BRITISH STANDARD

BS 6779-2:
1991

Incorporating Amendment No. 1

Highway parapets for bridges and other structures —

Part 2: Specification for vehicle containment parapets of concrete construction

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Road Engineering Standards Policy Committee (RDB/-) to Technical Committee RDB/18, upon which the following bodies were represented:

Aluminium Federation
Association of Consulting Engineers
British Cement Association
British Railways Board
British Steel Industry
Convention of Scottish Local Authorities
County Surveyors' Society
Department of Transport
Fencing Industry Association
Institution of British Engineers
Institution of Civil Engineers
Institution of Highways and Transportation
Royal Automobile Club
Royal Society for the Prevention of Accidents

The following body was also represented in the drafting of the standard, through subcommittees and panels:

Department of Transport (Transport and Road Research Laboratory)

This British Standard, having been prepared under the direction of the Road Engineering Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 28 February 1991

The following BSI references relate to the work on this standard:
Committee reference RDB/18
Draft for comment 89/15659 DC

ISBN 0 580 19025 0

Amendments issued since publication

Amd. No.	Date	Comments
7057	April 1992	Indicated by a sideline in the margin

Contents

Foreword

This Part of BS 6779 is one of a series prepared under the direction of the Road Engineering Standards Policy Committee. The other Part already published in the series is:

— *Part 1: Specification for vehicle containment parapets of metal construction.*

The other Part so far planned in the series is:

— *Part 3: Specification for vehicle containment parapets of combined metal and concrete construction.*

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

0 Introduction

0.1 This Part of BS 6779 specifies requirements for the design and construction of concrete parapets, intended to provide specific levels of vehicle containment on highways. These parapets are installed on bridges, retaining walls or other structures.

Parapets of metal or of combined concrete and metal are not covered in this Part of BS 6779.

0.2 The specification requirements are based upon the results of tests on panels of 2.1 m and 3.0 m lengths and it is considered reasonable to extrapolate to include panel lengths from 1.5 m to 3.5 m. Designers wishing to use panel lengths outside these limits will have to form their own judgement as to making further extrapolation in the light of the individual circumstances.

0.3 The design of free standing panels and of panels having adequate shear transfer arrangements are covered.

0.4 Containment levels are related to defined vehicle impacts and normal and high levels of containment are specified. A low level of containment, used in Part 1 of this series for the design of metal parapets in certain circumstances, is not considered appropriate to concrete construction. Appendix A to Part 1 of this series outlines the derivation of design forces in relation to containment levels. The normal level of containment specified in BS 6779 is considered to offer a reasonable level of protection under all but the most exceptional cases.

0.5 The main objectives of the forms of parapet defined in this Part of BS 6779 are:

a) to provide specified levels of containment to limit penetration by errant vehicles;

b) to protect highway users and others in the vicinity by redirecting errant vehicles with minimum deceleration forces on to a path as close as possible to the line of the parapet and to reduce the risk to the vehicle of overtopping the parapet and of overturning.

0.6 It is possible in the case of concrete parapets to give theoretical design criteria to produce satisfactory designs. This is because the dynamic response of such rigid structures is relatively predictable. In consequence full scale acceptance testing, as required for metal parapets in Part 1 of BS 6779; is not necessary.

1 Scope

This Part of BS 6779 specifies requirements for the design and construction of in situ and precast concrete parapets which are designed to provide specified levels of containment for vehicles on highways. The requirements for minimum panel length and for the prevention of composite action with the main structure limit the direct application in the case of bridge decks to those of 7.5 m and greater span. As they are of solid construction they also provide effective pedestrian protection without modification. Parapets are to be prevented from acting compositely with the main structure by dividing them into panels. Parapets designed to act compositely as part of the main structure are outside the scope of this Part of BS 6779 as are prestressed concrete parapets, parapets of metal construction and parapets of combined concrete and metal design.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 6779 the following definitions apply.

2.1
vehicle restraint system

an installation to provide a level of containment for errant vehicles to limit damage or injury to users of the highway

2.2
highway parapet

a barrier at the edge of a bridge, or on top of a retaining wall or similar structure, associated with a highway

2.3
safety fence

an installation, provided for the protection of users of the highway, consisting of horizontal beams mounted on posts

2.4
safety barrier

an installation, provided for the protection of users of the highway, that is continuously in contact with its supporting foundation

2.5
transition system

an arrangement for connecting dissimilar and/or different capacity protective systems

2.6
front face of a parapet

the face nearest to the traffic

2.7
outer face of a parapet

the opposite face to the front face

2.8
main structure

any part of the bridge, retaining wall or similar structure upon which the parapet is mounted

2.9
adjoining paved surface

the paved area on the traffic side of a parapet, immediately adjacent to the base of a parapet

2.10
datum for height considerations

the highest level of footway, verge, carriageway or any other part of the road construction within 1.5 m of, and on a line at right angles to, the front face

NOTE This will normally be the adjoining paved surface.

2.11
anchorage

that part contained within the main structure to which the parapet is directly fixed by means of the attachment system

NOTE For example, a cast-in anchorage cradle in a reinforced concrete deck beam.

