**Technical Note 18**

# Design Criteria for Motor Grids

**November 2019**

Queensland Government

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## Contents

# 1 Purpose

The purpose of this technical note is to address the design criteria for motor grids to the requirements of the Department of Transport and Main Roads.

# 2 Referenced documents

## *2.1 Australian Standards*

Table 2.1 is a list of Australian Standards referenced in this technical document.

***Table 2.1 – Referenced Australian Standards***

| Reference | Title |
|---|---|
| AS 1214 – (2016) | *Hot-dip Galvanized Coatings on Threaded Fasteners (ISO Metric Coarse Thread Series)* |
| AS/NZS 1554 Part 1 – (2014) | *Structural Steel Welding: Welding of Steel Structures* |
| AS/NZS 1597 Part2 – (2013) | *Precast Reinforced Concrete Box Culverts: Large Culverts (exceeding 1200 mm span or 1200 mm height and up to and including 4200 mm span and 4200 mm height)* |
| AS 3600 – (2018) | *Concrete Structures* |
| AS/NZS 4680 – (2006) | *Hot-dip Galvanized (Zinc) Coatings on Fabricated Ferrous Articles* |
| AS 5100 (All parts) – (2017) | *Bridge Design* |

## *2.2 Transport and Main Roads Technical Specifications*

Table 2.2 is a list of the department's technical specifications and manuals referenced in this technical document.

***Table 2.2 – Referenced Transport and Main Roads Technical Standards***

| Reference | Title |
|---|---|
| MRTS70 | *Concrete* |
| MRTS71 | *Reinforcing Steel* |
| MRTS72 | *Manufacture of Precast Concrete Elements* |
| MRTS78 | *Fabrication of Structural Steelwork* |
| Manual | *Design Criteria for Bridges and Other Structures* |
| Manual | *Product Index for Bridges and Other Structures* |
| Manual | *Proprietary Design Index for Bridges and Other Structures* |
| Manual | *Registered suppliers: Precast Concrete* |
| Manual | *Registered suppliers: Steel Fabrication* |

## *2.3 Transport and Main Roads Standard Drawings*

Table 2.3 is a list of the department's Standard Drawings referenced in this technical document.

***Table 2.3 – Referenced Transport and Main Roads Standard Drawings***

| Reference | Title |
|---|---|
| SD1561 | *Motor Grid – General Arrangement* |
| SD1562 | *Motor Grid – Cast In-situ Abutment* |
| SD1563 | *Motor Grid – Cast In-situ Base Slab* |
| SD1564 | *Motor Grid – Precast Base Slab* |
| SD1565 | *Motor Grid – Steelworks* |

# 3 Manufacture and installation of motor grids

## *3.1 Manufacture and installation of motor grids using Standard Drawings*

Motor grids shall be manufactured and installed in accordance with the Department's Standard Drawings referred in the Table 2.3. The foundation and abutment protection, such as stone pitching shown in Standard Drawing 1561 may be constructed where required, to meet the project specific requirements.

Where expansive soil is encountered, geotechnical specialist's advice shall be sought, and the standard drawings shall be modified accordingly.

## *3.2 Manufacture of motor grids using alternative designs*

Alternative proprietary motor grids that are not in accordance with the Department's Standard Drawings referred in Table 2.3 shall be designed in accordance with this technical note.

Alternative motor grid designs shall be submitted to the Director (Structures Design Review and Standards) for review and acceptance via email to: tmr.techdocs@tmr.qld.gov.au.

If a submission is not suitable for emailing, mail it to the Director (Structures Design Review and Standards) for review and approval:

Department of Transport and Main Roads

Engineering & Technology

Structures (Structures Design Review and Standards)

GPO Box 1412

Brisbane City Qld 4000.

Proprietary motor grids shall be registered with the Department. The Department registered motor grid products and suppliers are listed in the department's *Proprietary Design Index for Bridges and Other Structures*.

The current *Proprietary Design Index for Bridges and Other Structures* document and the lists of the Department registered precasters and steel fabricators are published on the department's web site at: www.tmr.qld.gov.au and search for: Approved products and suppliers > Bridges and other structures.

# 4 Design loads

## *4.1 Vertical traffic loads*

The motor grids shall be designed to the traffic loads as specified in AS 5100.2. The design shall allow for the worst effects of W80 wheel load, A160 axle load, S1600 stationary traffic load, M1600 moving traffic load and HLP400.

Design actions with dynamic load allowance equal to (1 + a), where a = 1 applies to a single axle or a wheel load on one design lane because impact of one wheel or one axle is more severe than an entire vehicle on the structure. All other cases, dynamic load allowance shall be in accordance with AS 5100.2.

