AS/NZS 2041.6:2010

Australian/New Zealand Standard™

Buried corrugated metal structures

Part 6: Bolted plate structures

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 9 September 2010 and on behalf of the Council of Standards New Zealand on 24 September 2010.
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Australian/New Zealand Standard™

Buried corrugated metal structures

Part 6: Bolted plate structures

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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, AS/NZS 2041:1998, *Buried corrugated metal structures*.

The objective of this Standard is to provide designers, manufacturers and installers of buried bolted plate structures with requirements for manufacture of such structures for use in earthworks primarily as culverts or access ways.

This Standard is Part 6 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
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) Installation requirements are referred to AS/NZS 2041.2.

(c) Notation has been based on ISO 3898.

(d) Materials and fabrication requirements (remaining in this Standard) have been updated.

(e) Class 1 and class 2 are now termed B68 and B200 profiles.

(f) New profile sizes, B152, B230 and B381, included.

(g) Reference tables for cover limits have been taken out.

In this document, the words ‘this Standard’ indicate AS/NZS 2041.6, which is regarded as Part 6 of the AS/NZS 2041 series of Standards.

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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SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies minimum requirements for the materials and manufacture of buried corrugated metal structures formed by bolting together plates with sinusoidal profile.

Sinusoidal profiles covered include the following:

(a) B68 (pitch 68 mm).....manufactured with either lapped joints or flanged joints.

(b) B152 (pitch 152 mm).....lapped joints only.

(c) B200 (pitch 200 mm).....lapped joints only.

(d) B230 (pitch 229 mm).....lapped joints only.

(e) B381 (pitch 381 mm).....lapped joints only.

The structure shapes are as follows (see Figure 1.1):

(i) Pipe.

(ii) Pipe-arch or underpass.

(iii) Horseshoe arch or elliptical arch.

(iv) Arch (one, two or three radius).

(v) Vertical ellipse.

(vi) Horizontal ellipse.

(vii) Metal box.

These structures are intended for use in stormwater drainage and as access tunnels to support roadway and railway and other loadings.

Bolted plate structures are constructed of corrugated section shapes buried in an embankment or in a trench, with correct installation in a soil envelope being essential to the performance of the structure.

This Standard does not consider the additional design requirements for internally pressurized applications.

NOTES:

1 Guidelines on requirements that may need to be specified at the time of calling for tenders or quotations, and information to be supplied by the manufacturer, are detailed in Appendix A.

2 Information on means of demonstrating compliance with this Standard is given in Appendix B.

3 When intended for use in internally pressurized applications, specialist advice should be obtained.

1.2 DESIGN AND INSTALLATION

Design shall be carried out in accordance with AS/NZS 2041.1 using the section properties given in Section 8 of this Standard. Installation shall be carried out in accordance with AS/NZS 2041.2.

NOTE: This Standard includes the product requirements and design properties. AS/NZS 2041.1 gives information on design issues and requirements for structural design of the metal structure. Performance of the structure depends on correct installation (particularly adequate compaction of appropriate fill material around the metal structure) for which AS/NZS 2041.2 gives the requirements.

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

1110 ISO metric hexagon bolts and screws

1111 ISO metric hexagon commercial bolts and screws (All parts)

1112 ISO metric hexagon nuts including thin nuts, slotted nuts and castle nuts (ISO 4032:1986, ISO 4033:1979, ISO 4034:1986 and ISO 4035:1986) (All parts)

1214 Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)

1252–1983 High strength steel bolts with associated nuts and washers for structural engineering (Incorporating Amdt 1.)

1275 Metric screw threads for fasteners

1397 Steel sheet and strip—Hot-dip zinc-coated or aluminium/zinc-coated

4100 Steel structures

4100 Supp 1 Supplement 1: Steel structures—Commentary

AS/NZS

1252 High strength steel bolts with associated nuts and washers for structural engineering

1365 Tolerances for flat-rolled steel products

1594 Hot-rolled steel flat products

1734 Aluminium and aluminium alloys—Flat sheet, coiled sheet and plate

2041 Buried corrugated metal structures

2041.1 Part 1: Design methods

2041.2 Part 2: Installation

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

ISO

3898 Bases for design of structures—Notations—General symbols

ASTM

A449 Standard specification for hex cap screws, bolts and studs, steel, heat treated, 120/105/90 ksi minimum tensile strength, general use

A563 Standard specification for carbon and alloy steel nuts

A742 Standard specification for steel sheet, metallic coated and polymer precoated for corrugated steel pipe

A761 Standard specification for corrugated steel structural plate, zinc-coated, for field-bolted pipe, pipe arches and arches

A929 Standard specification for steel sheet, metallic-coated by the hot-dip process for corrugated steel pipe

B209 Standard specification for aluminium and aluminium alloy sheet and plate

B695 Standard specification for coatings of zinc mechanically deposited on iron and steel

B746 Standards specification for corrugated aluminium alloy structural plate for field bolted pipe, pipe arches and arches

B744 Standard specification for aluminum alloy sheet for corrugated aluminum pipe

1.4 DEFINITIONS

For the purpose of this Standard, the definitions in AS/NZS 2041.1 and AS/NZS 2041.2 and those below apply.

1.4.1 Bedding

A prepared layer of uncompacted, non-cohesive material 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 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 shapes consisting of a curve and tangent profile as shown in this Standard.

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;

(b) base of sleepers for railway traffic loads, and surface of track formation for heavy vehicles or equipment running on the track formation;

(c) top of trench or embankment where Items (a) and (b) are not applicable; or

(d) base of a stockpile.

1.4.6 Depth of corrugation

Measured as the vertical distance from a straight edge resting on the corrugation crests parallel to the axis of the structure to the bottom of the intervening valley.

1.4.7 Diameter, internal

The minimum clear dimension measured from internal crest to internal crest.

1.4.8 Flexibility factor

A measure of wall flexibility of the corrugated metal structure for the purpose of handling and installation without permanent deformation of the metal structure.

1.4.9 Foundation

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

1.4.10 Pitch of corrugation

The distance measured from crest to crest of corrugations, at 90° to the direction of the corrugation.

1.4.11 Protective coating

A coating designed to isolate the substrate from the environment.

NOTE: Types of protective coating include aluminized, galvanized, polymer, bituminized and painted coatings.

1.4.12 Skew number

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

1.5 NOTATIONS

NOTE: Critical dimensions of buried corrugated metal structures are shown in Figure 1.1.

The notations in this Standard are based on the notations and principles given in ISO 3898 and AS/NZS 2041.1. The notations used are as follows:

A = cross-sectional area of wall of the metal structure per unit length (based on structural base metal thickness), in millimetres squared per millimetre

d_c = depth of sinusoidal corrugation, in millimetres

d_h = effective horizontal geometrical dimension of structure (to the neutral axis of the corrugation), in millimetres

d_v = effective vertical geometrical dimension of structure (to the neutral axis of the corrugation), in millimetres

$F_{f,max}$ = maximum flexibility factor, in millimetres per newton

f_u = minimum ultimate tensile strength, in megapascals

f_y = minimum yield strength, in megapascals

I = second moment of area of the corrugated section (based on structural base metal thickness), in millimetres to the fourth power per millimetre

i = radius of gyration of corrugated section (based on structural base metal thickness), in millimetres

p = pitch of corrugation, in millimetres

R_{bs} = seam strength (characteristic) in compression of bolted longitudinal seams, in kilonewtons per metre run of seam

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

R_c = inside radius of sinusoidal corrugation, in millimetres

r_b = bottom radius (neutral axis of corrugation), in millimetres

r_c = corner radius, sometimes called the shoulder (neutral axis of corrugation), in millimetres

r_h = haunch radius (neutral axis of corrugation), in millimetres

r_s = side radius (neutral axis of corrugation), in millimetres

r_t = top radius (neutral axis of corrugation), 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

t = structural base metal thickness without coatings, in millimetres; ie (nominal base metal thickness minus base metal tolerance)/0.95 but not greater than the nominal base metal thickness. For ASTM A761 material, the nominal base metal thickness equals total specified thickness minus the coating thickness

W_{el} = elastic section modulus of the corrugated section (based on structural base metal thickness), in millimetres to the third power per millimetre

W_{pl} = plastic section modulus of the corrugated section (based on structural base metal thickness), in millimetres to the third power per millimetre

θ_{bs} = angle between the horizontal and the bottom of the side arc (below) in elliptical arches, horseshoe arches and two and three radius arches, in degrees; *or*
angle between the horizontal and the bottom of the side arc (above) in single radius arches with rise ≤ radius and metal box shapes, in degrees

θ_c = angle subtended by corner arc (full arc) sometimes called the shoulder, in degrees

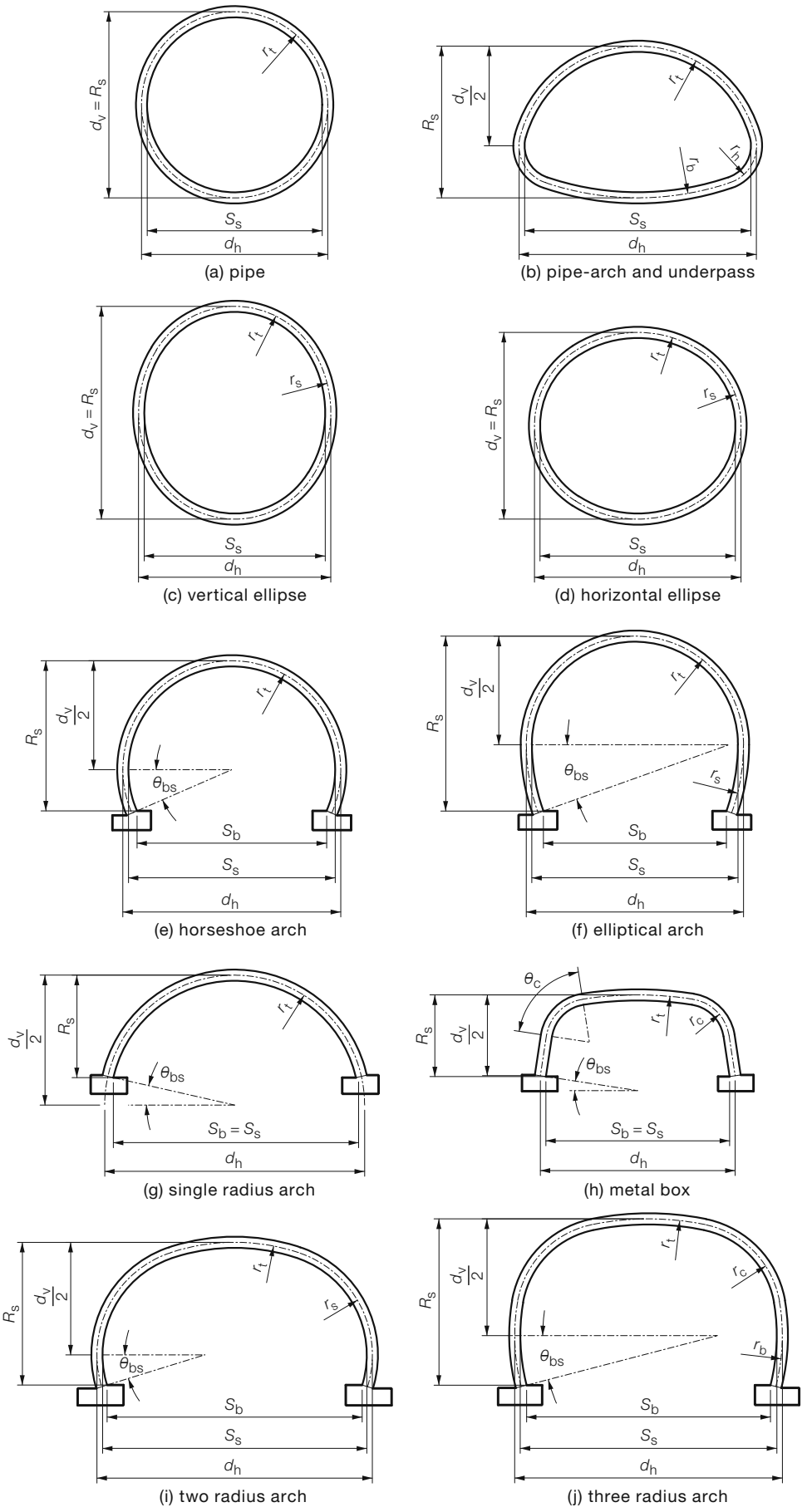


FIGURE 1.1 CRITICAL DIMENSIONS OF BURIED CORRUGATED METAL STRUCTURES

SECTION 2 SPECIFICATION

2.1 GENERAL

Corrugated bolted metal plate structures shall comply with the following:

(a) Shape designation as given by the manufacturer shall include the corrugation pitch as a prefix.

NOTE: For example, a vertical ellipse shape in 200 × 55 corrugation would be 200-VE-XX where XX is the manufacturer's shape designation.

(b) Materials and fabrication shall be in accordance with Sections 3, 4, 5, 6 and 7 (B68: 68 × 13, B152: 152 × 51, B200: 200 × 55, B230: 229 × 64, B381: 381 × 140, sinusoidal section).

NOTE: Section properties for design are given in Section 8.

(c) For the shapes described in this Standard, structures shall have the geometric limitations given in Section 9.

NOTE: Structural design shall be in accordance with AS/NZS 2041.1.

(d) Structures shall be manufactured to provide the assembled tolerances given in AS/NZS 2041.2.

(e) Marking shall be in accordance with Clause 2.2.

NOTE: For dimensions of special shapes, specialist advice should be sought.

2.2 MARKING OF STRUCTURES

Each structure shall be legibly and permanently marked in a conspicuous place agreed by the purchaser. The marking shall include the following:

(a) Name of the manufacturer.

(b) Date of manufacture including the month and year.

(c) A unique number identifying the structure, which shall include the thickness and profile, the structure identifier and a number for traceability of the details of the particular installation, such as 5.0-200-30HE21-001.

NOTE: Manufacturers making a statement of compliance with this 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 3 MATERIALS AND FABRICATION FOR B68 STRUCTURES

3.1 SCOPE OF SECTION

This Section specifies the materials to be used, method of manufacture, and dimensional requirements to be observed in the manufacture of B68 bolted plate structures.

3.2 MATERIALS

3.2.1 Base material

The base material consisting of the base metal and a protective coating shall be—

(a) galvanized metal strip complying with the requirements of AS 1397 for steel base grade G250 and galvanized to Z600;

(b) clad aluminium alloy strip with substrate metal classification 3004—H34 and cladding metal classification 7072 in accordance with AS 1734 or ASTM B744;

(c) steel of grade G230 minimum with an aluminized (Type II) coating in accordance with ASTM A929; or

(d) steel of grade G230 minimum with a polymer coating in accordance with ASTM A742.

The materials specified in Items (a) to (d) are appropriate for the design methods specified in AS/NZS 2041.1

3.2.2 Steel sheet

3.2.2.1 *Material properties*

The base steel shall be as shown in Table 3.2.2(A).

TABLE 3.2.2(A)

MATERIAL PROPERTIES FOR B68 STEEL SHEET

Standard	Metal grade	Minimum yield strength (f_y) MPa	Minimum tensile strength (f_u) MPa	Minimum elongation % over 50 mm
AS 1397	G250 steel	250	320	25
ASTM A929 ASTM A742	G230 steel	227.5	310.3	20

3.2.2.2 *Base metal thickness*

Tolerances on base metal thickness shall be in accordance with Table 3.2.2(B), Table 3.2.2(C) and Table 3.2.2(D).

TABLE 3.2.2(B)

STRUCTURAL BASE METAL WALL THICKNESS—AS 1397 G250 Z600 GALVANIZED STEEL

Specified (uncoated) wall thickness mm	Nominal coated wall thickness mm	Minimum coated wall thickness mm	Structural base metal wall thickness (t) mm
1.20	1.29	1.24 (1.13)	1.20 (1.09)
1.60	1.69	1.63 (1.53)	1.60 (1.52)
2.00	2.09	2.02 (1.91)	2.00 (1.92)
2.50	2.60	2.52 (2.41)	2.50 (2.43)
3.00	3.10	3.01 (2.89)	3.00 (2.94)
3.50	3.60	3.50 (3.37)	3.50 (3.44)
4.00	4.10	4.00 (3.87)	4.00 (3.97)

NOTE: Specified AS 1397 wall thickness is uncoated. AS/NZS 1365 strip tolerance assumes cold rolled. Section properties in Section 8 also assumes cold rolled strip tolerances. Hot rolled values are shown in brackets and their section properties can be calculated using Note 1 of Tables in Section 8.

TABLE 3.2.2(C)

STRUCTURAL BASE METAL WALL THICKNESS—ASTM A929 G230 Al TYPE 2 AND ASTM A929 G230 ZINC 610 g/m^2 ALUMINIZED STEEL AND GALVANIZED STEEL

Specified (coated) wall thickness mm	Nominal uncoated wall thickness mm	Minimum coated wall thickness mm	Structural base metal wall thickness (t) mm
1.02	0.92	0.91	0.92
1.32	1.22	1.17	1.22
1.63	1.53	1.45	1.52
2.01	1.91	1.83	1.91
2.77	2.67	2.57	2.67
3.51	3.42	3.28	3.42
4.27	4.18	4.04	4.18

NOTE: Specified ASTM A929 wall thickness is coated.

TABLE 3.2.2(D)

STRUCTURAL BASE METAL WALL THICKNESS—ASTM A742 POLYMER-COATED STEEL

Base galvanized steel specification	Specified wall thickness mm	Nominal coated wall thickness including polymer mm	Minimum coated wall thickness including polymer mm	Structural base metal wall thickness (*t*) mm
AS 1397 G250 Z600	1.60 (uncoated)	2.20	2.14	1.60
ASTM A929 G230 Zinc 610 g/m^2	1.02 (zinc coated)	1.51	1.42	0.92
	1.32 (zinc coated)	1.82	1.68	1.22
	1.63 (zinc coated)	2.12	1.96	1.52
	2.01 (zinc coated)	2.50	2.34	1.91
	2.77 (zinc coated)	3.26	3.07	2.67
	3.51 (zinc coated)	4.02	3.78	3.42
	4.27 (zinc coated)	4.78	4.55	4.18

NOTE: Polymer coating thickness 254 microns per side.

3.2.2.3 *Coating*

The base steel shall have a coating in accordance with AS 1397, ASTM A929 or ASTM A742.

3.2.2.4 *Alternative coatings*

Where an alternative coating to that referred to in Clause 3.2.2.3 is used, it shall comply with the following:

(a) *Heavy galvanized coating* The base steel shall be hot-dip galvanized in accordance with the requirements for general articles in AS/NZS 4680.

(b) *Coating other than heavy galvanized* The base metal and application of the coating shall be in accordance with the coating manufacturer's specification.

(c) *Duplex coatings* To protect the structure in abnormally corrosive or abrasive conditions a secondary coating shall be applied over the primary coating (nominated in Clauses 3.2.2.3, 3.2.2.4(a) or 3.2.2.4(b)), in accordance with the coating manufacturer's specification.

NOTE: Information on durability of suitable materials and coatings for various environmental conditions is given in AS/NZS 2041.1.

3.2.3 Steel bolts and nuts

3.2.3.1 *Diameter*

The bolts for the field assembly of bolted steel B68 structures shall be 12 mm in diameter for lapped structures and 10 mm in diameter for flanged structures.

3.2.3.2 *Dimensions*

The width across the flats of bolt heads and nuts shall be within the limits specified in AS 1111.

The form of thread and pitch of the bolt threads shall be ISO coarse pitch series in accordance with AS 1275. The threads shall comply with M12 8g tolerance in accordance with AS 1275, with thread tolerance class 8g before zinc coating. Threads for nuts shall be in accordance with AS 1214.

3.2.3.3 *Mechanical properties*

For all structures, the bolts shall comply with the material and mechanical properties specified in AS 1110 for property class 8.8.

The galvanized nuts shall pass a proof load test carried out in accordance with AS 1112 for property class 8.

For fluming and flanged structures, the property class shall be class 4.6 for bolts (in accordance with AS 1110) and class 5 for nuts (in accordance with AS 1112).

