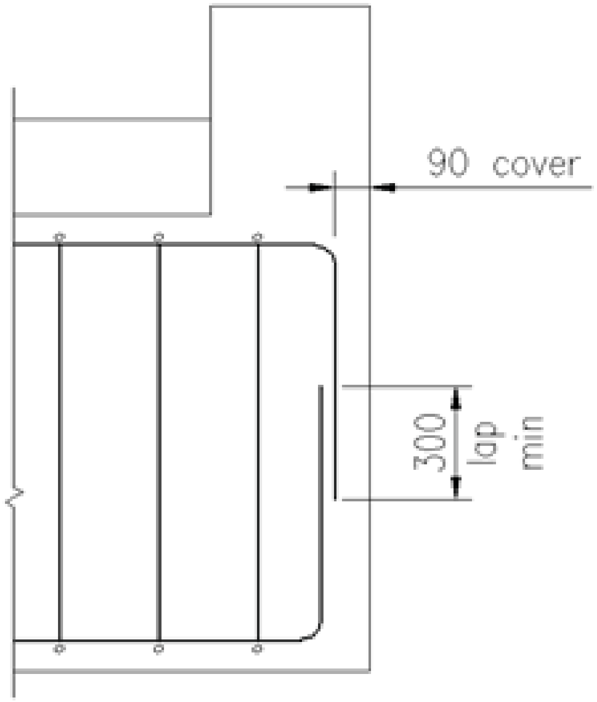
Girders always sit on bearings rather than cement mortar seating, therefore provision must be made for jacking to replace the bearings.

12.17 Reinforcement

Cover to ends of abutment headstocks

The main reinforcement in abutment headstocks shall have 90 mm of cover at the ends of the headstock to allow room for the wingwall reinforcement to bond into the headstock. If the concrete cover is more than 60 mm, the 90 mm of cover at the ends will need to be increased accordingly. The cover is unusually large to allow for fitment of the wingwall reinforcement. Refer Figure 12.17(a) *Cover at Ends of Abutment Headstocks*.

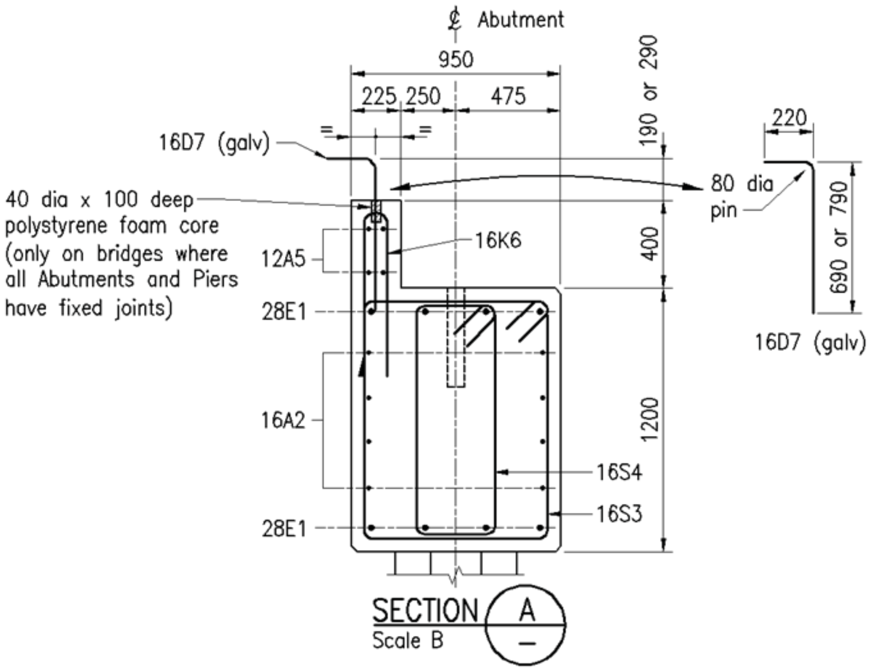
Figure 12.17(a) - Cover at ends of abutment headstocks



Relieving slab starter bars

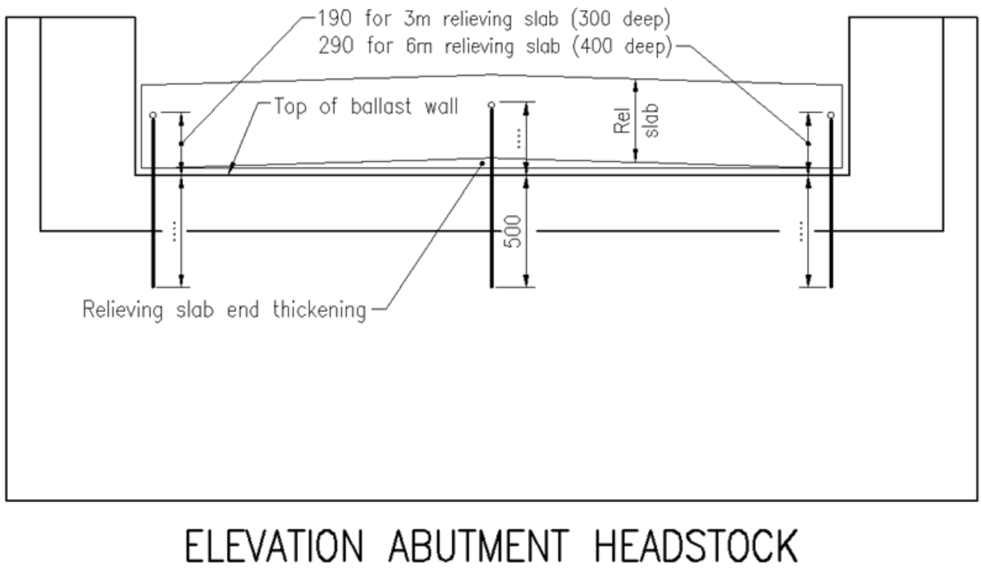
All starter bars for relieving slabs are to be hot dip galvanised to AS/NZS 4680 and spaced at 200 mm centres. A dimension must be given to the top of the bar from the top of the ballast wall. For 3 m span (300 mm deep) relieving slabs the bars shall protrude 190 mm. For 6 m span (400 mm deep) relieving slabs the bars shall protrude 290 mm. In both cases the bars shall bond 500 mm into the ballast wall. Refer Figure 12.17(b) *Relieving Slab Starter Bars*.

Figure 12.17(b) - Relieving slab starter bars



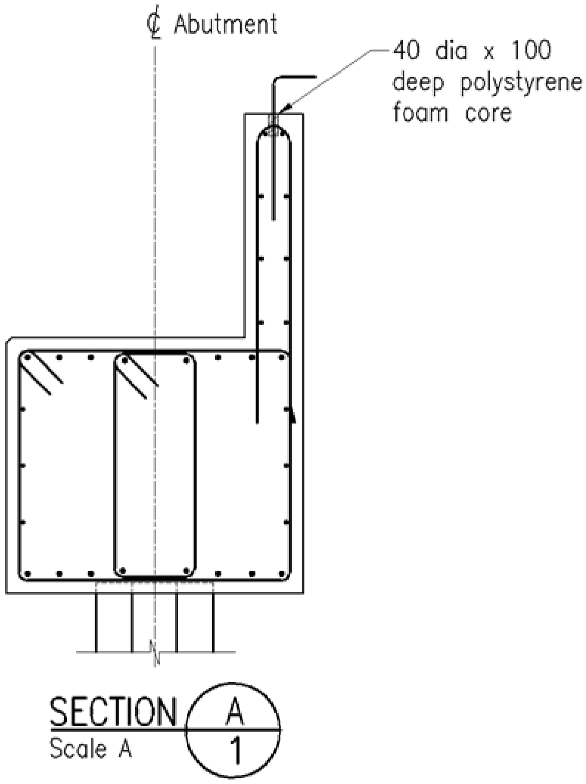
If the bridge deck has crossfall both ways from the bridge centreline and the abutment ballast wall ignores the crossfall, the relieving slab will require end thickening. The highest bar and lowest bars must be dimensioned on the abutment drawing. The starter bars shall all be the same size and shall be bonded a minimum of 500 mm into the ballast wall. Refer Transport and Main Road's Standard Drawings 1505 and 1506 and Figure 12.17(c) *Variable Relieving Slab Starter Bars*.

Figure 12.17(c) - Variable relieving slab starter bars



A deck unit bridge that does not have an expansion joint must have a 40 mm diameter x 100 mm deep polystyrene foam core to be placed around every starter bar. Refer Figure 12.17(d) *Relieving Slab Starter Bar Polystyrene Foam Core*.

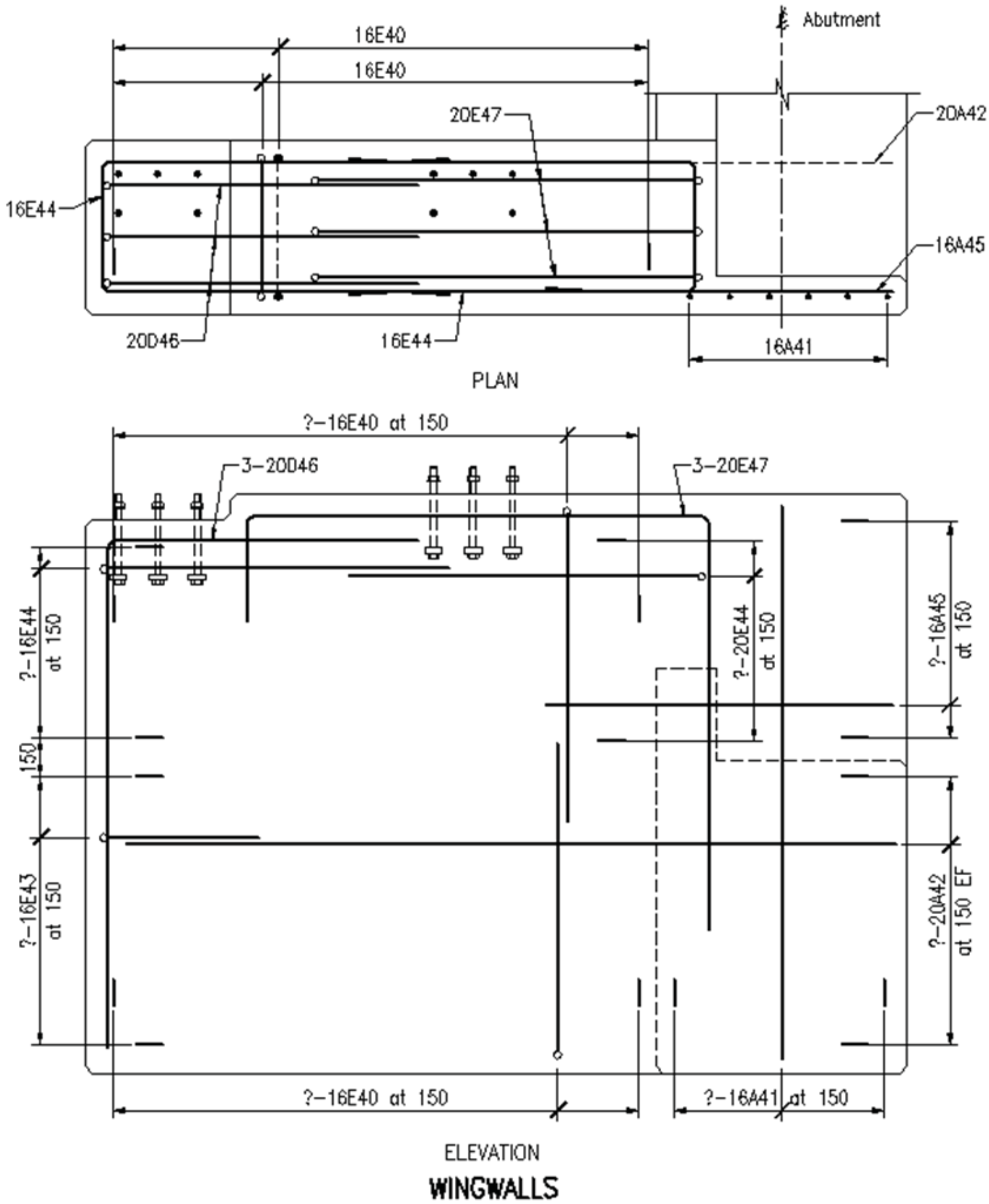
Figure 12.17(d) - Relieving slab starter bar polystyrene foam core



Wingwall reinforcement (bridge steel traffic barrier type)

Sample reinforcing details are supplied for reference in Figure 12.17(e) *Wingwall Reinforcement Details (Bridge Steel Traffic Barrier Type)*. Project specific designs are required to be assessed and certified for each project.

Figure 12.17(e) - Wingwall reinforcement details (bridge steel traffic barrier type)

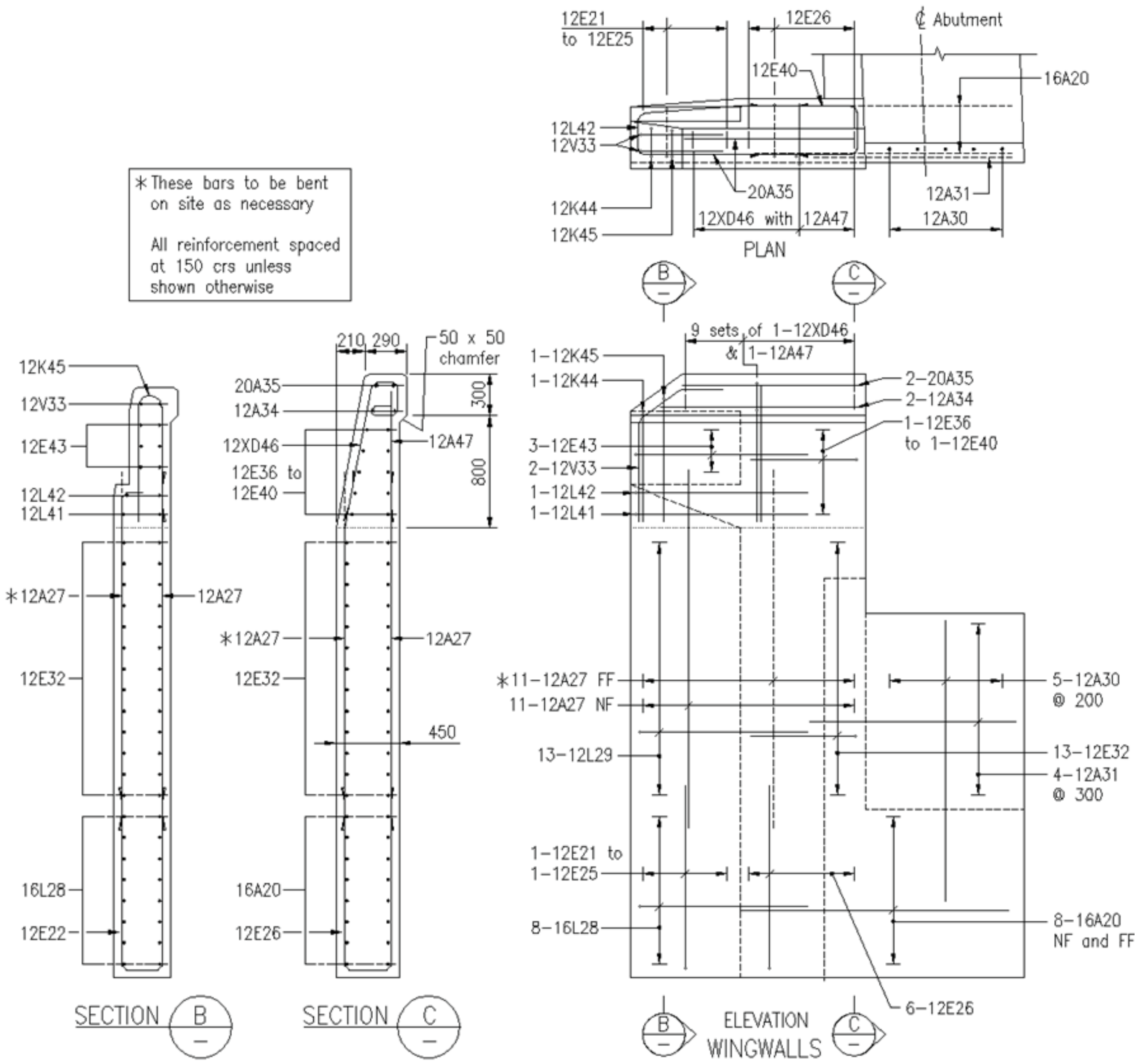


Wingwall reinforcement (concrete traffic barrier type)

The bar size and spacing of reinforcing steel is standard with the number and length of bars depending on the height, width and length of the wingwalls.

