British Standard

BRITISH STANDARD

BS 6779-3:1994

Highway parapets for bridges and other structures —

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

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee B/509, Road equipment, to Subcommittee B/509/13, Bridge parapets, upon which the following bodies were represented:

Aluminium Federation
Association of Consulting Engineers
British Railways Board
British Steel Industry
County Surveyors' Society
Department of Transport (Transport Research Laboratory)
Institution of Civil Engineers
Institution of Highways and Transportation

This British Standard, having been prepared under the direction of the Technical Committee B/509, was published under the authority of the Standards Board and comes into effect on 15 May 1994

The following BSI references relate to the work on this standard:
Committee reference B/509/13
Draft for comment 92/13171 DC

ISBN 0 580 22158 X

Amendments issued since publication

Amd. No.	Date	Comments

Contents

Foreword

This Part of BS 6779 is one of a series prepared under the direction of Technical Committee B/509 “Road equipment”. The other Parts already published in the series are:

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

— *Part 2: Specification for vehicle containment parapets of concrete construction;*

The other Part so far planned in the series is:

— *Part 4: Specification for vehicle containment parapets of composite masonry and concrete construction;*

Parapets are multi-purpose in that they have to serve the safety of errant vehicles and their occupants, pedestrians and other road users, and may be used to guard against possible initiation of a major incident in areas adjoining highways such as high-speed rail lines.

Parapets are generally required to have an acceptable appearance, and not to impose such weight or force on the edge of a bridge or structure as to add unduly to its structural requirements.

All or any of these requirements may be in conflict in any particular circumstance, and a judgement as to the solution providing the best overall balance of advantage and safety then has to be made.

The range of vehicles using the roads is vast and constantly developing as changes take place in design, axle loadings and other characteristics, and errant vehicles will produce impacts of differing severity over a range of angles, speeds and disposition of loaded weight. Open frame parapets may be required to have mesh, bar or solid infill for additional safety and protection of pedestrians, animals and rail users, hence the range of variables and their combinations is virtually infinite.

Thus, specifying desirable characteristics for parapets, deciding upon levels of containment to be achieved, and specifying designs and/or tests to produce parapets which perform accordingly is fraught with difficulty. There are inevitably areas of imprecision: for example, for practical reasons ordinary production vehicles have to be used in testing parapets, and while these will conform to the specified parameters, they all may not have precisely the same effect upon a particular parapet.

A programme of full scale dynamic testing of prototype parapets was carried out for Part 1 of BS 6779 and is continuing for subsequent Parts of the standard. The results from these tests have been used to supplement and extend what was considered to be the best of current practice. Unfortunately such tests are costly and resource consuming and the range is necessarily limited. Some references will be found in the text of the various Parts to such problems and to the inclusion of established parapet designs. Appendix A of BS 6779-1:1992 in particular provides some background to the consideration of impact from errant vehicles.

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.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 36, 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.

blank

Section 1. General

Introduction

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

The design requirements specified for normal containment parapets are based upon the results of tests on parapets having precast concrete panel lengths of 3.0 m. Although these tests were carried out some time ago the testing regime and criteria for successful performance were similar to those currently specified in BS 6779-1:1992 if somewhat less well defined. It is considered reasonable to extrapolate to include panel lengths from 2.6 m to 3.1 m for parapets conforming to the dimensional requirements of Figure 1.

The design requirements specified for high containment are based upon the results of more recent tests on parapets having precast concrete panel lengths of 2.1 m. It is considered reasonable to extrapolate to include panel lengths from 1.8 m to 2.4 m for parapets conforming to the dimensional requirements of Figure 1.

As combined metal and concrete parapets are comparatively rigid structures the dynamic response is more predictable than for metal parapets covered in Part 1. Therefore, within the above ranges of panel lengths and outline configurations it is possible to give theoretical design criteria to produce satisfactory designs.

For parapets outside these ranges of panel lengths or having dimensions that do not conform to Figure 1, to be deemed to conform to this specification, designs may be produced making such extrapolations or modifications from those set out herein as are considered reasonable but any such design needs to be validated by full scale dynamic testing to the requirements of Appendix E of BS 6779-1:1992. The performance criteria to be met for such a test are to be those required in **26.2** of BS 6779-1:1992, for normal containment and **26.4** for high containment, with the addition of "or concrete" after "metal" in the **26.2.3** and **26.4.3**.

The design of parapets having free-standing panels and of parapets with panels having adequate shear transfer arrangements are covered.

Containment levels are related to defined vehicle impacts and a "normal level of containment" and a "high level 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 combined construction. Appendix A to BS 6779-1:1992 outlines the derivation of design forces in relation to containment levels. Under all but the most exceptional cases the normal level of containment specified in BS 6779 is considered to offer the best overall compromise between the safety of impacting vehicles and their occupants, the safety of other vehicles on the highway and their occupants and the prevention of penetration by the impacting vehicle into adjoining areas.

The main objectives of the forms of parapet defined in this Part 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 both of overturning and of overtopping the parapet.

Prototype, high level containment combined parapets using both aluminium and steel have been successfully tested and details are given in Annex B.

1 Scope

This Part of BS 6779 specifies requirements for the design and construction of combined concrete and metal parapets to provide specified levels of containment for vehicles on highways. Normal containment parapets have concrete panel heights of 0.4 m to 0.8 m with one, two or three effective longitudinal metal members. High containment parapets have a panel height of 0.9 m and a single metal, effective, longitudinal member. The metal members are carried on metal posts attached to the concrete panels which may be in situ or precast, with or without shear transfer. Prestressed concrete and parapets designed to act compositely with the main structure are not covered in this Part of BS 6779.

2 References

2.1 Normative references

This Part of BS 6779 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on page 35. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 6779 only when incorporated in it by updating or revision.

2.2 Informative references

The Part of BS 6779 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover but reference should be made to the latest editions.

3 Definitions

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

3.1
vehicle restraint system

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

3.2
highway parapet

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

3.3
combined parapet

a parapet having one, two or three metal effective longitudinal members, carried on metal posts, mounted on concrete panels of not less than 0.4 m height

3.4
safety fence

an installation provided for the protection of users of the highway consisting of horizontal beams or wire ropes mounted on posts

3.5
safety barrier

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

3.6
transition system

an arrangement for connecting dissimilar and/or different capacity vehicle restraint systems

3.7
front face

the face nearest to the traffic

3.8
outer face

the opposite face to the front face

3.9
traffic face of a combined parapet

the front face of the concrete base and a continuation vertically from the top of this, tangential to the front face of the rail(s)

3.10
main structure

any part of the bridge, retaining wall or other structure on which the parapet is mounted

3.11
adjoining paved surface

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

3.12
datum for height considerations

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

NOTE This will normally be the adjoining paved surface.

3.13
anchorage

that part contained within the main structure to which a precast parapet is directly fixed by means of the attachment system; for example, a cast-in anchorage cradle in a reinforced concrete deck beam

3.14
attachment system

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

3.15
shear transfer arrangement

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

3.16
infilling panel

a non-structural panel used to cover the spaces between rails and between the bottom rail and the panel or plinth on the front face of a parapet to safeguard pedestrians or meet other requirements

3.17
effective longitudinal member

those longitudinal metal rails of a parapet which are intended and designed to become effective in restraining a vehicle in an impact

3.18
non-effective longitudinal member

an additional longitudinal member above the effective longitudinal members provided to give additional height to the parapet for the protection of pedestrians or animals or to support noise or other environmental barriers

3.19
panel

the section of the precast or in situ concrete part of a combined parapet between vertical joints

3.20
panel wall

the vertical or near vertical wall of a panel

3.21
panel base

the part of a panel below the panel wall (usually only present in precast parapets)

4 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	Effective depth to tension reinforcement
D	Nominal bolt diameter (mm)
f_k	Characteristic (or nominal) strength of the material
h	Vertical distance from top of parapet to the applied impact (m)
H	Vertical distance from top of parapet to the horizontal section where bending moment is considered (m)
L	Length of parapet panel (m)
L_d	Distance from centre of reinforcement area to the extreme compression fibre
Q^*	Design loads
Q_k	Nominal loads
R^*	Design resistance
S^*	Design load effects
γ_{fL}	Partial load factor
γ_{f3}	Partial factor for load effects
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)
n	Number of effective longitudinal members

Table 1 — Designation of combined vehicle parapets

Item	Designation	Clause reference number
a)	***Levels of containment*** N = Normal H = High	**6**
b)	***Height above datum*** 1.00 = 1 m height 1.25 = 1.25 m height 1.50 = 1.50 m height, etc.	**9**
c)	**Type** ***Without shear transfer between the concrete panels*** F = In situ concrete and metal f = Precast concrete and metal ***With shear transfer between the concrete panels*** T = In situ concrete and metal t = Precast concrete and metal	**12.3.8**

NOTE 1 Examples of designation:
N/1.00/F indicates an in situ panel, combined parapet of 1 m height above the datum of normal level of containment, with no shear transfer arrangement.
H/1.50/t indicates a precast panel, combined parapet of 1.50 m height above the datum of high level of containment, with shear transfer arrangement.
NOTE 2 Infill items are to be described separately in addition.

5 Designation of combined metal and concrete 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 above the datum;

c) type of parapet.

Designation details are set out in Table 1.

Section 2. Design

6 Levels of containment

6.1 Normal level of containment

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

Vehicle type	Saloon car
Mass	1 500 kg
Height of centre of gravity	530 mm
Angle of impact	20°
Speed	113 km/h (70 mile/h)

NOTE 1 The normal level of containment is that suitable for general use.

NOTE 2 The choice of car is open but the Department of Transport choose a particular model for their tests only changing when necessary.

6.2 High level of containment

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

Vehicle type	Four axle rigid HGV
Mass	30 000 kg
Height of centre of gravity	1.65 m
Angle of impact	20°
Speed	64 km/h (40 mile/h)

NOTE 1 The high level of containment is for use only in situations where penetration presents the probability of extreme high risk.

NOTE 2 Tankers are used by the Department of Transport for their tests.

7 Vehicle impact loading

NOTE The results of a series of impact tests carried out on combined parapets have been analysed to produce the equivalent static loads and design methods set out in clause **7** and **12**.

7.1 General

The parapet shall be designed to resist loading appropriate to the designated level of containment with or without shear transfer provision using the equivalent static nominal loadings given in **7.2** and **7.3** which are applicable to panel lengths (L) 2.6 m to 3.1 m and 1.8 m to 2.4 m respectively.

The nominal loadings given in **7.2** and **7.3** are summarized in Table 2 and Table 3.

Q_k is the nominal value given in Table 2;

n is the number of effective longitudinal members including the concrete panel in the parapet (not exceeding 4 for normal containment and 2 for high containment);

For normal containment, the minimum height to the top of the concrete panel shall be 400 mm. Panels are counted as:

a) 400 mm height up to and including 600 mm, $n = 1$;

b) over 600 mm and up to and including 800 mm (maximum), $n = 2$.

For high containment the height is taken as 900 mm only, $n = 1$.

7.2 Normal containment: no shear provision between panels

NOTE Shear transfer provision between panels of normal containment parapets is not recommended because of the problem of joint formation in the thinner section.

7.2.1 *Metal posts, rails and their interconnection*

7.2.1.1 *Posts, post to base plate connection and base plate*

An individual horizontal nominal load of Q_k/n kN is applied transversely to the post, acting at the level of the centroid of each effective rail section.

An individual horizontal nominal load of $Q_k/8n$ kN is applied longitudinally to the post, acting at the level of the centroid of each effective rail section.

Concurrently, a horizontal nominal load of $(0.9 \times Q_k/n)$ kN is applied transversely and a horizontal nominal load of $(0.9 \times Q_k/8n)$ kN is applied longitudinally to the post, both acting at the level of the centroid of each effective rail section.

7.2.1.2 *Rail*

An individual horizontal nominal load of Q_k/n kN is applied transversely as a point load at mid-point between the centres of support, acting at the level of the centroid of each effective rail section.

An individual vertical load of $Q_k/2n$ kN is applied as a point load at mid-point between the centres of support, acting through the centroid of each effective rail section.

