TRANSPORT FOR NSW (TfNSW)

QA SPECIFICATION R271

DESIGN AND CONSTRUCTION OF NOISE WALLS

REVISION REGISTER

Ed/Rev Number	Clause Number	Description of Revision	Authorised by	Date
Ed 1/Rev 0		First issue	GM, IC	22.02.07
Ed 1/Rev 1	Global	Text revised to direct imperative style.	GM, IC	06.05.10
	1.3	Definitions of "you" and "your" added.		
	3.2	Subclause relating to landscaping deleted.		
	8.5	Reference to RTA Q changed to RTA G71 for construction surveys.		
	8.8	Clause on removal of graffiti (during maintenance period) deleted.		
	Annex M	Referenced documents updated.		
Ed 2/Rev 0	Guide Notes	Guide Notes on design inputs for use in Annex A moved to new Guide NR271. References to "Guide Notes" changed to "Specification Guide NR271".	GM, IC (M Andrew)	16.09.11
	3.5.13	New clause on fatigue design added.		
	5.1	Electronic drawing format revised.		
	6.3.4	New clause on autoclaved aerated concrete added. Following clause renumbered.		
	6.3.6, 6.3.7	Requirements for glass and plastics split into separate clauses. Following clauses renumbered.		
	6.4.6 (c)	ISO standard for UV test changed.		
	7.1	Contact telephone number updated.		
	8.9	Clause reworded to clarify intent.		
	Annex E3.8 (a) & F4 (i)	Test method source clarified.		
	Annex M1	Referenced Documents updated.		
Ed 2/Rev 1	7.3.1	Paint for lightweight concrete panels clarified to be "Dulux Duremax" or "Duramax Finesse" or approved equivalent.	GM, IC (M Andrew)	27.01.12

Ed/Rev Number	Clause Number	Description of Revision	Authorised by	Date
Ed 2/Rev 2	Annex A	New referenced clauses and notes added.	GM, IC	03.05.12
Ed 2/Rev 3	6.3.12	Type of anti-graffiti protective treatment required on noise walls changed from "sacrificial" to "non-sacrificial". Noise walls with private property side not requiring treatment clarified to be walls along property boundary.	GM, CPS	27.11.13
Ed 2/Rev 4	Annex M	Pay Item P9 added for painting and anti-graffiti treatment.	GM, CPS	26.11.15
Ed 2/Rev 5	6.3.9 Annex M	Reference to "B201" inserted. Referenced documents updated.	DCS	27.10.17
Ed 2/Rev 6	6.3.3 6.3.4 Annex M	Autoclaved aerated concrete removed from acceptable masonry block material. Requirements for autoclaved aerated concrete amended. Referenced documents updated.	MCQ	29.10.18
Ed 2/Rev 7	Global	References to "Roads and Maritime Services" or "RMS" changed to "Transport for NSW" or "TfNSW" respectively.	DCS	22.06.20

GUIDE NOTES

(Not Part of Contract Document)

Background

Specification TfNSW R271 "Design and Construction of Noise Walls" was originally issued for trial use as draft Specifications TfNSW NB1 and TfNSW B348 from 1999 to October 2004, and subsequently draft TfNSW R271 from November 2004 onwards.

R271 Edition 1 incorporates a front GUIDE NOTES section, pages G1 to G32 (separate from these Guide Notes), as a guide to the design of noise walls.

In Edition 2 Revision 0, this front GUIDE NOTES section has been moved to a separate document, titled NR271 "Guide to Design of Noise Walls".

Design and Development Process

TfNSW R271 is a QA specification that requires the implementation of a quality management system by the Contractor that meets the quality management system requirements specified in TfNSW Q.

This Specification is part of the design and development process for noise walls, which goes through the following main stages:

1. Development of Concept Design

At the concept design stage, the functional requirements of the noise walls are formulated by TfNSW, taking into consideration urban planning issues, alignment, noise abatement requirements, environmental impact, etc.

TfNSW conducts initial survey and preliminary geotechnical investigations, which can lead to preparation of architectural drawings, landscaping and drainage layouts, selection of appropriate materials for the noise abatement and basic design calculations and drawings.

2. Preliminary Design

At this stage, adequate information must be supplied to complete all the Project Specific Requirements listed in Annexure R271/A (which may be varied as required for specific projects). Specification Guide NR271 will aid the user in determining the Project Specific Requirements.

3. Detailed Design and Construction

This Specification has to be supplemented with appropriate additional specifications for the various possible modes of contract delivery.

The design process may be conducted in one of the following ways:

(a) The Contractor complies with all the requirements of this Specification. Where applicable, the Contractor may base their design on the information supplied in Annexure R271/A, but is nonetheless fully responsible for the design and construction. Any additional investigations such as surveys and geotechnical investigations required to ensure the safety and integrity of the completed Works is done at the Contractor's own expense.

(b) TfNSW, or Consultants engaged by TfNSW, are fully responsible for the design. If this is the case, then Clause 3 of the Specification applies.

Wherever TfNSW is involved in any aspect of the design, it may evolve the design on its own and take full responsibility for the design. TfNSW may engage Consultants to do the design and take responsibility for it.

Some interaction between stakeholders will occur between the three design stages. At each stage, the design needs to be submitted to the TfNSW's Noise Wall Review Panel for review. The Noise Wall Review Panel does not take responsibility for the adequacy of the design.

Notes regarding this Specification are:

1. The Specification incorporates detailed requirements for design but also accepts proprietary products by testing of samples or prototypes.

2. The Specification provides detailed requirements for materials of construction and requires testing for certain aspects such as impact resistance of brittle materials.

3. The principal design requirements are based on Clause 24 of AS 5100.2, Bridge design – Part 2: Design loads and AS/NZS 1170.0, Structural design actions – Part 0: General principles.

4. It incorporates minimum wind design loadings which are based on AS/NZS 1170.2, Structural design actions, Part 2: Wind actions.

5. It incorporates earthquake analysis and detailing requirements that are based on AS 1170.4, Minimum design loads on structures, Part 4: Earthquake loads.

6. Several inputs for the design have to be obtained from the Project Specific Requirements in Annexure R271/A. Specification Guide NR271 have been written to enable the requirements to be specified correctly. In particular, the multipliers for wind loads in AS/NZS 1170.2 have been modified and elaborated, to make them more appropriate for noise walls. The proposed modifications are based on tests of models in a wind tunnel and their analysis and recommendations by a consultant specialising in this field.

7. Several examples to indicate how the provisions of the wind design clauses should be applied are given in Guide NR271. Nevertheless, the wide variety of conditions likely to be encountered along a noise wall leaves a number of situations open to interpretation of the designer. Where there are ambiguities in interpretation of the requirements, the most conservative interpretation should be adopted.

Any technical questions regarding the specification are to be referred to Senior Bridge Engineer, Capability and Special Projects, TfNSW Bridge and Structural Engineering

Transport for NSW

QA SPECIFICATION R271

DESIGN AND CONSTRUCTION OF NOISE WALLS

IC-QA-R271

VERSION FOR:
DATE:

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CLAUSE PAGE

FOREWORD

TFNSW COPYRIGHT AND USE OF THIS DOCUMENT

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW R271 Edition 2 Revision 6.

All revisions to the previous version (other than minor editorial and project specific changes) are indicated by a vertical line in the margin as shown here, except when it is a new edition and the text has been extensively rewritten.

PROJECT SPECIFIC CHANGES

Any project specific changes are indicated in the following manner:

(a) Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. ***Additional Text***.

(b) Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. ~~Deleted Text~~.

TfNSW QA SPECIFICATION R271

DESIGN AND CONSTRUCTION OF NOISE WALLS

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the Preliminary and Detailed design and the construction of noise walls. It is not applicable to the Concept design.

If a noise wall becomes a part of a structure or facility, then compliance with the appropriate design requirements for that structure or facility is required.

Walls whose primary function is to act as earth retaining structures are not included within the scope of this Specification. However, incidental earth retaining functions have been taken into consideration.

Small earth mounds constructed at the base of the wall are included in the scope of the Specification, but walls comprising entirely of earth berms are not.

1.2 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

1.2.1 Project Specific Requirements

Project specific requirements are shown in Annexure R271/A. These include a list of drawings and reports that are supplied by the Principal.

1.2.2 Measurement and Payment and Resolution of Nonconformities

The method of measurement and payment must comply with Annexure R271/B.

Acceptance of materials and work must comply with Annexure R271/B.

1.2.3 Schedules of HOLD POINTS and Identified Records

The schedules in Annexure R271/C list the **HOLD POINTS** that must be observed. Refer to Specification TfNSW Q for the definition of **HOLD POINTS**.

The records listed in Annexure R271/C are **Identified Records** for the purposes of TfNSW Q Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure R271/D and must be implemented.

1.2.5 Testing Procedures

Refer to Clause 4.

1.2.6 Referenced Documents

Unless specified otherwise, the applicable issue of a referenced document is the issue current at the date one week before the closing date of tenders, or where no issue is current at that date, the most recent issue.

Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given in Annexure R271/M.

1.3 DEFINITIONS

The terms "you" and "your" mean "the Contractor" and "the Contractor's" respectively.

The following definitions apply to this Specification:

Acceleration coefficient: An index related to the expected severity of earthquake ground motion.

Annual probability of exceedance: The probability that the event will be exceeded at least once in any given year.

Approved Drawings: The final design drawings prepared specifically for the work under the Contract and accepted by the Principal as the construction drawings.

Average recurrence interval: The number of years (R) after which an event of specified magnitude or greater will probably recur, on average, over a very long period. The annual probability of exceedance is $1/R$.

Base shear: The total horizontal earthquake shear force (V) at the base of the structure.

Consultant: An Engineer appointed by TfNSW to do the design and development work on its behalf.

Dead loads: Self weight of the structure and other permanent loads.

Design life: The minimum number of years for which a structure or a structural element is assumed in design to be used for its intended purpose with minimal maintenance but without major structural repair being necessary.

Design strength/resistance: Nominal strength (or resistance or capacity) multiplied by the appropriate reduction factor.

Design load: Nominal load multiplied by the appropriate load factor.

Design wind speed: Wind speed for use in design, adjusted for annual probability of exceedance, wind direction, geographic position, surrounding environment and height.

Ductility: The ability of the structure or element to undergo repeated and reversing inelastic deflections beyond the point of first yield while maintaining a substantial proportion of its initial load-carrying capacity.

Earthquake design category: A category assigned to a structure based on its structural classification, acceleration coefficient and site factor for the Site.

Engineer: Engineer(s) eligible for Membership of Engineers Australia and with appropriate qualifications and experience for the relevant type of engineering work.

Escarpment: Long, steeply sloping face between nominally level lower and upper plains where the plains have average slopes of not greater than 5%.

Freestanding walls: Walls that are exposed to the wind on both sides, with no roof attached (e.g. fences).

Hoarding: Freestanding (rectangular) panels supported clear off the ground or on a bridge or viaduct, allowing passage of wind underneath as well as over it.

Job-specific Specification: Technical specification prepared specifically for the work under the Contract and accepted by the Principal.

Limit states: States beyond which the structure no longer satisfies the design criteria.

Nominal load: The unfactored loads and load effects as specified in this Specification.

Nominal strength/resistance: Characteristic value of strength (or resistance or capacity) of material or structural element calculated from the material properties.

Prototype testing: The application of test loads to one or more prototypes of structures, sub-structures, members or connections, to ascertain the structural characteristics of the design.

Return period: Same as average recurrence interval.

Segment: A length of the noise wall, within the contract length, where the type of wall, geotechnical conditions and design loads are constant.

Site factor: A factor accounting for the soil profile. Soil profile is established from substantiated geotechnical data.

Structure classification: A classification assigned to a structure based on its use.

Surveyor: Surveyor(s) eligible for membership of the Institution of Surveyors to the grade of Associate Member or membership of the Institution of Engineering and Mining Surveyors, Australia, to the category of Member.

Terrain: Surface roughness condition when considering the size and arrangement of obstructions to the wind load.

Topography: Major land surface features, comprising hills, valleys and plains, that strongly influence wind flow patterns.

Wall type noise wall: A noise wall which is free standing and does not permit flow of wind underneath it.

2 DESIGN REQUIREMENTS

For the stages of design referred to in the front "Guide Notes", this clause specifies the information to be procured and work to be done. The outputs required for certification are specified in Clause 5.

2.1 CONCEPT DESIGN

Concept design is done by TfNSW who may or may not engage consultants or contractors for individual items of work. Noise abatement studies are done to evolve the basic layout and requirements of the noise wall system. Various matters are planned in consultation with the community. The effect of the proposed noise walls on the environment is studied.

The following information will be supplied for the Preliminary and the Detailed design:

(i) Alignment of the walls along the road;

(ii) Height, length and location of walls in cross section;

(iii) Material selected for noise abatement and minimum thickness;

(iv) Cadastral/Boundary survey data;

(v) Basic geotechnical information such as reference to geological maps, description of site and data from trial pits or from any previous projects in the area;

(vi) Drainage requirements and outlets and layout of any existing drains;

(vii) Layout of known utilities; and

(viii) Location of fences and gates.

2.2 PRELIMINARY DESIGN

Based on the information supplied by TfNSW in Concept Design, carry out the minimum investigations and design outlined in this clause to evolve a Preliminary Design for all aspects of the project.

Design the Works so that no additional acquisition of land is required.

The output of the Preliminary Design must conform to the requirements of Clause 5.2.

2.2.1 Design and Maintenance Life

The Design Life, for the purpose of strength, stability and serviceability calculations, must be 50 years, as specified in AS 5100.2. Design any connections to bridge and retaining wall structures for a life of 100 years.

The maintenance-free period must be as per Table R271.7, for the appropriate material, unless specified otherwise in Clause A2.1 of Annexure R271/A.

2.2.2 Survey and Alignment

(a) Define the boundaries from the Cadastral survey; and

(b) Carry out a detailed topographic survey in accordance with Specification TfNSW G73. All work must be done by a Surveyor. Electronic data transferred to TfNSW at the completion of the survey must generate valid digital terrain models in the current TfNSW CADD software without requiring manipulation by TfNSW. String notation must be in accordance with TfNSW G73.

2.2.3 Architectural Design, Acoustics and Landscaping

(a) Develop the basic concept layouts to include all relevant details such as road crossings, bridge crossings, viaducts, points of entry and exit, smooth transitions etc.;

(b) Develop wall elevations based on acoustic and other requirements;

(c) Integrate the wall layout with the road and building architecture;

(d) Specify protection from vandalism, and anti-graffiti treatment;

(e) Select appropriate materials for the wall walls. Ensure that the materials satisfy the acoustic design requirements in Clause 3.3 and requirements of strength, aesthetics and durability. Ensure that the maintenance-free periods of these materials (refer to Clause 2.2.1) are compatible with the Design Life;

(f) Specify the surface texture, colouring and motifs of the walls; and

(g) Include urban and landscaping design in accordance with information in the Principal Supplied Documents and Specification TfNSW G1. Choose plants from endemic species grown from locally collected seed to the extent possible.

2.2.4 Geotechnical Investigations

Take full responsibility for planning the extent and details of the subsurface investigations. The number of boreholes and soil tests must not be less than those specified in Clause 6.2 of AS 5100.3.

As a minimum, the following work is required:

(a) Conduct adequate soil investigation, testing and analysis to enable the detailed design of the entire structure to be done at the (subsequent) detailed design stage;

(b) Derive the soil properties, nominal strength and bearing capacity from the soil tests and specify the appropriate capacity reduction factors for strength design and allowable stresses for permissible stress design;

(c) Define serviceability limits such as maximum total and differential settlement and/or subsidence;

(d) Submit recommendations for the type of foundations to be adopted;

(e) For pile foundations, recommend an appropriate method of analysis for piles subjected to lateral loads;

(f) Check the stability of slopes if modifications to cuttings or embankments are required or if loads are imposed by wall footings or piles along the edge of the embankment; and

(g) Specify the Site Factor for earthquake analysis in accordance with AS 1170.4 in Table R271/A.4.

2.2.5 Design of Services and Utilities

(a) Conduct full hydrologic investigations to develop a drainage scheme for a new development. In case of an existing development, study the repercussions of the noise wall on the existing drainage scheme and recommend additions and alterations;

(b) Do preliminary hydraulic design to determine approximate sizes of drains, layout of manholes and requirements for scour protection if any;

(c) Procure details of all public utilities, notwithstanding any information supplied at the concept design stage; and

(d) Check conflicts with proposed foundations.

2.2.6 Preliminary Structural Design and Drawings

(a) Study the overall scheme and group all the factors so as to define appropriate number of Segments for structural design;

(b) Define all the General Requirements listed in Clause A2 of Annexure R271/A, with additions and alterations as applicable to the project. Specify the serviceability requirements in Clause A2 of Annexure R271/A. Obtain deflection limits from Standards for the appropriate materials wherever available;

(c) Define the wind load parameters in Table R271/A.3 of Annexure R271/A after studying the topographic features and cross-sections;

(d) For walls on bridges, retaining walls or other supporting structures, define appropriate site factors (S) and earthquake response factors (R_f) in Table R271/A.4 of Annexure R271/A;

(e) For each Segment decide the type of substructure to be adopted and supply the basic information for foundation design in Table R271/A.5 of Annexure R271/A;

(f) Assess approximate member sizes to serve as a starting point for the detailed design. Alternatively recommend the appropriate method in Clause 4 for certifying the structural integrity of the panels by prototype testing;

(g) Where walls interact with other structures, design appropriate isolation joints. Alternatively, consider whether loads imposed by the walls on supporting structures are significant enough to require analysis of the supporting structure also and if so, define the scope and extent of work in Table R271/A.6 of Annexure R271/A;

(h) Study the methods of procurement, manufacture and erection of all the materials so that they satisfy the requirements of Clause 6 and the acoustic requirements;

(i) If prototype testing is required or expected, formulate the requirements in Clause A7 of Annexure R271/A; and

(j) Prepare reliable cost estimates and schedule of quantities to procure funding and invite tenders for the detailed design and construction.

2.3 DETAILED DESIGN AND DRAWINGS

Based on the preliminary designs and drawings, detailed designs, drawings and specifications for construction are required. The work will comprise, but not be limited to, the items listed in this clause.

Notwithstanding the provisions of TfNSW Q, control the design in accordance with the requirements of AS/NZS ISO 9001 Clause 7.3 “Design and Development”.

All designs must be done by suitably qualified Engineers and the complete design must be certified by an Engineer who is approved by the Principal.

2.3.1 Basis of Structural Design

Designs may be based on the preliminary information supplied in Annexure R271/A. However, this can be modified by the Engineer carrying out the detailed designs, provided that appropriate

justification is given in the Design Report. Responsibility for the final design data and assumptions rests with the Engineer certifying the detailed design.

Follow the structural design procedure in Clause 3, as a minimum requirement. The design loads and design procedures outlined in Clause 3 for wind loads, earthquake loads and foundation design, are based on certain simplifications of the appropriate code requirements, which are expected to result in slightly conservative designs.

