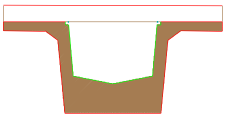

Standardisation
and
Detailing
for

SUPER-T

Bridge Girders

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Wolf Merretz has been practicing as a structural & civil engineer since graduating with Credits from University of Technology in 1973.

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He has represented on industry and Standards Australia codes committees. Currently he is Vice-President of the Concrete Institute of Australia (NSW) branch.

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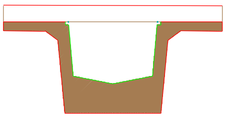
Godfrey Smith has been practicing as a structural & civil engineer since graduating. In 1979 he founded Structural Concrete Industries (Aust) Pty Ltd

He has specialised for 40 years in design, construction and erection of a vast range of precast concrete bridge and other infrastructure projects including precast grandstands and prestigious high-rise buildings Australia wide and has presented lectures on precast design and construction, and on concrete technology.

Godfrey has been active in Precast Concrete industry associations in Queensland, Victoria and NSW and was instrumental in the formation of the National Precast Concrete Association of Australia (NPCAA) of which he is a director. He is the immediate past President of that association.



TOWARDS NATIONAL STANDARDISATION
of
SUPER-T BRIDGE GIRDERS

This paper was presented at the AUSTROADS 1997 Bridge Conference
BRIDGING THE MILLENNIA and published in the proceedings of that conference

1 INTRODUCTION

Development of the precast Super-T's girder for the construction of bridge superstructures was commenced in 1993 by design engineers at VicRoads and was reported on at the proceedings of the Austroads bridge conference in 1994(1). At that time a number of prototype structures had been built to spans of 19 metres using the T-Slab. It was considered that spans to 35 metres should be possible and preliminary designs were developed. An overriding consideration centred on the willingness of the precast industry to invest in, and to design and construct the necessary infrastructure for manufacture of such new and large components.

In NSW the challenge to develop the use of the Super-T came with the construction of the M2 Motorway in north-western Sydney. On this project the majority of bridges were constructed with Super-T's and the full range of sections was used over a span range of 16 to 38 metres.

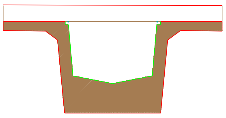
As it is in Victoria, the Super-T is now firmly established in NSW as the preferred section by bridge authorities, designers and constructors alike for bridge construction. As the popularity has grown the need for standardisation has arisen both in design and for manufacture in precast plants. It is only with standardisation of geometry and detail where possible, that the economies of construction will be maintained in the future. The Roads and Traffic Authority of NSW (RTA) has fully recognised the importance of, and need for, standardisation and has sought to develop this standardisation in concert with the **N**ational **P**recast **C**oncrete **A**ssociation **A**ustralia.

Based upon the valuable experience gained by both designers and manufacturers over the past four years in using the sections, this paper describes areas for standardisation which the precast industry, in consultation with the RTA, has embarked upon.

2 SUPER-T BRIDGES IN NSW

Table 1, (an abridged list) shows the locations, primary dimensions and prestress requirements for bridges constructed using closed top Super-T's in NSW over the last four years.

None of the bridges constructed to date have utilised intermediate diaphragms and while this does not permit the full utilisation of the beam torsion characteristics, all designs have been satisfactory. The non-use of intermediate diaphragms between girders has resulted in overall cost economies.



Super-T (Closed Top) Bridges Constructed in NSW

Bridge	No of Span (s)	Girder length (m)	Girder Type	Flange Width (mm)	Number of Girders Total No	Number of Strands per girder			Mass Tonnes
						Internal 15.2 dia 12.7*	External 15.2 dia 12.7*	Fully Prestress	
M2 Khartoum	1	31.6	T3	2050	11	47	53	Y	47
M2 Christie	2	20.0	T1	1850	16	38	42	Y	27
M2 Devlins	33	20.0	T1	2100	231	38	42	Y	27
M2 Culloden	1	36.0	T4	1900	6	46	50	Y	60
M2 Wicks	1	32.3	T3	1920	13	50	50	3Y36	51
M2 Delhi	1	25.0	T2	2050	17	42	45	Y	35
M2 Windsor	2	23.0	T3	2220	28	36+4*	36+4*	Y	35
M2 Yale Cl	1	38.0	T4	1825	16	38	38	6Y32	63
M2 Murray	3	23.9	T2	2320	15	24	24	2Y36	32
Tarro	2	28.8	T3	2310	8	42+2	42+2	2Y32	34
Georges River	7	35.6	T4	2450	49	38+2	38+2	4Y32	59
Devlin st Ryde	1	25.4	T2	2000	37	34+4	34+4	Y	37
Victoria Rd	1	35.9	T4	1980	13	50	50	Y	60.3
Warrimoo	2	34.7	T4	2200	20	40	40	Y	54.9
Bengalla Mine	9	22.2	T1	2290	36	30	30	N	26.9
Quakers Hill	2	26.7	T3	1800	14	42+4*	48+4*	Y	38

+2 and +4 indicates strands placed in top flange of external girders

Table 1

The choice between using closed or open top Super-T's is dependent on deck geometry, number of spans and variability of span within a bridge. Open top girders are cost effective only where standard internal forms of modular length can be utilised. The inner forms are expensive to construct and difficult to adjust for incremental length changes. Irrespective of the degree of deck skew, inner void profiles must always be detailed as square ended and internal diaphragms must be normal to the girder axis as shown in Figure 1.