Concurrently, a horizontal nominal load of $(0.75 \times Q_k/n)$ kN applied transversely and a vertical nominal load of $(0.75 \times Q_k/2n)$ kN is applied as a point load at mid-point between the centres of support, both acting at the level of the centroid of each effective rail section.

NOTE The point load is nominal and rails do not require reinforcement against local damage.

Table 2 — Nominal loads for parapets

Level of containment	Nominal load Q_k	Post, post to base plate connection, base plate				Rail				Post to rail connection				Concrete panels			
		Loads considered individually		Loads considered concurrently		Loads considered individually		Loads considered concurrently		Horizontal transverse nominal load kN	Vertical nominal load kN	Horizontal longitudinal nominal load kN		Horizontal transverse nominal loads applied concurrently kN		Nominal shear in panel kN/panel	Nominal shear transfer across joint kN
		Horizontal transverse nominal load from each effective metal longitudinal member kN (see **7.1**)	Horizontal longitudinal nominal load from each effective metal longitudinal member kN (see **7.1**)	Horizontal transverse nominal load from each effective metal longitudinal member kN (see **7.1**)	Horizontal longitudinal nominal load from each effective metal longitudinal member kN (see **7.1**)	Horizontal transverse nominal load kN	Vertical nominal load kN	Horizontal transverse nominal load kN	Vertical nominal load kN			Intermediate posts	End posts (end bay)	Top of panel	Centroid of each effective longitudinal member (see **7.1**)		
Normal	50	$\frac{Q_k}{n}$	$\frac{Q_k}{8n}$	$\frac{0.9Q_k}{n}$	$\frac{0.9Q_k}{8n}$	$\frac{Q_k}{n}$	$\frac{Q_k}{2n}$	$\frac{0.75Q_k}{n}$	$\frac{0.75Q_k}{2n}$	$\frac{Q_k}{n}$	$\frac{Q_k}{2n}$	$\frac{Q_k}{2n}$	$\frac{Q_k}{n}$	$\frac{Q_k}{n}$	$\frac{Q_k}{n}$	50	—
High with shear transfer	320	$\frac{Q_k}{n}$	$\frac{Q_k}{8n}$	$\frac{0.9Q_k}{n}$	$\frac{0.9Q_k}{8n}$	$\frac{Q_k}{n}$	$\frac{Q_k}{2n}$	$\frac{0.75Q_k}{n}$	$\frac{0.75Q_k}{2n}$	$\frac{Q_k}{n}$	$\frac{Q_k}{2n}$	$\frac{Q_k}{4n}$	$\frac{Q_k}{2n}$	$\frac{Q_k}{n}$	$\frac{Q_k}{n}$	380	70
High without shear transfer														$\frac{1.4Q_k}{n}$	$\frac{Q_k}{n}$	440	—

NOTE For n see **7.1**.

Table 3 — Nominal loads for attachment systems and anchorages

Level of containment	Attachment systems and anchorages for connection of metal posts to concrete panels			Attachment systems and anchorages for connection of precast concrete units to supporting structure				
	Horizontal transverse nominal load from each effective metal longitudinal member kN	Horizontal longitudinal nominal load from each effective metal longitudinal member kN	Vertical nominal load from each effective metal longitudinal member kN	Parapet collapse load kN	Horizontal longitudinal nominal load applied at		Vertical downward nominal load applied at	
					Centroid of post kN	Top of front face of concrete panel kN	Centroid of post kN	Top of front face of concrete panel kN
Normal	$\frac{Q_k}{n}$	$\frac{Q_k}{8n}$	$\frac{Q_k}{2n}$	As specified in **12.2.2**	—	—	—	—
High with shear transfer	$\frac{Q_k}{n}$	$\frac{Q_k}{8n}$	$\frac{Q_k}{2n}$	As specified in **12.2.2**	25	75	75	75
High without shear transfer								
NOTE For n see **7.1**								

7.2.1.3 *Post to rail connections*

Connections shall be designed to resist the following nominal loads acting individually.

a) A horizontal load acting at right angles to the traffic face, towards the post centreline, through the centroid of the effective rail section of value $\frac{Q_k}{n}$ kN.

b) A vertical load, applied either upwards or downwards, acting through the centroid of the effective rail section of value $\frac{Q_k}{2n}$ kN.

c) A load acting parallel to the rail at its centroid of section of value:

1) for intermediate posts, $Q_k/2n$ kN;

2) for special end posts, Q_k/n kN;

NOTE 1 The strength of post to rail connections has not previously been specified and there is wide variation in the strengths of connections used in successful parapet designs. It is considered, however, that the minimum criteria suggested above will help to improve overall performance.

NOTE 2 Where the strength of a connection is not amenable to verification by analysis it may be justified by test.

7.2.2 *Concrete panels*

7.2.2.1 *Nominal bending moment in panels where n = 1* (i.e. other than those for normal containment exceeding 600 mm in height)

NOTE The panel acts as an effective longitudinal member and carries the loads from the post.

The bending moment to be resisted shall be that produced by applying the following combined nominal loads acting concurrently:

a) a horizontal, continuous, uniformly distributed load of $\frac{Q_k}{n}$ kN/panel applied transversely to the top of the front face of the panel;

b) a horizontal load of $\frac{Q_k}{n}$ applied transversely, acting at the level of the centroid of each effective metal rail section applied at the centreline of the post.

7.2.2.2 *Nominal bending moment in panels where n = 2* (i.e. for normal containment exceeding 600 mm in height)

NOTE The panel acts as an effective longitudinal member and carries the loads from the post.

The bending moment to be resisted shall be that produced by applying the following combined nominal loads acting concurrently:

a) a horizontal, continuous, uniformly distributed load of $\frac{2Qk}{n}$ kN/panel applied transversely to the top of the front face of the panel;

b) a horizontal load of $\frac{Q_k}{n}$ applied transversely, acting at the level of the centroid of each effective metal rail section applied at the centreline of the post.

7.2.2.3 *Nominal shear in panel*

The nominal shear force to be resisted by any transverse horizontal section of a panel shall be 50 kN/panel.

7.2.3 *Attachment systems and anchorages for connection of metal posts to concrete panels*

Attachment systems and anchorages for connection of metal posts to concrete panels shall be designed to resist:

a) a horizontal load acting at right angles to the traffic face, towards the post centreline, through the centroid of each effective rail section of value Q_k/n kN;

b) a vertical load, applied either upwards or downwards, acting through the centroid of each effective rail section at midway between centres of support of value $Q_k/2n$ kN;

c) a load acting parallel to each effective rail at its centroid of section of value $Q_k/8n$ kN;

d) the most severe combination of the above individual nominal loads multiplied by a factor of 0.65.

7.2.4 *Attachment systems and anchorages for connection of precast concrete units to bridge decks*

Attachment systems and anchorages shall be designed to resist the loadings given in **12.2.2**.

7.3 High containment: applicable to both no shear provision and with shear provision between panels

7.3.1 *Metal components* (except anchorages and attachment systems for precast units to deck connections)

7.3.1.1 *Posts, post to base plate connection and base plate*

An individual horizontal nominal load of Q_k/n kN is applied transversely to the post, acting at the level of the centroid of each effective rail section.

An individual horizontal nominal load of $Q_k/8n$ kN is applied longitudinally to the post, acting at the level of the centroid of each effective rail section.

Concurrently, a horizontal nominal load of $(0.9 \times Q_k/n)$ kN is applied transversely and a horizontal nominal load of $(0.9 \times Q_k/8n)$ kN is applied longitudinally to the post, both acting at the level of the centroid of each effective rail section.

7.3.1.2 *Rail*

An individual horizontal nominal load of Q_k/n kN is applied transversely as a point load at mid-point between the centres of support, acting at the level of the centroid of each effective rail section.

An individual horizontal vertical load of $Q_k/2n$ kN is applied as a point load at mid-point between the centres of support, acting through the centroid of each effective rail section.

Concurrently, a horizontal nominal load of $(0.75 \times Q_k/n)$ kN applied transversely and a vertical nominal load of $(0.75 \times Q_k/2n)$ kN is applied as a point load at mid-point between the centres of support, both acting at the level of the centroid of each effective rail section.

NOTE The point load is nominal and rails do not require reinforcement against local damage.

7.3.1.3 *Post to rail connections*

Connections shall be designed to resist the following individual nominal loads:

a) a horizontal load acting at right angles to the traffic face, towards the post centreline, through the centroid of the rail section of value $\frac{Q_k}{n}$ kN;

b) a vertical load, applied either upwards or downwards, acting through the centroid of the rail section of value $\frac{Q_k}{2n}$ kN;

c) a load acting parallel to the rail at its centroid of section of value:

1) for intermediate posts, $\frac{Q_k}{4n}$ kN;

2) for special end posts, $\frac{Q_k}{2n}$ kN;

NOTE 1 The strength of post to rail connections has not previously been specified and there is wide variation in the strengths of connections used in successful parapet designs. It is considered, however, that the minimum criteria suggested above will help to improve overall performance.

NOTE 2 Where the strength of a connection is not amenable to verification by analysis it may be justified by static test.

7.3.2 *Concrete panels (no shear provision between panels)*

7.3.2.1 *Nominal bending moment in panel*

NOTE The panel acts as an effective longitudinal member and carries the loads from the post.

The bending moment to be resisted shall be that produced by applying the following combined nominal loads acting concurrently:

a) a horizontal, continuous, uniformly distributed load of $1.4\frac{Q_k}{n}$ kN/panel applied transversely to the top of the front face of the panel;

b) a horizontal load of $\frac{Q_k}{n}$ applied transversely, acting at the level of the centroid of each effective metal rail section applied at the centreline of the post.

7.3.2.2 *Nominal shear in panel*

The nominal shear force to be resisted by any transverse horizontal section of a panel shall be 440 kN/panel.

7.3.3 *Concrete panels (with shear provision between panels)*

7.3.3.1 *Nominal bending moment in panel*

The bending moment to be resisted shall be that produced by applying the following combined nominal loads acting concurrently:

a) a horizontal, continuous, uniformly distributed load of $\frac{Q_k}{n}$ kN/panel applied transversely to the top of the front face of the panel;

b) a horizontal load of $\frac{Q_k}{n}$ kN applied transversely, acting at the level of the centroid of each effective metal rail section.

7.3.3.2 *Nominal shear in panel*

The nominal shear force to be resisted by any transverse section of a panel shall be 380 kN/panel.

7.3.3.3 *Nominal shear transfer at panel joints*

The minimum ultimate transverse shear resistance to be provided in the panel wall shall be 70 kN.

7.3.4 *Attachment systems and anchorages for connection of metal posts to concrete panels*

Attachment systems and anchorages for connection of metal posts to concrete panels shall be designed to resist:

a) a horizontal load acting at right angles to the traffic face, towards the post centreline, through the centroid of each effective rail section of value Q_k/n kN;

b) a vertical load, applied either upwards or downwards, acting through the centroid of each effective rail section at midway between centres of support of value $Q_k/2n$ kN;

c) a load acting parallel to each effective rail at its centroid of section of value $Q_k/8n$ kN;

d) the most severe combination of the above individual nominal loads multiplied by a factor of 0.65.

7.3.5 *Attachment systems and anchorages for connection of precast concrete units to bridge decks*

7.3.5.1 Attachment systems and anchorages shall be designed to resist the loadings given in **12.2.2**.

7.3.5.2 In addition, the following nominal loads shall be considered in combination with the loadings from **7.3.5.1**.

a) A horizontal longitudinal load of 25 kN applied to the metal post and acting at the level of the centroid of each effective metal rail section.

b) A horizontal longitudinal load of 75 kN applied at the top of the front face of the concrete panel and uniformly distributed over the panel length.

c) A downward vertical load of 75 kN acting through the centroid of the metal post.

d) A downward vertical load of 75 kN applied at the top of the front face of the concrete panel and uniformly distributed over the panel length.

7.4 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 [1].

8 Wind loading

Wind loading shall be derived from BS 5400-2:1978. Wind loading and vehicle impact shall not be considered coexistent.