This does not prevent the Design Engineer from adopting more refined design methods, provided that the requirements of the respective codes are properly followed. Data from authoritative sources and publications or from model studies or prototype test measurements on such items as wind pressure coefficients and seismic response factors can be used, if acceptable to the Principal.

This approach is also acceptable for checking the integrity of noise walls designed to earlier codes and specifications.

2.3.2 Foundation Design

(a) Utilise the geotechnical information to prepare detailed designs and drawings of the substructure work; and

(b) Analyse stability of slopes if these are affected by construction of the wall.

2.3.3 Design of Services and Utilities

(a) Design the complete drainage scheme, including drainage filters behind walls, layout, levels and sizes of all drains, locations of manholes and disposal of the runoff; and

(b) Check layout of all utilities. In case of conflict with foundations, modify the foundation design to bridge over the utilities. If relocation of utilities is inevitable, you will be responsible for getting approval from the relevant authority for the modifications.

2.3.4 Materials

(a) All materials must satisfy the requirements of Clause 6 and applicable specifications or standards;

(b) The construction procedures and sequences specified on the Drawings must comply with the supplier’s instructions;

(c) Provide test results for the strength of the proposed materials if these are not available in Standards;

(d) Submit test reports on the shatter resistance and impact resistance of brittle materials as outlined in Annexures R271/E and R271/F;

(e) If the noise wall serves as a traffic barrier, comply with the requirements in Annexure R271/G; and

(f) For acceptance by testing in accordance with Clause 4, specify the test procedures in detail and the number of units or samples to be tested.

2.3.5 Architectural Design

(a) Prepare plans, elevations and sections for the full noise wall layout;

(b) Prepare detailed architectural drawings of isolation joints and connections;

(c) Specify details of surface treatment and anti-graffiti coating; and

(d) Prepare landscaping and layout of plants. Specify seeding of slopes of embankments and cuttings if construction of a new road is included.

2.3.6 Structural Design

Prepare detailed designs of the complete Works. The scope of detailed structural design and drawings is limited to the design of the noise walls.

Where interaction with other structures occurs, such as noise walls on bridges or retaining walls, the scope of work is limited to determining the forces imposed by the noise wall on the supporting structure.

Carry out also an analysis of the supporting structure if specified in Clause A6 of Annexure R271/A.

You must:

(i) Complete the structural design of each Segment in accordance with the requirements of Clause 3, with the help of the information supplied in Clauses A1 to A5 of Annexure R271/A;

(ii) Verify if 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, analyse the safety and serviceability of the affected utilities or design suitable bridging members;

(iii) Design and detail all members, isolation joints and connections;

(iv) Specify the sequence of construction and erection and the methods of lifting, handling, transport and storage of all prefabricated members; and

(v) Prepare complete "For Construction" drawings of the Works.

3 DESIGN PROCESS

Without limiting the General Conditions of Contract (TfNSW Contract Document C2-GC21 TfNSW General Conditions of Contract), the design of the Works must be based on and developed from the conditions set out in this Specification and the documents supplied by the Principal.

3.1 ALIGNMENT AND ARCHITECTURE

Alignment and architectural drawings prepared for Preliminary Design must be generally in accordance with the architectural concept and design objectives provided in the Concept Design. Some of the requirements are as follows:

(a) The layout of each wall must accommodate pedestrian and vehicle access as indicated in the architectural concept;

(b) All parts of the noise walls, including footings, must be located within the road reserve; and

(c) The wall height must be at least equal to that required by the acoustic design and indicated in the architectural concept.

For Detailed Design, minor modifications to horizontal alignment are permitted to allow for factors such as:

(i) reasonable access for construction or maintenance;

(ii) existing signage, transmission poles and towers or similar obstructions;

(iii) the presence of obstructions that could cause increase in sound transmission or loss of structural integrity of the wall;

(iv) retaining established vegetation identified for retention in the Contract Documents;

(v) specified clearances to underground utilities; and

(vi) standard panel lengths and changes in direction.

The final alignment must provide an even and straight line, with neat physical appearance, consistent spacing of panels or blocks, even and gradual steps at changes of level and direction and uniform transition in wall height. Surface texture, colouring and motifs must be such as to provide a coherent and harmonious design along the full length of the noise wall.

3.2 URBAN DESIGN

Follow the format for urban design in the Principal Supplied Documents.

3.3 ACOUSTICS

Design noise walls so as to produce a continuous solid construction, without gaps that would permit the passage of sound.

The panels must be constructed of either reflective or absorptive type material, to achieve a Weighted Sound Reduction Index R_w, when determined in accordance with AS/NZS ISO 717.1, of not less than 26.0 for normal use and an R_w of not less than 31.0 where noise reductions of more than 10 dB(A) are required.

Where the reflective surface of a noise wall is within a wall separation to height ratio of 20:1, construct the noise wall with an absorptive surface having a Noise Reduction Coefficient (NRC) not less than 0.8.

Submit documentary evidence that the materials proposed for wall panels and walls comply with these requirements.

3.4 DRAINAGE

The drainage design must provide for surface runoff from the Road Reserve and adjoining properties and for drainage of ground water from the noise wall, such that soil erosion is prevented. Do not allow water to pond against noise walls or to discharge onto private property. Design drainage structures to be self-cleansing and to only require occasional maintenance.

Where the noise wall is located along the boundary of the TfNSW Road Reserve, calculate the peak flow discharge using the Rational Method, in accordance with Chapter 5 of Volume 1 of "Australian Rainfall and Runoff" (1987).

State the choice of average recurrence interval for drainage and Site Conditions (Urban/Rural) in the design assumptions for the calculation of the runoff coefficient (C_Y). Also check the drainage system to ensure that, in the event of a storm with an ARI of 100 years, there is no damage to private property.

3.5 STRUCTURAL DESIGN

3.5.1 Principles of Structural Design

Follow the principles of limit state design. Each required limit state (stability, strength, serviceability, etc.) must satisfy the following requirements:

$$S^* \leq \phi R_{lim} = R^* \qquad (3.1)$$

where:

S^* = the design action effect (force, stress, deflection, etc) for the appropriate limit state

ϕ = the strength (or capacity) reduction factor for the material

R_{lim} = the nominal strength, corresponding to S*, for the appropriate limit state

R^* = the design strength, corresponding to S^*, for the appropriate limit state

Calculate the design action effects (S^*) for all the factored load combinations specified in Clause 3.6, for stability, strength and serviceability. Check any other relevant combination specified by the Standards.

Obtain values of ϕ and R_{lim} for the appropriate limit states from the relevant Standards. For foundations, show that Equation 3.1 is satisfied for the substructure component as well as the subsoil.

Design by the permissible stress method is acceptable if a material is used for which the strength reduction factors are not available in Standards, provided that the Standards specify the appropriate factors of safety to be adopted instead. For permissible stress design, calculate wind loads based on a wind velocity = ($0.82V_{des}$) where V_{des} is given by Equation 3.3. However, ensure stability of the noise wall for ultimate load combinations in all cases.

3.5.2 Selection of Design Parameters

Determine the design life (N) in accordance with Clause 2.2.1.

Obtain the importance level (I) of the segment of walls from Clause A2.2 of Annexure R271/A and determine the annual probability of exceedance ($1/R$) for wind and earthquake design from Table R271.1.

For checking the serviceability requirements, use R = 20 years unless specified otherwise in Clause A2.1 of Annexure R271/A.

Table R271.1 - Values of Annual Probabilities of Exceedance for Ultimate Limit State Design of Noise Walls

Importance Level (*I*)	Consequences of Failure	AS 5100.2 Comment	Application to Noise Walls	Annual Probability of Exceedance [1] (1/R)	
				Wind	Earthquake
1	Low	Minor structures (failure not likely to endanger human life)	Not applicable	1/100	1/50
2	Ordinary	Normal structures and structures not falling into other levels	Secondary roads; locations where walls cannot fall onto or slide down a slope onto other property, roadway, walkway or onto traffic areas	1/500	1/150
3	High	Major structures (affecting crowds)	Main highways; walls adjacent to school playgrounds, shopping centres, hospitals etc.	1/1000	1/250
4	High	Post-disaster structures (post-disaster functions or dangerous activities)	Walls that can fall onto railways and onto roadways designated as essential to post-disaster functions	1/2500	1/500
5	Exceptional	Exceptional structures	Not applicable	Not specified	Not specified

Note:

[1] For Design Working Life of 50 years and in non-cyclonic regions. For other cases, refer to Table F2 of AS/NZS 1170.0 Amendment No. 2.

3.5.3 Classification

Noise walls are classified as walls or hoardings, essentially with respect to drag effects of wind on the wall, as follows:

(i) A wall type barrier does not permit flow of wind underneath it; e.g. fences or walls mounted on retaining walls;

(ii) A hoarding is a wall mounted on supports which permit flow of wind underneath. A wall mounted on a bridge is treated as a hoarding in accordance with Clause 3.5.5(e).

3.5.4 Dead and Live Loads

For estimating dead loads, use the unit weights given in Appendix A of AS/NZS 1170.1 in the absence of specific information. For materials not listed in Appendix A of AS/NZS 1170.1, use test data or data from an authoritative reference.

Live loads may be neglected unless specified in Clause A2.2 of Annexure R271/A. If the wall retains earth fill, include the live load surcharge specified in Table R271/A.5 of Annexure R271/A.

3.5.5 Calculation of Wind Loads

Check the noise wall for ultimate strength and stability for the forces calculated in accordance with this clause. For the purpose of this clause, "the wind code" refers to AS/NZS 1170.2.

Follow the design procedure in this clause as a minimum requirement. It is based on the wind code, with certain modifications that are based on model studies carried out by TfNSW. The procedure is outlined in this clause and is explained in detail in Specification Guide NR271, with several examples. The designer can do more accurate analyses if necessary. The provisions of Clause 2.3.1 apply in that case.

(a) Calculate the Design Wind Velocity

For the appropriate annual probability of exceedance (1/*R*) from Table R271.1, calculate the regional wind speed (V_R):

$V_R = 67 - (41/R^{0.1})$ for Regions A1 to A7 (3.2a)

$V_R = 106 - (92/R^{0.1})$ for Region B (3.2b)

Round off values to the nearest 1 m/s. Typical values are given in Table R271.2.

Table R271.2 – Regional Wind Speeds

Annual Probability of Exceedance (1/*R*)	Regional Wind Speed, V_R, m/s	
	Regions A1 to A7	Region B
1/20	37	38
1/100	41	48
1/500	45	57
1/1000	46	60
1/2500	48	64

Calculate the design wind velocity (V_{des}) using the simplified equation:

$V_{des} = V_R M_d M_t M_{z,cat}$ (3.3)

This is a simplified version of the procedure given in Clauses 2.2 and 2.3 of the wind code. For explanation, refer to Clause 2.2.5 of Specification Guide NR271.

Values of the multipliers M_t, $M_{z,cat}$ etc. are summarised in Table A.3 of Annexure R271/A and must be calculated as follows.

(b) Evaluate the Terrain/Height Multiplier

Select the terrain category in accordance with the wind code and obtain the terrain/height multiplier ($M_{z,cat}$). For guidance in selecting the category in complex conditions, refer to Clause 2.2.3 of Specification Guide NR271.

(c) Evaluate the Topographic Multiplier

The topographic multiplier is given herein by $M_t = k\,M_h$, where M_h is the hill-shape multiplier defined in Clause 4.4.2 of the wind code and k is a modifier, assessed in accordance with Clause 2.2.4.3 of Specification Guide NR271, based on wind tunnel tests.

For noise barriers on bridges, M_t is replaced by M_b, which is calculated in accordance with Clause 2.2.4.4 of Specification Guide NR271.

(d) Evaluate the Direction Multipliers

Evaluate the direction multiplier (M_d) for each relevant wind direction, in accordance with Clause 2.2.5 of Specification Guide NR271. The wind directions are evaluated in accordance with either Method (a) or Method (b) of the clause.

(e) Determine the Pressure Coefficient

Obtain the pressure coefficient ($C_{p,n}$) based on the height, width and the angle of incidence of the wind to the wall and from Tables D2(A) to D2(D) of AS/NZS 1170.2. It is acceptable to use the values in Table R271.3, which are an envelope of the values in Tables D2(A) to D2(D) of AS/NZS 1170.2. Intermediate values may be linearly interpolated or calculated from the equation:

$$C_{pn} = 1.3 + 0.5\left[0.3 + \log_{10}\left(\frac{B}{c}\right)\right]\left(0.8 - \frac{c}{h}\right) \qquad (3.4)$$

The equation is applicable for $0.2 \le \frac{B}{c} \le 5$ and $0.2 \le \frac{c}{h} \le 1$. For ratios of $\frac{B}{c}$ and $\frac{c}{h}$ beyond the limiting values, use the limiting values to calculate $C_{p,n}$. For walls, $c = h$.

Wind pressure based on $C_{p,n}$ is always applied normal to the wall, regardless of the wind direction. For wind acting at 45° to the wall, one of the following applies:

(i) For an individual panel, apply the force at an eccentricity, as shown in Figure R271.2.

(ii) For long walls that are continuous or comprised of several panels placed end to end, increase the normal pressure on the end portions of the walls in accordance with Table D2(C) of the wind code.

The design requirements for the different cases that occur are summarised in Figure R271.1.

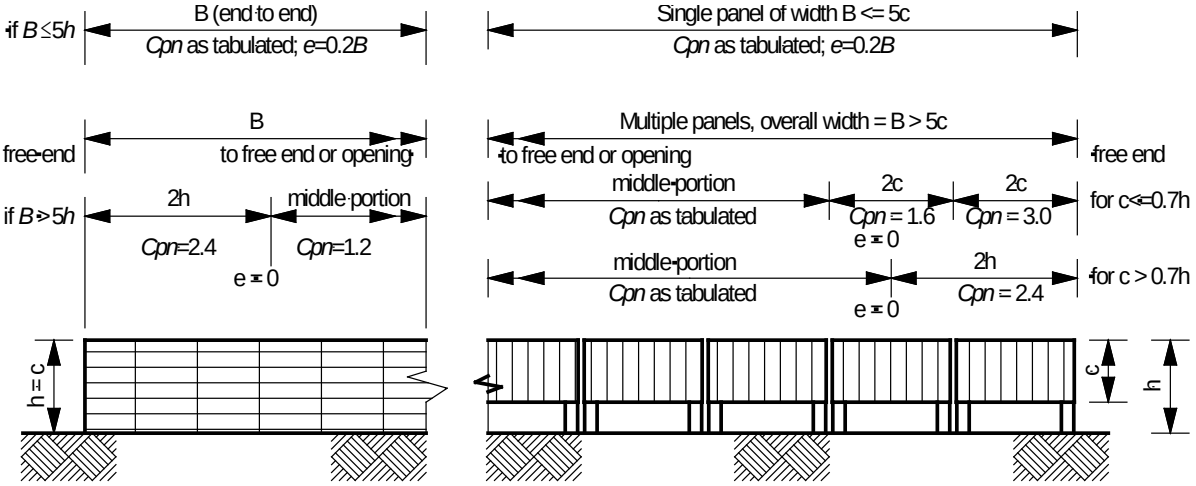
Table R271.3 – Pressure Coefficients ($C_{p,n}$) for Walls & Hoardings

Height ratio (c/h)	Aspect ratio (B/c)							
	0.2	**0.5**	**1**	**2**	**3**	**4**	**5**	**> 5**
≤ 0.2	1.18	1.30	1.39	1.48	1.53	1.57	1.60	refer to Figure R271.1
0.4	1.22	1.30	1.36	1.42	1.46	1.48	1.50	
0.6	1.26	1.30	1.33	1.36	1.38	1.39	1.40	
0.8	1.30	1.30	1.30	1.30	1.30	1.30	1.30	
1.0 (wall)	1.34	1.30	1.27	1.24	1.22	1.21	1.20	

Note: The pressure coefficients given herein are an envelope of the pressure coefficients given in Tables D2(A) to D2(D) of AS/NZS 1170.2.

Where significant gates or gaps occur in a noise wall, treat the wall adjacent to the gate or gap as a free end.

Design noise walls on bridges and viaducts as hoardings. Dimension *c* is the height from the soffit of the beam to the top of the wall, *h* is the height from ground level or minimum water level to top of wall and *B* is the length of the bridge.



(a) Wall type barrier (b) Hoarding type barrier

Figure R271.1 – Wind Pressure Coefficients ($C_{p,n}$) for Noise Walls

(f) Calculate the Aerodynamic Shape Factor

The aerodynamic shape factor is given by:

$$C_{fig} = C_{p,n}\, K_a \qquad (3.5)$$

where:

$C_{p,n}$ = Pressure coefficient

K_a = Span reduction factor

The Span Reduction Factor is given by:

$$K_a = 0.5 + \frac{1.35}{\exp[(a/h)^{0.15}]} \qquad (3.6)$$

where:

h = height of wall or hoarding as defined in Figure R271.1

a = span length between supports;
however, for walls with continuous footings, adopt a = the lesser of B or $2h$

(g) Calculate the wind pressure

The gust dynamic wind pressure, in kPa, is given by:

$$q = 0.6 \times 10^{-3} \times V_{des}^{2} \qquad (3.7)$$

The ultimate design pressure normal to the surface of the wall, in kPa, is given by:

$$p = q\, C_{fig} \qquad (3.8)$$

Hence:

$$p = 0.0006\, C_{p,n}\, K_a\, V_{des}^2 \qquad (3.9)$$

(h) Calculate the forces on the panel

Design each panel of the noise wall for the forces shown in Figure R271.2, comprising the following:

(i) A force acting normal to the wall (F_n), at mid-height of the panel. Apply the force at an eccentricity e from the centreline of the panel (refer to Figure R271.2) for the cases specified in Figure R271.1(a) or Figure R271.1(b):

$$F_n = b\, d\, p \qquad (3.10)$$

where:

d = h for a wall and $d = c$ for a hoarding, as shown in Figure R271.1

(ii) A longitudinal force on the end panel (F_t) of:

$$F_t = 1.2\, q\, t\, d \qquad (3.11)$$

where:

t = thickness of the panel

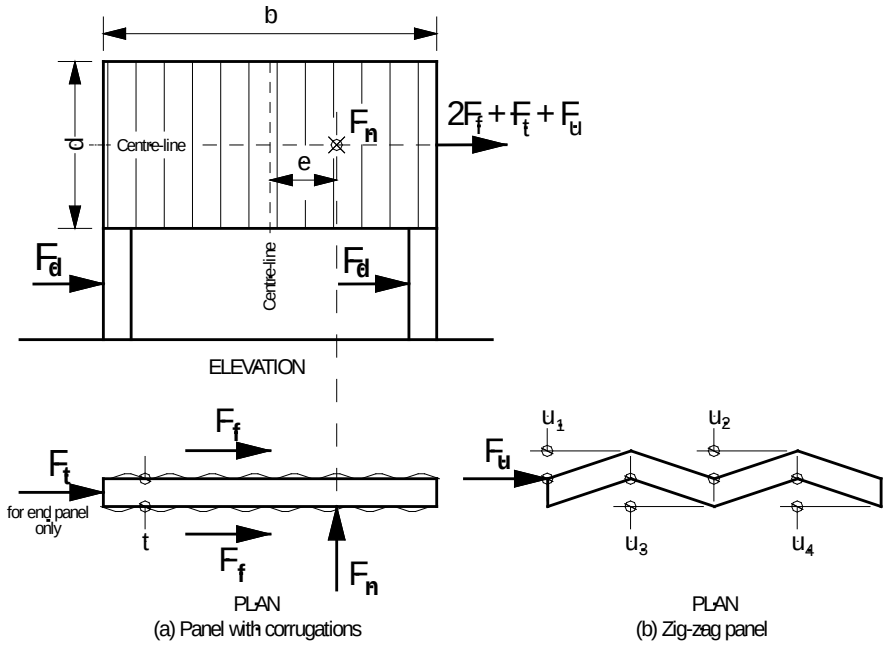


Figure R271. 2 – Forces on Noise wall due to Wind

(iii) A longitudinal force due to frictional drag effects of wind, acting along each exposed surface of the wall (F_f), at mid height, given by:

$$F_f = q\, C_f\, b\, d \qquad (3.12)$$

where:

C_f = the frictional drag coefficient for each exposed surface given by Table R271.4

(iv) For walls that have a zigzag profile (refer to Figure R271.2(b)), an additional longitudinal force (F_u) accounting for the cumulative effect of the projections must be considered as:

$$F_u = 1.2\, q\, d\, \Sigma u \qquad (3.13)$$

where:

u = width of each projection

Small projections which are in the nature of a surface roughness are accounted for in Item (iii) whereas Item (iv) accounts for major structural profiling, end returns or corners.