Refer Figure 12.17(f) *Wingwall Reinforcement Details (Concrete Traffic Barrier Type)* for an example of the details required on an abutment drawing. Note that this incorrectly shows the transition in barrier height at approximately one on one. It should be one on 10.

Figure 12.17(f) - Wingwall reinforcement details (concrete traffic barrier type)

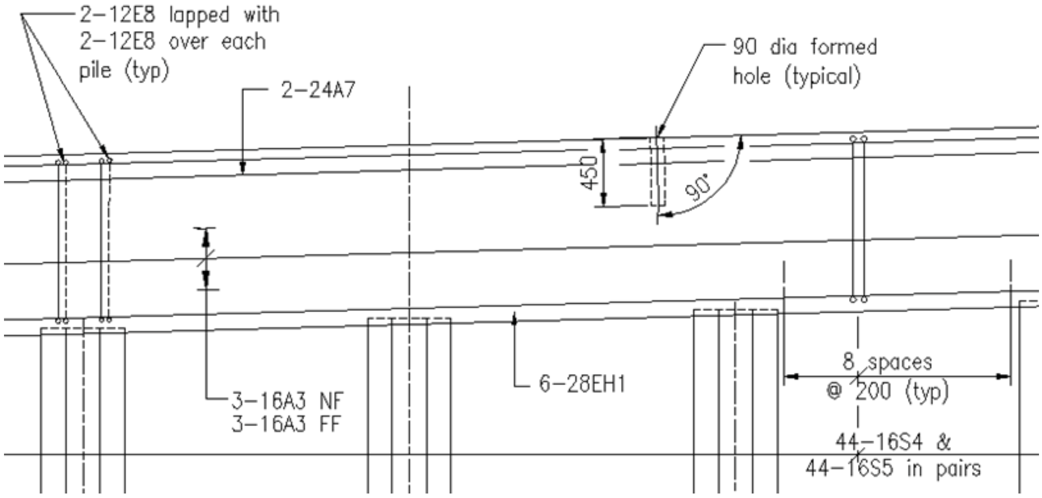


Reinforcement over piles

The designer is to determine the number, diameter and shapes of shear reinforcement over piles considering the ease of fitment of bars.

The minimum cover to the reinforcing from the headstock / pilecap soffit shall be 80 mm.

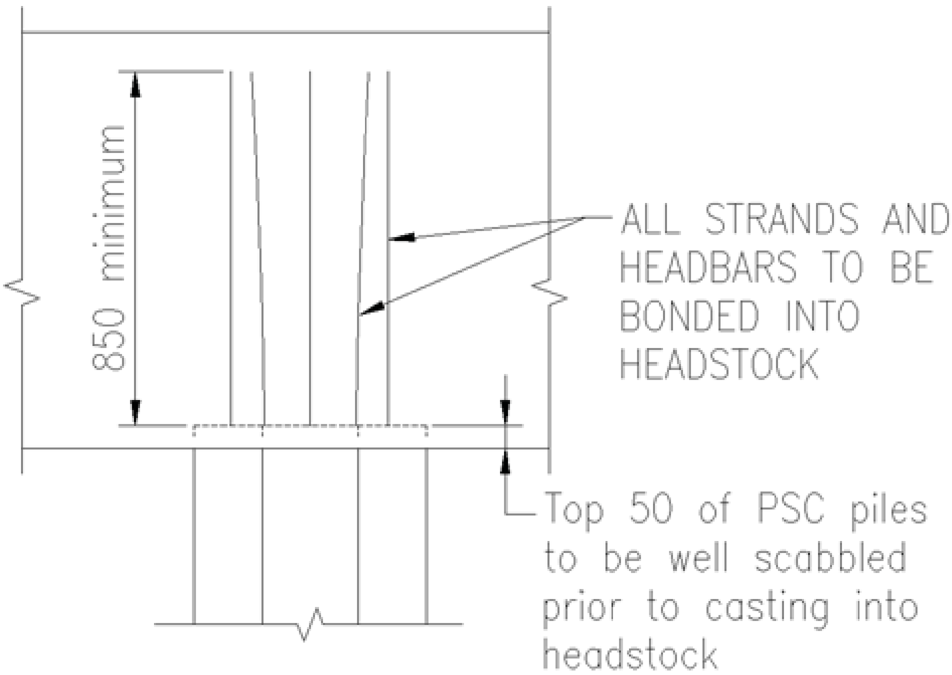
Figure 12.17(g) - Reinforcement over piles



Bonding of PSC pile steel

PSC pile steel must be bonded into the headstock / pilecap. The bond length shall be shown on the drawings. The top of the pile shall be cut away to a height which allows 50 mm of penetration of the pile. To emphasise the importance of the pile steel bonding into the headstock / pilecap, a separate detail shall be included on the drawing. Refer Figure 12.17(h) for an example of *PSC Pile Bond Detail*.

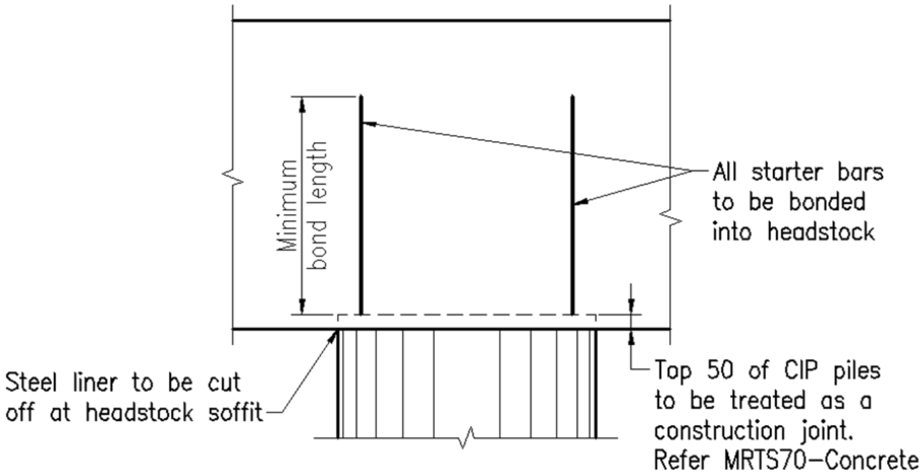
Figure 12.17(h) - PSC pile bond detail



Bonding of Cast-in Place (CIP) pile steel

CIP pile steel must be bonded into the headstock / pilecap. The bond length shall be the minimum standard lap distance for the bar diameter in question and shall be shown on the drawing. The top of the pile shall be cast 50 mm into the headstock / pilecap. The steel liner must be cut off at the headstock / pilecap soffit to expose the top 50 mm of pile. The top of the concrete shall be treated as a construction joint. Refer MRTS70 *Concrete*.

Figure 12.17(i) - Cast-in Place pile bond detail



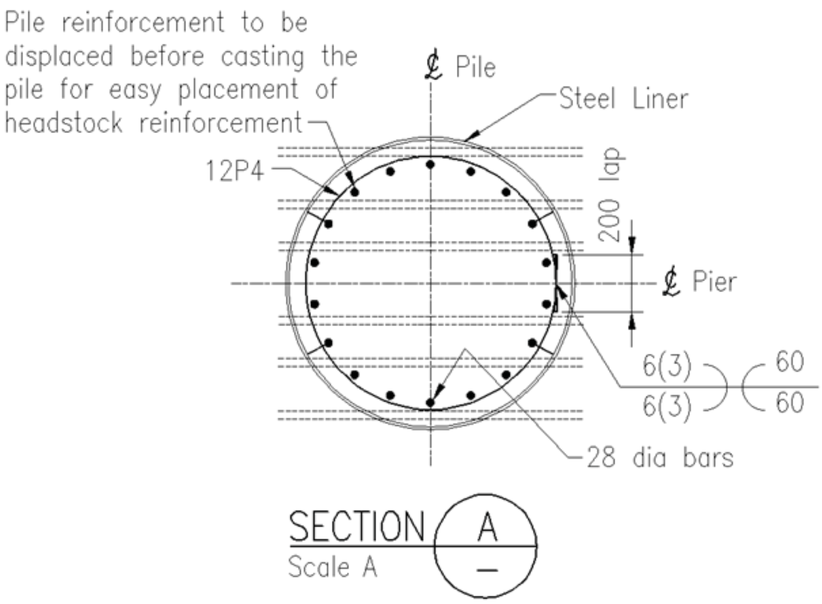
Bonding of column / stem / blade steel

Column / stem / blade starter bar steel must be bonded into the headstock / pilecap. The bond shall be shown on the drawing. The top of the column / stem / blade concrete shall be cast 50 mm into the headstock / pilecap. The top of the concrete shall be treated as a construction joint. Refer MRTS70 *Concrete*.

Cast-in Place pile reinforcement displacement

It may be difficult for the headstock / pilecap reinforcement to be placed when there is a lot of pile steel in the way. To make the builders aware of the potential problem, the main bars of the headstock / pilecap shall be shown in the pile section detail with a note that the pile steel may be displaced before the pile is cast. Refer Figure 12.17(j) for an example of *Cast-in Place Pile Reinforcement Displacement Detail.*

Figure 12.17(j) - Cast-in Place pile reinforcement displacement detail



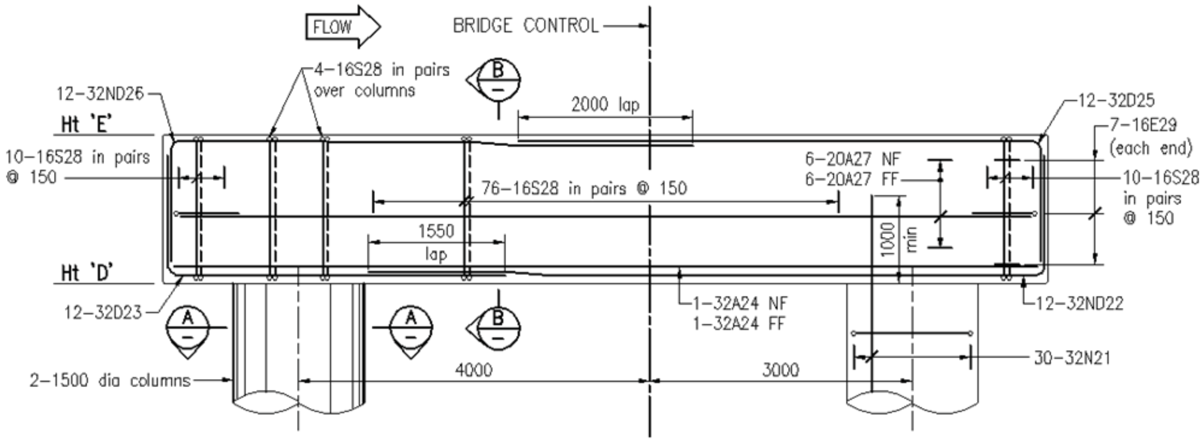
Lap position of main reinforcement in headstock / pilecap

The laps of the main reinforcing bars are to be positioned where the concrete is in compression rather than tension. Refer Figure 12.17(k) *Lap Positions*.

The position in the lower face shall be as close as practical to the piles / columns / stem, while ensuring the lap is located away from the congestion of the starter bar reinforcement.

The position in the upper face shall be midway between the piles / columns.

Figure 12.17(k) - Lap positions

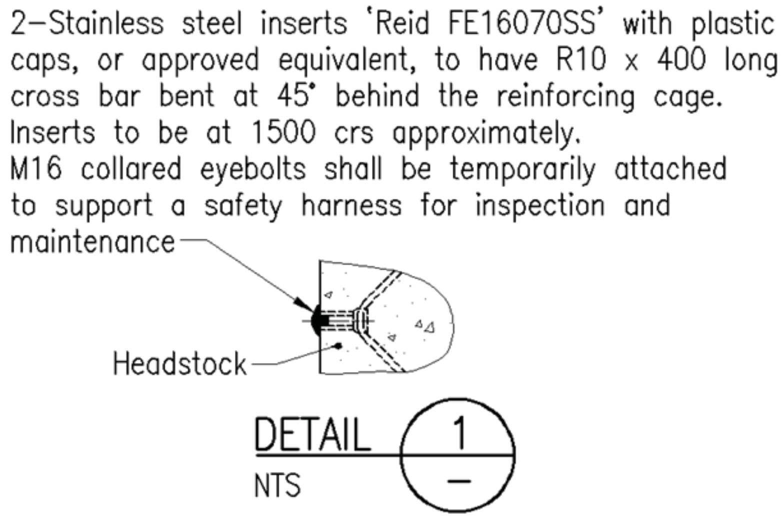


12.18 Inserts for safety harness attachment

Inserts may need to be cast into the abutment headstock to allow for attachment of a safety harness. For requirement guidelines refer Chapter 13 – *Provision for Bridge Jacking, Inspection and Maintenance*, *13.7 Abutment Protection*.

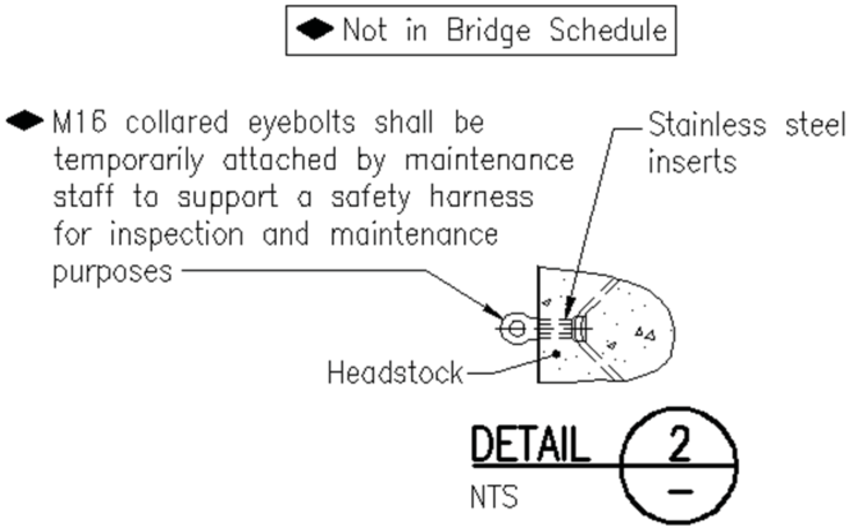
If inserts are required, the details shown in Figure 12.18(a) *Insert Details at Abutments* shall be shown on the abutment drawing.

Figure 12.18(a) - Insert details at abutments



The details shown in Figure 12.18(b) *Eyebolt Details* shall be shown on the maintenance and inspection drawings. It refers back to the abutment drawing for the insert details.

