

Australian/New Zealand Standard™

Buried corrugated metal structures

Part 2: Installation



AS/NZS 2041.2:2011

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee CE-025, Corrugated Metal Drainage Pipes and Arches. It was approved on behalf of the Council of Standards Australia on 20 October 2010 and on behalf of the Council of Standards New Zealand on 5 November 2010. This Standard was published on 4 April 2011.

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This Standard was issued in draft form for comment as DR 10016.

Australian/New Zealand Standard™

Buried corrugated metal structures

Part 2: Installation

Originated, in part, as AS 1762—1984, AS 3703.2—1989 and AS/NZS 2041:1998.
Revised and redesignated AS/NZS 2041.2:2011.

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PREFACE

This Standard was prepared by the joint Standards Australia/Standards New Zealand Committee CE-025, Corrugated Metal Drainage Pipes and Arches, to supersede, in part, the following:

AS/NZS 2041:1998, Buried corrugated metal structures

AS 3703.2—1989, Long-span corrugated steel structures, Part 2: Design and installation

AS 1762—1984, Helical lock-seam corrugated steel pipes—Design and installation

The objective of this Standard is to provide designers, manufacturers and installers of buried corrugated metal structures with requirements for installation of such structures for use in earthworks as culverts or accessways.

This Standard is Part 2 of the AS/NZS 2041 series, Buried corrugated metal structures, which comprises the following parts:

AS/NZS

2041 Buried corrugated metal structures

2041.1 Part 1: Design methods

2041.2 Part 2: Installation (this Standard)

2041.4 Part 4: Helically formed sinusoidal pipes

2041.6 Part 6: Bolted plate structures

Other parts of the series currently being drafted include the following:

Part 3: Assessment of existing structures

Part 5: Helically formed ribbed pipes

Part 7: Bolted plate structures with transverse stiffeners

Part 8: Metal box structures

This Edition includes the following changes:

- (a) Design requirements have been moved to AS/NZS 2041.1, which includes new limit states design methods.
- (b) Materials and fabrication requirements have been moved to the other parts of the AS/NZS 2041 series (Parts 4 and 6).
- (c) Clauses have been added to assist the installer to better understand the design issues relating to proper installation.

The term ‘informative’ has been used in this Standard to define the application of the appendix to which it applies. An ‘informative’ appendix is only for information and guidance.

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Australian/New Zealand Standard Buried corrugated metal structures

Part 2: Installation

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for the installation of buried corrugated metal structures intended for use in stormwater drainage and as access tunnels, to support or accommodate roadway and railway and other loadings.

Buried corrugated metal structures are flexible members that rely on soil-structure interaction. Correct installation is essential to performance. Adequate compaction of the specified fill material is a requisite for meeting the design criteria for strength.

NOTE: Incorrect backfilling procedure may result in collapse of the culvert.

1.2 APPLICATION

This Standard shall be used in conjunction with AS/NZS 2041.1 and the appropriate product Standard of this series (see Clause 1.3).

NOTE: This Standard specifies the installation requirements. The performance of the structure depends on correct installation (particularly adequate compaction of appropriate fill material around the metal structure) for which this Standard gives the requirements. AS/NZS 2041.1 gives information on design issues and requirements for structural design of the metal structure. Other Parts of the AS/NZS 2041 series give requirements for manufacture and fabrication of the products installed using this Standard.

1.3 NORMATIVE REFERENCES

The following are the normative documents referenced in this Standard:

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

AS	
1012	Method of testing concrete
1289	Methods of testing soils for engineering purposes
1289.3.4.1	Method 3.4.1: Soil classification tests—Determination of the linear shrinkage of a soil—Standard method
1289.5.1.1	Method 5.1.1: Soil compaction and density tests—Determination of the dry density/moisture content relation of a soil using standard compactive effort
1289.5.3.1	Method 5.3.1: Soil compaction and density tests—Determination of the field density of a soil—Sand replacement method using a sand-cone pouring apparatus
1289.5.3.2	Method 5.3.2: Soil compaction and density tests—Determination of the field dry density of a soil—Sand replacement method using a sand pouring can, with or without a volume displacer
1289.5.3.5	Method 5.3.5: Soil compaction and density tests—Determination of the field dry density of a soil—Water replacement method

AS

- 1289.5.4.1 Method 5.4.1: Soil compaction and density tests—Compaction control test—Dry density ratio, moisture variation and moisture ratio
- 1289.5.5.1 Method 5.5.1: Soil compaction and density tests—Determination of the minimum and maximum dry density of a cohesionless material—Standard method
- 1289.5.6.1 Method 5.6.1: Soil compaction and density tests—Compaction control test—Density index method for a cohesionless material
- 1289.5.8.1 Method 5.8.1: Soil compaction and density tests—Determination of field density and field moisture content of a soil using a nuclear surface moisture-density gauge—Direct transmission mode

1726 Geotechnical site investigations

3600 Concrete structures

4100 Steel structures

AS/NZS

2041 Buried corrugated metal structures

2041.1 Part 1: Design methods

2041.4 Part 4: Helically formed sinusoidal pipes

2041.6 Part 6: Bolted plate structures

3500 Plumbing and drainage

3500.0 Part 0: Glossary of terms

3750 Paint for steel structures

3750.9 Part 9: Organic zinc-rich paint

4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

NZS

3101 Concrete structures

3101.1 Part 1: The Design of Concrete Structures

1.4 DEFINITIONS

For the purpose of this Standard, the definitions in AS/NZS 3500.0 and those below apply.

NOTE: Where a definition given in AS/NZS 3500.0 differs from the one given below, the definition herein applies.

1.4.1 Bedding

A prepared layer of uncompacted, non-cohesive soil placed over the foundation, below the structure invert.

1.4.2 Camber

A variation to the bedding grade along the structure invert to compensate for post completion differential settlement.

1.4.3 Compaction

The process of soil densification, at a specified moisture content, through the application of load by rolling, tamping, rodding or vibration with mechanical or manual equipment.

1.4.4 Corrugation

Sinusoidal and ribbed profile section shapes.

1.4.5 Cover

The vertical distance between the neutral axis of the structure's corrugation profile at the top of the structure and the—

- (a) pavement surface of road; or
- (b) base of sleepers for railway traffic loads, and surface of track formation for heavy vehicles or equipment running on the track formation; or
- (c) top of trench or embankment where Items (a) and (b) are not applicable; or
- (d) base of a stockpile.

1.4.6 Embankment

Installation condition where the metal structure is to be erected within an embankment of imported compacted soil; or the installation condition where the distance to the undisturbed material from the side of the metal structure at the height of maximum span is greater than or equal to the value in Table 2.4.3 for embankment construction.

1.4.7 Fill, embankment

Fill placed beyond the specified zone of compacted select fill, in accordance with the job specification.

1.4.8 Fill, flowable

A mixture of granular material, fly ash, cement and water proportioned to achieve a compressive strength similar to select fill.

1.4.9 Fill, select

A soil with specified properties and grading, placed and compacted in layers around and over the corrugated metal structure, as specified in this Standard.

1.4.10 Foundation

Naturally occurring or prepared soil or rock underlying the installation, trench and embankment.

1.4.11 Haunch

Part of the periphery of pipe-arches and underpasses, between the crown and invert, that has a relatively small radius of curvature, or the zone outside the lower-side wall of a structure.

1.4.12 Protective coating

A coating designed to isolate the structural base metal wall thickness from the interior and soil side environment.

NOTE: Types of protective coatings include galvanized, polymer, bituminized and epoxy coatings.

1.4.13 Skew number

A number denoting the angle between the centre-line of the road, railway or other embankment and the centre-line of the structure, measured in a clockwise direction.

1.4.14 Spring line

Outermost points in the cross section of a structure (maximum span).

1.4.15 Trench condition

Installation condition where the distance to the undisturbed material from the side of the metal structure at the height of the maximum span is less than the value shown in Table 2.4.3.

1.5 NOTATIONS

The following symbols are used in this Standard:

- A_w = the cross-sectional area of fill material above the structure, but below the crown of the structure (measured from the neutral axis of the corrugated section) in metres squared
- b = minimum transverse backfill distance, in millimetres
- d_e = foundation width and depth, as defined in Figures 2.6.1 and 2.6.7, in millimetres
- d_h = effective horizontal geometrical dimension of structure (to the neutral axis of the corrugation) defined in Figures 1.5(A) and 1.5(B), in millimetres
- d_v = effective vertical geometrical dimension of structure (to the neutral axis of the corrugation) defined in Figures 1.5(A) and 1.5(B), in millimetres
- h = cover as defined in Clause 1.4.5, in millimetres
- h_b = minimum height of structural backfill cover over the crown neutral axis of the metal structure as specified by the designer but not less than $h_{\min}$ minimum cover as calculated in AS/NZS 2041.1, in millimetres
- r_b = bottom radius (centre-line of corrugation), in millimetres
- r_h = haunch radius (centre-line of corrugation), in millimetres
- R_s = effective rise of pipe-arch, arch and special shape or effective diameter of pipe, measured to neutral axis of corrugation profile, in millimetres
- S_b = clear internal bottom span of arch, in millimetres
- S_s = clear internal span of pipe-arch, arch and special shapes or internal diameter of pipe, measured to internal crests, in millimetres

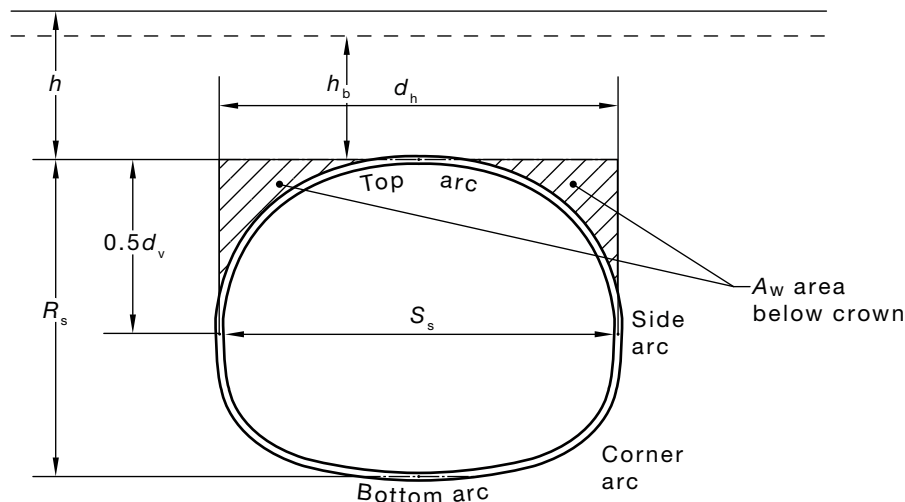


FIGURE 1.5(A) CRITICAL DIMENSIONS OF BURIED CORRUGATED METAL STRUCTURES

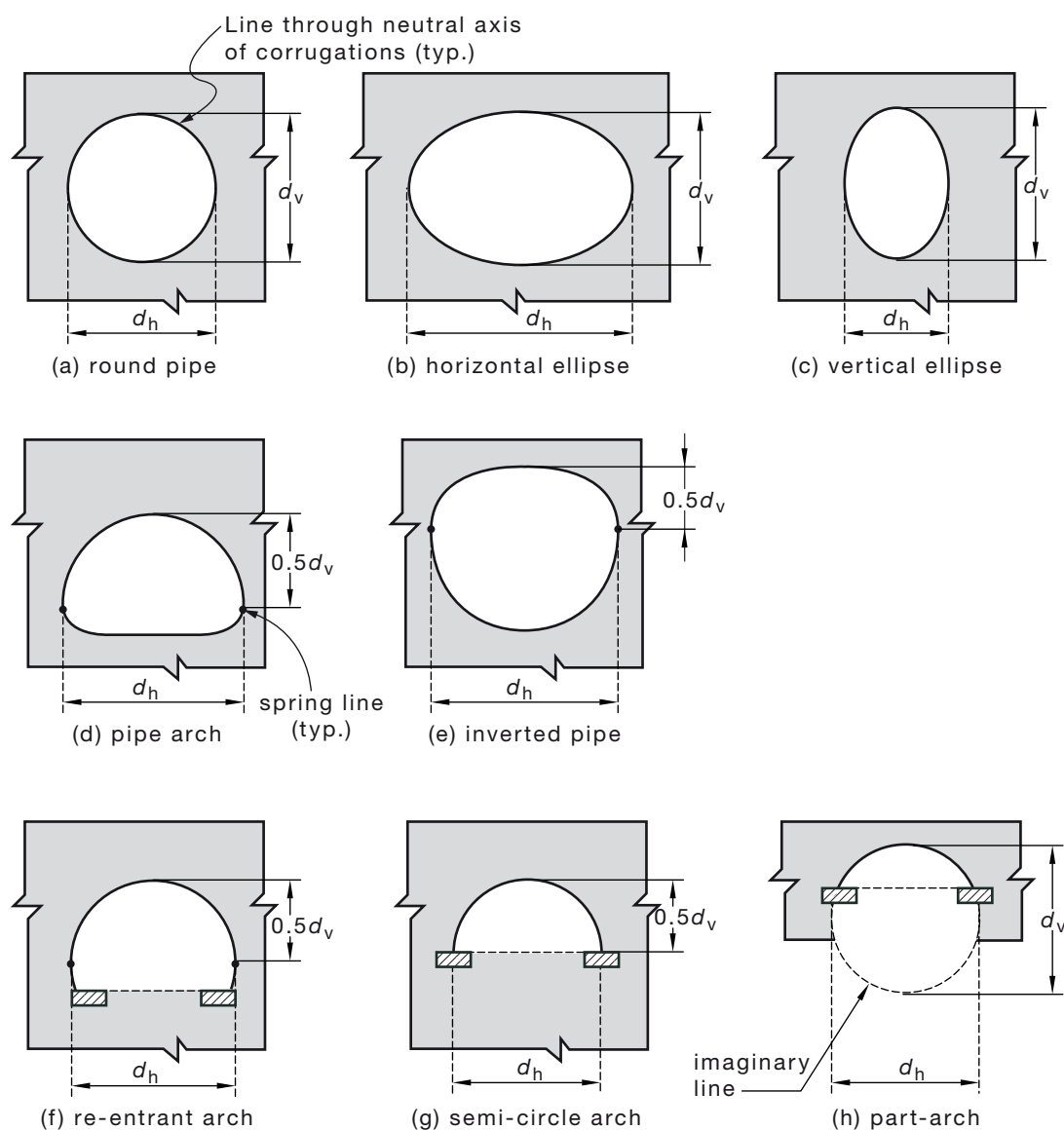


FIGURE 1.5(B) GENERAL DIMENSIONS OF BURIED CORRUGATED METAL STRUCTURES

1.6 MARKING OF STRUCTURES

The information listed below shall be marked on the product. The markings shall be permanent and applied in a conspicuous position that is visible after installation. It shall include the following:

- (a) Name of the manufacturer.
- (b) Date of manufacture including the month and year.
- (c) Plate thickness and profile to AS 2041.X

NOTES:

- 1 For example, XXX, 2005, 2.5-R19 × 19. To AS 2041.X
- 2 Manufacturers making a statement of compliance with the Australian Standard on product, packaging or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

SECTION 2 INSTALLATION

2.1 GENERAL

The adequacy of the foundation, trench, native embankment and locally available select fill material shall be investigated at each site. Regular monitoring of structure's shape and select fill density during construction are important requirements for ensuring a satisfactory installation.

The installation process shall comply with the following:

- (a) Conformance of installation to the design as specified in Clause 2.2.
- (b) Method of installation as specified in Clause 2.3 to cover the following:
 - (i) Determination of the installation method (i.e. embankment or trench).
 - (ii) Site set-out.
- (c) Structural backfilling as specified in Clause 2.4, including sourcing of suitable fill materials.
- (d) Spacing between structures as specified in Clause 2.5. (For multiple structures, the minimum spacing.)
- (e) Preparation of foundations, bedding and footings for arches as specified in Clause 2.6.
- (f) Inspection, receiving and storage of materials as specified in Clause 2.7, and checking supply of manufactured components.
- (g) Repair of defects, if required, as specified in Clause 2.8.
- (h) Assembly as specified in Clause 2.9.
- (i) Placement as specified in Clause 2.10.
- (j) Installation of any additional components of the structure (e.g. invert lining, end stiffening beams), as specified in Clause 2.11 and Section 3.
- (k) Backfilling as specified in Clause 2.12.
- (l) Design approval for all relevant construction vehicles used within the width of the select fill zone, and corresponding minimum covers, as specified in Clause 2.13.
- (m) Monitoring the final shape as specified in Clause 2.14.

Quality assurance procedures shall meet the project requirements at all stages of construction and installation.

2.2 CONFORMANCE TO THE DESIGN

Installation shall be carried out taking into account the design assumptions noted on the project drawings and specifications to ensure that adequate performance of the structure is obtained (see Note).

Where the design allows for specific construction vehicles (e.g. heavy compactor, scraper), care shall be taken to ensure that the cover assumed for the passage of the vehicles is in place before the vehicles pass over the structure.

NOTE: Ground conditions and soil properties may need to be tested to verify the design assumptions. Culverts may need to be precambered to eliminate the effect of settlement.

2.3 METHOD OF INSTALLATION

Structures shall be installed in either trench or embankment conditions (as specified by the designer) in accordance with Clauses 2.4.4 and 2.4.5 respectively (see Figures 2.4.1 and 2.4.2). Embankment condition is assumed (even for an installation requiring excavation) unless the material intended to surround the select fill (native soil, embankment material or trench walls) has strength and stiffness not less than the select fill specified in Clause 2.4.

2.4 STRUCTURAL BACKFILL

2.4.1 Select fill

Select fill shall comply with the grading and plasticity requirements given in Tables 2.4.1(B). Soil classification shall be determined in accordance with AS 1726 on geotechnical site investigation. Linear shrinkage shall be determined in accordance with AS 1289.3.4.1.

In trench installations and situations where a free-draining fill is required, single sized granular material such as crushed gravel may be satisfactory, however C_c and C_u grading requirement given in Table 2.4.1(B) may only be waived if the material has less than 40% passing the 4.75 mm sieve.

For select fill that does not comply with this Clause, advice shall be obtained from the design engineer.

Table 2.4.1(A) lists the soil description and classification symbols.

TABLE 2.4.1(A)
SOIL GROUP TYPE

Soil description	Unified soil classification symbol*
Well-graded gravel or sandy gravel	GW
Poorly graded gravel or sandy gravel	GP
Well-graded sand or gravelly sand	SW
Poorly graded sand or gravelly sand	SP
Clayey gravel or clayey-sandy gravel	GC
Clayey sand or clayey-gravelly sand	SC
Silty sand or silty gravelly sand	SM
Silty gravel with non-plastic fines	GM
Inorganic silts and very fine sands	ML
Inorganic clays of low to medium plasticity	CL
Organic silts and organic silty clays of low plasticity	OL
Inorganic silts	MH
Inorganic clays of high plasticity	CH
Organic clay of medium to high plasticity	OH
Peat and other highly organic soils	Pt

* Refer to AS 1726 for full details of unified soil classifications and requirements.

TABLE 2.4.1(B)
SELECT FILL SOIL PARAMETERS

	Span range	$d_h \leq 3000$	$3000 < d_h \leq 8000$	$8000 < d_h \leq 12000$	$d_h > 12000$
Soil type	Unified soil classification				
1-Coarse	GW, GP	Acceptable	Acceptable	Acceptable	Acceptable
	SW, SP	Acceptable	Acceptable	Acceptable	Acceptable
	GW-GM, GP-GM	Acceptable	Acceptable	Acceptable	Acceptable
	SW-SM, SP-SM	Acceptable	Acceptable	Acceptable	Acceptable
	GW-GC, GP-GC	Acceptable	Acceptable	Acceptable	Not acceptable
2-Medium	GM	Acceptable	Acceptable	Not acceptable	Not acceptable
	SM	Acceptable	Acceptable	Not acceptable	Not acceptable
	GC	Acceptable	Acceptable	Not acceptable	Not acceptable
	SC	Acceptable	Acceptable	Not acceptable	Not acceptable
3-Fine	ML, CL, OL	Not acceptable	Not acceptable	Not acceptable	Not acceptable
	MH, CH, OH	Not acceptable	Not acceptable	Not acceptable	Not acceptable
	Pt	Not acceptable	Not acceptable	Not acceptable	Not acceptable
Maximum percentage fines (%)*		20	12	10	10
Coefficient of gradation (C_c)		0.5–3.0	0.7–3.0	1–3	1–3
Minimum coefficient of uniformity (C_u)		2	3	4 for gravels 6 for sands	4 for gravels 6 for sands
Maximum linear shrinkage (%)		10	8	7	6
Maximum plasticity index (%)**		15	12	10	8

* The percentage of soil passing the 75 μ m sieve

** Plasticity index is waived if fines content is less than or equal to 5%

NOTE: For structures with $d_h > 12000$ mm the soil types and parameters shall be set out in the above table with additional parameters as specified by the designer.

2.4.2 Flowable and cement modified select fill

Flowable and cement modified select fill of the appropriate strength may be used in place of select fill where specified in the design. Flowable fill shall have a strength of 0.6 to 3 MPa (at 28 days) and an elastic modulus of 25 to 100 MPa.

Testing of cement shall be in accordance with the relevant parts of AS 1012.

NOTE: Guidance on flowable fill is given in Appendix B.

2.4.3 Extent of structural backfill

The structural backfill for single-conduit structures under different fill conditions shall extend transversely at least the distance specified in Table 2.4.3 and Figure 2.4.1 on each side beyond the spring lines of the conduit, and vertically up to the minimum design height of cover required, (h_b).

For multi-conduit structures, structural backfill shall be provided between the adjacent conduits and shall extend transversely beyond the outer conduits at least the applicable distance specified in Table 2.4.3 and Figure 2.4.1. In the vertical direction, the structural backfill shall extend up to the minimum design depth of cover required, (h_b).

TABLE 2.4.3
MINIMUM TRANSVERSE DISTANCE OF BACKFILL FOR SINGLE-CONDUIT BURIED CORRUGATED METAL STRUCTURES

Structural backfill location	Structural backfill type	Minimum transverse backfill distance (b), mm						
		Structure type						
		All structures except for metal box culverts					Metal box culverts	
		$d_h \leq 600$	$600 < d_h \leq 3000$	$3000 < d_h \leq 8000$	$8000 < d_h \leq 12000$	$d_h > 12000$	$d_h \leq 8000$	$d_h > 8000$
Trench in rock	Compacted	600	800	1000	1200	1200	1000	1200
Trench in rock	Flowable	150	200	300	750	750	300	750
Trench in good insitu soil	Compacted	600	800	1000	1200	1200	1000	1200
Trench in poor insitu soil	Compacted	600	$d_h/2$ but not less than 600	$d_h/2$ but not less than 1500	$d_h/2$ but not less than 3000	$d_h/2$ but not less than 5000 (see Note 1)	1000	$d_h/2$ (see Note 1)
Embankment construction	Compacted	600	$d_h/3$ but not less than 800	$d_h/3$ but not less than 1500	$d_h/3$ but not less than 3000	$d_h/3$ but not less than 5000 (see Note 1)	1000	$d_h/5$ (see Note 1)

NOTES:

- Minimum transverse backfill distance for structures with $d_h > 12000$ mm (or metal boxes with $d_h > 8000$ mm) may be larger (but not smaller) than the above values if required by the designer.
- Structures with a crown radius to side radius ratio >5 shall also satisfy the minimum transverse backfill distances for metal box culverts.
- Compacted backfill is select fill compacted by mechanical means.
- The minimum transverse backfill width for trench using compacted backfill is governed by sufficient space for the safe operation of walk behind mechanical compaction equipment. Depending on site equipment, the distances in this table may be larger (but not smaller) than those above, as required by the designer. The contractor may be required to compact thinner lifts using this equipment to demonstrate that design compaction is achieved.
- Flowable backfill is a controlled low strength material with equivalent strength to structural backfill compacted by mechanical means but placed in a similar manner to wet concrete. (Refer to Appendix B.)
- Good insitu soil is material of equivalent or superior strength to the specified structural backfill. (Refer Table 2.4.1(B).) Geotechnical analysis of good insitu soil shall be provided to the designer for approval.
- Poor insitu soil is trench wall material of lesser strength to specified structural backfill. (Refer Table 2.4.1(B).)
- Material described as 'not acceptable' in Table 2.4.1(B) may also be unsuitable for the 'secondary' trench or embankment material beyond the structural backfill envelope refined above and may need to be removed and replaced with more suitable material.
- For structures with $d_h > 15000$ mm, the designer shall check the effect on the structure of the 'not acceptable' material outside the structural backfill zone using the numerical modelling. The material outside the structural backfill zone shall be considered unsuitable if the unfactored change in d_h or R_s from numerical modeling exceeds 2% of the specified dimensions.
- For vertical ellipses where the vertical is the greater dimension, $d_h = d_v$.