Technical Specification

Transport and Main Roads Specifications
MRTS15 Noise Fences

July 2018

Queensland Government

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

Contents

1 Introduction

This Technical Specification applies to the design and construction of noise fences.

This Technical Specification shall be read in conjunction with MRTS01 *Introduction to Technical Specifications*, MRTS50 *Specific Quality System Requirements* and other Technical Specifications as appropriate.

This Technical Specification forms part of the Transport and Main Roads Specifications Manual.

2 Definition of terms

The terms used in this Technical Specification are as defined in Clause 2 of MRTS01 *Introduction to Technical Specifications*.

3 Referenced documents

Table 3 lists documents referenced in this Technical Specification.

Table 3 – Referenced documents

Reference	Title
AS 1111.1	*ISO metric hexagon bolts and screws – Product Grade C – Bolts*
AS 1112.3	*ISO metric hexagon nuts – Product Grade C*
AS 1237.1	*Plain washers for metric bolts, screws and nuts for general purposes - General plan*
AS 1237.2	*Tolerances for fasteners - Washers for bolts, screws and nuts - Product grades A, C and F*
AS 1288	*Glass in buildings – Selection and installation*
AS 1366.2	*Rigid cellular plastics sheets for thermal insulation – Part 2: Rigid cellular polyisocyanurate (RC/PIR)*
AS 1366.3	*Rigid cellular plastics sheets for thermal insulation – Part 3: Rigid cellular polystyrene - Moulded (RC/PS-M)*
AS 1397	*Continuous hot-dip metallic coated steel sheet and strip – Coatings of Zinc and zinc alloyed with aluminium and magnesium*
AS 1720.1	*Timber Structures – Design Methods*
AS 1874	Aluminium and aluminium alloys – Ingots and castings
AS 2334	*Steel nails - Metric series*
AS 2858	*Timber - Softwood - Visually stress-graded for structural purposes*
AS 3566.1	*Self-drilling screws for the building and construction industries – General requirements and mechanical properties*
AS 3600	*Concrete structures*
AS 3700	*Masonry structures*
AS 4100	*Steel structures*
AS 4506	*Metal finishing – Thermoset powder coatings*
AS 5604	*Timber – Natural durability ratings*
AS ISO 11654	*Acoustics – Rating of sound absorption – Materials and systems*
AS/NZS 1170.0	*Structural design actions – General principles*

Reference	Title
AS/NZS 1170.2	*Structural design actions - Wind actions*
AS/NZS 1214	*Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)*
AS/NZS 1252.1	*High strength steel fastener assemblies for structural engineering – Bolts, nuts and washers – Part 1: Technical requirements*
AS/NZS 1580.601.1	*Paints and related materials - Methods of test - Colour - Visual comparison*
AS/NZS 1594	*Hot-rolled steel flat products*
AS/NZS 1604.1	*Specification for preservative treatment – Sawn and round timber*
AS/NZS 1604.3	*Specification for preservative treatment - Plywood*
AS/NZS 1605.2	*Methods for sampling and analysing timber preservatives and preservative-treated timber – Determination of preservative penetration by spot tests*
AS/NZS 1664.1	*Aluminium structures – Limit state design*
AS/NZS 1734	*Aluminium and aluminium alloys – Flat sheet, coiled sheet and plate*
AS/NZS 1748.1	*Timber – Solid - Stress-graded for structural purposes – General requirements*
AS/NZS 1866	*Aluminium and aluminium alloys – Extruded rod, bar, solid and hollow shapes*
AS/NZS 1867	*Aluminium and aluminium alloys – Drawn tubes*
AS/NZS 2208	*Safety glazing materials in buildings*
AS/NZS 2269.0	*Plywood – Structural – Specifications*
AS/NZS 2908.2	*Cellulose-cement products – Flat sheet*
AS/NZS 3845.1	*Road Safety Barrier Systems and Devices - Road Safety Barrier Systems*
AS/NZS 4455.1	*Masonry units, pavers, flags and segmental retaining wall units – Masonry units*
AS/NZS 4600	*Cold-formed steel structures*
AS/NZS 4672.1	*Steel prestressing materials – General requirements*
AS/NZS 4680	*Hot-dip galvanized (zinc) coatings on fabricated ferrous articles*
AS/NZS ISO 717.1	*Acoustics – Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation*
AS/NZS ISO 9001	*Quality management systems - Requirements*
ASTM C158 - 02	*Standard Test Methods for Strength of Glass by Flexure (Determination of Modulus of Rupture)*
ASTM E111 - 04	*Standard Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus*
ASTM E424 - 71	*Standard Test Methods for Solar Energy Transmittance and Reflectance (Terrestrial) of Sheet Materials*
Broms Theory	Broms, B. B. "*Lateral Resistance of Piles in Cohesive and Cohesionless Soils*". ASCE Journal of the Soil Mechanics and Foundations Division 90, No. SM2 and SM3,1964
I.S. EN 1794-2	*Road Traffic Noise reducing devices – Non-acoustic performance, Part 2: General safety and Environmental Requirements*

Reference	Title
I.S. EN 1999-1-4	*Eurocode 9 - Design of Aluminium structures – Part 1 – 4: Cold-formed structural sheeting*
I.S. EN ISO 178	*Plastics – Determination of flexural properties*
I.S. EN ISO 527-2	*Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics*
I.S. EN ISO 4892-1	*Plastics – Methods of Exposure to Laboratory Light Sources – Part 1: General Guidance*
I.S. EN ISO 4892-3	*Plastics – Methods of Exposure to Laboratory Light Sources – Part 3: Fluorescent UV Lamps*
I.S. EN ISO 7823-1	*Plastics – Poly(methyl methacrylate) sheets – Types, dimensions and characteristics – Part 1: Cast Sheets*
I.S. EN ISO 7823-2	*Plastics – Poly(methyl methacrylate) sheets – Types, dimensions and characteristics – Part 2: Extruded Sheets*
I.S. EN ISO 11963	*Plastics – Polycarbonate Sheets – Types, dimensions and characteristics*
I.S. EN ISO 13468-2	*Plastics – Determination of the total luminous transmittance of transparent materials – Part 2: Double–beam instrument*
MRTS01	*Introduction to Technical Specifications*
MRTS03	*Drainage, Retaining Structures and Protective Treatments*
MRTS04	*General Earthworks*
MRTS50	*Specific Quality System Requirements*
MRTS70	*Concrete*
MRTS71	*Reinforcing Steel*
MRTS72	*Manufacture of Precast Concrete Elements*
MRTS73	*Manufacture of Prestressed Concrete Members and Stressing Units*
MRTS78	*Fabrication of Structural Steelwork*
MRTS78A	*Fabrication of Structural Stainless Steelwork*
MRTS79	*Fabrication of Aluminium Components*
MRTS88	*Protective Coating for New Work*
SD1602	*Fencing - Chainwire fences and gates*
SD1608	*Noise Fences – Structural Detail –Universal Beam Posts, Concrete Panels, Steel panels*
-	*Design Criteria for Bridges and Other Structures,* Transport and Main Roads
-	*Drafting and Design Presentation Standards Manual,* Transport and Main Roads
-	*Geotechnical Design Standard – Minimum Requirements,* Transport and Main Roads
-	*Standard Drawings Roads Manual,* Transport and Main Roads
-	*Transport Noise Management Code of Practice; Volume 1 – Road Traffic Noise,* Transport and Main Roads

4 Quality system requirements

General requirements for Hold Points, Witness Points and Milestones are specified in Clause 5.2 of MRTS01 *Introduction to Technical Specifications*.

The Hold Points, Witness Points and Milestones applicable to this Technical Specification are summarised in Table 4.

Table 4 – Hold Points, Witness Points and Milestones

Clause	Hold Point	Witness Point	Milestone
6.2	1. Permission to use noise fence design		Submission of design
6.6.3.1	2. Impact resistance		
7.2	3. Clearing and trimming of trees		
7.4	4. Treatment of cut plywood		
7.6		1. Excavation of footings	
7.18			Submission of construction certificate
8.1	5. Submission of certificate of noise fence construction materials		

5 Registered proprietary products and services

Transport and Main Roads maintains a register of pre-approved proprietary products for noise fences.

The requirements for noise fence construction for the items listed in Table 5 include the use of Transport and Main Roads registered products and suppliers.

Table 5 – Items requiring use of Transport and Main Roads registered products and suppliers

Clause	Product Type
6.8, 6.10, 6.11, 6.12, 6.13, 6.14	Panels (Plywood, Concrete, Composite, Steel, Aluminium, Transparent)
6.16	Acoustic seal
6.17	Paints
7.4	Preservative treatment of cut plywood above ground

Registered products and suppliers are listed in Clause 1 of Annexure MRTS15.1.

Noise fences other than private third party noise fences shall be designed and constructed by a company who is registered with the Department of Transport and Main Roads.

