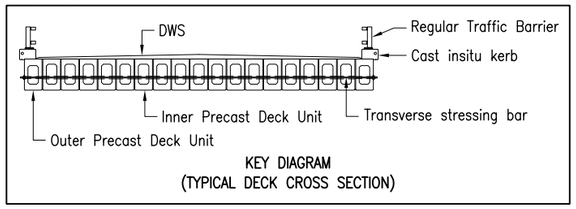
DESIGN ASSUMPTIONS FOR TRANSVERSELY STRESSED STANDARD DECK UNITS

EXPOSURE CLASSIFICATION B2, REGULAR PERFORMANCE BARRIER

1. Bridge Geometry

(a) These design assumptions are for bridge spans from 10m to 25m.
(b) Road carriageway width between barriers: 8.6m to 20m.
(c) The deck units have been designed as simply supported at each end.
(d) If the gradient of the deck along the bridge centerline is greater than 5%, the designer shall assess the effect on the supports.
(e) The Key Diagram for bridge deck cross section is shown below.



KEY DIAGRAM
(TYPICAL DECK CROSS SECTION)

2. Skew Angle

Skew angle is the angle between transverse stressing and the line perpendicular to the bridge centre line.
Bridges with a skew angle ranging from 0° to 30° may utilise standard deck units with transverse stressing.
Bridges with a skew angle ranging from 30° to 45° may utilise transverse stressing with shear keys or a reinforced concrete cast insitu deck slab.

3. General Arrangement of Deck Units

Standard deck unit width is 596mm.
The nominal spacing of the deck units measured at the centre line of holding down bolts shall be minimum 621mm and maximum 626mm centres, normal to the centre line of the units.
Transverse stressing bars are to be located as per relevant TMR Deck Unit Standard Drawing.
Transverse stressing bars are at 2050mm spacing.
Maximum void length shall be 1800mm.

4. Design Parameters

(a) General Parameters

Design for superimposed dead load for deck wearing surface (DWS) thickness:
for two–way crossfall carriageways, 70mm minimum DWS thickness at kerb, 85mm minimum at traffic lanes, plus 2.5% cross fall;
for one–way crossfall carriageways, the minimum DWS thickness shall be 85mm.
Density of concrete = 2600kg/m^3.
The characteristic strength of concrete at 28 days f'c = 50MPa.
Compressive strength at transfer f'cp = 40MPa.
Bridge Temperature variation = ±30°C (for longitudinal analysis).
Minimum cover to reinforcement shall be 40mm for all sides using rigid steel formwork and intense vibration utilising external vibrators.
The design exposure classification is B2 to AS 5100.5.

(b) Environment

Deck units have been designed for casting to be undertaken in a near coastal environment (1–50km from the coastline). If the units are not cast in a near coastal environment alteration to the prestress losses and hogs shall be considered in project designs.
Deck units have been designed for use in all bridge site locations through out Queensland.

(c) Design Traffic Loads

W80 Wheel Loading.
A160 Axle Loading.
S1600 Stationary Traffic Loading.
M1600 Moving Traffic Loading.
M1600 Moving Tri–axle Group Loading.
A160, S1600 and M1600 loads shall be positioned laterally within a 3.2m standard design lane.
HLP 320 or HLP 400 located ± 1.0m from centreline of two marked traffic lanes with co–existing half of either S1600 or M1600 loads in remaining marked traffic lanes. Accompany lane factor for S1600 and M1600 is not applicable.
Marked lanes are based on 0.8m shoulders and 3.5m lane width.
This design is not valid for HLP loading if the marked lanes are less than 3.5m width.
If lanes narrower than 3.5m, this shall be assessed on a project basis.

(d) Barrier Impact Loading

The standard designs allow for the impact loads on post and rail and reinforced concrete parapet type traffic barriers designed to Regular Barrier Performance level in accordance with AS 5100.2.
The design of external deck units assume the following load path for resistance of traffic barrier loading:
(i) reinforced concrete kerb has been assumed to act compositely with outer deck unit;
(ii) a maximum 340mm height of reinforced concrete parapet has been assumed to act compositely with outer deck unit. The remaining height of the parapet shall have joints located at 2000mm minimum and 4000mm maximum centres along the barrier;
(iii) barrier forces are distributed in the longitudinal direction via torsion in the composite beam; and
(iv) impact forces are transferred between barrier and deck via local flexure at transverse stressing locations.
This load path enables the steel barrier posts or concrete parapet joints to be independent of location of the transverse stressing bars.

(e) Transverse stressing bars material parameters shall be in accordance with AS/NZS 4672.1.
Transverse stressing bars shall be 29mm or 32mm diameter, tensile strength 1030MPa, jacking force 350kN.