9 Parapet heights

The minimum height of combined parapets shall be measured above the datum for height considerations and for particular applications shall be as listed below:

1.00 m — for vehicle and vehicle pedestrian parapets except as otherwise specified below;

1.25 m — with agreement (see clause **29**) for bridges carrying motorways over railways, or other situations where pedestrians are excluded;

1.50 m — for all other bridges over railways:

— for high containment applications;

— for protection of animals.

NOTE If additional height is required only for the protection of animals this may be provided by the addition of a non-effective member. (See **28.2**).

10 Front face, profile, freedom from projections and joint treatment

10.1 General arrangement

The dimensional requirements for combined metal and concrete parapets shall be as shown in Figure 1.

10.2 Concrete bases

10.2.1 The front face profile of the concrete panels shall be either vertical or uniformly inclined from the bottom to the top of the base at an angle not exceeding 3° (see Figure 1). The finish shall be plain and smooth. Tops of concrete bases shall be smooth and may be sloped sufficiently to prevent water standing.

The front face at the top of the concrete panel shall be vertically in line with the front face of the metal rails.

NOTE The outer face may be sloped and/or featured.

10.2.2 Front faces of adjacent concrete panels shall not be out of line by more than 3 mm at any point. Other than at movement joints (see **14.1**) 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 filler material of the closed cell flexible foamed plastics type. 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 design limit 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. Alternatively, the maximum movement due to flexure under live load and temperature should be calculated and the joint designed to cope with this movement.

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 **11.3** c)].

NOTE 4 Special treatment of joints at expansion joints is required.

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 5 In the end panel, recess(es) in the concrete may be provided to receive the safety fence or transition panel such that the front face of the member(s) 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.

10.3 Metal rails and posts

10.3.1 Metal rails shall present smooth surfaces on the traffic face and on the top and bottom faces and be free from sharp edges or corners on the front face. The minimum projected vertical depths shall be 50 mm for normal containment and 190 mm for high containment.

10.3.2 Projections and depressions on these faces and on tops of posts shall only be allowed at joints in rails and at connections to posts and shall be within the following limits.

a) Front face and top and bottom faces within 15 mm of the front face: a maximum of 15 mm including the heads of any fastenings which shall be of a well rounded shape. In the case of round or near round sections the front face shall be taken as the arc subtending 120°, centred about the horizontal and the top and bottom faces as adjacent arcs each subtending 60°.

b) Top and bottom faces beyond 15 mm from the front face: a maximum of 25 mm including the heads of any fastenings.

c) Tops of post, including any caps or straps, shall not project above the level of the top of the top rail by more than 16 mm and the heads of any fastenings to the top of the post shall not project above the top face of the top raft by more than 35 mm.

10.4 Infills and fixings

Infill shall be of one of the types allowed under clause **27** and shall be fixed closely to the traffic faces of the rails. Heads of fixings shall not project more than 10 mm forward of the traffic face of the infill and shall be of a well rounded shape.

10.5 Maximum vertical spacing of rails and panel

The maximum gap between the top of the concrete panel and the bottom rail and between rails shall be:

for normal containment 350 mm;

for high containment 410 mm.

10.6 Minimum clear outstand of rails from posts

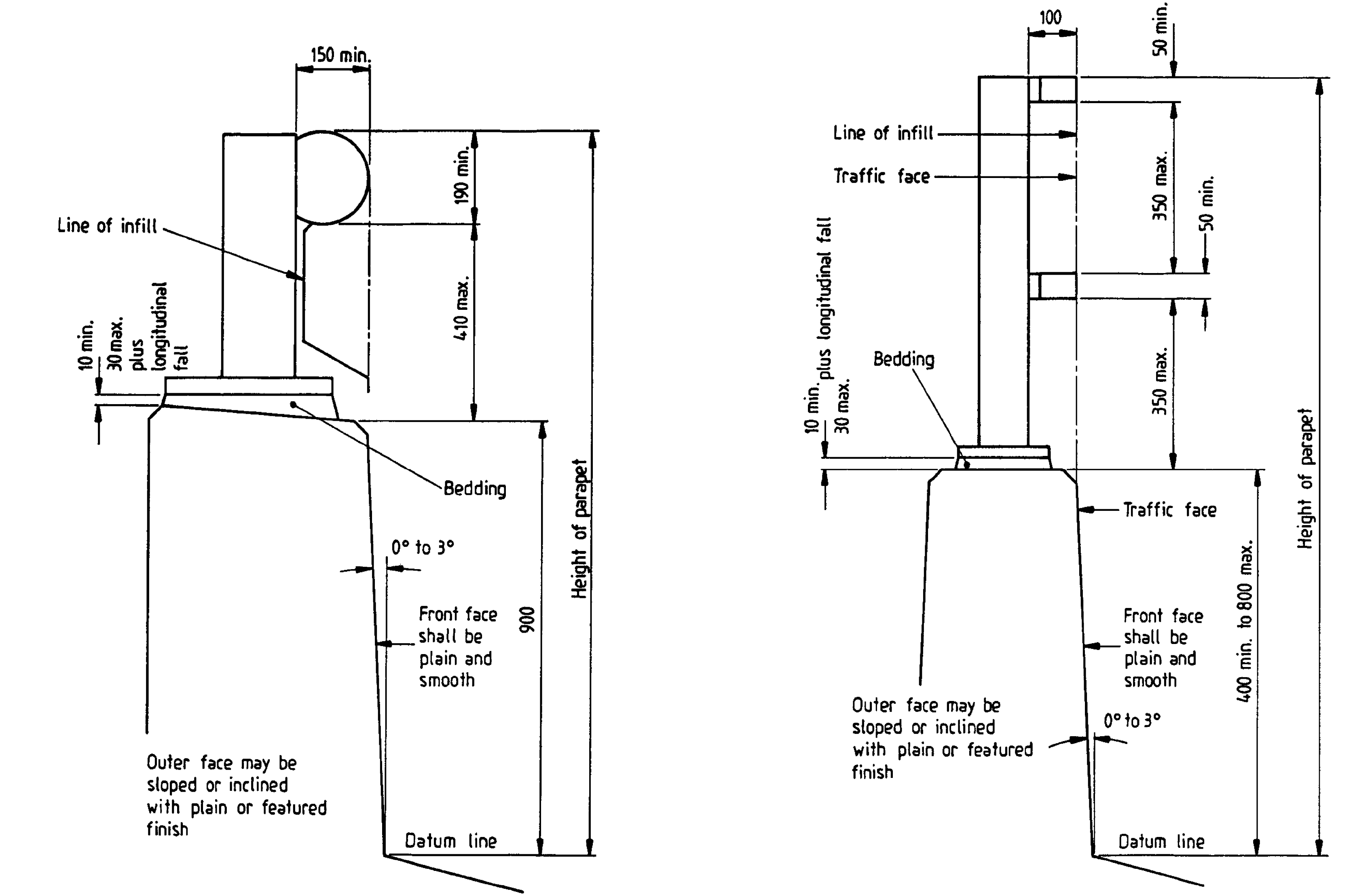
The minimum clearance between the front faces of the posts and the front faces of the rails shall be:

for normal containment 100 mm;

for high containment 150 mm.

10.7 Post to rail fixings

Post to rail fixings shall be contained within the limits for projections and depressions specified in **10.3.2**.



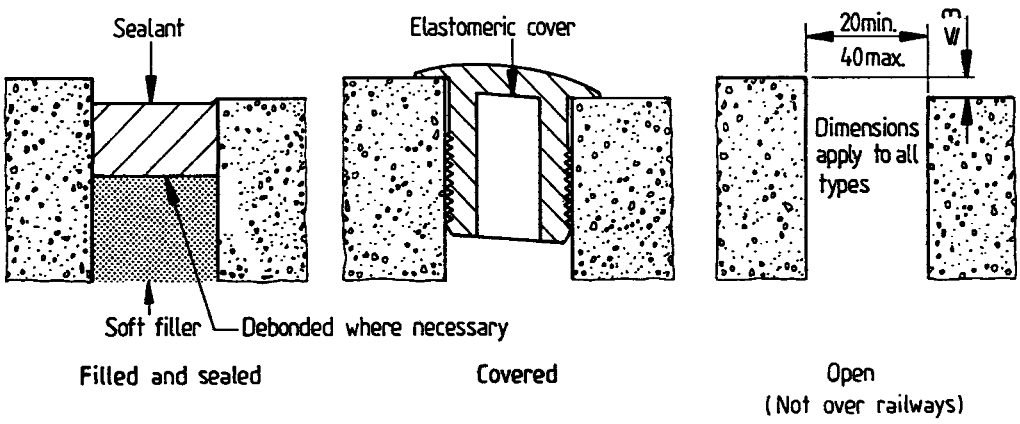
a) High containment
b) Normal containment

Linear dimensions are in millimetres.

NOTE 1 Infilling in accordance with clause **27** to be provided as required.

NOTE 2 For normal containment parapets the number of longitudinal members shall be selected to suit overall height and panel height required.

Figure 1 — Dimensional parameters for combined metal and concrete parapets



Dimensions are in millimetres.

NOTE These details are for normal panel joints in the concrete panels. Expansion joints require special treatment. (See clause **14**). Drainage of joint may be required [see **11.3** c)].

Figure 2 — Alternative joint details in concrete panel

11 Durability

11.1 General

11.1.1 *Environmental effects*

Parapets are likely to be directly affected by de-icing salts, traffic fumes and other corrosive elements and shall be designed taking this aggressive environment into account.

11.1.2 *Accessibility for maintenance*

Adequate clearance or means of access shall be provided around all parts requiring maintenance.

11.1.3 *Mixing different materials*

Parts requiring maintenance against corrosion shall not be incorporated into a parapet which is generally constructed of corrosion resistant materials. This requirement shall not preclude galvanized steel mesh being used on aluminium or steel parapets, nor the use of stainless steel bolts and washers with aluminium.

11.1.4 *Vandalism*

The need of the parapet to resist vandalism shall be taken into account in its design. It shall be ensured that fixings and fasteners are not so easily loosened as to allow parts of the parapet to be wilfully removed, simply and quickly using minimal tools, or to be easily damaged by a kick.

11.1.5 *Repair and replacement*

Parts or sections of parapets may need to be repaired or replaced after impact damage and design details shall take this into account.

11.2 Concrete panels

Concrete panels shall be constructed to withstand a "very severe" environment as classified in BS 5400-4:1990 and BS 5400-8:1978. In particular they shall conform to the following.

a) Grades of concrete shall be 40 or 50 and over as specified in BS 5400-7:1978 and BS 5400-8:1978. For grade 40 the concrete shall be air entrained.

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 5400-4:1990 (see also **12.3.2**).

NOTE 1 The Department of Transport has particular requirements for these grades of concrete.

NOTE 2 Silane impregnation may be considered for panels particularly adjacent to roads that are salted.

11.3 Base plates, attachment systems and anchorages

The following requirements shall be observed in addition to the general requirements of this Part of BS 6779.

a) Aluminium which is to be in contact with concrete or mortar shall be coated with at least two applications of bituminous coating solution conforming to BS 3416:1991 or with hot-dip bitumen, applied to a clean, degreased surface.

b) Metal-to-metal contact between dissimiliar materials shall be avoided by the use of non-metallic sleeves, washers or coatings to prevent galvanic corrosion.

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

d) Holding-down bolts shall be of stainless steel.

e) Parts of anchorages up to 80 mm below the surface of the plinth shall be of stainless steel.

11.4 Metal posts and rails

11.4.1 *General*

The minimum thickness of section of all metal parts shall be in accordance with Table 4.

11.4.2 *Steel*

Steel parapets shall be constructed of the materials specified in clause **18** and shall be treated with a suitable protective system in accordance with the intended parapet environment and life requirement.

NOTE 1 Suitable protective systems are described in BS 5493 or may be obtained from the Department of Transport.

NOTE 2 The purchaser should state his requirements for the protective system to be used as indicated in Annex A.

NOTE 3 Where unsealed steel hollow sections are used (see **11.4.4**) corrosion may take place internally. This has been found to affect a limited area around drainage holes, open ends, etc., the extent being to some degree affected by exposure conditions. Where hollow sections are hot dip galvanized, the internal galvanizing will be sufficient protection against this. Table 4 calls for extra thickness for such members where they are not galvanized but, although this may give the desired life, the products of corrosion may be unsightly.