2.12
attachment system

the system of attachment of the parapet to the anchorage, usually consisting of holding-down bolts

2.13
top of front face of a parapet

notional or actual point at a transverse section where the horizontal projection through the highest point intercepts the plane of the front face

2.14
shear transfer

an arrangement for transferring horizontal shear between adjacent panels across the vertical joint

2.15
vehicle parapet

highway parapet that acts as a vehicle restraint system

2.16
vehicle pedestrian parapet

vehicle parapet with safety provisions for pedestrians and animals

3 Symbols

The following is a list of the symbols used in this Part of BS 6779 to represent variables. Other symbols used for designation purposes are listed in Table 1.

D	Nominal bolt diameter (mm)
f_k	Characteristic (or nominal) strength of the material
H	Vertical distance from top of parapet to the horizontal section where shear force is considered (m)
L	Length of parapet panel (m)
Q^*	Design load (kN)
Q_k	Nominal load (kN)
R^*	Design resistance
S^*	Design load effect
γ_{fL}	Partial load factor
γ_{f3}	Partial factor for load effect
γ_m	Partial factor on material strength
σ_{vb}	Minimum ultimate tensile strength of bolt material (N/mm^2)
σ_{ya}	Minimum yield strength of anchorage material (N/mm^2)

Table 1 — Designation of vehicle parapets

Item	Designation	Clause ref.
a)	***Levels of containment***	**5**
	N = Normal level of containment	**5.1**
	H = High level of containment	**5.2**
b)	***Height above datum***	**8**
	1.00 = 1 m height	
	1.25 = 1.25 m height	
	1.50 = 1.50 m height etc.	
c)	***Type***	**11.3.9**
	Without shear transfer	
	I = In situ concrete	
	P = Precast concrete	
	With shear transfer	
	i = In situ concrete	
	p = Precast concrete	

NOTE Examples of designation:
N/1.00/I indicates an in situ concrete parapet of 1 m height, of normal level of containment, with no shear transfer arrangement.
H/1.50/p indicates a precast concrete parapet of 1.50 m height, of high level of containment, with shear transfer arrangement.

4 Designation of vehicle parapets

For the purposes of an abbreviated description, vehicle parapets shall be designated by three characters indicating:

a) level of containment;

b) height of parapet;

c) type of parapet.

Designation details are set out in Table 1.

NOTE Compatible designations for metal parapets are given in BS 6779-1.

Section 2. General design

5 Levels of containment

5.1 Normal level of containment

Normal level of containment shall be that required to resist penetration from the following vehicle impact characteristics:

Vehicle	Saloon car
Mass	1 500 kg
Height of centre of gravity	600 mm
Angle of impact	20°
Speed	113 km/h (70 mile/h)

NOTE The normal level of containment is that suitable for general use.

5.2 High level of containment

High level of containment shall be that required to resist penetration from the following vehicle impact characteristics:

Vehicle	Four axle rigid tanker or equivalent
Mass	30 000 kg
Height of centre of gravity	1.8 m
Angle of impact	20°
Speed	64 km/h (40 mile/h)

NOTE 1 The high level of containment is for use only in extremely high risk situations.

NOTE 2 Some authorities, notably British Rail, have specific requirements which should be determined for parapets on structures over their property. For applications over or adjacent to railways, reference should be made to British Rail or other appropriate railway authority.

6 Vehicle impact loading

NOTE The results of a series of impact tests carried out on concrete parapets have been analysed to produce the equivalent static loads and design methods set out in clauses **6** and **11**.

6.1 General

The parapet shall be designed to resist loading appropriate to the designated level of containment using the equivalent static nominal loadings from Table 2.

6.2 Attachment systems and anchorages for precast concrete parapet panels

6.2.1 Attachment systems and anchorages shall be designed to resist the loadings given in **11.2.2**.

6.2.2 In addition, when considering anchorage and attachment systems for high containment, the following nominal loads shall be considered in combination with the loadings in **6.2.1** to give the most severe effect:

a) a nominal horizontal longitudinal load of 72 kN applied at the top of the front face of the panel and uniformly distributed over a length of 3 m or the panel length if less;

b) a nominal downward vertical load of 175 kN uniformly distributed over a horizontal length of 3.0 m at the top of the front face of the parapet.

6.3 Main structure

The loads due to vehicle collision with parapets, and which are considered locally in the design of the elements of the parapet supporting structure and globally on main structures including bridge superstructures, bearings and substructures, shall be as specified in Department of Transport Standard BD 37/88.

Table 2 — Equivalent static nominal loads for in situ and precast concrete parapets applicable to panel lengths (L) 1.5 m to 3.5 m

Parapet containment level	Panel nominal bending moment[a]	Panel nominal shear[b]	Panel joint nominal shear transfer[c]
		kN/panel	kN
Normal[d] — without shear transfer provision between panels	50 kN over 1.0 m	$80L$	
High — with shear transfer provision between panels[e]	$(180 + 40L)$ kN/panel	$(90 + 50H) L$	110
High — without shear transfer provision between panels	$(210 + 40L)$ kN/panel	$(110 + 50H) L$	

[a] The bending moment to be resisted produced by applying transversely a horizontal, continuous, uniformly distributed nominal load to the top of the panel.
[b] The nominal shear force to be resisted by any transverse section of a panel.
[c] Minimum ultimate transverse shear resistance to be provided within the top 1.2 m of the panel wall.
[d] Shear transfer provision between panels of normal containment parapets is not recommended because of the problem of joint formation in the thinner sections.
[e] End panels to be designed without shear transfer effect, see **13.1**.

7 Wind loading

Wind loading shall be derived from BS 5400-2.

Wind loading and vehicle impact shall not be considered coexistent.