Load factors shall be as defined in AS 5100.2.

## *4.2 Longitudinal traffic loads*

The motor grid shall be designed to resist longitudinal loads in the direction of traffic. Transvers RHS rail sections shall be designed to resist longitudinal traffic loads by providing stiffeners arranged, sized and welded as per Transport and Main Roads Standard Drawing 1565.

## *4.3 Horizontal earth pressure*

The earth pressure shall be determined in accordance with Clause 3.3.3 and 3.3.4 of AS 1597.2.

### 4.3.1 Surcharge loads from road traffic loads

Live load surcharge shall be determined in accordance with Clause 14.2 of AS 5100.2. Construction surcharge shall be 2.5 kPa minimum.

## *4.4 Fatigue loading*

Motor grids are subject to fatigue loading. Motor grids are generally installed on roads with low volume of traffic but may have high percentage of heavy vehicles. Therefore, for fatigue design, 300 AADT with 40% heavy vehicle will suffice. For special circumstances, actual traffic data shall be used.

## *4.5 Differential settlement of base slab foundation*

Differential settlement of the founding material beneath the concrete base slab can occur over the service life, in particular, along both roadside edges of the base slab due to erosion or insufficient protection. As a result of differential settlement, the base slab or cast-in-situ abutment loses part of its support. This results in increase in stress in concrete structure or steel grid structure.

The settlement shall be considered at various locations to allow for the worst effect in the design. This effect shall be considered in the design of the steel grid structure, concrete abutments and base slab. To simplify the calculation, weaker support springs to represent one third stiffness of the subgrade material can be used for 1 m² area for various locations in the computer model (refer Clause 6.3 for Modulus of Sub-grade Reaction).

Where expansion soil encountered, such effect shall be considered in structural design, in addition to geotechnical specialist's advice.

# 5 Geometry

Standard grid widths shall be 8.0 m, 9.0 m and 10.0 m (Refer SD1565). A prefabricated grid can be provided in two modules to allow road crossfall to be built into the grid. The joint between grid segments shall be at the road centreline or between the lanes. The grid shall be designed for either a crown or superelevated road configuration. The grids shall be either 1.9 m or 2.7 m long (refer SD1565).

Motor grids of 6.0 m wide are acceptable for single lane roads. Grids shall be designed and constructed on a five degree skew to the road centreline to reduce noise and coincident wheel impact on the grid (refer SD1565).

The maximum spacing of the transversal grid rails shall be 200 mm centres, with a rail width of about 50mm. With this spacing and rail size arrangement, the designer can investigate whether the design wheel load can be shared by two rails of the grid.

Clear distance between the grid and concrete base slab under the grid shall be minimum 300 mm and maximum 600 mm (refer SD1561 and 1563).

# 6 Structural design

## *6.1 General*

- Grids are to be designed and checked under limit states to AS 5100.
- Minimum design life for motor grids shall be 50 years.
- Exposure classification and cover to reinforcement shall be to AS 3600.
- Minimum exposure classification shall be B1 to AS 3600.
- Minimum concrete strength for B1 exposure classification shall be N32/20 to MRTS70 *Concrete*.
- Minimum concrete strength for B2 exposure classification shall be S40/20 to MRTS70 *Concrete*.
- Minimum concrete strength for higher exposure classifications than B2 shall be in accordance with AS 3600, and grade 'S' concrete in accordance with MRTS70 *Concrete*.
- Notes on the project drawings shall include all design criteria and relevant departmental Standards, Codes and Specifications.
- The design and drawings shall be certified by a Registered Professional Engineer, Queensland (RPEQ), reviewed and accepted by Transport and Main Roads.
- Steel grids shall be analysed based on linear elastic assumptions. Non-linear analysis is not accepted as a primary analysis method.
- Railway rails are not permitted for use on new motor grid.

## *6.2 Cast in-situ reinforced concrete abutments*

Abutments (refer SD1562) shall be designed to withstand loads from road traffic vehicles including braking loads on the grid, lateral earth pressure and traffic surcharge loads on the back of the abutment. It can be assumed that the lateral loads due to braking loads and traffic surcharge are shared between two abutments if effective load transfer between the grid and each abutment is provided. Abutment stability shall be checked with maximum traffic load reactions on the abutment with lateral earth pressure on the back of the abutment.

Abutment stability and foundation bearing pressure without the grid installed on the abutments shall also be checked for staged construction loads. Backfilling behind the abutment before placing the grid is permitted if the abutment stability or movement for construction loads is satisfactory. Lateral earth pressure plus construction surcharge load of 2.5 kPa minimum on the back of abutment shall be used for the staged construction check.