For information regarding approved products and suppliers for above items, the panel approval procedures and the registration of design and construction companies refer to the '*Approved products and registered suppliers*' on the Transport and Main Roads website www.tmr.qld.gov.au/business-industry/Business-with-us/Approved-products-and-suppliers/Traffic-engineering-and-road-safety-approved-products.aspx

6 Design

6.1 General

A standard noise fence consists of posts connected by replaceable panels whose length and thickness are standardised and generally based in the earthworks on individual foundations in the form of bored piles or spread footing. It does not impede natural drainage flow paths. If the noise fence interacts with engineering structures (retaining walls, bridges, road safety barriers etc.), design analysis of the supporting structures is required to account for the forces imposed by the noise fence on the engineering structures.

Typical details for noise fences are found online in *Standard Drawings Roads – Noise Fences* (www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Standard-drawings-roads/Roadworks-drainage-culverts-and-geotechnical.aspx#FencingAndNoiseBarriers).

Noise fences shall have adequate strength, durability, acoustical parameters, constructability, safety and maintenance to satisfy the requirements and intentions of the Contract and this Technical Specification, including urban and landscaping design, and be environmentally safe.

The maximum panel length of a standard noise fence shall be:

a) 5.00 m, and

b) when located on an engineering structure 2.5 m.

All parts of the noise fence shall be located within the road reserve, except a third party noise fence which shall be entirely within the property including footing.

An embedded concrete sill beam (refer Clause 7.10) adjacent to the soil will be necessary for the base units of all type of noise fences except for concrete noise fences.

Noise fences shall avoid entrapment and ponding of water, dirt and debris on or within components.

Noise fences shall be painted.

6.2 Design approval and submission

Detailed drawings shall be made to comply the requirements of roads *Drafting and Design Presentation Standards Manual* and supporting documents (including neat and comprehensive design calculations and assumptions which comply with this Technical Specification and relevant Standard Drawings and geotechnical investigation report) of the noise fences shall be submitted to the Administrator for review not less than 14 business days prior commencement of any construction work. **Milestone**

The drawings shall include but not be limited to show the following:

- alignment of the noise fence/s
- cadastral / road edge and property boundary
- existing and proposed infrastructure, drains, road safety barriers, signs, known utilities, fences and gates
- topographic data (existing and proposed) over the area of interest including the road
- height and length of noise fence, location of all footings and depths, geotechnical information of the alignment, supporting structures and the drainage requirements in longitudinal sections

- panel material selected for noise fence and the minimum thickness
- height and details of structures that interact with the noise fence in cross sections for each segment of the noise fence, and
- design wind speeds.

The design drawings and the reports shall be certified as complying with this Technical Specification by a suitably qualified Engineer experienced in the design of noise fences and holding a current registration as a Registered Professional Engineer, Queensland with RPEQ number shown on the drawings.

Construction of noise fences shall not commence until the Contractor has been granted permission to use the noise fence design. **Hold Point 1**

6.3 Acoustic requirements

6.3.1 General

There shall be no gap in any part of the noise fence unless the gap is required for surface drainage at ground level. An acoustic seal (refer Clause 6.16) shall be inserted in any gaps in noise fence units including between panels and the lower side of the panel and concrete sill beam (refer Clause 7.10). If appropriate, vertical acoustic seals shall be inserted in noise fence units.

Noise fence panels shall use either reflective or absorptive type materials, to achieve an A Weighted Sound Reduction Index (R_w) of not less than 25.0 in accordance with AS/NZS ISO 717.1.

6.3.2 Absorptive type

An absorptive type noise fence absorbs a significant percentage of sound energy when facing the road. An absorptive type noise fence can be absorptive on one or both sides of a panel.

In addition to the minimum R_w requirements in Clause 6.3.1, the following properties shall apply to absorptive type noise fences:

a) the Weighted Sound Absorption Coefficient (α_w) of the noise fence panels shall not be less than 0.8 measured in accordance with AS ISO 11654

b) the absorptive face shall be on the traffic side of the noise fenc, and

c) absorption is not required in the noise fence between 0 mm and 500 mm above the ground.

6.3.3 Reflective type

A reflective type noise fence reflects most sound energy when facing the road. Reflective type noise fence can be reflecting on both sides or absorbing one or both sides.

In addition to the minimum R_w requirements in Clause 6.3.1, reflective type noise fence panels must have a minimum surface density at air dry moisture content (excluding structural components) of 15 kg/m².

6.4 Aesthetic requirements

Noise fences shall achieve aesthetically pleasing outcomes and be visually integrated with the adjacent natural or built environments in which they are situated. Notwithstanding, the technical requirements of this Clause 6.4 shall take precedence over the design integration guidelines found in the Chapter 7 of *Transport Noise Management Code of Practice; Volume 1 - Road Traffic Noise.*

Noise fences shall prioritise having a top of fence profile line which is either horizontally level, or visually parallel to the vertical geometry of the road surface. Such outcomes are considered more visually acceptable than top of fence profiles that are predominantly stepped. Horizontal panel joints within the noise fence shall generally be at a constant height level, to present long and level horizontal lines along the noise fence. This outcome shall be achieved through combined use of the following as required:

- consistent, standard sized panels;
- variable height sill beams;
- burying the base of panels below finished ground level; and
- incorporating additional panel height above that required for noise attenuation function, to achieve the desired top of fence profile line.

To be acceptable to the Administrator, where noise fence sections are required to be stepped in height due to site constraints (for instance, very steep roadway gradients or highly variable ground surface levels within the road verge), the stepped increments between noise fence panel heights (i.e. between the top of noise fences) shall be proportional to the grade of roadway (or landform) and applied as a consistent standard throughout the entire length of the noise fence. A uniform modular approach to the stepping of noise fences is preferred and shall be a priority in lieu of a sloping top of noise fence profile. This shall be achieved as follows:

- Where proprietary panel types with a maximum standard height of 600 mm or less are used, the panel height shall be used as the stepping height, with all joints between panel rows to the full height of the noise fence, to be in the same horizontal plane, and
- For larger custom sized panel types, noise fence stepping heights shall utilise equal height increments of 200 mm (minimum step height), 400 mm or 600 mm (maximum step height).

Where distinct sections of noise fences of significantly differing heights (as determined for noise attenuation requirements) abut each other, a minimum 100 m transition zone shall be provided around the interface of the noise fence sections, applying the stepping requirements specified above. Localised peaks and troughs less than 100 m in length to the top of noise fence profile shall be avoided, with the preferred horizontal top of noise fence profile maximised to the longest noise fence lengths practicable.

Transparent materials shall be considered for the uppermost sections of noise fences taller than 4.0 m to reduce the overall visual height and impact of the noise fences.

Transparent materials shall be used where noise fences impact upon the retention of views from the roadway to adjacent environmental features of high visual amenity, as determined by the Administrator.

The terminal ends of noise fences should be treated as a design feature with a higher level of design finish without compromising the acoustic requirements of the noise fence through end panel design (for instance, alternative panel widths and stepping) and or colour treatment. Consideration should be given to gradually diminishing end panels heights at a maximum gradient of 1:8 to a maximum terminal end height of 1.8 m, to promote integration with the surrounding site and landform.

6.5 Drainage requirements

The run-off and potential increased flood risk shall be assessed and appropriate drainage and flood resilience measures shall be included in design without compromising the noise fence's ability to achieve acceptable noise levels. Placement of noise fences in locations that will impede the passage of water should be avoided. Ponding of water against noise fences or discharge onto private property shall be avoided. Drainage slots (refer Clause 7.11) shall be provided as required to allow for all stormwater and surface drainage to pass under noise fences.

6.6 Structural and material requirements

6.6.1 General

Engineering structures (retaining walls, bridges, road safety barriers etc.) supporting or anchoring a noise fence shall be structurally adequate to withstand the superimposed load from the noise fence.

Retaining walls shall meet the requirements of *Geotechnical Design Standard – Minimum Requirements*, and additional requirements of the *Design Criteria for Bridges and Other Structures*. Timber retaining walls shall not be permitted in the vicinity of noise fences.

Where noise fences are installed on bridges, as far as practicable they shall be tilted away from the carriageway and the noise fences shall extend for a minimum distance of 20 m either side of the bridge abutment.

Generally noise fences on bridges shall be transparent panels.

The design shall account for the effects of both differential temperature and moisture, warping, twisting and bowing.

The noise fence in the transition area between the structure (bridge or retaining wall) and the road shall be able to accommodate movements of the structure and settlement of the structure backfill or of the embankment subsoil without damage.

Any specific material types required to be incorporated into the Contract are set out in Clause 2 of Annexure MRTS15.1.

6.6.2 Design and maintenance life

The design life of noise fences, for the purpose of strength, serviceability and stability calculations shall be 40 years. The design life for any connections to bridge and retaining walls shall be 100 years. The minimal maintenance-free life of the main construction materials other than protective coating shall be 25 years.

6.6.3 Vandal resistance

6.6.3.1 Impact resistance

Noise fence panels shall be able to withstand the impact of a 4 kg steel ball dropped from a height of 3 metres when the panel is supported at its edges horizontally above the ground.

The impact shall cause only superficial scratches and marks on the panel. The depth of permanent deformation considered to be acceptable is 4 mm within a circle of 20 mm diameter.

The testing shall be performed in the presence of the Administrator. **Hold Point 2**

6.6.3.2 Resistance to being defaced

Noise fences shall be resistant to defacing by sharp implements (e.g. a knife).

