TECHNICAL MEMORANDUM
(BRIDGES) No. B.E. 5

MINISTRY OF TRANSPORT

TECHNICAL MEMORANDUM

ON THE

DESIGN

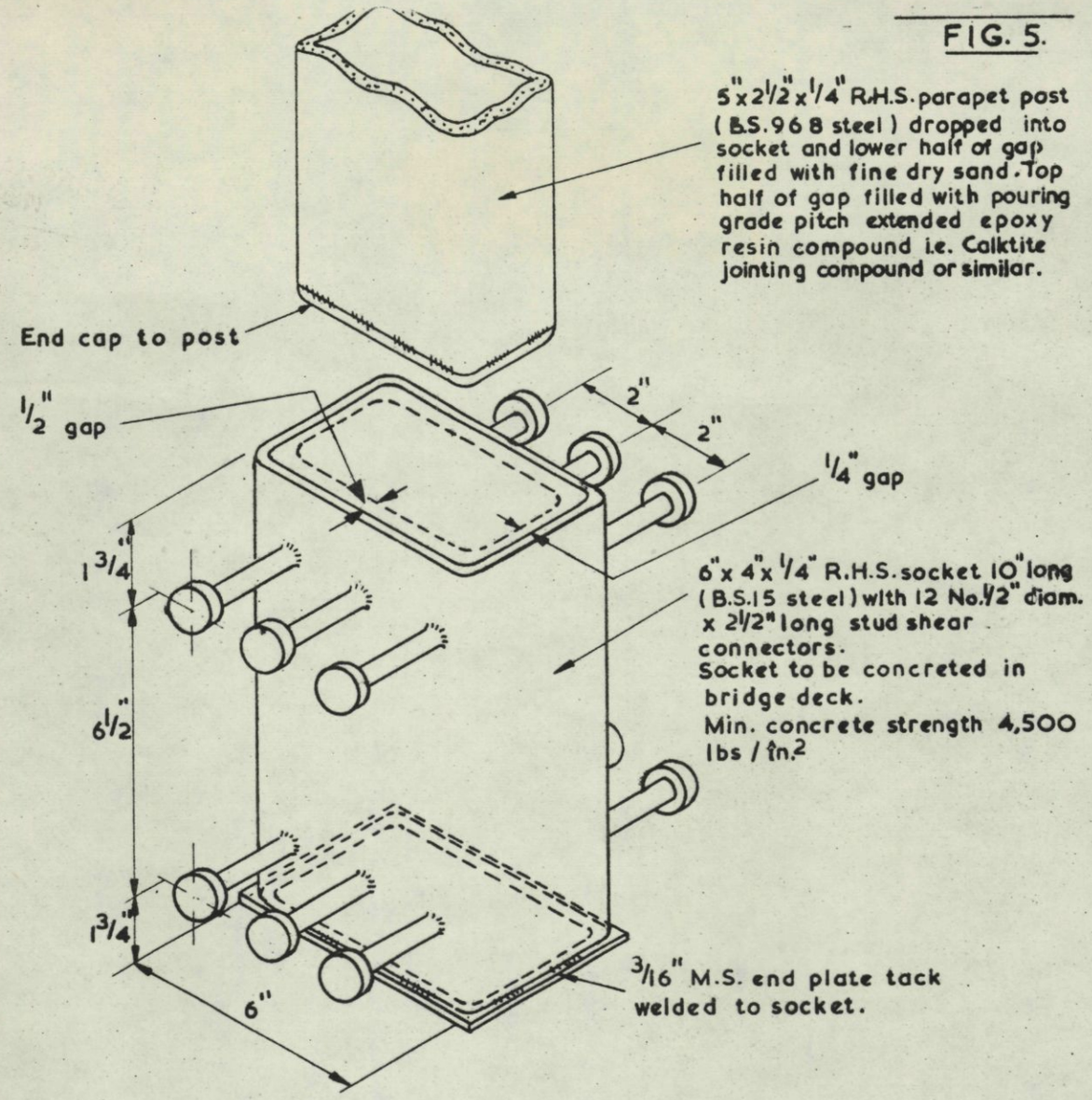
OF

HIGHWAY BRIDGE PARAPETS

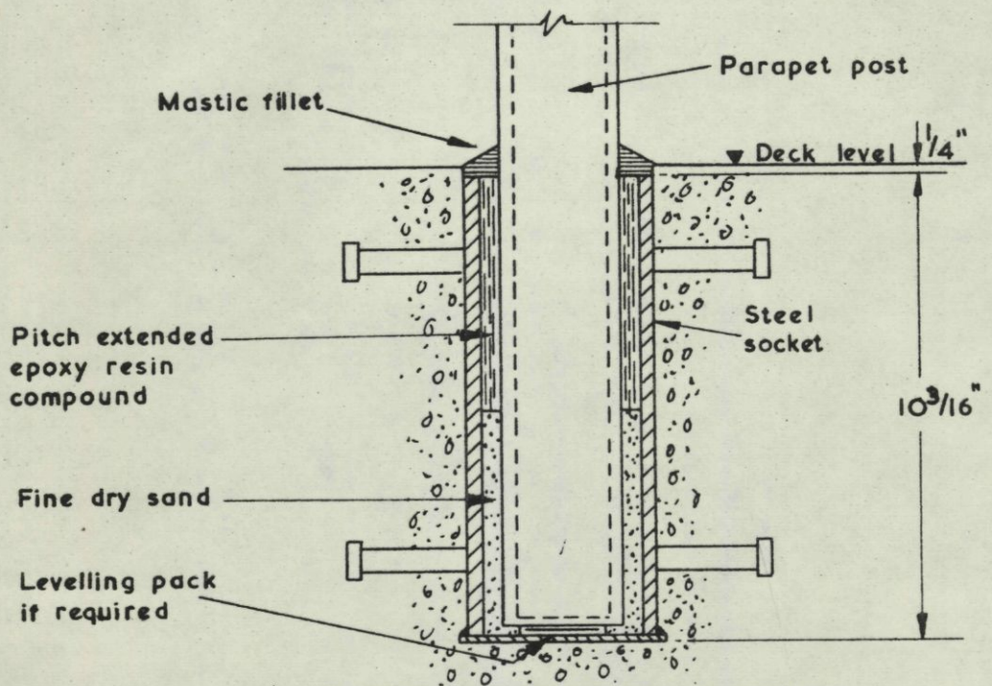
FIRST REPRINT JUNE, 1967

(Incorporating the JANUARY 1967 edition of Technical Memorandum BE 5, as revised by Amendment List No. 1, dated April, 1967 and Amendment List No. 2 dated June, 1967).

FIG. 5.



DETAILS OF SOCKET



SECTION THROUGH SOCKET AS CAST IN BRIDGE DECK

METHOD OF REPLACEMENT

1. Damaged post burnt off at deck level.
2. Inside of post stub heated with cutting torch to decompose jointing compound.
3. Stub extracted and socket cleaned out.
4. New post reset in jointing compound.

PARAPET POST FIXING FOR TYPE P.I. PARAPET

TECHNICAL MEMORANDUM (BRIDGES) NO. BE 5

THE DESIGN OF HIGHWAY BRIDGE PARAPETS

Amendment List No. 3

(Amendment Lists Nos. 1 and 2 were incorporated in the June 1967 edition of the Memorandum.)

1. AMENDMENTS

(a) In sub-clause 106(e) before "not less than 75%" insert: "with the following exception".

(b) To the end of sub-clause 106(e) add: "Where the allowable movement is 2 inches or more "end posts" complying with sub-clause 106(g)(ii) are to be provided on either side of the expansion joint. The joint in the longitudinal members between these posts need not be designed to transmit tension."