3.2.3.4 *Coating*

Bolts and nuts shall be zinc-coated by hot-dip galvanizing in accordance with AS 1214.

The bolts shall be centrifuged to remove surplus zinc from the threads after galvanizing.

The nuts shall be galvanized as blanks, and tapped after galvanizing using the oversize allowance specified in AS 1214 so that they can be assembled on the galvanized bolts by hand.

3.2.4 Aluminium sheet

3.2.4.1 *General*

The aluminium sheet shall be clad aluminium alloy with substrate metal classification 3004—H34 or 3004—H32 in accordance with AS/NZS 1734 or ASTM B744.

3.2.4.2 *Cladding thickness*

The nominal cladding thickness on each side shall be 5% of the total composite thickness. When determined by metallurgical microscope, the average cladding thickness shall be not less than 4% of the total composite thickness.

NOTE: Thickness examination should average ten separate measurements on each side of not less than three polished material samples.

3.2.4.3 *Chemical composition*

The chemical composition of the substrate and cladding shall be as given for alloys 3004 and 7072 respectively in AS/NZS 1734 or ASTM B744.

3.2.4.4 *Material properties*

The material properties of the clad aluminium alloy 3004—H34 or 3004—H32 shall be as specified in Table 3.2.4(A).

TABLE 3.2.4(A)

MATERIAL PROPERTIES FOR ALUMINIUM SHEET

Standard	Metal grade	Minimum yield strength (0.2% offset) min. (f_y) MPa	Minimum tensile strength (MPa) (f_u) Min.	Minimum tensile strength (MPa) (f_u) Max.	Minimum elongation % over 50 mm
AS/NZS 1734	Alclad 3004—H34	165	215	255	4% where t >1.3 mm t ≤3.0 mm 5% where t >3.0 mm t ≤6.0 mm
ASTM B744	Alclad 3004—H32	137.9	186.2	234.4	5% where t ≤2.8 mm 6% where t >2.8 mm
	Alclad 3004—H34	165.5	213.7	255.1	4% where t ≤2.8 mm 5% where t >2.8 mm

NOTE: The thickness given in this Table includes both the substrate and the cladding and can be considered to act together as the structural base metal thickness for the purpose of design, as outlined in AS/NZS 2041.1.

3.2.4.5 *Base metal thickness*

For structural base metal wall thickness, refer to Table 3.2.4(B) below.

TABLE 3.2.4(B)

STRUCTURAL BASE METAL WALL THICKNESS— AS/NZS 1734 AND ASTM B744 ALCLAD 3004—H32 G140 AND ALCLAD 3004—H34 G165 ALUMINIUM

Specified wall thickness mm	Minimum wall thickness mm	Structural base metal wall thickness (t) mm
0.91	0.86	0.91
1.22	1.14	1.20
1.52	1.45	1.52
1.91	1.83	1.91
2.67	2.57	2.67
3.43	3.30	3.43
4.17	4.01	4.17

3.2.5 Aluminium bolts and nuts

Aluminium bolts and nuts for Class 1 (B68) structures shall be alloy 6061—T6 with proof stress (0.2%) of 240 MPa, ultimate tensile strength of 260 MPa and elongation 8%. Other alloys with equal or higher proof stress are permissible substitutes.

NOTE: Stainless steel bolts (SS303) and nuts (SS313) or galvanized steel bolts and nuts may be substituted for aluminium bolts and nuts, as specified in this Clause.

3.3 FABRICATION

3.3.1 General

B68 structures shall be fabricated from material as specified in Clause 3.2.2 or 3.2.4 and shall be corrugated, hole-punched and curved in accordance with Clauses 3.3.2, 3.3.3 and 3.3.4. B68 structures are assembled on site with lapped seams or flanged seams.

3.3.2 Sinusoidal corrugations

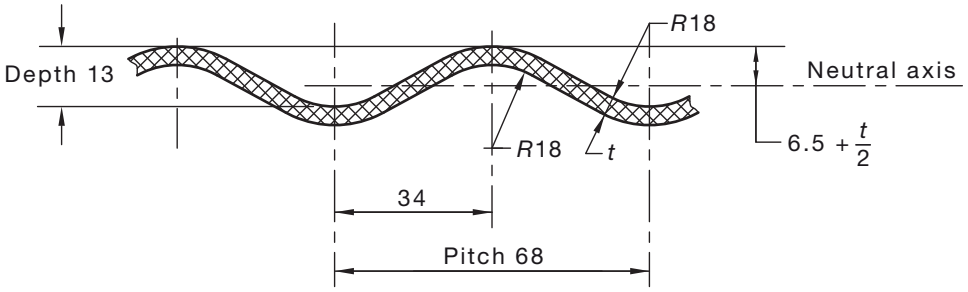
Corrugations shall comply with the following (see Figure 3.3.2):

(a) The pitch of the sinusoidal corrugations (p) shall be 67.73 ±5.29 mm.

(b) The depth of the sinusoidal corrugations (d_c) shall be 12.70±0.51 mm.

(c) The radius of sinusoidal corrugations (R_c) shall be 17.46 ±4.76 mm.

(d) The corrugations shall form smooth continuous curves and tangents.



DIMENSIONS IN MILLIMETRES

FIGURE 3.3.2 CORRUGATIONS FOR B68 STRUCTURES

3.3.3 Sheet tolerances

3.3.3.1 *Sheet width*

The actual net width of sheets measured along the corrugation shall differ from the specified net width by not more than ±3 mm (as shown in Figure 3.3.3).

NOTE: Typically, the periphery of B68 structures is comprised of two semi-circular sheets.

3.3.3.2 *Sheet length*

The actual net length of sheets measured across the corrugations shall be 610 mm ±3 mm, or 305 ±3 mm for closure panels, where continuous longitudinal seams are specified (see Figure 3.3.3).

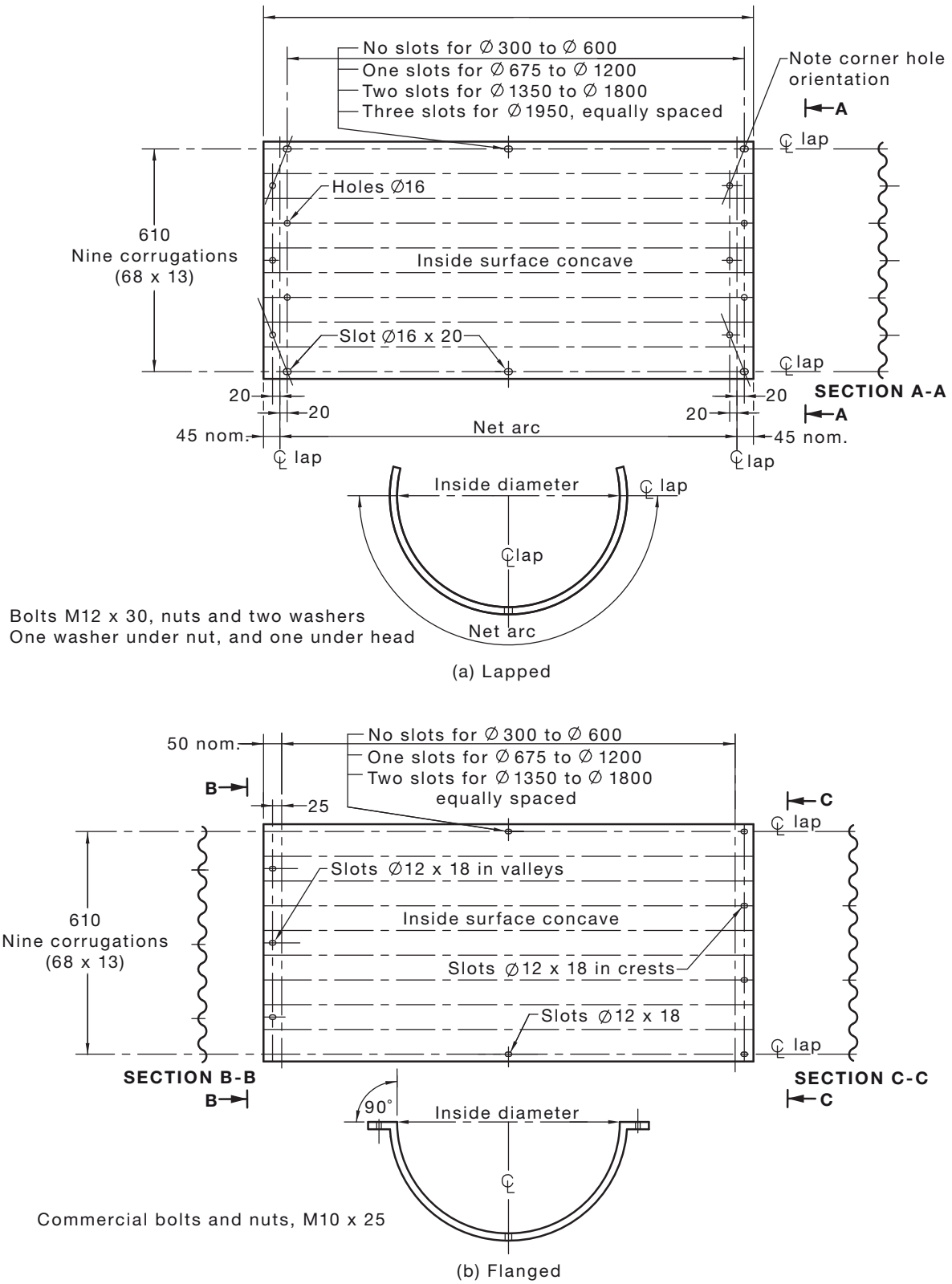
3.3.3.3 *Sheet curvature*

The tolerance on the measured rise, when compared to the calculated shop curvature, shall be ±6 mm (see Figure 4.2.3). The length of the straight edge used shall not be less than 75% of the chord length.

3.3.3.4 *Structure end finishing sheets*

B68 structures shall have either a stepped end or a vertical end specified. Vertical end structures shall be supplied with special top closure panels for this purpose.

NOTE: For an illustration of a stepped end, see Figure A2, Appendix A.



DIMENSIONS IN MILLIMETRES

FIGURE 3.3.3 SHEET LAYOUT FOR B68 STRUCTURES

3.3.4 Bolt-holes and slots

3.3.4.1 *General*

Bolt-holes and slots shall be provided to allow interchangeability of sheets and field assembly with the prescribed fasteners to achieve the specified structure shape.

3.3.4.2 *Longitudinal seams*

Bolt-holes for lapped sheet longitudinal seams, as shown in Figure 3.3.4(A), shall be 16 mm in diameter prior to sheet curving, located at 102 mm centres on alternate crests and valleys of corrugations, and offset on opposite sides of the plate lap centre-line by 20 mm. Bolt-holes for flanged steel longitudinal seams, as shown in Figure 3.3.4(A), shall be 12 mm in diameter prior to steel fabrication, located at 204 mm centres and on the plate lap centre-line.

NOTE: Alternative seam bolting configurations are not precluded, provided the allowable seam strength used in design calculations is determined by full scale bolted seam compression testing.

3.3.4.3 *Circumferential seams*

Bolt-holes for lapped sheet circumferential seams as shown in Figure 3.3.4(A) shall be 16 mm × 20 mm slots, prior to sheet curving, located centrally on the corrugation crest nearest the sheet edges. Bolt-holes for flanged steel circumferential as shown in Figure 3.3.4(B) shall be 12 mm × 18 mm slots prior to sheet curving, located centrally on the corrugated crest nearest the sheet edges.

Circumferential seam bolt-holes shall be equally spaced along the sheet edge with centre-to-centre spacing of no more than 1000 mm.

3.3.4.4 *Hole alignment*

Prior to sheet curving, the diagonal dimensions measured between bolt slots at opposite sheet corners shall not differ by more than 5 mm.

3.3.4.5 *Edge distance*

Bolt-holes and slots shall be no closer to the sheet edge than 1.75 times their diameter.

3.3.4.6 *Hole and slot defects*

Holes and slots shall be free of cracks, and free of ragged edges and burrs in excess of 1.5 mm.

3.4 REPAIR OF DEFECTS AND COATINGS

3.4.1 General

The manufactured structure shall be free of the following defects:

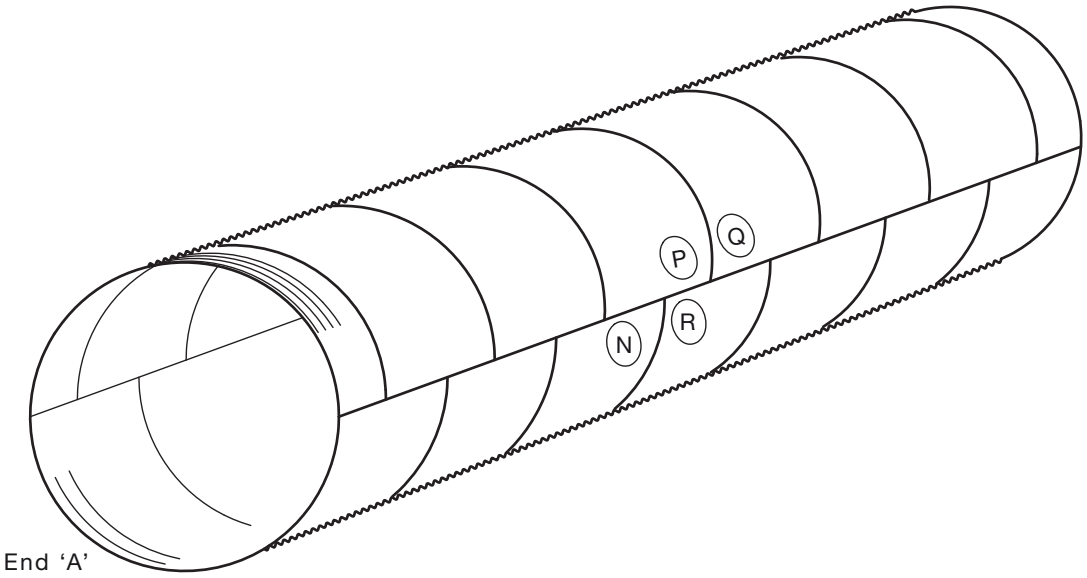
(a) Permanent deformation of the sheets that could impair assembly or the structural performance.

(b) Burrs that are likely to cause injury to installers.

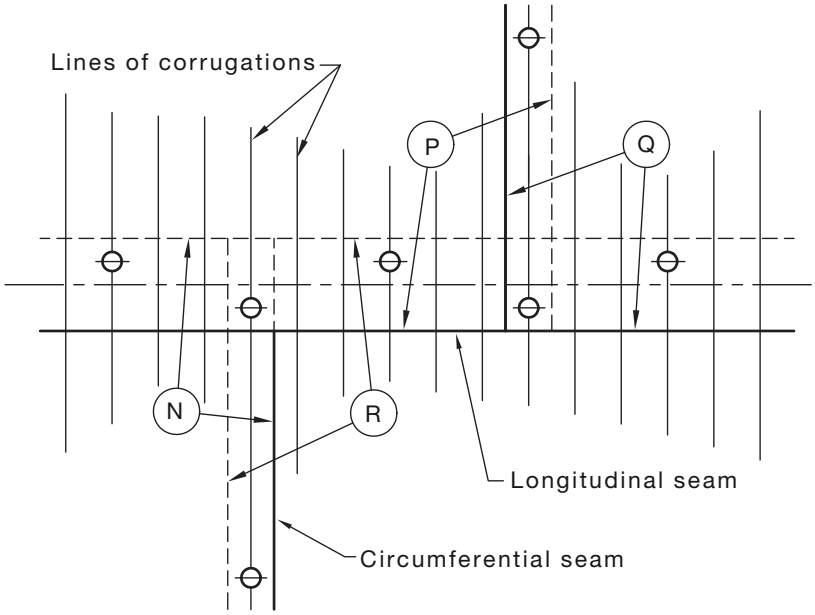
3.4.2 Assessment and repairs of damaged coatings

Where coatings have been damaged or are missing, they shall be repaired in accordance with AS/NZS 2041.2.

Cut ends shall be protected following cutting by application of appropriate coatings.



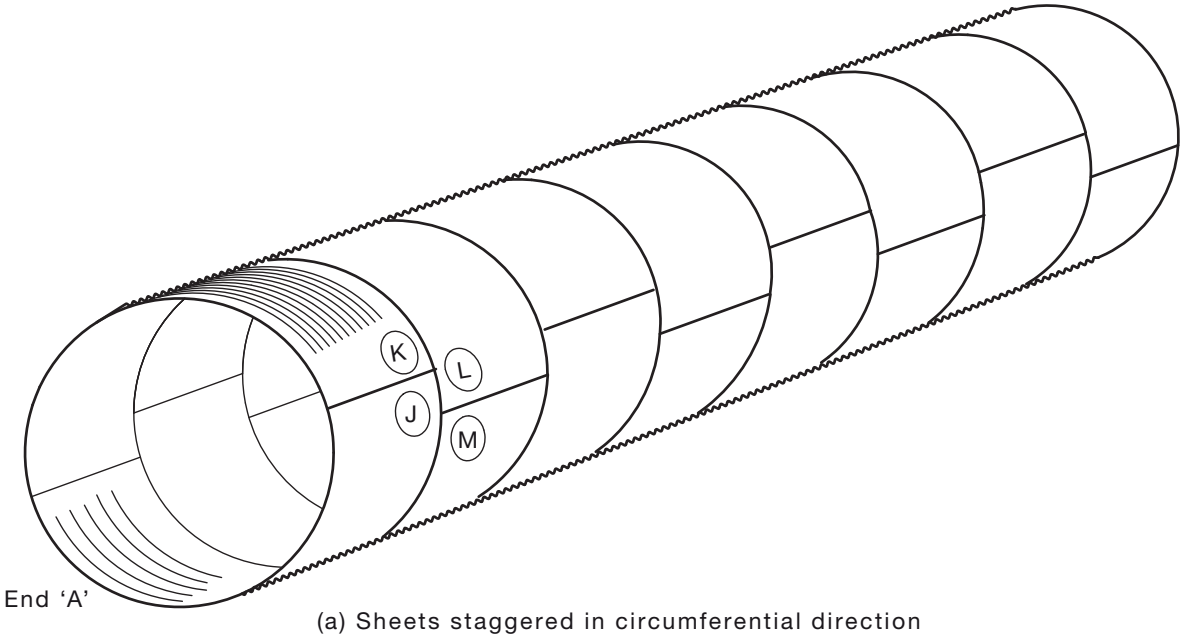
(a) Sheets staggered in longitudinal direction



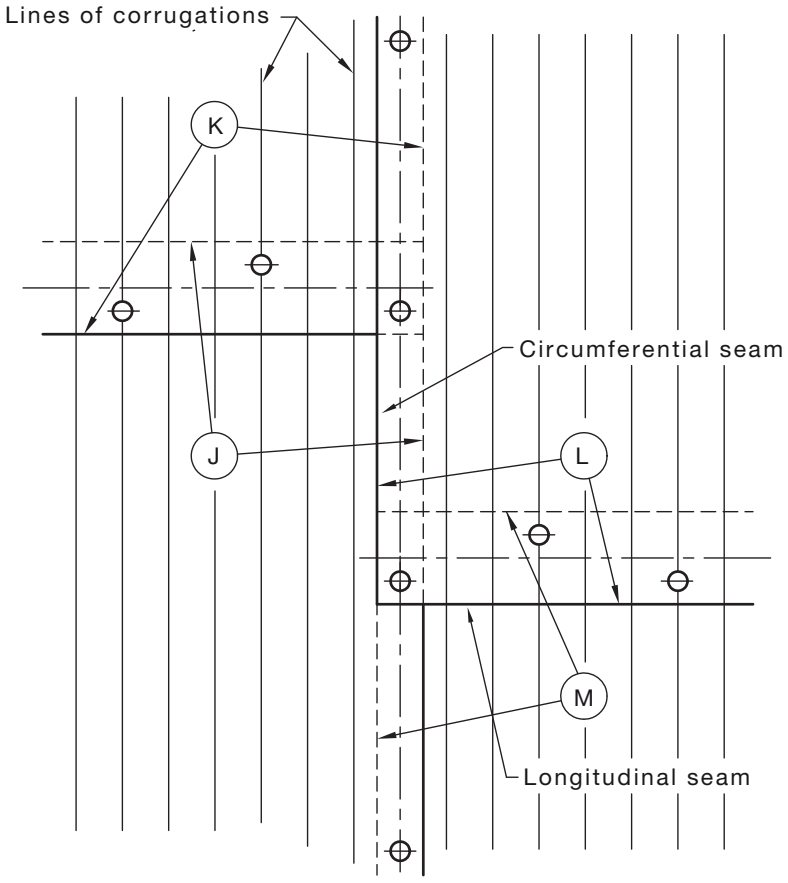
NOTES:
1 Lapped seam structures are assembled in this pattern
2 Arrows labelled N, P, Q, R denote the edges of the respective plates.
3 The closure panels are always installed in the pipe crown or are not used where there is a stepped end (see Figure A2(b), Appendix A).