6.6.4 Fire

On ignition by cigarettes or similar, flames must not spread easily. When burned, noise fences should not emit any noxious fumes or leachates in environmentally dangerous concentrations.

The required fire resistance shall be estimated based on the surrounding facilities and considering the amount of risk in accordance with the requirements of Appendix A of I.S. EN 1794-2 minimum Class 2 or equivalent Standard.

6.6.5 Vehicle impact and traffic safety

Noise fences are not required to withstand vehicle impact. Vehicle impacts may be prevented either by a suitable road safety barrier system or by providing adequate distance from the road. Where neither of these options is available, a combined noise fence and road safety barrier system which fulfils all the requirements for road safety barrier in a given containment class as defined in AS/NZS 3845.1 shall be considered.

Noise fences installed on bridges, retaining walls and similar exposed positions over or immediately next to public traffic shall be fitted with additional securing measures to protect them against falling onto the traffic.

6.6.6 Light reflection and transparency

The surfaces of the noise fence shall not produce excessive glare from incident light. Light Reflection and transparency shall conform to the requirements of Appendix E and F of I.S. EN 1794–2.

6.6.7 Robustness

Noise fence panels shall not become detached from their supports or fixings both in the horizontal and vertical planes when subjected to a combination of the ultimate wind load and the most unfavourable combination of the allowable tolerances on the manufacture of panels and construction of a noise fence.

Noise fences shall not rattle in any breeze or wind. A durable material shall be placed between all components so that no audible noise emanates from the noise fences.

The bottom of the noise fence panel shall be restrained from bowing and warping due to temperature, differential temperature and differential moisture.

6.6.8 Self-weight

Where panels are stacked vertically, the underlying panel shall not deform when exposed to a load of 1.35 times of the overlaying self-weight of the panels.

6.6.9 Wind loading

Design loads on noise fences shall be in accordance with AS/NZS 1170.2, unless modified below:

a) Regional wind speeds shall be based on Table 3.1 of AS/NZS 1170.2 using the following average recurrence intervals (ARI)

   i. ultimate – 1000 year ARI, and

   ii. serviceability – 20 year ARI

b) Region B or C as defined in Clause 3.1 of Annexure MRTS15.1. Region B shall be used where no region is specified. Region A of AS/NZS 1170.2 shall be defined as Region B for the purpose of this Technical Specification

c)	Terrain Category	Refer to Clause 3.2 of Annexure MRTS15.1
d)	Shielding Multiplier - M_s	1.0
e)	Topographic Multiplier - M_t	Refer to Clause 3.3 of Annexure MRTS15.1
f)	Terrain / Height Multiplier - $M_{z,cat}$	Refer to Clause 3.4 of Annexure MRTS15.1.
g)	Net Pressure Coefficient - $C_{p,n}$	Appropriate value from Table D2 of AS/NZS 1170.2 on end panels (i.e. 0 to 2h) and internal panels.

Where noise fences are within 4 metres of the road edge line, the design shall include an additional load of 0.65 kPa representing dynamic suction imposed by moving vehicles for serviceability wind. For noise fences greater than 4.0 m high, the suction load shall only be applied to the lower 4.0 m.

6.6.10 Load combinations

Where the noise fence is required to retain earth fill, the minimum live load surcharge shall be 5 kPa.

6.7 Steel posts

6.7.1 General

Steel posts shall comply with the requirements stated in Clauses 6.7.1 to 6.7.6, inclusive.

6.7.2 Materials

Materials used in the manufacture of steel posts shall be in accordance with those of materials referenced in AS 4100 and the minimum wall thickness shall be 4 mm.

All mild steel components shall be hot–dip galvanised after fabrication in accordance with the requirements of AS/NZS 4680 with an average coating mass of 600 g/m².

Generally the 180 range of Universal Beam section shall be used a convenient means of supporting noise fence panels.

The fence label and post number shall be identified by welding on the fence post or other method approved by the Administrator.

6.7.3 Fabrication of steel posts

All fabrication shall be in accordance with the requirements of MRTS78 *Fabrication of Structural Steelwork*.

6.7.4 Serviceability design

The horizontal deflection of the post under serviceability wind shall be limited to:

$$\frac{\text{Height of Fence}}{150}$$

The base of steel posts shall be located at 100 mm (nominal) from the bottom of the footing.

Post elements in contact with soil shall be provided with an additional corrosion protection system - either embed them in concrete or cover with grout layer.

Post elements in direct contact with other metals and materials causing galvanic corrosion shall be protected by an appropriate method.

Steel posts shall be restricted from coming into contact with any other corrosive material, to prevent steel corrosion.

Universal Beam section shall be securely attached top capping plate, if necessary (refer Clause 7.12).

6.7.5 Structural design

Design strength of steel components shall be in accordance with AS 4100 or AS/NZS 4600.

6.7.6 Testing and acceptance

Steel posts shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

6.8 Plywood

6.8.1 General

Plywood panels shall be preservative treated either softwood or hardwood and shall comply with the requirements stated in Clauses 6.8.1 to 6.8.7, inclusive.

Plywood panels shall conform to the requirements of reflective type noise fence in Clause 6.3.3.

Plywood panels shall be one of the Transport and Main Roads registered products (refer Clause 5).

6.8.2 Materials

6.8.2.1 Plywood

Structural plywood shall be Stress Grade F14 or better in accordance with AS/NZS 2269.0.

The grade of veneer on the face and back of panels shall be CC or better in accordance with AS/NZS 2269.0. Permitted imperfections under this grade may be left unfilled as long as they are within correct size limitations. Plywood veneers shall be as free of heart as possible.

The grade of all core veneers shall be Quality D or better in accordance with AS/NZS 2269.0.

Plywood shall be supplied kiln dried with a moisture content between 8% and 18%.

The plywood shall have a minimum thickness of 27 mm.

The bottom sheet of plywood shall be at least 450 mm high and the top sheet of plywood shall be 1200 mm high.

6.8.2.2 Battens

Structural sawn softwood shall be Stress Grade F5 or better, and either machine stress graded in accordance with AS/NZS 1748.1, or visually graded in accordance with AS 2858.

Hardwood battens shall be Durability Class 2 or better in accordance with AS 5604.

Battens shall be supplied kiln dried with a moisture content between 8% – 18%.

The batten in cross–section shall not be less than 70 x 35 mm.

A minimum of one batten (mid–span of the panel) shall be provided.

6.8.3 Manufacture of plywood panels

Manufacture of plywood panels shall be in accordance with the requirements of AS/NZS 2269.0.

The finish on both sides of the panel shall be textured wood with slimline grooves to reduce checking of the surface.

6.8.4 Serviceability design

The horizontal deflection of the panel under serviceability wind shall be limited to:

$$\frac{\text{Span of Panel}}{65}$$

Plywood panels shall incorporate a proprietary mechanical system that restricts differential movement of the panels. The system shall conform to the service life requirements of this Technical Specification. Edge joints shall have a strong polypropylene tongue and groove jointing system to help prevent warpage and eliminate gaps if movement occurs. The edge strip shall be glued to one panel to ensure that the strip does not move with vibration of the noise fence.

Top edge capping (for example, aluminium), suitably protected against corrosion shall be attached to the top of the upper panel section of noise fence.

6.8.5 Structural design

Structural design shall be in accordance with AS/NZS 2269.0 and AS 1720.1.

6.8.6 Performance requirements

The preservative treatment shall be either veneer treatment or treatment in the final form (envelope).

Plywood panels not in contact with the ground shall be treated to Hazard Level 3 (H3) as specified in AS/NZS 1604.3. Plywood panels in contact with the ground shall be treated to Hazard Level 4 (H4) as specified in AS/NZS 1604.3.

Battens shall be treated to Hazard Level 4 (H4) as specified in AS/NZS 1604.1.

For veneer treatment, each veneer shall be treated with a proprietary preservative approved under AS/NZS 1604.3. A proprietary water repellent shall be applied to all external surfaces of the plywood panel in the factory, not each veneer.

For envelope treatment, panels and battens shall be treated with a proprietary preservative approved under AS/NZS 1604.3 and AS/NZS 1604.1 respectively and with a proprietary water repellent that penetrates the plywood and battens to the same depth as the preservative.

Adequate time shall be allowed for fixation of the preservative in the plywood veneers before the panels are kiln dried.

After preservative treatment, the dimensions and shape of the plywood shall conform to AS/NZS 2269.0 criteria.

The surfaces of all plywood panels and the battens shall be free from treatment sludge deposits.

Untreated material exposed on cutting shall be treated in accordance with Clause 7.4.

On delivery all preservative treated material purporting to comply with this Technical Specification shall be branded in accordance with the requirements of AS/NZS 1604.1 for battens and AS/NZS 1604.3 for plywood.

Approved preservative treatments for timber are given in 'Approved Preservative Treatment Notification' issued by the Chief Executive under AS/NZS 1604.1 for battens and AS/NZS 1604.3 for plywood.