(v) A longitudinal force on each support of a hoarding due to wind drag effects (F_d):

$$F_d = q\, C_d\, A_e \qquad (3.14)$$

where:

A_e = exposed area of each support in the direction normal to wind

C_d = drag coefficient = 1.2 for cylindrical supports, or

= 2.5 for supports of any other shape

It is assumed that the force on the supports in the direction normal to the wall is negligible compared to the force on the wall.

Table R271.4 – Frictional Drag Coefficient (C_f)

Surface Description	C_f
Surfaces with ribs across the wind direction	0.04
Surfaces with corrugations across the wind direction	0.02
Smooth surfaces without corrugations or ribs or with corrugations or ribs parallel to the wind direction	0.01

3.5.6 More Detailed Analysis

Detailed calculations in accordance with Clauses 2.2 and 2.3 of AS/NZS 1170.2 can be done in lieu of the simplified analysis in previous Clause 3.5.5, as follows:

(i) For the 8 cardinal directions, assess the values of the M-multipliers and calculate $V_{sit,\beta}$ by Equation 2.2 of the wind code.

(ii) Consider wind acting at 8 different angles, in increments of 45° to the wall, in accordance with Figure D1 of the wind code. Calculate $V_{des,\theta}$ by interpolation in accordance with Figure 2.3 of the wind code, for the 8 sectors bounded by angles of $\theta \pm 22.5°$ to the wall. In each sector, find the maximum velocity V_{des}. (The computer program in Clause 2.2.8 of Specification Guide NR271 can be used provided that input values of M_d are replaced by values of $V_{sit,\beta}$.)

(iii) In each sector, evaluate the appropriate value of $C_{p,n}$ from Tables D2(A) to D2(D) of the wind code.

(iv) Calculate the wind pressure and hence the force on the noise barrier in each direction, in accordance with Clauses 3.5.5(g) and (h) above.

(v) For long and continuous walls, increase the value of $C_{p,n}$ in accordance with Table D2(C) of the wind code for the end portions. Alternatively, for walls comprising individual panels, apply the normal force at an eccentricity of 0.2b in accordance with Table D2(C) of the wind code. Note that this increase needs to be considered only for the relevant 45° directions as shown in Figure NR271.4(b) of Specification Guide NR271.

3.5.7 Serviceability Wind Loading

Base the wind load for checking serviceability requirements on a design life of 50 years and the Average Recurrence Interval (R_s) given in Clause A2 of Annexure R271/A. Calculate the appropriate wind velocity (V_s) by means of Equation 3.2a or Equation 3.2b. The corresponding normal wind force on the panel (F_{sn}) is given by:

$$F_{sn} = (V_s/V_R)^2 F_n \quad (3.15)$$

where F_n is calculated by Equation 3.10. Longitudinal forces may be neglected. Consider the force to be uniformly distributed over the area of the panel.

Combine the loads for serviceability in accordance with Clause 3.6.

Satisfy the serviceability requirements specified in Table R271/A.2 of Annexure R271/A.

3.5.8 Earthquake Loads

Earthquake design and detailing must comply with AS 1170.4, subject to the modifications in AS/NZS 1170.0. Obtain the necessary inputs from the project specific requirements tabulated in Clause A4 of Annexure R271/A.

Design the walls for earthquake effects in the transverse as well as the longitudinal directions, but do not consider effects in both directions to act concurrently.

(a) Design procedure

(i) Obtain the basic earthquake acceleration coefficient (a_o) from the project specific requirements of Item (e) of Clause A2.1 of Annexure R271/A.

(ii) Obtain the annual probability of exceedance (1/R) from Table R271.1 for the importance level (I) specified in Table R271/A.2 of Annexure R271/A.

(iii) Obtain the probability factor (k_p) from Table R271.5 below. Calculate the probable earthquake acceleration coefficient (a):

$$a = k_p\, a_o \quad (3.16)$$

Table R271.5 – Probability Factor (k_p) for Earthquake

Annual probability of exceedance (1/R)	Probability factor (k_p)
1/100	0.3
1/200	0.6
1/500	1.0
1/800	1.25
1/1000	1.4
1/2000	1.8

Note:
This table is reproduced from Table D1 of AS/NZS 1170.0.

(iv) Obtain the site factor (*S*) from Table R271/A.4 of Annexure R271/A and calculate the product *aS*.

(v) Ascertain the configuration as regular or irregular. Classify hoarding type panels, wall type panels with significant offsets in plan, and panels with large openings as irregular.

(vi) Consider whether the structure is ductile or not, based on the definition of ductility given in Clause 1.3. Structures of reinforced concrete, prestressed concrete, steel, timber or aluminium is considered to be ductile. Structures of unreinforced masonry (brick or concrete block), plastics, fibreglass and other composite materials are considered to be non-ductile, unless their ductility can be demonstrated by test results.

(vii) Obtain the earthquake design and/or detailing requirements from Table R271.6.

Table R271.6– Earthquake Analysis and Detailing

Product *aS*	**Importance Level (*I*)**	**Design Category**	**Type of Structure**	**Analysis Requirement**	**Detailing Requirement**
$aS < 0.1$	2	A	Regular ductile Irregular ductile	No	No
			Regular non-ductile Irregular non-ductile	No	Yes
	3	B	Regular ductile	No	Yes
$0.1 \le aS < 0.2$	2	B	Any non-ductile Irregular ductile	Yes	Yes
	3	C	Any	Yes	Yes
$aS \ge 0.2$	2	C	Any	Yes	Yes
	3	D	Any	Yes	Yes
	4	E	Any	Yes	Yes

(b) Earthquake Detailing Requirements

Detail the structure such that all parts are tied together and the forces generated by earthquake are carried to the foundation.

Where masonry infill panels are provided within a structural frame, limit either the height or the width of each panel to 1.2 m. Provide a longitudinal beam at the top. Strengthen large openings with reinforcement on each side.

Detail reinforced and prestressed concrete structures in accordance with Appendix A of AS 3600.

Adopt weld category SP in accordance with AS/NZS 1554.1 for welds in steel structures.

(c) Earthquake Design Requirements

Design the noise wall for an ultimate lateral force due to earthquake (F_{eq}) acting at the centre of gravity of the structure structures.

For walls on ground, $F_{eq} = V$, where V is the base shear calculated in accordance with Clause 6.2.2 of AS 1170.4. For walls not exceeding 8 m in height, the following simplified equation may be used, at the discretion of the Design Engineer, in lieu of the detailed procedure prescribed in AS 1170.4:

$$F_{eq} = 0.7\ a\ G\ I_{eq} \qquad (3.17)$$

where:

a = earthquake acceleration coefficient

G = unfactored dead load

I_{eq} = importance factor for earthquake analysis

= 1.0 for importance level I ≤ 3

= 1.25 for importance level I ≥ 4

For walls on bridges and elevated structures, the earthquake force given by Equation 3.18 may be adopted unless a detailed analysis of the bridge structure has been specified in Table R271/A.6 of Annexure R271/A:

$$F_{eq} = 1.4\ a\ G\ I_{eq} \qquad (3.18)$$

Factor the calculated earthquake force in accordance with Clause 3.6 to check the strength and stability of the wall in the transverse as well as the longitudinal directions.

3.5.9 Impact Loads

Where failure of the noise wall under impact may cause pieces of the wall to fall onto an area where it represents a high risk to public safety, such as a public thoroughfare, railway, light rail, playground, assembly area, playing field etc., design the noise wall so that it does not produce falling debris. The wall must be tested in accordance with the procedure given in Annexure R271/E and is satisfactory if all pieces meet the requirements of Class B or Class C.

Where failure of the noise wall under impact will not cause pieces of the wall to fall onto an area where it represents a high risk to public safety, design the wall to resist the stone impact test given in Annexure R271/F. A wall is satisfactory if the prototype passes the test in Annexure R271/F.

All noise walls within the clear zone of the roadway and are not protected against impact by a suitable traffic barrier must be designed and constructed to meet the requirements of Annexure R271/G.

A traffic barrier used to protect the noise wall must meet the requirements of AS 5100 for bridges and retaining walls or Austroads Guide to Road Design: Part 6 and AS/NZS 3845 for other locations. For bridges or retaining walls, the minimum level of protection is regular in accordance with AS 5100.

Refer to Table R271/A.2 of Annexure R271/A for the Segments for which the testing or design in accordance with the above is required. In the absence of any such requirement, no impact loading or shatter resistance needs to be considered.

3.5.10 Earth Pressures

For noise walls that are required to retain earth, the height of backfill retained and the surcharge pressure on the backfill must be in accordance with Table R271/A.5 of Annexure R271/A.

In all cases, the backfill material must meet the requirements of Clause 8.5.1 with drainage of the backfill integrated into the overall drainage scheme.

Walls that perform an incidental function of retaining earth that does not exceed one-third the height of the wall or 2 m above ground level, whichever is less, may be designed by the following simplified

method. The backfill must be placed with nominal compaction only and not be subjected to surcharge loading exceeding 5 kPa. The active pressure behind the wall is given by:

$$p_a = 6.5\, z + K_a\, q \qquad (3.19)$$

where:

p_a = active earth pressure due to fill (kPa)

K_a = active earth pressure coefficient = 0.34

z = height of fill behind wall (m)

q = surcharge pressure on retained earth surface (kPa)

Consider passive resistance only if the soil in front of the wall is thoroughly compacted after construction of the wall and there is no possibility of it being excavated. The passive pressure may be taken as:

$$p_p = 60\, y \qquad (3.20)$$

where:

y = height, in metres, from base of footing (or shear key, if provided) to 0.5 m below permanent ground level, provided the ground is not sloping

p_p = passive pressure at depth y (kPa)

Check the strength and stability of the footing for the factored load combinations specified in Clause 3.6. For checking bearing capacity of the subsoil, the value of R_u in Clause 3.6 may be based on the above soil properties and a value of $\phi = 0.5$ may be adopted for shallow footing foundations.

If a wall does not comply with the above limitations, design it as a retaining wall in accordance with AS 4678, with soil properties based on appropriate subsoil investigations and accounting for the characteristics of the backfill, such as slope, surcharge and compaction pressures.

3.5.11 Structural Robustness

Comply with the structural robustness requirements of AS/NZS 1170.0 for general detailing of components of the structural force-resisting system and other components.

For masonry walls, comply with the structural robustness requirements of AS 3700.

3.5.12 Imposed Deformations and Restraints

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

Where the wall height is built up from vertically stacked panels, the load on panels must account for bowing of panels. Assume that the panels will be stacked with bowing of adjacent panels such that the load distribution produces the worst load effects.

The design must consider that the bottom edge of the wall panel is restrained for bowing and warping due to temperature, differential temperature and differential moisture.

Design all structural support systems, including flexible edge seals, to effectively seal against noise and restrain the panels after accounting for the movements associated with temperature, differential temperature, moisture, differential moisture, warping, twisting and bowing.

3.5.13 Fatigue Design

The fatigue wind speed for noise barriers must be 5 m/s. At this wind speed, the stresses in all components of the noise barrier must be designed to be below the fatigue cut-off limit (f_5) stress.

3.6 LOAD COMBINATIONS

Check the following basic load combinations, in accordance with AS/NZS 1170.0. If the wall is carrying significant live load, consider additional load cases in accordance with AS/NZS 1170.1.

(a) For stability limit state:

$$F_{eq} \leq 0.9\ G \quad (3.21)$$

$$W_u \leq 0.9\ G \quad (3.22)$$

(b) For strength limit state:

$$G + F_{eq} \leq \phi R_u \quad (3.23)$$

$$1.2\ G + W_u \leq \phi R_u \quad (3.24)$$

(c) For serviceability limit state:

$$G + W_s \leq D \quad (3.25)$$

where:

G = dead load and other permanent load effects

W_u = ultimate wind effects computed in accordance with Clause 3.5.5

W_s = serviceability wind effects computed in accordance with Clause 3.5.7

F_{eq} = earthquake effects computed in accordance with Clause 3.5.8

ϕR_u = ultimate design strength of the structural component or foundation

D = serviceability criteria such as deflection, cracking etc.

Within the limitations specified in Clause 3.5.10, walls that retain earth backfill must comply with the following additional conditions:

(i) For stability limit state:

$$1.5\ F_d < 0.9\ G + 0.9\ F_s \quad (3.26)$$

(ii) For strength limit state:

$$1.2\ G + 1.5\ F_m \leq \phi R_u \quad (3.27)$$

(iii) For serviceability limit state:

$$G + W_s + F_s - F_d \leq D \quad (3.28)$$

where:

F_s = forces or moments that produce a stabilising effect

F_d = forces or moments that produce a de-stabilising effect

F_m = structural effects on members and foundation

3.7 DURABILITY AND CORROSION PROTECTION

For concrete noise walls designed for an average recurrence interval of $R \leq 200$, provide cover to reinforcing steel in accordance with the durability requirements of AS 3600. However, for walls designed for $R > 200$, determine the cover from the requirements of both durability and fire-resistance.

3.8 FIRE RESISTANCE

For walls designed for an average recurrence interval of $R \geq 200$, estimate the "fire-resistance period" based on the surrounding facilities and considering the amount of risk. Where more accurate information is unavailable, adopt a minimum fire-resistance period of 30 minutes.

4 LOAD TESTING

4.1 GENERAL

Carry out prototype testing only if specified in Clause A7 of Annexure R271/A.

The provisions of this clause have been formulated in general terms to be applicable to any material, as far as possible. It is recognised that different materials have different strengths, load-deformation characteristics and variation in properties. Wherever testing of structures or elements is specified in the relevant Standard for the material, such as:

(i) AS 1720 for timber structures;

(ii) AS 3600 for concrete structures;

(iii) AS 4100 for steel structures,

adopt the procedure for load testing, the test load factors and statistical variability factors specified in the relevant Standard.

4.1.1 Types of Test

Noise walls or any of their components can be accepted on the basis of load testing, from one of the following methods:

(i) If noise walls are designed in accordance with Clause 3 of this Specification, selected panels can be proof tested in accordance with Clause 4.2. The panels are considered to be acceptable if the deflections and crack widths at serviceability loading are below the specified limits and the panels sustain the ultimate design load.

(ii) Noise walls that are not designed can be accepted on the basis of non-destructive testing of prototypes carried out in accordance with Clause 4.3. In this case, the test load to be sustained is given by Equation 4.1 and the measured deflection limit, by Equation 4.2.

(iii) Noise walls that are not designed can also be accepted on the basis of tests on prototypes conducted up to the failure load in accordance with Clause 4.4. In this case, the design strength (R_d) is given by Equation 4.6, which depends on the number of prototypes tested. The serviceability requirements must comply with Clause 4.3.5.

4.1.2 Procedure

The number of panels to be tested is specified in Clause A7 of Annexure R271/A.

If completed wall panels need to be proof tested, the particular panels to be tested will be nominated by the Principal. Submit drawing(s) showing the test set up, for the approval of the Principal. Nevertheless it is your responsibility to ensure that the test is conducted in a safe manner, without any damage to the adjacent structure or risk to workers.

The magnitude of the load, the load increments, the rate of loading and unloading etc. must be in accordance with Clause A7 of Annexure R271/A. Submit a report for each load test conducted, describing the test set-up, method of loading, method of measuring loads and deflections and results, including a load-deflection curve.

Measure rack widths under serviceability test loads by means of feeler gauges at consecutive points spaced at 50 mm centres over a crack length of not less than 300 mm.

You are responsible for removing the test rig and restoring the structures and site to the condition before testing.

Address the testing as a separate Pay Item.

4.1.3 Acceptance of Tests

The Design Engineer must examine the test results and reports to confirm that the tested panels meet the requirements of structural strength, serviceability and stability.

Do not incorporate into the Works a noise wall (including an element or portion of a noise wall) that fails to comply with the acceptance criteria. Do not include in the frequency calculations panels that fail the testing.

If any panel fails to comply, rectify the construction represented by that panel to the satisfaction of the Principal before any further prototype testing is undertaken.

HOLD POINT

Process Held:	Manufacture of further prototypes / completion of construction.
Submission Details:	At least five (5) working days before doing any further work related to the tested panel, submit to the Project Verifier the test reports and a Clearance Certificate from the Design Engineer that the test results are satisfactory.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

4.2 PROOF TESTING

This clause applies to the testing of a noise wall (including an element or portion of a noise wall) to determine whether that particular noise wall or its element which has been designed in accordance with Clause 3 of this Specification complies with strength and serviceability requirements.

Apply the test load in accordance with Clause A7 of Annexure R271/A. A member is deemed to comply if all of the following conditions are satisfied:

(a) The maximum deflection for the serviceability design load is not greater than the value of δ_{max} in Clause A7 of Annexure R271/A;

(b) The measured crack widths for the serviceability design load and after removal of the load do not exceed the appropriate value (w_{max}) given in Clause A7 of Annexure R271/A;

(c) The member is able to sustain the calculated ultimate design load for the period of the test;

(d) If the recovery from deflection 24 hours after the removal of the test loading is greater than 75% of the deflection at ultimate load; and

(e) The load-deflection curve does not show any significant discontinuities.