(b) Detailed joint of sheet staggered in longitudinal direction

FIGURE 3.3.4(A) LONGITUDINAL SEAMS FOR LAPPED B68 STRUCTURES



(a) Sheets staggered in circumferential direction



NOTE: Arrows labelled J, K, L, M denote the edges of the respective plates.

(b) Detailed joint of sheets staggered in circumferential direction

FIGURE 3.3.4(B) CIRCUMFERENTIAL SEAMS FOR LAPPED B68 STRUCTURES

SECTION 4 MATERIALS AND FABRICATION FOR B152 STRUCTURES

4.1 MATERIALS

4.1.1 Steel plate

4.1.1.1 *Material properties*

For B152 structures, the base steel shall be grade G230 in accordance with ASTM A761, as shown in Table 4.1.1(A).

TABLE 4.1.1(A)

MATERIAL PROPERTIES—STEEL PLATE

Standard	Metal grade	Minimum yield strength (f_y) MPa	Minimum tensile strength (f_u) MPa	Minimum elongation % over 50 mm
ASTM A761	Type 38 G230 steel	227.5	310.3	25%

NOTE: ASTM A761 Type 33 (G190 steel) is not permitted in this Standard. Manufacturers of B152 corrugation shall provide test certificates verifying Type 38 (G230 steel).

4.1.1.2 *Coating*

The fabricated sheet or plate shall be hot-dip galvanized in accordance with the requirements for general articles of AS/NZS 4680.

NOTE: Imported hot-dip galvanized plate must be specified to the minimum zinc thickness requirements of AS/NZS 4680.

4.1.1.3 *Alternative and additional coatings*

When an alternative or additional coating to that specified in Clause 4.1.1.2 is used, it shall comply with the following:

(a) *Other coating* Preparation of the base steel and application of the coating shall be in accordance with the coating manufacturer's recommendations.

(b) *Duplex coating* For abnormally adverse conditions, a secondary coating shall be applied over the primary coating (nominated in Clause 4.1.1.2 or Clause 4.1.1.3(a)) in accordance with the coating manufacturer's specification.

NOTE: Information on durability of suitable materials and coatings for various environmental conditions is given in AS/NZS 2041.1.

4.1.1.4 *Base metal thickness*

Base metal thickness shall be in accordance with Table 4.1.1(B).

TABLE 4.1.1(B)

STRUCTURAL BASE METAL WALL THICKNESS—
ASTM A761 TYPE 38 G230 WITH ZINC 1220 g/m^2 GALVANIZED STEEL

Specified (coated) wall thickness ASTM A761	Nominal (coated) wall thickness (1220 g/m^2)	Minimum coated wall thickness (1220 g/m^2)	Nominal uncoated wall thickness	Structural base metal wall thickness (t)
mm	mm	mm	mm	mm
3.56	3.60	3.29	3.43	3.29
4.32	4.36	4.06	4.19	4.09
4.78	4.82	4.51	4.65	4.57
5.54	5.58	5.28	5.41	5.37
6.32	6.37	6.06	6.20	6.20
7.11	7.15	6.85	6.98	6.98
7.87	7.92	7.54	7.75	7.75

NOTE: Specified ASTM A761 wall thickness is coated. For B152 structures, minimum zinc coating is average coating thickness total for both sides

4.1.2 Steel bolts and nuts

4.1.2.1 *Diameter*

The bolts for the field assembly of the sheets and plates shall be 19 mm or 20 mm diameter, and shall have heads and nuts specially shaped to provide suitable bearing.

4.1.2.2 *Dimensions*

For 20 mm bolts, the width across the flats of bolt heads and nuts shall be within the limits specified in AS 1252—1983. The form of thread and pitch of the bolt threads shall be ISO coarse pitch series in accordance with AS 1275. The threads shall comply with M20 6G tolerance in AS 1275, with thread tolerance class 6g before zinc coating. Threads for nuts shall be in accordance with AS 1214.

For 19 mm bolts the dimensions shall comply with ASTM A449 and A563.

4.1.2.3 *Mechanical properties*

The 20 mm bolts shall comply with the material and mechanical properties specified in AS 1252—1983. The galvanized nuts shall pass a proof load test carried out in accordance with AS 1112 for property class 10.

For 19 mm bolts, the dimensions shall comply with ASTM A449 and A563.

4.1.2.4 *Coating*

The 20 mm bolts and nuts shall be zinc-coated by hot-dip galvanizing in accordance with AS 1214. The bolts shall be centrifuged to remove surplus zinc from the threads after galvanizing. The nuts shall be galvanized as blanks, and tapped after galvanizing using the oversize allowance specified in AS 1214 so that they are capable of assembly on the galvanized bolts by hand.

For 19 mm bolts the coating shall comply with ASTM B695 class 50.

4.1.2.5 *Lubrication*

Nuts shall be lubricated in accordance with AS/NZS 1252.

For 19 mm bolts the lubrication shall comply with ASTM A563.

4.2 FABRICATION

4.2.1 General

B152 structures shall be fabricated from material specified in Clauses 4.1.1 and 4.1.2 and shall be corrugated, hole punched and curved to the specified radii so that the cross-sectional dimensions of each structure shall be achieved when it is assembled. Assembled tolerances shall comply with the limits given in AS/NZS 2041.2.

Coatings, if required, shall be applied after fabrication.

4.2.2 Sinusoidal corrugations

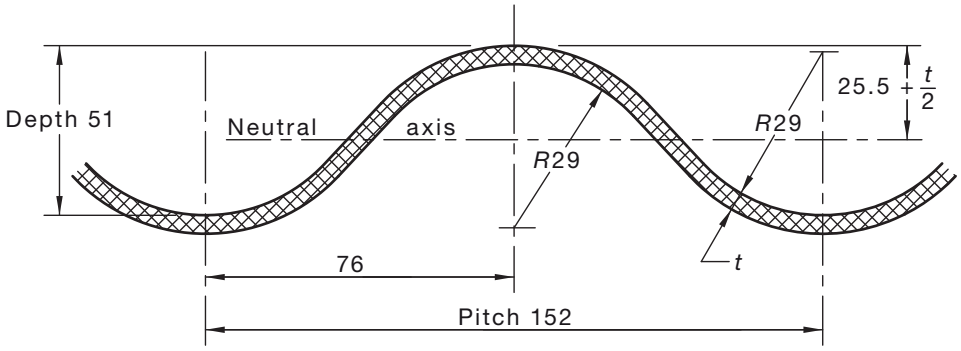
Sinusoidal corrugations, illustrated in Figure 4.2.2, shall comply with the following:

(a) The pitch of the sinusoidal corrugations (p) shall be 152.40 ±6.35 mm.

(b) The depth of sinusoidal corrugations (d_c) shall be 50.80 ±2.54 mm.

(c) The radius of sinusoidal corrugations (R_c) shall be 28.58 ±3.18 mm.

(d) The corrugations shall form smooth continuous curves and tangents.



DIMENSIONS IN MILLIMETRES

FIGURE 4.2.2 CORRUGATIONS FOR B152 STRUCTURES

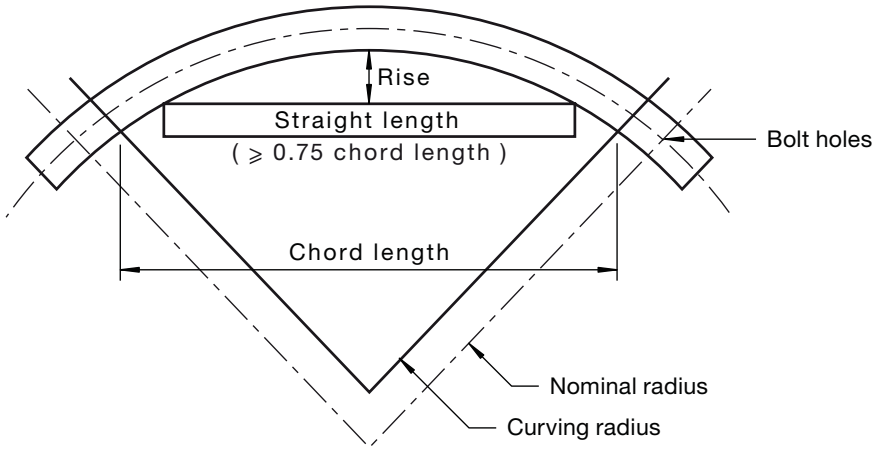
4.2.3 Plate tolerances

4.2.3.1 *Plate width and length*

The actual net width and length of sheets shall be as shown in Figure 4.2.4(A).

4.2.3.2 *Plate curvature*

The tolerance on the measured rise, when compared to the calculated shop curvature, shall be ±6 mm (refer to Figure 4.2.3). The length of the straight edge used shall not be less than 75% of the chord length.



DIMENSIONS IN MILLIMETRES

FIGURE 4.2.3 STRUCTURAL PLATE CURVATURE

4.2.4 Bolt-holes

4.2.4.1 *General*

The holes for bolts shall be spaced so that all plates of like dimension and curvature, and having the same number of bolts per unit length of seam, are interchangeable (see Figure 4.2.4(A)).

The diameter of the bolt-holes in longitudinal seams shall not exceed the diameter of the bolt by more than 6 mm.

4.2.4.2 *Edge distance*

The distance from the centre of a bolt to any plate edge shall be as specified in ASTM A761 or AS 4100.

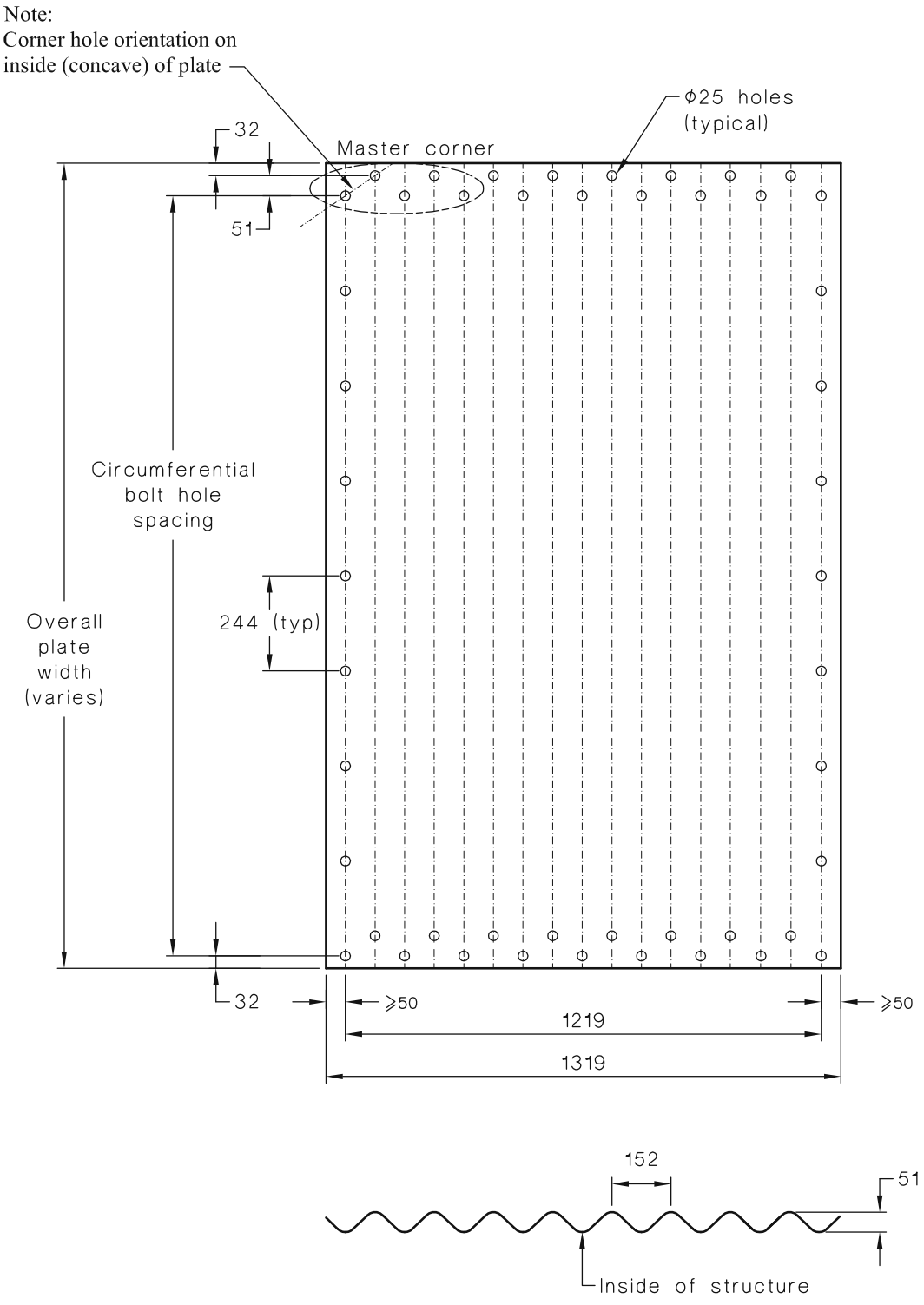
4.2.4.3 *Longitudinal seams*

The holes for bolts in longitudinal seams shall be in two rows spaced 51 mm apart, centre to centre. The minimum hole arrangement shall have holes in one row in every crest, and in the other row in every valley of the corrugations.

NOTE: Alternative seam bolting configurations are not precluded, provided the allowable seam strength used in design calculations is determined by full-scale bolted seam compression testing.

4.2.4.4 *Circumferential seams*

The centre-to-centre spacing of holes before curvature, for bolts in circumferential seams, shall not exceed 250 mm.



DIMENSIONS IN MILLIMETRES

FIGURE 4.2.4(A) SHEET LAYOUT FOR B152 STRUCTURES

4.2.4.5 *Hole alignment*

Prior to plate curving, the diagonal dimensions measured between bolt-holes in opposite corners of the plate shall not differ by more than 1%.

4.2.4.6 *Hole configuration*

The bolt-holes for fasteners shall be provided in a configuration that allows staggering of plate laps along circumferential or longitudinal seams (see Figures 4.2.4(B) and 4.2.4(C)).

4.2.4.7 *Hole defects*

Punched bolt-holes shall be free of cracks, and free of ragged edges and burrs in excess of 2.0 mm.

4.2.5 Plate identification and traceability

Plates for B152 structures shall be permanently marked to show curvature, thickness and a unique number to achieve quality assurance requirements for identification and traceability. Special plates for skewed structures or for bevelled ends shall be legibly and permanently marked to identify their proper positions in the finished structure.

4.3 REPAIR OF DEFECTS AND COATINGS

4.3.1 General

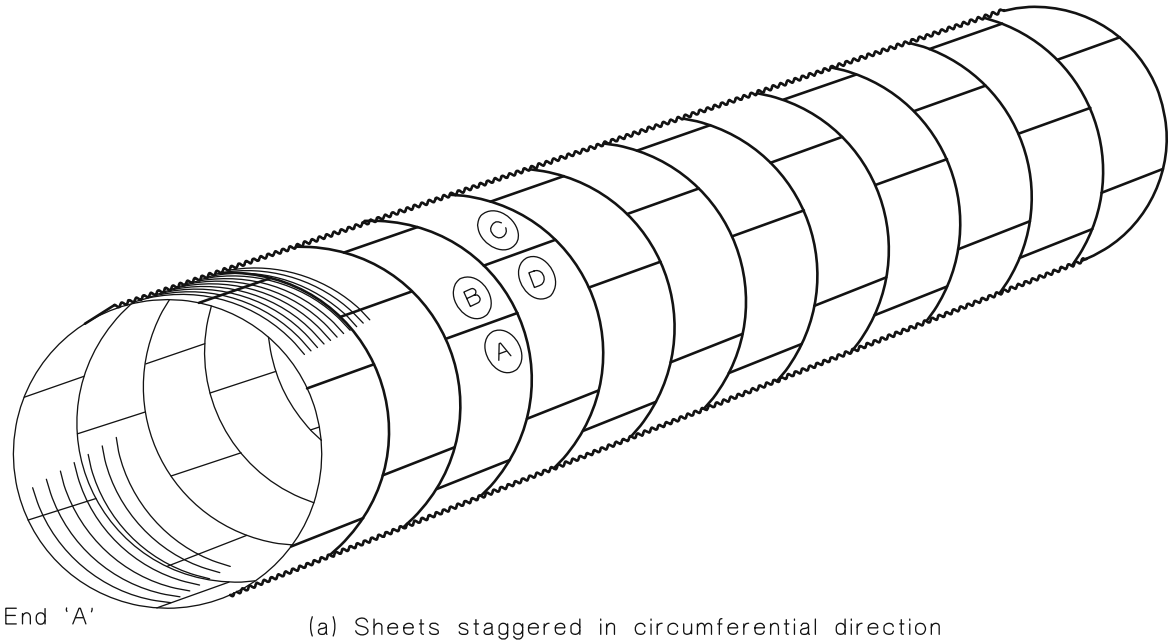
The manufactured structure shall be free of the following defects:

(a) Permanent deformation of the sheets that could impair assembly or the structural performance.

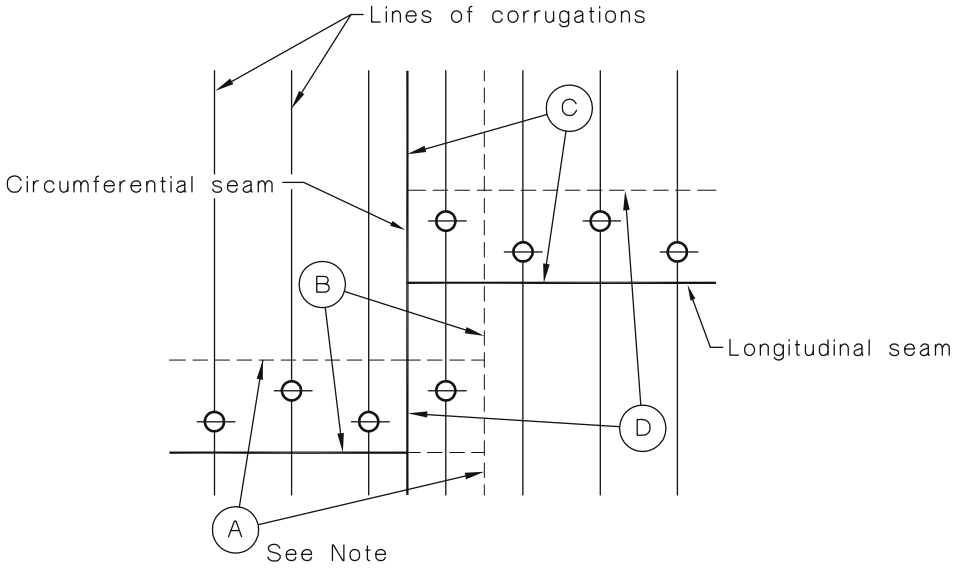
(b) Burrs that are likely to cause injury to installers.

4.3.2 Assessment and repairs of damaged coatings

Where coatings have been damaged or are missing, they shall be repaired in accordance with AS/NZS 2041.2.