11.4.3 *Aluminium*

Aluminium parapets shall be constructed of the materials specified in clause **18**.

NOTE The aluminium alloys specified in clause **18** are satisfactory for all the usual exposure conditions but undue corrosion has been found to occur where salt can accumulate and the normal cleansing effects of weather are absent. An example is a parapet on a multi-level junction shielded by a bridge structure. In such cases protective coatings should be considered.

11.4.4 *Hollow sections*

Hollow sections shall be either drained to prevent corrosion and damage occurring due to the freezing of water which may accumulate inside them or completely sealed, with all joints being made with continuous welds of structural quality.

Holes for galvanizing and/or drainage shall have a diameter not greater than one-twelfth of the circumference of the member, with a minimum diameter of 8 mm prior to galvanizing (or 6 mm if not galvanized) and a maximum diameter of 15 mm. Holes shall not be spaced closer than 700 mm if they are to be left open.

NOTE 1 Consideration should be given to the effect on the strength of members by the design, location and making of the holes.

NOTE 2 Moisture can collect in a section not open to direct penetration by condensation of water vapour drawn in by the breathing effect caused by changes in air temperature and pressure.

12 Design method

12.1 General

12.1.1 *Design principles*

Except as provided for in **12.1.2**, parapets of combined concrete and metal 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 requirements of BS 5400-1:1988 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 concrete panel and metal components of the parapet will sustain damage during impact.

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

NOTE 3 The factors given in Table 4 and Table 5 are chosen to achieve:

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

b) a base (to precast concrete panels) that is in the order of 25 % stronger than the vertical wall;

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

12.1.2 *Aluminium and steel post and rail high containment systems exempt from the design requirements*

Certain established aluminium and steel post and rail high containment systems shall be exempted from **12.1.1**

This exemption shall apply only to those designs listed in Annex B.

If either of the designs in Annex B is adopted without modification no further design is required.

NOTE Enquiries regarding reference copies of drawings listed in Annex B should be made to Customer Services, Information Services Group, BSI, Linford Wood, Milton Keynes MK14 6LE.

Table 4 — Minimum thickness of members, infill panels and other components

Material	Section	Minimum thickness			
		Primary load carrying members mm	Non-load carrying members and secondary elements of load carrying mm	Infilling panels, bars and mesh mm	Clips, covers fixings, etc. mm
Steel	Hollow sections, galvanized inside and outside or fully sealed	3	3	3	3
	All other sections	4	3	3	3
Aluminium alloy	All	3	1.2	3	1.2
Stainless steel	All	2	1	2	0.5

12.2 Design loading values

12.2.1 *Design loads for parapet components* (except as **12.2.2** below)

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 5. In the design of pamper components the nominal load for vehicular impact with the parapet shall be in accordance with **7.1**.

Wind loading shall be considered when appropriate (see clause **8**).

12.2.2 *Design loads for anchorages and attachment systems for connection of precast concrete panels to main structure*

The design loads Q^* 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 forces distributed equally between the effective longitudinal members. The loads shall be applied at the top of the front face of the concrete panel, if applicable, and to the metal post at the level of the rail. The nominal load shall be based on the lesser of either the calculated ultimate moment of resistance at the critical section of the panel wall and the coexistent shear force or the calculated ultimate shear resistance at the critical section of the panel wall and the coexistent moment, depending on the failure mode. The critical section can be frequently taken as the bottom of the wall. The calculated resistance of the parapet shall be determined as the unfactored design resistance, i.e. $f(f_k)$, in accordance with **12.2.4**.

NOTE γ_m is not used in connection with the calculation of design loads based on parapet collapse.

The partial load factor γ_{fL} is a function of the loading and element to be designed, and shall be as given in Table 5, for the attachment system and anchorage of parapet to deck.

NOTE 2 See **7.3.5.2** for additional nominal loads for the design of attachment systems and anchorages of parapet to main structure.

Table 5 — Values of γ_{fL}: ultimate limit state

Element	Loading	Containment	
		High γ_{fL}	Normal γ_{fL}
Metal parapet components	Vehicular impact	1.0	1.0
	Wind loading	1.4	1.4
Reinforced concrete components	Vehicular impact	1.0	1.0
	Wind loading	1.4	1.4
Metal post to concrete panel			
Attachment system	Post collapse	1.4	1.5
Anchorage	Post collapse	1.6	1.8
Concrete panel to main structure			
Attachment system	Parapet collapse	1.2	1.3
Anchorage	Parapet collapse	1.4	1.6

12.2.3 ***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 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.

12.2.4 ***Design resistance values***

12.2.4.1 The design resistance R^* shall be defined as:

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

or optionally

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

where

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

γ_m is the partial factor on material strength.

Values for f_k and γ_m are given in Table 6.

Table 6 — Values of f_k and γ_m

Component	Material	Characteristic (or nominal) strength of material f_k	γ_m
Metal parapet (including anchorage and attachment system to concrete panel)	Steel (excluding stainless steel nuts, bolts and washers)	As given in BS 5400-3:1982	
	Stainless steel nuts, bolts and washers	As given in BS 6105:1981 or BS 1449-2:1983, as appropriate	1.2
	Aluminium extrusions and plate (excluding weld affected areas) (see **12.2.4.4**)	0.2 % proof stress as given in BS 1470:1987 or BS 1474:1987, as appropriate	0.9
	Aluminium castings (excluding weld affected areas) (see **12.2.4.4**)	0.2 % proof stress as given in BS 1490:1988	1.3
In situ and precast concrete panel wall	Concrete	As given in BS 5400-4:1990	1.0
	Reinforcement	As given in BS 5400-4:1990	0.8
Precast concrete panel base	Concrete	As given in BS 5400-4:1990	1.2
	Reinforcement	As given in BS 5400-4:1990	1.0
Anchorage and attachment system (concrete panel to deck)	Steel (excluding stainless steel nuts, bolts and washers)	As given in BS 5400-3:1982	
	Stainless steel nuts, bolts and washers	As given in BS 6105:1981 or BS 1449-2:1983, as appropriate	1.2

NOTE The values of γ_m for concrete are chosen to ensure failure of the parapet by yielding of the tensile reinforcement at the critical section of the wall.

12.2.4.2 For the purpose of evaluating the design resistance R^*, $f(f_k)$ shall be determined in accordance with BS 5400-3:1982 for steel, BS 8118-1:1991 for aluminium and BS 5400-4:1990 for reinforced concrete.

12.2.4.3 For the reinforced concrete sections of parapet panel walls the design bending resistance shall be determined from first principles, taking into account all reinforcements which might contribute to the resistance of the section under consideration.

12.2.4.4 Where aluminium alloy components are welded or partially welded, the strength of the material will be reduced in the vicinity of the weld and allowance for this shall be made in accordance with BS 8118-1:1991.

12.2.5 ***Verification of design adequacy***

12.2.5.1 *Metal parapet components* (including attachment system and anchorage to concrete panel)

For a satisfactory design the following relationship shall be satisfied:

$R^* \geq S^*$

i.e.

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

or, for steel and aluminium:

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

NOTE When applying BS 5400-3:1982 care should be taken as the above expression has been rearranged as follows:

$$\left(\frac{1}{\gamma_{f3}\,\gamma_m}\right) f(f_k) \geq (\text{effects of } \gamma_{fL} Q_k)$$

The γ_{f3} values given in **12.2.3** shall be substituted for the values given in BS 5400-3:1982.

12.2.5.2 *Reinforced concrete components*

For a satisfactory design of concrete panel walls and precast concrete panel bases, the following relationship shall be satisfied:

$R^* \geq S^*$

i.e.

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

or, for steel and concrete:

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

In addition, for bending resistance of the lower half of the design height of the concrete parapet wall:

generally, $R^* \ngtr 1.4\ S^*$;

For high containment only at least one section, $R^* \ngtr 1.1\ S^*$ (see note 1 to **12.1**) but $R^* \nless S^*$.

12.2.5.3 *Attachment system and anchorage (precast concrete panel to main structure)*

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

$R^* \geq S^*$

i.e.

$$f\left(\frac{f_k}{\gamma_m}\right) \geq \gamma_{f3}(\text{effects of } \gamma_{f1} Q_k)$$

NOTE When applying BS 5400-3:1982 care should be taken as the above expression has been rearranged as follows:

$$\left(\frac{1}{\gamma_{f3}\,\gamma_m}\right) f(f_k) \geq (\text{effects of } \gamma_{fL} Q_k)$$

The γ_{f3} value given in **12.2.3** shall be substituted for the value given in BS 5400-3:1982.

12.3 Design of reinforced concrete components, attachment systems and anchorages

12.3.1 ***General***

Concrete components shall be designed in accordance with BS5400-4:1990 and with **12.3.2** to **12.3.8**.

12.3.2 ***Parapet panel walls***

Parapet panel walls shall conform to 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 vertical and horizontal reinforcement in the outer face shall be not less than 50 % of that of the vertical and horizontal reinforcement respectively in the front face;

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

f) a reinforced concrete fillet (minimum 50 mm × 50 mm) shall be provided at the front face junction between the wall and base of the unit;

g) the tops of panel walls shall incorporate horizontal containment link reinforcement around the embedded anchorage of the metal post connection.

NOTE These requirements are to limit cracking and possible dislodgement of pieces of concrete under impact.

12.3.3 ***Bolted down anchorages and bedding to precast concrete panels and posts***

12.3.3.1 *General*

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

12.3.3.2 *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 all the combined design load effects given in **12.3.3.1**.

12.3.3.3 *Transfer of horizontal shear through bedding grout between the concrete bases and the main structure*

Where transfer of horizontal shear is achieved through the 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 cleaned of laitance, roughened and dampened;

c) any temporary levelling devices are removed.

NOTE 1 The ability of cementitious bedding grout to transfer horizontal shear between the concrete base and the main structure 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.

12.3.4 ***Vertical shear***

The precast concrete panel base 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.

12.3.5 ***Attachment system***

Stainless steel holding-down bolts conforming to BS 6105:1981 grade A4-80 shall be provided to connect the precast panel base and the metal post base plates with the anchorages in the main structure and top of the panel wall respectively. Stainless steel for washers or plates, conforming to BS 1449-2:1983, grade 316S31 or 316S33 shall be provided as bearings to transfer bolt tensions to the top of the precast units, in accordance with BS 5400-4:1990. Design of bolts and of dispersion of stresses through washers or plates shall conform to BS 5400-3:1982.

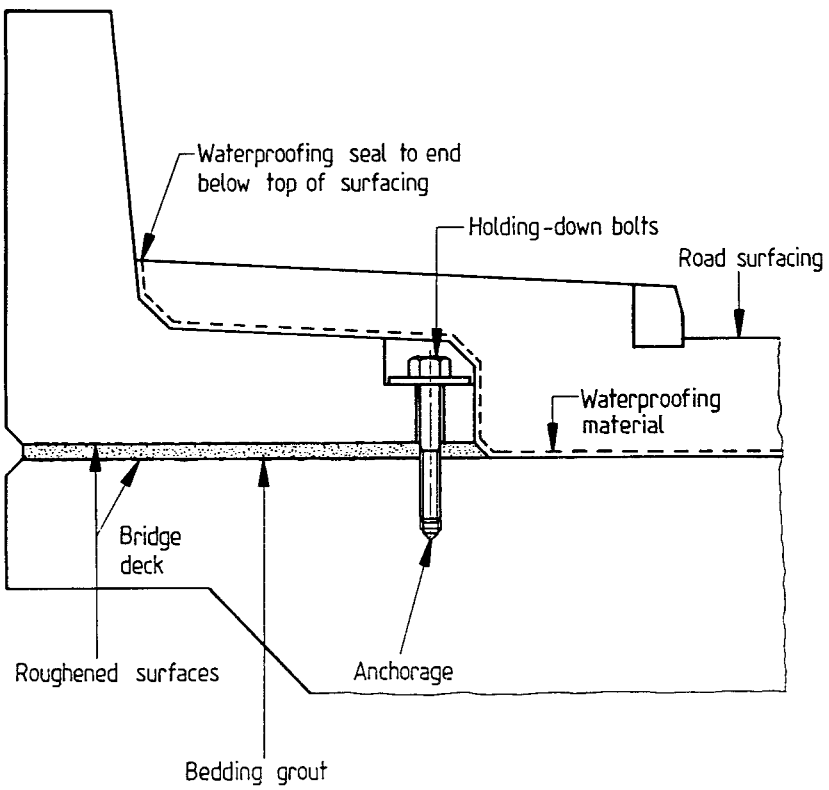


Figure 3 — Diagrammatic arrangement of a possible precast reinforced concrete panel installation

The design of the attachment system shall be such that removal and replacement of damaged panels, posts and rails can be readily achieved.