5. Prestress Losses

Losses shall be calculated in accordance with AS 5100.5.
The following assumptions have been made:

(a) Losses at Transfer

In checking concrete stresses at transfer (minimum losses to be used)
(i) Relaxation Loss = 7% steam curing of deck units.
(ii) Elastic deformation based on the modulus of elasticity of concrete = 32000MPa.

(b) Losses at Serviceability

In checking service stresses at 30 years (maximum losses to be used)
(i) Relaxation Loss = 10% steam cured.
(ii) Elastic deformation based on the modulus of elasticity of concrete = 35750MPa.
(iii) Losses due to shrinkage strain and creep strain shall be calculated in accordance with AS 5100.5.

6. Hog Calculation

To determine the upper limit of the hog of deck units at transfer the following parameters have been assumed:
(a) Loss due to relaxation = 5%
(b) The modulus of elasticity of the concrete = 25600MPa.
Hog at 30 days and 100 days have been determined by multiplying the hog at transfer with appropriate creep factors.

7. Structural Analysis

The following section properties shall be used in Grillage model:

(a) Sectional properties for longitudinal members

(i) Inner deck units are modelled using full 'I'(I_{du});
(ii) Outer composite beam has been modelled using an effective 'I' ($I_{ku,\ model}$) where:

$I_{ku,\ model} = \{M_{u,ku} / M_{u,du}\} \times I_{du} \leq I_{ku}$

$M_{u,ku}$ – Ultimate bending strength of outer composite beam
$M_{u,du}$ – Ultimate bending strength of deck unit adjoining the outer composite beam
(Ref. Manual *S02: Modelling deck unit bridge superstructures for Tier 1 assessments)*

(iii) I_{ku} and $M_{u,ku}$ have been calculated using the transformed kerb width (b_{ef}). The b_{ef} shall be based on the modified kerb dimension ($b_m \times D_m$) and the properties as follows:

Transformed kerb width $b_{ef} = k_{tK} \times b_m$

$k_{tK} = E_{kerb} / E_{unit}$

E_{kerb} = Modulus of Elasticity of concrete for cast insitu kerb at maturity

E_{unit} = Modulus of Elasticity of concrete for precast unit at maturity

In the absence of more accurate information a default value of k_{tK} = 0.9 shall be used (based on E_{kerb} = 32000 and E_{unit} = 35750MPa)

b_m = modified kerb width = (b – 100) where 100 is the allowance for nominal conduits

D_m = modified kerb height = the lesser of {D & D_0}
b = actual kerb width (mm), 550mm nominal
D = actual kerb height (mm)
D_0 = 340 mm

(iv) Grillage model assumes the centroid of all the members are in one plane.
(v) Effective 'I' calculated in (i) and (ii) above have been used for deck unit stress calculations; and
(iv) For the calculation of action effects (bending moment, shear forces and torsion) under ultimate limit state load using grillage analysis, deck units have been modelled with a torsion stiffness equivalent to 20% of torsion stiffness for uncracked section. In checking concrete stresses under serviceability limit state, the bending moment have been calculated using full torsion stiffness for uncracked section.

(b) Section Properties of Transverse Members

The distribution of traffic loads in the transverse direction is dependent on the transverse stiffness of the deck. Transverse stressing bar in combination with segmental precast elements form a post–tensioned deck member which distribute the load in the transverse direction. For the purpose of analysis, the effect of post tension in the transverse direction is modelled as hypothetical transverse members with an equivalent stiffness of 10% of deck unit flexural and axial stiffness at 2.0 m centres or 5% of deck unit flexural and axial stiffness at 1.0 m centres.

Refer to Drawing 2 for Design Assumptions in respect of:
8. Structural Design
9. Design and Detail of Lifting Devices
10. Detailing of Reinforcement and Strands
11. Transport and Storage of Units

NOTES:

REFERENCED DOCUMENTS:
Departmental Specifications:
MRTS70 Concrete
MRTS71 Reinforcing Steel
MRTS73 Manufacture of Prestressed Concrete Members and Stressing Units
MRTS74 Supply and Erection of Prestressed Concrete Deck and Kerb Units

Departmental Manuals:
Design Criteria for Bridges and Other Structures

Department of Transport and Main Roads

PRECAST UNITS

DESIGN ASSUMPTIONS FOR TRANSVERSELY STRESSED STANDARD DECK UNITS
DRAWING 1 OF 2

Queensland Government

A3
Not to Scale

Standard Drawing No
2042
Date 7/18

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8. Structural Design

After the action effects have been determined in Section 7 above, the deck units shall be designed in accordance to AS 5100.5.

The units shall be designed for strength and serviceability. The design shall satisfy the following requirements.