6.8.7 Testing and acceptance

Plywood panels shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

Plywood panels are the least preferred panel materials for noise fences despite their low cost, ease of construction, natural aesthetic appeal, and ready availability. Common problems associated with durability of panels are shrinkage, deterioration, warping, moisture content, quality control by installers (poor design and construction), and discoloration around fasteners. Panels are susceptible to fire and, if the panel is not treated properly, it will rot. The treated panels contain arsenic and, in event of a fire, can give off highly toxic fumes. Such panels shall not be used in bushfire prone areas. The above common problems negatively affect the acoustic performance, obtrusiveness, need for ongoing maintenance and the design life. Plywood panels are useful on a domestic scale, away from the road along property boundaries. For such plywood panels, noise fence height is restricted to a maximum of 2.0 m.

6.9 Masonry

6.9.1 General

Masonry walls shall comply with the requirements of stated in Clauses 6.9.1 to 6.9.5, inclusive.

Masonry walls shall be either unreinforced or reinforced masonry.

Masonry walls shall conform to the requirements of reflective type fences in Clause 6.3.3.

6.9.2 Materials

6.9.2.1 Blocks

Masonry block material shall be either burned clay, plain concrete or autoclaved aerated concrete in accordance with AS/NZS 4455.1.

6.9.2.2 Reinforcing steel

Reinforcing Steel shall be in accordance with MRTS71 *Reinforcing Steel*.

6.9.2.3 Concrete

Concrete shall be in accordance with MRTS70 *Concrete* unless specified otherwise in Clauses 6.10.2.3 and 6.10.2.4.

6.9.3 Serviceability design

The horizontal deflection of the wall under serviceability wind shall be limited to:

$$\frac{\text{Height of Wall}}{150}$$

The top of the masonry wall shall be provided with protective capping or flashing.

Masonry walls in contact with soil shall be coated with minimum 1 mm dry thickness of water based bituminous paint to the extent of the soil in contact.

6.9.4 Structural design

Design of masonry components shall be in accordance with the requirements of AS 3700.

A continuous concrete beam shall be provided at the base of all masonry walls and vertical reinforcing steel anchored into the footing.

Articulation / control joints shall be incorporated in all masonry walls at a maximum 8 m spacing.

The foundation shall be designed in such a way that cracks do not form in the area between the expansion joints.

6.9.5 Testing and acceptance

Masonry walls shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

Brick and block masonry are best used on a more domestic scale or where some detail is desired, for example where walls are in close proximity to residences or pedestrian paths. Some form of pier is usually required to provide the necessary support for the wall.

6.10 Concrete

6.10.1 General

Concrete walls and panels shall comply with the requirements stated in Clauses 6.10.1 to 6.10.9, inclusive.

Concrete panels shall be either precast concrete or prestressed concrete panels.

Concrete walls and panels shall conform to the requirements of reflective type fences in Clause 6.3.3.

Prestressed concrete panels shall be one of the Transport and Main Roads registered products (refer Clause 5).

6.10.2 Materials

6.10.2.1 Concrete

Concrete shall be in accordance with MRTS70 *Concrete* unless specified otherwise in Clause 6.10.3.

6.10.2.2 Reinforcing steel

Reinforcing Steel shall be in accordance with MRTS71 *Reinforcing Steel*.

6.10.2.3 Prestressing strand

Strand used for longitudinal stressing shall be 7-wire ordinary strand compliant with AS/NZS 4672.1.

6.10.3 Cover

The cover requirements shall conform to the requirements of AS 3600. Normal conditions shall have an exposure classification of B1.

6.10.4 Formwork removal

Formwork shall not be removed from the concrete walls until the concrete has attained 60% of the specified 28 day characteristic strength.

6.10.5 Manufacture of precast concrete panels

Manufacture of precast concrete panels shall be in accordance with MRTS72 *Manufacture of Precast Concrete Elements*.

6.10.6 Manufacture of prestressed concrete panels

Manufacture of prestressed concrete panels shall be in accordance with the relevant requirements of MRTS73 *Manufacture of Prestressed Concrete Members and Stressing Units*.

6.10.7 Serviceability design

The horizontal deflection of the panel under serviceability wind shall be limited to:

$$\frac{\text{Span of Panel}}{150}$$

Concrete walls and panels in contact with soil shall be coated with minimum 1 mm dry thickness of water based bituminous paint to the extent of the soil in contact.

6.10.8 Structural design

Concrete panels shall be designed for handling and transport loads equivalent to 50% of their self-weight in addition to self-weight.

Design of concrete components shall be by:

a) calculation in accordance with AS 3600, or

b) a recognised test method subject to acceptance by the Administrator. As a minimum, the testing shall satisfy the requirements of Appendix B of AS 3600.

6.10.9 Testing and acceptance

Concrete panels shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

Concrete has great inherent flexibility, and is therefore very suitable for noise fences. It is highly durable, weathers well and is not damaged easily. Whilst it is possible to construct concrete walls in-situ, this is not recommended due to the difficulty of ensuring quality control. Texture and pattern can be created in precast concrete panels. The disadvantage of patterned panels is, if damaged some years after initial construction, they may be difficult to replace (when using block systems).

6.11 Composite

6.11.1 General

Composite panels shall comply with the requirements stated in Clauses 6.11.1 to 6.11.6, inclusive.

Composite panels shall conform to the requirements of reflective type fences in Clause 6.3.3.

Composite panels are defined as panels having a low density and thick core bonded between two relatively thin, hard, strong and rigid faces.

Composite panels shall be one of the Transport and Main Roads registered products (refer Clause 5).

6.11.2 Materials

6.11.2.1 Faces

Facing materials shall be fibre reinforced cement flat sheet conforming to the requirements of AS/NZS 2908.2 and require acceptance by the Administrator. Hot-dip metallic coated steel sheet conforming to the requirements of AS 1397 may be attached to the inner faces, if necessary.

6.11.2.2 Core

Core material shall be either rigid cellular polyisocyanurate (RC/PIR) conforming to the requirements of AS 1366.2 and having a minimum density of 30 kg/m^3, or rigid cellular expanded polystyrene (EPS) conforming to the requirements of AS 1366.3 and having a minimum density of 11 kg/m^3.

6.11.2.3 Adhesive

Adhesive material shall be phenolic or similar material type that maintains its adhesive properties for extreme long-term exposure to Ultraviolet (UV) light or wet or damp conditions and/or long-term structural performance without glueline breakdown or glueline failure and be acceptable to the Administrator.

The bond between the face and core shall cover the whole area of the sheet.

6.11.3 Manufacture of composite panels

Manufacturers are required to demonstrate the following are in place and maintained:

- A quality system certified to AS/NZS ISO 9001 is in place and maintained. The system will be audited an Auditor acceptable to the Administrator. The Auditor shall ensure that the manufacturer is working as stated in their system requirements and the system confirms to the requirements of Transport and Main Roads.
- Technical conformance to the details shown on approved Drawings and supporting documents that are accepted by the Administrator. The technical capability shall be audited by an Auditor acceptable to the Administrator. The Auditor shall ensure that the manufacturer is able to comply with the approved Drawings and the supporting documents that are accepted by the Administrator and comply with this Technical Specification.

6.11.4 Serviceability design

The horizontal deflection of the panel under serviceability wind shall be limited to:

$$\frac{\text{Span of Panel}}{150}$$

Top and bottom edge capping (for example, aluminium), suitably protected against corrosion, shall be attached to the top of the upper and bottom section of noise fence and the vertical edges shall be protected by a system approved by the Administrator.

Capping shall be attached at top of the post (refer Clause 7.12).

6.11.5 Structural design

Composite panels shall be designed for handling and transport loads equivalent to 50% of their self-weight in addition to self-weight.

Composite panels shall incorporate a proprietary mechanical system that restricts face-sheet core delamination. The system shall conform to the service life requirements of this Technical Specification and eliminate air gaps if movement occurs.

Design of composite panel shall be by a recognised design method or a recognised accelerated proof load test method accepted by the Administrator. In addition, the testing shall satisfy the intent of Appendix B of AS 3600.

6.11.6 Testing and acceptance

Composite panels shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

This characteristic highlights the high strength and low weight advantages of composite panel their excellent design flexibility qualities provide simple to construct and cost-effective alternatives to timber panels. Composite panels are generally inert, do not rot in wet and / or moist environments and are termite proof.

6.12 Steel

6.12.1 General

Steel panels shall comply with the requirements stated in Clauses 6.12.1 to 6.12.6, inclusive.

Steel panels shall be either absorptive or reflective.

Absorptive steel panels shall conform to the requirements of absorptive type fences in Clause 6.3.2 and the reflective steel panels shall conform to the requirements of reflective type fences in Clause 6.3.3.

Steel panels shall not come in contact with the ground. A concrete sill beam, 100 mm (minimum) above the ground surface shall be provided to conform to the requirements of Clause 7.10.

Steel panels (absorptive and reflective) shall be one of the Transport and Main Roads registered products (refer Clause 5).

6.12.2 Materials

6.12.2.1 Steel

All steel components shall have a minimum thickness of 1.0 mm.

Materials used in the fabrication of both absorptive and reflective panels shall be in accordance with AS/NZS 4600.

All mild steel components shall be hot–dip galvanised after fabrication in accordance with the requirements of AS/NZS 4680 with an average coating mass of 600 g/m².