12.3.6 ***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 tensile strength of the bolt (in N/mm2);

σ_{ya} is the minimum yield strength of the anchorage material (in N/mm2);

D is the nominal bolt diameter (in mm).

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.

12.3.7 ***Anchorages in main structures and tops of concrete bases***

Anchorages shall be either cast-in anchors or anchor cages or drilled individual bolt anchorages, that are of purpose design or of proprietary manufacture. It shall be ensured that they will provide the necessary long-term 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 and/or the top of the panel wall may need additional local reinforcement to resist, without damage, the forces which may be 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.

12.3.8 ***Horizontal shear transfer between panels of high containment***

12.3.8.1 Suitable arrangements shall be made for providing transfer of horizontal shear between panels of high containment parapets if it is required to allow the use of the reduced equivalent static loading in respect of loads in **7.3.3**.

12.3.8.2 The shear transfer shall be designed for the shear force given in **7.3.3.4** and shall not inhibit movement at the gap in a direction longitudinal to the parapet.

NOTE Figure 4 shows the arrangement used on the tested parapets. Particular care is required to ensure that all grout between panels is removed.

13 Prevention of composite action between the parapet and main structure

Composite action could occur where the concrete parapet is attached to a bridge deck or other element of the main structure which is designed to deflect under load, so 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 1 500 mm. Joints between panels shall not be capable of transmitting longitudinal forces.

For in situ concrete panels, the free 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 concrete panels, the free joint between panels shall extend throughout the cross section of the precast panel and any part of the supporting structure not included in the design of the main structure, such as a laced reinforcement cast in situ anchorage.

For metal rails, the parapet rails shall contain at least one movement joint per deck span of the main structure and a further joint for each 50 m or part thereof over 50 m.

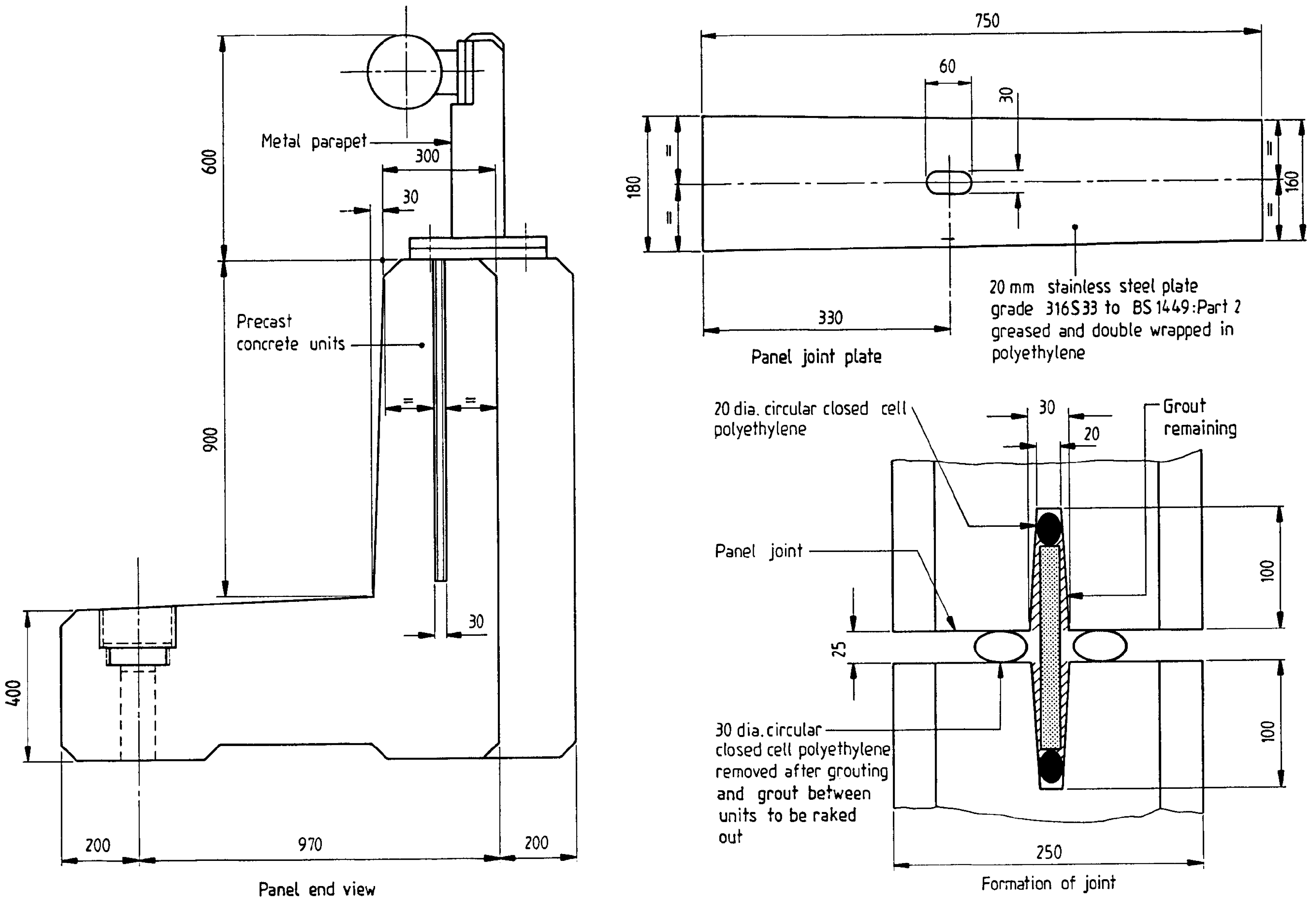
14 Ends of parapets and movement joints

14.1 Concrete panels

14.1.1 All end panels, including those at each side of movement joints shall be designed as stand alone units with no allowance for any load shedding by shear transfer arrangements. No shear transfer arrangements shall be incorporated across such joints but where a parapet is designed with shear transfer arrangements generally these shall be present between end panels and the next adjacent panels.

14.1.2 Where larger movements take place which would require an unacceptable gap (see **10.2.2**) between panels at a joint a bridging piece shall be incorporated.

14.1.3 Any such bridging piece shall be securely fixed to the panel at the traffic approach side sufficiently to provide a total tensile resistance in the longitudinal direction of 10 kN for normal containment and 40 kN for high containment, distributed over the height of the bridging piece.



Dimensions are in millimetres.

Figure 4 — Shear transfer arrangement used in the tested high containment parapet

14.1.4 The bridging piece shall be of sufficient width to cover the nominal joint gap plus the maximum movement plus 50 mm. It shall be corrosion resistant and replaceable.

14.1.5 The bridging piece shall preferably be rebated into the faces of the panels and any projection beyond the traffic face shall conform to the requirements for those on the traffic faces of rails under **10.3.2** a).

14.1.6 Bridging pieces shall be capable of withstanding an ultimate load of 25 kN for normal containment and 160 kN for high containment, applied as a distributed, line load, at the centre of their span across the maximum joint opening.

14.2 Metal rails at movement joints

14.2.1 *Movement joints for total movements 0 mm to 50 mm*

14.2.1.1 Joints providing continuity between lengths of rails or across movement joints where the total longitudinal movement at rail level is 50 mm or less shall conform to the following.

a) *Tension*

The joint shall be capable of transmitting 60 % of the tensile strength of the gross theoretical rail section.

b) *Bending*

The joint shall be capable of transmitting the full maximum design requirement of the rail in bending at any extension of the rail joint.

14.2.2 *Movement joints for total movements greater than 50 mm*

14.2.2.1 Joints across expansion and/or rotational joints where the total longitudinal movement at rail level is greater than 50 mm shall conform to the following:

a) *Tension*

No requirement to transmit tension.

b) *Bending*

Joints shall be capable of transmitting the full maximum design requirement of the rail in bending at any extension up to the full design movement of the joints plus 100 mm.

14.3 Posts at joints with movements greater than 50 mm

14.3.1 *Posts for normal containment*

Either an additional post shall be provided at each side of the joint spaced as close together as practicable, or the method given in **14.3.2** may be used.

14.3.2 *Posts for high or normal containment*

A special end bay shall be provided on each side of the joint designed to be capable of resisting and transmitting to the main structure the horizontal and vertical nominal loads on the rails from Table 2.

NOTE This may be achieved by the use of a full height concrete panel wall, designed in accordance with BS 6779-2.

14.3.3 *Joints where complex movements take place*

Joints where significant movements take place in a vertical transverse horizontal direction shall, where practicable, conform to **14.2.1** to **14.3.2** but in extreme cases, it may not be possible to provide a bridging piece conforming to **14.1.6** when otherwise conforming to **14.3.2**. In such cases this requirement may be waived but every effort shall be made to provide some form of bridging piece or otherwise avoid projections into the path of an impinging vehicle.

14.4 Ends of parapets

A special end bay conforming to **14.3.2** shall be provided at the ends of parapets.

NOTE This bay could also be required to provide connection to the transition, vertical concrete barrier (VCB) or safety fence as detailed in clause **15**.

15 Protection at ends of parapets

15.1 Normal containment parapets with safety fences, vertical concrete barriers (VCBs) or transitions

Where a safety fence, VCB or transition is provided at a parapet end it shall, except as provided for in the following, 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, either close to the parapet or at the transition from a tensioned to an untensioned safety fence. A connection capable of resisting an ultimate tensile force of not less than 50 kN shall also be made with the parapet having sufficient overlap to maintain support for a movement of 100 mm.

NOTE Safety fences and VCBs provide protection to the end of the parapet and will normally be present on motorway(s) or normal high speed roads and on new major roads in rural areas.

15.2 Normal containment parapets without safety fences, VCBs or transitions

Where there is no safety fence or VCB 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.

15.3 High containment parapets with safety fences or VCBs

In the case where safety fences or VCBs are present, a suitable transition arrangement shall provide protection from impact to the end of the parapet; details are obtainable from the Department of Transport.

NOTE 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.

15.4 High containment parapets without safety fences or VCBs

Where there is no safety fence or VCB 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.

Section 3. Concrete construction

16 Materials and workmanship

Materials and workmanship for concrete construction shall conform to BS 5400-7:1978.

17 Surface finish

The front and top faces shall be plain and smooth. The purchaser shall state any special requirements in respect of surface finish on the outer face (see Annex A).

All concrete shall be free of blow holes and evidence of grout loss or lack of compaction.

Section 4. Metal construction

18 Materials

18.1 Steel construction

18.1.1 Materials used for the construction of steel parapets shall conform to the appropriate British Standards listed in Table 7.

18.1.2 Steel used for all structural parts of parapets and anchorages shall have adequate notch toughness. This requirement shall be deemed to be satisfied provided the steel thickness conforms to **6.5.4** of BS 5400-3:1982 (using $U = -10$ °C) as modified by Department of Transport Standard BD 13/90 [2].

18.2 Aluminium construction

18.2.1 ***Materials***

Materials used for the construction of aluminium alloy parapets shall conform to the appropriate British Standards listed in Table 8.

18.2.2 ***Extruded material***

Extruded material to be used in aluminium alloy structural members shall be subject to the following additional testing requirements unless the purchaser is satisfied that the extruder's quality control system can demonstrate that such procedures are not necessary, when random checks only shall be required.

18.2.3 ***Additional testing requirements for aluminium alloy structural members***

18.2.3.1 *Mechanical testing of rail sections*

18.2.3.1.1 *Mechanical test piece selection procedure*

18.2.3.1.1.1 For batches of material consisting of five or more extruded lengths, a piece of material approximately 300 mm long shall be cut from each of four extruded lengths within the batch, for tensile testing.