4.3 PROTOTYPE TESTING

4.3.1 Application

This Clause applies where the strength and/or serviceability of the noise wall or its components is verified by the load testing of a prototype.

Test one or more prototypes.

4.3.2 Construction of Prototype

The construction or manufacture of a prototype for a planned production run must take into account the intended practices and quality of materials and workmanship likely to be achieved during that production run.

4.3.3 Compliance for Strength

The noise wall represented by the prototype sample is deemed to comply with the requirements for strength provided that

(a) The load carrying capacity of each prototype panel tested exceeds the ultimate design load calculated in accordance with Clause 3, multiplied by the appropriate variability factor for ultimate loads given in Clause A7.4 of Annexure R271/A.

$$P^* \geq \lambda_u S^* \qquad (4.1)$$

where S^* is as defined in Clause 3.5.1, and:

P^* = test loading in accordance with the calculated loads S*

λ_u = variability factor for ultimate loads

(b) The load is sustained for at least 5 minutes.

The design strength (R^* in Equation 3.1) is taken as the least of the P^* values obtained for all the panels tested.

4.3.4 Compliance for Impact

The design represented by the prototype will be deemed to comply with the requirements for impact if:

(a) For debris created by impact, 3 prototypes of the wall pass the testing regime given in Annexure R271/E at Class B or Class C;

(b) For stone impact, 3 prototypes of the wall pass the testing regime given in Annexure R271/F; and

(c) For traffic impact, the wall passes the testing regime given in Annexure R271/G.

4.3.5 Compliance for Serviceability

The noise wall represented by the prototype sample will be deemed to comply with the requirements for serviceability if both the following equations are satisfied:

$$\delta_s \lambda_s \leq \delta_{max} \quad (4.2a)$$

$$w_s \lambda_s \leq w_{max} \quad (4.2b)$$

where:

δ_s = observed deflection at serviceability loading

λ_s = variability factor for serviceability loads given in Clause A7 of Annexure R271/A

δ_{max} = deflection limit specified in Clause A7 of Annexure R271/A

w_s = observed crack width at serviceability loading

w_{max} = maximum crack width specified in Clause A7 of Annexure R271/A

4.4 TESTING OF PROTOTYPES TO FAILURE

4.4.1 Application

This clause applies to tests to failure carried out on prototypes to establish empirical assessments of the design strengths of noise walls without theoretical strength calculations.

4.4.2 Test Requirements

Carry out the testing on a minimum of five prototypes for each relevant load combination or observed mode of failure. More than one mode of failure may be obtained from each test specimen. Record the details of the failure modes and failure loads so that the relevant ultimate load capacities can be assessed.

Apply the loads to produce failures in proportions that are consistent with the relevant design load combinations specified in Clause 3.6.

4.4.3 Failure Load Statistics

Take failure loads to be the measured peak load associated with each ultimate limit state. Determine a characteristic failure load magnitude (P_i) for each failure mode.

Determine the sample mean peak load (μ_P), the standard deviation (σ_P) and coefficient of variation (ν) from the characteristic failure load magnitudes P_i. The sample size (n) must not be less than five for each failure mode. The statistics are given by the following:

$$\mu_P = \Sigma P_i / n \qquad (i = 1, 2, \ldots n) \quad (4.3)$$

$$\sigma_P = \sqrt{[\Sigma\{(P_i - \mu_P)\}^2 / (n - 1)]} \qquad (i = 1, 2, \ldots n) \quad (4.4)$$

$$\nu = \sigma_P / \mu_P \quad (4.5)$$

4.4.4 Design Strength

Determine a test capacity reduction factor (Φ_T) from Clause A7 of Annexure R271/A for the sample size (n) and the coefficient of variation (ν) obtained from the tests. The load capacity (R_d) for each load combination and failure mode is given by the following:

$$R_d = \Phi_T \mu_P \quad (4.6)$$

The construction represented by the prototype samples subject to failure load test is deemed to comply if the load capacity, R_d, is greater than the ultimate design load calculated in accordance with Clause 3.6. The design strength R^* in Equation 3.1 is taken as the minimum of all the R_d values obtained.

5 DESIGN OUTPUT

5.1 GENERAL REQUIREMENTS

Provide electronic copies of all the survey work in a file format compatible for import into MX and able to be easily integrated into the road and/or bridge design drawings. String notation must be in accordance with TfNSW G73. Refer all survey levels to Australian Height Datum (AHD) and all survey plan co-ordinates to the applicable Map Grid of Australia (MGA) zone. Specify the applicable MGA scale factors for the Site on the layout Drawings.

Produce all structural drawings in a file format which can be imported into "Microstation".

Prepare all drawings to A1 size but with font size and details which can be easily read when reduced to A3 size. Submit the final design documentation which must comprise an electronic copy of all drawings and reports, two sets of drawings printed in A1 size, one set printed in A3 size and one printed copy of all reports and two printed copies of the design calculations.

Present all calculations in a neat and comprehensible manner. If spreadsheets are submitted as part of the calculations, submit the detailed calculation for a typical member. If any computer program is specially developed for the design, provide a detailed description of the analytical basis, input and outputs and adequate number of test examples, unless it is standard software which is commercially available.

5.2 PRELIMINARY DESIGN

The output of the Preliminary Design must contain all the information necessary to commence the Detailed Design. Supply all the information required in Annexure R271/A, with appropriate modifications to suit the particular project. Supplement with relevant drawings and reports. The output must include results of all the investigation and design work done in accordance with Clause 2.2. Main items are as follows:

5.2.1 Survey and Alignment

Use the electronic survey data to prepare contour plans extending up to the boundaries of the survey. Produce at least one longitudinal section through the centre of the roadway and at least one cross section through each Segment.

Show co-ordinates of the start and finish locations of each wall and, if it is subdivided into Segments, the length of each Segment.

5.2.2 Architectural Design and Landscaping

Submit plans and elevations of each wall, with all main features such as door openings, junctions and bends. Plot finished ground levels on front and back of each wall elevation. Specify the surface texture, colouring and motifs.

Show the landscaping details and layout of plants.

5.2.3 Geotechnical Investigations

Submit a report on the geotechnical investigations. Provide the information required in Table R271/A.5 for each Segment and the seismic Site Factor in Table R271/A.4.

5.2.4 Services and Utilities

Submit drawings of the drainage scheme, with preliminary sizing and invert levels of all drains and locations of manholes and discharge points.

Collect drawings of all utilities from the relevant Authorities.

5.2.5 Structural Designs and Drawings

Summarise results of the preliminary design done in accordance with Clause 2.2.6 in Tables R271/A.1 to R271/A.6 of Annexure R271/A.

Submit a report outlining the design concepts, main assumptions made in the design, requirements for further investigations if any, and basis and justification for the proposed design. Include all design calculations, presented in a neat and comprehensible manner.

Submit preliminary structural drawings of the superstructure and substructure, indicating the structural system proposed and with sizes and dimensions adequate to serve as the starting point for the detailed design.

Provide specifications for materials and methods of construction.

HOLD POINT

Process Held:	Completion of Preliminary Design.
Submission Details:	Calculations, reports, documents and drawings detailed in Clause 5.2.
Release of Hold Point:	The Principal will consider the submitted documents and offer comments or ask for clarifications, within ten (10) working days. On receipt of satisfactory replies to the queries, the Principal will authorise the release of the Hold Point within three (3) working days. No extension of time will be given if the replies are unsatisfactory and further clarifications are required.

5.3 DETAILED DESIGN

The Detailed Design must be based on the concepts proposed in the Preliminary Design and accepted by TfNSW. Following the Principal's acceptance of the Preliminary Design, produce drawings "For Construction". Work required on various aspects of the design is outlined in Clause 2.3. The outputs must comprise, but not necessarily be limited to, the items listed in this clause.

If spreadsheets are submitted as part of the calculations, submit the detailed calculation for a typical member. If any computer program is specially developed for the design, provide detailed description of the analytical basis, input and outputs and adequate number of test examples. This requirement does not apply to software which is commercially available.

5.3.1 Layout and Alignment

Submit drawings showing the following:

(i) General arrangement;

(ii) Setting out co-ordinates and levels for all items of work;

(iii) Boundaries of all properties and the road reserve including layout of fencing;

(iv) Layout of road and footpath if any; and

(v) Existing structures that interact with the noise walls.

5.3.2 Architectural Drawings

Submit architectural drawings showing the following:

(i) Plans, elevations and sections of all walls;

(ii) Details of joints and connections, gates and fencing;

(iii) Details of cast-in patterns, texture and colour of paints or other finishes and anti-graffiti treatment;

(iv) Levels of existing and finished ground on both sides of the wall, in elevation views; and

(v) Landscaping, with locations and schedules of species of plants, preparation of topsoil and mulch, turfing of slopes etc.

5.3.3 Services and Utilities

Submit the following calculations and drawings:

(i) Drawings procured from appropriate authorities for all existing services. Drawings showing relocation of any services if required, approved by the relevant Authority;

(ii) Hydrologic and hydraulic calculations for the drainage scheme; and

(iii) Drawings for construction of all drains, manholes and filter materials.

5.3.4 Structural Designs and Drawings

Carry out the complete detailed design of substructure, superstructure including isolation or movement joints, connections, method of handling and erection etc. and submit the following calculations, drawings and reports:

(a) Report on the design of the structure and foundations, comprising:

  (i) design concepts;

  (ii) brief description of methods used for design;

  (iii) conclusions; and

  (iv) references.

(b) Detailed design calculations of substructure, based on recommendations in the Geotechnical Report. Justify any modifications to these recommendations that may be considered necessary;

(c) Detailed design calculations of the superstructure, including overall strength, stability and serviceability, design of individual members, components, isolation joints, movement joints and connections; and

(d) Detailed drawings of the substructure and superstructure, suitable for construction. Specify methods of fabrication, transportation and erection.

5.3.5 Specifications for Construction

Prepare comprehensive Job-specific Specifications from this Specification and your Drawings, to fully define all criteria for manufacture and construction. Include clauses for the materials selected for construction only. Include relevant specifications for other members, such as piles or precast panels, from those listed in Annexure R271/M.

5.3.6 Maintenance, Inspection and Monitoring

Consider the maintenance-free periods specified in Table R271.7 and prepare a Maintenance Manual recommending:

(a) Frequency of inspections for serviceability of the structural members, such as observations for cracking, deflection and settlement;

(b) Recommendations for painting or other maintenance measures;

(c) Procedure for removing graffiti;

(d) Monitoring of noise; and

(e) Procedures for repair or replacement of damaged panels.

5.4 REVIEW OF DETAILED DESIGN

On completion of the detailed design, submit two paper copies and one compatible electronic copy of the completed Detailed Design Documentation for review by the Principal. The material to be included in the Detailed Design Documentation comprises all the design and drawing outputs specified in Clause 5.3.

The Principal may submit the Detailed Design Documentation to a third party for checking or review of the design to ensure that it conforms to the requirements of this Specification. The Design Engineer must respond to the comments or queries raised by the checking Engineer and make necessary changes to the design calculations and drawings, within the allotted time. No extension of time will be granted for queries not properly answered or for repeated revisions.

Acceptance of the Detailed Design Documentation by the Principal does not relieve the Design Engineer or the checking Engineer of the correctness of the documentation.

No extension of time will be considered due to any delays caused to you due to the need to submit revised Detailed Design Documentation where the submitted documentation does not meet the requirements of this Specification.

HOLD POINT	
Process Held:	Commencement of manufacture, fabrication and/or construction of the noise walls.
Submission Details:	Before commencement of the manufacture, fabrication or construction of the noise walls, submit to the Principal the complete Detailed Design Documentation specified in Clause 5.3, for review and checking within the allotted time.
Release of Hold Point:	On Certification of the above documents by the checking Engineer, the Principal will authorise the release of the Hold Point.

6 MATERIALS AND DETAILS

6.1 GENERAL

Select appropriate materials for structural components and finishes during the Preliminary Design and specified in the architectural drawings. Some of the characteristics that must be taken into consideration are strength, durability, noise absorption, shatter resistance, fire resistance and aesthetics. Assess the cost of the chosen materials with respect to the initial cost and the cost of maintenance during the Design Life of the project. The expected maintenance-free periods for various materials are tabulated in Table R271.7.

Assess the thicknesses of panels of the chosen material and sizes of various structural members during Preliminary Design, based on acoustic, structural and other considerations. In addition, the Preliminary Design and drawings must take into consideration the particular features and construction requirements for various materials. Some of these are listed in Clause 6.3.

During Detailed Design, the drawings and specifications must specify the test requirements of the chosen materials in accordance with Clause 6.3. Where there is a discrepancy between the Standards and the requirements listed in Clause 6.4, refer the matter to the Principal.

You may propose alternative materials if the properties and test requirements of these materials are submitted to the Principal for approval.

6.2 NOMINAL MAINTENANCE-FREE PERIOD

The period over which no maintenance is expected to be required must be the appropriate maintenance-free period for each material specified in Table R271.7, unless specified otherwise in Clause A2.1 of Annexure R271/A. The maintenance-free periods refer to the main construction materials only but do not apply to the following items:

(i) Paints;

(ii) Surface texture;

(iii) Sealing of joints; and

(iv) Landscaping.

Table R271.7 – Maintenance-Free Periods for Materials

Accepted material	Maintenance -free period (1)	Applicability		
		Inland (farther than 50 km from coast)	Coastal (up to 50 km from coast but excluding tidal and/or splash zones)	Coastal areas in tidal and/or splash zones
Concrete	50 years	Yes	Yes	No
Masonry	40 years	Yes	Yes	No
Aluminium panels	40 years	Yes	Yes	No
Hot-dip galvanized steel	25 years (2)	Yes	Yes	No
Hot-dip galvanized plus painted steel	25 years (2)	Yes	Yes	Yes
Stainless steel	50 years	Yes	Yes	Yes
Treated timber, “Cypress Pine” only	25 years	Yes	Yes	No
Painted steel	25 years (2)	Yes	Yes	No
Timber (3)	25 years	Yes	Yes	No
Plastic	25 years (4)	Yes	Yes	No
Glass	25 years (4)	Yes	Yes	Yes
Lightweight concrete	40 years	Yes	Yes	No

Notes:

(1) Choose an appropriate grade from relevant material specifications to achieve the specified periods.

(2) Period shown refers to the years of service till the first major maintenance required to arrest corrosion (e.g. recoating, patch repairs).

(3) Softwoods treated in accordance with AS 1604.1 to Hazard Class 4 or Class 5.
Hardwoods Durability Class 1 and Class 2 to AS 1720.2.

(4) For plastic or fibreglass, period shown is not regarding the clearness of transparent materials.

Noise walls comprising earth berms do not fall within the scope of this Specification.

6.3 MATERIAL CHARACTERISTICS AND THEIR APPLICATION

Designs incorporating different materials must take into account the characteristic features of those materials, some of which are listed in the following clauses. Also note that for all materials:

(i) design must avoid entrapment and ponding of water, dirt and debris on or within components;

(ii) all components of the noise wall system must be resistant to vermin and micro-organisms; and

(iii) the surfaces of panels must not produce excessive glare from incident light.

6.3.1 Plain, Reinforced and Prestressed Concrete

Design and construction must comply with all the requirements of AS 3600 and this Specification.

6.3.2 Structural Steel

Design of structural steel members must be in accordance with AS 4100.

Provide long-life corrosion protection in accordance with recommendations on protection systems in AS/NZS 2312.

Comply with the following features, especially with regard to achieving the maintenance-free periods specified in Table R271.7:

(i) Do not allow structural steel sections to contact soil directly. Either embed them in concrete or let them bear on concrete over a suitable grout layer;

(ii) Do not allow other metals causing galvanic corrosion with steel to come in contact with steel in the noise wall system, unless an appropriate method of protection is undertaken. The protection may comprise electrical isolation of the contacting surfaces of both metals by thick coating, or, if this is not possible, by at least coating the cathodic metal;

(iii) Restrict the steel from coming into contact with any other corrosive material, to prevent steel corrosion. Provide thick coatings to the contacting surfaces so that water cannot penetrate into their contact faces. When steel is used with treated timber, select the timber preservative carefully so that it does not promote steel corrosion;

(iv) Protect bolts, nuts and washers against corrosion to the same degree of durability as required for the structure;

(v) Avoid use of weathering steel in aggressive industrial and marine environments. Consider the use of stainless steel if shown to be economical; and

(vi) If adequate corrosion protection is not possible, take loss of section due to corrosion into account in the design. Assess the sacrificial steel thickness by considering the insitu conditions.

6.3.3 Masonry

Design and construct masonry noise walls in accordance with AS 3700 and this Specification.

Masonry block material may be burned clay or plain concrete. The strength of masonry satisfying the above requirements must be based on values in AS 3700. However, special materials are not excluded provided that their strength can be demonstrated by tests in accordance with AS 3700.

Masonry walls may be either reinforced masonry (in which some or all grouted cavities or cores are reinforced with steel reinforcement) or prestressed masonry (in which some or all grouted cavities or cores are reinforced with stressed tendons) or unreinforced masonry.

Observe the following requirements:

(i) Do not provide unreinforced masonry walls on bridges, viaducts and at any location where the return period for design in Clause 3.5.2 exceeds 500 years;

(ii) Provide continuous concrete footings for all masonry walls and anchor vertical reinforcement into the footing; and

(iii) On top of masonry noise walls, provide protective capping or flashing.

6.3.4 Autoclaved Aerated Concrete

Autoclaved aerated concrete (AAC) panels are normally manufactured 600 mm wide in thicknesses of 100 mm, 125 mm, 150 mm or 200 mm.

Do not provide unreinforced AAC walls on bridges, viaducts and at any location where the return period for design in Clause 3.5.2 exceeds 500 years.

Design and construct AAC noise walls in accordance with AS 5146 Parts 1, 2 and 3 and this Specification.

Reinforce AAC panels in accordance with AS 5146 Parts 1, 2 and 3 and this Specification. The reinforcement must have a minimum cover of 30 mm and, if not of stainless steel, have a robust protective coating to ensure that the required design life will be achieved in service.

Where the panels are supported at each end, provide even bearing at each support for a minimum length of 200 mm from the end of the panel. The maximum ultimate bearing stress on AAC panels must not exceed 0.5 MPa (assuming a load factor on self-weight of 1.3 and density not less than 750 kg/m^3).

The length of cleats used to fix panels to posts must allow for deflections of the posts due to loads and soil movements. The maximum bearing stress on AAC panels from fixing cleats under the prying actions of ultimate wind loads, and beneath bolt heads, nuts or washers, must not exceed 0.5 MPa.

Where noise walls panels are supported near the face of a concrete pile, provide either a strip footing between piles or else construct the bottom panel of the noise wall in reinforced concrete.