(c) Delete sub-clause 106(h) and substitute the following:

(h) STRENGTH AND DESCRIPTION OF POST FIXINGS

(i) The fixing of the post to the bridge deck shall be either by means of a socket fixing such as that developed by Bridges Engineering and indicated in Appendix Fig. 5, or by means of a baseplate and holding-down bolts. In either case, the fixing shall be capable of developing a moment of resistance about either axis, calculated in accordance with paragraphs (ii) and (iii) below, at least 50% greater than the appropriate maximum fully plastic moment of the post.

(ii) The design moment of resistance of a socket fixing shall be taken as the sum of the moment developed in bearing by the sides of the socket and the moment developed by shear connectors. The design load of shear connectors shall not exceed the ultimate capacity given in Table 2 of CP 117: Part 2. The bearing stress in the concrete shall be assumed to vary linearly over the depth of the post in the socket and shall not exceed two thirds of the twenty-eight day cube strength.

After the post has been positioned the top of the socket shall be sealed with a mastic fillet which will prevent the ingress of water.

(iii) The attachment of a post to a baseplate shall be as strong as the post in bending and shear.

The stress in the attachment of the baseplate to the deck shall be calculated elastically.

The calculated stress in holding-down bolts, based on the net cross-sectional area at the root of the thread, shall not exceed the minimum guaranteed yield stress of the bolt material and the bearing stress in the concrete shall not exceed two thirds of the twenty-eight day cube strength.

The supporting concrete must be additionally reinforced against the bursting associated with any internal forces e.g. those generated by expanding anchorages.

Holding-down bolts should either screw into sockets contained within the supporting concrete or be capped with domed nuts.

(d) Add Appendix Fig. 5 enclosed.

2. EXPLANATORY NOTES

(a) Amendment 1 (a and b)

Joints in longitudinal members designed to accommodate expansion movement can only transmit tension when they come to the end of their travel. It is therefore necessary to decide the amount of travel which is acceptable and to make alternative provision for developing tensile force in longitudinal members when this amount is exceeded.

(b) Amendment 1(c)

The Ministry, up to the present, has been opposed to the setting of parapet posts into concrete, because of the difficulties of removing them if they were damaged, and for preventing a corrosion ring forming at the point of entry of the posts into the concrete. With the development of new materials, further consideration has been given to the problem by the Bridges Engineering Division of the Ministry, which has developed and tested the method shown in the attached Appendix Fig. 5. The detail shown has proved satisfactory for the post of a P.1 parapet and may be adapted as required to take account of different horizontal forces.

L. R. Greenaway

L. R. GREENAWAY
Assistant Chief Engineer

30 April 1968

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TECHNICAL MEMORANDUM

(BRIDGES) No. B.E.5

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(Incorporating the JANUARY 1967 edition of Technical Memorandum BE 5, as revised by Amendment List No.1, dated April, 1967 and Amendment List No.2 dated June, 1967).

[redacted]

To be attached to, and form part of the
First Reprint of Technical Memorandum (Bridges) No.BE.5

File Ref. BE 21/5/05

Technical Memorandum (Bridges) No. B.E.5
The Design of Highway Bridge Parapets

1. The attached Technical Memorandum is based on the recommendations of a Panel of the Bridge Committee of the former Road Research Board. The Panel advised on parapets for motorway under and overbridges, and their findings have been extended to cover parapets for all other highway and footbridges.

2. The Memorandum is mandatory for the design of parapets over railways and on new bridges over or carrying motorways and trunk roads, and is commended for the design of parapets for bridges over or carrying classified roads.

3. The first edition of this memorandum, dated January 1967, was modified by Amendment Lists Nos. 1 to 2, dated April 1967 and June 1967 respectively. This reprinted edition of the memorandum dated June 1967 incorporates all the modifications given in Amendment Lists 1 and 2.

4. The amendments in respect of parapets over railways have been agreed by the Railway Inspectorate of this Ministry and by the British Railways Board.

5. Application for copies of this memorandum should be sent to the Engineering Intelligence Division of the Ministry of Transport in Room 5/14 St. Christopher House.