8 Parapet heights

The minimum height of concrete parapets shall be measured from the datum to the top of the front face and it shall be for a particular application as listed below:

1.00 m	—	For vehicle and vehicle pedestrian parapets except as otherwise specified below
1.25 m	—	with agreement (see note 2 of **5.2**) for bridges carrying motorways over railways, or situations where pedestrians are excluded
1.50 m	—	for all other bridges over railways
	—	for high containment applications
	—	for protection of animals.

In the latter case if additional height is required only for the protection of animals this may be provided by the addition of a metal rail mounted on posts anchored into the top of the concrete parapet. The rail, posts and anchorages shall be designed to resist a horizontal ultimate loading of 1.4 kN/m applied to the rail.

9 Front face profile, freedom from projections and joint treatment

9.1 The front face profile shall be either vertical or uniformly inclined from the base to the top of the parapet at an angle not exceeding 5° (see Figure 1).

9.2 Where pedestrians have access adjacent to the parapet the top of the parapet shall have a steeple coping as shown in Figure 1 or as otherwise specified by the purchaser.

9.3 The front faces of panels and the steeple or other copings shall be plain and smooth except as given in **9.5**.

9.4 Front faces of adjacent panels shall not be out of line by more than 3 mm at any point. Gaps between panels shall not exceed 40 mm or be less than 20 mm. Gaps shall be open, covered or sealed and filled with a durable soft joint filler of the closed cell flexible foamed plastics type (see Figure 2). Open gaps shall not be used over railways.

NOTE 1 Where parapets are mounted on flexible bridge decks a 20 mm joint gap could be subjected to displacement under live load of up to 25 % of the gap width. The joint filler and any surface sealant should therefore be able to sustain such a range of cyclic movement or otherwise the joint width should be extended to an amount which reduces the calculated displacement to an acceptable percentage of gap width compatible with the proposed filler and sealant.

NOTE 2 Surface sealants may need to be debonded from the adjacent faces of joint fillers to sustain the anticipated movement without volume change.

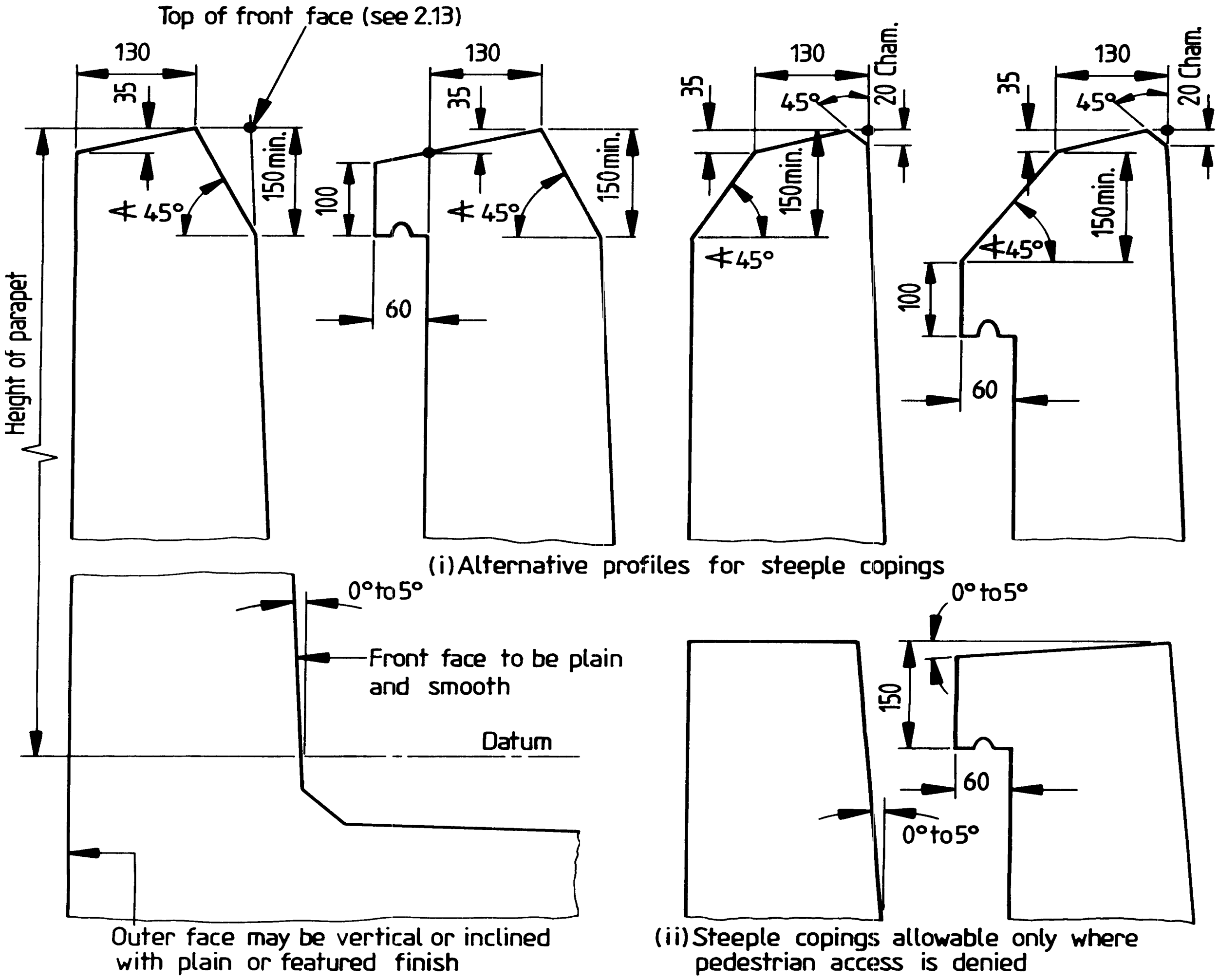
NOTE 3 Joints may require drainage (see item f) of clause **10**).