6.3.5 Timber

Timber structures must satisfy the requirements of the relevant Australian Standards (e.g. AS 1720), Specification TfNSW 2380 and the following:

(i) Noise wall wood product must be resistant to decay naturally for at least 20 years or be pressure treated;

(ii) A certificate of preservative treatment from the relevant Authority is required for any pressure treated wood product. Preservative treatment must comply with AS/NZS 1604.5;

(iii) The moisture content of all timber sheeting must be reduced to the required level (in compliance with the relevant Australian Standards or guidelines) before and after pressure treatment;

(iv) Exterior and interior moisture contents of timber columns must be reduced to the required levels to the depth of penetration of the preservative (in compliance with relevant Australian Standards or guidelines);

(v) All wood products must be treated against insect infestation;

(vi) Laminated timber panels must be resistant to warping, splitting, loosening of particles, knots and imperfections;

(vii) Any laminated timber sheeting must be double-depth, tongue and groove;

(viii) Glue laminated timber must be pressure preservative treated to achieve retention at a level complying with the requirements of the relevant Authority, the relevant Australian Standards or guidelines, prior to gluing; and

(ix) Large washers under nuts and bolt heads must be provided to prevent damage to timber. Bolted connections of thick timber sections must have lock nuts to prevent loosening due to shrinkage of timber.

6.3.6 Glass

Unless specified specifically in the design, do not use glass for noise wall panels to avoid breakage and other damage during the design life. Where used, the material must be sufficiently strong, stable and durable to comply with the performance and design requirements of this Specification.

The characteristic values of material parameters for glass used in the design must allow for:

(a) Prevention of deformation or breakage over the design life of the noise wall under service conditions from impact, fire and vandalism etc.;

(b) Loss of performance due to environmental degradation (e.g. sunlight and chemical attack);

(c) Variations in the manufacturing process;

(d) Installation damage, including weathering during storage and/or mechanical damage during installation.

If transparent glass noise walls are proposed, comply with the following items:

(i) Transparent glass walls must be tinted or superimposed with a pattern of thin opaque stripes to reduce the problem of birds flying into transparent walls;

(ii) Do not use glass where reverberation could cause problems; and

(iii) Consider the possibility of the glass, laminations or coatings losing transparency due to degradation in service.

Fixing of panes of glass within more flexible supports must allow for deformations within the sealing elements. Use standards such as AS 1288 as a guide.

6.3.7 Plastics

Plastics must be sufficiently strong, stable and durable to comply with the performance and design requirements of this Specification.

Characteristic values of material parameters for plastics used in the design must allow for:

(a) Any creep deformation or rupture over the design life of the noise wall at the service conditions;

(b) Loss of strength and embrittlement due to environmental degradation (e.g. sunlight, biological, hydrolysis and chemical attack);

(c) Variations in the manufacturing process;

(d) Extrapolation of uncertainties where test duration is less than the design life;

(e) Installation damage, including weathering during storage and/or mechanical damage during installation; and

(f) Resistance to damage from impact, fire and vandalism.

If transparent plastics are proposed, comply with the following items:

(i) Transparent walls must be tinted or superimposed with a pattern of thin opaque stripes to reduce the problem of birds flying into transparent walls;

(ii) Consider the possibility of the material losing its transparency due to degradation during its design life.

Plastic panes must be sufficiently ductile to provide for deformations within supports. Alternatively, use flexible seals. Standards such as AS 1288 may be followed as a guide.

6.3.8 Metals

Use of non-ferrous metals is acceptable if design and construction comply with the relevant Standards.

6.3.9 Panel Connections and Other Components

Panel connections and other components must comply with Specifications TfNSW B201, TfNSW B240 or TfNSW B246.

Design panel connections so that:

(a) Panels are securely connected to the supporting or framing members;

(b) Connections are detailed to accommodate:

  (i) thermal movements between materials with different coefficients of expansion;

  (ii) differential settlements;

  (iii) deformations between materials with different moduli of elasticity;

(c) Where noise walls are connected to traffic barriers, connections are such that the panels can be easily replaced, in case damage is caused by an errant vehicle;

(d) Connections are given the same degree of corrosion protection as the main members.

6.3.10 Joint Fillers and Sealants

Where required, provide joint fillers and sealants to acoustically seal gaps between panels and under the wall.

Use joint fillers composed of durable inert materials resistant to atmospheric attack, which will maintain joint thickness within design tolerances.

For horizontal joint fillers, use resin bonded cork strip or similar material. For vertical joint fillers, use open cell polyethylene or polyurethane foam strip or similar material.

Use sealants comprising polysulphide or polyurethane based elastomeric compounds applied in accordance with the manufacturer's recommendations (including primers).

Do not use joint fillers and sealants for joints below finished ground level, or where the noise wall design requires the wall face to be free draining.

6.3.11 Paints and Other Coatings

Unless specified otherwise on the Drawings or in Annexure R271/A2, the colour must be:

(a) “Environment Green” as per AS 2700; or

(b) “Dulux charcoal” or approved equivalent.

Apply one base coat and two top coats of paint.

Protective treatment of steelwork must be in accordance with Specification TfNSW B220.

Coatings must be free of lead (except trace amounts in additives) and must be provided over all exterior panel surfaces to protect them from atmospheric corrosion, weathering, exposure to road salts and ultraviolet colour degradation.

Plastic coating of panels is acceptable if it complies with manufacturing Standards. Plastic coating must be resistant to chipping, crushing and handling damage, and must be free of defects.

6.3.12 Anti-graffiti Treatment

The noise wall design must include a non-sacrificial type of anti-graffiti protective treatment applied to all surfaces exposed to public areas, unless directed otherwise by the Principal. Where the wall forms the property boundary, the private property side of the wall does not require treatment.

Anti-graffiti treatment must comply with the manufacturer's recommendations and must seal and protect fully the treated areas from permanent graffiti damage. The material must be clear with a matt finish.

Submit procedures for the removal of graffiti and reapplication of the anti-graffiti treatment in the Maintenance Manual. The procedures for treatment and removal must comply with the relevant SafeWork NSW and Environment Protection Authority (EPA) requirements and the treatment and removal must not cause any damage to the surrounding landscaping.

6.4 TESTING OF MATERIALS

Carry out testing in accordance with the procedure set out in the relevant Australian Standards; or, if such procedure is not available in Australian Standards, in accordance with the procedure set out in ISO, EN, BS or ASTM Standards.

6.4.1 General Test Requirements

The following general requirements are applicable to all types of noise wall materials:

(a) All noise wall materials must be tested in accordance with ASTM E 84 or equivalent Standard for flame spread and smoke development classifications. Test results must satisfy the requirements of the relevant Standards and guidelines;

(b) Noise wall material must be tested for water absorption characteristics in accordance with the relevant Standards. The test must demonstrate that the wall material can withstand prolonged periods of exposure to moisture. The water absorption percentage must comply with the requirements of the relevant Standards or guidelines;

(c) Noise wall materials must be tested in accordance with ASTM G 21 or other relevant Standard for their resistance to fungus. There must be no observed growth of fungus.

6.4.2 Reinforced and Prestressed Concrete

All concrete products must be visually inspected and must be free from defects such as honey-combing, knuckling, cracks and voids.

The production, delivery, sampling and testing of concrete materials and constituents must comply with AS 1379.

For precast concrete panels and other precast concrete members, submit to the Principal the details of the precasting manufacturer and the location of the precasting yard, in addition to the PROJECT QUALITY PLAN details specified in Annexure R271/D.

Where colour is to be achieved by pigmentation, prepare samples in accordance with Clause 7.6.1.

Curing compounds, if used, must not mark or discolour the cured concrete panel.

6.4.3 Structural Steelwork

Structural steel members and their fasteners must conform to the relevant Standards listed in AS 4100.

Welding of steel structures must conform to AS/NZS 1554.1.

Hot-dip galvanized steel panel elements must conform to the relevant Australian Standards and AS/NZS 4680.

Stainless steel must comply with AS/NZS 4673.

Provide priming and painting over all exposed steel, other than weathering steel, in accordance with TfNSW B220.

If weathering steel is proposed, it must have adequate corrosion resistance. Do not use weathering steel in aggressive industrial and marine environments.

6.4.4 Masonry

Carry out tests, in accordance with the relevant Australian Standards, to determine:

(i) Compressive strengths of all structural components of the noise wall, e.g. brick or masonry block, mortar, the concrete to fill the voids and the footing concrete; and

(ii) Quality of mortar.

Testing of specimens cut from panel elements for compressive strength is permissible.

The minimum frequency of checking the dimensions of masonry is one unit per pallet.

6.4.5 Timber

Timber must conform to AS 1720.

Glue laminated timber with wet-use adhesive in accordance with AS/NZS 1328.1 and AS/NZS 1328.2.

Plywood must be an exterior type and must conform to AS/NZS 2269; and the mass requirement for an R_w rating of 26 is 16 kg/m^2 and for an R_w rating of 31 is 35 kg/m^2.

Testing of small clear specimens of timber may be carried out in accordance with AS 1720.

6.4.6 Glass and Plastics

Glass panels must conform to AS 1288, subject to the glazed area not exceeding 15 m^2 and unidirectional glazing span not exceeding 4 m. Verify the structural integrity of larger panels by testing in accordance with the relevant provisions of AS/NZS 4284.

For a claimed life expectancy of plastic materials, demonstrate the durability based on outdoor exposure testing in accordance with the method specified in AS 1745.1:1989.

Carry out tests on the following items and submit to the Principal test results verifying that the materials comply with the requirements of the relevant Standards:

(a) Burning characteristics;

(b) Shrinkage;

(c) Temperature and ultraviolet light protection;

(d) Creep;

(e) Vandalism;

(f) Shatter resistance;

(g) Glare;

(h) Scratch resistance;

(i) Impact resistance;

(j) Exposure to water and/or aggressive fluids; and

(k) Chemical and/or bacterial composition of fill material.

Comply with the following in the design:

(i) Light transmittance of clear transparent materials must not be less than 90% on delivery and 85% after 10 years when tested in conformity with DIN 5036 Part 3 Illuminant C;

(ii) Susceptibility to bleaching must be tested in a weatherometer;

(iii) Panels must be tested for resistance to ultraviolet-light exposure to ISO 4892-2. Test results must comply with the requirements of the relevant Australian Standards or guidelines;

(iv) All glazing materials must conform to ANSI/SAE Z26.1 or the equivalent Australian Standard.

6.4.7 Metals

Comply with the following requirements for metal testing:

(a) **Accelerated weathering**: This is a test for the metal and the coating to withstand long term exposure to harsh environment (e.g. extreme moisture, high temperatures, harsh light i.e. high dose of ultraviolet). Test methods must be to AS 2331.3.1 to 3;

(b) **Coating thickness**: Verify coating thickness against the requirements of the relevant Australian Standards. This coating refers to all galvanized, painted, sprayed or dipped types;

(c) **Coating durability**: Carry out a test of the coating system in a weatherometer chamber to ISO 11341 and ISO 11507. Evaluate the weathering effects on the coating system in conformity with the following Standards where relevant:

  (i) Checking: AS/NZS 1580.481.1.7

  (ii) Cracking: AS/NZS 1580.481.1.8

  (iii) Blistering: AS/NZS 1580.481.1.9

  (iv) Adhesion: AS/NZS 1580.408.5

  (v) Colour change: AS/NZS 1580.601.4

  (vi) Chalking: AS/NZS 1580.481.1.11

(d) **Metal properties**:

  (i) Provide Mill Classification Certificates for all metal components;

  (ii) Provide standard test results verifying the tensile strength, hardness and brittleness of metal components;

(e) **Corrosion resistance**: Demonstrate corrosion resistance by a test method in the relevant Standard by subjecting a coated metal sample to constant exposure to salt and moisture.

6.4.8 Composites

Composites must conform to this Specification and the relevant Standards.

The following fundamental tests are applicable for all types of composite noise wall materials:

(a) **Flame retardants**: The minimum allowable smoke generation and flame spread rate must not exceed the rate of a typical fence material, such as pine;

(b) **Toxicity**: Adopt leachate testing or other methods to determine the toxicity (e.g. health hazards, environmental damage) of the final noise wall panel material;

(c) **Structural strength**: Verify by load testing on a production panel;

(d) **Bonding**: Confirm that prolonged exposure to ultraviolet light does not affect the stability of the primary materials and binders and that the appropriate binders are used for the specific materials;

(e) **Coatings**: Verify the longevity of coatings in coated panels by weatherometer testing;

(f) **Noise Reduction**: Verify the Noise Reduction Coefficient of coated panels by testing after the panels are coated;

(g) **Sound Transmission**: Verify the R_w rating of the completed noise wall system by testing; and

(h) **Freeze-thaw/Salt Scaling**: Where relevant, verify the ability of the noise wall material to resist harsh weather conditions by testing in accordance with the relevant Australian Standards (or ISO, BS or ASTM Standard in case such tests are unavailable in Australian Standards). The testing must be a combination of tests to determine the material's resistance to salt scaling as well as to frequent freezing and thawing cycles.

6.4.9 Other Materials

Other materials may be used provided that they comply with the requirements of this Specification and the relevant Standards. Selection of noise wall materials must be based on their ability to meet the durability, safety, serviceability and functionality requirements. In addition, address life cycle costs and cost effectiveness of these materials.

6.4.10 Paints and Other Coatings

(a) Test coated specimens by subjecting them to constant exposure to light and temperature variations with intermittent exposure to water spray to ISO 11341 and ISO 11507. Then evaluate the coating system for the following weathering effects in accordance with the following Australian Standards.

(i)	Checking	AS/NZS 1580.481.1.7
(ii)	Cracking	AS/NZS 1580.481.1.8
(iii)	Blistering	AS/NZS 1580.481.1.9
(iv)	Colour change	AS/NZS 1580.601.4
(v)	Adhesion	AS/NZS 1580.408.5
(vi)	Chalking	AS/NZS 1580.481.1.11

There must be no checking, cracking, blistering or loss of adhesion;

(b) In regions where roadway de-icing salts are used, test coated specimens for the salt fog exposure effects in accordance with the relevant Australian Standards (or equivalent ISO, EN, BS or ASTM Standards if such test is unavailable in Australian Standards); and

(c) Test resistance to abrasion of the coating system in accordance with AS/NZS 1580.403.2 or equivalent test procedures.

6.5 CERTIFICATION OF SELECTED MATERIALS

At least 5 working days before the supply of noise wall materials, provide certification that the materials conform to this Specification. Provide conforming test reports and a copy of the verification checklist.

HOLD POINT

Process Held:	Selection of materials for panels.
Submission Details:	At least 5 working days before the supply of a noise wall material, submit to the Principal: (i) Certification that the material supplied conforms to this Specification (ii) Test reports and a copy of the verification checklist on the suitability of the noise wall material.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

7 MANUFACTURE

7.1 DIMENSIONS AND TOLERANCES

The materials and methods of construction must comply with the relevant Standards, where available, such as:

(i) AS 3600 for concrete structures;

(ii) AS 3700 for masonry structures, and

(iii) AS 4100 for steel structures; and

Where other more appropriate requirements, such as those specified in:

TfNSW B349 Precast Concrete Noise Walls Members (Not Pretensioned)

are available, comply with these requirements.

Where no Standard that is appropriate for the material and type of structure is available, comply with the following clauses and Clause 8.6.2.

7.1.1 Measurement of Dimensions

Size: Determine the length and height dimensions of the noise wall panels by taking measurements at 200 mm from each edge and at the midpoint of the length and height of the panel. Take the size dimension for length and height of the noise wall panels as the mean of the three values.

Thickness: Determine the thickness of the noise wall panels by taking measurements at the ends and midpoint of the panel at locations 200 mm from each edge and at the midpoint of the length of the unit. Take the thickness as the mean of the nine values.

Concrete Cover: For concrete noise wall panels, determine the concrete cover to reinforcement as follows:

(i) directly, by cutting a chase into the concrete surface; or

(ii) indirectly, using an electromagnetic or similar device (cover meter).

7.1.2 Tolerances for Manufacture

The tolerance for a measured dimension is the difference between the dimension specified on the Drawings and the value determined in accordance with Clause 7.1.1.

Size: The size dimensions of the noise wall panels must not differ from the dimension specified on the Drawings by more than ±10 mm.

Thickness: The thickness of the noise wall panels must not differ from the dimension specified on the Drawings by more than +10 mm or –5 mm.

Concrete cover: For reinforced concrete noise wall panels, the actual concrete cover to reinforcement must not differ from the specified cover by more than +10 mm or –5 mm.

Ends: When tested by means of a tri-square, the end faces of the noise wall panel at any location must be square within ±4 mm when measured across the panel section thickness.

Verticality: With the base of the noise wall panel horizontal, the vertical side faces of the panel must not deviate from the vertical at any location by more than ±20 mm for the entire overall height dimension of the noise wall panel.

Squareness: The plan diagonals of the noise wall panel must not differ by more than ±20 mm.

Warping and twisting: The deviation of any point on a surface of a member, from a straight line joining any two points on the surface, must not be greater than 1/250 times the length of the line or 10 mm, whichever is the greater.

7.1.3 Panel Identification

Establish and adopt an appropriate method for temporary identification of the members until permanent markings have been made.

Make permanent markings (in characters approximately 75 mm high) to indicate the date of casting and identification number on each member using indelible marking materials. Locate such markings so that they are not visible in the completed structure.

7.2 FORMING AND CASTING

For precast concrete panels and other precast concrete members, submit to the Principal the details of the precasting manufacturer and the location of the precasting yard, in addition to the PROJECT QUALITY PLAN details specified in Annexure R271/D.

All moulds or forms used for forming the textured patterns or motifs for concrete panels will become the property of the Principal at the end of the contract period, and must be delivered free of charge to a storage yard within the Sydney Metropolitan Area or other location nominated by the Principal.

7.3 PAINTING OR OTHER COATING

Apply a site reference sample to establish colour, texture and workmanship prior to commencing painting.

7.3.1 Painting of Lightweight Concrete Panels

Apply one base coat and two top coats. Where the substrate is concrete, including "*Hebel*" block, lightweight aerated concrete block, concrete block and fibre reinforced cement panel, the base coat must be certified by the manufacturer as suitable for the particular type and finish of concrete panel.

Paint both sides of panels after installation. On the traffic side, paint one coat of tinted maxi-prime (a water based acrylic primer) and then one coat of "*Dulux Duremax*" or "*Duramax Finesse*" or approved equivalent. Apply both coats through a hopper gun with conventional air pressure, as these are fine aggregate texture coatings. The application rate of "*Dulux Duremax*" and "*Duramax Finesse*" must be not less than 1 litre/m^2 and the finishing coat must have a dry film thickness (DFT) of not less than 1000 microns.

On the side facing a residential area, paint the concrete panels with two coats of acrylic based paint.

Seal all panels that will come into contact with the ground with "*Dulux Duremax GPE*" or approved equivalent, to a height of at least 150 mm above ground level.

7.3.2 Painting of Other Types of Panels

Submit for the Principal's approval a coating system that will give a minimum coating life of 15 years under the conditions prevailing at Site.

7.3.3 Painting of Steel Supports

Prior to painting, clean and degrease the steel supports. Use "Dulux Duremax GPE" or approved equivalent to seal the galvanized steel vertical supports, applying the sealer to a height of at least 150 mm above ground level, prior to the installation of wall panels.