A. D. Holland

(A. D. Holland)
Deputy Chief Engineer

22 June, 1967

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APPENDIX

DIAGRAMMATIC SKETCHES SHEWING MAXIMUM AND MINIMUM DIMENSIONS

TECHNICAL MEMORANDUM ON THE DESIGN OF HIGHWAY BRIDGE PARAPETS

INTRODUCTION

This memorandum should be regarded as being of an interim nature and is subject to modification in the light of long term tests at the Road Research Laboratory and elsewhere.

Part I describes the design standards and basic principles which apply to parapets in general.

Part II gives the particular requirements applicable to each group of parapets.

PART I
GENERAL REQUIREMENTS FOR HIGHWAY BRIDGE PARAPETS

101. DEFINITIONS

(a) SAFETY FENCE

A continuous barrier erected alongside a carriageway and intended to prevent vehicles from entering areas which the barrier protects.

(b) PARAPET

A protective fence or wall at the edge of a bridge or similar structure.

(c) VEHICLE PARAPET

A parapet designed to contain vehicles on a structure from which pedestrians, animals and cyclists are excluded by Order.

(d) PEDESTRIAN PARAPET

A parapet designed to safeguard pedestrians, but not intended to contain vehicles.

(e) VEHICLE PEDESTRIAN PARAPET

A parapet designed to contain vehicles and to safeguard pedestrians.

(f) ADJOINING PAVED SURFACE

The paved area of a bridge deck, on the traffic side of a parapet, immediately adjacent to the base of the plinth of a metal parapet, or to the base of a concrete parapet.

(g) MAIN LONGITUDINAL MEMBER

The member whose centre line is between 1'9" and 2'3" above the adjoining paved surface, in a parapet which contains longitudinal members. Not all parapets have a main longitudinal member.

(h) TRAFFIC FACE OF A PARAPET (See Appendix, Figs.1-4)

A vertical plane containing the front face of the main longitudinal member and/or the bottom edge of the plinth.

(i) FRONT FACE OF A MEMBER

The face nearest to the traffic.

102. DESIGN CRITERIA

(i) Parapets are intended to protect pedestrians and/or errant vehicles. In addition they may be required to protect the area below. In special circumstances they may be required to be solid, to prevent splash and to reduce noise.

(ii) On divided structures it is preferable to protect the void between two bridge decks by a horizontal grid designed to carry H.A. loading, but where this is impracticable, parapets shall be provided. Where the divided structure crosses a railway with an existing or proposed electrified over-head system, the void shall be protected by a solid slab capable of carrying H.A. loading, or by parapets conforming to Clause 205.

(iii) It is not practicable to make parapets completely unclimbable, but where pedestrians have access, the parapet should not have footholds. Children must not be able to pass through the parapet.

(iv) Where parapets are intended to contain a vehicle they should do so without stopping it adruptly, and without deflecting it into the path of other traffic, so far as is practicable.

(v) For the purpose of this memorandum, parapets have been divided into five groups, designated P.1 to P.5.

(vi) In general, a Group P.2 parapet is intended to have half the strength, and a Group P.3 parapet one third of the strength of a P.1 parapet. These strengths are approximately proportional to the square of the speed of the vehicle to be contained.

(vii) The design standards of the various groups of parapets are given in Table I.