NOTE 4 Special treatment of joints at expansion joints is required, see clause **14**.

9.5 Projections or depressions in the front faces of panels shall be permitted only at panel joints, joints with the safety fences and at movement joints.

NOTE In the end panel, a recess, in the concrete may be provided to receive the safety fence such that the front face of the safety fence rail is flush with the front face of the parapet panel.

Where bolts are used in connections, e.g. fixings of bridging plates at the movement joints, the bolts shall be of a well rounded shape with a maximum projection of 15 mm from the front face of the panel or bridging plate.



(a) General dimensions

(b) Alternative details for tops of parapets

All dimensions are in millimetres

NOTE See clause **12** for panel length requirements.

Figure 1 — Dimensional parameters for reinforced concrete parapets

10 Durability

10.1 Concrete parapets are likely to be directly affected by de-icing salts, traffic fumes and other corrosive elements: therefore they shall be constructed to withstand a "very severe" environment as classified in BS 5400-4 and BS 5400-8. In particular they shall comply with the following.

a) Grades of concrete shall be 40 or 50 and over as specified in BS 5400-7 and BS 5400-8; for grade 40 the concrete shall be air entrained.

NOTE The Department of Transport has particular requirements for these grades of concrete.

b) The minimum cement content for any grade of concrete shall be 325 kg/m^3.

c) The nominal cover to reinforcement shall be as specified in BS 5400-4 (see also **11.3.2**).

d) Holding-down bolts shall be of stainless steel in accordance with BS 6105. Parts of anchorages within 50 mm of any formed surface shall be of corrosion resistant material or of steel galvanized in accordance with BS 729. (See **11.3.5**.)

e) Metal to metal contact between dissimilar materials shall be avoided.

f) Unfilled holes, annular spaces, gaps, etc., where water could collect and freeze or cause local deterioration shall not be present.

10.2 Both in situ and precast concrete parapet panels may need to be repaired or replaced after impact damage and design details shall take this into account.

11 Design method

11.1 General

Parapets of concrete construction, attachment systems and anchorages shall be designed by the application of limit state principles. The limit state to be adopted shall be the ultimate limit state using appropriate partial factors. The appropriate recommendations of BS 5400-1 shall be followed.

NOTE 1 Because of the effects on the anchorages and the main structure, it is important to limit the strength of the parapet to be sufficient only to resist penetration at the level of containment intended, it being accepted that the vertical panel of the parapet will sustain damage during impact.

NOTE 2 The failure mode which is to be produced is by yielding of the tension steel in the front face of the parapet panel. To achieve this effect it is essential that the equivalent static design forces produce stresses at, or approaching, the ultimate limit state in the tensile reinforcement. This requires a rather different approach from normal to the application of load factors and material factors.

NOTE 3 The factors given in Table 3 and Table 4 are chosen to achieve:

a) the required mode of failure in the vertical wall of the panel on application of the appropriate equivalent static nominal force;

b) precast concrete parapet panel bases that are in the order of 25 % stronger than the vertical wall;

c) a progressive increase in strength through the attachment system, anchorage and the element of the main structure which carries the anchorage.

Table 3 — Value of γ_{fL} — ultimate limit state[a]

Element	Loading	Containment	
		Normal	High
		γ_{fL}	γ_{fL}
Parapet panels	Vehicular impact Wind loading	1.0 1.4	1.0 1.4
Attachment system	Parapet collapse	1.3	1.2
Anchorage	Parapet collapse	1.6	1.4

[a] See notes 1, 2 and 3 in **11.1**.

11.2 Design loading values

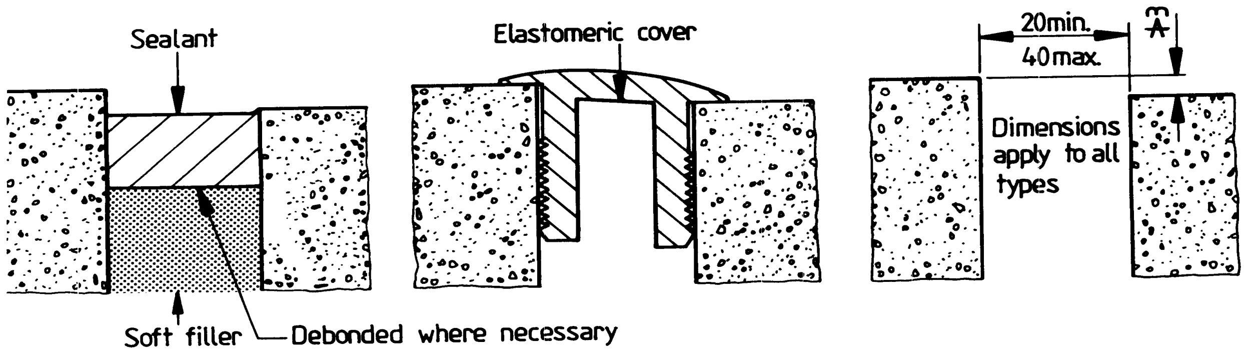
11.2.1 *Design loads for parapet panels*

The design loads Q^* shall be determined from the nominal loads Q_k according to the relationship:

$$Q^* = \gamma_{fL} Q_k$$

where the partial load factor γ_{fL} is a function of the loading and element to be designed, as given in Table 3 for the parapet panels.