18.2.3.1.1.2 For batches of material consisting of four or less extruded lengths, a piece of material approximately 300 mm long shall be cut from each extruded length, for tensile testing.

An extruded length is the product of one extrusion billet.

A batch shall consist of a maximum of 2 t of extruded product. All material in a batch shall be extruded from billet produced in the same cast and homogenized in the same furnace charge. All material in a batch, and its associated tensile test pieces, shall be precipitation heat treated in the same furnace charge. Where material is solution treated, rather than press quenched, all material in a batch shall be solution treated in the same furnace charge. If tensile test pieces are cut prior to solution treatment they shall be included in the same furnace charge as the lengths for which they were taken.

18.2.3.1.2 *Mechanical testing procedure*

18.2.3.1.2.1 Either conductivity testing or hardness testing shall be carried out after precipitation heat treatment, to the following procedure. Each test piece obtained from **18.2.3.1.1** shall be conductivity or hardness tested at its mid-point, on the traffic face of the section. The reading obtained shall be marked on the test piece. The front and back ends of all lengths of rail shall be conductivity or hardness tested on their traffic face and the readings marked on the rail.

18.2.3.1.2.2 The highest conductivity reading or the lowest hardness reading for a batch of material, including its associated test-piece lengths, shall be found.

If a test piece length has the highest conductivity reading or the lowest hardness reading it shall have a tensile test piece, in accordance with BS EN 10002-1:1990, machined from it.

If a length of rail has the highest conductivity reading or the lowest hardness reading it shall have a length, approximately 300 mm long, cut from the end of the rail at which the reading is found. A tensile test piece, in accordance with BS EN 10002-1:1990, shall be machined from this length.

18.2.3.1.2.3 The machined test piece shall be tensile tested in accordance with BS EN 10002-1:1990 on a tensile test machine calibrated by the National Measurement Accreditation Scheme (NAMAS), or similar approved body. The test piece shall meet the minimum mechanical property requirements of BS 1474:1987, except for 6061-T6 and 6082-T6 alloys which shall have the additional minimum requirement of either 10 % elongation on 50 mm when measured by fitting the broken pieces of the test piece back together or 9 % elongation on 50 mm when measured using an extensometer.

18.2.3.1.2.4 If the test piece in **18.2.3.1.2.3** fails to meet its minimum mechanical property requirements a re-test shall be carried out. If the failed test piece has been taken from a length of rail this shall be scrapped. A new test piece shall be selected as in **18.2.3.1.2.2** taking the next highest conductivity value or next lowest hardness value. This test piece shall be tested as in **18.2.3.1.2.3**.

Where necessary, **18.2.3.1.2.2** to **18.2.3.1.2.3** shall be repeated until a test piece meets the minimum mechanical property requirements.

Table 7 — Materials of construction for steel parapets

Form of material	Specification	
	BS number	Requirements specified
Hot rolled sections Hot finished hollow sections Equal and unequal angle sections	BS 4-1:1980 BS 4848-2:1991 BS 4848-4:1972	Dimensions and sectional properties (see BS 4360 for other relevant requirement)
Weldable structural steels (includes appropriate requirements for items above)	BS 4360:1990 BS EN 10025:1990	Physical properties, chemical composition, and dimensional tolerances
Plate, sheet and strip: Carbon steel Stainless steel	 BS 1449-1 BS 1449-2:1983 Grades 316S31 or 316S33	 Physical properties, chemical composition material condition and dimensional tolerances
Bars, rods: Carbon steel Stainless steel Welded wire mesh	 BS EN 10083-1:1991 BS EN 10083-2:1991 BS 970-3:1991 Grades 316S31 or 316S33 BS 4483:1985	Physical properties, chemical composition General requirements
Expanded metal: Carbon steel Stainless steel	 BS 1449-1 BS 1449-2:1983 Grades 316S31 or 316S33	 Properties, chemical compositions, material condition and dimensional tolerances
Fasteners (see note) ISO metric black hexagon bolts, screws and nuts ISO metric precision hexagon bolts, screws and nuts Washers Spring washers Corrosion resistant stainless steel fasteners High strength friction grip bolts	 BS 4190:1967 BS 3692:1967 BS 4320:1968 BS 4464:1969 BS 6105:1981 Grade A4 or equivalent BS 4395-1:1969	Dimensions, sizes, physical properties, chemical compositions, grades, tolerances and marking
NOTE the standards listed in this table relating to the form of fastener do not cover special bolts, nuts, screws, etc. which may be used for particular fixings where it is not possible to incorporate bolts, screws, etc. of standard dimensions or where special fixings are required to resist vandalism (see **11.1.4**).		

18.2.3.2 *Drift testing of hollow sections*

18.2.3.2.1 *Drift test piece selection procedure*

For hollow sections, a drift test piece, approximately 150 mm long, shall be taken from the front of every extruded length, adjacent to the front length of the hollow section. The position of every cut length and test piece shall be marked on the material.

An extruded length is the product of one extrusion billet.

The front of the length is that which has been extruded first.

18.2.3.2.2 *Drift testing procedure*

Every drift test piece obtained from **18.2.3.2.1** shall be flared using a conical or tapered steel mandrel with an angle of 30° to 60°. The mandrel shall be forced into each test piece without shock. Load shall be applied to tear a sufficient length of the test piece that the fracture surface may be visually examined.

18.2.3.2.3 *Drift test piece acceptance criteria*

18.2.3.2.3.1 If the fracture surface of the test piece shows tearing or plastics type fracture across 100 % of its surface it shall be deemed to have passed and all material in the extruded length from which it was taken shall be deemed acceptable.

18.2.3.2.3.2 If the test piece splits down an extrusion weld and does not show tearing or plastics type fracture across 100 % of its fracture surface then it shall be deemed to have failed.

If there is only one member in the extruded length from which the test piece was taken this shall be scrapped.

If there is more than one member in the extruded length from which the test piece was taken a further drift test piece shall be taken from the back end of the first member. The remainder of the first member shall be scrapped. If the new test piece passes then the remainder of the extruded length shall be deemed acceptable. If it fails then the remainder of the extruded length shall be scrapped.

The front member is that which has been extruded first and the front of the member is the end that has been extruded first.

19 Workmanship, inspection and testing

19.1 General

19.1.1 ***Workmanship in aluminium alloy***

Workmanship in aluminium alloy shall be carried out in accordance with BS 8118-2:1991.

19.1.2 ***Laminar defects***

Steel base plates shall not have laminar defects exceeding the limits of BS 5996:1980 for quality grade B2. Pretesting of plates is not required but if laminar defects are revealed during fabrication or ultrasonic testing the base plate shall be rejected or testing for conformity.

19.1.3 ***Cutting***

Flame cut surfaces on steel components shall be smooth and free from gutters.

Cutting of aluminium alloy components shall be carried out in accordance with BS 8118-2:1991.

19.1.4 ***Forming of holes***

Holes in steel components shall be drilled except that:

a) holes may be punched full size in cleats and brackets where the thickness of the material does not exceed 10 mm and where the fabrication is not subject to repeated stresses;

b) slotted holes may be flame cut.

Holes in aluminium alloy components shall conform to BS 8118-2:1991.

19.1.5 ***Tolerances on holes other than in base plates***

The diameter of holes or the width of slots shall be not more than 2 mm larger than the nominal size of the associated fastener except that where the material is to be galvanized, the diameter of the hole or width of slot may be increased by up to an additional 2 mm or 15 % of the nominal diameter of the fastener, whichever is the greater.

19.1.6 ***Tolerance on holes in base plates***

The diameter of holes or the width of slots in base plates may be increased but shall not be greater than 50 % larger or wider than the nominal size of the holding bolt.

19.1.7 ***Washers***

Washers of sufficient bridging strength shall be provided to all fixings and in particular where tolerances greater than normal are allowed in **19.1.5** and **19.1.6**.

19.2 Welding

19.2.1 ***General***

Arc welding of carbon manganese steels shall conform to BS 5135:1984. Arc welding of aluminium alloys shall be in accordance with BS 3019-1:1984 or BS 3571-1:1985 as appropriate. Processes other than arc welding shall be to the approval of the engineer. Welding of stainless anchorages shall be in accordance with BS 7475:1991.

Table 8 — Materials of construction for aluminium alloys parapets

Form of material (see note 1)	Specification: BS number and designation	Requirements specified
Extruded sections	BS 1474:1987, alloys 6 060, 6 061, 6 063 and 6 082	Chemical composition, properties and tolerances
Drawn tube	BS 1471:1972, alloys 6060, 6061, 6063 and 6082	Chemical composition, properties and tolerances
Seam welded tube	BS 4300/1:1967, alloy 5 251	Tolerances, properties and mechanical tests
Plate and sheet	BS 1470:1987, alloys 1 200, 3 103, 3 105, 5 083, 5251 and 6 082	Chemical composition, properties and tolerances
Rivets	BS 1473:1972, alloys 5 154A and 6 082 BS 1474:1987, alloy 5 065A	Chemical composition, properties and tolerances
Castings	BS 1490:1988, alloys LM6 and LM25	Chemical composition, properties and chemical tests
Welding filler rods and wire	BS 2901-4:1990	Chemical composition, properties, diameters and tolerances
Welded wire mesh	BS 4483:1985	General requirements
Expanded metal:		Properties, chemical composition, material condition and dimensional tolerances
Aluminium alloy	BS 1470:1987	
Carbon steel	BS 1449-1	
Stainless steel	BS 1449-2:1983 Grades 316S31 and 316S33	
Fasteners (see note 2):		
ISO metric black hexagon bolts, screws and nuts	BS 4190:1967	Dimensions, sizes and tolerances
ISO metric precision hexagon bolts, screws and nuts	BS 3692:1967	
Washers	BS 4320:1968	
Spring washers	BS 4464:1969	
Corrosion resistant stainless steel fasteners	BS 6105:1981 Grade A4	Chemical composition and physical properties
High strength friction grip bolts	BS 4395-1:1969	

NOTE 1 The physical properties of aluminium alloys may be modified by welding. A method of dealing with this effect for design purposes is given in **12.2.4.4**.

NOTE 2 The standards listed in this table relating to the form of fasteners do not cover special bolts, screws, etc. which may be used for particular fixings where it is not possible to incorporate bolts, screws, etc. of standard dimensions or where special fixings are required to resist vandalism.

19.2.2 ***Welding procedures***

The manufacturer shall produce and work in conformity with written approved procedures, confirmed by testing, in accordance with BS EN 288-1:1992, BS EN 288-2:1992 and BS EN 288-3:1992 for steel and BS EN 288-1:1992, BS EN 288-2:1992 and BS EN 288-4:1992 for aluminium alloys for all production and repair welds. These shall be subject to reapproval after a period of 7 years. When applying BS EN 288-1:1992, BS EN 288-2:1992 and BS EN 288-3:1992 the welding consumable procedures used shall be such that the mechanical properties of deposited weld metal will not be less than the respective minimum specified values of the parent metal being welded.

Approval shall be by an independent inspecting authority using registered welding engineers, registered welding quality engineers or equivalent to the satisfaction of the purchaser.

19.2.3 ***Welder qualifications***

All welders shall hold certificates of approval to BS EN 287-1:1992 for steel and BS EN 287-2:1992 for aluminium alloys, obtained within the previous 2 year period, for all weld types which they produce.

Certificates of approval shall be from an independent inspection authority using personnel who are either registered as in **19.2.2** or apropriately certified in accordance with the Certification Scheme for Welding and Inspection Personnel (CSWIP). Tests shall be carried out by a laboratory accredited by the National Measurement Accreditation Service (NAMAS) for weld testing.

19.2.4 ***Production inspection and testing***

19.2.4.1 *Inspection personnel*

The manufacturer shall provide suitable personnel to carry out inspection of production welds as required by **19.2.4.2** to **19.2.4.4**. Personnel conducting visual inspection shall have a nationally regonized certificate of competence appropriate to the type of welding being inspected. Personnel conducting non-destructive testing (NDT) shall be certified according to a nationally recognized certification scheme appropriate to the equipment used and the weld groups inspected. Evidence of training and qualification shall be retained and made available for examination when required.