Super-T (Open Top) Bridges Constructed in NSW

Bridge	No of Span (s)	Girder length (m)	Girder Type	Flange Width (mm)	Number of Girders Total No	Number of Strands per Girder			Mass Tonnes
						Internal 15.2 dia 12.7*	External 15.2 dia 12.7*	Fully Prestress	
Terrys Creek	5	34.3	T4	2105	55	33	33	Y	45.4
Darling Mills	5	33.7	T4	2110	70	33	33	Y	46.7
Lane Cove Rd	2	18.8	T3	2390	31	14	14	Y	25.0
Barclay Rd	2	24.2	T3	2210	16	20	20	N	28.5
Pennant Hills	2	21.6	T3	2150	72	30*	30*	Y	26.0
Bombala R	9	23.5	T2	1870	45	32	32	4Y28	30.9
Raleigh Devtn	8	33.0	T4	2040	43	41	41	Y	43.8
Illalong Creek	3	29.8	T4	2000	15	32	32	Y	40.0
Taree Bypass	2	25.6	T3	1730	12	32	32	Y	30.1

Table 2

3 STANDARDISATION OF CROSS SECTION

The cross section profiles and dimensions have been standardised in accordance Figure 2 and Figure 3 below.

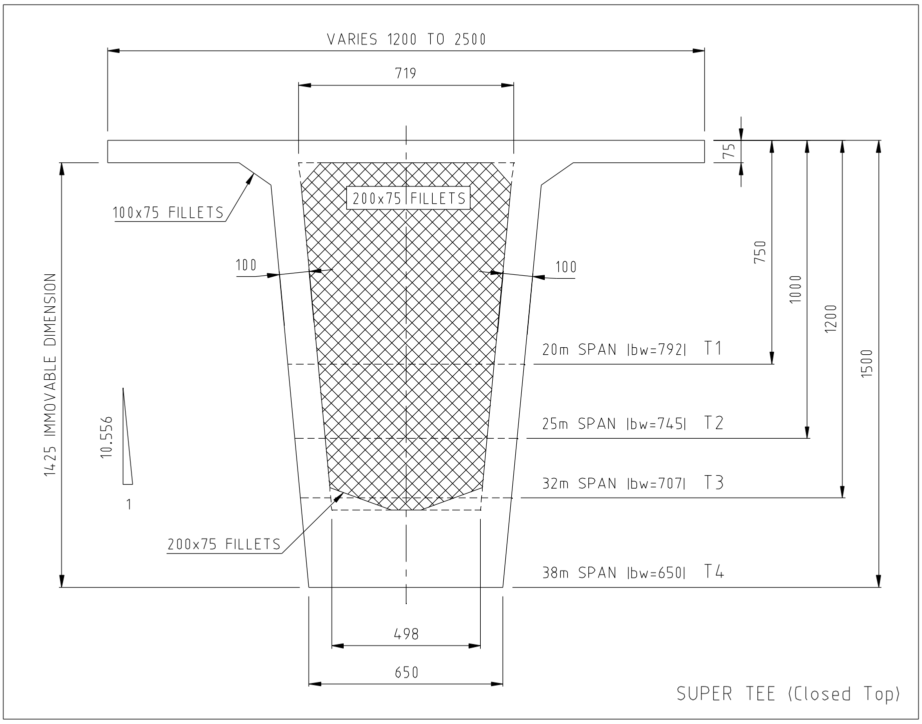


FIGURE 2

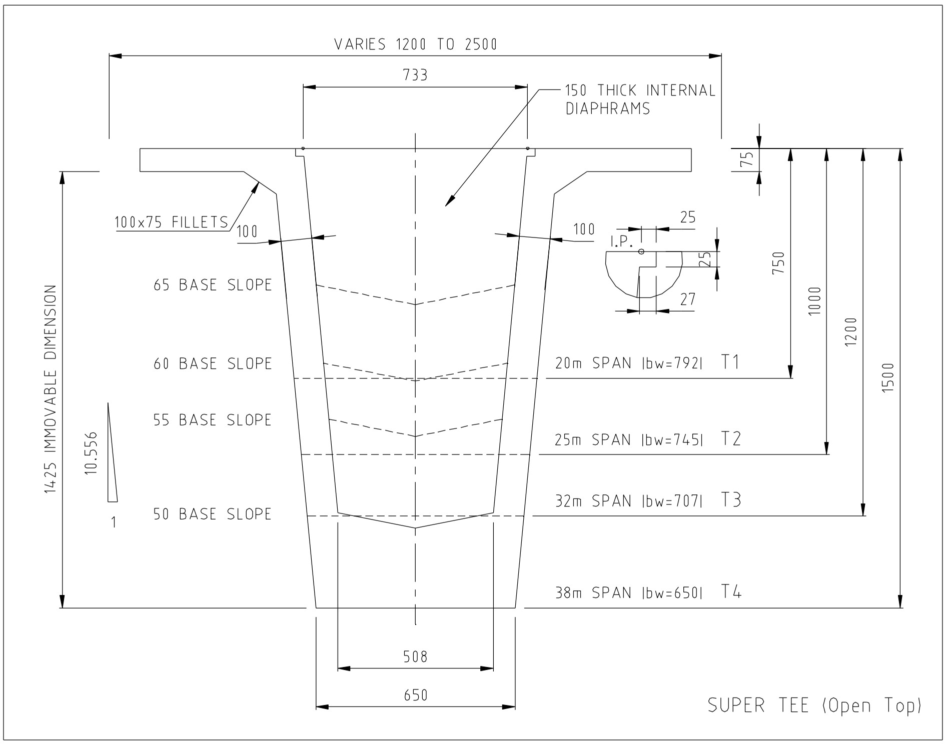
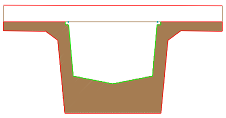


FIGURE 3



For both closed and open top sections the standard girder depths are as shown in **Table 3**. Minimum web thickness is 100mm. Where increased web thickness is required for abnormal loading conditions, the closed top girder is preferred because the styrene void former size is readily adjustable. It is generally considered that a web thickness of 100mm is adequate for highway loading including the effects of the heavy load platform loading, HLP320.

Use of non-standard depths is strongly discouraged primarily because of mould design and construction details. Moulds are stiffened at depth zones of 750, 1000, 1200 and 1500 from the top to provide adequate mould soffit clamping forces and to allow external compaction equipment to function effectively. As well, non standard depth usage very quickly deteriorates the mould profile, resulting in a shortened production life cycle and in turn, increased unit cost.