Both sides of the galvanised surface shall be “brush” blasted to reduce glare prior to erection, “Brush” blasting shall be in accordance with AS/NZS 4680.

6.12.2.2 Insulation

The sound insulation for absorptive panels shall be hydrophobic, free of materials promoting corrosion and resistant to light, weathering, salting and rotting. It consists of glass fibre or mineral wool with a minimum specific gravity of 100 kg/m³. The sound insulation shall retain dimensional stability even after ageing, and maintain its designed position.

6.12.3 Fabrication of steel panels

Fabrication of steel shall be in accordance with MRTS78 *Fabrication of Structural Steelwork*.

The sound insulation in an absorptive panel shall be placed a minimum 20 mm from front or back of the steel panel.

Hollow sections shall be ventilated.

If spacers are used to ensure back ventilation of absorptive panels, no more than 20% of the area between the sound insulating material and the closed section of the panel shall be obstructed. Sound insulation in the absorptive panel shall be covered on the absorbent side with glass fleece to protect from water, rain or road spray. Protective films shall not be used.

All water penetrating an absorptive panel shall drain off rapidly and completely. Drain water shall not be channelled into underlying units (drainage towards steel posts). Water shall not be retained in the groove and tongue system.

6.12.4 Serviceability design

The horizontal deflection of the panel under serviceability wind shall be limited to:

$$\frac{\text{Span of Panel}}{150}$$

6.12.5 Structural design

Steel panels shall incorporate a proprietary mechanical system that restricts differential movement of the panels. The system shall conform to the service life requirements of this Technical Specification and eliminate air gaps if movement occurs.

Structural design of both reflective and absorptive panels shall comply with the requirements of AS/NZS 4600.

6.12.6 Testing and acceptance

Steel panels shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

Steel is the least expensive and most common of all metals used in construction. Absorptive steel panels shall be securely attached at top of the post to avoid theft (refer Clause 7.12).

6.13 Aluminium

6.13.1 General

Aluminium panels shall comply with the requirements stated in Clauses 6.13.1 to 6.13.6, inclusive.

Aluminium panels shall be either absorptive or reflective.

Absorptive aluminium panels shall conform to the requirements of absorptive type fences in Clause 6.3.2 and reflective aluminium panels conform to the requirements of reflective type fences in Clause 6.3.3.

Aluminium panels shall not come in contact with the ground. A concrete sill beam, 100 mm (minimum) above the ground surface shall be provided to conform to the requirements of Clause 7.10.

Aluminium panels (absorptive and reflective) shall be one of the Transport and Main Roads registered products (refer Clause 5).

6.13.2 Materials

6.13.2.1 Aluminium

All aluminium components shall have a minimum thickness of 1.0 mm.

Materials used in the manufacture of absorptive and reflective panels shall be in accordance with AS/NZS 1734, AS/NZS 1866, AS/NZS 1867 and AS 1874.

Aluminium panels shall be protected against corrosion to show minimal deterioration in general appearance by means of coating with 60 µm nominal thickness of polyester powder stove enamel or polyurethane wet paint with forced oven drying in accordance with the requirements of AS 4506, or 100 µm nominal thickness of two coat of polyurethane wet paint as site coating.

6.13.2.2 Insulation

The sound insulation for absorptive panels shall be hydrophobic, free of materials promoting corrosion and resistant to light, weathering, salting and rotting. It consists of glass fibre or mineral wool with a minimum specific gravity of 100 kg/m³. The sound insulation shall retain dimensional stability even after ageing, and maintain its designed position.

6.13.3 Fabrication of aluminium panels

All fabrication shall be in accordance with MRTS79 *Fabrication of Aluminium Components*.

The sound insulation in an absorptive panel shall be placed a minimum 20 mm from front or back of the aluminium panel.

Hollow sections shall be ventilated.

If spacers are used to ensure back ventilation of absorptive panels, no more than 20% of the area between the sound insulating material and the closed section of the panel shall be obstructed. Sound insulation shall be covered on the absorbent side with glass fleece to protect from water, rain or road spray. Protective films shall not be used.

All water penetrating an absorptive panel shall drain off rapidly and completely. Drain water shall not be channelled into underlying units (drainage towards steel posts). The water shall not be retained in the groove and tongue system.

6.13.4 Serviceability design

The horizontal deflection of the panel under serviceability wind shall be limited to:

$$\frac{\text{Span of Panel}}{150}$$

Aluminium panels shall be separated from timber, concrete, steel, copper and copper alloys by means of appropriate insulating layers.

6.13.5 Structural design

Aluminium panels shall incorporate a proprietary mechanical system that restricts differential movement of the panels. The system shall conform to the service life requirements of this Technical Specification and eliminate air gaps if movement occurs.

Structural design of absorptive panels shall comply with the requirements of I.S. EN 1999-1-4.

Structural design of reflective panels shall comply with the requirements of either AS/NZS 1664.1 or I.S. EN 1999-1-4.

6.13.6 Testing and acceptance

Aluminium panels shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

Aluminium is a lightweight and high strength metal. Aluminium panel is typically coated with a bonded power or enamel paints. Aluminium panels are sometimes stolen because of the resale value. They should only be used in locations where there is low risk. Remote locations are more likely to be subject to theft than populated areas. Aluminium panels shall be securely attached at top of the post to avoid theft (refer Clause 7.12).

6.14 Transparent

6.14.1 General

The panels shall comply with the requirements stated in Clauses 6.14.1 to 6.14.5 inclusive.

Transparent panels shall be either toughened laminated safety glass or thermoplastic safety panels.

Thermoplastic safety panels shall be either acrylic or polycarbonate.

Transparent safety panels shall conform to the requirements of reflective type fences in Clause 6.3.3.

Special conditions apply to transparent noise fences:

a) in public areas to ensure they remain intact when accidentally impacted

b) on bridges and elevated structures to ensure that no dangerous shards are created if the transparent panel is impacted by an errant vehicle

c) in areas where light reflection is a potential hazard, to ensure to minimise risks resulting from possible light reflection from the transparent panels, and

d) in areas where birds frequently fly, to ensure prevention of bird collisions with the transparent panel and to ensure that such measures have no adverse effect on the performance and maintenance of the transparent panel.

Transparent safety panels shall be one of the Transport and Main Roads registered products (refer Clause 5).

6.14.2 Materials

6.14.2.1 General

Transparent panels shall be evaluated as a system consisting of panel, gasket, and restraint/support system. The source of all components for the panels, including gasket shall be specified.

Characteristic values of panel parameters may be subjected to a change due to:

- the effect of environmental degradation [Ultra Violet (UV) and chemical attack]. In the case of thermoplastic safety panels, transparency must not be visibly reduced during the useful design life. To improve resistance to environmental degradation and abrasion, they must either have added stabiliser or be surface-coated
- deformation and breakage under service conditions from impact, fire and vandalism
- variations in the manufacturing process, and
- installation damage, including weathering during storage and /or mechanical damage during installation.

Consequently, it is necessary to evaluate transparent safety panels in an "as new" condition and after accelerated ageing to the equivalent of their expected design life.

6.14.2.2 Toughened Laminated Safety Glass

Toughened Laminated Safety Glass shall conform to AS/NZS 2208 and satisfy the following criteria:

a) two or more layers of equal thickness of toughened safety glass permanently bonded together by one or more sheets of polyvinyl butyral or equivalent type interlayer with a minimum thickness of 1.52 mm, and Modulus of Elasticity of 24.1 MPa and Poisson's Ratio of 0.50 at 20ºC

b) heat soaked

c) Grade A to AS/NZS 2208

d) optical transmission and strength properties as per Table 6.14.2.2, and

e) no mottling and Colour Rating less than 2 to AS/NZS 1580.601.1 at the end of the 40 year period when exposed to weather conditions appropriate for Queensland.

Table 6.14.2.2 – Optical and strength properties of Toughened Laminated Safety Glass

Property	Testing Standard	Minimum value		
		As new	After 10 years	After 40 years
Light Transmission	ASTM E424	85%	80%	80%
Modulus of Elasticity	ASTM E111	69 GPa	69 GPa	69 GPa
Tensile Strength	ASTM C158	19 MPa	19 MPa	19 MPa
Flexural Strength	ASTM C158	140 MPa	140 MPa	140 MPa

6.14.2.3 Acrylic

Material used in the manufacture of acrylic panels shall comply with the requirements of I.S. EN ISO 7823-1 or I.S. EN ISO 7823-2 and satisfy the following criteria:

a) manufactured from 100% virgin poly methyl methacrylates (PMMA), using materials which may include up to 5% colourants, UV absorbers and pigments. Polyamide threads shall be embedded in processes for sites (a) and (b) specified in Clause 6.14.1

b) Grade A to AS/NZS 2208

c) optical transmission and strength properties as per Table 6.14.2.3, and

d) no mottling and Colour Rating less than 2 to AS/NZS 1580.601.1 at the end of the 40 year period when exposed to weather conditions appropriate for Queensland.

Table 6.14.2.3 – Optical and strength properties of acrylic

Property	Testing Standard	Minimum value		
		As new	After 10 years	After 40 years
Light Transmission	I.S. EN ISO 13468-2	90%	88%	80%
Modulus of Elasticity	I.S. EN ISO 527-2	2900 MPa	2600 MPa	2000 MPa
Tensile Strength	I.S. EN ISO 527-2	60 MPa	50 MPa	45 MPa
Flexural Strength	I.S. EN ISO 178	100 MPa	80 MPa	75 MPa

6.14.2.4 Polycarbonate

Material used in the manufacture of polycarbonate panels shall comply with the requirements of I.S. EN ISO 11963 and satisfy the following criteria:

a) manufactured from 100% bisphenol A (BPA) using phosgene free processes with colorants, additives and by both UV absorbing coating on both sides and processing aids up to a total content of 5% and continuous polymeric hard over-coat sheet adhered permanently

b) Grade A to AS/NZS 2208

c) optical transmission and strength properties as per Table 6.14.2.4, and

d) no mottling and Colour Rating less than 2 to AS/NZS 1580.601.1 at the end of the 40 year period when exposed to weather conditions appropriate for Queensland.

Table 6.14.2.4 – Optical and strength properties of polycarbonate

Property	Testing Standard	Minimum value		
		As new	After 10 years	After 40 years
Light Transmission	I.S. EN ISO 13468-2	80%	73%	50%
Modulus of Elasticity	I.S. EN ISO 527-2	2200 MPa	1800 MPa	1700 MPa
Tensile Strength	I.S. EN ISO 527-2	55 MPa	49 MPa	42 MPa
Flexural Strength	I.S. EN ISO 178	90 MPa	80 MPa	75 MPa

6.14.2.5 Gaskets

All gaskets shall be neoprene or EPDM (Ethylene Propylene Diene Monomer) with the following material properties:

a) hardness of 70°- 75° Shore ‘A’, and

b) elongation at break of 200% minimum.

6.14.3 Serviceability design

The horizontal deflection of the toughened laminated safety glass panel under serviceability wind shall be limited to:

$$\frac{\text{Span of Panel}}{80}$$

The horizontal deflection of the acrylic or polycarbonate safety panel under serviceability wind shall be limited to:

$$\frac{\text{Span of Panel}}{70}$$

However, the maximum horizontal deflection for all transparent safety panels under serviceability wind shall be 50 mm, but it shall never exceed:

a) 33 mm where the panel is more than 4 metres of pedestrian areas and the edge line of the road, or

b) 20 mm where the panel is within 4 metres of pedestrian areas and the edge line of the road.

The permanent horizontal deflection of the transparent panel under 1.5 times the ultimate wind shall be less than:

$$\frac{\text{Span of Panel}}{320}$$

6.14.4 Structural design

6.14.4.1 General

This Technical Specification applies only to flat panels supported on:

a) 4 sides, or

b) 3 sides and bent on the top side, or

c) 3 sides and no bend on the top side, or

d) 2 sides, or

e) 2 sides and bent on both top and bottom side.

Curved sheets are outside the scope of this Technical Specification.

The structural behaviour of panels is heavily influenced by the support method.

Panels shall incorporate a proprietary mechanical system that restricts differential movement of the panels. The system shall conform to the service life requirements of this Technical Specification and eliminate air gaps if movement occurs.

A minimum of 50 mm bearing on support is needed for all types of panels. If necessary, both acrylic and polycarbonate panels shall be installed in a channel frame engaging all edges.

Steel fastenings through panels shall be avoided.

6.14.4.2 Design criteria

The panel shall meet the requirements stated in Clause 6.6.7.

Structural design of toughened laminated safety glass panels shall be in accordance with AS 1288.

Structural design of acrylic or polycarbonate safety panels shall utilise a recognised design method.

6.14.5 Testing and acceptance

Transparent panels shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

The selection of suitable transparent materials involves consideration of vandalism or accidental damage, accessability by the public and probability of graffiti. Remote locations are more likely to be subject to vandalism than populated areas. Although glass possesses excellent light transmittal, resistance to chemicals, strength and ease of cleaning and tends not to accumulate static electricity which attracts dirt, it is more prone to breaking or shattering through vandalism than acrylic or polycarbonate. Both acrylic and polycarbonate can become more brittle due to the ageing process, tending to become yellow and less solid. Acrylic is stronger than polycarbonate with better light transmittal and excellent environmental stability, but it is easily scratched. Polycarbonate is the most vandal resistant transparent material available. However it is more susceptible to abrasion and becoming opalescent over time than glass or acrylic as it absorbs water, especially at exposed edges. Therefore hard coating shall be applied to polycarbonate. In the majority of applications, acrylic panels will not shatter but instead break into large dull pieces. Acrylic is more established and recommended internationally and in Australia for noise fences than polycarbonate. Many manufacturers will offer warranties for acrylic up to 30 years and polycarbonate unto 15 years.

6.15 Connectors

6.15.1 General

Connectors shall comply with the requirements stated in Clauses 6.15.1 to 6.15.5, inclusive.

6.15.2 Bolts, nuts, screws and washers

All bolts, nuts, screws and washers shall be in accordance with AS 1111.1, AS 1112.3, AS 1237.1, AS 1237.2 and AS/NZS 1252.1, as appropriate. All bolts, nuts and screws shall be hot–dip galvanised with a minimum 50 microns thickness in accordance with AS/NZS 1214. All washers shall be hot–dip galvanised in accordance with AS/NZS 4680.

All stainless steel bolts, nuts and washers shall be in accordance with Clause 7.3 of MRTS78A *Fabrication of Structural Stainless Steelwork*.

Levelling nuts under a post base plate shall be avoided if anchor bolts are used.

6.15.3 Self-drilling screws

6.15.3.1 Steel member

Screws used to connect a noise panel to steel shall be:

a) ST 6.3 (No. 14) Type CSD Point Hexagon washer head self–drilling screws, or

b) ST 6.3 (No. 14) Type ASD Point Hexagon washer head screw (self–drilling or non-self-drilling) utilising a 5.8 mm diameter pilot hole within the steel, manufactured in accordance with AS 3566.1.

Screws shall have a minimum of 40 micron hot–dip galvanising or 50 micron mechanical/chemical galvanised corrosion protection over the length of the screw.

6.15.3.2 Timber member

Screws used to connect a noise panel to timber shall be ST 6.3 (No. 14) Type 17 Point Hexagon washer head screws, manufactured in accordance with AS 3566.1 and shall have a minimum of 40 micron hot–dip galvanising or 50 micron mechanical/chemical galvanised corrosion protection over the length of the screw. Washers for screws shall be moulded with EPDM Polymer.

6.15.4 Structural design

All connections shall be designed to adequately secure all members for the design loading.

6.15.5 Testing and acceptance

Connectors shall be tested as stated in Clause 8. Acceptance shall be as stated in Clause 8.

6.16 Acoustic seal

Acoustic seals shall be composed of durable inert materials resistant to atmospheric attack, which will maintain joint thickness within design requirements.

Horizontal acoustic seals shall be one of the Transport and Main Roads registered products (refer Clause 5).

Vertical acoustic seals shall be filled by open cell polyethylene or polyurethane foam strip or similar material.

6.17 Paints

Paint shall be in accordance with the requirements of MRTS88 *Protective Coating for New Work*.

The painting system shall protect the panel surfaces from atmospheric corrosion, weathering, and exposure to Ultra Violet (UV) colour degradation, and be suitable for application to mask graffiti.

Painting shall be in such a way that the colour changes as little as possible due to weather or Ultra Violet (UV) light and under no circumstances is mottling to appear during the guarantee period.

The painting system shall give a minimum coating life of 15 years.

Generally anti-graffiti paint is not required, except where specified.

Unless specified otherwise in drawing or in Annexure, the colour shall be either Yellow (Paperbark) or Grey (Dune) for urban background, and Green (Wilderness) or Monument (Black) for vegetative background from the Colourbond® range of colours.

6.18 Footings

6.18.1 General

Footings shall preferably be circular bored pile, depending on the properties of the subsoil and whether they are located on flat or sloping ground or earthmound. Spread footings are allowed if circumstances render drilling impractical.

Footings shall comply with the requirements stated in Clauses 6.18.1 to 6.18.5 inclusive.

The footing of any noise fence located on a property boundary shall be desirably be located completely outside the abutting property.

Posts on earth mounds or on batters shall have a 1.0 m minimum berm between the posts and the top of batter to provide for footing protection, prevention of gaps below the noise fence, and access for

construction and maintenance. Spread footing shall not be located closer than 1.5 m from the edge of the batter.

Footings shall be designed for both ultimate and serviceability limit states based on site-specific geotechnical investigation parameters. Serviceability limit deflection requirements shall meet the specified deflection tolerance limits of Table 7.14.

It is necessary to verify whether underground utilities and services lie within the zone of influence of the footings or piles or are liable to disturbance due to excavation or pile driving operations. If so, the safety and serviceability of the affected utilities must be analysed and a suitable bridging member designed.

All footing designs shall be certified by a Registered Professional Engineer, Queensland.

6.18.2 Materials

6.18.2.1 Concrete

Concrete in footings shall be in accordance with MRTS70 *Concrete*.

Concrete in circular bored pile footings shall be N25/20, minimum.

Concrete in spread footings shall be S32/20 minimum.

6.18.2.2 Reinforcing steel

Reinforcing steel shall be in accordance with MRTS71 *Reinforcing Steel*.

6.18.2.3 Foundation material

The design strength of the subsoil encountered during the geotechnical investigation shall be used for the footing design. Factored short-term undrained shear strength and factored effective angle of internal friction shall be considered for cohesive and cohesionless soils respectively. Both factored short-term undrained shear strength and the effective angle of friction shall be the characteristic undrained shear strength and the angle of internal friction divided by a Factor of Safety of 1.5. For both cases the characteristic shear strength and the angle of internal friction shall be the smaller of the average value over a depth equal to the proposed noise fence height or a depth equivalent to 1.5 times of the proposed noise fence height.

A design undrained shear strength of no more than 50 kPa can be assumed for engineered fill subject to acceptance by the Administrator.

6.18.3 Cover

Concrete cover shall be in accordance with AS 3600.

A minimum of 45 mm concrete cover shall be provided from the edge of the footing to the post.

6.18.4 Circular footings

6.18.4.1 General

The details of the proposed footing locations and depths shall be included on the drawings.

The minimum diameter of a circular footing shall be 450 mm.

The depth of footings shall be not less than the larger of 1.5 times the footing diameter and 1500 mm.

6.18.4.2 Footing depth on flat terrain

The acceptable method for estimation of ultimate lateral capacity of minimum footing depth design is based on *Broms Theory*.

Estimation of the serviceability lateral deflection of footing is based on the subgrade reaction approach, elastic continuum approach or alternative methods accepted by the Administrator.

6.18.4.3 Footing depth on batters

For batters, where the noise fence is less than 4.0 metres high and the post is within five times the footing diameter of the batter point, the depth of footing on flat terrain shall be adjusted for the effect of the batter in accordance with Table 6.18.4.3. These factors may be changed where a detailed geotechnical assessment has been undertaken.

If the noise fence is greater than 4.0 metres high geotechnical assessment will be required.

All noise fence footing designs shall be certified by a Registered Professional Engineer, Queensland.

Table 6.18.4.3 – Adjustment factors for footing on batters

Slope of Batter (V:H)	Footing Depth for well compacted embankment
Flat – 1:5	As for flat ground
1:5 – 1:3	1.25 x footing depth for flat ground
1:3 – 1:2	1.5 x footing depth for flat ground
> 1:2	Specialist design required

6.18.5 Spread footings

The details of the proposed locations and dimensions of the spread footing shall be included in the drawings.

Spread footings shall be designed to prevent instability in overturning, sliding and uplift in accordance with AS/NZS 1170.0 Ultimate loads and a maximum bearing pressure of 100 kPa under serviceability wind load shall be assumed.

Design of concrete components shall be in accordance with AS 3600.

7 Construction

7.1 General

Noise fences shall be constructed in accordance with the details shown on the approved drawings and this Technical Specification. Construction of the noise fence/s shall ensure that the design requirements are met.

The noise fence shall be vertical and continuous with no visible air gap between components.

7.2 Clearing and trimming of trees

Clearing and trimming of trees and disturbance to surrounding ground are to be minimised. Clearing will comprise the orderly removal or trimming of all trees, plants and shrubs that would prevent normal construction of the noise fence. Disturbed areas shall be reinstated to a condition at least equivalent to the existing before the construction. No clearing or trimming of trees shall be carried out unless detailed in the drawing. **Hold Point 3**

7.3 Disposal of treated timber waste

All treated timber or plywood off–cuts/waste shall be removed from Site daily and disposed of as per local government requirements. Treated timber or plywood shall not be burnt.

7.4 Treatment of cut plywood / batten

Where an envelope treated plywood panel is cut on Site 100 mm or more from an edge of a sheet, the cut area shall be treated with one of the Transport and Main Roads registered products for preservative treatment of cut plywood (refer Clause 1 of Annexure MRTS15.1) **Hold Point 4** applied as per the manufacturer's requirements. The applied product shall be completely dry before incorporation of the panel into the noise fence.

Alternatively, the cut plywood panels shall be retreated in accordance with Clause 6.8.6.

Plywood panels in contact with the ground shall be veneer treated and such cut plywood will then not have to be retreated. Plywood panels / battens off the ground shall be treated with a product registered for preservative treatment of cut plywood.

7.5 Battens

Battens shall be fixed to the noise fence panel within five days of the panel being erected.

7.6 Footings

The Contractor shall carry out all necessary excavations for footings. **Witness Point 1**

Posts shall be set in the concrete footing truly vertical and to the dimensions shown on the drawings. The entire top of the concrete footing shall not be lower than ground level and be shaped such that water flows away from the post.

Concrete footings shall be a minimum of three days of age prior to fixing the panels.

Before placement of the concrete footing, steel posts shall be coated with minimum 1 mm dry thickness of water based bituminous paint 150 mm above and minimum 100 mm below the finish ground level.

7.7 Retaining walls

Retaining walls shown on the drawings shall be undertaken in accordance with the requirements of MRTS03 *Drainage, Retaining Structures and Protective Treatments*.

7.8 Earthmounds

Earthmounds shown on the drawings and shall be constructed in accordance with the requirements of MRTS04 *General Earthworks* and the batters shall be landscaped in order to provide erosion control.

7.9 Batter restoration

Where excavation for foundations on, or adjacent to the batter face results in some over–break of the batter face, the over–break of the batter face shall be backfilled in accordance with the requirements of MRTS04 *General Earthworks*, so that the backfill around the foundations is flush with the adjoining batter surface.

7.10 Sill beam

Any concrete sill beam shall be connected to the ground and the posts to ensure the acoustic properties and the drainage performances are not impeded. Concrete sill beam height varies with design requirements. Depending on the design requirements, the concrete sill beam shall be either plain concrete or reinforced concrete. Sill beams shall be constructed as detailed on the drawings. Typical concrete levelling sill beam is shown in SD1608 *Noise Fences – Structural Detail –Universal Beam Posts, Concrete Panels, Steel panels*.

Concrete sill beams are not necessary for concrete panel noise fences.

Concrete shall be Class N25/20, in accordance with MRTS70 *Concrete* and the reinforcing steel shall be in accordance with MRTS71 *Reinforcing Steel*.

7.11 Drainage slots

Drainage slots shall be integrated with the sill beam to ensure that the noise fence does not impede natural drainage flow paths. Drainage slots shall be constructed at low points along the noise fence, and at the minimum intervals nominated on the drawings. The internal dimensions and effective cross sectional area of the drainage slot shall not reduce the acoustic performance of the noise fence. Drainage slots shall be constructed as detailed on the drawings. A typical drainage slot is shown in SD1608 *Noise Fences – Structural Detail –Universal Beam Posts, Concrete Panels, Steel panels*

Unless detailed on the drawings, where a defined drainage path crosses under the noise fence, a minimum of two drainage slots shall be provided. The drainage slots shall be provided separately in adjoining noise fence panels. One slot shall be located directly over the drainage path, and the other slot shall be provided as close as possible in level to the first slot.

The concrete slab at drainage slots shall be finished flush with the finished ground level, and shall be shaped to suit the natural contours of the surrounding ground. Concrete shall be Class N25/20, in accordance with MRTS70 *Concrete*.

7.12 Post capping

Hot–dip galvanised mild steel plate shall be securely attached at top of the post for composite, aluminium and steel absorptive panel noise fences.

7.13 Painting

Painting shall be in accordance with the requirements of MRTS88 *Protective Coating for New Work*.

Both sides of noise fences shall be painted after installation.

7.14 Tolerances

The tolerances specified in Table 7.14 shall apply to the construction of noise fences.

Tolerances are permitted to cater for variability caused during manufacture and construction only.

Table 7.14 – Allowable tolerances

Criteria	Tolerance
Depth of footing	+ 200 mm - 0 mm
Diameter of footing	+ 150 mm - 0 mm

Criteria	Tolerance
Centre-to-centre distance between posts for panels supported between the posts	+ 10 mm - 0 mm
Thickness of plywood, concrete and composite panels	+ 5 mm - 1 mm
Thickness of steel and aluminium panels	+ 3 mm - 0 mm
Thickness of extruded toughened laminated safety glass panels	± 0.5 mm
Thickness of cast toughened laminated safety glass panels	+ 15% - 0%
Thickness of acrylic or polycarbonate panels	+ 0.5 mm
Height and span of panels	+ 20 mm - 5 mm
Warping and twisting any point on a surface of a panel	- 10 mm
Maximum out-of-verticality of posts	5 mm/metre Maximum of 10 mm
Maximum out-of-verticality of panels	2 mm/metre
Cover to reinforcement	+ 10 mm - 5 mm
Tendon exit holes and formwork end plates	± 2 mm
Tendon location along panel	± 5 mm
Horizontal alignment	± 50 mm over 3 posts
Hot-dipped galvanising	Refer to AS/NZS 4680
Bottom of clamp angle surface clearance	± 50 mm

7.15 Noise fences at property boundaries

Where an existing property boundary fence requires removal to facilitate construction of the noise fences, the Contractor shall:

a) remove and dispose of existing fences, walls, footings and other obstructions for a distance of 1 metre inside the property or lesser distance as may be possible to allow construction of the noise fence

b) backfill excavations/holes associated with work carried out in (a) above

c) perform ground surface treatment including:

   i. supplying, placing and compacting fill material in holes and localised depressions, and

   ii. adjusting the moisture content of in-situ material and compacting material below the existing ground surface

d) reinstate side fences to new noise fence including supply of any materials similar to the side fences

e) supply, erect, dismantle and remove temporary fencing

f) reinstate facilities temporarily removed to facilitate construction of the noise fence, and

g) where pools/ponds exist within property, the noise fence shall comply with the pool safety legislation.

If there is any damage to the property including gardens, pools, sheds, lawns, mulching, retaining walls, trees, shrubs, paths drainage and other fixtures and features, the property shall be reinstated to the original condition.

7.16 Temporary security fencing

Where the existing property boundary fence requires removal to facilitate construction of the noise fences, the Contractor shall liaise with property owners and occupants regarding the location of temporary fencing. The alignment of the temporary fence shall be approved by the property owners.

Temporary security fencing shall be man–proof and a minimum of 1.8 m high chain wire fencing. Materials shall be as shown on SD1602 *Fencing - Chainwire fences and gates.*

The Contractor may use "removable concrete shoes" in lieu of the permanent concrete footings shown on SD1602, provided that the temporary security fence is securely fixed in position and adequately tied down against storm damage.

Temporary fencing shall be erected prior to the removal of the existing fences or noise fences in order to maintain the security and protection of private properties and the occupants, pets or livestock. The temporary fence shall be located approximately 1 m offset inside the private property where possible. The alignment of the fence shall deviate to avoid fixed objects and trees.

A shade cloth or equivalent shall be installed on the inside face of the temporary security fence to provide visual privacy to the occupants.

The temporary fencing shall only be removed upon completion of the noise fence, or property being secured otherwise by permanent fencing. During the progress of the Works, the Contractor shall dismantle and re-erect temporary fencing as necessary to maintain the security of private properties and the occupants. On completion of the Works, all temporary fencing shall be dismantled, removed from Site and disposed of by the Contractor.

Temporary fencing shall comply with the pool safety legislation.

7.17 Removal and salvage of existing noise fence

7.17.1 Components to be salvaged

Sections and components of noise fence to be salvaged are detailed in Clause 4.1 of Annexure MRTS15.1.

7.17.2 Location of storage site

Salvaged items shall be transported to the storage site nominated in Clause 4.2 of Annexure MRTS15.1.

7.17.3 Demolition

Noise fence components that are to be removed and/or salvaged under the Contract shall be dismantled and removed with minimum damage to the components regardless of the original construction method.

Footings shall be demolished to a minimum of 0.5 m below ground level and the depression backfilled in accordance with MRTS04 *General Earthworks*. Hollow post sections shall be filled with 'lean mix' concrete.

Salvaged materials shall be directly transported to the storage site, such that no damage to the materials is incurred.

Salvaged materials shall be neatly stacked at the storage site on suitable timber packers.

The remainder of the existing noise fence including non-salvageable materials shall be demolished and disposed of in accordance with MRTS04 *General Earthworks*. Non-salvageable materials include connectors, and all miscellaneous items, e.g. acoustic seals, etc.

Any materials that have been damaged during the salvage operation shall be rejected. The Contractor shall replace or reimburse the Principal for materials damaged during salvage.

7.18 Acceptance of construction

At the end of construction, the Registered Professional Engineer, Queensland who supervised the construction shall forward a certificate to the Administrator including the “as constructed” drawings and all relevant tests records that meet the requirements of the approved drawings and this Technical Specification. **Milestone**

8 Testing and acceptance of construction materials

8.1 General acceptance requirements

Acceptance shall follow the requirements of this Technical Specification and the relevant Australian Standards or when such requirements in Australian Standards is unavailable, International Standards, European Standards or American Standards.

At least twenty business days before the supply of noise fence materials, a certification of construction materials with supporting documents including any Performance Warranty Statement that the materials conform to this Technical Specification shall be submitted to the Administrator. **Hold Point 5**

Third (3rd) party certification of the Company’s quality management systems undertaken by a conformity assessment body accredited by the Joint Accreditation System for Australia and New Zealand (JAS-ANZ) to the relevant standards shall be submitted to the Administrator.

Provided that the Transport and Main Roads registered products (refer Clause 5) are delivered without modification and both chemical and material composition, mechanical properties (outline strength properties) and production processes do not change, the existing certificate is valid for the noise fence construction.

8.2 Structural steelworks

Structural steel members shall conform to this Technical Specification.

Structural steelworks shall be fabricated by a fabricator that is registered by Transport and Main Roads.

The manufacture of steel panels shall be audited by an Auditor acceptable to the Administrator.

The Auditor’s report shall be submitted to the Administrator for verification of conformity to ensure that the manufacturer is working as stated in their quality system requirements and the production system conforms to the requirements of Transport and Main Roads.

Connectors shall conform to this Technical Specification.

8.3 Plywood panels

Plywood panel shall conform to this Technical Specification. A certificate of preservative treatment shall be submitted to the Administrator.

8.4 Masonry

Masonry walls shall satisfy the requirements of AS 3700 and shall conform to this Technical Specification.

8.5 Concrete

Concrete walls, panels and concrete footing shall satisfy the requirements of AS 3600 and shall conform to this Technical Specification.

Concrete panels shall be manufactured only by a Transport and Main Roads registered manufacturer.

The concrete panels shall be free from any defects such as honey-combing, knuckling, cracks and voids.

8.6 Composite panels

Composite panels shall conform to this Technical Specification.

Design calculations and the copy of all test results including structural properties of components and the fully dimensioned fabrication and installation details of composite panels shall be provided to the Administrator.

The panels shall be manufactured and satisfactorily tested according to the Transport and Main Roads approved design and testing methods.

Accelerated load testing in accordance to requirements of AS/NZS 2908.2 or other approved methods shall be submitted to the Administrator to demonstrate that the panel system confirm to the design life requirements of this Technical Specification. In addition, the load testing shall satisfy the intent of Appendix B of AS 3600.

The manufacturer shall submit the third (3rd) party quality system certified to AS/NZS ISO 9001. The manufacturer of composite panels shall be audited by an Auditor acceptable to the Administrator.

The Auditor's report shall be submitted to the Administrator for verification of conformity to ensure that the manufacturer is working as stated in their quality system requirements and that the production system conforms to the requirements of Transport and Main Roads that is, provide evidence of this by means of work-test certificates.

The composite panels shall be substantially free of defects such as chipped or marked edges, unintentional surface roughness, fractures, cracks, dents and bulges.

Once accepted by the Administrator, the panel sample shall be retained as the quality standard for the Contract.

8.7 Aluminium panels

Aluminium panel members shall conform to this Technical Specification.

Aluminium panels shall be fabricated by a fabricator that is registered by Transport and Main Roads.

The manufacture of aluminium panels shall be audited by an Auditor acceptable to the Administrator.

The Auditor's report shall be submitted to the Administrator for verification of conformity to ensure that the manufacturer is working as stated in their quality system requirements and that the production system conforms to the requirements of Transport and Main Roads.

8.8 Transparent safety panels

Sufficient testing shall be carried out to ensure that the transparent safety panels comply with the requirements of this Technical Specification.

Toughened Laminated Safety Glass shall satisfy the requirements of AS/NZS 2208.

If any detectable transmission loss is detected in the UV region of the spectrum (200 – 350 nm) by simple UV / visible spectrophotometry testing, the acrylic or polycarbonate panel shall be rejected for further testing.

After successful screening, a sample of the acrylic or polycarbonate panel material shall be subject to artificial weathering, that is, exposed to accelerated UV radiation, moisture, atmospheric pollution and cleaning and maintenance procedures, in a NATA-recognised weatherometer. The accelerated environmental exposures included the following are derived from the guidelines given in I.S. EN ISO 4892-1 and I.S. EN ISO 4892-3:

- UV irradiation of 550 W/m² to 800 W/m² in the wavelength range of 290 nm to 800 nm
- UV exposure at elevated temperature of 60°C with high humidity and condensation temperature of 40°C with moisture
- UV exposure consisting of four hour irradiation periods followed by four hour condensation periods
- UV exposure irradiation period of 3500 hours and
- Chemical exposure to cleaning and graffiti removal products.

Sufficient quantity of UV stabilisers must be present in any acrylic panel. Any polycarbonate panel shall be protected on both sides by both a UV-absorbing coating and a hard top-coat.

The transparent panel shall remain in good condition defined as:

a) no evidence of cracking, crazing, peeling, delamination blistering, chalking, wrinkling, bubbling, or edge shrinkage greater than 2 mm, and

b) no evidence of visible or visual defects, inclusions or faults that can be seen from a moving vehicle under normal or night driving conditions by a driver with normal vision.

Once accepted by the Administrator, the panel sample shall be retained as the quality standard for the Contract.

9 Supplementary requirements

The requirements of MRTS15 *Noise Fences* are varied by the supplementary requirements given in Clause 5 of Annexure MRTS15.1.