(a) Sheets staggered in circumferential direction

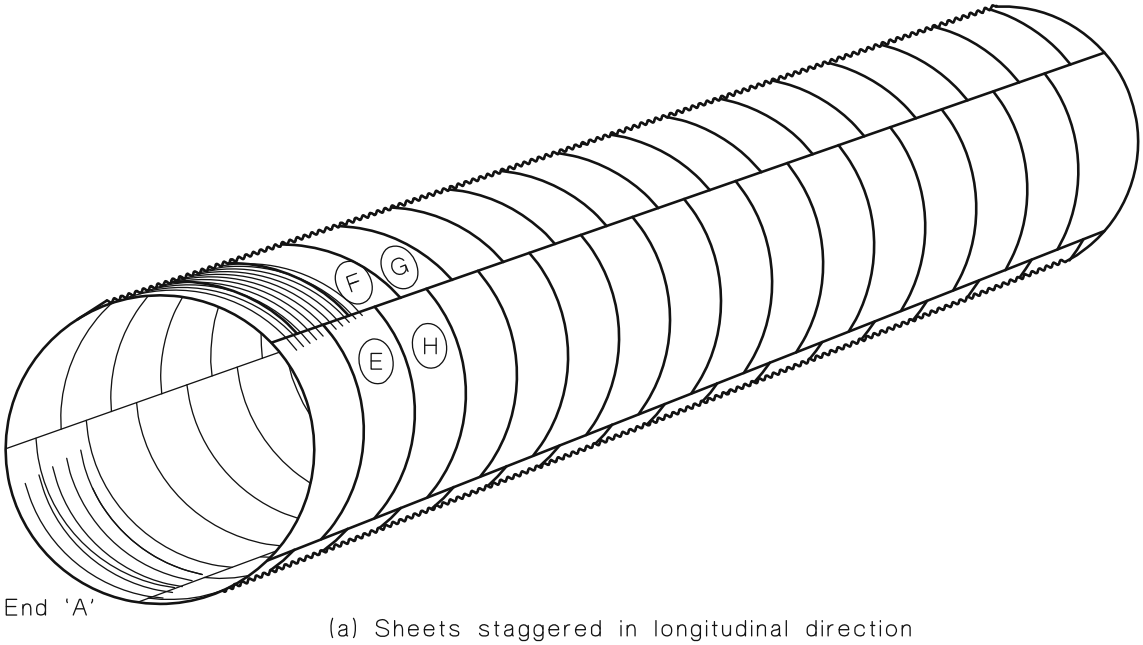


NOTE: Arrows denote the edges of the respective plates

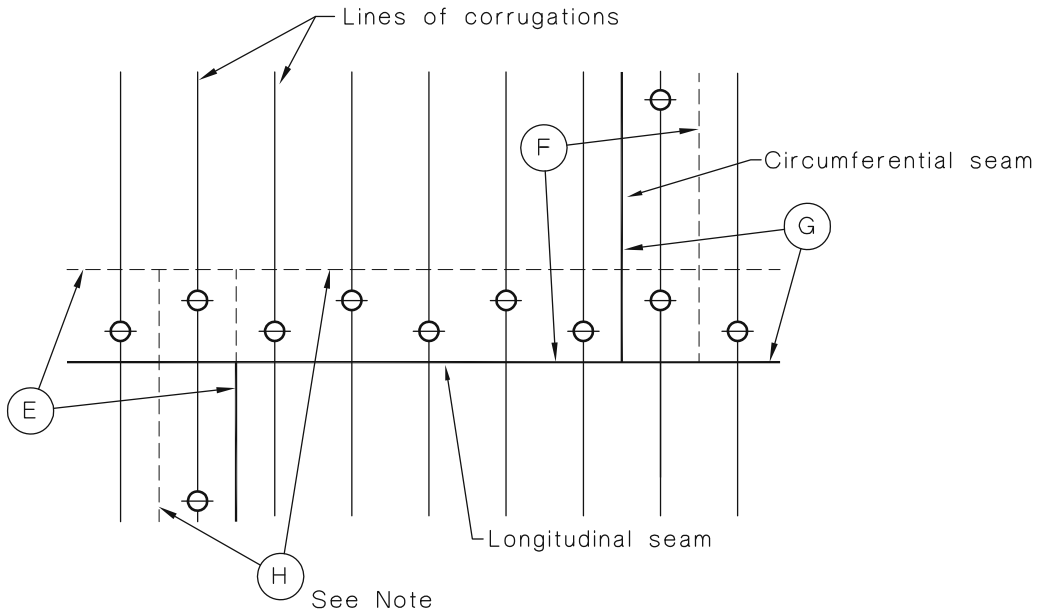
(b) Detailed joint of sheets staggered in circumferential direction

DIMENSIONS IN MILLIMETRES

FIGURE 4.2.4(B) CIRCUMFERENTIAL SEAMS FOR B152 STRUCTURES



(a) Sheets staggered in longitudinal direction



NOTE: Arrows denote the edges of the respective plates

(b) Detailed joint of sheets staggered in longitudinal direction

DIMENSIONS IN MILLIMETRES

FIGURE 4.2.4(C) LONGITUDINAL SEAMS FOR B152 STRUCTURES

SECTION 5 MATERIALS AND FABRICATION FOR B200 STRUCTURES

5.1 MATERIALS

5.1.1 Steel plate

5.1.1.1 *Material properties*

For B200 structures, the base steel shall be grade G250 or G300 in accordance with AS/NZS 1594, as shown in Table 5.1.1(A).

TABLE 5.1.1(A)

MATERIAL PROPERTIES—STEEL PLATE

Standard	Metal grade	Minimum yield strength (f_y) MPa	Minimum tensile strength (f_u) MPa	Minimum elongation % over 200 mm
AS/NZS 1594	G250 steel	250	350	17%
	G300 steel	300	400	16%

5.1.1.2 *Coating*

The fabricated sheet or plate shall be hot-dip galvanized in accordance with the requirements for general articles of AS/NZS 4680.

NOTE: Imported hot-dip galvanized plate must be specified to the minimum zinc thickness requirements of AS/NZS 4680.

5.1.1.3 *Alternative and additional coatings*

When an alternative or additional coating to that specified in Clause 5.1.1.2 is used, it shall comply with the following:

(a) *Other coating* Preparation of the base steel and application of the coating shall be in accordance with the coating manufacturer's recommendations.

(b) *Duplex coating* For abnormally adverse conditions, a secondary coating shall be applied over the primary coating (nominated in Clause 5.1.1.2 or Clause 5.1.1.3(a)) in accordance with the coating manufacturer's specification.

NOTE: Information on durability of suitable materials and coatings for various environmental conditions is given in AS/NZS 2041.1.

5.1.1.4 *Base metal thickness*

Tolerances on base metal thickness shall be in accordance with Table 5.1.1(B).

TABLE 5.1.1(B)

STRUCTURAL BASE METAL THICKNESS AS/NZS 1594 G250 AND G300 GALVANIZED STEEL TO AS/NZS 4680

Specified (uncoated) wall thickness mm	Nominal coated wall thickness mm	Minimum coated wall thickness mm	Structural base metal wall thickness (t) mm
2.50	2.61	2.42	2.43
3.00	3.11	2.90	2.94
4.00	4.14	3.91	3.97
5.00	5.14	4.89	5.00
6.00	6.14	5.87	6.00
7.00	7.17	6.88	7.00
8.00	8.17	7.88	8.00

5.1.2 Steel bolts and nuts

5.1.2.1 *Diameter*

The bolts for the field assembly of the sheets and plates shall be 20 mm diameter, and shall have heads and nuts specially shaped to provide suitable bearing.

5.1.2.2 *Dimensions*

The width across the flats of bolt heads and nuts shall be within the limits specified in AS 1252—1983.

The form of thread and pitch of the bolt threads shall be ISO coarse pitch series in accordance with AS 1275. The threads shall comply with M20 6G tolerance in AS 1275, with thread tolerance class of 6g before zinc coating. Threads for nuts shall be in accordance with AS 1214.

5.1.2.3 *Mechanical properties*

The bolts shall comply with the material and mechanical properties specified in AS 1252—1983.

The galvanized nuts shall pass a proof load test, carried out in accordance with AS 1112 for property class 10.

5.1.2.4 *Coating*

Bolts and nuts shall be zinc-coated by hot-dip galvanizing in accordance with AS 1214.

The bolts shall be centrifuged to remove surplus zinc from the threads after galvanizing.

The nuts shall be galvanized as blanks, and tapped after galvanizing using the oversize allowance specified in AS 1214 so that they are capable of assembly on the galvanized bolts by hand.

5.1.2.5 *Lubrication*

Nuts shall be lubricated in accordance with AS/NZS 1252.

5.1.3 Aluminium plate

5.1.3.1 *Material properties*

The material properties for alloy 5052 shall be in accordance with AS/NZS 1734, as shown in Table 5.1.3(A).

TABLE 5.1.3(A)

MATERIAL PROPERTIES—ALUMINIUM PLATE

Standard	Metal grade	Yield strength (0.2% offset) min. (f_y) MPa	Minimum tensile strength (f_u) MPa		Minimum elongation
			Min.	Max.	% over 50 mm
AS/NZS 1734	5052—H34	180	235	285	7% where 1.3 <t ≤3 9% where 3 <t ≤6

5.1.3.2 *Base metal thickness*

Tolerances on base metal thickness shall be in accordance with Table 5.1.3(B).

TABLE 5.1.3(B)

STRUCTURAL BASE METAL THICKNESS AS/NZS 1734 ALLOY 5052—H34 G180 ALUMINIUM

Specified wall thickness mm	Minimum wall thickness mm	Structural base metal wall thickness (t) mm
3.00	2.82	2.97
4.00	3.64	3.83
5.00	4.59	4.83
6.00	5.54	5.83

5.1.4 Aluminium bolts and nuts

5.1.4.1 *General*

Aluminium bolts and nuts shall be manufactured from alloy 6061—T6 with dimensions in accordance with Clauses 5.1.2.1 and 5.1.2.2.

5.1.4.2 *Mechanical properties*

Alloy 6061—T6 shall have the properties specified in Clause 3.2.5. Other alloys with equal or higher proof stress are permissible substitutes subject to chemical compatibility.

NOTE: Stainless steel bolts (SS303) and nuts (SS313) or galvanized steel bolts and nuts as specified in Clause 5.1.2 may be substituted for aluminium bolts and nuts.

5.2 FABRICATION

5.2.1 General

B200 structures shall be fabricated from material specified in Clauses 5.1.1 and 5.1.3 and shall be corrugated, hole punched and curved to the specified radii so that the cross-sectional dimensions of each structure shall be achieved when it is assembled. Assembled tolerances shall comply with limits given in AS/NZS 2041.2. Coatings, if required, shall be applied after fabrication.

5.2.2 Sinusoidal corrugations

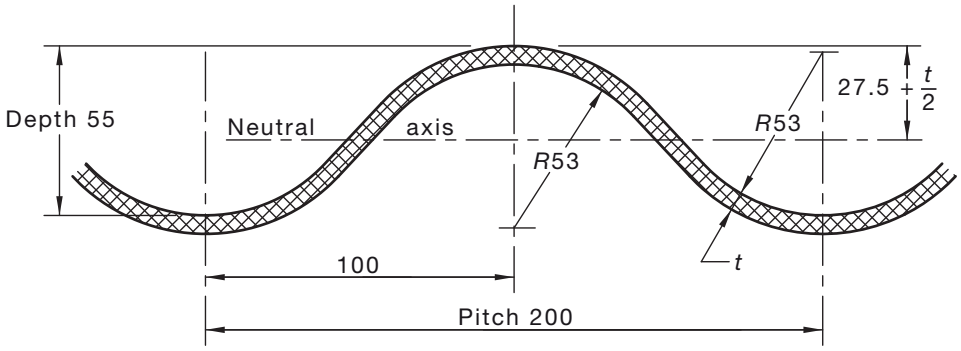
Sinusoidal corrugations, illustrated in Figure 5.2.2, shall comply with the following:

(a) The pitch of the sinusoidal corrugations (p) shall be 200.00 ±6.00 mm.

(b) The depth of sinusoidal corrugations (d_c) shall be 55.00 ±3.00 mm.

(c) The radius of sinusoidal corrugations (R_c) shall be 53.00 ±3.00 mm.

(d) The corrugations shall form smooth continuous curves and tangents.



DIMENSIONS IN MILLIMETRES

FIGURE 5.2.2 CORRUGATIONS FOR B200 STRUCTURES

5.2.3 Plate tolerances

5.2.3.1 *Plate width*

The actual net width of sheets measured along the corrugation shall not differ from the specified net width by more than 5 mm as shown in see Figure 5.2.3.

5.2.3.2 *Plate length*

The actual net length of a plate measured between the crests of the two outer corrugations shall have a length tolerance of ±0.5%.

5.2.3.3 *Plate curvature*

The tolerance on the measured rise, when compared to the calculated shop curvature shall be ±6 mm (see Figure 4.2.3). The length of the straight edge used shall not be less than 75% of the chord length.

5.2.4 Bolt-holes

5.2.4.1 *General*

The holes for bolts shall be spaced so that all plates of like dimension and curvature, and having the same number of bolts per unit length of seam, are interchangeable (see Figure 5.2.3).

The diameter of the bolt-holes in longitudinal seams shall not exceed the diameter of the bolt by more than 5 mm.

5.2.4.2 *Edge distance*

The distance from the centre of a bolt to any plate edge shall be as specified in AS 4100.

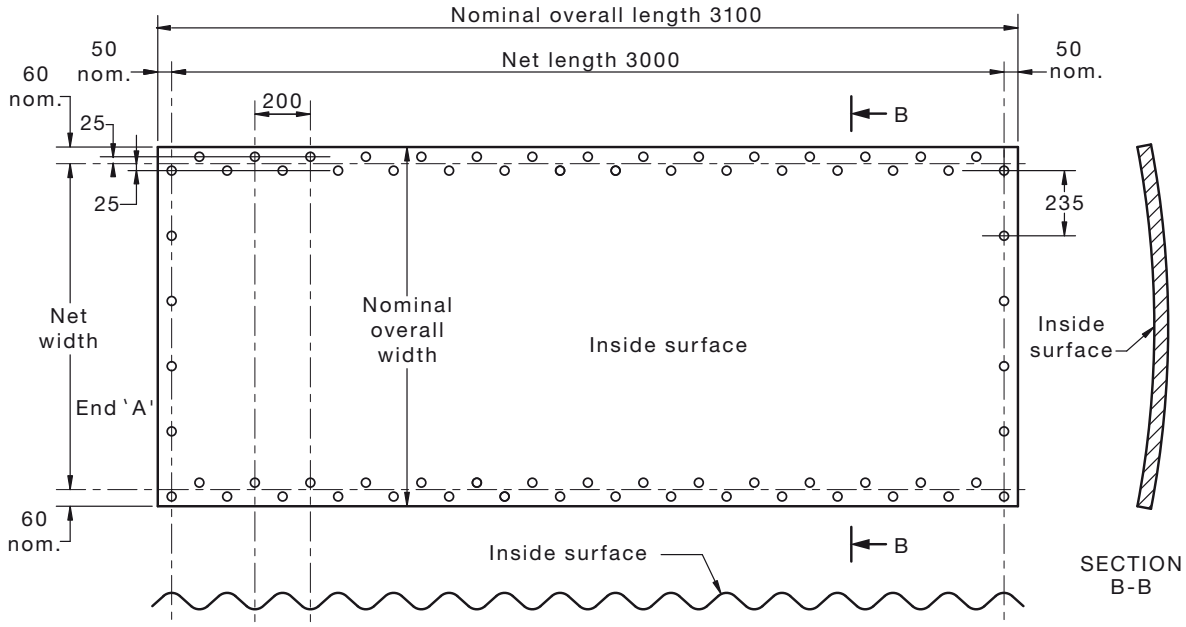
5.2.4.3 *Longitudinal seams*

The holes for bolts in longitudinal seams shall be in two rows spaced 50 mm apart, centre to centre. The minimum hole arrangement shall have holes in one row in every crest, and in the other row in every valley of the corrugations.

NOTE: Alternative seam bolting configurations are not precluded, provided the allowable seam strength used in design calculations is determined by full-scale bolted seam compression testing.

5.2.4.4 *Circumferential seams*

The centre-to-centre spacing of holes for bolts in circumferential seams shall not exceed 235 mm.



DIMENSIONS IN MILLIMETRES

FIGURE 5.2.3 SHEET LAYOUT FOR B200 STRUCTURES

5.2.4.5 *Hole alignment*

Prior to plate curving, the diagonal dimensions measured between bolt-holes in opposite corners of the plate shall not differ by more than 1%.

5.2.4.6 *Hole configuration*

The bolt-holes for fasteners shall be provided in a configuration that allows staggering of plate laps along circumferential or longitudinal seams (see Figures 5.2.4(A) and 5.2.4(B)).

5.2.4.7 *Hole defects*

Punched bolt-holes shall be free of cracks, and free of ragged edges and burrs in excess of 2.0 mm.

5.2.5 Plate identification and traceability

Plates for B200 structures shall be permanently marked to show curvature, thickness and a unique number to achieve quality assurance requirements for identification and traceability. Special plates for skewed structures or for bevelled ends shall be legibly and permanently marked to identify their proper positions in the finished structure.

5.3 REPAIR OF DEFECTS AND COATINGS

5.3.1 General

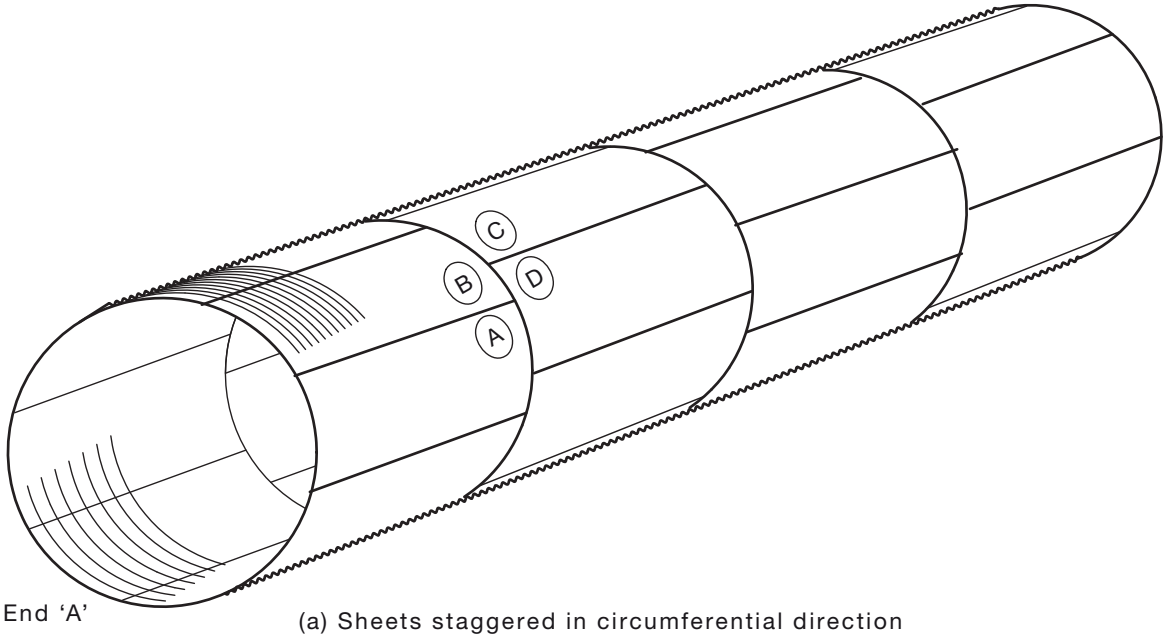
The manufactured structure shall be free of the following defects:

(a) Permanent deformation of the sheets that could impair assembly or the structural performance.