Super-T Standard Section Dimensions

Section	Depth (mm)	Top Flange (mm)	Bottom Flange (mm)	Web Thickness
T1	750	75	240	100
T2	1000	75	240	100
T3	1200	75	280	100
T4	1500	75	280	100

Table 3

The top flange thickness has been standardised at 75mm. This can be increased but only upwards and by maintaining the external underside mould profiles. Therefore, eg; use of a 100 flange in a nominal T3-1200 deep section results in overall girder depth of 1225.

Two preferred thickness of bottom flange have been agreed. For girders T1 and T2 the flange is 240mm thick while for T3 and T4 the flange is 280 thick. The 240mm dimension allows for recessed concrete profiles at bearing locations to accommodate elastomeric bearing pads placed directly in contact with T1 and T2 girder soffits. The 280mm dimension allows maximum concrete area for tendon location for T3 & T4 sections using cast-in and/or compensator plates as part of the bearing assembly. These agreed standards permit standardisation of inner forms for open topped Super-T's.

Critical dimensions for open top tees T1 to T4 are presented collectively in **Figure 4**.

4 DESIGN OF FULL AND PARTIAL PRESTRESSED SECTIONS

Since the Austroads Bridge Design Specification was introduced in 1992, designers have had available the options to design sections either as fully-prestressed or partially-prestressed for a defined proportion of the total loading history and to accept controlled flexural cracking in members depending upon serviceability criteria limitations.

It has become evident to the precast manufacturer that partial pre-stressed design options are currently very popular among many, but not all experienced designers. Observation of post manufacture and in-service behaviour of partially prestressed precast members in general indicates an urgent need for designers to correctly mathematically model service behaviour in terms of camber and deflection history as well as crack distribution under full service load. These observations include planks and I-girders as well as Super-T's.

At the time of transferring the prestress and shortly after demoulding, initial cambers may trend at significant variance to the designer's predictions as stated on the contract drawings. This matter needs to be addressed.

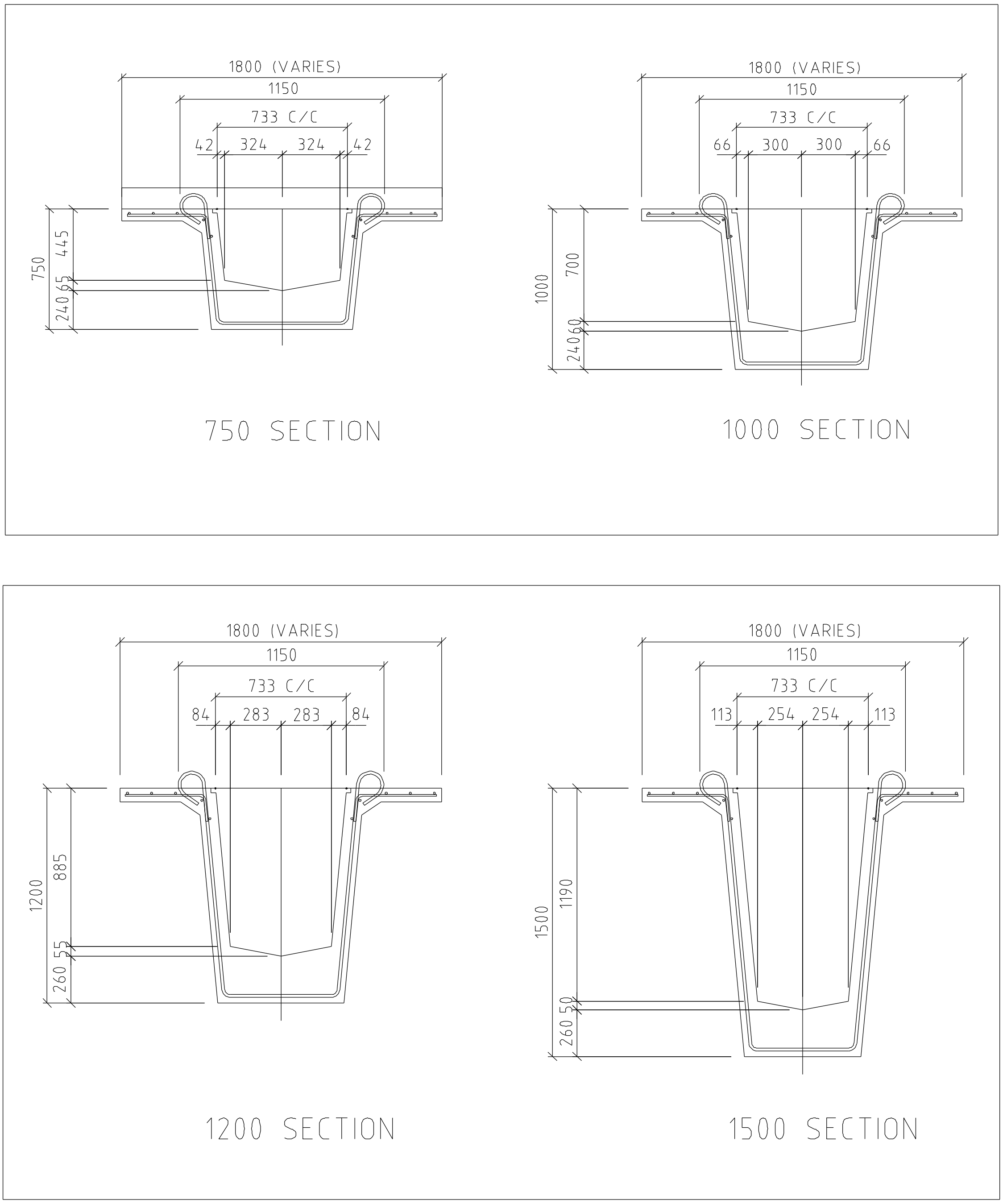


FIGURE 4

On the other hand, fully prestressed sections behave in a predictable and consistent manner. While previously used other standard sections (eg. I-Girders, planks etc) may have deformed undesirably over time, the more balanced section properties of Super-T's together with debonding and exclusive use of low relaxation strand is producing deformation in girders within the normally acceptable range.