In the design of the parapet panels the nominal load for vehicular impact with the parapet shall be in accordance with **6.1**. Wind loading shall be considered when appropriate (see clause **7**).



a) Filled and sealed b) Covered c) Open (not over railways)

All dimensions are in millimetres.

NOTE These details are for nominal panel joints, expansion joints require special treatment (see clause **14**). Drainage of joint may be required [see **10.1** f)].

Figure 2 — Alternative joint details

11.2.2 ***Design loads for anchorages and attachment systems***

In the design of attachment systems and anchorages the nominal load shall be determined from the nominal loads Q_k according to the relationship:

$Q^* = \gamma_{fL} Q_k$

Q_k shall be taken as the load transmitted at collapse by the parapet induced by transverse force applied at the top of the front face of the panel. Depending on the failure mode, the nominal load shall be based on the lesser of either:

a) the calculated ultimate moment of resistance at the base of the parapet wall and the coexistent shear force; or

b) the calculated ultimate shear resistance at the base of the parapet wall and the coexistent moment.

The calculated resistance of the parapet shall be determined as the unfactored design resistance, i.e. $f(f_k)$ in accordance with **11.2.4**.

γ_{fL} is a function of the loading and element to be designed, and shall be as given in Table 3 for the attachment system and anchorage.

11.2.3 ***Design load effects***

The design load effects S^* shall be obtained from the design loads Q^* by the following relationship:

$$S^* = \gamma_{f3} \text{ (effects of } Q^*)$$
$$= \gamma_{f3} \text{ (effects of } \gamma_{fL} Q_k)$$

where γ_{f3} is a factor that takes account of inaccurate assessment of the effects of loading and unforeseen stress distribution in the parapet. For wind loading, γ_{f3} shall be taken as **1.1**. For vehicular impact loading and parapet collapse γ_{f3} shall be taken as **1.0**.

11.2.4 ***Design resistance values***

The design resistance R^* shall be defined as:

$$R^* = f\left[\frac{(f_k)}{(\gamma_m)}\right]$$

or, optionally for steel and concrete,

$$R^* = \frac{f(f_k)}{\gamma_m}$$

where

f_k is the characteristic (or nominal) strength of the material;

γ_m is a partial factor on material strength.

NOTE Values for f_k and γ_m are given in Table 4. Note that in accordance with **11.2.2**, γ_m is not used in connection with calculation of design loads based on parapet collapse.

For the purpose of evaluating the design resistance R^*, $f(f_k)$ shall be determined in accordance with BS 5400-3 or BS 5400-4 as appropriate. For parapet panel wall of reinforced concrete sections the design bending resistance shall be determined from first principles taking into account all reinforcement which contributes to the resistance of the section under consideration.

11.2.5 ***Verification of design suitability of panel, attachment system and anchorage***

11.2.5.1 For a satisfactory design of parapet panel and precast panel base, the following shall be satisfied:

a) $R^* \geq S^*$

i.e. $f\left[\frac{(f_k)}{(\gamma_m)}\right] \geq \gamma_{f3}$ (effects of $\gamma_{fL} Q_k$)

or, optionally for steel and concrete,

$$\frac{f(f_k)}{\gamma_m} \geq \gamma_{f3} \text{ (effects of } \gamma_{fL} Q_k)$$

b) In addition, for bending resistance of the lower third of the design height of the parapet wall:

1) generally $R^* \ngtr 1.4\, S^*$

2) at least one section $R^* \ngtr 1.1\, S^*$ (see note 1 to **11.1** but $R^* \nless S^*$

Table 4 — Values of f_k and γ_m

Component	Material		fk	γ_m
Parapet panel wall in situ and precast	RC	Concrete	As given in BS 5400-4	1.0
		Reinforcement	As given in BS 5400-4	0.8
Parapet panel base precast	RC	Concrete	As given in BS 5400-4	1.2
		Reinforcement	As given in BS 5400-4	1.0
Anchorage and attachment system	Steel		As given in BS 5400-3	
	Stainless steel nuts, bolts and washers		As given in BS 6105 or BS 1449-2 as appropriate	1.2

11.2.5.2 For a satisfactory design of attachment system and anchorage the following shall be satisfied:

$$R^* \geq S^*$$

$$\text{i.e.}\quad f\left[\frac{f_k}{\gamma_m}\right] \geq \gamma_{f3}\ (\text{effects of } \gamma_{fL}\ Q_k)$$

or, optionally for steel and concrete,

$$\frac{f\ (f_k)}{\gamma_m} \geq \gamma_{f3}\ (\text{effects of } \gamma_{fL}\ Q_k)$$

NOTE When applying BS 5400-3 care should be taken as the above expression has been rearranged as follows:

$$\frac{1}{\gamma_{f3}\ \gamma_m}\ [f\ (f_k)] \geq (\textit{effects of}\ \gamma_{fL}\ Q_k)$$

The values of γ_{f3} given in **11.2.3** shall be substituted for the values given in BS 5400-3.

11.3 Design of reinforced concrete components, attachment systems, anchorages and bedding

11.3.1 *General*

Concrete components shall be designed in accordance with BS 5400-4 and **11.3.2** to **11.3.6**.