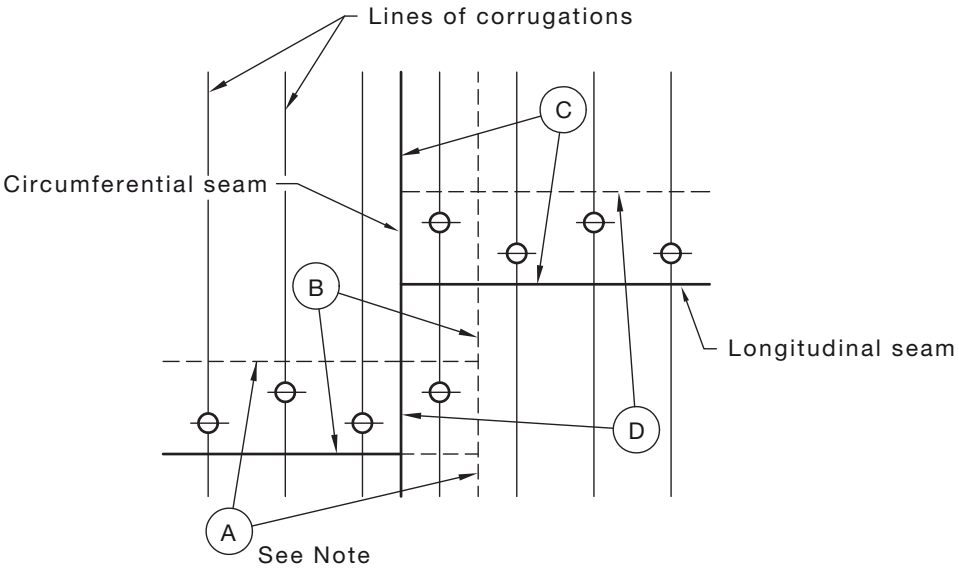
(b) Burrs that are likely to cause injury to installers.

5.3.2 Assessment and repairs of damaged coatings

Where coatings have been damaged or are missing, they shall be repaired in accordance with AS/NZS 2041.2.



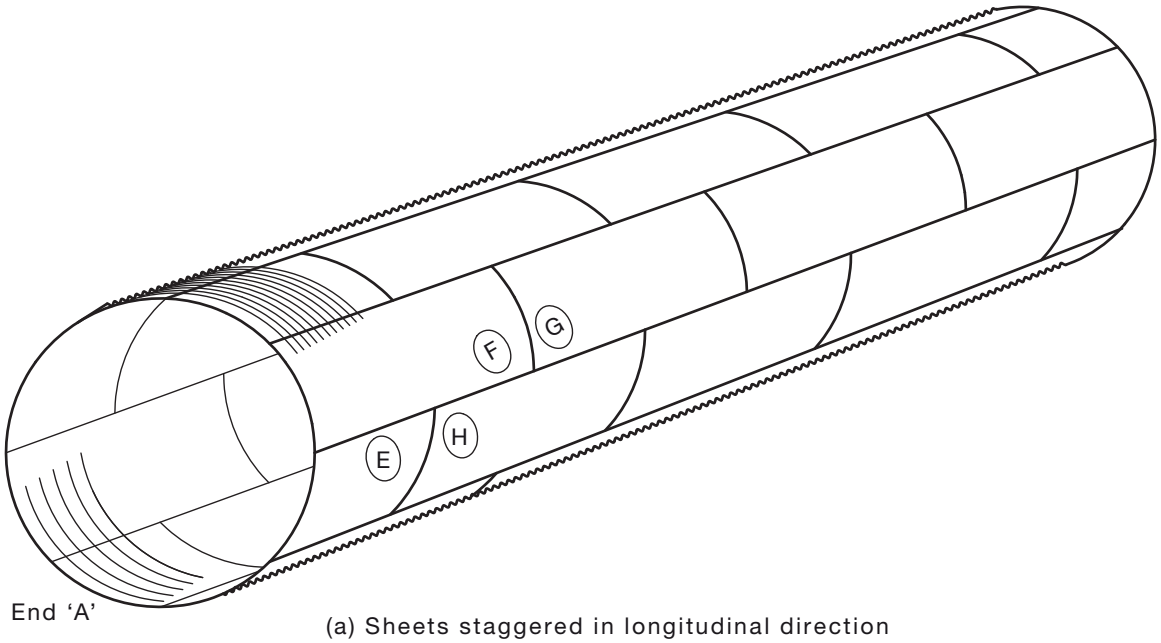
(a) Sheets staggered in circumferential direction



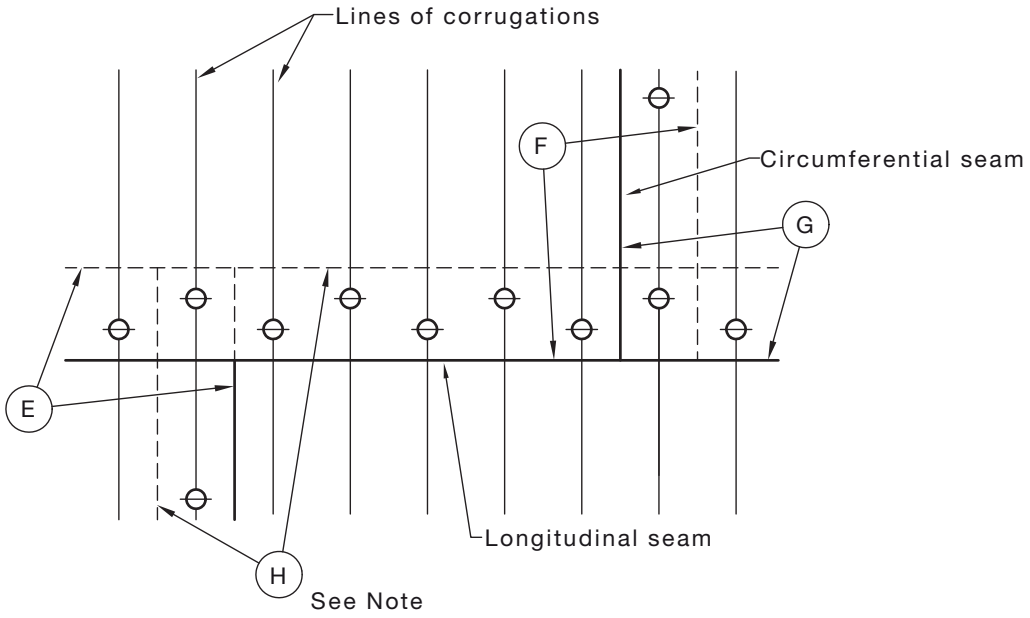
NOTE: Arrows denote the edges of the respective plates.

(b) Detailed joint of sheets staggered in circumferential direction

FIGURE 5.2.4(A) CIRCUMFERENTIAL SEAMS FOR B200 STRUCTURES



(a) Sheets staggered in longitudinal direction



NOTE: Arrows denote the edges of the respective plates.

(b) Detail joint of sheets staggered in longitudinal direction

FIGURE 5.2.4(B) LONGITUDINAL SEAMS FOR B200 STRUCTURES

SECTION 6 MATERIALS AND FABRICATION FOR B230 STRUCTURES

6.1 MATERIALS

6.1.1 Aluminium plate

6.1.1.1 *Material properties*

For B230 structures, the aluminium plate shall be of structural alloy 5052—H141 in accordance with ASTM B209, as shown in Table 6.1.1(A).

TABLE 6.1.1(A)

MATERIAL PROPERTIES—ALUMINIUM PLATE

Standard	Thickness (mm)	Minimum yield strength (0.2% offset) min. (f_y) MPa	Minimum tensile strength (MPa) (f_u) MPa	Minimum elongation % over 50 mm
ASTM B209	2.29–4.42	165.5	244.8	6%
	4.43–6.35	165.5	234.4	8%

6.1.1.2 *Base metal thickness*

Tolerances on base metal thickness shall be in accordance with Table 6.1.1(B).

TABLE 6.1.1(B)

STRUCTURAL BASE METAL THICKNESS ASTM B746 AND ASTM B209 ALLOY 5052—H141 G165 ALUMINIUM

Specified wall thickness mm	Minimum wall thickness mm	Structural base metal wall thickness (t) mm
2.54	2.36	2.49
3.18	3.00	3.15
3.81	3.51	3.69
4.45	4.09	4.30
5.08	4.72	4.97
5.72	5.31	5.59
6.35	5.89	6.20

6.1.2 Steel bolts and nuts

6.1.2.1 *Diameter*

The bolts for the field assembly of the sheets and plates shall be 19 mm or 20 mm diameter, and shall have heads and nuts specially shaped to provide suitable bearing.

6.1.2.2 *Dimensions*

For 20 mm bolts, the width across the flats of bolt heads and nuts shall be within the limits specified in AS 1252—1983. The form of thread and pitch of the bolt threads shall be ISO coarse pitch series in accordance with AS 1275. The threads shall comply with M20 6G tolerance in AS 1275, with thread tolerance class 6g before zinc coating. Threads for nuts shall be in accordance with AS 1214.

For 19 mm bolts the dimensions shall comply with ASTM A449 and A563.

6.1.2.3 *Mechanical properties*

The 20 mm bolts shall comply with the material and mechanical properties specified in AS 1252—1983. The galvanized nuts shall pass a proof load test, carried out in accordance with AS 1112 for property class 10.

For 19 mm bolts the dimensions shall comply with ASTM A449 and A563.

6.1.2.4 *Coating*

The 20 mm bolts and nuts shall be zinc-coated by hot-dip galvanizing in accordance with AS 1214. The bolts shall be centrifuged to remove surplus zinc from the threads after galvanizing. The nuts shall be galvanized as blanks and tapped after galvanizing using the oversize allowance specified in AS 1214, so that they are capable of assembly on the galvanized bolts by hand.

For 19 mm bolts the coating shall comply with ASTM B695 class 50.

6.1.2.5 *Lubrication*

Nuts shall be lubricated in accordance with AS/NZS 1252.

For 19 mm bolts the lubrication shall comply with ASTM A563.

6.1.3 Aluminium bolts and nuts

6.1.3.1 *General*

Aluminium bolts and nuts shall be manufactured from alloy 6061—T6 with dimensions in accordance with Clauses 6.1.2.1 and 6.1.2.2.

6.1.3.2 *Mechanical properties*

Alloy 6061—T6 shall have the properties specified in Clause 3.2.5. Other alloys with equal or higher proof stress are permissible substitutes subject to chemical compatibility.

NOTE: Stainless steel bolts (SS303) and nuts (SS313) or galvanized steel bolts and nuts as specified in Clause 6.1.2 may be substituted for aluminium bolts.

6.2 FABRICATION

6.2.1 General

B230 structures shall be fabricated from material specified in Clause 6.1.1, and shall be corrugated, hole punched and curved to the specified radii so that the cross-sectional dimensions of each structure shall be achieved when it is assembled. Assembled tolerances shall comply with the limits given in AS/NZS 2041.2. Coatings, if required, shall be applied after fabrication.

6.2.2 Sinusoidal corrugations

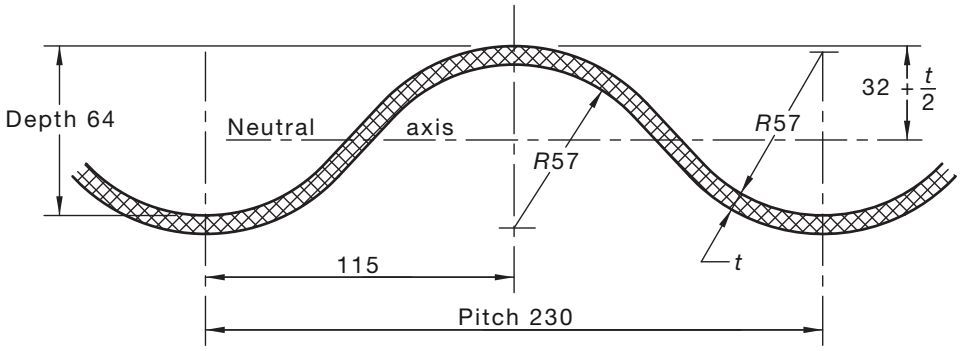
Sinusoidal corrugations, illustrated in Figure 6.2.2, shall comply with the following:

(a) The pitch of the sinusoidal corrugations (p) shall be 228.60 ±9.53 mm.

(b) The depth of sinusoidal corrugations (d_c) shall be 63.50 ±3.18 mm.

(c) The radius of sinusoidal corrugations (R_c) shall be 57.15 ±6.35 mm.

(d) The corrugations shall form smooth continuous curves and tangents.



DIMENSIONS IN MILLIMETRES

FIGURE 6.2.2 CORRUGATIONS FOR B230 STRUCTURES

6.2.3 Plate tolerances

6.2.3.1 *Plate width and length*

The actual net width and length of sheets shall be as shown in Figure 6.2.4(A).

6.2.3.2 *Plate curvature*

The tolerance on the measured rise, when compared to the calculated shop curvature shall be ±6 mm (see Figure 4.2.3). The length of the straight edge used shall not be less than 75% of the chord length.

6.2.3.3 *Plate thickness tolerance*

The minimum thickness for aluminium plate shall be the specified thickness. Plate thickness shall be measured at any point on a plate not less than 10 mm from an edge, and at the neutral axis of the corrugated plate (refer to Figure 6.2.2).

6.2.4 Bolt-holes

6.2.4.1 *General*

The holes for bolts shall be spaced so that all plates of like dimension and curvature and having the same number of bolts per unit length of seam are interchangeable (see Figure 6.2.4(A)).

The diameter of the bolt-holes in longitudinal seams shall not exceed the diameter of the bolt by more than 5 mm. Bolt holes in the circumferential seam, including corner holes, may be slotted as per ASTM B746.

6.2.4.2 *Edge distance*

The distance from the centre of a bolt to any plate edge shall be as specified in ASTM B746.

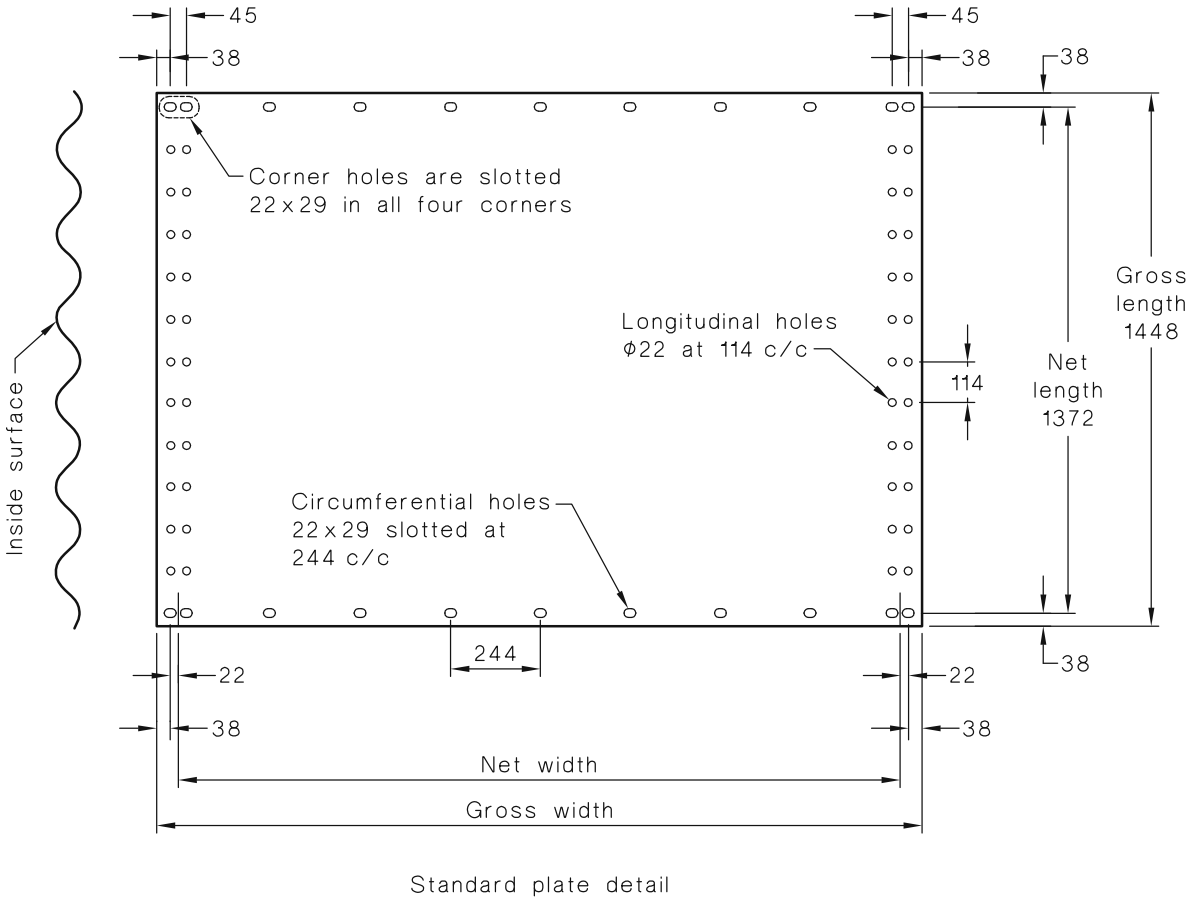
6.2.4.3 *Longitudinal seams*

The holes for bolts in longitudinal seams shall be in two rows spaced 45 mm apart, centre to centre. The minimum hole arrangement on each longitudinal seam shall have two holes in every crest, and two holes in every valley of the corrugations.

NOTE: Alternative seam bolting configurations are not precluded, provided the allowable seam strength used in design calculations is determined by full-scale bolted seam compression testing.

6.2.4.4 *Circumferential seams*

The centre-to-centre spacing of holes before curvature, for bolts in circumferential seams, shall not exceed 244 mm.



DIMENSIONS IN MILLIMETRES

FIGURE 6.2.4(A) SHEET LAYOUT FOR B230 STRUCTURES

6.2.4.5 *Hole alignment*

Prior to plate curving, the diagonal dimensions measured between bolt-holes in opposite corners of the plate shall not differ by more than 1%.

6.2.4.6 *Hole configuration*

The bolt-holes for fasteners shall be provided in a configuration that allows staggering of plate laps along the longitudinal seams (see Figures 6.2.4(B)).

6.2.4.7 *Hole defects*

Punched bolt-holes shall be free of cracks, and free of ragged edges and burrs in excess of 2.0 mm.

6.2.5 Plate identification and traceability

Plates for B230 structures shall be permanently marked to show curvature, thickness and a unique number to achieve quality assurance requirements for identification and traceability. Special plates for skewed structures or for bevelled ends shall be legibly and permanently marked to identify their proper positions in the finished structure.