There is a strong case for reverting to fully prestressed sections. Most certainly, there is a strong case for a re-evaluation of the desirability for designing cracked sections in 100-year-plus-design-life structures. There exists a need to limit the ratio of normal grade to prestressed steel in partial prestress designs. **Appendix A** provides section properties for the precast sections alone as well as composite properties for deck thickness of 160, 170 and 180mm for a range of girder spacing from 1800 to 2500mm.

5 STANDARDISATION OF PRESTRESS STRAND WITHIN SECTIONS

The infrastructure required for manufacture of Super-T's consists essentially of a long steel mould, a pre-tensioning bed to resist the applied prestress forces and stressing reaction bulkheads. The total length of the system is chosen to manufacture either one or two of the T4 girders in line. Shorter girders are then cast from the mould by adjusting the end shutters which slide within the section profile of the mould.

This practice can result in significant waste in the use of prestressing strand, particularly for shorter girders. The strand external to the girder will usually be mechanically coupled to the girder strand. This allows the external strand to be re-used many times with resultant reduction of waste and therefore effecting cost economies.

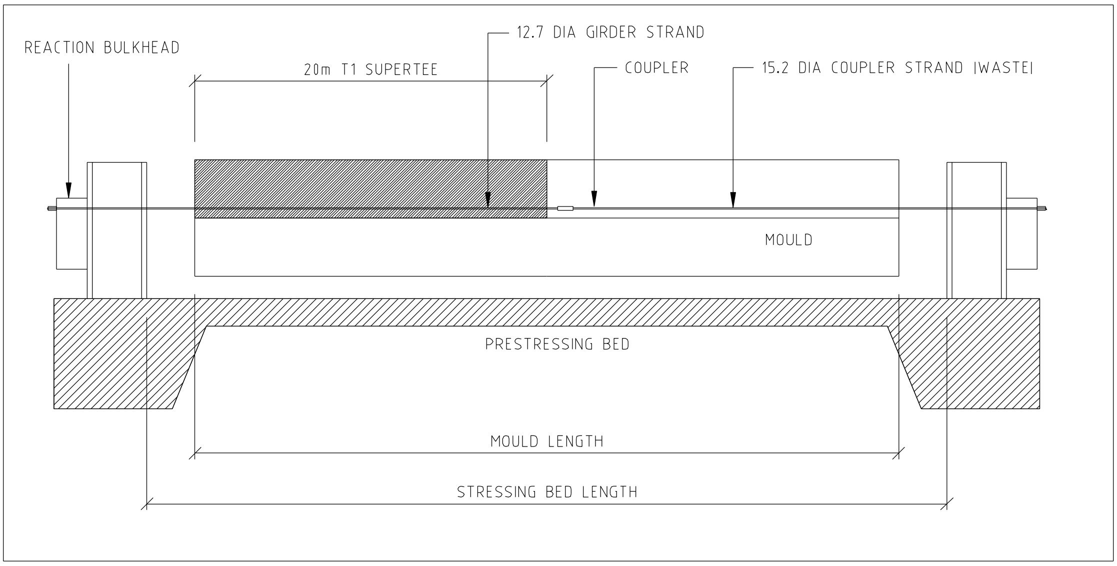
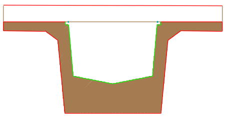


FIGURE 5



Of necessity, the coupling strand is required to be of larger diameter than the strand in the girder because of repeated daily tension loads. **Figure 5** refers. It is usual to couple 12.7mm dia strand to 15.2mm dia strand. Accordingly, Super-T's type T1 and T2 should preferably be designed using 12.7mm dia strand and T3, T4 designed using 15.2mm diameter. Because they occupy a larger proportion of the total bed length, the material waste on T3 and T4 will be lower or insignificant.

When detailing the typical cross sections and end blocks for both types of tees, please consider standardisation as shown in **Figure 6** and **Figure 8**. The following points should be adhered to:

- 12.7 and 15.2 dia strand should be placed on 50mm x 50mm pitch horizontally and vertically.
- **Never** locate strands on centreline of girder as this location is required for centreline hardware.
- The lowest layer of tendons should be located either 65 or 80mm above girder soffit.
- Keep bottom row strands away from the internal bend area of the Y16 stirrup reinforcement.
- Debond strands a minimum amount to ensure tensile and compressive stresses at transfer are within acceptable limits. Eg. 2.5 MPa tension and up to 20 MPa compression.
- Never debond more that 40 percent of prestress force near ends of girders.
- Always position at least two strands in the top flange of all girders. This helps to control stresses, minimises debonding, generally eliminates top fibre tension and helps to maintain concrete cover to shear reinforcement.
- Proportion section and reinforcement to limit maximum compressive strength of concrete at transfer of prestress to no greater than 37 Mpa. Always nominate the minimum actual transfer strength required.
- Concrete cover on all girder types to be 30mm irrespective of exposure classification. This permits standardisation of main vertical reinforcement.
- Use welded fabric in the flange of Super-T's, F818, F918, or F1018 depending on flange bending requirements. These meshes are detailed with main wires running upper and across the girder flange. To avoid clashes and cutting of fabric, detail stirrup spacing only in modular units relative to the mesh, ie 100, 200, 300mm centres.
- Always place girder shear reinforcement normal to the girder axis. Do not place on the skew angle if one exists except where required locally in endblocks.
- Do not detail reinforcing bars transversely in the top surface of the bottom flange except locally as required in endblocks.