The design bearing pressure under the abutment base shall not exceed 150 kPa. The design bearing pressure shall be specified in the detailed design drawings. The abutments shall be constructed on minimum 500 mm thick sub-grade (fill or existing, non-expansive soil) with a minimum soaked CBR of 15% unless the actual bearing capacity of founding material is assessed and certified by an experienced RPEQ (geotechnical).

A reinforced concrete slab (non-structural) 130 mm minimum thick shall be constructed to cover the remaining area below the steel grid between the abutments. This slab shall be reinforced with SL82 welded steel mesh or equivalent.

### *6.3 Precast concrete abutments on a reinforced concrete base slab*

Where precast abutments are supported on a reinforced concrete base slab (load bearing), the base slab consists of either a cast in-situ reinforced concrete slab over the entire grid footprint or precast concrete slab panels over the entire grid footprint (refer SD1562 and 1563).

If precast base slab panels are used, the joints between panels are only parallel to the direction of the traffic. Each panel shall be continuous in the traffic direction from one abutment to another without any transversal joint.

The size of the precast components shall be selected to meet the lifting limitations.

The joints of precast abutment segments and the joints of the precast base slab panels shall be staggered to provide interlocking effect and better load transfer. Maximum gap between the precast sections of either slab panels or abutments shall be 20 mm. Any such gap shall be filled with approved low shrinkage cementitious mortar.

Precast abutments for single lane roads shall be a single precast section.

Stability of the precast abutments shall also be checked for stage construction loadings as stated in Section 6.2 of this document as appropriate.

Cast in-situ base slab for precast abutments shall be constructed with a minimum 70 mm high nib cast on to the base slab for the entire length of the abutment at the internal face of the abutment to resist possible lateral movement of the abutment. The gap between the abutment and the nib shall be filled with the 20 mm thick mortar.

Precast base slabs for precast abutments shall have dowelled anchor connections between the abutment and base slab to avoid the differential settlement between the slab panels. The nib on the base slab shall be constructed as per the cast in-situ slab arrangement. At least one anchor shall be installed per each slab panel.

The precast abutments shall be installed on a nominal 20 mm thick fresh levelling mortar.

The reinforced concrete base slab shall have a minimum thickness of 200 mm. Required slab thickness shall be determined depending on exposure classification, concrete grade, minimum reinforcement cover, foundation stiffness and structural capacity requirements.

The base slab shall be designed for the total loads including the transferred from the precast abutments and the steel grid.

Base slab shall be analysed as supported on an elastic foundation. The structural capacity of the slab shall be checked in accordance with AS 5100. The slab bearing reaction of the sub-grade shall be considered under both static load and full dynamic load as the modulus of sub-grade reaction varies considerably for these two cases.

For static loading

- Wheel load located in the central portion of the grid
- No impact
- Modulus of Sub-grade Reaction 40 kPa/mm shall be used for structural modelling

For dynamic loading

- Wheel load located anywhere on the grid
- 100% impact
- Modulus of Sub-grade Reaction 200 kPa/mm shall be used for structural modelling
- Allowable deflection for the base slab shall be 2 mm

The design bearing pressure under the base slab shall not exceed 100 kPa. The design bearing pressure shall be specified in the detail drawings. The concrete slab shall be constructed on minimum 500 mm thick sub-grade (fill or existing, non-expansive soil) with a minimum soaked CBR of 10% unless otherwise actual bearing capacity of founding material is assessed by an experienced RPEQ (geotechnical).

Base slab reinforcement shall be designed for crack control as required in Clause 9.4.3 of AS 5100.

## 7 Corrosion protection to structural steelwork

All exposed steelwork including holding down bolts shall be hot-dipped galvanised in accordance with AS 1214 or AS 4680 as appropriate.

## 8 Casting and fabrication

All precast concrete components associated with motor grids shall be manufactured by the department registered precasters in accordance with MRTS72 *Manufacture of Precast Concrete Elements*. All structural steelworks associated with motor grids shall be fabricated by the department registered steel fabricators in accordance with MRTS78 *Fabrication of Structural Steelwork*.

The following standards are applied. Refer also to departmental Standard Drawings SD1561 to 1565 for general notes and associated Technical Specifications and Standards.

- Concrete shall conform to MRTS70 *Concrete*.
- Reinforcing steel shall conform to MRTS71 *Reinforcing Steel*.
- Manufacture of precast concrete elements shall be in accordance with MRTS72 *Manufacture of Precast Concrete Elements*.
- Structural steelwork shall be in accordance with MRTS78 *Fabrication of Structural Steelwork*.
- Welding shall be in accordance with AS 1554.1.
- Hot dipped galvanising shall be in accordance with AS/NZS 4680.