19.2.4.2 *Visual inspection*

All production welds shall be subject to visual inspection after cleaning prior to NDT and protective treatment. The relevant techniques in BS 5289:1976 shall be applied as appropriate. Weld surfaces shall be free of slag residues, sharp edges, cracks, lack of fusion including overlap. All surfaces shall be free of weld spatter, arc strikes and contaminants. The throat dimensions of butt welds and the leg length and appparent throat dimensions of fillet welds, as measured by a welding gauge and taking into acount lack of fit, shall be not less than those specified, except that local shortfalls up to 1 mm are acceptable, provided the average dimension over any 50 mm length is not less than the specified dimension. The toe angle shall be not less than 90°.

NOTE Isolated discontinuous porosity may be accepted provided it is not detrimental to the protective treatment.

Undercut shall not result in a section loss of more than 5 % over any 50 mm length of joint, nor shall its depth exceed 0.5 mm or 10 % of the thickness, whichever is less.

Where on visual inspection, the presence of cracking or lack of fusion could be suspected, testing by magnetic particle inspection or liquid penetrant inspection shall be carried out in accordance with BS 6072:1981 or BS 6443:1984 as appropriate.

19.2.4.3 *Magnetic particle inspection (MPI) and liquid penetrant inspection (LPI)*

MPI shall be applied in accordance with BS 6072:1981 to joints in steel parapets selected in accordance with **19.2.4.5**, where any of the material thickness exceeds 20 mm. Liquid penetrant inspection in accordance with BS 6443:1984 shall be applied to transverse welds in aluminium alloy posts, and to welds in aluminium alloy posts between the post and the base plate and any gusseting to this connection.

NOTE To aid inspection the profile of the joint may be dressed by burr grinding provided that the specified throat size and leg length is still maintained.

The surface of the weld shall be free of cracks, lack of fusion and slag.

19.2.4.4 *Ultrasonic testing*

Post to base plate joints selected in accordance with **19.2.4.5** shall be ultrasonically tested where the post is butt welded and is 8 mm thick or greater in the traffic face half of the post section or, if fillet welded, the leg length is greater than 12 mm nominal. The ultrasonic testing of steel shall be in accordance with BS 3923 and for aluminium in accordance with the principles of BS 3923. The weld shall be free of cracks. The height of buried slag and lack of fusion shall not exceed 3 mm and within 6 mm of the outer surface, their individual length shall not exceed 10 mm. The resulting net throat area loss over any 50 mm length shall not exceed 5 %.

19.2.4.5 *Frequency of non-destructive testing (NDT)*

Joints for MPI, LPI or ultrasonic testing shall be selected as follows: 10 % of all components of each type (see **19.2.4.3**) shall be inspected. If non-conformity is found, the scope of testing shall be doubled. If further non-conformity is found, the whole batch shall be tested.

19.2.4.6 *Reporting*

Inspection records for production welds shall be retained by the manufacturer for 3 years and those covering the production periods relating to the components supplied shall be made available for examination.

19.2.5 ***Destructive testing***

19.2.5.1 *Supply of test components*

The supplier shall provide complete components or sample joints cut from components for destructive testing as selected by the purchaser. The basis of selection shall be as in **19.2.5.3**.

19.2.5.2 *Test required*

The purchaser shall carry out such testing as he requires such as sectioning, nick break tests and for steel hardness survey. The purchaser shall return the samples to the supplier after his tests are completed.

19.2.5.3 *Frequency of destructive testing*

The purchaser may have particular requirements which shall be given in Annex A, otherwise selection shall be carried out as follows.

a) For orders containing fewer than 50 posts. No test required providing that certified records are produced of successful destructive testing carried out on reasonably similar posts within the previous 3 months. If no satisfactory record is available. One intermediate post.

b) For orders containing 50 to 150 posts. One intermediate post unless successful destructive testing has been carried out within the last 6 weeks on a post of that type, where the post to be tested was selected by a purchaser.

c) For orders of 151 to 300 posts. Two posts intermediate or other.

d) For orders exceeding 300 posts. Three posts intermediate or other.

e) For orders containing fewer than 50 shop splices and/or less than 50 site splices. One shop splice and/or one site splice as appropriate unless successful destructive testing has been carried out within the last 3 months on a similar splice(s), where the splice to be tested was selected by a purchaser and the welding is to be carried out by the same personnel.

f) For orders containing 51 to 100 intermediate shop splices and/or site welded rail splices. One shop splice and/or one site splice as appropriate for each order.

g) For orders containing more than 100 intermediate shop splices and/or site welded rail splices. Two shop splices and/or two site splices as appropriate for each order.

h) For all other components that contain a structural weld such as safety fence connections. One component for each type, unless successful destructive testing has been carried out within the last 6 months on a component of that type, where the component to be tested was selected by a purchaser.

19.2.5.4 *Acceptance criteria*

The general acceptance criteria shall be as specified in **19.2.4**, except that the throat and leg dimension shall apply to the true rather than the apparent dimension.

19.2.5.5 *Non-conformity*

In the event that there is a non-conformity arising from a serious deviation in materials, preparation, assembly or welding procedure, the batch concerned shall be rejected and further production of the components affected stopped until such time as the fault has been corrected. A minor non-conformity shall only be accepted on the basis that further sampling and testing shows that fault is not repetitive and in the view of the purchaser will not in that instance impair structural integrity.

NOTE If the problem can be traced to a particular manufacturing period, operator, piece of equipment or batch of materials and if proper traceability to individual batches of components can be assured, only those batches affected may be subject to rejection.

19.2.5.6 *Test reports*

The destructive test report shall be retained by the supplier and recorded in a register for a period of 3 years. The destructive test specimens shall be retained for a period of 18 months. These shall be made available for examination on future contracts.

19.2.6 ***Remedial work***

Weld repairs, if allowed, shall conform to an approved procedure, as described in **19.2.2**. Welds in aluminium alloys shall not be repaired more than once.

20 Tolerances in metal construction

20.1 Components fabricated in either aluminium or steel shall be assembled so that they are not twisted or otherwise damaged and shall be so prepared that the specified inclinations, if any, are provided. Shims and packings shall not be used except under the post base plate (see clause **24**).

20.2 The fit of mating components shall be such as to allow practical site assembly without inducing stress or distortion in the components whilst meeting the design strength requirements (see **23.2**).

20.3 The tolerance on the position of rail fixings on posts shall be within ± 3 mm of the specified dimension.

20.4 For sections, plate and sheet, tolerances shall be in accordance with clause **18**.

NOTE See **19.1.5** for tolerances on holes and steelwork.

21 Fastenings

Structural fastenings shall conform to the relevant British Standards (see clause **18**, note to Table 7 and note 2 to Table 8).

22 Storage and transportation, handling and stacking

Parapets shall be handled and stacked in such a manner that permanent damage to components and to any temporary or permanent protective treatment is avoided. Any damage sustained shall be made good by approved repair or replacement.

Where craneage is required fabric slings shall be used.

Parapet components shall be stored clear of the ground in such a way that contact with standing water, soil, cement or ash or any other deleterious substance is prevented. Parapet components shall not be stored in contact with other materials. Suitable packings shall be placed between the components to prevent contact, to allow the free circulation of air and allow the dispersion of any water. Means shall be provided to prevent the accumulation of water on any surface.

NOTE Particular care in this respect should be taken to prevent white rust forming on galvanized sections or those painted with zinc-rich priming paints and exposed to weathering before the surface is sealed with a finishing paint coating.

23 Packing and transportation

23.1 Parapets shall be protected from damage during transportation. Means shall be provided to prevent distortion of metal fabrications and any machined or unprotected surface shall be coated with a suitable temporary protective system.

23.2 All bolts, screws, nuts and washers and any small loose components shall be suitably packed, protected and identified.

24 Installation and site workmanship

NOTE 1 Infill panels when fitted should present a uniform and smooth appearance after fixing.

NOTE 2 Where extra bedding thickness is allowed (see **24.6**), it may be necessary to increase the length of the holding-down bolts to satisfy **12.3.6**.

NOTE 3 The completed parapet may need protection from damage or contaminations by the activities of other trades.

NOTE 4 Permanent packers or washers should not be so large as to reduce the bearing capacity of the bedding.

24.1 The supplier of the parapet shall produce a statement of method of erection and site work to completion including layout drawings detailing anchorage positions.

Particular attention shall be given to any special bolt torque requirements, weld gaps, the gap setting at expansion or bridge movement joints, protection of the underside of aluminium post base plates (see **11.3**) and holding-down bolt engagement (see **12.3.6**).

24.2 Parapets shall be set true to line and level, within the tolerances set for bedding, throughout their length to give a smooth flowing line to the finished parapet. Where the plinth has cross and/or longitudinal fall, the maximum thickness of bedding to the underside of the base plate shall be 30 mm plus an amount sufficient to allow for the effect of these falls over the area under the base plate.

24.3 Parapets shall be securely held in their correct final position until the anchorages and bedding have attained the required strength.

Permanent packers or washers below metal base plates shall be of an inert material.

Bedding shall completely fill the space between metal base plates and the parapet base and shall not project above the underside of the base plate.

24.4 Bedding grout shall completely fill the space between the concrete bases and the main structure, all temporary packings and levelling devices shall be removed and the bedding made good.

24.5 Damaged areas of protective coatings shall be made good after completion of the erection.

24.6 Any bedding used between base plates and concrete bases 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 plinth (see **24.2** and note 2). Due regard shall be given to the bearing stresses developed in any bedding or in the concrete plinth. (See **12.3.3.3** for bedding grout for concrete bases.)

25 Identification marking of parapets

An easily legible and durable plate or marking shall be applied and located near to the top of the first post at each approach end in an easily visible position.

Marking shall have lettering not less than 5 mm high and shall include the following information.

a) names and trade marks of the designer and manufacturer;

b) design serial number;

c) designation of the parapet;

d) year of manufacture.

Section 5. Additional design requirements for parapets for particular applications

NOTE This section deals with those applications which call for requirements such as pedestrian protection in addition to vehicular containment. The usual need is to fill gaps in open parapets, such as post-and-rail types.
Cladding made to parapets for the purpose of meeting those requirements could affect performance in respect of vehicle containment; appropriate standard treatments are given for the most common requirements. These are considered to be satisfactory for the situations described and care should be taken if there are any departures to ensure that additional hazards are not created.

26 General requirements for infilling and additional members

Infilling or additional members for particular applications shall conform to the following:

a) there shall be no footholds or projections exceeding those permitted in clause **10** on the traffic face where pedestrians have access;

b) they shall be securely fixed and shall not be easily detachable (see **11.1.4** and item k) of Annex A;

c) no reflective surfaces shall be used which might create a hazard for users of any road or railway. (See note to clause **26**).

27 Requirements for particular types of infilling

Infilling used for the protection of pedestrians and/or livestock and environmental barriers shall be one of the following (see **10.4**).

a) *Wire mesh and expanded metal for applications not over or adjacent to railways.*

Wire mesh and expanded metal shall have apertures with a perimeter not exceeding 200 mm. The minimum metal thickness shall be in accordance with Table 4 and the maximum metal thickness shall not exceed the minimum requirement by more than 1.5 mm.

Expanded metal shall be supplied in a deburred and pressure roll flattened condition so that the strands are in the same plane as the sheet.

b) *Wire mesh and expanded metal for railway applications.* Wire mesh and expanded metal sheet shall have a minimum metal thickness in accordance with Table 9 and the maximum metal thickness shall not exceed the required minimum thickness by more than 1.5 mm.

Wire mesh infill shall have apertures not exceeding 25 mm × 25 mm.