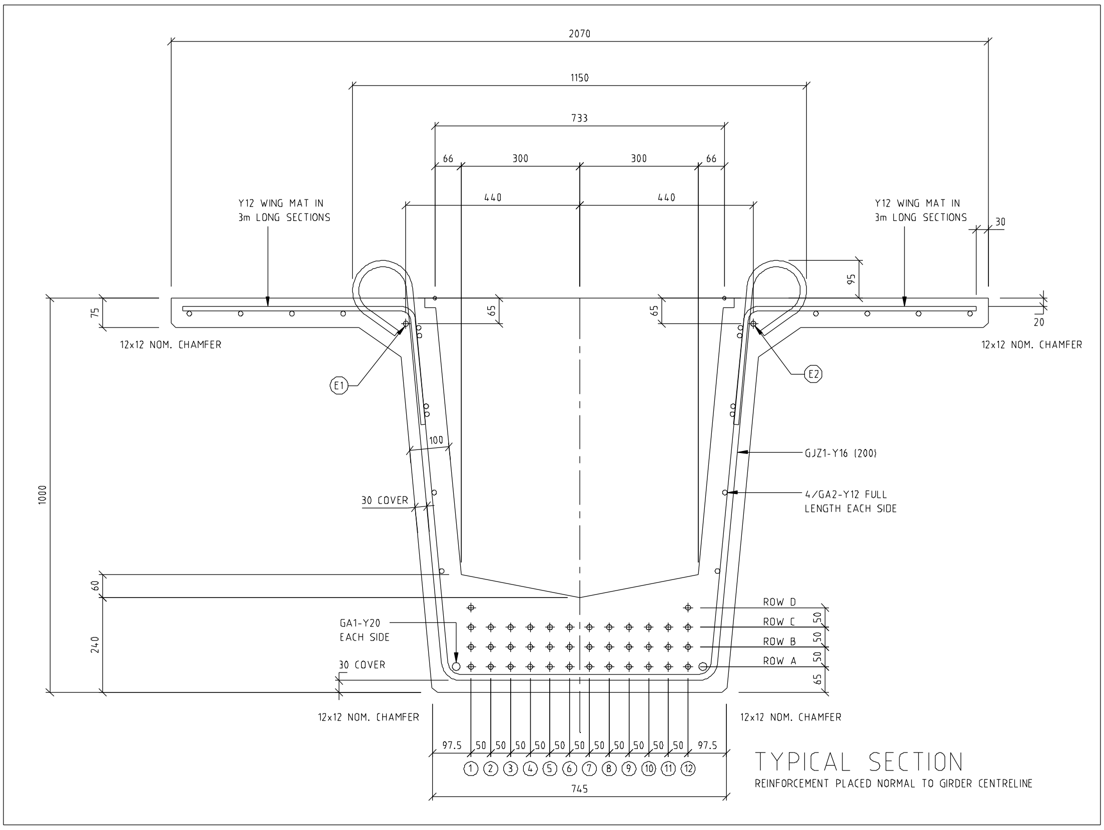


FIGURE 6

- Standardise on a single geometry for the stirrup reinforcement projection to connect the deck slab compositely with the precast section. **Figure 7** shows the preferred geometry and stirrup projection. This detail applies to both open and closed top SuperT’s.

- To allow placing of girder lifting hardware and adequate room for cross girder connections, the end block length should be a minimum length of 900mm.

- To accommodate transverse diaphragms at ends of girders it is preferred that the upper portion of flange and stem be notched.

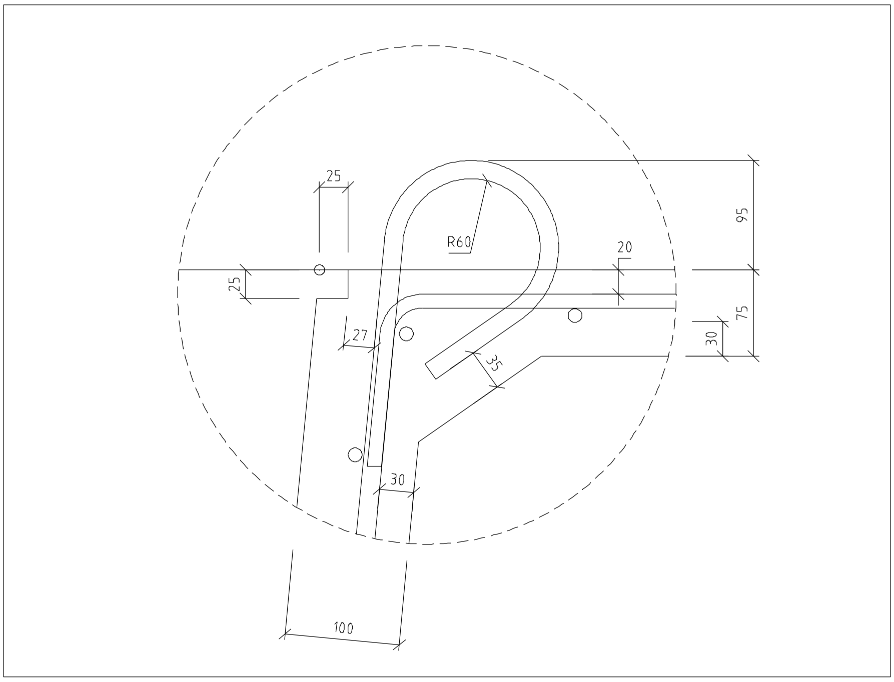


FIGURE 7

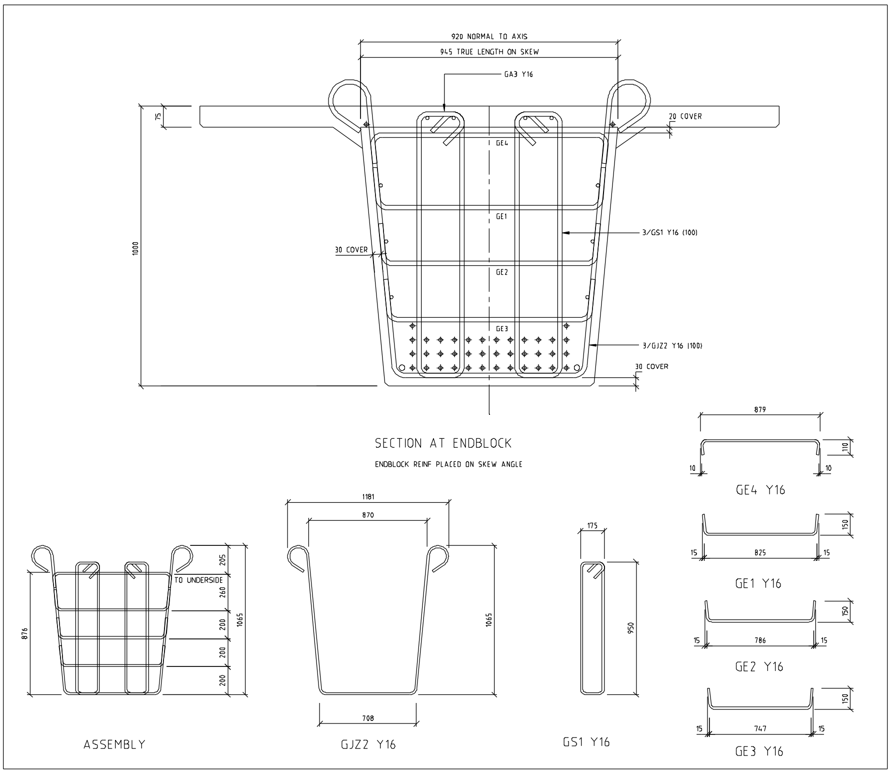


FIGURE 8

6 CONCLUSION

It will have become obvious that major benefits will flow from the process of national standardisation of this important structural form. Those who will benefit include the Bridge Authorities, the Design Consultants, the Precasters and the Bridge Contractors.

All of these groups will be able to proceed with their respective interests in the knowledge that they are dealing with a well defined and well understood standard system. No longer will it be necessary for individual groups to develop from first principles important design detail. Standardisation has taken care of this costly procedure.

7 REFERENCES

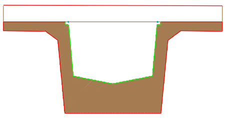
1) Proceedings of the Austroads 1994 Bridges Conference.

2) Austroads Bridge Design Code, 1992.

3) RTA Specification Part B80, Concrete Work for Bridges, Edition 3, Revision 1, December 1995.

4) RTA Specification Part B110, Manufacture of Pretensioned Precast Concrete Members, Edition 2, Revision 0, 1995.

5) Structural Concrete Industries (Aust) Pty Limited, (**SCI**) Internal Report on Design, Development and Detailing of Super-T's.



APPENDIX A

Super-T (Open Top) - Precast Section Properties

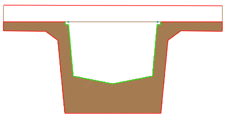
F'c(pc)=50MPa

T1	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Depth	(mm)	750	750	750	750	750
	Area	(mm2)	390,340	405,340	420,340	435,340	442,840
	Ix	(mm4)	2.47150E+10	2.67930E+10	2.87240E+10	3.05220E+10	3.13750E+10
	yb	(mm)	334	348	361	373	379
	Zt	(mm3)	5.939E+07	6.662E+07	7.381E+07	8.095E+07	8.450E+07
	Zb	(mm3)	7.403E+07	7.703E+07	7.960E+07	8.184E+07	8.284E+07
	Bf(bottom)	(mm)	792	792	792	792	792
	Mass	(T/m)	1.015	1.054	1.093	1.132	1.151

T2	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Depth	(mm)	1000	1000	1000	1000	1000
	Area	(mm2)	425,750	440,750	455,750	470,750	478,250
	Ix	(mm4)	5.14890E+10	5.53660E+10	5.89880E+10	6.23790E+10	6.39950E+10
	yb	(mm)	446	463	480	495	502
	Zt	(mm3)	9.289E+07	1.032E+08	1.134E+08	1.235E+08	1.286E+08
	Zb	(mm3)	1.155E+08	1.195E+08	1.230E+08	1.260E+08	1.274E+08
	Bf(bottom)	(mm)	745	745	745	745	745
	Mass	(T/m)	1.107	1.146	1.185	1.224	1.243

T3	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Depth	(mm)	1200	1200	1200	1200	1200
	Area	(mm2)	464,830	479,830	494,830	509,830	517,330
	Ix	(mm4)	8.16280E+10	8.73380E+10	9.27020E+10	9.77500E+10	1.00170E+11
	yb	(mm)	536	556	574	591	600
	Zt	(mm3)	1.229E+08	1.355E+08	1.481E+08	1.606E+08	1.668E+08
	Zb	(mm3)	1.523E+08	1.572E+08	1.615E+08	1.653E+08	1.671E+08
	Bf(bottom)	(mm)	707	707	707	707	707
	Mass	(T/m)	1.209	1.248	1.287	1.326	1.345

T4	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Depth	(mm)	1500	1500	1500	1500	1500
	Area	(mm2)	507,840	522,840	537,840	552,840	560,340
	Ix	(mm4)	1.40580E+11	1.49330E+11	1.57600E+11	1.65420E+11	1.69170E+11
	yb	(mm)	688	710	731	751	760
	Zt	(mm3)	1.730E+08	1.890E+08	2.049E+08	2.208E+08	2.287E+08
	Zb	(mm3)	2.045E+08	2.104E+08	2.157E+08	2.204E+08	2.225E+08
	Bf(bottom)	(mm)	650	650	650	650	650
	Mass	(T/m)	1.320	1.359	1.398	1.437	1.457



APPENDIX A

Super-T (Open Top) - Composite Section Properties

D=160

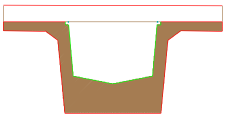
Deck Thickness D=160mm F'c(sl)=40MPa F'c(pc)=50MPa m=0.894

T1	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	910	910	910	910	910
	Depth(pc)	(mm)	750	750	750	750	750
	Area	(mm2)	647,940	691,420	734,900	778,700	800,600
	Ix	(mm4)	6.34700E+10	6.63930E+10	6.89950E+10	7.13500E+10	7.24390E+10
	yb	(mm)	531	547	562	574	580
	Zt(deck)	(mm3)	1.67507E+08	1.83072E+08	1.98068E+08	2.12661E+08	2.19765E+08
	Zt(pc)	(mm3)	2.89937E+08	3.27608E+08	3.66332E+08	4.06530E+08	4.27066E+08
	Zb(pc)	(mm3)	1.19509E+08	1.21301E+08	1.22841E+08	1.24197E+08	1.24813E+08
	Bf(bottom)	(mm)	792	792	792	792	792
	Mass	(T/m)	1.685	1.798	1.911	2.025	2.082

T2	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1160	1160	1160	1160	1160
	Depth(pc)	(mm)	1000	1000	1000	1000	1000
	Area	(mm2)	683,350	726,830	770,310	814,110	836,010
	Ix	(mm4)	1.16610E+11	1.21950E+11	1.26720E+11	1.31030E+11	1.33030E+11
	yb	(mm)	685	706	725	742	750
	Zt(deck)	(mm3)	2.45402E+08	2.68630E+08	2.91210E+08	3.13311E+08	3.24147E+08
	Zt(pc)	(mm3)	3.69979E+08	4.14838E+08	4.60549E+08	5.07455E+08	5.31270E+08
	Zb(pc)	(mm3)	1.70278E+08	1.72726E+08	1.74822E+08	1.76640E+08	1.77468E+08
	Bf(bottom)	(mm)	745	745	745	745	745
	Mass	(T/m)	1.777	1.890	2.003	2.117	2.174

T3	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1360	1360	1360	1360	1360
	Depth(pc)	(mm)	1200	1200	1200	1200	1200
	Area	(mm2)	722,430	765,910	809,390	853,190	875,090
	Ix	(mm4)	1.73910E+11	1.81990E+11	1.89220E+11	1.95790E+11	1.98830E+11
	yb	(mm)	801	826	848	868	878
	Zt(deck)	(mm3)	3.11287E+08	3.40927E+08	3.69852E+08	3.98336E+08	4.12322E+08
	Zt(pc)	(mm3)	4.36215E+08	4.86852E+08	5.38153E+08	5.90583E+08	6.17063E+08
	Zb(pc)	(mm3)	2.17029E+08	2.20276E+08	2.23034E+08	2.25440E+08	2.26515E+08
	Bf(bottom)	(mm)	707	707	707	707	707
	Mass	(T/m)	1.878	1.991	2.104	2.218	2.275

T4	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1660	1660	1660	1660	1660
	Depth(pc)	(mm)	1500	1500	1500	1500	1500
	Area	(mm2)	765,440	808,920	852,400	896,620	918,100
	Ix	(mm4)	2.77240E+11	2.89960E+11	3.01400E+11	3.11830E+11	3.16690E+11
	yb	(mm)	988	1018	1044	1068	1080
	Zt(deck)	(mm3)	4.12510E+08	4.51342E+08	4.89429E+08	5.27105E+08	5.45688E+08
	Zt(pc)	(mm3)	5.41400E+08	6.01028E+08	6.61226E+08	7.22514E+08	7.53396E+08
	Zb(pc)	(mm3)	2.80630E+08	2.84956E+08	2.88648E+08	2.91864E+08	2.93327E+08
	Bf(bottom)	(mm)	650	650	650	650	650
	Mass	(T/m)	1.990	2.103	2.216	2.331	2.387



APPENDIX A

Super-T (Open Top) - Composite Section Properties

D=170

Deck Thickness D=170mm F'c(sl)=40MPa F'c(pc)=50MPa m=0.894

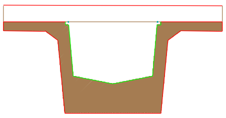
T1	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	920	920	920	920	920
	Depth(pc)	(mm)	750	750	750	750	750
	Area	(mm2)	664,040	709,300	754,560	800,160	822,960
	Ix	(mm4)	6.57850E+10	6.87490E+10	7.13850E+10	7.37720E+10	7.48750E+10
	yb	(mm)	540	557	571	584	589
	Zt(deck)	(mm3)	1.73301E+08	1.89188E+08	2.04465E+08	2.19318E+08	2.26530E+08
	Zt(pc)	(mm3)	3.13860E+08	3.55494E+08	3.98509E+08	4.43421E+08	4.66424E+08
	Zb(pc)	(mm3)	1.21734E+08	1.23514E+08	1.25046E+08	1.26402E+08	1.27021E+08
	Bf(bottom)	(mm)	792	792	792	792	792
	Mass	(T/m)	1.727	1.844	1.962	2.080	2.140

T2	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1170	1170	1170	1170	1170
	Depth(pc)	(mm)	1000	1000	1000	1000	1000
	Area	(mm2)	699,450	744,710	789,970	835,570	858,370
	Ix	(mm4)	1.20230E+11	1.25630E+11	1.30430E+11	1.34780E+11	1.36790E+11
	yb	(mm)	696	717	736	753	760
	Zt(deck)	(mm3)	2.53580E+08	2.77360E+08	3.00398E+08	3.22950E+08	3.33976E+08
	Zt(pc)	(mm3)	3.95324E+08	4.44001E+08	4.93698E+08	5.44918E+08	5.70958E+08
	Zb(pc)	(mm3)	1.72777E+08	1.75204E+08	1.77260E+08	1.79072E+08	1.79887E+08
	Bf(bottom)	(mm)	745	745	745	745	745
	Mass	(T/m)	1.819	1.936	2.054	2.172	2.232

T3	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1370	1370	1370	1370	1370
	Depth(pc)	(mm)	1200	1200	1200	1200	1200
	Area	(mm2)	738,530	783,790	829,050	874,650	897,450
	Ix	(mm4)	1.78920E+11	1.87060E+11	1.94340E+11	2.00950E+11	2.04010E+11
	yb	(mm)	814	838	861	881	890
	Zt(deck)	(mm3)	3.21573E+08	3.51934E+08	3.81538E+08	4.10664E+08	4.24941E+08
	Zt(pc)	(mm3)	4.63055E+08	5.17426E+08	5.72666E+08	6.29286E+08	6.57906E+08
	Zb(pc)	(mm3)	2.19909E+08	2.23094E+08	2.25809E+08	2.28179E+08	2.29248E+08
	Bf(bottom)	(mm)	707	707	707	707	707
	Mass	(T/m)	1.920	2.038	2.156	2.274	2.333

T4	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1670	1670	1670	1670	1670
	Depth(pc)	(mm)	1500	1500	1500	1500	1500
	Area	(mm2)	781,540	826,800	872,060	917,660	940,460
	Ix	(mm4)	2.84470E+11	2.97290E+11	3.08810E+11	3.19290E+11	3.24170E+11
	yb	(mm)	1002	1032	1058	1082	1094
	Zt(deck)	(mm3)	4.25770E+08	4.65651E+08	5.04740E+08	5.43343E+08	5.62375E+08
	Zt(pc)	(mm3)	5.71076E+08	6.34638E+08	6.98950E+08	7.64510E+08	7.97604E+08
	Zb(pc)	(mm3)	2.83939E+08	2.88195E+08	2.91831E+08	2.94994E+08	2.96433E+08
	Bf(bottom)	(mm)	650	650	650	650	650
	Mass	(T/m)	2.032	2.150	2.267	2.386	2.445

APPENDIX A



Super-T (Open Top) - Composite Section Properties

Deck Thickness D=180mm

F'c(sl)=40MPa F'c(pc)=50MPa m=0.894

D=180

T1	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	930	930	930	930	930
	Depth(pc)	(mm)	750	750	750	750	750
	Area	(mm2)	680,140	727,180	774,220	821,620	845,320
	Ix	(mm4)	6.81100E+10	7.11160E+10	7.37880E+10	7.62070E+10	7.73260E+10
	yb	(mm)	550	566	580	593	598
	Zt(deck)	(mm3)	1.79001E+08	1.95191E+08	2.10739E+08	2.25825E+08	2.33155E+08
	Zt(pc)	(mm3)	3.39701E+08	3.85787E+08	4.33690E+08	4.83977E+08	5.09898E+08
	Zb(pc)	(mm3)	1.23949E+08	1.25722E+08	1.27251E+08	1.28611E+08	1.29232E+08
	Bf(bottom)	(mm)	792	792	792	792	792
	Mass	(T/m)	1.768	1.891	2.013	2.136	2.198

T2	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1180	1180	1180	1180	1180
	Depth(pc)	(mm)	1000	1000	1000	1000	1000
	Area	(mm2)	715,550	762,590	809,630	857,030	880,730
	Ix	(mm4)	1.23850E+11	1.29290E+11	1.34130E+11	1.38510E+11	1.40530E+11
	yb	(mm)	707	728	746	763	771
	Zt(deck)	(mm3)	2.61646E+08	2.85907E+08	3.09390E+08	3.32350E+08	3.43552E+08
	Zt(pc)	(mm3)	4.22192E+08	4.74964E+08	5.29050E+08	5.85023E+08	6.13534E+08
	Zb(pc)	(mm3)	1.75264E+08	1.77647E+08	1.79686E+08	1.81476E+08	1.82282E+08
	Bf(bottom)	(mm)	745	745	745	745	745
	Mass	(T/m)	1.860	1.983	2.105	2.228	2.290

T3	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1380	1380	1380	1380	1380
	Depth(pc)	(mm)	1200	1200	1200	1200	1200
	Area	(mm2)	754,630	801,670	848,710	896,110	919,810
	Ix	(mm4)	1.83880E+11	1.92090E+11	1.99420E+11	2.06070E+11	2.09150E+11
	yb	(mm)	826	850	873	893	902
	Zt(deck)	(mm3)	3.31668E+08	3.62742E+08	3.92992E+08	4.22716E+08	4.37287E+08
	Zt(pc)	(mm3)	4.91119E+08	5.49535E+08	6.09028E+08	6.70168E+08	7.01163E+08
	Zb(pc)	(mm3)	2.22726E+08	2.25869E+08	2.28546E+08	2.30888E+08	2.31948E+08
	Bf(bottom)	(mm)	707	707	707	707	707
	Mass	(T/m)	1.962	2.084	2.207	2.330	2.392

T4	**Flange w**	(mm)	**1800**	**2000**	**2200**	**2400**	**2500**
	Total D	(mm)	1680	1680	1680	1680	1680
	Depth(pc)	(mm)	1500	1500	1500	1500	1500
	Area	(mm2)	797,640	844,680	891,720	939,120	962,820
	Ix	(mm4)	2.91610E+11	3.04540E+11	3.16120E+11	3.26660E+11	3.31550E+11
	yb	(mm)	1015	1045	1072	1096	1107
	Zt(deck)	(mm3)	4.38808E+08	4.79727E+08	5.19746E+08	5.59254E+08	5.78692E+08
	Zt(pc)	(mm3)	6.01816E+08	6.69584E+08	7.38219E+08	8.08364E+08	8.43789E+08
	Zb(pc)	(mm3)	2.87173E+08	2.91376E+08	2.94949E+08	2.98075E+08	2.99484E+08
	Bf(bottom)	(mm)	650	650	650	650	650
	Mass	(T/m)	2.074	2.196	2.318	2.442	2.503