Figure 12.18(b) - Eyebolt details



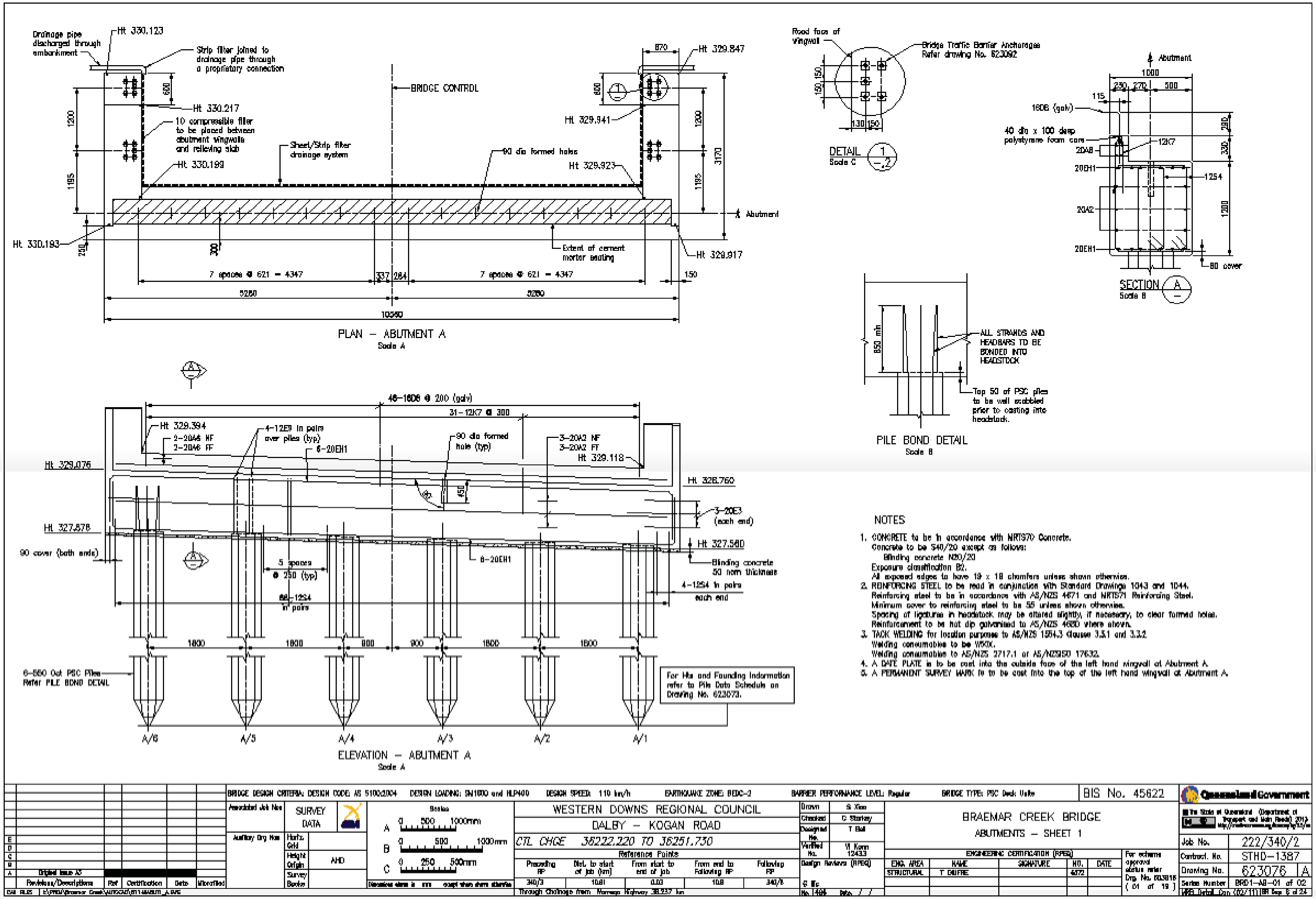
12.19 Abutment protection

Abutments form the transition from bridge deck to the road embankment. The embankment is protected against scour and erosion by the abutment protection. For design criteria and general notes for the various abutment protection types refer Transport and Main Road's Standard Drawings 2232 to 2242 and Chapter 13 *Provision for Bridge Jacking, Inspection and Maintenance*.

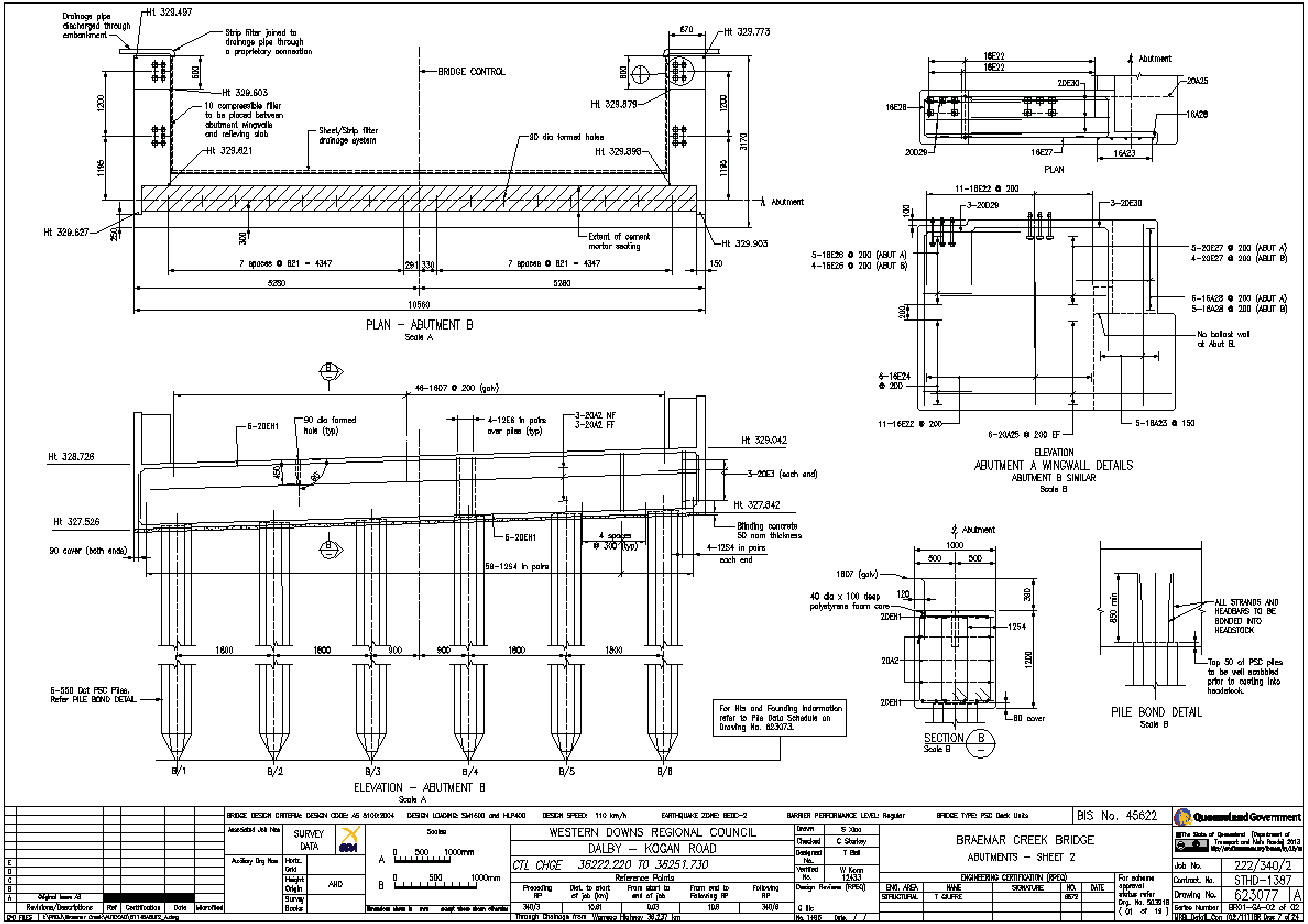
For an explanation of the details required on the General Arrangement drawings refer Chapter 11 - *General Arrangement Drawings, Detailed Design General Arrangement Drawings*.

Appendix A – Example Abutment Drawings

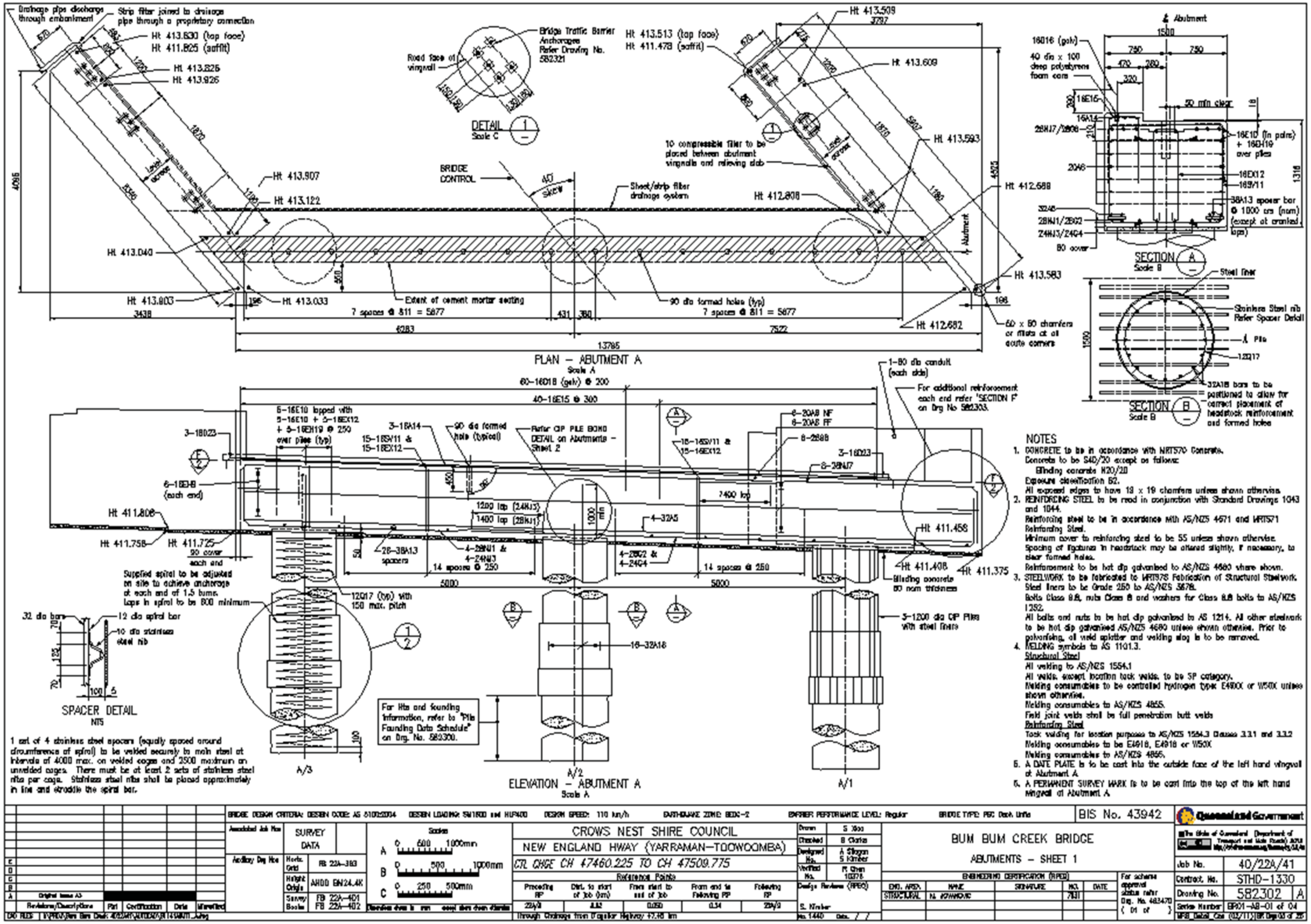
Appendix A - Example Abutment Drawings – Sheet 1



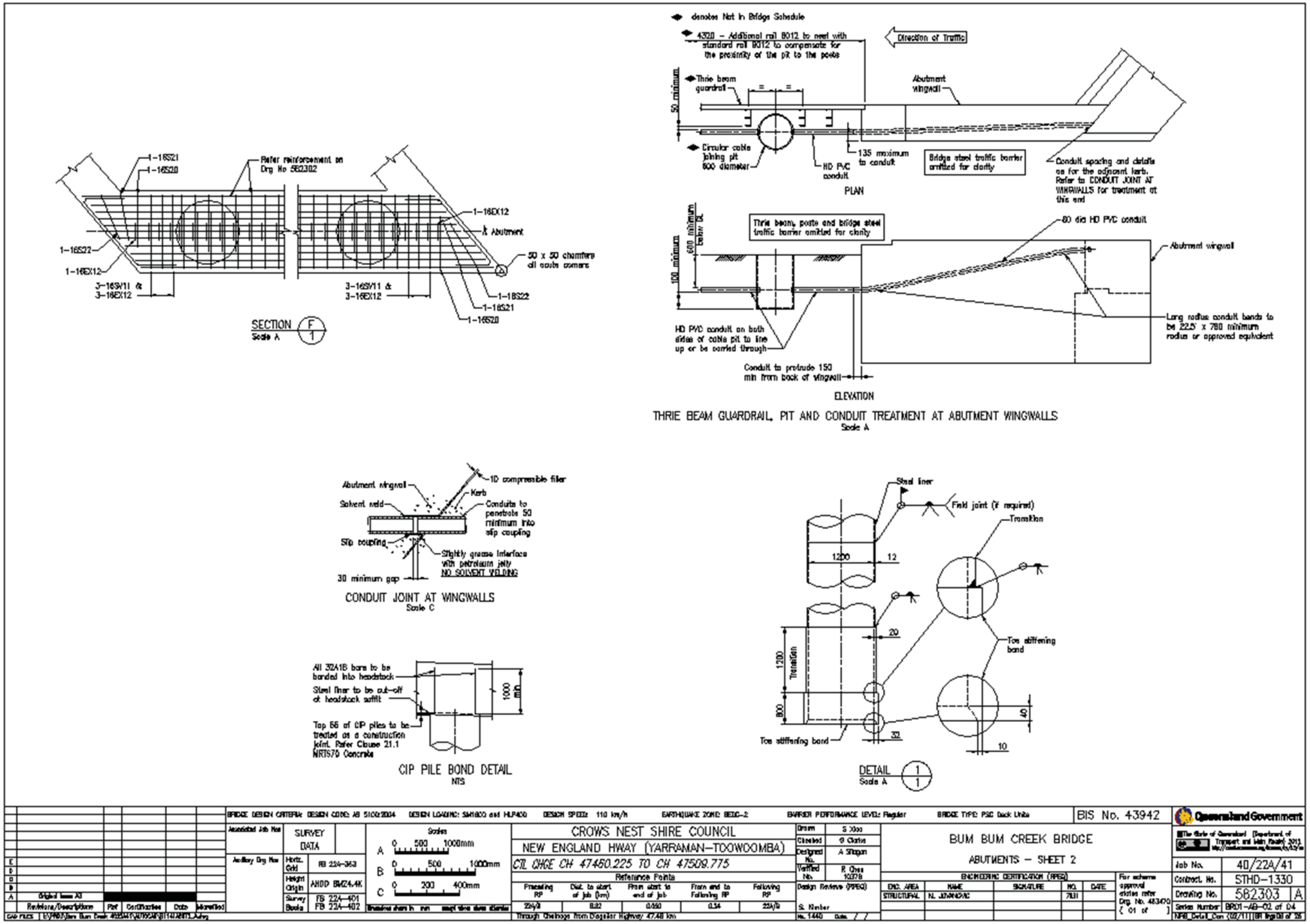
Appendix A - Example Abutment Drawings – Sheet 2



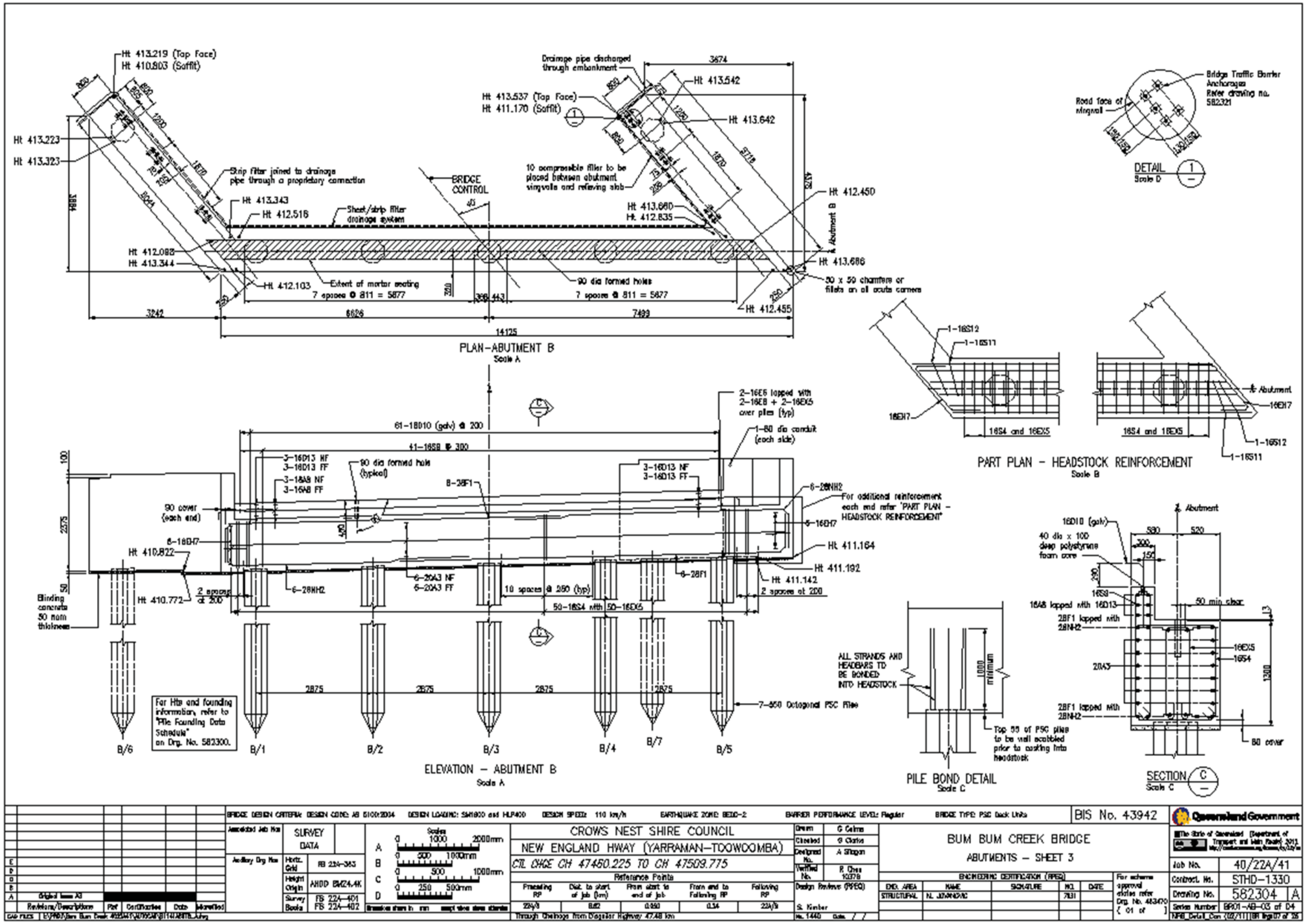
Appendix A - Example Abutment Drawings – Sheet 3



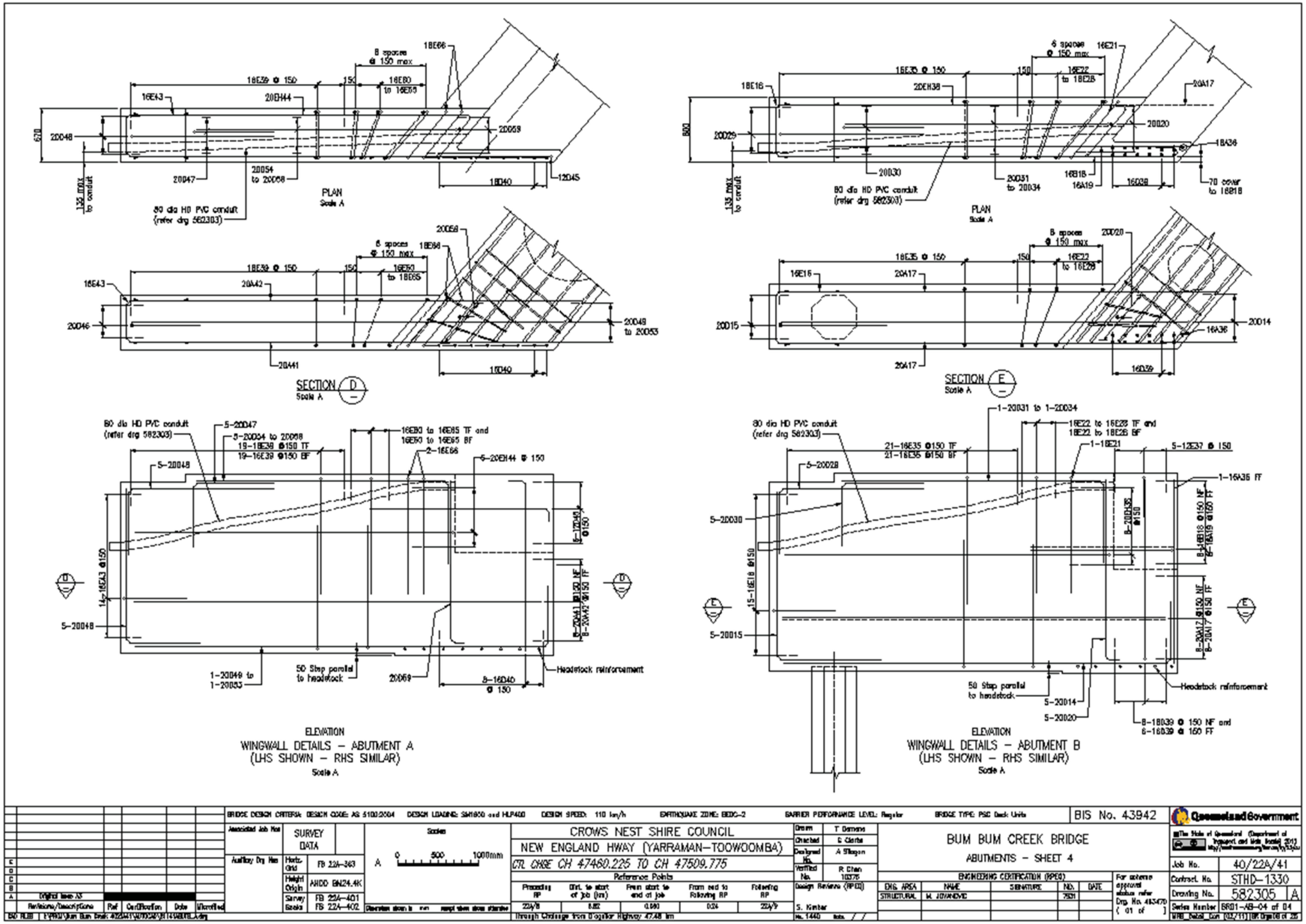
Appendix A - Example Abutment Drawings – Sheet 4



Appendix A - Example Abutment Drawings – Sheet 5



Appendix A - Example Abutment Drawings – Sheet 6



Appendix A - Example Abutment Drawings – Sheet 7

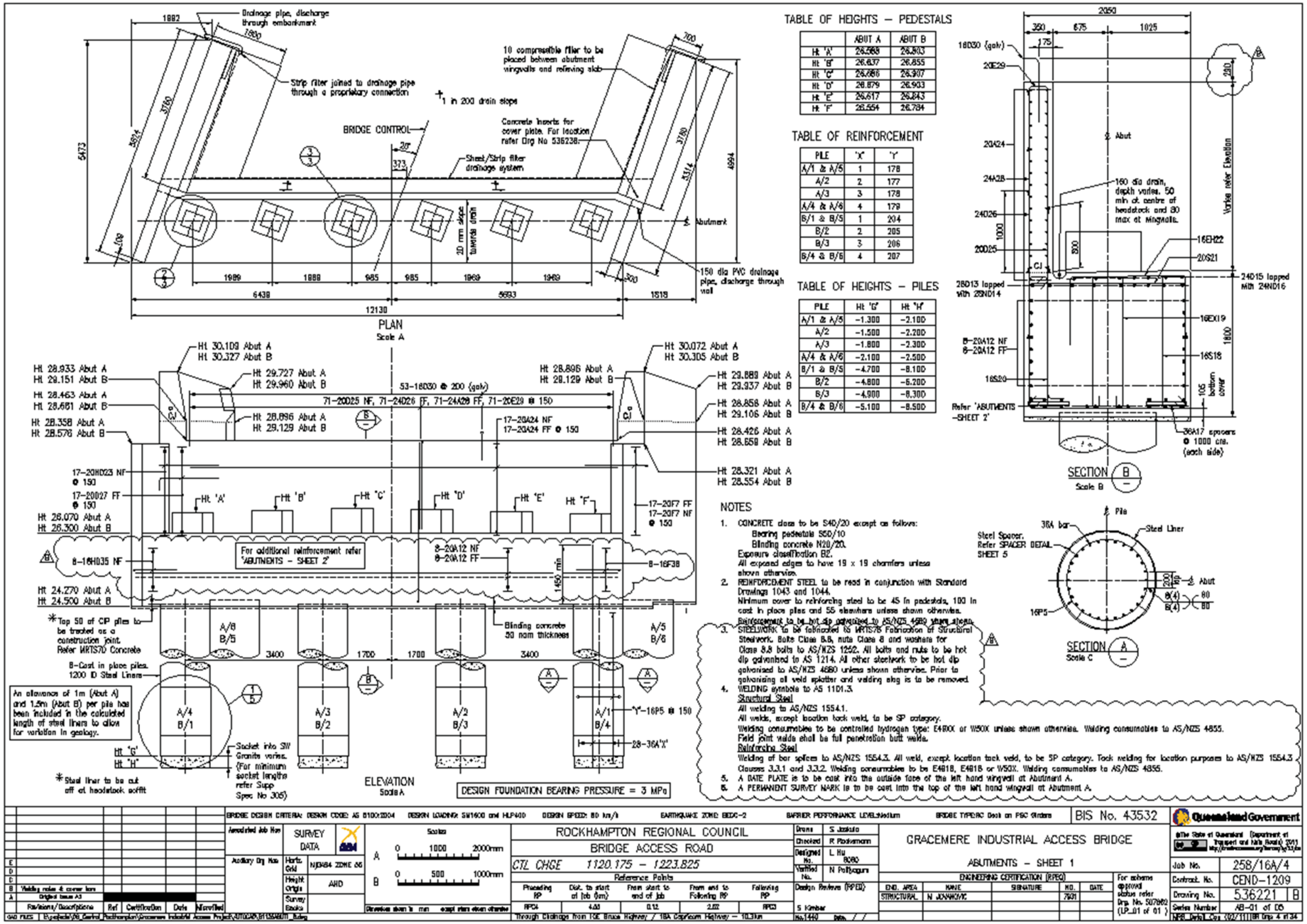


TABLE OF HEIGHTS – PEDESTALS

	ABUT A	ABUT B
Ht 'A'	26.569	26.803
Ht 'B'	26.637	26.855
Ht 'C'	26.686	26.907
Ht 'D'	26.879	26.903
Ht 'E'	26.617	26.843
Ht 'F'	26.554	26.784

TABLE OF REINFORCEMENT

PILE	'X'	'Y'
A/1 & A/5	1	178
A/2	2	177
A/3	3	178
A/4 & A/6	4	179
B/1 & B/5	1	204
B/2	2	205
B/3	3	206
B/4 & B/6	4	207

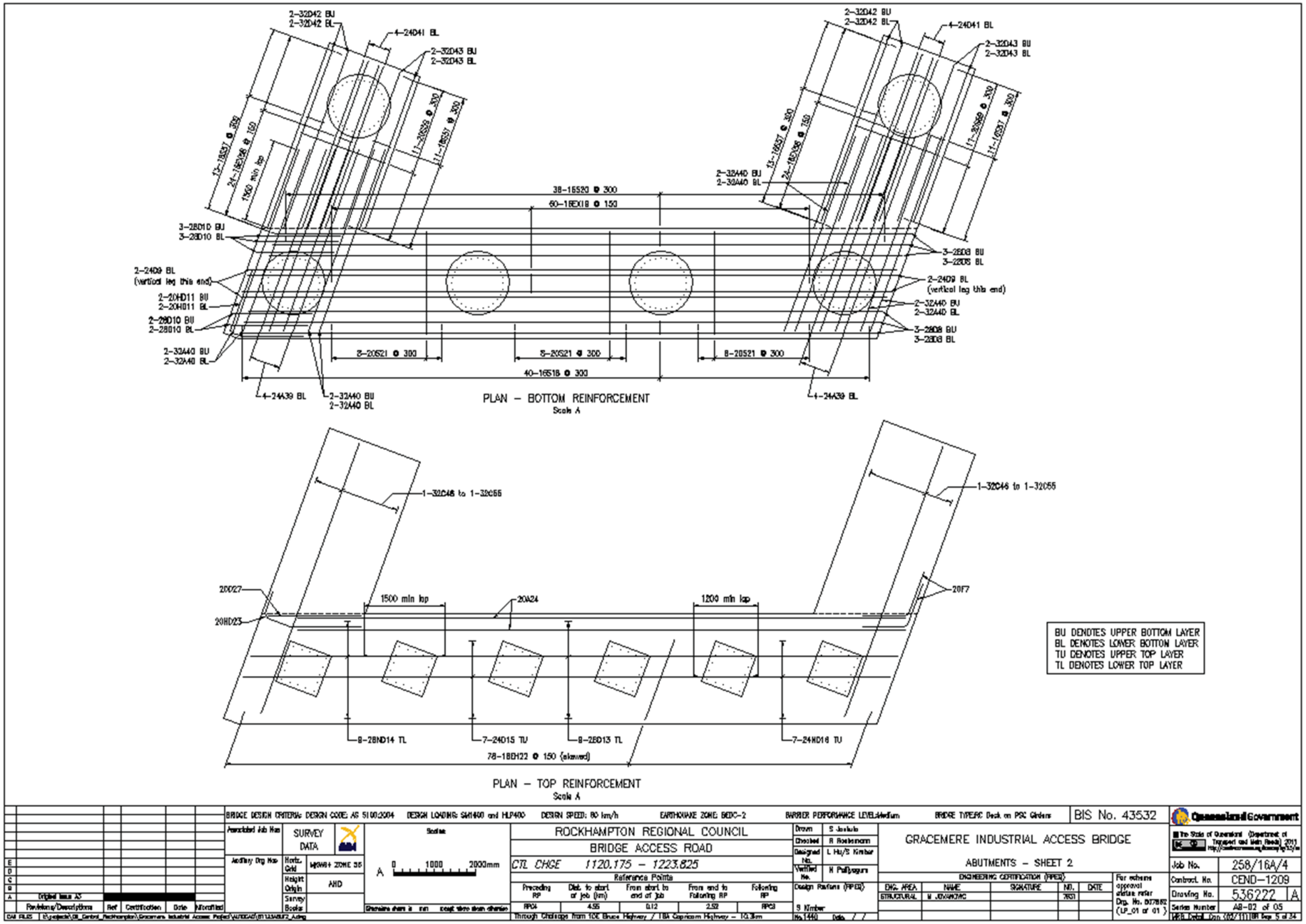
TABLE OF HEIGHTS – PILES

PILE	Ht 'G'	Ht 'H'
A/1 & A/5	-1.300	-2.100
A/2	-1.500	-2.200
A/3	-1.800	-2.300
A/4 & A/6	-2.100	-2.500
B/1 & B/5	-4.700	-8.100
B/2	-4.800	-6.200
B/3	-4.900	-8.300
B/4 & B/6	-5.100	-8.500

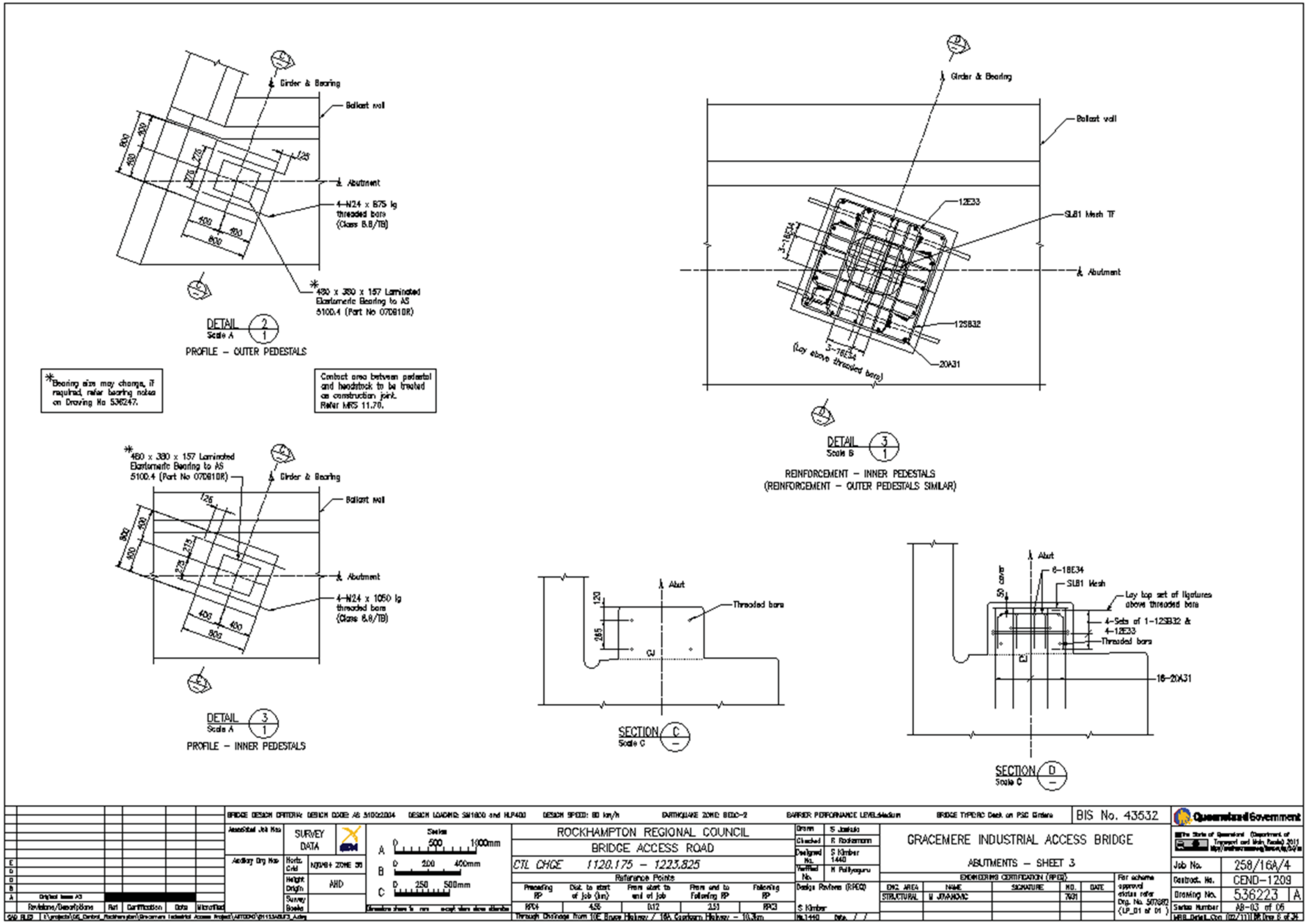
NOTES

1. CONCRETE class to be S40/20 except as follows:
   Bearing pedestals S50/10
   Blinding concrete N20/20.
   Exposure classification B2.
   All exposed edges to have 19 x 19 chamfers unless shown otherwise.
2. REINFORCEMENT STEEL to be read in conjunction with Standard Drawings 1043 and 1044.
   Minimum cover to reinforcing steel to be 45 in pedestals, 100 in cast in place piles and 55 elsewhere unless shown otherwise.
   Reinforcement to be hot dip galvanized to AS/NZS 4680 where shown.
3. STEELWORK to be fabricated to MRTS78 Fabrication of Structural Steelwork. Bolts Class 8.8, nuts Class 8 and washers for Class 8.8 bolts to AS/NZS 1252. All bolts and nuts to be hot dip galvanised to AS 1214. All other steelwork to be hot dip galvanised to AS/NZS 4680 unless shown otherwise. Prior to galvanising all weld splatter and welding slag is to be removed.
4. WELDING symbols to AS 1101.3.
   Structural Steel
   All welding to AS/NZS 1554.1.
   All welds, except location tack weld, to be SP category.
   Welding consumables to be controlled hydrogen type: E49XX or W50X unless shown otherwise. Welding consumables to AS/NZS 4855.
   Field joint welds shall be full penetration butt welds.
   Reinforcing Steel
   Welding of bar splices to AS/NZS 1554.3. All weld, except location tack weld, to be SP category. Tack welding for location purposes to AS/NZS 1554.3 Clauses 3.3.1 and 3.3.2. Welding consumables to be E4918, E4818 or W50X. Welding consumables to AS/NZS 4855.
5. A DATE PLATE is to be cast into the outside face of the left hand wingwall at Abutment A.
6. A PERMANENT SURVEY MARK is to be cast into the top of the left hand wingwall at Abutment A.

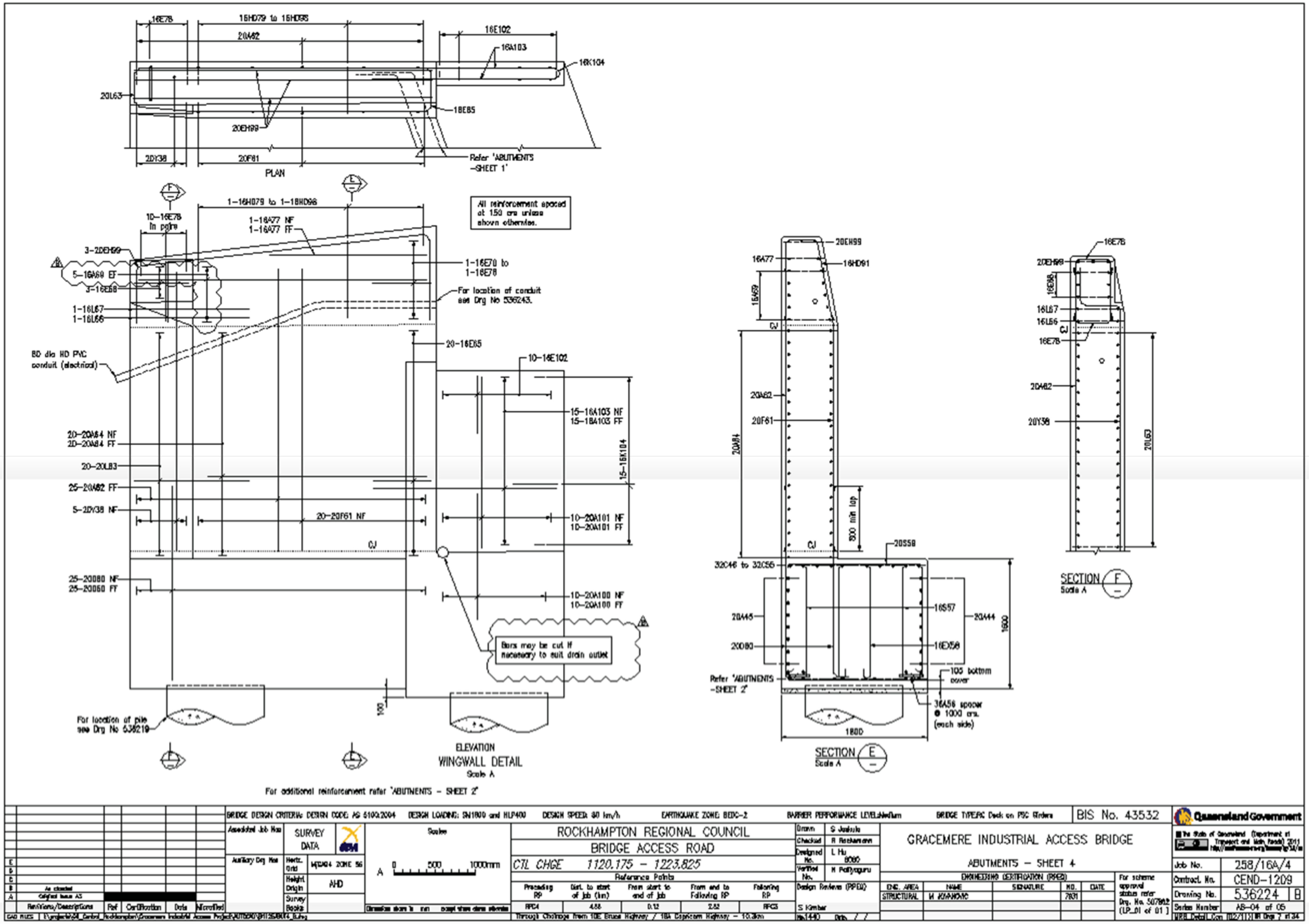
Appendix A - Example Abutment Drawings – Sheet 8



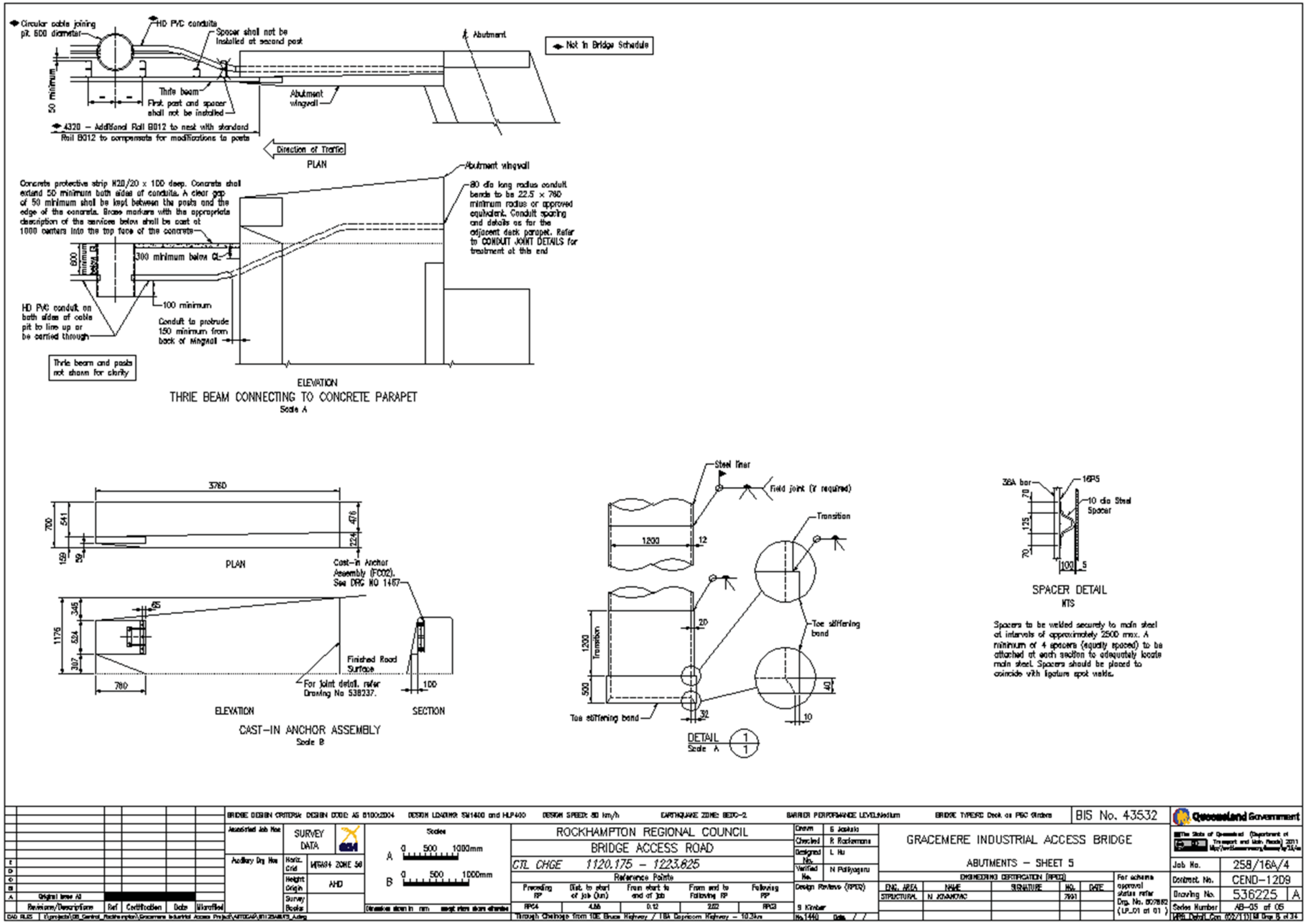
Appendix A - Example Abutment Drawings – Sheet 9



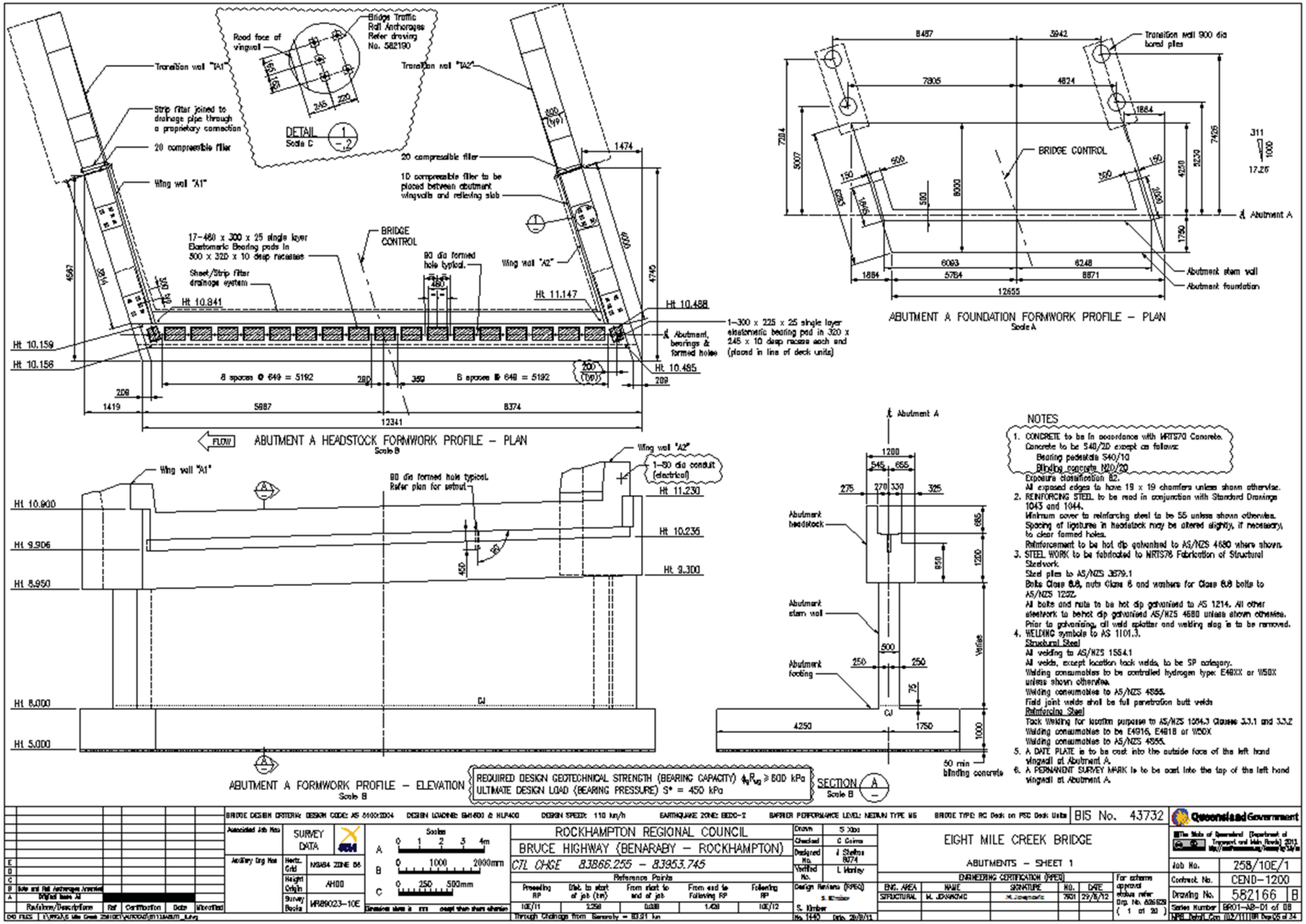
Appendix A - Example Abutment Drawings – Sheet 10



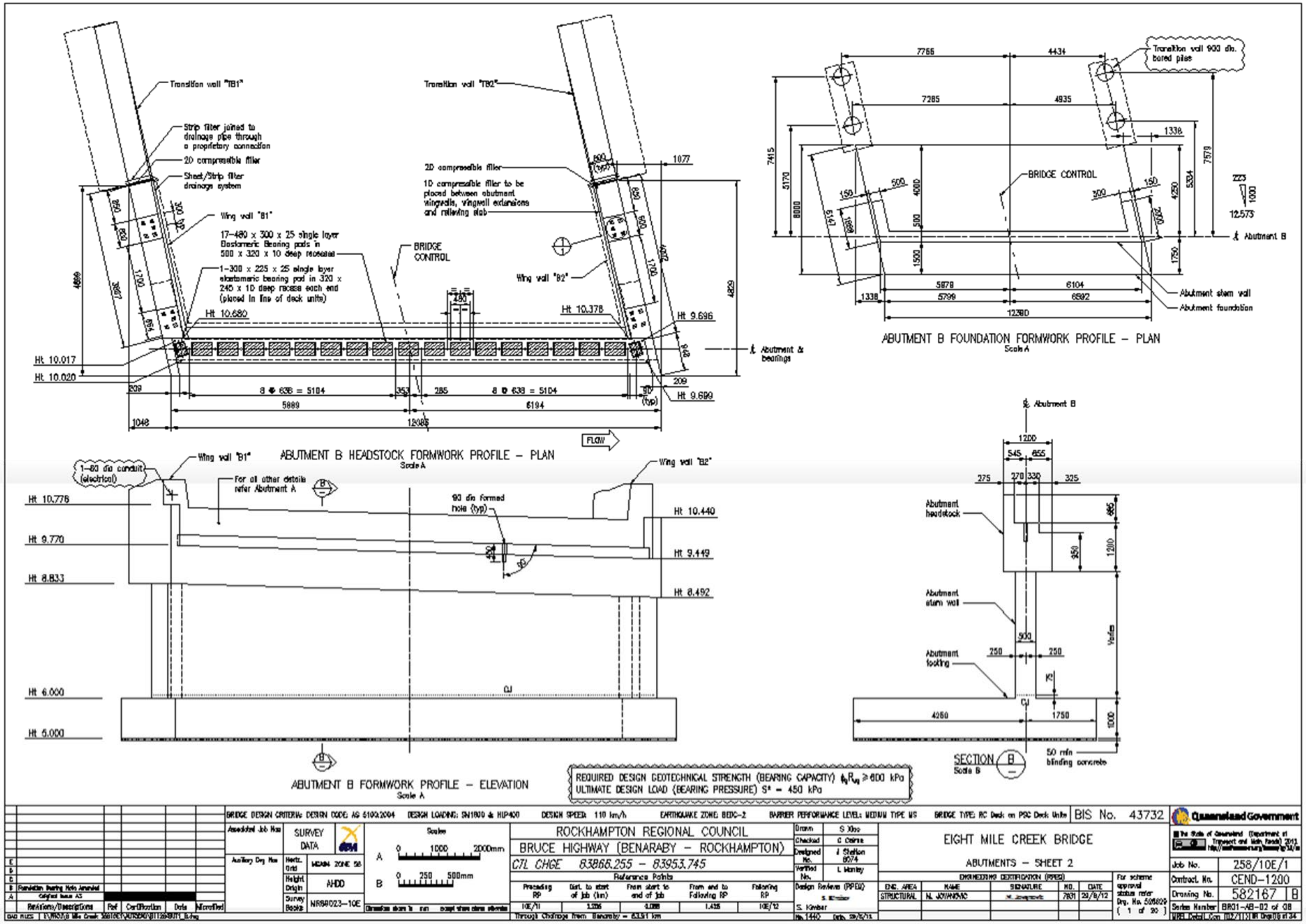
Appendix A - Example Abutment Drawings – Sheet 11



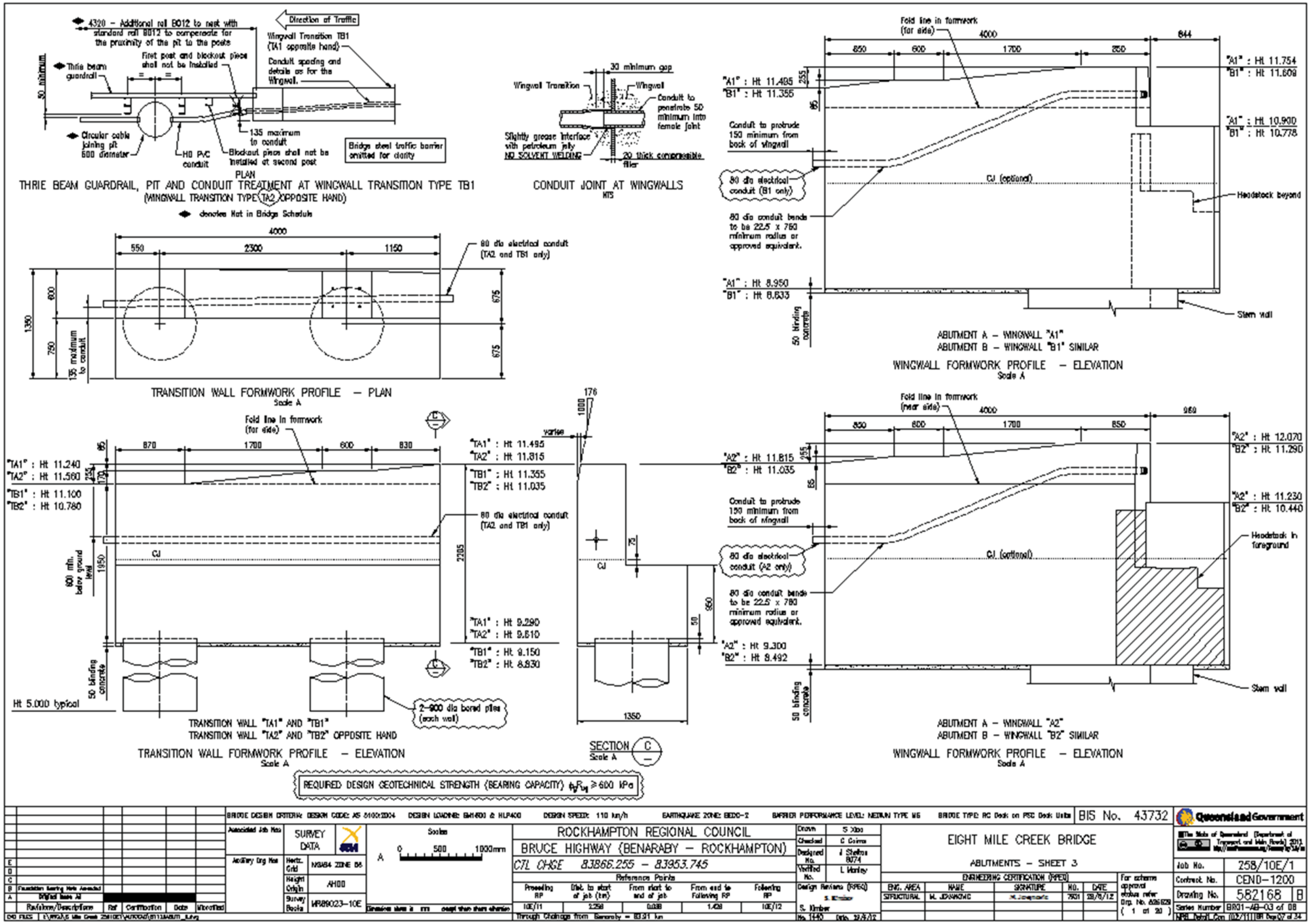
Appendix A - Example Abutment Drawings – Sheet 12



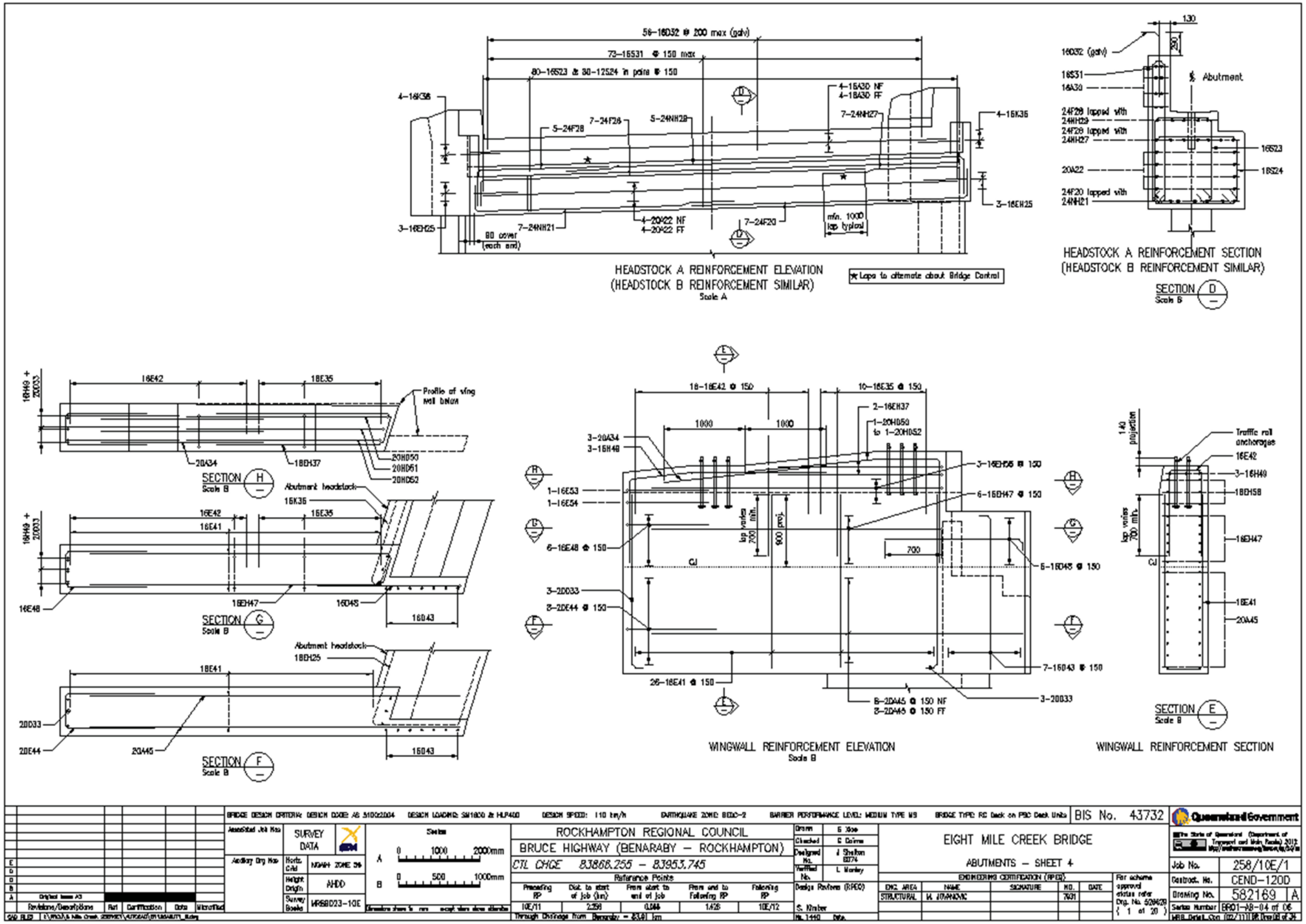
Appendix A - Example Abutment Drawings – Sheet 13



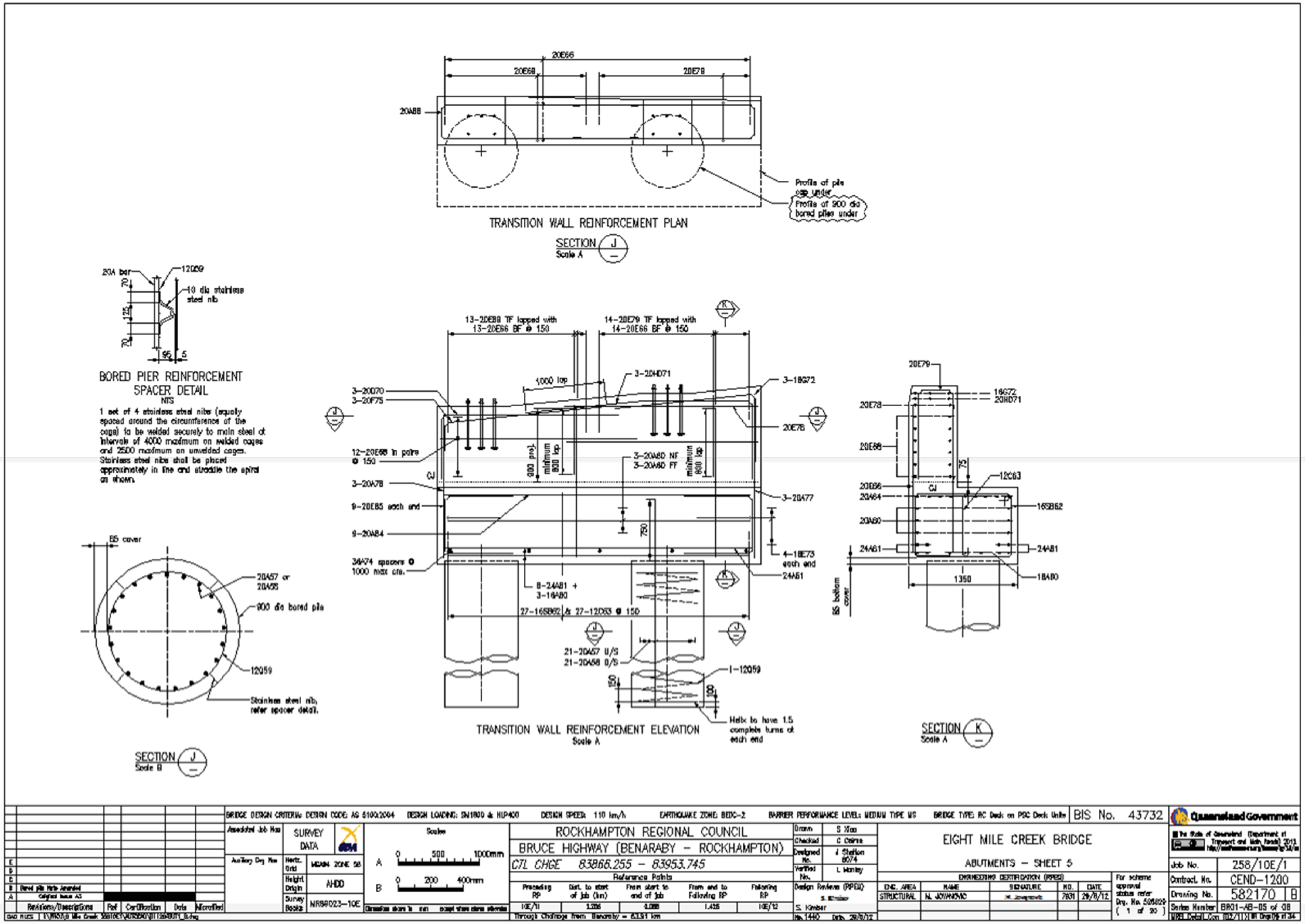
Appendix A - Example Abutment Drawings – Sheet 14