For painted steel, the system must comply with TfNSW B220, except for the above and except that the colours must comply with Clause 6.3.11.

7.4 LIFTING AND TRANSPORT

Panel materials must attain their minimum strength as per design drawings and the relevant Australian Standards before they are lifted and transported.

Transport and store all prefabricated components in accordance with the manufacturer's instructions, to prevent damage and deterioration. Pay particular attention to the protection of motifs and other architectural features during transport and handling.

Lift panels only in accordance with the methods shown on approved Drawings. Alternative lifting arrangements may be accepted provided that you submit designs and drawings for the lifting arrangement, certified by your Engineer. The lifting points, devices and methods must comply with the relevant Australian Standards.

Support precast concrete panels in a vertical position at least 100 mm above ground level. Secure panels at all times to prevent them from toppling over. Temporary supports must be timber and the panels must be supported over the full width.

7.5 WORKMANSHIP AND FINISH

Noise wall panels must be substantially free of defects such as chipped or marked edges, unintentional surface roughness, fractures, cracks, dents and bulges.

The PROJECT QUALITY PLAN must provide for verification of conformity of the noise wall panels prior to delivery and erection.

7.6 SAMPLES AND TEST SPECIMENS

Precast concrete panels must conform to the requirements for Test Panels in AS 3610.

7.6.1 Concrete Pigment Samples

Where concrete panel coloration is to be achieved by pigmentation, the Principal will determine the background colour of the noise wall panels by selection from a range of coloured concrete samples prepared by you. Unless advised otherwise by the Principal, the nominal concrete colour must be as specified in Clause A2.1 of Annexure R271/A.

Prepare three sample concrete panels for each background colour using a range of pigment quantities up to a maximum of 5 kg/m^3 of concrete. Manufacture sample panels 1000 mm × 1000 mm in size under the same conditions and processes as the prototypes. Deliver the panels to Site and arrange with the Principal, on reasonable notice, a date and time for an inspection of the panels.

HOLD POINT

Process Held:	Manufacture of sample full size test panel.
Submission Details:	Sample panels demonstrating colour range of pigment quantities.
Release of Hold Point:	The Principal will examine the sample panels for compliance with the Specification and advise within two (2) working days as to which sample is selected.

Keep the selected sample at Site at an accessible but protected area for comparison with the panels delivered for inclusion in the Works. Remove and dispose of the remaining sample colour panels.

The costs associated with the preparation of sample colour panels will be made under a separate Pay Item.

7.6.2 Reparability

Demonstrate on one sample panel that noise walls can be repaired in the field in accordance with the procedures stated in the Maintenance Manual. The colour and texture of the repair must match the remainder of the panel.

Demonstrate that graffiti can be removed by appropriate treatment recommended in the Maintenance Manual, such as recoating, removal using chemical agents, or sandblasting.

Alternatively, replace a damaged panel to the satisfaction of the Principal.

The sample needs to be only of adequate size to demonstrate the method of repairs.

The state of repairs of the sample panel must be approved by the Principal.

The costs associated with the sample repair panel will be made under a separate Pay Item. Do not use the sample panel in the Works.

HOLD POINT	
Process Held:	Precasting/manufacture/fabrication of panels.
Submission Details:	Sample panel demonstrating that it can be satisfactorily repaired in accordance with the procedures stated in the Maintenance Manual.
Release of Hold Point:	The Principal will advise within two (2) working days whether the repairs are satisfactory.

7.6.3 Full Size Specimen

Prior to production of the panels for the Works, submit to the Principal one full size panel specimen, which is representative of that proposed to be used in the Works. The panel must be fully fabricated and finished in accordance with the Drawings and Project-specific Requirements. The panels must be indicative of the artistic pattern or motif, finish and colour likely to be achieved for the production panels, including the anti-graffiti treatment.

The specimen may be used in the Works if approved by the Principal. Keep the panel at an accessible location at the work site for comparison during the delivery of panels used for the Works. This does not relieve you of the responsibility to assess panels for conformity prior to delivery.

HOLD POINT	
Process Held:	Precasting/manufacture/fabrication of panels.
Submission Details:	Specimen panel that is fully representative of that proposed to be used for the Works.
Release of Hold Point:	The Principal will assess the specimen panel prior to authorising the release of the Hold Point within two (2) working days.

The Principal may reject panels that do not comply with this Specification. Any rejected panels will remain your property and must be removed from the Site and replaced by you at your cost.

8 CONSTRUCTION

8.1 SETTING OUT

You are responsible for the setting out of the Works in accordance with the approved Drawings and will be responsible to maintain such setting out for the duration of the Contract. The setting out must include establishment of recovery positions.

Install marked stakes to identify the noise wall alignment and footing depth.

Take care during setting out that minimal damage is done to existing flora at Site. Confine line of sight clearing through trees and shrubbery to a width of 0.5 m from either side of the noise wall centreline.

Install marked stakes to identify real property marks or permanent marks placed under the provisions of the Survey Co-ordination Act and avoid disturbing them. Notify the Principal if any such survey mark is disturbed and arrange for the disturbed marks to be replaced by a registered Surveyor at your cost. Also notify the Surveyor General of the Land Titles Office of such instances.

Do not commence excavations for footings until the set-out has been inspected by the Principal and the Hold Point released.

HOLD POINT	
Process Held:	Excavation for footings.
Submission Details:	Notice of the date when setting out will be completed, at least two working days prior.
Release of Hold Point:	The Principal will examine the set-out for compliance with the Drawings and advise within one (1) working day of the inspection whether the Hold Point is released.

8.2 SERVICES

Locate all underground and overhead utilities or services that are present near the proposed noise wall. Carry out a risk assessment and implement a risk management plan in order to avoid damage to services.

Prior to any excavation near the services, locate them and their positions with pegs painted above ground in a bright colour

If any service is not in accordance with the Drawings, notify the Principal. If a service occupies the same space as a substructure element, a conflict exists and must be dealt with in accordance with Specification TfNSW G2. If the clearance between any service and a substructure element is less than that shown on the Approved Drawings, refer the matter to the Design Engineer to check that the service will not be subjected to detrimental stress or displacement, such as due to superimposed stress from a footing or displacement due to pile driving.

8.3 PRIVATE PROPERTY

Take photographs prior to commencement of construction activities to record the conditions of all adjoining properties at the construction boundaries. Liaise with the owners before commencing construction of noise walls, to establish suitable arrangements for any work within private property associated with construction of the walls.

During construction, erect temporary boundary fencing or strengthen existing fencing, as required, to maintain properties in a secure condition against the ingress or egress of people and animals. The quality of temporary fencing must be similar to that of the existing fencing at each property.

Where existing fencing is replaced by noise walls, secure side fencing to the noise walls.

You are responsible for reinstating any fencing, lawns and gardens that may be disturbed during construction activities to a condition equivalent to or better than that at the commencement of construction.

8.4 CLEARING

Prior to commencing clearing, implement erosion and sedimentation control procedures in accordance with the requirements of Specification TfNSW G38.

Clear only the area that is required for access to and construction of the Works, up to 1.5 m from either side of the noise wall. Clearing will comprise the orderly removal or trimming of trees, plants and shrubs that would prevent normal construction of the noise walls.

Where construction requires access through private property, liaise with the affected property owners regarding the arrangements for access and do not alter existing fences unless agreed with the property owner.

You have to make good at your cost any damage occurring during clearing operations, such as damage to fencing or removal of trees beyond the permitted zone.

Unless specified otherwise in Clause A.2 of Annexure R271/A, materials cleared in accordance with this Specification will become your property and must be removed from the Site.

8.5 SUBSTRUCTURE WORK

Carry out site preparation, bulk excavation including removal of any unsuitable material and placing of replacement fill in accordance with Specifications TfNSW B30 and TfNSW R44. Also comply with the requirements of Specification TfNSW G71 for Construction Surveys.

8.5.1 Fill Material

Backfilling of footing excavations and fill behind walls acting as retaining walls must be selected granular material. Fill material that is placed in contact with the noise wall must comply with the following requirements:

(i) It must be hard and durable material, such as clean sand, decomposed rock or crushed rock;

(ii) It must be free draining granular material; and

(iii) It must be free from organic or other deleterious material such as plastic, metal, rubber or other synthetic material, inorganic contaminants, dangerous or toxic material or material susceptible to combustion.

8.5.2 Footings

Prepare the footings for panel elements to the alignment and level required so that panel elements can be placed accurately and within the specified tolerance, with due allowance for movement of footings which may occur during construction.

For footings founded on rock, excavate in rock to the depth and profile shown on the approved Drawings. Fill any over-excavation in rock with concrete of the same quality as that of the foundation member. Minor fissures must be thoroughly cleaned out and refilled with concrete, mortar or grout. The rock surface must be clean and wet at the start of placing concrete for footings.

Footings on earth must not be founded on backfill material unless specifically catered for in the structural design or unless the Principal directs that existing material at the foundation floor has to be removed and replaced as unsuitable material. Compact any backfill material replacing unsuitable material under the foundation so that the relative compaction as determined by Test Method TfNSW T166 is not less than 100%. The minimum frequency for compaction testing is one representative test

per 100 m^3 of uniformly compacted backfill with a minimum of one per foundation member and one per day.

Construct reinforced concrete footings and pile caps in accordance with AS 3600.

8.5.3 Piling

Piling for noise walls must comply with the requirements of Specification TfNSW B50, TfNSW B51, TfNSW B53, TfNSW B54, TfNSW B57, TfNSW B58, TfNSW B59 or TfNSW B61, as appropriate.

8.5.4 Inspection

On completion, arrange for a Geotechnical Engineer to inspect the Site. Submit a report validating the material characteristics of the foundation soil. Where any geotechnical characteristic of the founding material is found to be different from what was assumed in the design, assess the impact of this on the design and arrange for the Designer to amend the design.

Dispose all excess excavated material off the site.

HOLD POINT

Process Held:	Construction of noise wall.
Submission Details:	At least five (5) working days before the proposed construction of the noise wall, submit to the Principal the following: (i) A report from the Geotechnical Engineer verifying that the site and foundation meet the design requirements; (ii) Drawings showing the locations of all underground and overhead utilities or services in the vicinity of the noise wall.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

8.6 SUPERSTRUCTURE

Where not defined in the Job-specific Specifications, construction of reinforced and prestressed concrete structures must comply with AS 3600 and construction of steel structures must comply with AS 4100.

8.6.1 Erection

The erection operation must be such that each noise wall element is placed in position safely and without damage to the member or the structure. The intended permanent structural action of the member must not be restrained or otherwise adversely affected by the process of erection or by movements which occur due to environmental or construction-related forces before the member is finally integrated with the adjacent parts of the structure.

Where a capping is specified as part of the noise wall, finish the top of the panel elements so that the capping is within tolerance of its design alignment.

Falsework and temporary supports must have adequate provision for adjustment to achieve the required panel profile detailed on the Drawings.

After erection, remove all temporary supports, packers, falsework and temporary bracing and carry out any repairs due to the use of such temporary works.

Apply anti-graffiti treatment in accordance with Clause 6.3.12. Remove any graffiti and reapply anti-graffiti treatment, prior to completion.

8.6.2 Tolerances for Erection

Tolerances must be in accordance with this clause, immediately following the completion of the noise wall and the application of all dead loads:

(a) Any clearances required from the face of the noise wall must not be infringed upon at any point;

(b) No point on the face of the noise wall must deviate from the design position by more than 50 mm;

(c) The inclination of the face of the completed wall must not deviate from the specified inclination by more than 5 mm per metre height towards the back of the noise wall and nil towards the front;

(d) The flatness of the wall must be such that the maximum deviation from a 4.5 m straight edge must not exceed 20 mm. In the case of a wall curved in plan, the horizontal deviation must be measured from a 4.5 m long reference curved to the specified curvature measured at panel joints; and

(e) The level of any point on the wall must not deviate from the specified level by more than 100 mm.

Where no other tolerance is given, a value (dimension, level, position) that is within 6 mm of the required value will be accepted as conforming.

8.7 DAMAGE TO PANELS

Do not install damaged panels.

Unless approved otherwise by the Principal, replace damaged panels with new panels.

Where installation of repaired panels is proposed, submit details of the damage and the proposed method of repair to the Principal for approval. Repaired panels must meet the structural requirements of this Specification and must be free of marks, discolouration and other visible blemishes. Do not install repaired panels without the Principal's inspection and acceptance of each affected panel.

HOLD POINT

Process Held:	Repairs to damaged panel/s.
Submission Details:	Details of the damage and the proposed method of repair.
Release of Hold Point:	The Principal will consider the submitted details and advise within three working days of the submission whether the Hold Point is released.

HOLD POINT	
Process Held:	Installation of repaired panel/s.
Submission Details:	Principal's inspection of the repaired panel/s.
Release of Hold Point:	The Principal will inspect the repaired panel/s and advise within two working days of the inspection whether the Hold Point is released.

Minor cracks not longer than 100 mm that appear after installation must be repaired. Where cracks longer than 100 mm appear after installation, submit details of the cracking and the proposed method of repair for the Principal's consideration.

Resolution of repairs will be in accordance with Annexure R271/B.

HOLD POINT	
Process Held:	Repair of cracks that appear after installation of the panels.
Submission Details:	Details of the cracking and the proposed method of repair.
Release of Hold Point:	The Principal will examine the submitted details and advise within three working days of the submission whether the Hold Point is released.

8.8 (NOT USED)

8.9 NOISE MONITORING

Carry out noise monitoring in accordance with the requirements specified in Clause A2.1(f) of Annexure R271/A. Any monitoring equipment will be supplied by the Principal and installed as detailed in the noise wall drawings.

8.10 CERTIFICATION OF CONSTRUCTION

At the end of construction, forward a certificate to the Principal verifying that the materials used and the construction conform to this Specification.

HOLD POINT	
Process Held:	Completion.
Submission Details:	Certify that the materials used and the construction conform to this Specification.
Release of Hold Point:	The Principal will consider the submitted documents prior to authorising the release of the Hold Point.

8.11 WORK-AS-EXECUTED DRAWINGS

On completion of construction, submit to the Principal a set of work-as-executed drawings, incorporating approved modifications made during construction, and in accordance with TfNSW G2.

8.12 MAINTENANCE MANUAL

On completion of construction, submit a Maintenance Manual that contains the maintenance requirements and procedures for the various types of noise walls.

ANNEXURE R271/A – PROJECT SPECIFIC REQUIREMENTS

Refer to Clauses 1.2.1, 2.2 and 5.2. Provide the information stated below under this Annexure R271/A.

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R82/A)

The format of this information is for the guidance of the Engineer responsible for the noise wall design only, and may be changed as required for specific projects. For assistance in specifying some of the requirements, refer to Specification Guide NR271.

A1 DOCUMENTS

(Add to list or delete as required)

A1.1 Drawings

1. Survey drawings
2. Road alignment drawings
3. Preliminary architectural drawings
4. Preliminary structural drawings
5. Drawings of existing services

etc.

A1.2 Reports

1. Concept Design Report
2. Geotechnical Investigation Report
3. Preliminary Design Report
4. Acoustic Design Report

etc.

A1.3 Subdivision of Walls into Segments:

Each wall is subdivided into segments as listed in the table below. Within each segment, treat the type of wall, its materials and conditions pertaining to each design requirement (soil bearing capacity, wind loads, earthquake forces, etc.) as constant. From one segment to another, the type of wall, the materials, or any of the design parameters may vary. Design parameters in Clauses A3 to A6 of Annexure R271/A are tabulated in accordance with these segments.

Table R271/A.1 – Layout of Wall Design Segments

Segment Mark	Wall Mark	Drawing	Chainage at Start	Chainage at End

A2 GENERAL

A2.1 Requirements for Entire Works

(a) Average recurrence interval for serviceability limit state design: R_s = ____ years

(b) Nominal maintenance-free period (refer to Clause 6.2): ____ years

(c) Clearance requirements:

Under bridges: Horizontal = ____ mm; Vertical = ____ mm

Other Segments: Horizontal = ____ mm; Vertical = ____ mm

(d) Wind Region (refer to Clause A3 of Annexure R217/A): _____

(e) Earthquake acceleration coefficient from Figure 2.3 of AS 1170.4-1993 as required in Clause 3.5.8(a): a_o = _____

(f) Monitoring requirements:

…..……..

(g) Type of panel elements:

…..……..

(h) Finish of panel elements:

…..……..

(i) Details of any minor structures on top of, behind or within the noise wall:

…..……..

(j) Details of services and utilities affected by the noise wall:

Existing: ……...……...

Future: ……...…….....

(k) Load testing requirements:

…..……..

A2.2 Requirements for Each Segment

General requirements pertaining to each segment are in the table below.

Table R271/A.2 – General Requirements for Each Segment

Item	Description	Units	First Segment		Last Segment
1	Importance level (***I*** in Table R271.1)				
2	Live load	kPa			
3	Allowable deflection at serviceability[1]	mm			
4	Differential settlement	mm			
5	Mining subsidence (if any)	mm			
6	Vehicle impact loading (if any) and applicable Annexure (R271/E, F or G)				

A3 WIND LOADS

For assessing wind loads, use the project-specific data provided in Table R271/A.3. For explanations, refer to Specification Guide NR271.

(a) Wind Region

The Wind Region applicable to the project is specified in Clause A2.1(d). This is based on Figure 3.1 of AS/NZS 1170.2:2002 and is one of the following:

(i) Region B, if the area of NSW is above 30° latitude and within 100 km of coast;

(ii) Regions A1, A2, A3, A4 for other areas of NSW, as shown in Figure 3.1 of AS/NZS 1170.2.

(b) Design Information for Each Segment

Information specific to each Segment is contained in Table R271/A.3. The methodology for evaluating these multipliers is dealt with in detail in Specification Guide NR271.

Table R271/A.3 – Design Inputs for Wind Analysis

Item	Description	First Segment		Last Segment
1	Terrain-height multiplier ($M_{z,cat}$)			
2	Hill shape multiplier (M_h)			
3	Hill slope modifier (k)			
4	Multiplier for bridges (M_b)			
5	Shielding multiplier (M_s)			

A4 EARTHQUAKE

The earthquake acceleration coefficient applicable to the project is specified in Clause A2.1(e). Other information specific to the given segment is as follows.

[1] Deflection limits for concrete and steel members are specified in Annexure R271/H. For some other materials, suggested deflection limits are given in Table C1 of AS/NZS 1170.0:2002.

Table R271/A.4 – Design Inputs for Earthquake Analysis

Item	Description	First Segment		Last Segment
1	Site factor (S)			
2	Response factor (R_f)			

A5 GEOTECHNICAL

For design of footings, the ultimate bearing resistance of the subsoil (p_u) and the minimum depth below ground level at which it can be mobilised (d_f) is assessed in the preliminary design, and may serve as a guide for the detailed design. The wall footing may be founded at a depth d_f or deeper if required for stability.

Table R271/A.5 – Project-Specific Geotechnical Requirements

Item	Description	Units	First Segment		Last Segment
1	Type of founding material				
2	Type of substructure				
3	Ultimate design pressure of subsoil (p_u)	kPa			
4	Minimum founding depth (d_f)	m			
5	Height of backfill retained (if applicable)	m			
6	Surcharge on backfill (if applicable)	kPa			

A6 INTERACTION WITH OTHER STRUCTURES

This clause pertains to the design of structures affected by the construction of the noise walls such as bridge decks, parapets or retaining walls on which the noise walls are mounted. Design of noise walls in the Contract is limited to supplying the loads imposed by the noise wall on the structure. If the structure also needs to be analysed for the effect of these loads, the design must be based on the information in Table R271/A.6.

Table R271/A.6 – Details of Structures to be Designed for Loads Imposed by Noise Walls

Type of structure	Segment	Brief description of design work required	List of drawings supplied

A7 LOAD TESTING

If load testing is required, provide the following information. Values for the factors below are in Annexure R271/H.

Description and marking of unit(s) to be tested ……

A7.1 Test Load

(i) Test load applied for ultimate limit state ……

(ii) Test load applied for serviceability limit state ……

(iii) Number of load increments ……

(iv) Rate of loading ……

(v) Time for which test load must be maintained ……

(vi) Rate of unloading ……

(vii) Time after which deflection recovery must be measured ……

A7.2 Serviceability Requirements

(i) Maximum permissible deflection (δ_{max}) ……

(ii) Maximum permissible crack width (w_{max}) ……

A7.3 Proof Testing

(i) Number of units to be tested ……

A7.4 Prototype Testing

(i) Number of units to be tested ……

(ii) Variability factor for serviceability loads (λ_s) ……

(iii) Variability factor for ultimate loads (λ_u) ……

A7.5 Testing of Samples to Failure

(i) Number of units to be tested ……

(ii) Test capacity reduction factor (Φ_T) ……

A7.6 Testing for Debris (Annexure R271/E)

(i) Number of units to be tested ……

(ii) Recommended laboratory for the test ……

A7.7 Testing for Stone Impact (Annexure R271/F)

(i) Number of units to be tested ……

(ii) Recommended laboratory for the test ……

A7.8 Testing for Traffic Impact (Annexure R271/G)

(i) Number of units to be tested ……

(ii) Recommended laboratory for the test ……

ANNEXURE R271/B – MEASUREMENT AND PAYMENT AND RESOLUTION OF NONCONFORMITIES

B1 PAYMENT

Payment will be made for all costs associated with completing the work detailed in this Specification in accordance with the following Pay Items, except for the following:

(i) Payment for clearing and grubbing will be in accordance with Specification TfNSW G40.

(ii) Payment for the removal and stockpiling of topsoil, general excavation, removal and replacement of unsuitable foundation material, and supply and placement of fill material, will be in accordance with TfNSW R44.

Where no specific pay items are provided for a particular item of work, the costs associated with that item of work are deemed to be included in the rates and prices generally for the Work Under the Contract.

Unless specified otherwise, a lump sum price for any of these items will not be accepted.

Pay Item R271P1 – Design of Noise Wall

This is a Lump Sum item covering all activities associated with the design of the noise wall including the design, preparation of design output, design verification and certification, as well as any site investigation and testing required or other works specified in this Specification not included in the Pay Items below.

Pay Item R271P2 – Preparation of Samples

Refer to Clause 7.6 of this Specification.

This is a Lump Sum item.

Pay Item R271P3 – Testing of Noise Wall Prototypes or Samples

Refer to Clauses 4.3, 4.4 and 6.4 of this Specification.

This is a Lump Sum item.

Pay Item R271P4 – Supply of Components

This item covers the supply to site of all components for the noise wall, including those for foundations and footings, panel elements, connections, joint fillers and sealants and any other required components.

The unit of measurement is square metres of wall surface area ("m^2").

The area is determined on the basis of the design exposed surface area of one side of the wall, but excluding footings and any buried area of wall.

Pay Item R271P5 – Preparation of Foundation

This item covers all work necessary to prepare the foundations for the noise wall, including any detailed excavation. It includes any treatment of existing surfaces to accept the footings for the noise walls.

This is a Lump Sum item.

Pay Item R271P6 – Footings

This item covers all work and materials required for the construction of the noise wall footings, including piling. It is determined on the basis of the length of the wall.

The unit of measurement is metre ("m") length of the wall.

Pay Item R271P7 – Erection of Noise Wall

This item covers the erection of the panel elements and associated components and the placement of joint fillers and sealants.

The area is determined on the basis of the design exposed surface area of one side of the wall, but excluding footings and any buried area of wall.

The unit of measurement is square metres of wall surface area ("m^2").

Pay Item R271P8 – Testing of Noise Wall

Refer to Clauses 4.1 and 4.2 of this Specification.

This is a Lump Sum item.

Pay Item R271P9 – Painting and Anti-graffiti Treatment of Noise Wall

Pay Item R271P9.1 - Painting

Pay Item R271P9.2 - Anti-graffiti Treatment

These items cover the painting and anti-graffiti treatment of the panel elements and associated components.

The area is determined on the basis of the design exposed surface area of one side of the wall, but excluding footings and any buried area of wall.

The unit of measurement is square metres of wall surface area ("m^2").

B2 NONCONFORMITIES

Damaged panels may be repaired, subject to the approval of the Principal. If the repair is considered inadequate or not up to the standard required by the Principal, the panel will be rejected.

The repair or removal, disposal and replacement of damaged panels are at your own cost.

ANNEXURE R271/C – SCHEDULES OF HOLD POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS

Clause	Description
4.1.3	Acceptance of load test results
5.2.5	Submission of preliminary design
5.4	Certification of detailed design documentation
6.5	Certification of materials for panels
7.6.1	Preparation of concrete pigment samples
7.6.2	Demonstration of reparability
7.6.3	Preparation of panel specimen
8.1	Survey marks
8.5.4	Inspection of foundations
8.7	Damaged panels
8.7	Repaired panels
8.7	Repairs after installation
8.10	Completion Certificate

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of TfNSW Q Annexure Q/E.

Clause	Description of Identified Record
4.1.3	Record of Acceptance test results and clearance certificate from the design Engineer that the results are satisfactory.
4.2	If applicable, record of proof testing results and certification of compliance of the tested members.
4.3	If applicable, record of prototype testing results and certification of compliance of the tested members.
4.4	If applicable, record of results of prototypes tested to failure and certification of compliance of the tested members.
5.2	If preliminary design is involved, reports, calculations and drawings detailed in Clause 5.2 and all the information required in Annexure R271/A.
5.3.1 to 5.3.4	If detailed design is involved, reports, calculations and drawings detailed in Clauses 5.3.1 to 5.3.4.
5.3.5	If applicable, job-specific specification prepared for manufacture and construction.

Clause	Description of Identified Record
5.3.6, 7.6.2, 8.12	If applicable, Maintenance Manual.
6.4	Record of results of tests carried out on materials.
6.5	Certification of compliance of the materials proposed.
8.5	Drawings showing the locations of all underground and overhead utilities or services in the vicinity of the noise wall.
8.5.4	Verification by Geotechnical Engineer that the Site and foundation meet design requirements.
8.7	If applicable, details of damaged panels and their repairs including those with cracks appeared after installation.
8.10	Certification of the Work of its conformity with this Specification.

ANNEXURE R271/D – PLANNING DOCUMENTS

Refer to Clause 1.2.4.

The information to be submitted by you as part of your PROJECT QUALITY PLAN must include, but not be limited to, the following:

(a) Certification that all the components supplied for the construction of noise wall meet this Specification (refer to Clause 6). Submit documentation associated with the PROJECT QUALITY PLAN, including all inspections and records.

(b) Details of construction materials to be used and their conformity with design requirements (refer to Clause 7), such as:

  (i) Nomination of the components of the concrete mix, with the amount of cementitious materials expressed in kg/m^3 of concrete;

  (ii) Method of placing and compacting concrete;

  (iii) Method of curing and if curing by steam, details of hours and temperature during all stages of the curing; and

  (iv) Copy of the current certificate for accuracy of all batch weighing machines.

(c) Details of preparation of the foundations (refer to Clause 8.5).

(d) Method of construction of noise walls (refer to Clause 8), including:

  (i) Method of determining strength for lifting panel off the bed and the time and method of lifting;

  (ii) Lifting, handling, stacking and delivery methods;

  (iii) Type and number of formwork elements to be used for the Contract;

  (iv) Panel identification codes;

  (v) Details of the dimensional check method for panel tolerances; and

  (vi) Erection methods.

This information is in addition to the information required by TfNSW Q.

ANNEXURE R271/E – TESTING FOR FALLING DEBRIS DUE TO IMPACT

Refer to Clauses 2.3.4, 3.5.9 and 4.3.4.

This Annexure is an amended extract from European Standard EN 1794-2.

E1 GENERAL

Noise walls can be mounted on structures or in such a way that, if damaged, they could pose a hazard to road users or to others. In particular, even if the noise wall is protected by the safety system on an elevated structure, there is a possibility for pieces or whole panels from a noise wall becoming detached as the result of a violent collision and falling, thus endangering those below.

Noise walls that are to be used in a vulnerable position may be required to be restrained by internal or external linkages between panels and/or elements to prevent them from becoming detached and falling.

The standard provides some general indications of factors which need to be considered, and also provides a method of establishing the resistance of a product to a severe blow.

Note that it is principally the responsibility of the Design Engineer to consider the potential consequences of a wall becoming damaged and to provide protection accordingly.

Alternatively, a means of catching falling pieces detached from vulnerable walls may be specified for wall systems which are not restrained.

E2 REQUIREMENTS

E2.1 Susceptibility to Shattering

Where it is known that any component of a wall is liable to shatter if struck or shocked, this must be clearly stated.

E2.2 Fastening of Structural and Acoustical Elements

A noise wall can be assumed to be safety fastened if the elements are secured in such a way that they do not fall when they are deformed or broken. Design the restraint systems to withstand the self-weight of the relevant parts of the device, multiplied by a load factor of 4. The wet self-weight must be used and calculated in accordance with Annexure B of EN 1794-1.

If structural and acoustical elements of the noise wall are prevented from falling by a system of restraints linking them together, each link must take the load of all adjoining elements. Assume that the load applied by broken pieces of a wall is the weight of a single element acting at the most unfavourable position on the restraint system.

E3 TEST METHOD

This is the test method to assess the characteristics of the falling debris produced by fixed energy impacts.

E3.1 Principle

The method of testing is to cause a heavy mass to strike normally at the centre or the most sensitive point of the test specimen or other tested element or system, so that the test specimen is destroyed or pushed out of the holding structure, or, alternatively to show its behaviour during the test.

E3.2 Test Equipment

The test equipment consists of:

(i) impactor;

(ii) structure holding the test specimen;

(iii) structure used to produce the impact; and

(iv) high speed video camera to record the test.

E3.3 Impactor

The impactor consists of a rotation symmetrical full steel double cone. Based on a density of 7700 kg/m^3 for steel, the impactor has a mass of 400 kg, with the dimensions shown without parentheses in Figure E.1, and a mass of 45 kg with the dimensions shown in parentheses.

E3.4 Test Specimen

Assemble the test specimen in the supporting structure in the way intended by the manufacturer, including dimensions, fixings, seals and any connecting systems. Test elements or systems with an integrated or attached restraint structure as complete units.

E3.5 Structure Holding the Test Specimen

Design the structure holding the test specimen to be able to withstand the whole impact energy. In all cases, the structure must allow a good camera position for proper documentation.

E3.6 Structure Used to Produce the Impact

Produce the impact by a pendulum. The impactor must swing on two wires fixed on two points above the structure holding the test sample as shown in Figure R271/E.1. In order to reach the impact energy of 6.0 (0.5) kJ, the height of the fall of the impactor with 400 (45) kg mass must be 1.50 (1.10) m, corresponding to a speed of 19.5 (16.7) km/h or 5.42 (4.64) m/s. The radius of the pendulum must be 4 m minimum.

E3.7 Evaluation

Take into account the falling debris caused by the first impact only. This can be achieved, for example, by restraining the pendulum after the first impact or by proper analysis of the video documentation.

E3.7.1 Acceptance Criteria

(i) No rigid pieces of test specimen larger than 25 cm^2 weighing more than 0.1 kg;

(ii) No rigid pieces of test specimen longer than 15 cm;

(iii) No rigid pieces with angles of less than 15° and weighing more than 0.1 kg;

(iv) No pieces weighing more than 0.4 kg; and

(v) No rigid sharp pieces thinner than 1 mm and weighing more than 0.1 kg.

E3.7.2 Results

Classify the pieces as follows:

A Free pieces not meeting the criteria;

B Free pieces meeting the criteria;

C No pieces at all.

Table R271/E.1 – Classification of Results of Impact Test

Class	Test Energy (kJ)	Result
0	Not tested	
1	0.5	A
2	0.5	B
3	0.5	C
4	6.0	A
5	6.0	B
6	6.0	C

E3.8 Test Report

The test report must include a full description of the test arrangement, including details of supports, procedures and locations of points of impact. It must also include:

(a) Applicable version (Edition and Revision number) of TfNSW R271;

(b) Name and address of the testing institute with a dated signature of the person responsible;

(c) Exact identification of the specimen, the name and address of the manufacturer;

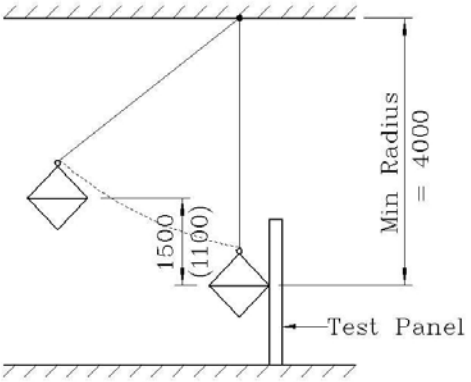
(d) Full description of the materials and their thicknesses;

(e) Drawing showing the cross section of the specimen;

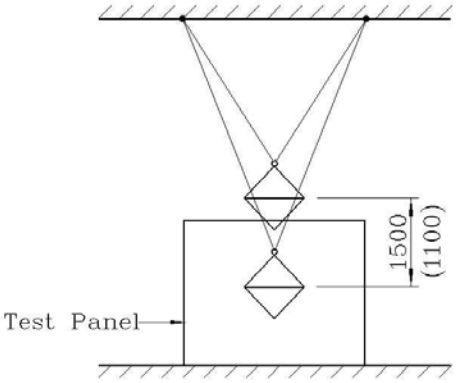
(f) Results of tests and the resulting classification; including details of pieces not meeting the criteria;

(g) Documentation of development and the effect of every impact by means of high-speed video cameras and photos;

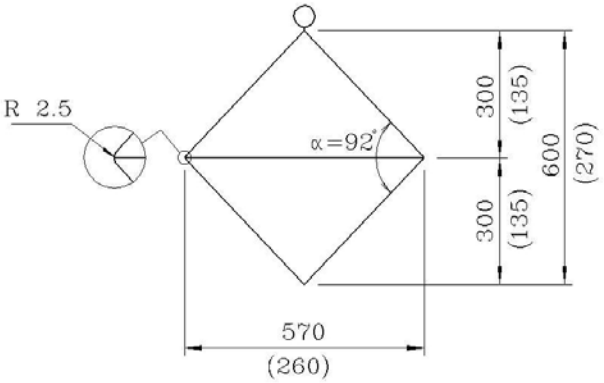
(h) Description and documentation of any damages to the sample like cracks and deformations.



(a) Arrangement for the test



(b) End view in (a)



(c) Detail of Impactor

Notes:

1) All dimensions are in millimetres
2) Dimensions in parenthesis are for 45 kg Impactor and impacting energy of 0.5 kJ
3) Dimensions without parenthesis are for 400 kg Impactor and impacting energy of 6.0 kJ

Figure R271/E.1 – Impact Test for Falling Debris

ANNEXURE R271/F – IMPACT OF STONES

Refer to Clauses 2.3.4, 3.5.9 and 4.3.4.

F1 GENERAL

This Annexure is an amended extract from European Standard EN 1794-1.

Noise walls placed alongside roads are exposed to the impacts of stones thrown up from the road surface. It is essential that they are resistant to such impacts, only sustaining superficial damage.

This annexure provides a standard laboratory test which simulates minor impacts such as those caused by stones thrown up from the road surface. It does not allow for the impact of heavy objects or acts of vandalism.

F2 REQUIREMENTS

When testing in accordance with Clause F3:

(i) Use a hardened steel striker of the dimensions shown in Figure R271/F.1(b);

(ii) The impact energy of the hammer must be 30 Nm ± 1 Nm;

(iii) Confine damage to the outer parts of the construction and internal elements must not be damaged or displaced by the impacts;

(iv) The striker must not penetrate the outer wall of hollow elements, but localised damage in the form of splits less than 50 mm long is acceptable;

(v) Minor damage to the surface of brittle materials in the form of craters (where fragments are broken out) is acceptable, provided that the depth of any crater is less than the thickness of the outer wall or 20 mm, whichever is smaller.

F3 TEST METHOD

Simulate the impact of stones by testing with a mechanical hammer, as described in this clause.

Carry out tests at the following three points within a test area bounded by a margin of 125 mm around the edge of the test panel, on each exposed face as shown in Figure R271/F.1(a):

(i) near one corner of the test area;

(ii) near the centre of the test area; and

(iii) at one other point within the test area, chosen at random.

Choose the exact position of the points to be tested to be representative of the panel as a whole, by avoiding ribs, or other obvious places of local strength.

Hold test panels made from materials which become brittle at low temperatures at –20°C for 2 hours prior to testing for impact.

Precautions must be taken to prevent the hammer passing completely through the device under test should it fail completely. In order to ensure the safety of the operator, place a solid abutment approximately 50 mm behind the test specimen opposite the point of impact.

F4 TEST REPORT

The test report must include full description of the test arrangement, including details of supports, procedures and locations of points of impact.

It must also include:

(i) edition and revision number and date of this Specification R271 Annexure R271/F;

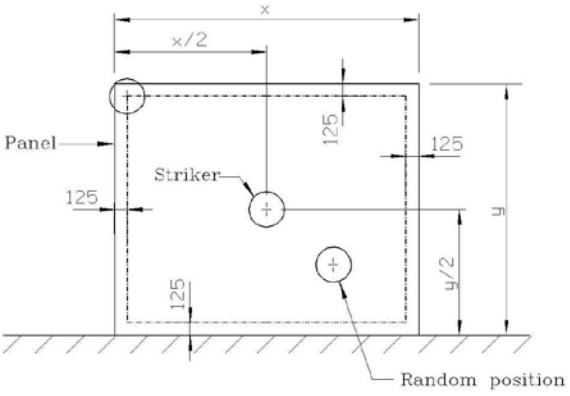
(ii) the name and address of the testing institute with a dated signature of the person responsible;

(iii) an exact identification of the specimen, the name and address of the manufacturer;

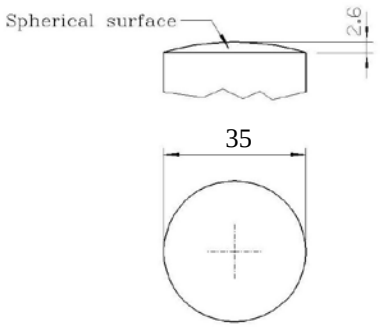
(iv) a full description of the materials and their thicknesses;

(v) a drawing showing the cross section of the specimen; and

(vi) the results of tests; and assessment as to whether these indicate satisfactory performance.



(a) Reference Points for the Impact Test
All dimensions are in millimetres



(b) Dimensions of Striker Point
All dimensions are in millimetres

Figure R271/F.1 – Arrangement of Stone Impact Test

ANNEXURE R271/G – TRAFFIC SAFETY: SAFETY IN COLLISIONS

Refer to Clauses 2.3.4, 3.5.9 and 4.3.4.

G1 GENERAL

In general, noise walls are not required to withstand vehicle impact. Such impacts may be prevented either by using a road restraint system or by providing adequate distance from the road. Where neither of these options are available, the relevant authorities will need to consider the consequences of vehicle impact and whether the noise wall must itself act as a traffic barrier.

This annexure applies to noise walls for which the consequences of vehicle impact can be considered to be acceptable from the point of view of the vehicle occupants.

G2 TESTING AND CALCULATIONS

Evaluate the safety performance of noise walls in respect of controlling the behaviour of errant vehicles in accordance with AS/NZS 3845.

State the masses, crash speeds and angles of the test vehicles for which the requirements are fulfilled when applied to particular noise wall systems.

The acceptance criteria for vehicle occupant safety for traffic safe noise walls are as follows:

(i) Elements of the noise wall must not penetrate the passenger compartment of the vehicle. Deformations of, or intrusion into, the passengers' compartment that could cause serious injuries are not permitted;

(ii) The vehicle must remain upright driving after collision, although moderate rolling, pitching and yawing are acceptable;

(iii) The impact severity level must be as defined in AS/NZS 3845, excepting that, where a wall may fall onto a roadway, footway or house behind.

The acceptance criteria for vehicle occupant safety for combined traffic barriers and noise walls are the same as for traffic barriers to AS/NZS 3845. Design loads must be to AS 5100.2. For noise walls on bridges or retaining walls, the minimum class of wall is regular in accordance with AS 5100.2.

ANNEXURE R271/H – LOAD TESTING

Refer to Clause A7 of Annexure R271/A.

This Annexure specifies load testing criteria for noise walls. The requirements for precast concrete elements regarding crack widths, variability factors etc. are adopted from AS 1597.2 (for load testing of precast concrete culverts). If more appropriate criteria are available from recognised Standards for the material being tested, these should be substituted and testing procedures also modified as necessary. For example, for timber structures, the duration of the load is significant and the test load must be modified to account for the difference in durations between the test loading and the actual loading (predominantly wind gusts) in accordance with AS 1720.1.

Masonry panels may be tested in accordance with AS 3700.

Steel components may be tested in accordance with AS 4100.

H1 PROOF TESTING

Proof testing normally validates only the unit which is tested. If the results are to be extrapolated to the population, then increase the design load by a "Proof Load Factor" to give the test load. Values of the Proof Load Factor, which depends on the size of the sample being tested are given in AS 1597.2 for precast reinforced concrete box culverts and may serve as a guide.

H1.1 Deflection Limitations

The maximum permissible deflection (δ_{max}) must be as follows:

(i) For concrete and steel members:

$\delta_{max} = L_n/250$ mm, for a member acting as a beam or slab, or

$\delta_{max} = L_n/125$ mm for a member acting as a cantilever

where:

L_n = the span length in millimetre

H1.2 Crack Width Limitations

The measured crack width in the proof test unit under serviceability test load and after removal of the load must not exceed the appropriate value given in Table R271/H.1

Table R271/H.1 – Maximum Crack Widths at Serviceability Test Loads

Cover (mm)	Maximum crack widths (mm)	
	Serviceability load applied	After serviceability load removed
23 – 35	0.35	0.20
> 35	0.50	0.30

H2 PROTOTYPE TESTING

The Variability Factors are as follows:

Table R271/H.2 – Factor to Allow for Variability of Structural Units

Number of similar units tested	Variability Factor for serviceability loads (λ_s)	Variability Factor for ultimate loads (λ_u)	
		Element of a unit	Complete unit
1	1.2	1.5	1.8
2	1.2	1.4	1.6
3	1.2	1.3	1.5
4	1.1	1.3	1.5
5	1.1	1.3	1.5
10 or more	1.1	1.2	1.3

For steel structures, the Variability Factors are similar and must be in accordance with AS 4100.

For timber elements, apply a similar "Sampling Factor" in accordance with AS 1720.1.

H3 TESTING OF SAMPLES TO FAILURE

The test capacity reduction factors must be read off Figure R271/H.1 for the number of units tested (*n*).

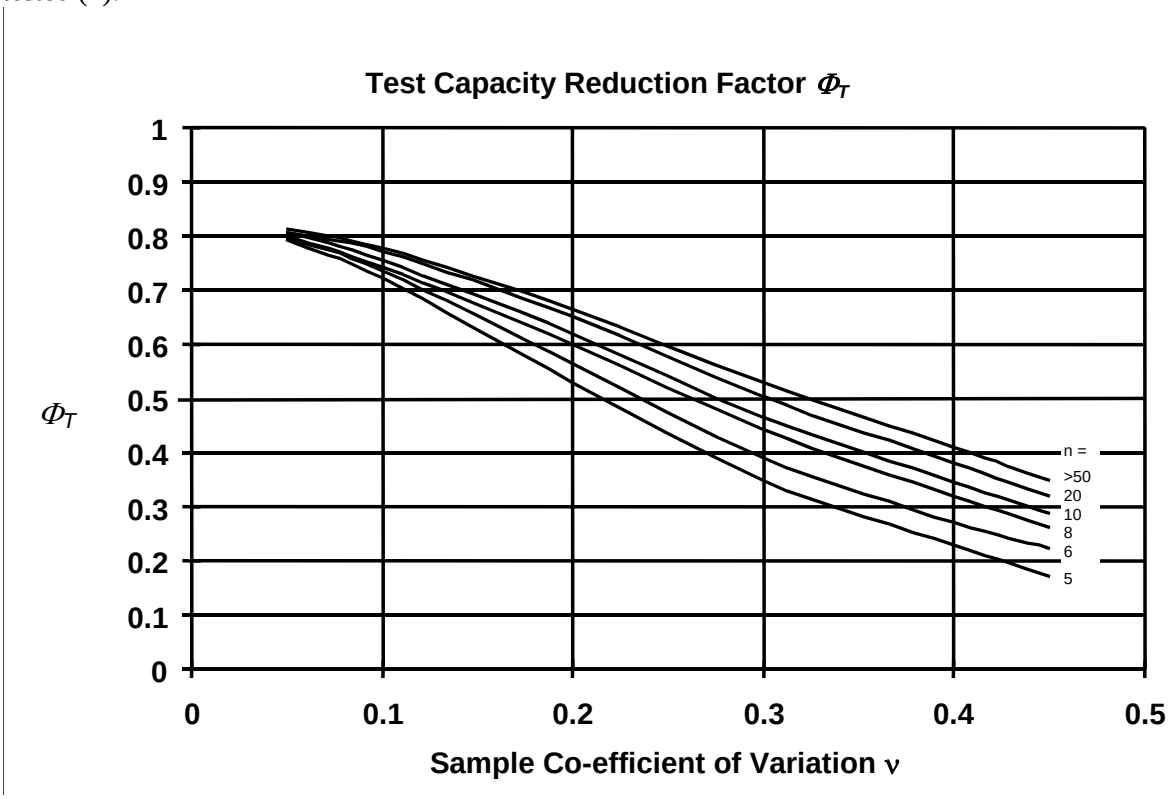


Figure R271/H.1 – Test Capacity Reduction Factor

ANNEXURES R271/I TO R271/L – (NOT USED)

ANNEXURE R271/M – REFERENCED DOCUMENTS AND GUIDE DOCUMENTS

Refer to Clause 1.2.6.

M1 REFERENCES

TfNSW Specifications

TfNSW G1	Job Specific Requirements
TfNSW G2	General Requirements
TfNSW G38	Soil and Water Management
TfNSW G40	Clearing and Grubbing
TfNSW G71	Construction Surveys
TfNSW G73	Detail Survey
TfNSW Q	Quality Management System
TfNSW B30	Excavation and Backfill for Bridgeworks
TfNSW B50	Driven Reinforced Concrete Piles
TfNSW B51	Driven Prestressed Concrete Piles
TfNSW B53	Driven H-Section Steel Piles
TfNSW B54	Driven Tubular Steel Piles
TfNSW B57	Driven Cast-in-place Concrete Piles
TfNSW B58	Bored Cast-in-place Reinforced Concrete Piles (With Permanent Casing)
TfNSW B59	Bored Cast-in-place Reinforced Concrete Piles (Without Permanent Casing)
TfNSW B61	Driven Composite Piles
TfNSW B201	Steelwork for Bridges
TfNSW B220	Protective Treatment of Bridge Steelwork
TfNSW B240	Steel Fasteners
TfNSW B246	Manufacture and Supply of Minor Aluminium Items
TfNSW B349	Precast Concrete Noise Wall Members (Not Pretensioned)
TfNSW R44	Earthworks
TfNSW 2380	Timber for Bridges

TfNSW Test Methods

TfNSW T166	Determination of Relative Compaction

Australian Standards

AS/NZS 1170	Structural design actions
AS/NZS 1170.0	General principles

AS/NZS 1170.1	Permanent, imposed and other actions
AS/NZS 1170.2	Wind actions
AS 1170.4	Earthquake actions in Australia
AS 1276	Methods for determination of sound transmission class and noise isolation class of building partitions (superseded)
AS 1288	Glass in buildings – Selection and installation
AS/NZS 1328	Glued laminated structural timber
AS/NZS 1328.1	Performance requirements and minimum production requirements
AS/NZS 1328.2	Guidelines for AS/NZS 1328: Part 1 for the selection, production and installation of glued laminated structural timber
AS 1379	Specification and supply of concrete
AS/NZS 1554.1	Structural steel welding – Welding of steel structures
AS/NZS 1580	Paints and related materials – Methods of test
AS/NZS 1580.403.2	Abrasion resistance – Taber abraser
AS/NZS 1580.408.5	Adhesion – Pull-off test
AS/NZS 1580.481.1.7	Coatings – Exposed to weathering – Degree of checking
AS/NZS 1580.481.1.8	Coatings – Exposed to weathering – Degree of cracking
AS/NZS 1580.481.1.9	Coatings – Exposed to weathering – Degree of blistering
AS/NZS 1580.481.1.11	Coatings – Exposed to weathering – Degree of chalking
AS/NZS 1580.601.4	Colour – Calculation of colour differences
AS 1597.2	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/NZS 1604	Specification for preservative treatment
AS 1604.1	Sawn and round timber
AS/NZS 1604.5	Glued laminated timber products
AS 1720	Timber structures
AS 1720.1	Design methods
AS 1720.2	Timber properties
AS 1720.4	Fire resistance for structural adequacy of timber members
AS 1745.1	Outdoor weathering of plastics in the Australian environment – Commercial products (withdrawn)
AS/NZS 2047	Windows in buildings – Selection and installation
AS/NZS 2269	Plywood – Structural
AS/NZS 2312	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
AS 2331	Methods of test for metallic and related coatings
AS 2331.3.1	Corrosion and related property tests – Neutral salt spray (NSS) test
AS 2331.3.2	Corrosion and related property tests – Acetic acid salt spray test (ASS test)

AS 2331.3.3	Corrosion and related property tests – Copper accelerated acetic acid salt spray test (CASS test)
AS 2700	Colour standards for general purposes
AS 3600	Concrete structures
AS 3610	Formwork for concrete
AS 3700	Masonry structures
AS/NZS 3845	Road safety barrier systems
AS 4100	Steel structures
AS/NZS 4284	Testing of building facades
AS/NZS 4673	Cold-formed stainless steel structures
AS 4678	Earth-retaining structures
AS/NZS 4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
AS 5100	Bridge design
AS 5100.2	Design loads
AS 5100.3	Foundations and soil supporting structures
AS 5146	Reinforced Autoclaved Aerated Concrete
AS 5146.1	Structures
AS 5146.2	Design
AS 5146.3	Construction
AS/NZS ISO 9001	Quality management systems – Requirements

Other Standards

ASTM E 84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM G 21	Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
ANSI/SAE Z26.1	Safety Glazing Materials for Glazing Motor Vehicles and Motor Vehicle Equipment Operating on Land Highways--Safety Standard
DIN 5036.3	Radiometric and photometric properties of materials; methods of measurement for photometric and spectral radiometric characteristics
EN 1794-1	Road traffic noise reducing devises – Non-acoustic performance – Part 1: Mechanical performance and stability requirements
EN 1794-2	Road traffic noise reducing devises – Non-acoustic performance – Part 2: General safety and environmental requirements
ISO 4892-2	Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps
ISO 11341	Paints and varnishes – Artificial weathering and exposure to artificial radiation – Exposure to filtered xenon-arc radiation
ISO 11507	Paints and varnishes – Exposure of coatings to artificial weathering – Exposure to fluorescent UV and water

ZTV Lsw 88 Additional Technical Regulations and Guidelines for the Design of Noise Protection Walls along Roads, Ministry of Traffic, Federal republic of Germany, 1988

M2 GUIDE DOCUMENTS

Holmes, J. D. A wind-tunnel study of wind loads on traffic noise barriers, Report JDH 99/3, June 1999, JDH Consulting, PO Box 269, Mentone VIC 3194.

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ANNEXURE R271/N – NOTATION

Notation is generally defined as follows. However, when symbols are defined locally, the local definition supersedes the general definition below.

a = span length of panel; earthquake acceleration coefficient

a_o = basic earthquake acceleration coefficient

b = width of panel

c = height of wall; height of hoarding

d = height of panel as shown in Figure R271.1

e = eccentricity of force from the centreline of the panel

h = distance from top of wall to the ground

h_b = height of the noise wall plus traffic barrier, if any, above deck level

k = hill slope modifier (Clause 2.2.4.3 of Specification Guide NR271)

k_p = probability factor for earthquake analysis

n = factor equal to 4 upwind for all slope types and downwind for hills and ridges, or 10 downwind for escarpments; sample size

p = ultimate design wind pressure normal to wall

p_a = active earth pressure due to fill

p_c = computed normal pressure to wall for tested model

p_m = pressure measured on noise wall model in wind tunnel

p_p = passive pressure at specified depth

q = gust dynamic wind pressure; surcharge pressure on retained earth surface

r = ratio p_c / p_m

s = clear height below bridge deck

t = thickness of the panel

u = width of each projection

w = distance between parallel noise walls

x = horizontal distance from crest of topographic feature to noise wall

x_i = length of the transition zone

y = height, in metres, from base of footing (or shear key, if provided) to 0.5 m below permanent ground level, provided the ground is not sloping

z = height from top of noise wall to appropriate level

A_e = exposed area of each support in the direction normal to wind

B = overall length of noise wall

C = earthquake design coefficient

C_d = drag coefficient

C_f = frictional drag coefficient for each exposed surface

C_{fig} = aerodynamic shape factor

$C_{p,n}$ = a normal pressure coefficient

C_Y = runoff coefficient

D = serviceability criteria such as deflection, cracking etc.

F = resultant force on panel

F_d = forces or moments that produce a de-stabilising effect or longitudinal force on each support of a hoarding due to wind drag effects

F_{eq} = computed earthquake effects

F_f = longitudinal force due to frictional drag effects of wind, acting along each exposed surface of the wall at mid height

F_m = structural effects on members and foundation

F_n = force acting normal to the wall at mid-height of the panel

F_r = longitudinal force due to frictional drag

F_s = forces or moments that produce a stabilising effect

F_{sn} = corresponding normal wind force on the panel

F_t = longitudinal force on the end panel

F_u = additional longitudinal force accounting for the cumulative effect of the projections

G = dead load and other permanent load effects

H = height of topographic feature to crest

I = importance level of the structure

I_{eq} = importance factor for earthquake analysis

K_a = span reduction factor for panel; active earth pressure coefficient

L = appropriate length as defined, with subscripts

L_1 = greater of $0.36L_u$ or $0.4H$

L_2 = given by nL_1

L_n = span length in millimetres

L_u = horizontal distance upwind from the crest of the hill, ridge or escarpment to a level half the height below the crest

M = abbreviated expression refering to all multipliers with letter M

M_b = multiplier replacing topographic multiplier for bridges

M_d = wind direction multiplier

M_h = hill shape multiplier

M_s = shielding multiplier

M_t = topographic multiplier

$M_{z,.cat}$ = terrain category multiplier for appropriate height z

N = design life of noise wall, in years

P^* = test loading in accordance with the calculated loads S^*

P_i = characteristic failure load for each failure mode

P_N = probability of the event being exceeded during the full design life of a structure

R = average recurrence interval

R^* = design strength

R_d = load capacity for each load combination and failure mode

R_f = response factor

R_{lim} = nominal strength, corresponding to S^* for the appropriate limit state

R_s = average recurrence interval for limit state design

R_u = ultimate strength of the structural component or foundation to be factored by ϕ

S = site factor

S^* = design action effect (force, stress, deflection, etc.) for the appropriate limit state

T = structure period, in seconds

V = base shear

V_{des} = design wind velocity

$V_{des,\theta}$ = orthogonal design wind speeds as specified in AS/NZS 1170.2

V_R = regional wind velocity

V_s = site specific wind velocity

$V_{sit,\beta}$ = site wind speed in a direction whose bearing is β

W_s = serviceability wind effects

W_u = ultimate wind effects

β = bearing angle measured clockwise from the north direction

δ = deflection, in mm, due to the dead load of the panel acting horizontally

δ_{max} = deflection limit or maximum permissible deflection

δ_s = observed deflection at serviceability loading

ϕ = strength (or capacity) reduction factor

λ_s = variability factor for serviceability loads

μ_P = sample mean peak load

μ_r = mean value of pressure ratio r

ν = coefficient of variation from the characteristic failure load of magnitude P_i

θ = angle between wind direction and normal to the wall

ρ = criterion for assessing the safety of the proposed formula

σ_P = standard deviation of characteristic failure load of magnitude P_i

σ_r = standard deviation of pressure ratio r

w_{max} = specified maximum crack width

w_s = observed crack width at serviceability loading

ξ = ratio $|x|/H$ for calculating M_h

ψ = average slope of upper half of topographic feature

ζ = ratio H/z for calculating M_h

Φ_T = test capacity reduction factor