11.3.2 *Parapet panel walls*

Parapet panel walls shall comply with the following:

a) all external faces shall be reinforced at centres not exceeding 200 mm × 150 mm;

b) the cover to all external faces shall not exceed 70 mm;

c) in the front face the area of secondary reinforcement shall be not less than 50 % of the area of the main reinforcement;

d) the area of reinforcement in the outer face, both vertical and horizontal, shall be not less than 50 % of that in the front face;

e) the horizontal reinforcement shall be continuous around the ends of the panels and shall enclose the vertical reinforcement.

NOTE These requirements are intended to limit dislodgement of concrete under impact.

11.3.3 *Bolted down anchorages to and bedding of precast concrete panels*

11.3.3.1 *General*

The attachment system and anchorage of precast concrete panels to the main structure shall be designed to resist the combined bending, shear and torsion design load effects of the nominal applied loads.

11.3.3.2 *Holding-down bolt design*

Unless other suitable arrangements are made for the transfer of horizontal shear, the holding-down bolts shall be designed to resist the combined design load effects given in **11.3.3.1**.

11.3.3.3 *Transfer of horizontal shear through bedding grout*

Where transfer of horizontal shear is achieved through bedding grout in an arrangement such as that shown in Figure 3, the following shall apply:

a) a full bed of grout is made;

b) surfaces are cleansed of laitance and roughened;

c) any temporary levelling devices are removed.

NOTE 1 The ability of cementitious bedding grout to transfer horizontal shear in this type of design has been demonstrated by a full scale testing programme. The grout used in the test was a high flow; non-shrink, high bond strength proprietary material.

NOTE 2 Other properly designed fixing methods may be used.

11.3.4 *Vertical shear*

The base of the precast unit and the supporting structure shall each be designed to accommodate the shear forces which are created between the centres of compression and tension in the connection.

11.3.5 *Attachment system*

Stainless steel holding-down bolts in accordance with BS 6105 shall be provided to connect the precast panel with the anchorage in the main structure. Stainless steel washers or plates, in accordance with BS 1449-2, shall be provided as bearings to transfer bolt tensions to the top of the precast units, in accordance with BS 5400-4. Design of bolts and of dispersion of stresses through washers or plates shall be in accordance with BS 5400-3.

The design of the attachment system shall be such that removal and replacement of damaged panels may be readily achieved.

NOTE The purchaser should specify the grade of stainless steel required.

11.3.6 *Engagement of holding-down bolts*

Each holding-down bolt shall have a length of engagement into the anchorage of not less than that given by the following expression:

$$0.7 \times \frac{\sigma_{vb}}{\sigma_{ya}} \times D$$

where

σ_{vb} is the minimum ultimate tensile strength of the bolt material (in N/mm^2);

σ_{ya} is the minimum yield strength of the anchorage material (in N/mm^2);

D is the nominal bolt diameter (in mm).

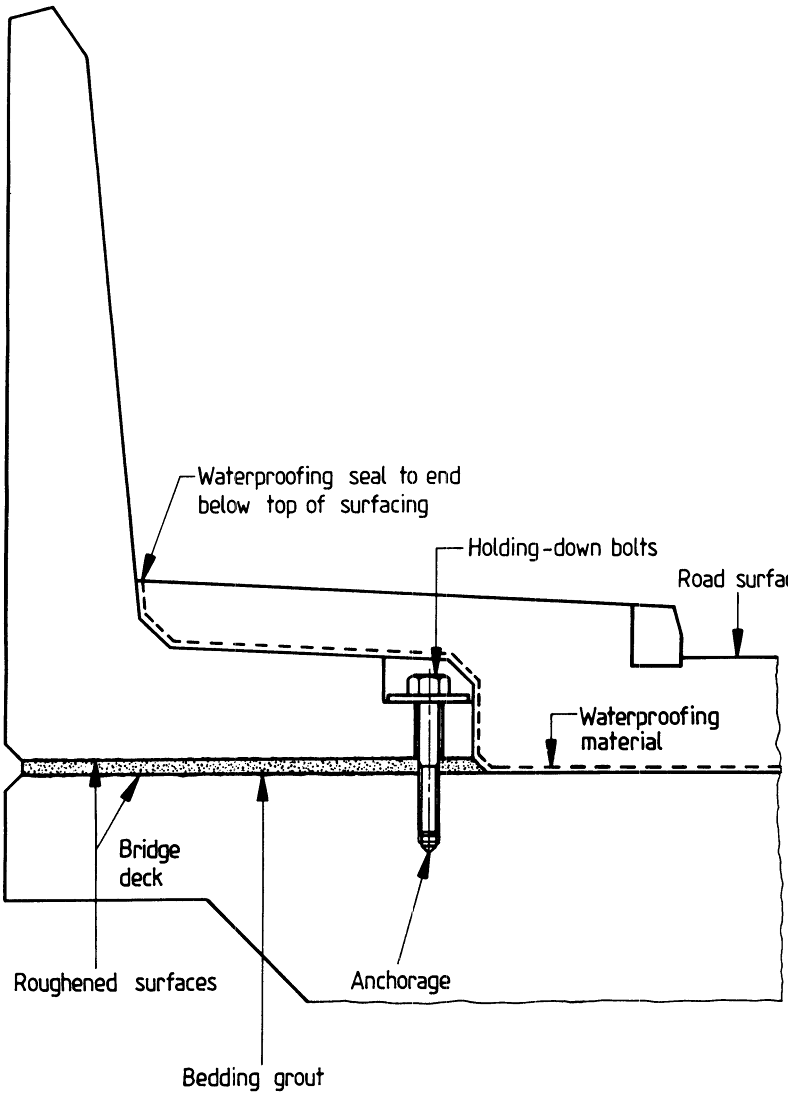


Figure 3 — Possible diagrammatic arrangement of a precast reinforced concrete parapet

NOTE 1 This is to ensure that bolt failure occurs prior to anchorage thread failure. Tolerance for erection levelling needs to be allowed.