Expanded metal sheet infill shall have openings not exceeding 45 mm × 20 mm and shall be fixed vertically with the long dimension horizontal. It shall be supplied in a deburred and flattened condition so that the strands are in the same plane as the sheet.

c) *Solid panels.* Solid infill panels shall present a smooth surface to the traffic face. Joint gaps shall not exceed 3 mm except at movement joints. The minimum metal thickness shall be in accordance with Table 4. The maximum metal thickness shall not exceed the required minimum thickness by more than 1 mm generally and 2 mm in the case of environmental barriers and high containment cladding in aluminium (see notes 1, 2, 3 and 4), but in the case of high containment parapets the cladding panels may be lapped in the direction of the adjacent traffic flow and the consequent outstand accepted.

d) *Environmental barriers.* On occasions it will be necessary to combine a noise/visual barrier with a vehicle parapet with or without pedestrian access. The noise attenuation requirements may give variable heights and thickness of infill and each case shall be considered on its merits observing the general requirements of this section.

e) Where cladding or infilling is used on high containment barriers the line shall be as indicated of Figure 1 and fixings shall be such as not to materially modify the design action of the parapet.

NOTE 1 A grit blasted finish or a patterned surface with maximum depth of 1 mm may be used on solid panels to offset the risk of dazzle (see note 3).
NOTE 2 Solid infill may also be used for anti-splash or anti-dazzle purposes.
NOTE 3 Deeply corrugated infill panels can present a hazard on vehicle impact. They should not be located on the traffic face.
NOTE 4 Wind loading should be considered where solid infill is used.

Table 9 — Minimum requirements for construction of parapets over or adjacent to railways

Type of road	Type of railway					
	Without overhead electrification and where electrification is not likely			With overhead electrication or where electrification is likely		
	Minimum height of parapet	Infill		Minimum height of parapet	Infill	
		Type	Minimum height		Type	Minimum height
	m		m	m		
Motorways and situations where pedestrians are excluded	1.25	Rail mesh (see clause **27** b) or solid infill (see clause **27** c)	0.6	1.25	Rail mesh (see clause **27** b) or (see clause **27** c)	Full height of parapet
Others, i.e. pedestrians may be present	1.50	Solid infill (see clause **27**c)	Full height of parapet	1.50	Solid infill (see clause **27** c)	Full height of parapet
	Infill shall extend not more than 3 mm above the plinth at the traffic face. The faces of the parapet shall not have ledges or projections upon which a person could stand. As an alternative for the outer face access shall be denied by suitable means.					

NOTE 1 The need and requirements for high containment will be determined by specific reference to British Rail.
NOTE 2 Additional requirements are likely for bridleways.

28 Applications not over or adjacent to railways

28.1 The following requirements shall be observed.

a) *Pedestrian protection.* Mesh or solid infill shall extend from not more than 25 mm above the top of the panel at the traffic face to the full height.

b) *Livestock protection.* Vehicle pedestrian parapets on accommodation bridges requiring to contain livestock, including horses, shall be of a minimum height of 1.5 m. If required this height shall be achieved by the use of an additional "non-effective" longitudinal member. Infilling shall be provided in accordance with clause **27**.

28.2 Non-effective longitudinal members shall be designed to withstand a horizontal ultimate loading of 1.4 kN/m and the parapet posts shall be checked to prove that they are capable of providing support for the consequent effects.

This loading shall not be considered coexistent with the loading required for vehicle containment.

In the case of application to high containment parapets the post extensions to carry the non-effective rail shall be designed sufficient for this purpose only.

NOTE A too strong extension could interfere with or modify parapet performance.

29 Applications over or adjacent to railways

29.1 For specific applications reference shall be made to British Rail or other appropriate railway authority.

29.2 Minimum requirements for railways, intended for British Rail use, shall be as summarized in Table 9.

Annex A (informative)
Information to be provided by the supplier/purchaser

The following information should be provided by the purchaser.

Where the purchaser indicates alternatives or does not specify, the supplier should state what he intends to provide.

Information to be supplied	Example of information required
a) Parapet material	Steel or aluminium alloy.
b) Surface protection	For a steel parapet, the preparation and protective system.
c) Designation	The designation of parapet (see clause **5**).
d) Infill material and protection (if infill required)	Steel or aluminium alloy; whether galvanized, etc.; expanded metal, welded mesh or solid; fixing method, non-effective member. Special requirements, such as acoustic barrier.
e) Anchorage type	Cast-in cradle, drilled holes, static testing, etc.
f) Type of holding-down bolts	Normal; expanding; cast-in resin, etc. Any torque or static testing requirements. Passive filler (see note 3 to **12.3.7**).
g) Detailed layout	Relevant details including the following information: 1) horizontal and vertical dimensions and alignment; 2) joints required, giving details of position and movement and any special features such as vertical movements, etc.
h) Details of connections to any safety fence/transition	
i) Availability of storage at site, etc.	Position; area; type of surface.
j) Erection requirements	Relevant details including the following information: 1) dates required; 2) access to site and availability 3) availability to craneage; 4) other operations in progress; 5) special conditions, e.g. proximity of traffic, site welding hazards.
k) Method of securing attachments against vandalism	High torque, spot welding, punch locking.
l) Production testing requirements	Any variation from levels specified in clause **19**.
m) Weld defect levels for acceptance	Any variation from levels specified in clause **19**.
n) Any special surface finish to the panels	Outer face to be featured.

Annex B (informative)
Parapet post and rail systems exempted from design requirements

B.1 General

The steel and aluminium post and rail systems for high containment combined parapets detailed in the drawings referred to in this annex are exempted from the design requirements of this Part of BS 6779 (see **12.1.2**).

NOTE Enquiries regarding reference copies of drawings listed in this annex should be made to Customer Services, Information Services Group, BSI, Linford Wood, Milton Keynes MK14 6LE.

B.2 Combined aluminium and concrete high containment parapets

Designer	Designation	Drawing ref.
Alcan Extrusions Latchford	H/1.50/F	To follow
Latchford Works		
PO Box 151		
Thelwall Lane		
Warrington WA4 1NR		

B.3 Combined steel and concrete high containment parapets

Designer	Designation	Drawing ref.
British Steel Tubes and Pipes	H/1.50/F	To follow
PO Box 101		
Corby		
Northants NN17 5UA		

blank

List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS4, *Structural steel sections.*

BS 4-1:1980, *Specification for hot-rolled sections.*

BS 729:1971, *Specification for hot dip galvanized coatings on iron and steel articles.*

BS 970, *Specification for wrought steels for mechanical and allied engineering purposes.*

BS 970-1:1991, *General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steels.*

BS 1449, *Steel plate, sheet and strip.*

BS 1449-1, *Carbon and carbon-manganese plate, sheet and strip.*

BS 1449-2:1983, *Specification for stainless and heat-resisting steel plate, sheet and strip.*

BS 1470:1987, *Specification for wrought aluminium and aluminium alloys for general engineering purposes: plate, sheet and strip.*

BS 1471:1972, *Specification for wrought aluminium and aluminium alloys for general engineering purposes — drawn tube.*

BS 1473:1972, *Specifications for wrought aluminium and aluminium alloys for general engineering purposes — rivet, bolt and screw stock.*

BS 1474:1987, *Specification for wrought aluminium and aluminium alloys for general engineering purposes: bars, extruded round tubes and sections.*

BS 1490:1988, *Specification for aluminium and aluminium alloy ingots and castings for general engineering purposes.*

BS 2901, *Filler rods and wires for gas-shielded arc welding.*

BS 2901-4:1990, *Specification for aluminium and aluminium alloys and magnesium alloys.*

BS 3019, *TIG welding.*

BS 3019-1:1984, *Specification for TIG welding of aluminium, magnesium and their alloys.*

BS 3416:1991, *Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water.*

BS 3571, *MIG welding.*

BS 3571-1:1985, *Specification for MIG welding of aluminium and aluminium alloys.*

BS 3692:1967, *Specification for ISO metric precision hexagon bolts, screws and nuts. Metric units.*

BS 3923, *Methods for ultrasonic examination of welds.*

BS 3923-1:1986, *Methods for manual examination of fusion welds in ferritic steels.*

BS 3923-2:1972, *Automatic examination of fusion welded butt joints in ferritic steels.*

BS 4190:1967, *Specification for ISO metric black hexagon bolts, screws and nuts.*

BS 4300, *Wrought aluminium and aluminium alloys for general engineering purposes (supplementary series).*

BS 4300/1:1967, *Aluminium alloy longitudinally welded tube.*

BS 4320:1968, *Specification for metal washers for general engineering purposes. Metric series.*

BS 4360:1990, *Specification for weldable structural steels.*

BS 4395, *Specification for high strength friction grip bolts and associated nuts and washers for structural engineering.*

BS 4395-1:1969, *General grade.*

BS 4464:1969, *Specification for spring washers for general engineering and automobile purposes. Metric series.*

BS 4483:1985, *Specification for steel fabric for the reinforcement of concrete.*

BS 4848, *Hot-rolled structural steel sections.*

BS 4848-2:1991, *Specification for hot-finished hollow sections.*

BS4848-4:1972, *Equal and unequal angles.*

BS 5135:1984, *Specification for arc welding of carbon and carbon manganese steels.*

BS 5289:1976, *Code of practice. Visual inspection of fusion welded joints.*

BS 5400, *Steel, concrete and composite bridges.*

BS 5400-1:1988, *General statement.*

BS 5400-2:1978, *Specification for loads.*

BS 5400-3:1982, *Code of practice for design of steel bridges.*

BS 5400-4:1990, *Code of practice for design of concrete bridges.*

BS 5400-7:1978, *Specification for materials and workmanship, concrete, reinforcement and prestressing tendons.*

BS 5400-8:1978, *Recommendations for materials and workmanship, concrete, reinforcement and prestressing tendons.*

BS 5996:1980, *Methods for ultrasonic testing and specifying quality grades of ferritic steel plate.*

BS 6072:1981, *Method for magnetic particle flaw detection.*

BS 6082, *Guide to compilation of performance test schedules for complete filled transport packages.*

BS 6082-1:1981, *General principles.*

BS 6082-2:1981, *Quantitative data.*

BS 6105:1981, *Specification for corrosion-resistant stainless steel fasteners.*

BS 6180:1982, *Code of practice for protective barriers in and about buildings.*

BS 6443:1984, *Method for penetrant flaw detection.*

BS 7475:1991, *Specification for fusion welding of austenitic stainles steels.*

BS 8118, *Structural use of aluminium.*

BS 8118-1:1991, *Code of practice for design.*

BS 8118-2:1991, *Specification for materials, workmanship and protection.*

BS EN 287, *Approval testing of welders for fusion welding.*

BS EN 287-1:1992, *Steels.*

BS EN 287-2:1992, *Aluminium and aluminium alloys.*

BS EN 288, *Specification and approval of welding procedures for metallic materials.*

BS EN 288-1:1992, *General rules for fusion welding.*

BS EN 288-2:1992, *Welding procedures specification for arc welding.*

BS EN 288-3:1992, *Welding procedure tests for the arc welding of steels.*

BS EN 288-4:1992, *Welding procedure tests for the arc welding of aluminium and its alloys.*

BS EN 10002, *Tensile testing of metallic materials.*

BS EN 10002-1:1990, *Method of test at ambient temperature.*

BS EN 10025:1990, *Specification for hot rolled products of non-alloy structural steels and their technical delivery conditions.*

BS EN 10083, *Specification for quenched and tempered steels.*

BS EN 10083-1:1991, *Technical delivery conditions for special steels.*

BS EN 10083-2:1991, *Technical delivery conditions for unalloyed quality steels.*

Other references

[1] BD 37/88 *Loads for highway bridges*. Department of Transport, 1988. Available from Department of Transport, Publications Sales Unit, Room 1, Spur 2, Block 3, Government Buildings, Lime Grove, Eastcote, Middlesex, HA4 8SE.

[2] BD 13/90 *Design of steel bridges — Use of BS 5400-3*. Department of Transport, 1990. Available from Department of Transport, Publications Sales Unit, Room 1, Spur 2, Block 3, Government Buildings, Lime Grove, Eastcote, Middlesex, HA4 8SE.

Informative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 5493:1977, *Code of practice for protective coating of iron and steel structures against corrosion.*

BS 6779, *Highway parapets for bridges and other structures.*

BS 6779-1:1992, *Specification for vehicle containment parapets of metal construction.*

BS 6779-2:1991, *Specification for vehicle containment parapets of concrete construction.*

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL