
British Standard Code of practice for
**Protective barriers in
and about buildings**

Code de bonne pratique relatif aux barrières dans le bâtiment

Leitfaden für Schutzgitter in und außerhalb von Gebäuden

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This code of practice represents a standard of good practice and takes the form of recommendations. Compliance with it does not confer immunity from relevant legal obligations.

Foreword

This British Standard code of practice, prepared under the direction of the Elements and Components (of Diverse Materials) for Buildings Standards Committee, gives recommendations for protective barriers that are provided in and about buildings to protect users from common hazards. It supersedes CP 499 : Part 1 : 1972, which was restricted to metal railings and balustrades and covered only a limited range of applications, and which is now withdrawn.

In view of the variety of materials available for barrier construction and the wide range of possible uses for protective barriers, this code does not attempt to standardize methods of design but refers instead to existing structural design codes. However, clause 3 allows users freedom to choose materials and methods of design and construction not specifically mentioned, subject to the provision of research data and test results.

This code gives comprehensive recommendations for design loads for protective barriers. The values given are based on

practical experience and the recommendations of existing codes, since only limited research into barrier loading has been carried out in recent years. The safety factors implicit in this code provide acceptable levels of protection, although designers should be prepared to increase these safety factors where special circumstances prevail.

This code covers detail design and construction of protective barriers in a wide range of materials. The range has been made as comprehensive as possible in the light of existing knowledge.

The recommendations of this code have been written to ensure that protective barriers are adequate for their intended use and are positioned and fixed correctly. In all cases, the careful application of the basic principles described in clause 4 is essential.

Attention is drawn to the fact that statutory legislation may impose more stringent requirements for protective barriers in certain circumstances.

British Standard Code of practice for

Protective barriers in and about buildings

Section one. General

1. Scope

This code of practice gives recommendations for the general design and construction of temporary and permanent protective barriers to be provided in and about buildings and places of assembly, such barriers being positioned and designed to protect persons from various hazards and to restrict or control the movements of persons and/or vehicles.

Protective barriers that indicate routes or provide support are included as well as protective barriers capable of stopping or diverting moving vehicles within areas restricted to a maximum speed of 16 km/h (4.44 m/s, 10 mile/h).

However, protective barriers for resisting high-speed vehicular impact, for example motorway safety barriers and bridge parapets outside the curtilages of buildings, are excluded from this code.

The recommendations in this code also apply to walls, glazing and other elements of buildings or structures where such elements act as protective barriers (see 2.1).

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

2. Definitions

For the purposes of this code the following definitions apply.

2.1 protective barrier. Any element of building or structure, permanent or temporary, intended to prevent persons from falling and to stop persons or vehicles.

2.2 characteristic load or characteristic mass. The load or mass that has a probability of not more than 5 % of being exceeded during the design life of the structure.

2.3 datum level. The finished level of the floor, roof, foundation slab, balcony, ramp, stage or pitch line of stairs, etc. (see figure 1).

2.4 design level. The level at which the horizontal force on the barrier is assumed to act for the purposes of design.

2.5 safety glass or safety plastics material. Glass or plastics sheet material that reduces or eliminates unreasonable risk of death or serious injury, as indicated by its remaining unbroken or breaking safely under the test specified in BS 6206.

Section two. General design

3. Materials, components and methods of design and construction

Recommendations for the detail design and construction of protective barriers using various materials, components and methods are given in clauses 6 to 12. Where materials, components and methods of design and construction are not covered by these clauses or by any other British Standard, this is not to be regarded as discouraging their use. The designer should satisfy himself that the materials and methods to be employed are such as to ensure durability, integrity and a level of performance at least equal to that recommended in this code.

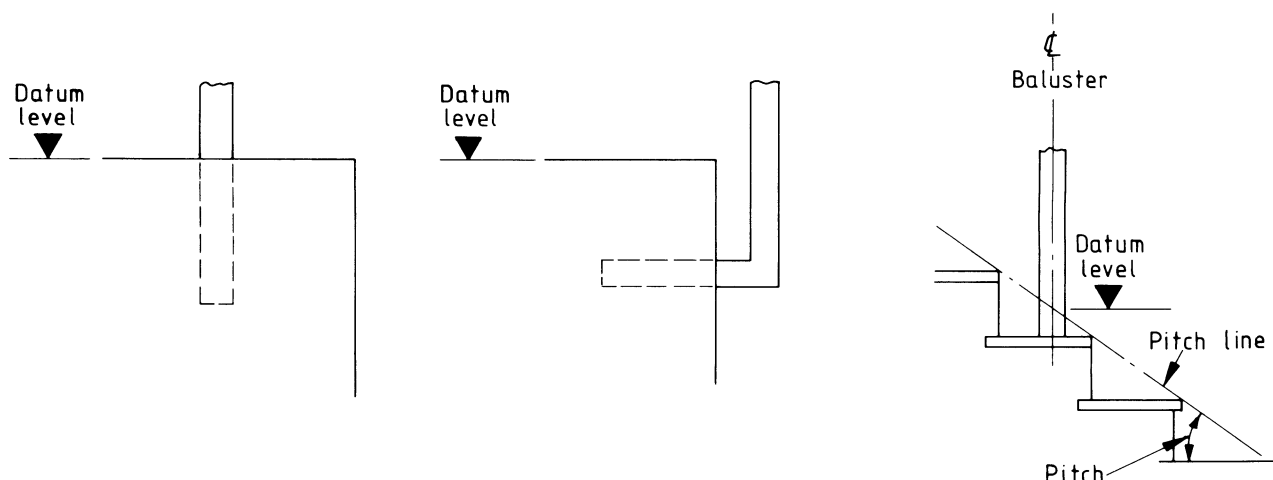


Figure 1. Datum level

Alternatively, a test assembly should be built to prove the material, component or method under consideration. The test assembly should be representative, as to materials, workmanship and details, of the design and construction for which approval is desired, and should be built under conditions truly representative of the conditions in the actual building construction or curtilage involved.

4. Preliminary considerations

4.1 The nature of the building use (see table 1) and the type of user, as well as the extent of supervision and control and the protection afforded by the building enclosure, requires careful consideration by the designer when assessing:

- (a) the need for a protective barrier;
- (b) the type of protective barrier to be provided.

As a general rule, where there is a difference in adjacent levels greater than 0.5 m, protective barriers should be installed to restrict or control the movement of persons and vehicles.

4.2 Where the building cladding or enclosure, which may have been designed in accordance with the appropriate code(s) of practice, would not satisfy the design criteria given in clause 5 of this code, either the design should be modified to meet these criteria or an additional protective barrier should be provided.

4.3 The design of protective barrier adopted should be such as to minimize the risk of persons falling, rolling, sliding or slipping through gaps in the barrier. In areas frequented by children, protective barriers should be designed so that the widest gap in the barrier does not permit a sphere of diameter 100 mm to pass through, making due allowance for deflection under load.

4.4 Where more than one use is anticipated, either the protective barrier should be chosen to suit the worst case or more than one barrier should be provided.

4.5 Designers should always consider protection of critical structural elements abutting any road where vehicle impact could initiate progressive collapse.

5. Design criteria

5.1 Introduction. Protective barriers should be designed to resist the most unfavourable combination of imposed and wind loads with an adequate margin of safety against collapse (see 5.3 and 5.4) and without unacceptable deflections or distortions (see 5.7 and 5.8).

In some circumstances, walls, glazing and other elements of buildings or structures may be required to satisfy the criteria given in this clause (see 4.2).

5.2 Types of protective barrier. The location and use of a protective barrier determine the design criteria and the overall dimensions, in particular the minimum height.

The types of protective barrier covered by this code fall into two distinct groups, as follows:

- (a) protective barriers designed to resist vehicular impacts (see 5.3.2);
- (b) protective barriers not designed to resist vehicular impacts, as listed in tables 2 and 3.

Table 2 gives the design loads, the design level (see 2.4) and the minimum height that should be used for:

- (1) protective barriers in building-use categories 1 to 6 and 8 (see table 1); and

- (2) protective barriers for users of footways or pavements adjacent to access roads, basements or sunken areas in all building-use categories.

Table 3 gives the design loads, the design level and the minimum height that should be used for protective barriers in building-use categories 7(a) and 7(b) (see table 1), including 'designated' stadia, which are those requiring a safety certificate under the Safety at Sports Grounds Act 1975 (see appendix A).

Protective barriers should be designed to resist separately applied loads as given in columns 2, 3 or 4 of tables 2 or 3.

5.3 Imposed loading

5.3.1 General. Unless special conditions exist, the design imposed loads should be chosen to suit the type of protective barrier (see 5.2).

For protective barriers listed in tables 2 and 3, either permissible stress or limit state design procedures may be used, according to the recommended procedure given in the code of practice appropriate for the material to be used, treating the loads given in tables 2 and 3 as:

- (a) working loads, for permissible stress design;
- (b) characteristic loads, for limit state design.

When using limit state design, the partial safety factors for load and materials should be those normally applicable to the limit state of collapse or to accidental damage, as recommended by the appropriate code.

However, in designing barriers to resist equivalent static loads, such as those due to vehicular impact (see 5.3.2), the permissible stress procedure is not appropriate. In such cases, it is essential to use a limit state approach based on the partial safety factors for load and materials appropriate to accidental damage or misuse. Where a code of practice makes no specific provision for design against impact loads, decisions should be made regarding the possible reduction of the overall factor of safety, according to the relative influence of dynamic loads compared with static loads on the properties of the material, the anticipated frequency of impacts and the failure mode or modes of the structure.

5.3.2 Imposed loading due to vehicles. When designing barriers to resist vehicular impact, an estimate of the characteristic mass m of the vehicle should be made. Ideally, this should be determined statistically; if this is not possible, the characteristic mass should be taken to be equal to the maximum mass anticipated during the life of the structure.

Figure 2 should be used to estimate the direct potential static equivalent impact force F for a given characteristic mass and displacement. (For the derivation of figure 2, see appendix B.)

The area and position of contact subsequent to initial impact may be used in calculating the ultimate strength of the barrier if the pattern of vehicle or barrier deformation can be reliably predicted. BS 6399 : Part 1 recommends simplified design requirements for the area and position of contact in relation to vehicles of up to 2.5 t (tonnes) mass in car parks. Further information to enable designers to derive potential static equivalent impact forces for cases where different parameters may apply is given in appendix B.

Design loading for car park barriers should be calculated following the recommendations of clause 10 of BS 6399 : Part 1 : 1984, which allow a characteristic mass of 1.5 t to be taken for car parks designed for vehicles not exceeding