NOTE 2 If the type of holding-down bolt used requires an initial torque to be effective, this torque should be specified.

11.3.7 *Anchorages in main structure*

Anchorages shall be either cast-in or drilled individual bolt anchorages, that are of purpose design or of proprietary manufacture. It shall be ensured that they will provide the necessary resistance, taking into account the effect of possible overlap of stress cones from individual bolts and any bursting forces from expanding type anchorages.

NOTE 1 The concrete of the main structure may need additional local reinforcement to resist, without damage, the forces transmitted from the parapet.

NOTE 2 Static testing of the proposed assembly may be considered advisable if other evidence is not available covering the particular application.

NOTE 3 It is good practice to fill any voids in anchorages, such as those around bolts in holes drilled for individual anchorages, with a non-setting passive filler to prevent the collection of water which may freeze and engender bursting stresses.

NOTE 4 It is good practice to grease internal threads of anchorages with a grease having a high resistance to flow/creep to assist with any need for renewal.

11.3.8 *Bedding*

Any bedding used, e.g. between base of precast panel and main structure, shall be capable of permanently transmitting the loads involved, safely and without undue deformation. The finished bedding shall not contain voids and shall be resistant to penetration by water. It shall have a minimum thickness of 10 mm and a maximum thickness of 30 mm plus allowance for falls on the top of the main structure. Where extra bedding thickness is allowed the length of the holding-down bolts shall comply with **11.3.6**. Due regard shall be given to the bearing stresses developed in any bedding or in the main structure.

11.3.9 *Horizontal shear transfer between panels of high containment parapets*

11.3.9.1 Suitable arrangements shall be made for providing transfer of horizontal shear between panels if it is required to allow the use of the reduced equivalent static loads in Table 2 which take account of load distribution to adjacent panels.

NOTE Figure 4 shows the arrangement used on the tested parapets.

11.3.9.2 The shear transfer shall be designed for the shear force given in Table 2 and shall not inhibit gap displacement.

12 Prevention of composite action between the parapet and main structure

NOTE Composite action could occur where the parapet is attached to a bridge deck or other element of the main structure which is designed to deflect under load.

In such circumstances significant composite effects shall be avoided by dividing the parapet, whether in situ or precast, into panels throughout its length. Panel lengths shall not exceed one fifth of the span of the main structure nor 3.5 m and shall be not less than 1.5 m. Joints between panels shall not be capable of transmitting longitudinal forces.

For in situ parapet panels, the joint between panels shall extend from the top of the panel down to not more than 25 mm above the level of the main structure.

For precast parapet panels, the joint between panels shall extend throughout the cross section of the precast panel and any part of the supporting structure, such as a laced reinforcement cast in situ anchorage.

13 Ends of parapets

13.1 Strength of end panels

All end panels shall be designed as stand alone units without any load shedding due to shear transfer arrangements.

13.2 Ends of parapets for normal containment

13.2.1 *Parapets with safety fences*

Where a safety fence is provided at each end of a parapet it shall be made continuous with the parapet by a connection capable of resisting an ultimate tensile force of not less than 330 kN.

Where such a connection is not practicable, a full height anchorage capable of resisting an ultimate tensile force of not less than 330 kN shall be provided to the safety fence.

NOTE For more information on safety fences see BS 6579.

13.2.2 *Parapets without safety fences*

Where there is no safety fence at the end of a parapet, such precautions as are practicable under the circumstances shall be taken to prevent errant vehicles colliding directly with the end of the parapet.

13.3 Ends of parapets for high containment

13.3.1 *Parapets with safety fences*

Where safety fences are present, there shall be a suitable transition arrangement to provide protection from impact to the end of the parapet.

NOTE 1 General details are obtainable from the Department of Transport.

NOTE 2 At some future date it is intended that a British Standard will be produced to cover the requirements for transition between safety fences and high containment parapets, but it will be some time before this will be available and no design parameters can be laid down at this time.

13.3.2 *Parapets without safety fences*

Where there is no safety fence at the end of a parapet, such precautions as are practicable under the circumstances shall be taken to prevent errant vehicles colliding directly with the end of the parapet.

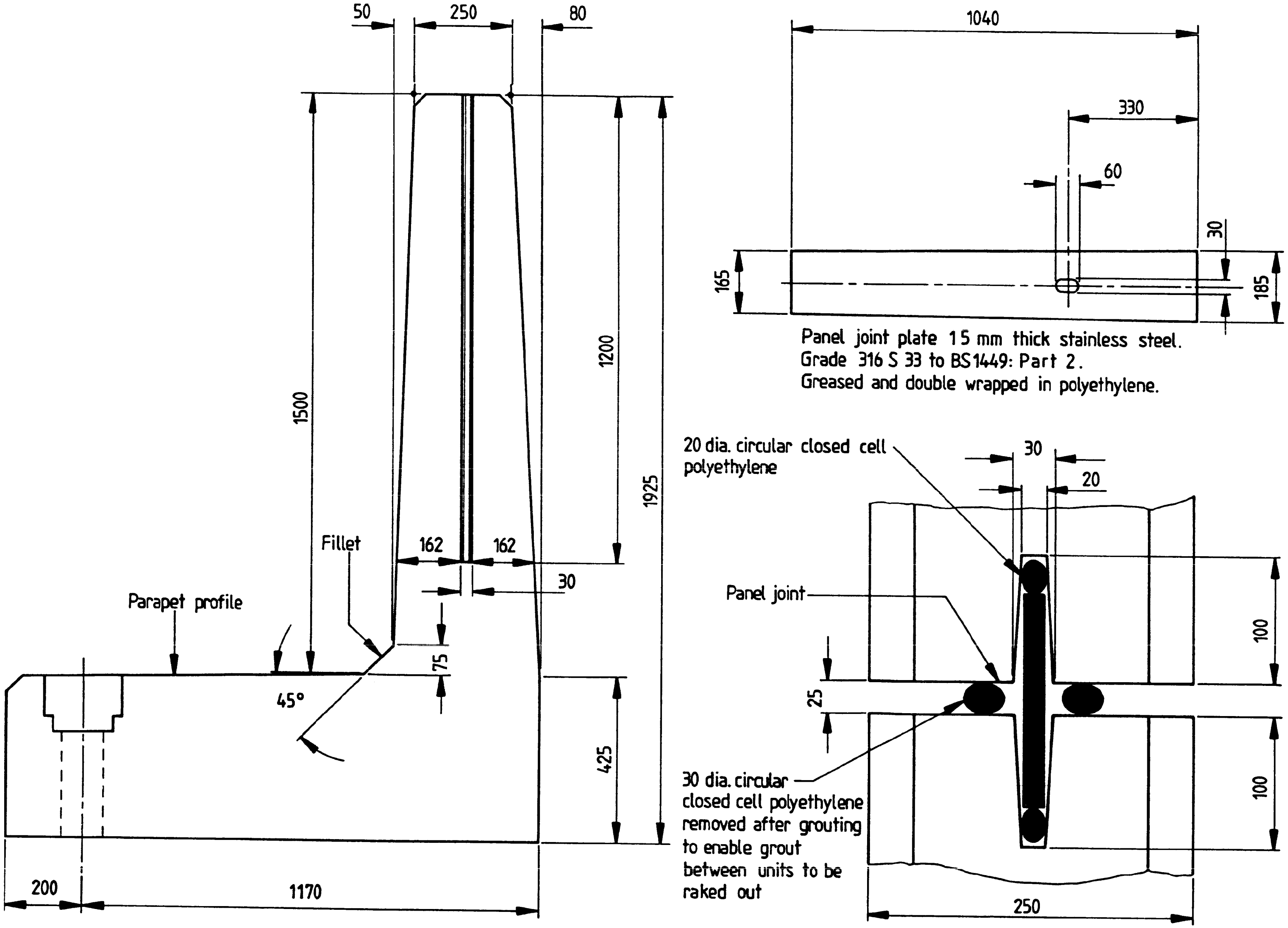
14 Movement joints in parapets

14.1 Panels on either side of movement joints shall be designed to stand alone and shall not have any shear transfer arrangements incorporated across the joint.

14.2 Where large movements take place which would produce an unacceptable gap between panels a bridging plate shall be incorporated.

14.3 Any such bridging piece shall be securely fixed at the traffic approach end and shall be corrosion resistant and replaceable.

14.4 Fixings of bridging plates shall comply with **9.5**.



All dimensions are in millimetres.

Figure 4 — Shear transfer arrangement used in the tested parapets

Section 3. Construction

15 Materials and workmanship

Materials and workmanship for concrete construction shall be in accordance with BS 5400-7.

16 Surface finish

Unless otherwise specified by the purchaser all surfaces of the parapet shall have a plain smooth finish free from blow holes and evidence of grout loss or lack of compaction.

NOTE The purchaser should state any special requirements in respect of surface finishes.

Publications referred to

BS 729, *Specification for hot dip galvanized coatings on iron and steel articles.*
BS 1449, *Steel plate, sheet and strip.*
BS 1449-2, *Specification for stainless and heat- resisting steel plate, sheet and strip.*
BS 5400, *Steel, concrete and composite bridges.*
BS 5400-1, *General statement.*
BS 5400-2, *Specification for loads.*
BS 5400-3, *Code of practice for design of steel bridges.*
BS 5400-4, *Code of practice for design of concrete bridges.*
BS 5400-7, *Specification for materials and workmanship, concrete, reinforcement and prestressing tendons.*
BS 5400-8, *Recommendations for materials and workmanship, concrete, reinforcement and prestressing tendons.*
BS 6105, *Specification for corrosion-resistant stainless steel fasteners.*
BS 6579, *Safety fences and barriers for highways.*
BS 6779, *Highway parapets for bridges and other structures.*
BS 6779-1, *Specification for vehicle containment parapets of metal construction.*
BS 6779-3, *Specification for vehicle containment parapets of combined metal and concrete construction*[1].
BD 37/88, *Department of Transport Standard "Loads for Highway Bridges"*[2].

[1] In preparation and referred to in the foreword only.
[2] Published by the Department of Transport and available from HMSO.

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