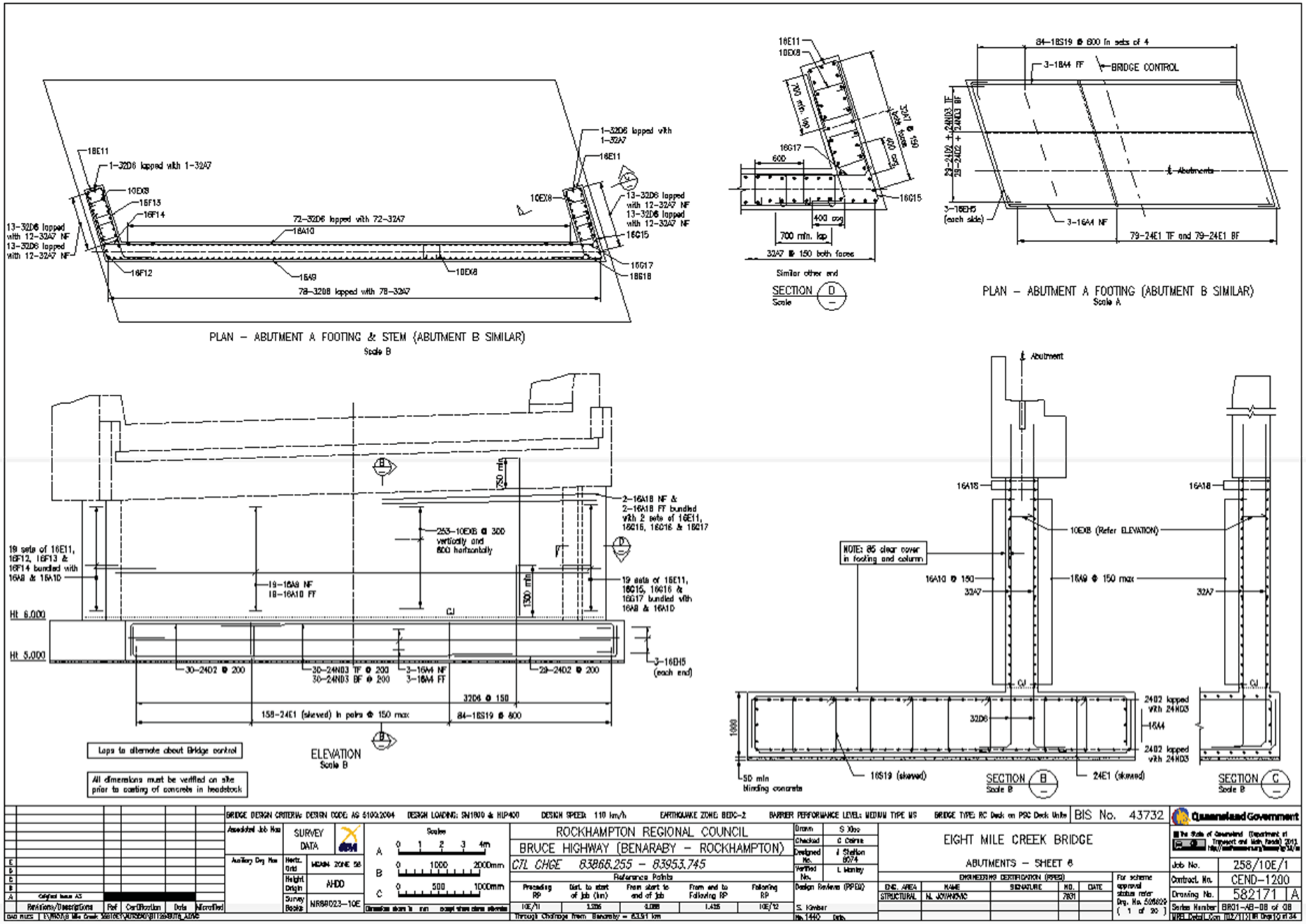
Appendix A - Example Abutment Drawings – Sheet 15



Appendix A - Example Abutment Drawings – Sheet 16

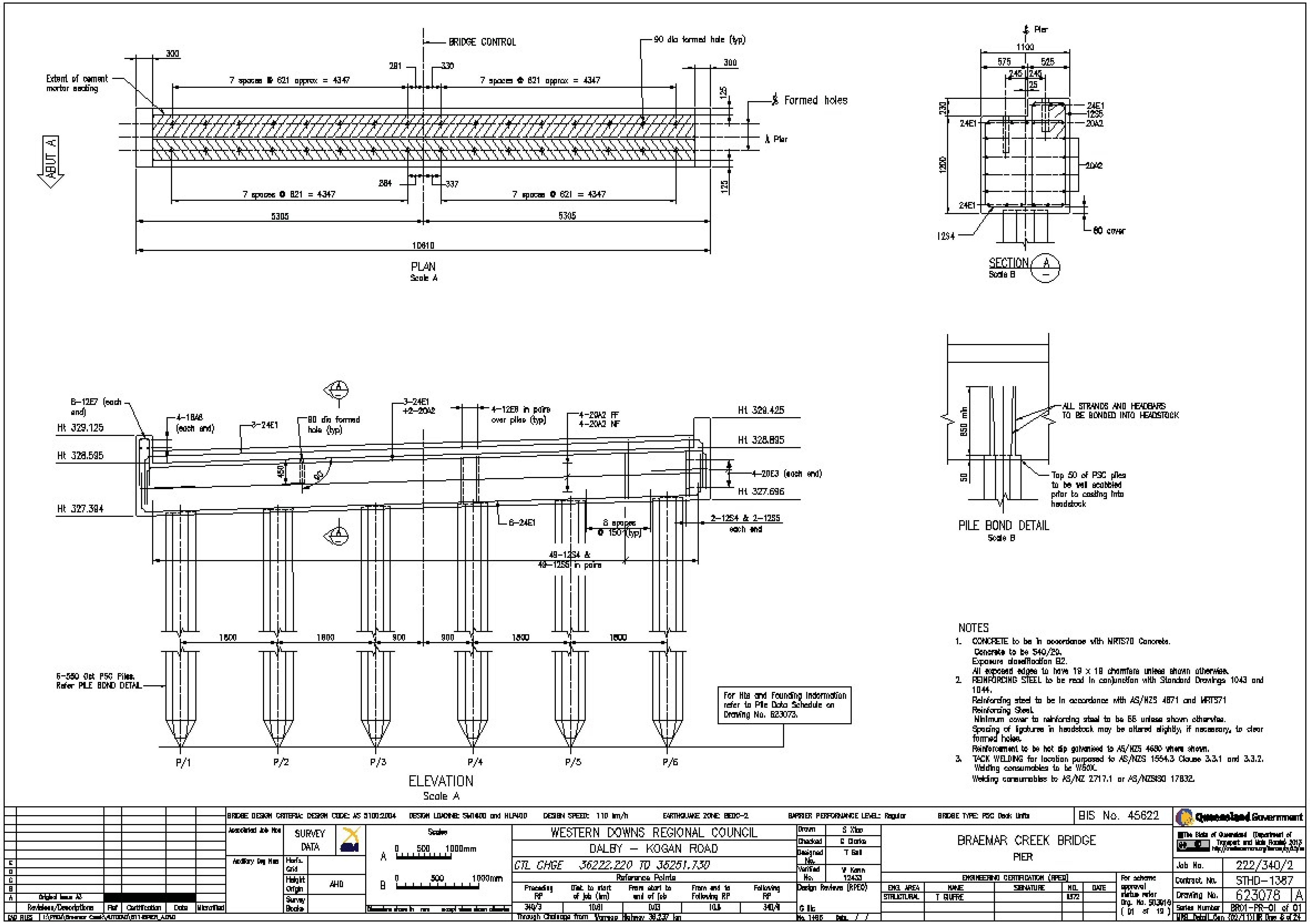


Appendix A - Example Abutment Drawings – Sheet 17

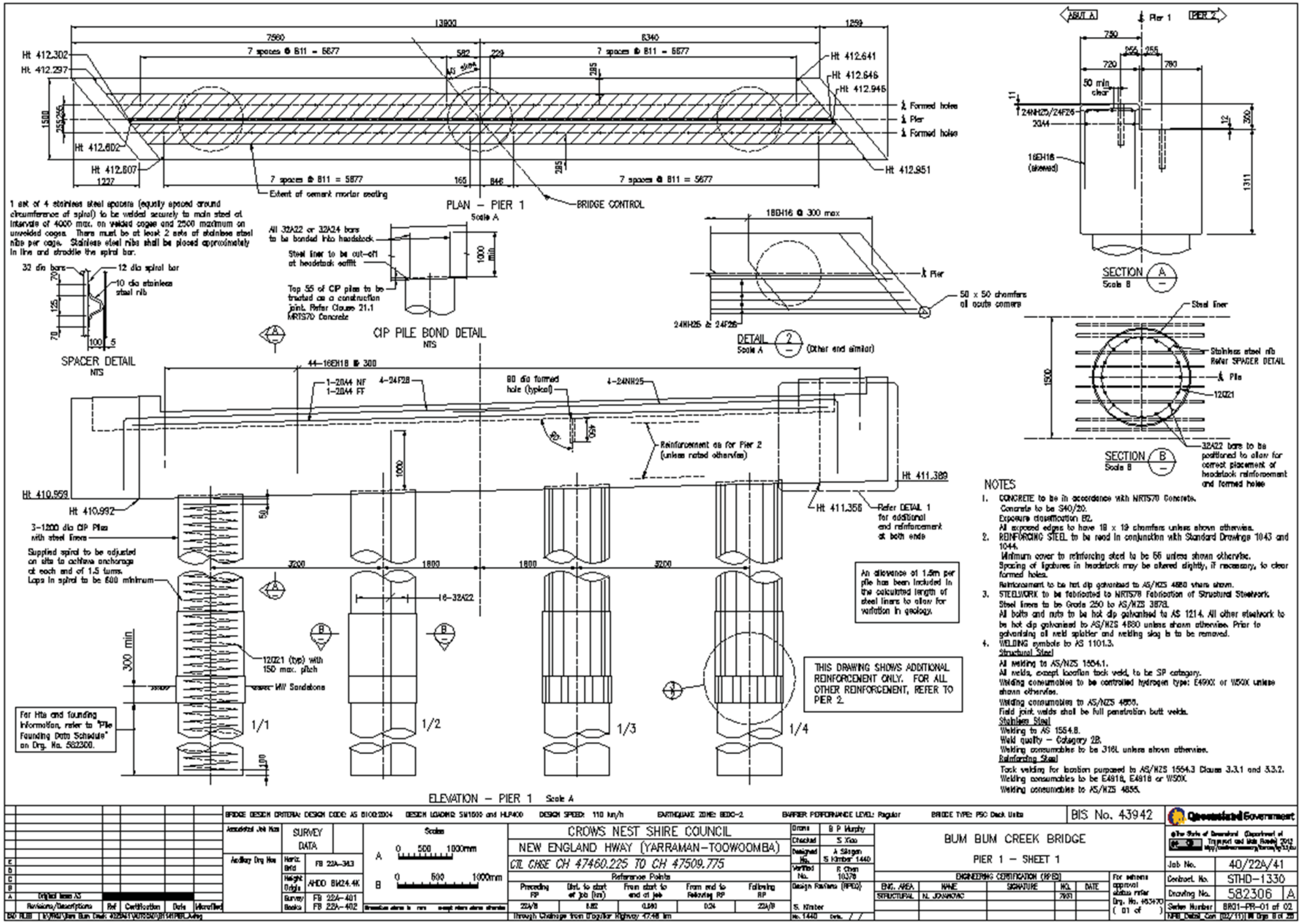


Appendix B - Example Pier Drawings

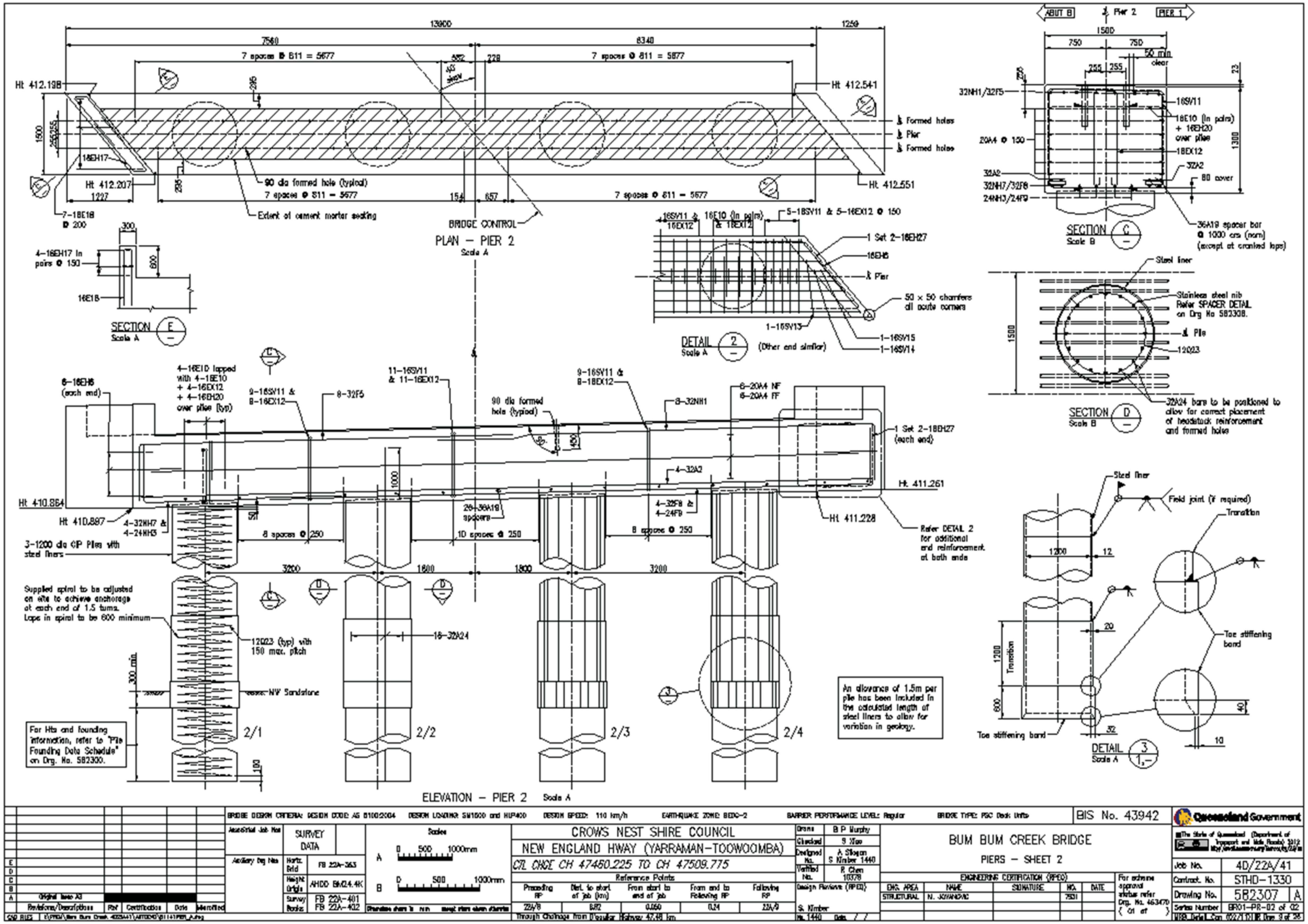
Appendix B - Example Pier Drawings – Sheet 1