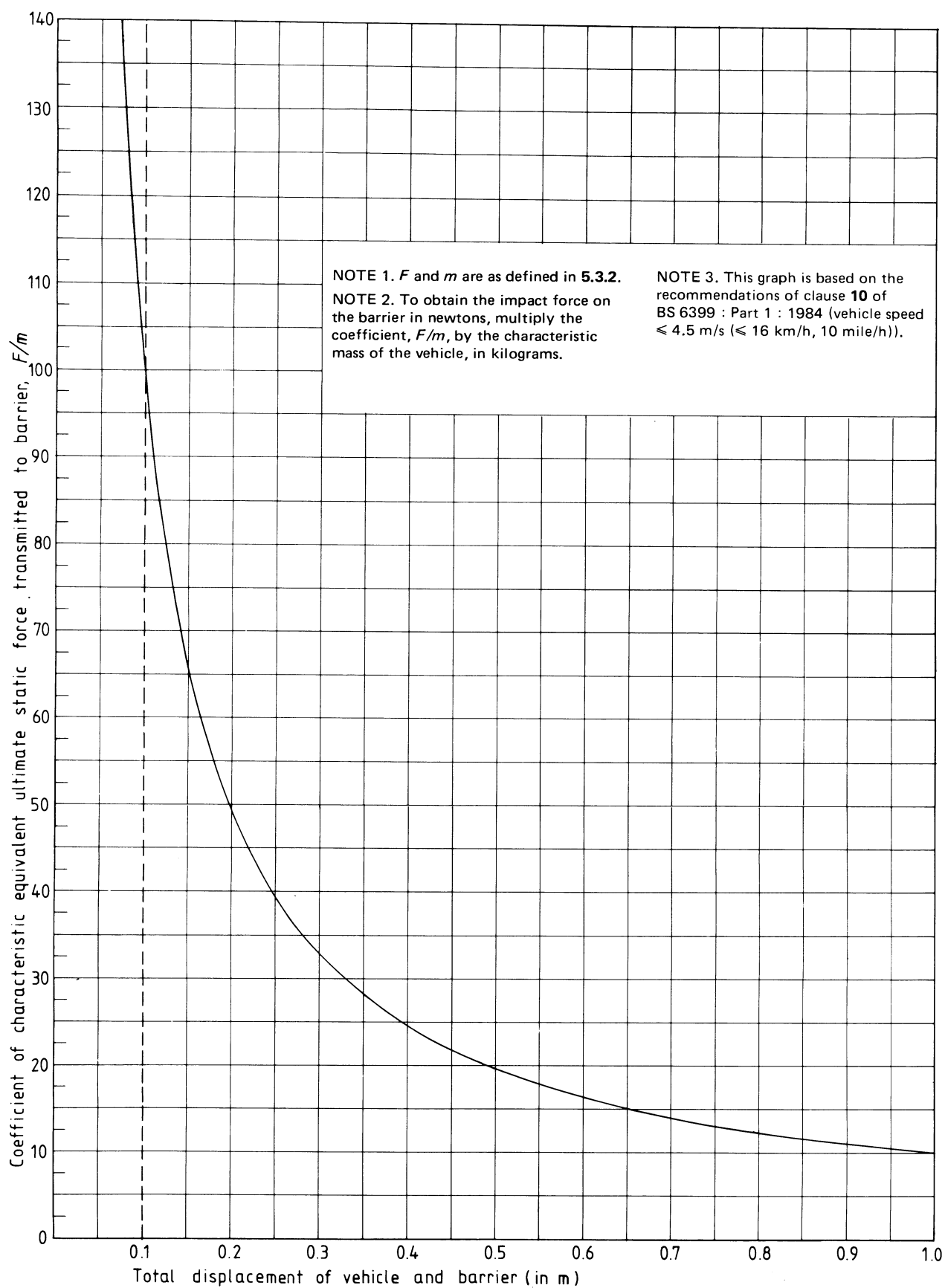


Figure 2. Impact forces for vehicles impacting at right angles to a barrier

2.5 t in mass. (Figure 2 may be used, since it is based on these recommendations.)

When designing barriers to resist vehicular impact in or about buildings, including access roads, depots, garages, loading docks and warehouses, the assumed distribution of the impact force and the design level (see 2.4) at which it is applied should be related to the likely area and position of initial contact. The total displacement shown in figure 2 or figure 5 should be taken to be the displacement of the vehicle, which may be assumed to be not less than 100 mm, plus the displacement of the barrier system, where this is designed to absorb impact energy by lateral displacement.

Angular impacts may give rise to additional forces directed along the line of the barrier. Where the construction of the barrier is such that frictional contact between it and the vehicle is likely to be high, or such that projections may snag the vehicle, these additional forces can reach three times the lateral applied forces.

The designer should wherever possible avoid introducing projections on the vehicular face of the barrier and should also consider ways of redirecting vehicles in such a way as to cause minimum damage after impact.

Consideration should be given to applying an appropriate weight restriction to vehicles protected by a given barrier.

5.4 Wind loading. In all cases, external barriers should be designed to resist the wind loads given in CP 3 : Chapter V : Part 2. The partial safety factor for the wind load should be that normally recommended by the code of practice used to derive the design imposed load, as described in 5.3.

5.5 Infill panels and balusters. Infill panels should be designed as recommended in 5.3 and 5.4. Where the infill consists of successive balusters, each baluster should be designed to resist half the load given in column 4 of tables 2 or 3, applied at mid-height.

5.6 Support from adjacent construction. Designers should ensure that the adjacent construction acting as support for protective barriers is of adequate strength and stability to sustain all applied loads safely without excessive strain, deflection or distortion.

5.7 Deflection. A barrier for the protection of persons that is structurally safe may nevertheless possess sufficient flexibility to alarm the general public when subjected to normal service loads. When barriers are subjected to a loading equal to *half* the loading derived from the most unfavourable combination of imposed and wind loads given in tables 2 or 3, the horizontal displacement of any point of the barrier at design level should not exceed $L/125$ (where L is the clear span between supports or, for glass protective barriers, as given in 7.3 or 7.4) or 25 mm, whichever is the lesser.

This recommendation is in addition to any recommendations for limiting deflection given in the appropriate structural codes for the material to be used.

5.8 Distortion. Barriers designed to resist vehicular impacts may be distorted by such impacts but should remain substantially in place thereafter.

5.9 Fixing. Wherever a fixing, connection or support is essential to prevent the collapse or failure of a barrier, or of a critical part of a barrier, it should not be permitted to rely

wholly on pull-out strength (see note). When designing fixings, connections, supporting brackets and other supports, the design loads for the components should be multiplied by a factor of 1.5.

The designer should be responsible for specifying the strength of fixings, having regard to whether the imposed load is intended to be transmitted horizontally or vertically by the panel.

NOTE. The term 'pull-out strength' is not intended to refer to reinforcement in concrete, which should be designed following the recommendations of CP 110. These give an appropriate factor of safety.

5.10 Safety details. The finished protective barriers should have no sharp edges or projections that may cause injury to persons or damage to clothing.

The ends of protective barriers on unlit access roads should be provided with reflectors or reflective markings.

Table 1. Building-use categories

Building-use category	Descriptive title	Typical uses of building or part of building
1	Private residential	Private dwelling, house
2	Institutional	Hospital, home or school rooms not covered by category 7 (see note)
3	Other residential	Residential purposes other than any in categories 1 and 2, such as hostel, hotel or motel rooms not covered by category 7 (see note)
4	Office	Office, bank, telephone exchange
5	Shop	Shop, public house, café, restaurant
6	Factory	Factory, works
7	(a) Place of entertainment	Theatre, cinema, concert hall
	(b) Place of assembly	Assembly hall, stadium and other uses not covered by categories 1 to 6 (see note)
8	Storage and general	Storage, deposit or parking of goods, materials or vehicles other than motor vehicles Any other uses not covered by categories 1 to 7

NOTE. The same building may include two or more different building-use categories. For example, a sports hall in a school might come under category 7(b) whereas a classroom in the same school would come under category 2.

Table 2. Building user and pedestrian protection

1	2	3	4	5
Barrier protecting users of:	Barriers should be designed to resist the following loads (see note 2), separately applied			Barriers should be of a height above datum level not less than:
	A horizontal UDL * applied at design level (see note 3) of:	A UDL applied to the infill of:	A point load applied to any part of the infill of:	
(a) Staircases within or serving exclusively one dwelling in building-use categories 1 and 3	kN/m 0.36	kN/m ² 0.5	kN 0.25	mm 850
(b) Ramps, landings, or floors within or serving exclusively one dwelling in building-use categories 1 and 3	0.36	0.5	0.25	900
(c) Staircases not covered by (a)	0.36 (building-use category 3) or 0.74 (other building-use categories)	1.0	0.50	900
(d) Landings not covered by (b)	0.74	1.0	0.50	1100
(e) Situations other than (a) to (d), including all floors, landings, balconies, flat roofs with access, walkways and edges of sunken areas, in building-use categories 1 to 6 and 8	0.74	1.0	0.50	1100
(f) Footways or pavements, within building curtilage, adjacent to access roads, basements or sunken areas	1.0	1.0	1.0	1100

*Uniformly distributed load.

NOTE 1. Building-use categories referred to in rows (a) to (f) are listed in table 1.

NOTE 2. Design loads given should be treated as working loads when using permissible stress design or characteristic loads when using limit state design (see 5.3.1).

NOTE 3. The design level (see 2.4) should be taken to be 1.1 m above datum level (see 2.3). (The height of 1.1 m is the assumed height of the centre of gravity of the human body above datum.)

Table 3. Audience, spectator and crowd protection

1		2	3	4	5
Barrier protecting audiences, spectators or crowds using:		Barriers should be designed to resist the following loads (see note 2), separately applied			Barriers should be of a height above datum level not less than:
		A horizontal UDL* load applied at design level (see note 3) of:	A UDL applied to the infill of:	A point load applied to any part of the infill of:	
(a) Balconies or parts of balconies, stands, etc. having fixed seating within 530 mm of the barrier (see note 4)	and forming part of building-use category 7(a)	kN/m 1.5	kN/m ² 1.5	kN 1.5	mm 800, for narrow barriers (for guidance, see 5.11)
	and forming part of building-use category 7(b)	1.5	1.5	1.5	800
(b) Staircases		3.0	1.5	1.5	900
(c) Situations other than (a), (b), (d) or (e) forming part of building-use category 7		3.0	1.5	1.5	1100
(d) 'Designated' stadia (see note 5) with crush barriers spaced in accordance with column B of table 10		3.4	N/A	N/A	1100
(e) 'Designated' stadia (see note 5) with crush barriers spaced in accordance with column A of table 10		5.0	N/A	N/A	1100
(f) Pavements or areas not less than 3 m wide adjacent to sunken areas, e.g. light wells, basement areas		3.0	1.5	1.5	1100

*Uniformly distributed load.

NOTE 1. Building-use categories are listed in table 1.

NOTE 2. Design loads given should be treated as working loads when using permissible stress design or characteristic loads when using limit state design (see 5.3.1).

NOTE 3. The design level (see 2.4) should be taken to be 1.1 m above datum level (see 2.3). (The height of 1.1 m is the assumed height of the centre of gravity of the human body above datum.)

NOTE 4. The dimension of 530 mm is taken to be the minimum distance measured from any part of the fixed seating to the barrier. Tip-up seats should be considered in the up position.

NOTE 5. Designated stadia referred to in rows (d) and (e) are those requiring a safety certificate (see 5.2 and appendix A).

5.11 Sight lines. It is essential to consider sight lines as well as safety aspects when designing barriers in theatres, cinemas and concert halls. This applies particularly to barriers protecting balconies or parts of balconies having fixed seating within 530 mm of the barrier. The relationship between the height and width of a barrier affects both sight lines and safety. A lower, wider barrier may provide the same degree of protection as a higher, narrower barrier. The height for a narrow barrier given in table 3 is 800 mm. This height may be reduced if the barrier is increased in width and designed to provide adequate protection. The Building Regulations for England and Wales and Northern Ireland permit a minimum height of 790 mm, whilst the Building Standards (Scotland) Regulations state that the minimum height shall be 790 mm or may be reduced to 750 mm provided that the barrier has a coping or super-imposed padded rest with an overall width of not less than 230 mm. However, if the reduction in height permitted by the Building Standards (Scotland) Regulations is adopted for the purposes of this code, a width considerably greater than 230 mm may be desirable.

Section three. Detail design, construction and maintenance

6. Concrete

All concrete used in the construction of protective barriers should be designed and constructed using the design criteria in clause 5 and following the recommendations of BS 8110 : Part 1, which covers in situ and precast concrete, plain, prestressed and reinforced.

When concrete is used to form the external face of protective barriers, it is essential that the designer should take into account the mode or modes of failure that any envisaged overload would cause and provide appropriate reinforcement so as to prevent the spread of debris to a dangerous extent.

Special consideration should be given to the ultimate strength and strain behaviour of the fixings for precast concrete elements in protective barriers. The designer may choose to design the barrier so that restraints in one zone