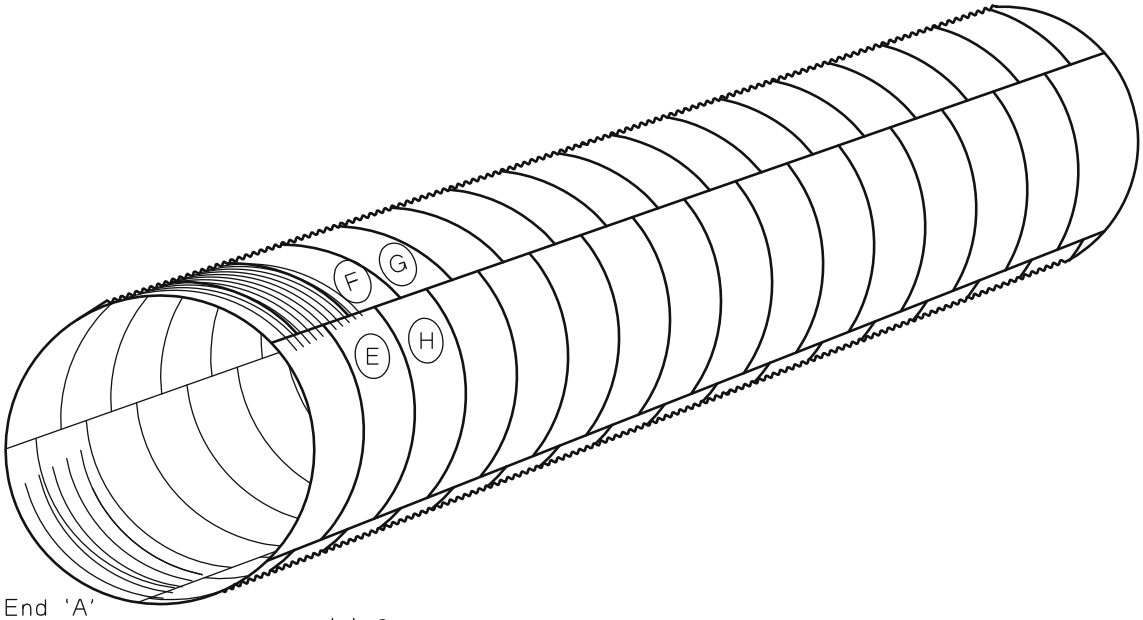
6.3 REPAIR OF DEFECTS

6.3.1 General

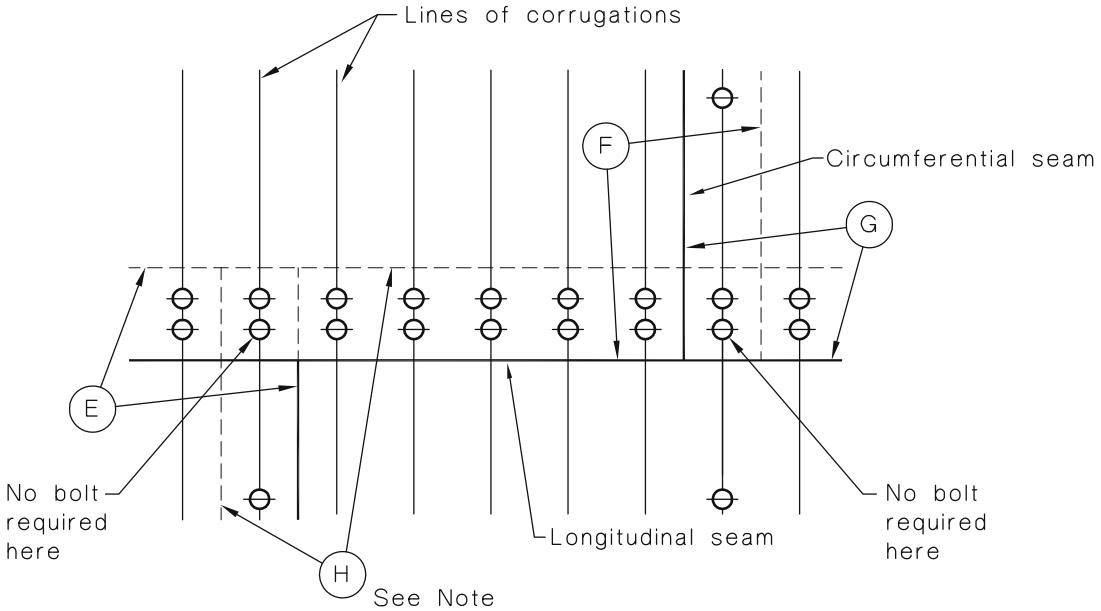
The manufactured structure shall be free of the following defects:

(a) Permanent deformation of the sheets that could impair assembly or the structural performance.

(b) Burrs such that are likely to cause injury to installers.



(a) Sheets staggered in longitudinal direction



NOTE: Arrows denote the edges of the respective plates

(b) Detailed joint of sheets staggered in longitudinal direction

DIMENSIONS IN MILLIMETRES

FIGURE 6.2.4(B) LONGITUDINAL SEAMS FOR B230 STRUCTURES

SECTION 7 MATERIALS AND FABRICATION FOR B381 STRUCTURES

7.1 MATERIALS

7.1.1 Steel sheet

7.1.1.1 *Material properties*

For B381 structures, the base steel shall be G300 or G400 in accordance with AS/NZS 1594 or Type 40 in accordance with ASTM A761, as shown in Table 7.1.1(A).

TABLE 7.1.1(A)

MATERIAL PROPERTIES—STEEL SHEETS

Standard	Metal grade	Minimum yield strength (f_y) MPa	Minimum tensile strength (f_u) MPa	Minimum elongation %
AS/NZS 1594	G300 steel	300	400	16% over 200 mm
	G400 steel	380	460	14% over 200 mm
ASTM A761	Type 40 G275 steel	300	379.2	25% over 50 mm

7.1.1.2 *Coating*

The fabricated sheet or plate shall be hot-dip galvanized in accordance with the requirements for general articles of AS/NZS 4680.

7.1.1.3 *Alternative coatings*

Where an alternative coating to that specified in Clause 7.1.1.2 is used, it shall comply with the following:

(a) *Other coating* Preparation of the base steel and application of the coating shall be in accordance with the coating manufacturer's recommendations.

(b) *Duplex coating* For abnormally adverse conditions, a secondary coating shall be applied over the primary coating (nominated in Clause 7.1.1.2 or Clause 7.1.1.3(a)) in accordance with the coating manufacturer's specification.

NOTE: Information on durability of suitable materials and coatings for various environmental conditions is given in AS/NZS 2041.1.

7.1.1.4 *Base metal thickness*

Tolerances on base metal thickness shall be in accordance with Table 7.1.1(B).

TABLE 7.1.1(B)

STRUCTURAL BASE METAL THICKNESS ASTM A761 TYPE 40 G275 GALVANIZED STEEL WITH ZINC 1220 g/m^2

Specified (coated) wall thickness mm	Nominal coated wall thickness (1220 m/g^2) mm	Minimum (coated) wall thickness mm	Nominal uncoated wall thickness mm	Structural base metal wall thickness (*t*) mm
3.56	3.60	3.29	3.43	3.29
4.32	4.36	4.06	4.19	4.09
4.78	4.82	4.51	4.65	4.57
5.54	5.58	5.28	5.41	5.37
6.32	6.37	6.06	6.20	6.20
7.11	7.15	6.85	6.98	6.98
7.87	7.92	7.54	7.75	7.75

NOTE: For B381 structures, minimum zinc coating is average coating thickness total for both sides.

7.1.2 Steel bolts and nuts

7.1.2.1 *Diameter*

The bolts for the field assembly of the sheets and plates shall be 19 mm, 20 mm or 22 mm diameter, and shall have heads and nuts specially shaped to provide suitable bearing.

7.1.2.2 *Dimensions*

For 20 mm bolts, the width across the flats of bolt heads and nuts shall be within the limits specified in AS 1252—1983. The form of thread and pitch of the bolt threads shall be ISO coarse pitch series in accordance with AS 1275. The threads shall comply with M20 6G tolerance in AS 1275, with thread tolerance class 6g before zinc coating. Threads for nuts shall be in accordance with AS 1214.

For 19 mm and 22 mm bolts the dimensions shall comply with ASTM A449 and A563.

7.1.2.3 *Mechanical properties*

The 20 mm bolts shall comply with the material and mechanical properties specified in AS 1252—1983. The galvanized nuts shall pass a proof load test, carried out in accordance with AS 1112 for property class 10.

For 19 mm and 22 mm bolts the dimensions shall comply with ASTM A449 and A563.

7.1.2.4 *Coating*

The 20 mm bolts and nuts shall be zinc-coated by hot-dip galvanizing in accordance with AS 1214. The bolts shall be centrifuged to remove surplus zinc from the threads after galvanizing. The nuts shall be galvanized as blanks, and tapped after galvanizing using the oversize allowance specified in AS 1214 so that they are capable of assembly on the galvanized bolts by hand.

For 19 mm and 22 mm bolts the coating shall comply with ASTM B695 class 50.

7.1.2.5 *Lubrication*

Nuts shall be lubricated in accordance with AS/NZS 1252.

For 19 mm and 22 mm bolts the lubrication shall comply with ASTM A563.

7.2 FABRICATION

7.2.1 General

B381 structures shall be fabricated from material as specified in Clauses 7.1.1 and shall be corrugated, hole-punched and curved to the specified radii so that the cross-sectional dimensions of each structure shall be achieved when it is assembled. Assembled tolerances shall comply with the limits given in AS/NZS 2041.2. If required, coatings shall be applied after fabrication.

7.2.2 Sinusoidal corrugations

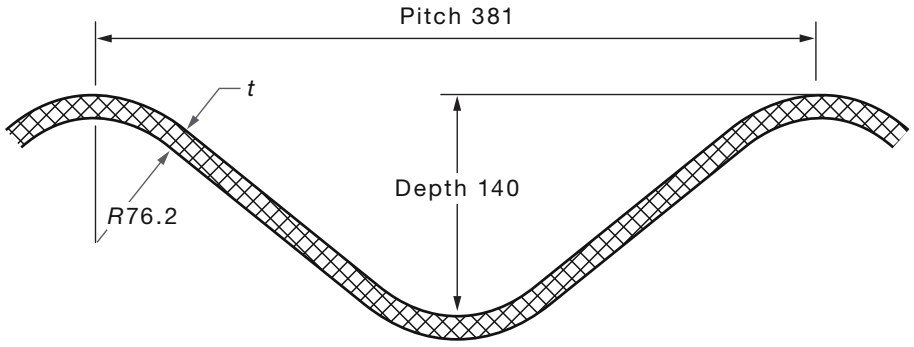
Sinusoidal corrugations, illustrated in Figure 7.2.1, shall comply with the following:

(a) The pitch of the sinusoidal corrugations (p) shall be 381.00 ±12.70 mm.

(b) The depth of sinusoidal corrugations (d_c) shall be 139.70 ±6.86 mm.

(c) The radius of sinusoidal corrugations (R_c) shall be 76.20 ±7.62 mm.

(d) The corrugations shall form smooth continuous curves and tangents.



DIMENSIONS IN MILLIMETRES

FIGURE 7.2.1 CORRUGATIONS FOR B381 STRUCTURES

7.2.3 Plate tolerances

7.2.3.1 *Longitudinal dimension*

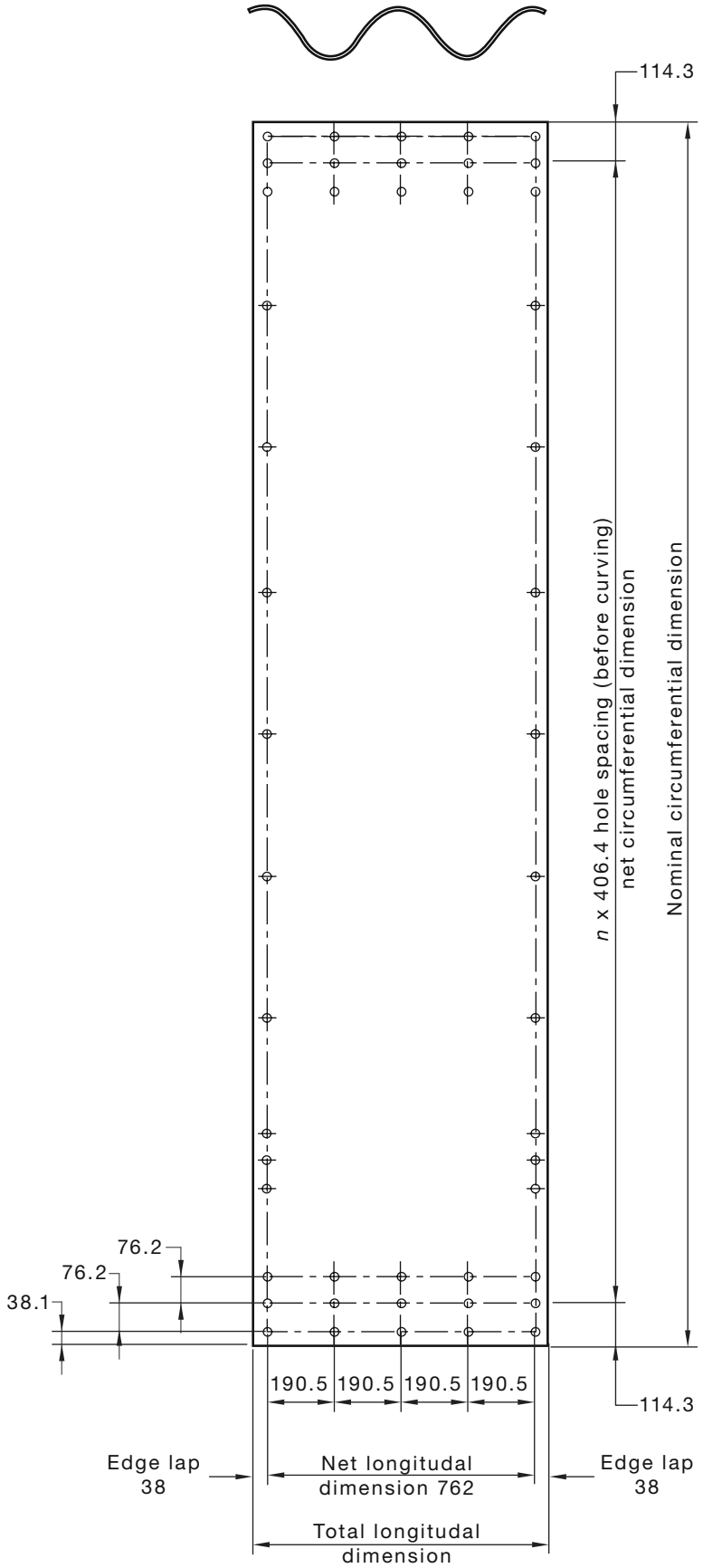
The actual net longitudinal dimension of a plate measured between the crests of the two outer corrugations shall have a dimension tolerance of ±20 mm.

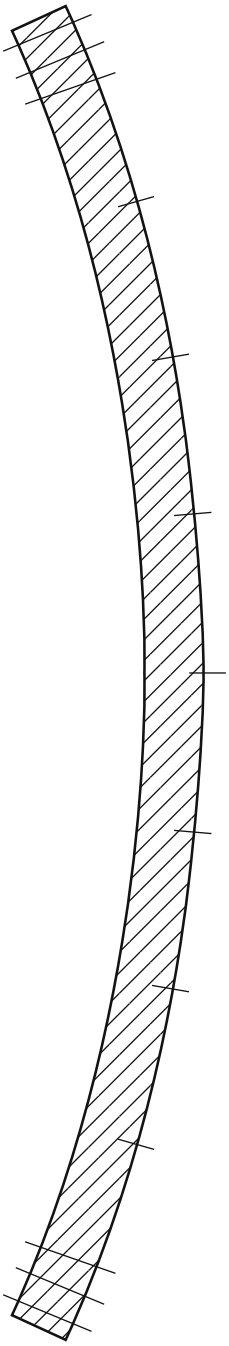
7.2.3.2 *Circumferential dimension*

The actual net circumferential dimension before curvature of sheets measured along the corrugation between bolt-holes shall not differ from the specified net dimension by more than ±5 mm (see Figure 7.2.3).

7.2.3.3 *Plate curvature*

The tolerance on the measured rise, when compared to the calculated shop curvature, shall be ±6 mm (refer to Figure 4.2.3). The length of the straight edge used shall not be less than 75% of the chord length.





DIMENSIONS IN MILLIMETRES

FIGURE 7.2.3 SHEET LAYOUT FOR B381 STRUCTURES

7.2.4 Bolt-holes

7.2.4.1 *General*

The holes for bolts shall be spaced so that all plates of like dimension and curvature, and having the same number of bolts per unit length of seam are interchangeable (refer to Figure 7.2.3).

The diameter of the bolt-holes in longitudinal seams shall not exceed the diameter of the bolt by more than 6 mm.

7.2.4.2 *Edge distance*

The distance from the centre of a bolt to any plate edge shall be as specified in AS 4100.

7.2.4.3 *Longitudinal seams*

The holes for bolts in longitudinal seams shall be in three rows spaced 190.5 mm apart, centre to centre.

NOTE: Alternative seam bolting configurations are not precluded, provided the allowable seam strength used in design calculations is determined by full-scale bolted seam compression testing.

7.2.4.4 *Circumferential seams*

The centre-to-centre spacing of holes for bolts in circumferential seams shall not exceed 406.4 mm.

7.2.4.5 *Hole configuration*

The bolt-holes for fasteners shall be provided in a configuration that allows staggering of plate laps along circumferential seams (see Figure 7.2.4).

7.2.4.6 *Hole defects*

Punched bolt-holes shall be free of cracks, and free of ragged edges and burrs in excess of 2.0 mm.

7.2.5 Plate identification and traceability

Plates for B381 structures shall be permanently marked to show curvature, thickness and a unique number to achieve quality assurance requirements for identification and traceability. Special plates for skewed structures or for bevelled ends shall be legibly and permanently marked to identify their proper positions in the finished structure.

7.3 REPAIR OF DEFECTS AND COATINGS

7.3.1 General

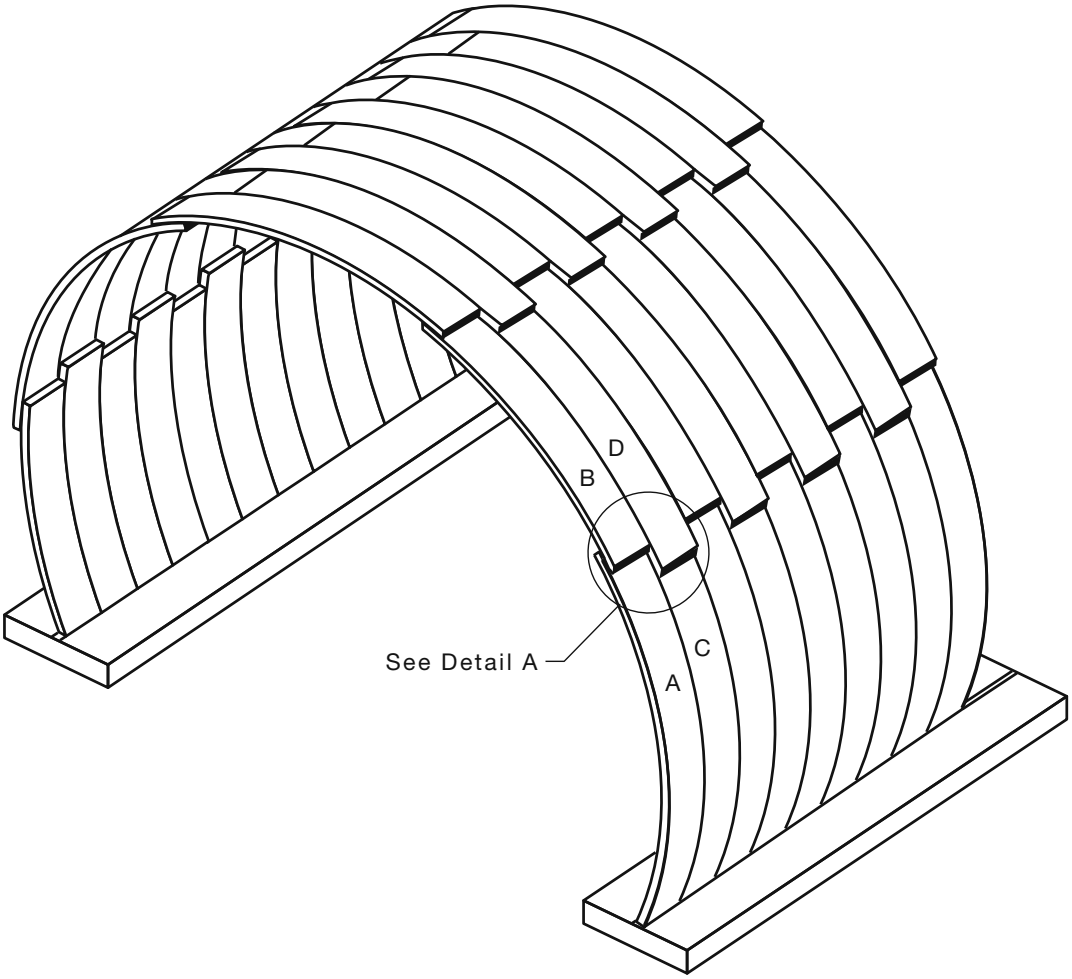
The manufactured structure shall be free of the following defects:

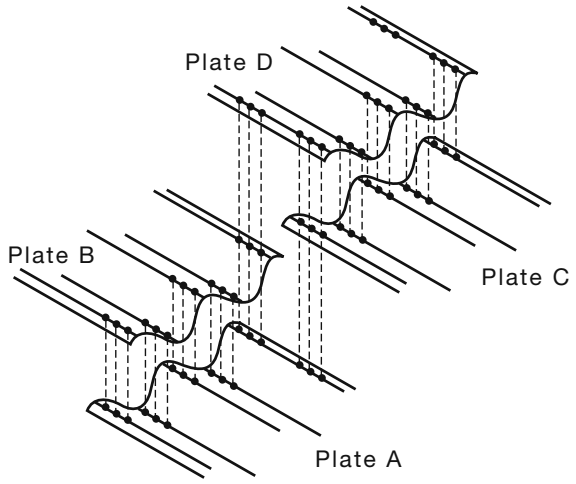
(a) Permanent deformation of the sheets that could impair assembly or the structural performance.

(b) Burrs that are likely to cause injury to installers.

7.3.2 Assessment and repairs of damaged coatings

Where coatings have been damaged or are missing, they shall be repaired in accordance with AS/NZS 2041.2.





Detail A

FIGURE 7.2.4 LAPPING OF PLATE SEAMS FOR B381 STRUCTURES

SECTION 8 SECTION PROPERTIES FOR DESIGN

8.1 SCOPE OF SECTION

This Section specifies the sinusoidal profile requirements of the design properties.

8.2 DIMENSIONS AND TOLERANCES

The dimensions and tolerances for sinusoidal profiles are given in Table 8.2(A) and Figure 8.2.

TABLE 8.2(A)

PROFILE DIMENSIONS AND TOLERANCES

Corrugation designation mm	Nominal pitch × depth mm	Pitch (p) mm	Depth (D_c) mm	Radius of sinusoidal corrugation (R_c) mm
B68	68 × 13	67.73 ± 5.29	12.70 ± 0.51	17.46 ± 4.76
B152	152 × 51	152.40 ± 6.35	50.80 ± 2.54	28.58 ± 3.18
B200	200 × 55	200.00 ± 6.00	55.00 ± 3.00	53.00 ± 3.00
B230	230 × 64	228.60 ± 9.53	63.50 ± 3.18	57.15 ± 6.35
B381	381 × 140	381.00 ± 12.70	139.70 ± 6.86	76.20 ± 7.62

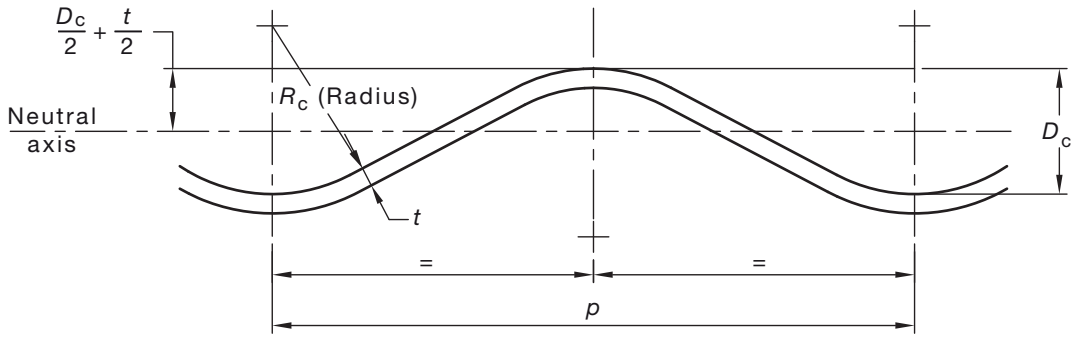


FIGURE 8.2 DIMENSIONS OF SINUSOIDAL CORRUGATIONS

8.3 MATERIAL AND SECTION PROPERTIES

The sectional and material properties used for the design of sinusoidal corrugated sheets shall be as given in the following tables:

Table 8.3(A) Sectional properties of sinusoidal B68 corrugated sheets.

Table 8.3(B) Sectional properties of sinusoidal B152 corrugated sheets.

Table 8.3(C) Sectional properties for sinusoidal B200 corrugated sheets.

Table 8.3(D) Sectional properties for sinusoidal B230 corrugated sheets.

Table 8.3(E) Sectional properties for sinusoidal B381 corrugated sheets.

The ultimate characteristic seam strengths of bolted longitudinal seam are given in the following tables:

Table 8.3(F) Ultimate characteristic strength of bolted longitudinal seam for B68 profiles.

Table 8.3(G) Ultimate characteristic strength of bolted longitudinal seam for B152 profiles.

Table 8.3(H) Ultimate characteristic strength of bolted longitudinal seam for B200 profiles.

Table 8.3(I) Ultimate characteristic strength of bolted longitudinal seam for B230 profiles.

Table 8.3(J) Ultimate characteristic strength of bolted longitudinal seam for B381 profiles.

The maximum flexibility factor for pipes are given in Table 8.3(K).

TABLE 8.3(A)
B68—SECTIONAL PROPERTIES OF SINUSOIDAL CORRUGATED SHEETS

Material Standard and specified thickness mm	Structural wall thickness (t) mm	Material (see Note 4)	Section area (A) mm^2/mm	Second moment of area (I) mm^4/mm	Elastic section modulus (W_{el}) mm^3/mm	Radius of gyration (i) mm	Plastic section modulus (W_{pl}) mm^3/mm
AS/NZS 1734, ASTM B744, 1.22 mm	1.20	Al	1.30	24.23	3.48	4.32	4.97
AS 1397, 1.20 mm	1.20	Gal	1.30	24.16	3.48	4.32	4.96
ASTM A929, ASTM A742, 1.32 mm	1.22	Az, Poly	1.32	24.66	3.54	4.32	5.06
AS/NZS 1734, ASTM B744, 1.52 mm	1.52	Al	1.65	30.77	4.33	4.32	6.31
ASTM A929, ASTM A742, 1.63 mm	1.52	Az, Poly	1.65	30.77	4.33	4.32	6.31
AS 1397, 1.60 mm	1.60	Gal	1.73	32.33	4.52	4.33	6.63
AS/NZS 1734, ASTM B744, 1.91 mm	1.91	Al	2.06	38.60	5.29	4.33	7.92
ASTM A929, ASTM A742, 2.01 mm	1.91	Az, Poly	2.06	38.65	5.29	4.33	7.93
AS 1397, 2.00 mm	2.00	Gal	2.16	40.56	5.52	4.33	8.32
AS 1397, 2.50 mm	2.50	Gal	2.70	50.93	6.70	4.34	10.46
AS/NZS 1734, ASTM B744, 2.67 mm	2.67	Al	2.88	54.41	7.08	4.35	11.18
ASTM A929, ASTM A742, 2.77 mm	2.67	Az, Poly	2.88	54.41	7.08	4.35	11.18
AS 1397, 3.00 mm	3.00	Gal	3.24	61.39	7.82	4.35	12.62
ASTM A929, ASTM A742, 3.51 mm	3.42	Az, Poly	3.70	70.33	8.72	4.36	14.48
AS/NZS 1734, ASTM B744, 3.43 mm	3.43	Al	3.71	70.44	8.73	4.36	14.50
AS 1397, 3.50 mm	3.50	Gal	3.78	71.95	8.88	4.36	14.82
AS 1397, 4.00 mm	4.00	Gal	4.32	82.60	9.89	4.37	17.04
AS/NZS 1734, ASTM B744, 4.17 mm	4.17	Al	4.50	86.14	10.22	4.37	17.79
ASTM A979, ASTM A742, 4.27 mm	4.18	Az, Poly	4.52	86.53	10.25	4.37	17.87

NOTES:

1 t = the structural base metal thickness (BMT) without coatings.

2 Section properties are calculated from the nominal rolled shape of the sinusoidal profile with the nominal dimensions given in Table 8.2(A).

3 For the purposes of calculating the minimum structural wall thickness, the properties of the above thicknesses may be interpolated to approximate intermediate thicknesses using the following equations:

(a) $A = 1.082t - 0.003$

(b) $I = 20.891t - 1.097$

(c) $W_{el} = 2.275t + 0.879$

(d) $i = 0.019t + 4.296$

(e) $W_{pl} = 4.323t - 0.288$

4 Al is aluminium, Gal is galvanised steel, Az is aluminized steel, Poly is polymer-coated steel.

TABLE 8.3(B)

B152—SECTIONAL PROPERTIES OF SINUSOIDAL CORRUGATED SHEETS ASTM A761 TYPE 38 G230 GALVANIZED STEEL WITH ZINC 1220 g/m^2

Specified wall thickness	Structural base metal wall thickness	Section area	Second moment of area	Elastic section modulus	Radius of gyration	Plastic section modulus
	(t)	(A)	(I)	(W_{el})	(i)	(W_{pl})
mm	mm	mm^2/mm	mm^4/mm	mm^3/mm	mm	mm^3/mm
3.56	3.29	4.08	1226	45.34	17.34	62.68
4.32	4.09	5.08	1532	55.84	17.37	78.24
4.78	4.57	5.68	1718	62.04	17.39	87.64
5.54	5.37	6.68	2028	72.22	17.43	103.38
6.32	6.20	7.71	2350	82.47	17.46	119.68
7.11	6.98	8.69	2661	92.10	17.50	135.37
7.87	7.75	9.65	2964	101.26	17.53	150.68

NOTES:

1 t = the structural base metal thickness (BMT) without coatings.

2 Section properties are calculated from the nominal rolled shape of the sinusoidal profile with the nominal dimensions given in Table 8.2(A).

3 For the purposes of calculating the minimum structural wall thickness, the properties of the above thicknesses may be interpolated to approximate intermediate thicknesses using the following equations:

(a) $A = 1.250t - 0.033$

(b) $I = 391.502t - 65.839$

(c) $W_{el} = 12.443t + 4.750$

(d) $i = 0.043t + 17.200$

(e) $W_{pl} = 19.813t - 2.674$

4 Material is hot-dip galvanized steel.

TABLE 8.3(C)

B200—SECTIONAL PROPERTIES OF SINUSOIDAL CORRUGATED SHEETS

Specified wall thickness	Structural base metal wall thickness (t)	Section area (A)	Second moment of area (I)	Elastic section modulus (W_{el})	Radius of gyration (i)	Plastic section modulus (W_{pl})
mm	mm	mm^2/mm	mm^4/mm	mm^3/mm	mm	mm^3/mm
AS/NZS 1594 G250 AND G300 GALVANIZED STEEL TO AS/NZS 4680						
2.50	2.43	2.87	1094	38.10	19.52	50.42
3.00	2.94	3.47	1324	45.71	19.54	60.99
4.00	3.97	4.69	1797	60.94	19.57	82.71
5.00	5.00	5.91	2273	75.77	19.60	104.58
6.00	6.00	7.10	2739	89.79	19.64	125.94
7.00	7.00	8.29	3208	103.49	19.67	147.46
8.00	8.00	9.49	3681	116.86	19.70	169.15
AS/NZS 1734 5052—H34 G180 ALUMINIUM						
3.00	2.97	3.51	1339	46.18	19.54	61.66
4.00	3.83	4.53	1734	58.94	19.57	79.82
5.00	4.83	5.72	2195	73.38	19.60	101.00
6.00	5.83	6.90	2660	87.46	19.63	122.33

NOTES:

1 t = the structural base metal thickness (BMT) without coatings.

2 The section properties are calculated from the nominal rolled shape of the sinusoidal profile with the nominal dimensions given in Table 8.2(A).

3 For the purposes of calculating the minimum structural wall thickness, the properties of the above thicknesses may be interpolated to approximate intermediate thicknesses using the following equations:

(a) $A = 1.188t - 0.020$

(b) $I = 464.352t - 41.793$

(c) $W_{el} = 14.161t + 4.323$

(d) $i = 0.032t + 19.442$

(e) $W_{pl} = 21.312t - 1.690$

TABLE 8.3(D)

B230—SECTIONAL PROPERTIES OF SINUSOIDAL CORRUGATED SHEETS ASTM B746 AND ASTM B209 ALLOY 5052—H141 G165 ALUMINIUM

Specified wall thickness mm	Structural base metal wall thickness (t) mm	Section area (A) mm^2/mm	Second moment of area (I) mm^4/mm	Elastic section modulus (W_{el}) mm^3/mm	Radius of gyration (i) mm	Plastic section modulus (W_{pl}) mm^3/mm
2.54	2.49	2.93	1462	44.30	22.32	58.64
3.18	3.15	3.72	1859	55.78	22.34	74.54
3.81	3.69	4.36	2178	64.83	22.36	87.31
4.45	4.30	5.09	2547	75.12	22.38	102.04
5.08	4.97	5.88	2949	86.14	22.40	118.12
5.72	5.59	6.61	3321	96.13	22.42	132.96
6.35	6.20	7.34	3694	106.00	22.44	147.87

NOTES:

1 t = the structural base metal thickness (BMT) without coatings.

2 The section properties are calculated from the nominal rolled shape of the sinusoidal profile with the nominal dimensions given in Table 8.2(A).

3 For the purposes of calculating the minimum structural wall thickness, the properties of the above thicknesses may be interpolated to approximate intermediate thicknesses using the following equations:

(a) $A = 1.184t - 0.011$

(b) $I = 600.758t - 36.221$

(c) $W_{el} = 16.595t + 3.403$

(d) $i = 0.033t + 22.235$

(e) $W_{pl} = 24.009t - 1.197$

4 Material is aluminium.

TABLE 8.3(E)

B381—SECTIONAL PROPERTIES OF SINUSOIDAL CORRUGATED SHEETS ASTM A761 TYPE 40 G275 GALVANIZED STEEL WITH ZINC 1220 g/m^2

Specified wall thickness mm	Structural base metal wall thickness (t) mm	Section area (A) mm^2/mm	Second moment of area (I) mm^4/mm	Elastic section modulus (W_{el}) mm^3/mm	Radius of gyration (i) mm	Plastic section modulus (W_{pl}) mm^3/mm
3.56	3.29	4.58	11206	146.71	49.45	202.59
4.32	4.09	5.70	13956	181.83	49.48	252.21
4.78	4.57	6.37	15610	202.78	49.50	282.03
5.54	5.37	7.49	18372	237.49	49.54	331.79
6.32	6.20	8.63	21214	272.86	49.57	382.97
7.11	6.98	9.73	23939	306.44	49.60	431.99
7.87	7.75	10.79	26582	338.72	49.63	479.52

NOTES:

1 t = the structural base metal thickness (BMT) without coatings.

2 The section properties are calculated from the nominal rolled shape of the sinusoidal profile with the nominal dimensions given in Table 8.2(A).

3 For the purposes of calculating the minimum structural wall thickness, the properties of the above thicknesses may be interpolated to approximate intermediate thicknesses using the following equations:

(a) $A = 1.393t - 0.004$

(b) $I = 3\,448.962t - 147.483$

(c) $W_{el} = 43.056t + 5.724$

(d) $i = 0.040t + 49.321$

(e) $W_{pl} = 62.116t - 1.804$

4 Material is hot-dip galvanized steel.

TABLE 8.3(F)

B68—ULTIMATE CHARACTERISTIC SEAM STRENGTH OF BOLTED LONGITUDINAL SEAMS

Specified wall thickness	Ultimate seam strength (R_{bs}) kN/m	
	Steel	
mm	Lapped seam	Flanged seam
1.2	75	85
1.23	89	85
1.54	161	112
1.6	180	115
1.92	249	145
2.5	390	195
2.68	425	212
3.0	500	240
3.42	597	277
3.5	610	285
4.0	731	328

TABLE 8.3(G)

B152—ULTIMATE CHARACTERISTIC SEAM STRENGTH OF BOLTED LONGITUDINAL SEAMS (STEEL)

Specified wall thickness	Structural base metal wall thickness (t)	Ultimate characteristic compressive seam strength (R_{bs}) for 19 mm bolts kN/m		
mm	mm	2 bolts per corrugation	3 bolts per corrugation	4 bolts per corrugation
3.56	3.29	905	—	—
4.32	4.09	1182	—	—
4.78	4.57	1357	—	—
5.54	5.37	1635	—	—
6.32	6.20	1926	—	—
7.11	6.98	2102	2627	2831
7.87	7.75	—	—	3430

TABLE 8.3(H)

B200—ULTIMATE CHARACTERISTIC SEAM STRENGTH OF BOLTED LONGITUDINAL SEAMS

Specified wall thickness	Structural base metal wall thickness (t)	Ultimate seam strength (R_{bs}), kN/m					
		Steel plate			Aluminium plate		
mm	mm	2 bolts per corrugation	3 bolts per corrugation	4 bolts per corrugation	2 bolts per corrugation	3 bolts per corrugation	4 bolts per corrugation
2.50	2.43	520	580	640	—	—	—
3.00	2.94	650	900	1150	320	460	580
4.00	3.97	930	1220	1660	385	555	715
5.00	5.00	1180	1560	2170	450	650	850
6.00	6.00	1430	1900	2400	515	745	985
7.00	7.00	1630	2080	2600	—	—	—
8.00	8.00	1800	2265	3200	—	—	—

TABLE 8.3(I)

B230—ULTIMATE CHARACTERISTIC SEAM STRENGTH OF BOLTED LONGITUDINAL SEAMS (STEEL AND ALUMINIUM BOLTS)

Specified wall thickness	Structural base metal wall thickness (t)	Ultimate characteristic compressive seam strength (R_{bs})	
		19 mm steel bolts, 4 bolts per corrugation	19 mm aluminium bolts, 4 bolts per corrugation
mm	mm	kN/m	kN/m
2.54	2.49	409	385
3.18	3.15	598	508
3.81	3.69	746	648
4.45	4.30	930	771
5.08	4.97	1071	771
5.72	5.59	1214	771
6.35	6.20	1359	771

TABLE 8.3(J)

B381—ULTIMATE CHARACTERISTIC SEAM STRENGTH OF BOLTED LONGITUDINAL SEAMS (STEEL)

Specified wall thickness mm	Structural base metal wall thickness (t) mm	Ultimate characteristic compressive seam strength (R_{bs}) for 19 mm bolts kN/m	Ultimate characteristic compressive seam strength (R_{bs}) for 22 mm bolts kN/m
3.56	3.29	963	—
4.32	4.09	1270	—
4.78	4.57	1489	—
5.54	5.37	1853	—
6.32	6.20	2102	2320
7.11	6.98	2102	2583

TABLE 8.3(K)

MAXIMUM FLEXIBILITY ($F_{f,max}$) mm/N

Corrugation	Maximum flexibility ($F_{f,max}$) mm/N		
	Steel pipes and ellipses		Aluminium pipes and ellipses
	Trench installation	Embankment and multiple installation	Trench, embankment or multiple installation
B68	0.342	0.245	For t = 1.5 mm, 0.18 t = 2.0 mm, 0.35 t > 2.0 mm, 0.53
B152	0.114	Round—0.114 Arches, pipe-arches and underpasses—0.171	—
B200	0.114	Round—0.114 Arches, pipe-arches and underpasses—0.171	Round—0.14 Arches, pipe-arches and underpasses—0.21
B230	—	—	Round—0.14 Arches, pipe-arches and underpasses—0.21
B381	0.114	Round—0.114 Arches, pipe-arches and underpasses—0.171	—

SECTION 9 SHAPE LIMITATIONS

The preferred dimensions of corrugated metal pipes, pipe-arches, arches and special shapes for B68, B152, B200, B230 and B381 structures are governed by the dimensions of their component sheets and plates, and are shown in Table 9.1.

TABLE 9.1

SHAPE LIMITATIONS FOR BOLTED PLATE STRUCTURES

Shape (Figure 1.1)	Geometrical parameter	Corrugation									
		B68		B152		B200		B230		B381	
		Geometrical limits (m)									
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Pipe	S_s	0.30	1.95	1.52	7.93	1.40	8.50	1.52	6.40	—	—
Pipe arch and underpass	S_s	0.45	1.80	1.85	6.27	1.90	6.60	2.00	6.55	—	—
	R_s	0.34	1.12	1.39	4.01	1.60	4.70	1.72	3.95	—	—
	r_h	0.15	—	0.75	—	0.75	—	0.80	—	—	—
Vertical ellipse	S_s	—	—	1.44	7.62	1.60	8.10	1.60	8.10	—	12.00
	R_s	—	—	1.57	8.44	1.80	9.00	1.80	9.00	—	16.00
	r_s	—	—	0.95	4.70	0.95	4.70	0.95	4.70	—	—
Horizontal ellipse	S_s	—	—	2.23	4.55	1.80	12.22	1.80	12.22	—	16.00
	R_s	—	—	1.67	3.41	1.60	9.05	1.60	9.05	—	12.00
	r_t	—	—	0.95	7.60	0.95	7.60	0.95	7.60	—	—
Horshoe arch	S_s	—	—	2.40	8.50	2.40	8.50	2.40	8.50	—	—
	R_s	—	—	1.80	6.40	1.80	6.40	1.80	6.40	—	—
Elliptical arch	S_s	—	—	2.30	8.50	2.30	8.50	2.30	8.50	—	—
	R_s	—	—	2.30	8.30	2.30	8.30	2.30	8.30	—	—
Single radius arch	S_s	—	—	1.50	8.50	1.50	8.50	1.52	9.14	6.90	25.00
	R_s	—	—	0.60	3.81	0.85	4.20	0.53	2.88	3.45	12.50
	r_t	—	—	0.75	4.40	0.75	4.40	0.80	4.40	2.80	12.50
Metal box	S_s	—	—	—	—	—	—	2.67	7.75	3.10	15.80
	R_s	—	—	—	—	—	—	0.76	3.10	1.10	4.00
	r_c	—	—	—	—	—	—	0.76	6.50	1.01	16.50
Two radius arch	S_s	—	—	2.00	11.80	2.00	11.80	2.00	11.80	8.00	25.50
	R_s	—	—	0.85	4.80	0.85	4.80	0.85	4.80	3.59	7.69
	r_t	—	—	1.00	7.62	1.00	7.62	1.00	7.62	2.80	19.00
	r_s	—	—	1.00	7.62	1.00	7.62	1.00	7.62	2.80	7.00
Three radius arch	S_s	—	—	2.00	12.00	2.00	12.00	2.00	11.60	9.00	17.00
	R_s	—	—	2.00	7.90	2.00	7.90	2.00	7.17	5.16	8.48
	r_t	—	—	1.00	7.62	1.00	7.62	1.00	7.62	2.80	19.00
	r_s	—	—	1.00	7.62	1.00	7.62	1.00	7.62	2.80	16.00

APPENDIX A

GUIDELINES FOR DESIGN INFORMATION FOR SUPPLY AND INSTALLATION

(Informative)

A1 GENERAL

This Appendix contains a brief checklist of some of the more important information that should be supplied by the designer or owner to the manufacturer and installer, to ensure that all parties are aware of the design requirements.

It aims to avoid misunderstanding and to result in satisfactory products and service being provided.

A2 DESIGN INFORMATION TO BE SUPPLIED TO THE MANUFACTURER AND INSTALLER

Complete design of buried corrugated metal structures involves considerations including site investigations, durability, flow analysis, availability of suitable backfill material and compaction equipment, consideration of the method of installation, and detailed structural design of the metal structure. AS/NZS 2041.1 provides the structural design method and gives guidance on the remaining issues, while AS/NZS 2041.2 gives requirements for installation.

Where a full design has been carried out the following minimum information should be provided:

(a) Design life and durability assumptions.

(b) Base material Standard, specified thickness, base metal thickness and coating.

(c) Description or designation of corrugation type.

(d) Structure designation (where relevant).

(e) Internal clear span or diameter (S_s).

(f) Invert length and grade.

(g) Coupling system required (where relevant).

(h) Gasket for coupling system (if required).

(i) Installation type (trench or embankment).

(j) Backfill specifications.

(k) Height of cover and unit weight of fill for construction loads.

(l) Height of cover and unit weight of fill for in service live loads.

(m) End type (see Figures A1 and A2).

NOTE: Ends with protruding metal (e.g. stepped or vertical ends) may catch debris that will affect the hydraulic performance of the structure.

(n) Design live loads:

(i) For highway, the construction live load and any special load specified by the authority.

(ii) For railway track, the rail size, dimension of sleeper and depth of ballast.

(o) Where skew is required, details should be submitted in diagrammatic form in accordance with Figure A3, including an arrow to designate the direction of flow, if applicable.

(p) Special requirements, such as invert lining, protective coating or perforation requirements.

(q) Any marking requirements (see Paragraph A4).

A3 INFORMATION TO BE SUPPLIED BY THE MANUFACTURER

The manufacturer should supply the following information:

(a) Details of the structure ordered (for example, designation and basic dimensions).

(b) Instructions for field assembly including assembly of connections and similar (see AS/NZS 2041.2).

(c) Any special instructions for back filling.

(d) Means of achieving installation tolerances, such as propping, control of construction equipment (e.g. axle load), covers required during construction and similar.

(e) When specified in the order, any details of special requirements such as end treatment, invert lining and similar.

A4 MARKING

Each structure shall be legibly and permanently marked in a conspicuous place agreed by the purchaser. The marking shall include the following:

(a) Name of the manufacturer.

(b) Date of manufacture including the month and year.

(c) A unique number identifying the structure, which shall include the thickness and profile, the structure identifier and a number for traceability detailing the particular installation, such as 3.5-200-30HE21-001

NOTE: Manufacturers making a statement of compliance with this Australian Standard on product, packaging or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

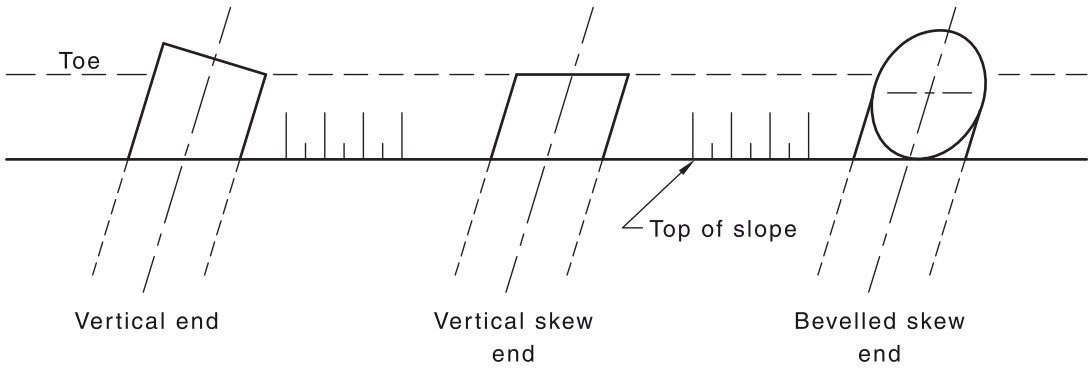
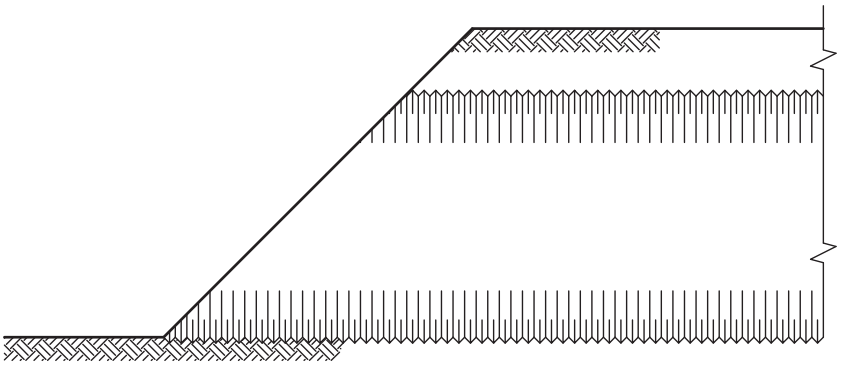
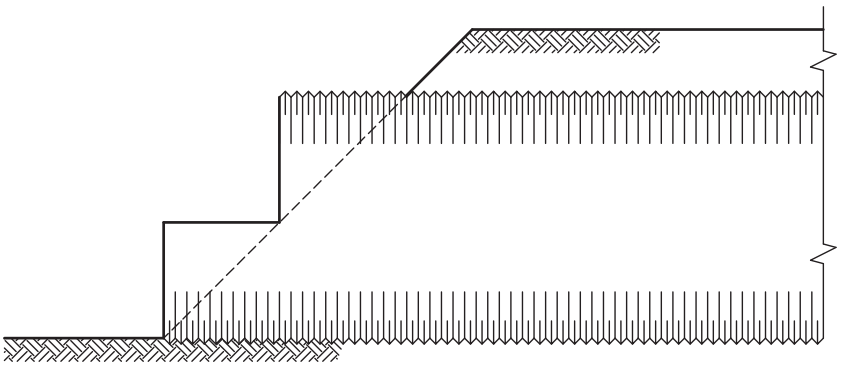


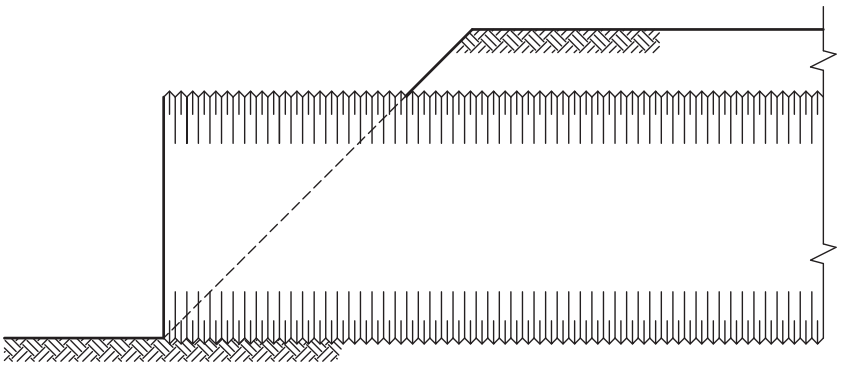
FIGURE A1 EXAMPLES OF END TYPES AND SKEWS



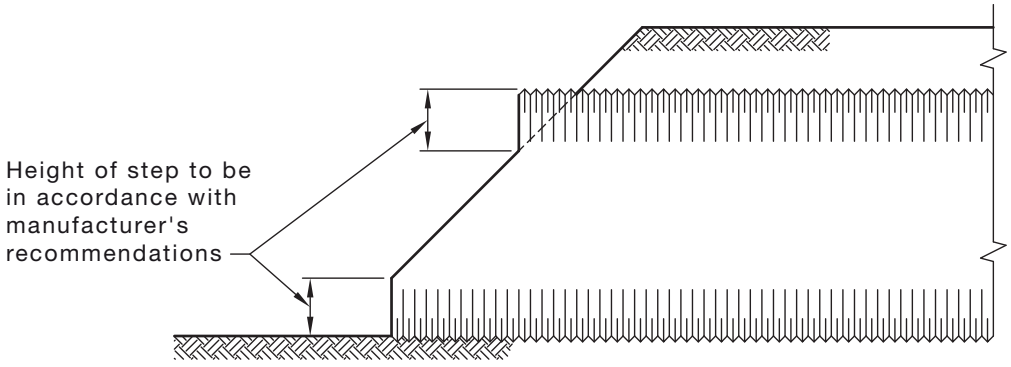
(a) Bevelled end



(b) Stepped end

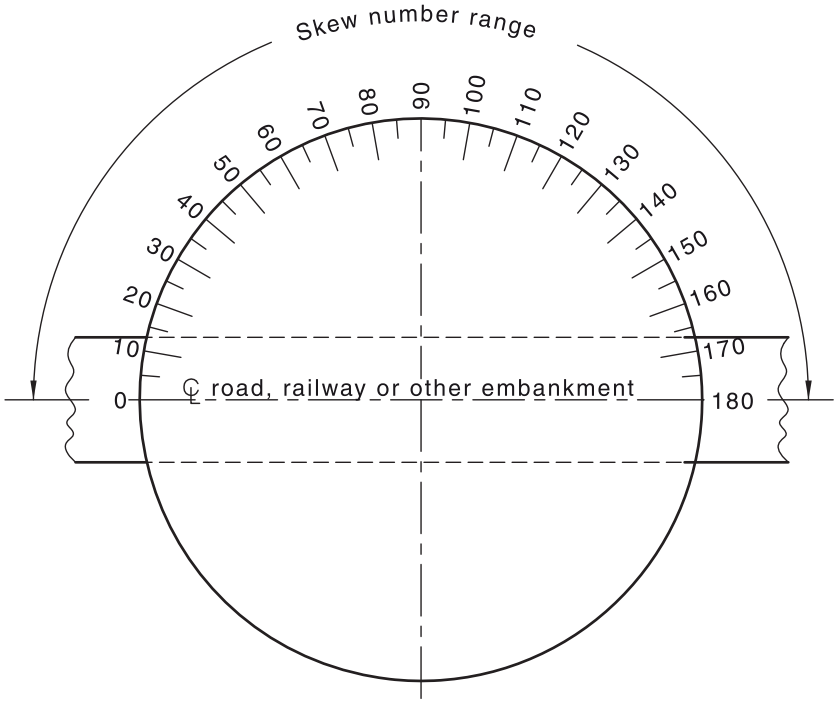


(c) Vertical end

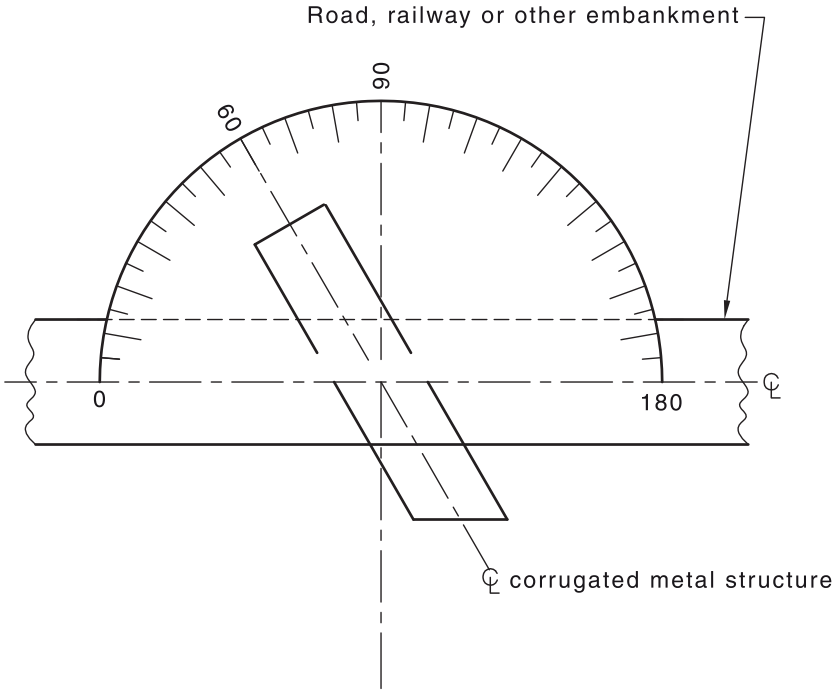


(d) Step-bevelled end

FIGURE A2 METHODS OF SPECIFYING END TYPE



(a) Diagram for indicating skew number



(b) Example showing skew number of 60

FIGURE A3 METHODS OF SPECIFYING SKEW NUMBER

APPENDIX B

MEANS FOR DEMONSTRATING COMPLIANCE WITH THIS STANDARD

(Informative)

B1 SCOPE

This Appendix sets out the following different means by which compliance with this Standard can be demonstrated by the manufacturer or supplier:

(a) Evaluation by means of statistical sampling.

(b) The use of a product certification scheme.

(c) Assurance using the acceptability of the supplier's quality system.

(d) Other such means proposed by the manufacturer or supplier and acceptable to the customer.

B2 STATISTICAL SAMPLING

Statistical sampling is a procedure that enables decisions to be made about the quality of batches of items after inspecting or testing only a portion of those items. This procedure will only be valid if the sampling plan has been determined on a statistical basis and the following requirements are met:

(a) The sample needs to be drawn randomly from a population of product of known history. The history needs to enable verification that the product was made from known materials at essentially the same time, by essentially the same processes and under essentially the same system of control.

(b) For each different situation, a suitable sampling plan needs to be defined. A sampling plan for one manufacturer of given capability and product throughput may not be relevant to another manufacturer producing the same items.

In order for statistical sampling to be meaningful to the customer, the manufacturer or supplier needs to demonstrate how the above conditions have been satisfied. Sampling and the establishment of a sampling plan should be carried out in accordance with AS 1199.1, guidance to which is given in AS 1199.0.

B3 PRODUCT CERTIFICATION

The purpose of product certification is to provide independent assurance of the claim by the manufacturer that products comply with the stated Standard.

The certification scheme should meet the criteria described in HB 18.28 (SANZ HB 18.28) in that, as well as full type testing from independently sampled production and subsequent verification of conformance; it requires the manufacturer to maintain effective quality planning to control production.

The certification scheme serves to indicate that the products consistently conform to the requirements of the Standard.

B4 SUPPLIER'S QUALITY MANAGEMENT SYSTEM

Where the manufacturer or supplier can demonstrate an audited and registered quality management system complying with the requirements of the appropriate or stipulated Australian or international Standard for a supplier's quality management system or systems, this may provide the necessary confidence that the specified requirements will be met. The quality assurance requirements need to be agreed between the customer and supplier, and should include a quality or inspection and test plan to ensure product conformity.

Information on establishing a quality management system is set out in AS/NZS ISO 9001 and AS/NZS ISO 9004.

B5 OTHER MEANS OF ASSESSMENT

If the above methods are considered inappropriate, determination of compliance with the requirements of this Standard may be assessed from the results of testing, coupled with the manufacturer's guarantee of product conformance.

Irrespective of acceptable quality levels (AQLs) or test frequencies, the responsibility remains with the manufacturer or supplier to supply products that conform to the full requirements of the Standard.

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1199 Sampling procedures and tables for inspection by attributes

1199.0 Part 0: Introduction to the ISO 2859 attribute sampling system

1199.1 Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection

2205 Methods of destructive testing of welds in metal

2205.3.1 Part 3.1: Transverse guided bend test

AS/NZS

1554 Structural steel welding

1554.1 Part 1 Welding of steel structures

1665 Welding of aluminium structures

3750 Paints for steel structures

3750.9 Part 9: Organic zinc-rich primer

4600 Cold-formed steel structures

HB 18 Guidelines for third-party certification and accreditation

HB 18.28 Guide 28—General rules for a model third-party certification scheme for products

ISO

9001 Quality management systems—Requirements

9004 Quality management systems—Guidelines for performance improvements

ASTM

A796 Standard practice for structural design of corrugated steel pipe, pipe arches and arches for storm and sanitary sewers and other buried applications

B221 Standards specification of corrugated Aluminium Alloy Structural Plate for field bolted pipe, pipe arches and arches

B790 Standard practice for structural design for corrugated aluminium pipe, pipe arches, arches and other shapes

Standards Australia

Standards Australia is an independent company, limited by guarantee, which prepares and publishes most of the voluntary technical and commercial standards used in Australia. These standards are developed through an open process of consultation and consensus, in which all interested parties are invited to participate. Through a Memorandum of Understanding with the Commonwealth government, Standards Australia is recognized as Australia's peak national standards body.

Standards New Zealand

The first national Standards organization was created in New Zealand in 1932. The Standards Council of New Zealand is the national authority responsible for the production of Standards. Standards New Zealand is the trading arm of the Standards Council established under the Standards Act 1988.

Australian/New Zealand Standards

Under a Memorandum of Understanding between Standards Australia and Standards New Zealand, Australian/New Zealand Standards are prepared by committees of experts from industry, governments, consumers and other sectors. The requirements or recommendations contained in published Standards are a consensus of the views of representative interests and also take account of comments received from other sources. They reflect the latest scientific and industry experience. Australian/New Zealand Standards are kept under continuous review after publication and are updated regularly to take account of changing technology.

International Involvement

Standards Australia and Standards New Zealand are responsible for ensuring that the Australian and New Zealand viewpoints are considered in the formulation of international Standards and that the latest international experience is incorporated in national and Joint Standards. This role is vital in assisting local industry to compete in international markets. Both organizations are the national members of ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission).

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