(a) Strand Pattern

Edge distances and strand spacing shall conform to standard strand patterns shown in TMR standard deck unit drawings and be in accordance with the following requirements

Strand size	Minimum distance from soffit to ℄ of strands	Minimum clear distance to void	Minimum spacing centre to centre	Minimum distance from side form to ℄ of strands
12.7 and 15.2	65	60	55(V); 45(H)	70

Dimensions are in millimetres

Both internal and external units shall have same strand pattern and numbers and have same void shape and size to limit the variation of the hogs.

There shall be a maximum of 8 strands per layer providing provision for holding down bolt holes at the centre of the units.

The chamfer for the void shall be 75mm x 75mm.

(b) Jacking Force

Maximum jacking force at stressing of pretensioned strands shall be in accordance with AS 5100.5. Jacking force shall be specified on the drawings.

(c) Stresses at Transfer

Maximum allowable tensile stress shall be $-0.25\sqrt{f'_{cp}}$ or, $-0.5\sqrt{f'_{cp}}$ if reinforcement or bonded strands are provided near the tensile face.

Maximum allowable compressive stress shall be $0.6\ f'_{cp}$.

(d) Serviceability Limit State

The allowable maximum tensile stress in concrete shall be $-0.25\sqrt{f'_c}$ or, $-0.5\sqrt{f'_c}$ if reinforcement or bonded strands are provided near the tensile face.

For permanent loads plus SM1600 loading, no partial prestress is permitted (for any exposure classification).

For permanent loads plus HLP400 only, partial prestress is permitted in accordance with Clause 8.6.2.1(b) of AS 5100.5.

"Partial prestress" referred to above, is defined as the procedure for crack control for flexure in prestressed beams specified in Clause 8.6.2.1 of AS 5100.5.

Maximum allowable compressive stress = $0.4\ f'_c$.

In addition, stress limitations specified in Clause 8.6.2.3 of AS 5100.5 shall be complied.

The effect of longitudinal restraints (such as thermal, creep and shrinkage) shall be included using the load combination factors specified in AS 5100.2, for the calculation of all the above compressive and tensile stresses.

(e) Debonding of Strands

Sufficient number of strands shall be debonded in order to achieve stress limitations described in (c).

However ultimate capacity shall be satisfied at location of debonded cross sections.

(f) Ultimate Capacity

The ultimate capacity of the deck unit shall be determined in accordance with AS 5100.5.

9. Design and Detailing of Lifting Anchors

Lifting anchors shall be designed for the following criteria:

Mould adhesion = 1.00 kPa

Minimum dynamic Load Factor = $(1 + \alpha) = 1.50$, where α is dynamic load allowance.

Higher dynamic load factors as stated in the table below shall be used where applicable and included on the drawings:

Dynamic Load Factor	Lifting Situation (Refer Note above)
1.7	Lifting with a crawler crane travelling with load suspended on an even surface
2.0	Lifting with a rubber tyred mobile crane either stationary or travelling with the load suspended on an even surface

The minimum factor of safety (FoS) for the design of lifting points for both lifting anchor and concrete pullout capacity shall be 4.0.

Working load limit (WLL) of anchor shall be calculated as R_u/FoS, where R_u is the critical characteristic load of the anchor.

All deck units shall have 4 lifting anchors per unit (two near each end). A load equalisation device is required to share load between the lifting anchors in each end of the unit.

Refer to relevant TMR standard deck unit drawings for details of lifting anchors and lifting diagram for each particular deck unit length.

TMR approved proprietary lifting anchors shall be used.

10. Detailing of Reinforcement and Strands

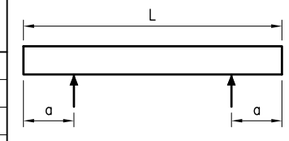
Particular attention is drawn to AS 5100.5 Clauses 8.3.1.3 and 8.3.1.4 for the detailing of reinforcement and strands, as appropriate.

11. Transport and Storage of Units

Designers shall ensure that allowable concrete stresses are not exceeded during transportation and storage, when unit is subjected to a loading of 1.5 times self weight of the units and supported as shown in the table below.

Provide additional reinforcing steel as required.

Unit Type	Nominal Length ★ L (m)	Maximum Overhang ★ a (m)
596mm wide deck units	≤ 13	L/8
	> 13 to < 15	1.3
	≥ 15 to ≤ 16	1.2
	≤ 17	1.0



★ Measured along centreline of deck unit

Refer to Drawing 1 for Design Assumptions in respect of:

1. Bridge Geometry
2. Skew Angle
3. General Arrangement of Deck Units
4. Design Parameters
5. Prestress Losses
6. Hog Calculation
7. Structural Analysis

Department of Transport and Main Roads

PRECAST UNITS

DESIGN ASSUMPTIONS FOR TRANSVERSELY STRESSED STANDARD DECK UNITS
DRAWING 2 OF 2

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