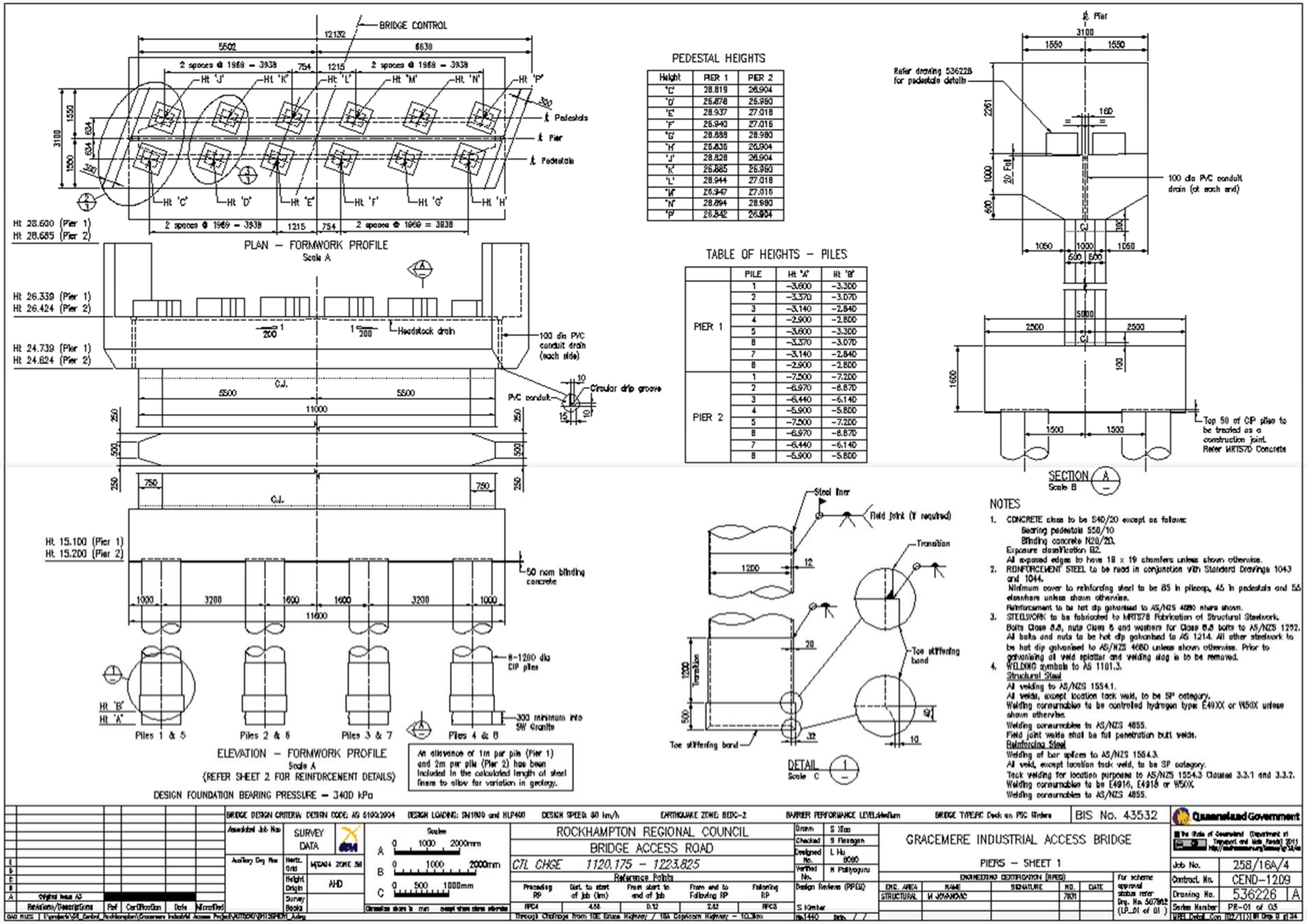
Appendix B - Example Pier Drawings – Sheet 2



Appendix B - Example Pier Drawings – Sheet 3



Appendix B - Example Pier Drawings – Sheet 4



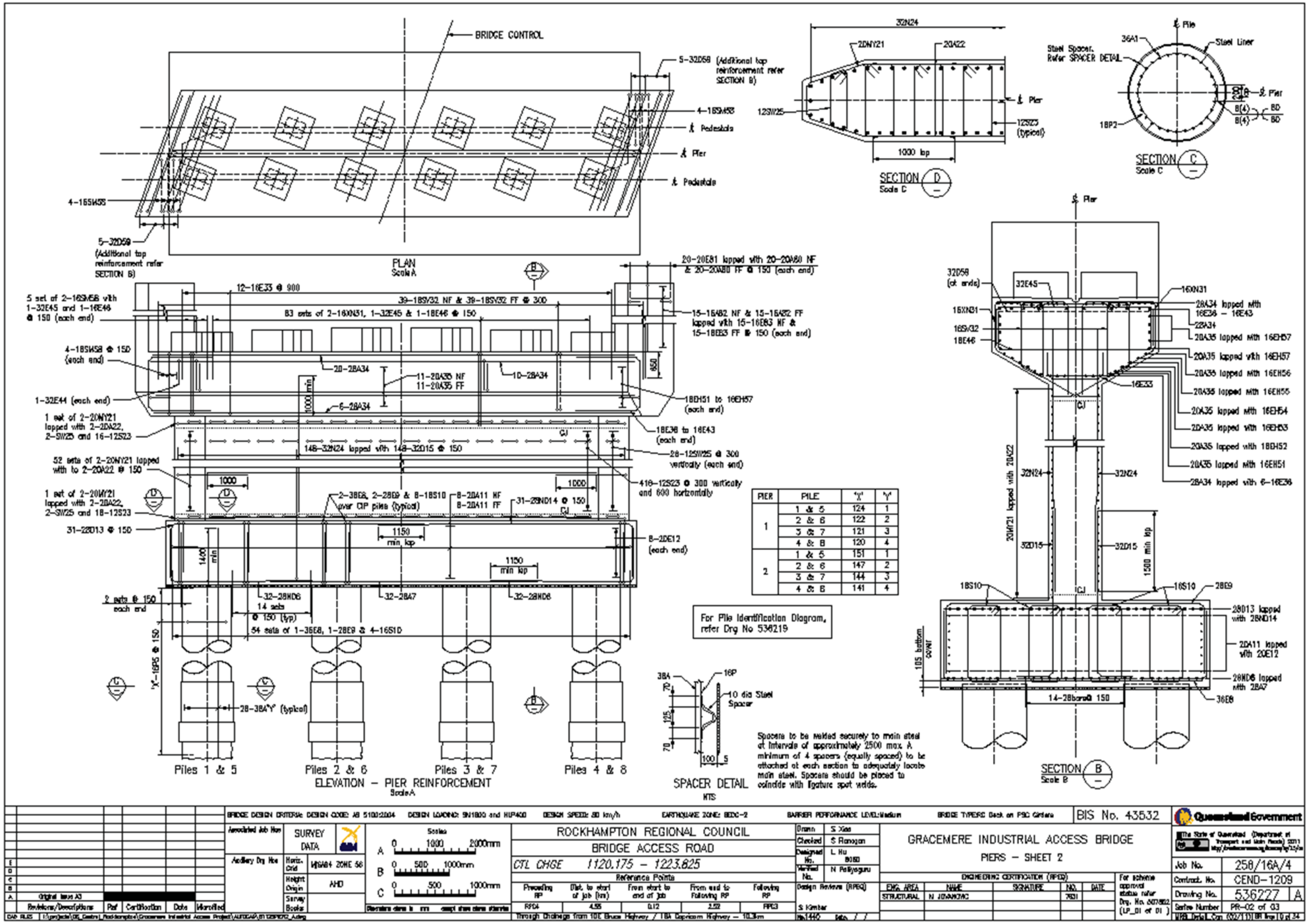
PEDESTAL HEIGHTS

Height	PIER 1	PIER 2
'C'	28.819	28.904
'D'	26.878	26.960
'E'	28.937	27.018
'F'	26.940	27.016
'G'	28.888	28.980
'H'	26.836	26.904
'J'	28.828	28.904
'K'	26.885	26.960
'L'	28.944	27.018
'M'	26.947	27.016
'N'	28.894	28.980
'P'	26.842	26.904

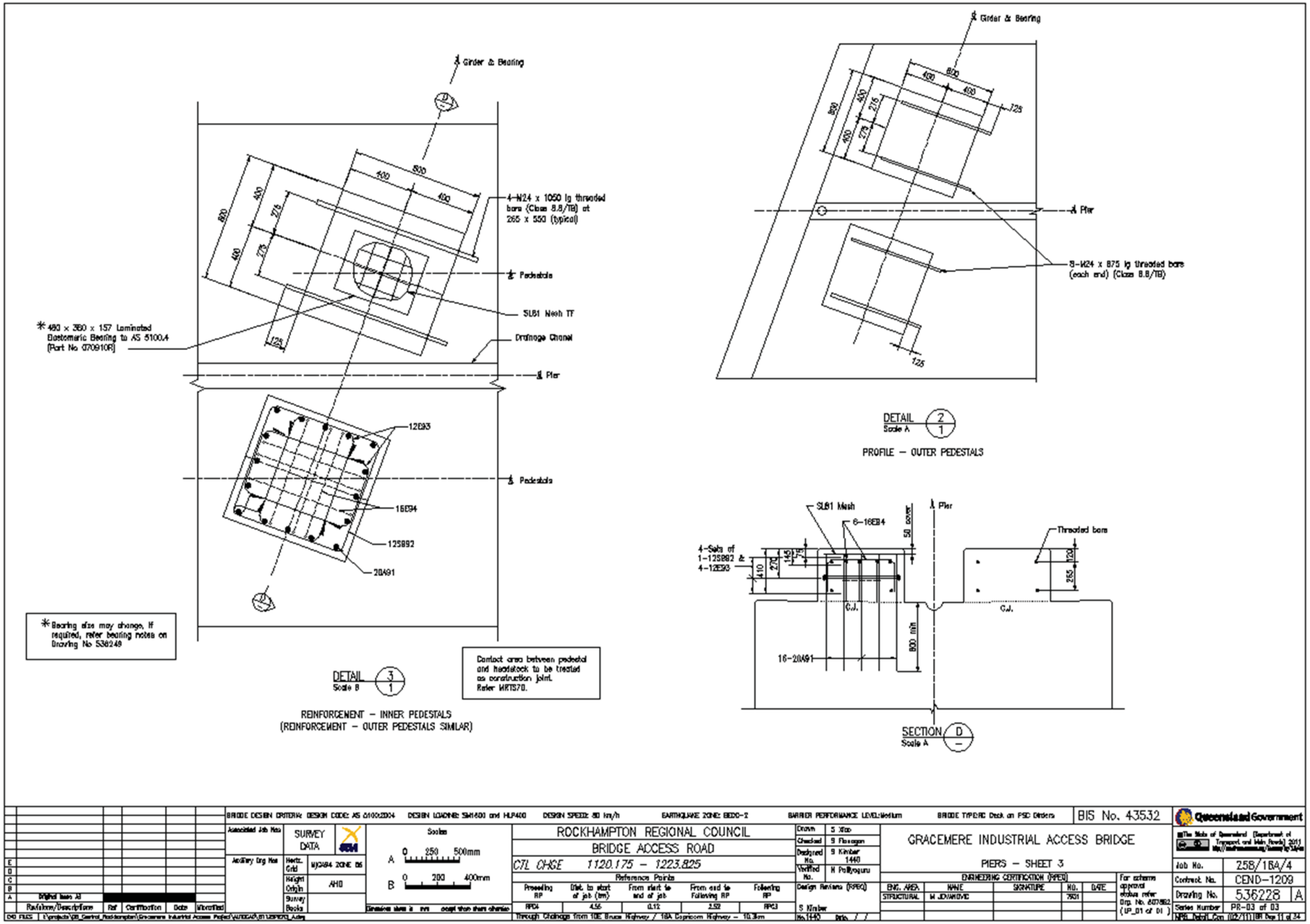
TABLE OF HEIGHTS – PILES

	PILE	Ht 'A'	Ht 'B'
PIER 1	1	-3.600	-3.300
	2	-3.370	-3.070
	3	-3.140	-2.840
	4	-2.900	-2.800
	5	-3.600	-3.300
	6	-3.370	-3.070
	7	-3.140	-2.840
	8	-2.900	-2.800
PIER 2	1	-7.500	-7.200
	2	-6.970	-6.870
	3	-6.440	-6.140
	4	-5.900	-5.800
	5	-7.500	-7.200
	6	-6.970	-6.870
	7	-6.440	-6.140
	8	-5.900	-5.800

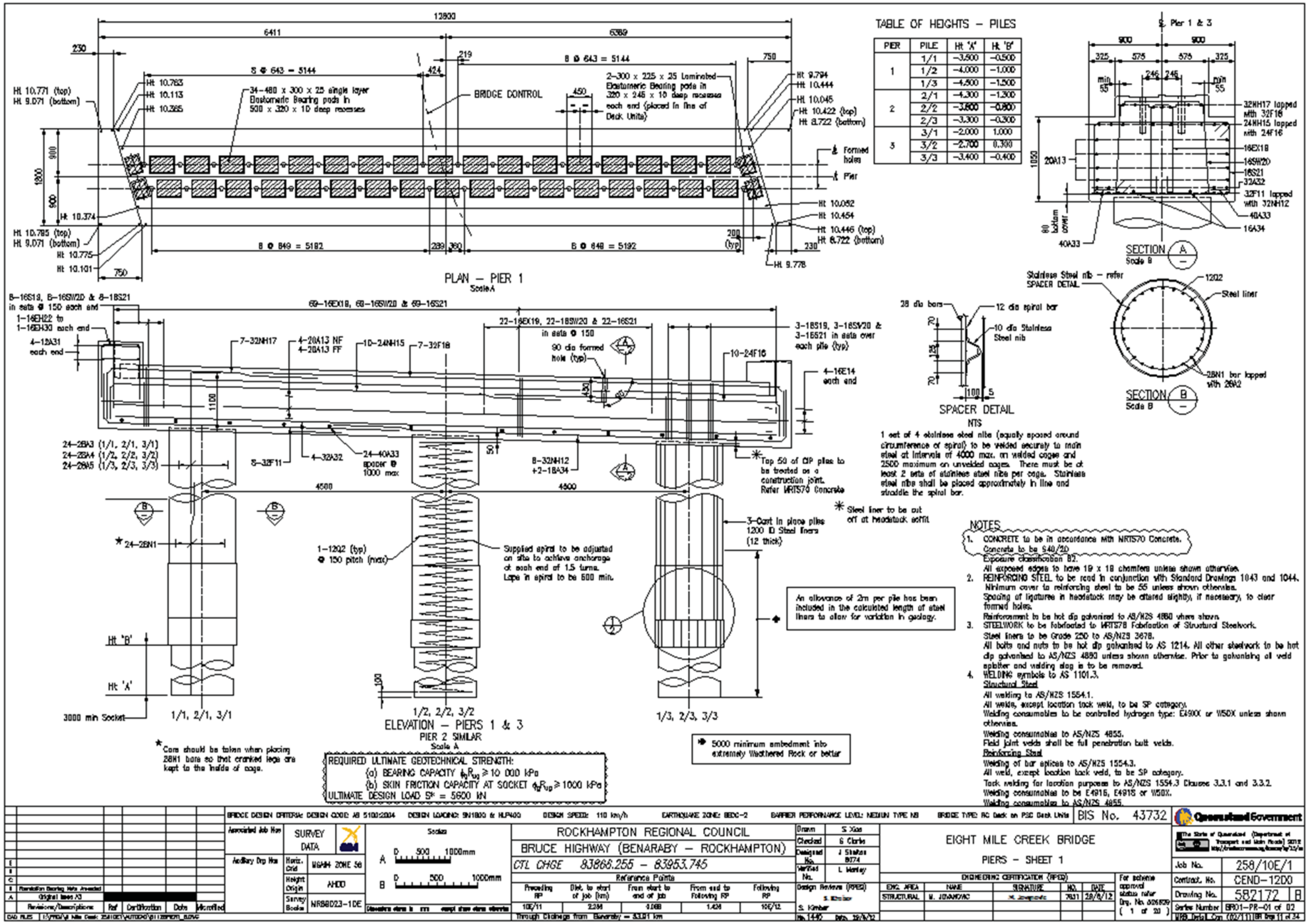
Appendix B - Example Pier Drawings – Sheet 5



Appendix B - Example Pier Drawings – Sheet 6



Appendix B - Example Pier Drawings – Sheet 7



Appendix B - Example Pier Drawings – Sheet 8