TABLE I. DESIGN STANDARDS FOR PARAPETS

PARAPET GROUP DESIGNATION	APPLICATION	CONTAINMENT FOR WHICH DESIGNED
P.1	Vehicle parapets for bridges carrying motorways, or roads to motorway standards. (Excluding culverts, cattle creeps and motorway bridges over railways).	30 cwt. vehicle at 70 m.p.h. and 20° angle of incidence, or at lesser speed and greater angle.
P.2	Vehicle Pedestrian parapets for highway bridges and accommodation bridges, over motorways or roads to motorway standards.	30 cwt. vehicle at 50 m.p.h. and 20° angle of incidence, or at lesser speed and greater angle. (See also Clause 202 (a)(i)).
P.3	Vehicle Pedestrian parapets for all-purpose road bridges, other than motorway and railway overbridges.	30 cwt. vehicle at 40 m.p.h. and 20° angle of incidence, or at lesser speed and greater angle.
P.4	Pedestrian parapets for use on footbridges.	Horizontal loads of 50 to 100 lb. per linear foot, acting at a height of 3 ft. above level of footway. The value taken to be at the discretion of the Engineer. (The maximum value will only occur in extreme cases of crowd loading).
P.5	Parapets for use over railways:-	
	(i) On bridges carrying a motorway or equivalent.	As for Group P.1.
	(ii) On bridges carrying all-purpose roads.	As for Group P.2
	(iii) On footbridges	As for Group P.4

103. MATERIALS

All parapets except pedestrian parapets shall be constructed of metal or reinforced concrete or a combination of the two materials. In exceptional cases, when it is necessary to harmonise with local conditions, reinforced concrete may be clad in masonry or brickwork, provided that the cladding is securely fixed to the concrete core.

Pedestrian parapets may incorporate material other than metal or reinforced concrete provided that it has adequate strength and resistance to weathering and vandalism.

104. HEIGHT

Except on bridges over railways, all parapets shall have a minimum height of 3'3" above the adjoining paved surface. The height may be increased where additional safety is required (e.g. where the bridge is high or over fast flowing water). For bridges over railways, see Part II, Clause 205(b).

105. FREEDOM FROM PROJECTIONS

Longitudinal members of vehicle and vehicle pedestrian parapets shall be placed in front of their supporting posts, and present a smooth face to the traffic, except that metal members may contain minor projections of not more than $\frac{3}{4}$".

106. PROPERTIES OF METAL MEMBERS

(a) ELONGATION

The metal shall normally have a minimum elongation of 10%, but where the base of a post is a casting it must be so constructed that the casting will not fail before the post yields.

(b) MINIMUM THICKNESS AND PROTECTION AGAINST CORROSION

All hollow sections should be sealed where possible. Unsealed sections are liable to collect water due to condensation etc. and where this may be trapped, drain holes shall be provided.

(i) Steel members shall have a minimum thickness as follows:-

Sealed hollow sections	10 S.W.G.
Unsealed sections	8 S.W.G.

All exposed surfaces shall be protected against corrosion.

(ii) The thickness of non-ferrous members shall be determined by the strength requirement, subject to a minimum thickness of 10 S.W.G. Satisfactory proof of their resistance to corrosion must be obtained.

The protection of non-ferrous metal members of a parapet must be considered in relation to the alloy of which the members are made. The possibility of fatigue caused by vibration and wind loading over a very long period should also be examined.

(c) MAXIMUM DISTANCE BETWEEN POSTS SUPPORTING LONGITUDINAL MEMBERS

The maximum span of a continuous metal longitudinal member between supporting posts shall be 12'6".

(d) STRENGTH OF EFFECTIVE LONGITUDINAL MEMBERS

The product of the plastic modulus and the minimum guaranteed yield stress of each effective longitudinal member of a parapet, at mid span and at the supports, shall be not less than the values given in Table II. (See Page 5).

(e) CONTINUITY OF STRENGTH OF LONGITUDINAL MEMBERS

Longitudinal members shall be structurally continuous over the whole length of the bridge, except where it is necessary to provide for expansion. An expansion joint in a member shall maintain the full strength of the member in bending at all times, and not less than 75% of the full strength of the member in tension when the limit of the allowable movement is reached.

(f) STRENGTH OF SUPPORTING POSTS UNDER TRANSVERSE LOADING

The product of the minimum guaranteed yield stress and the plastic modulus of any post about an axis parallel to the line of the parapet, shall be not less than the moment induced by the transverse force F, given in Table II, acting on the post according to the disposition of the effective longitudinal members.

(g) STRENGTH OF SUPPORTING POSTS UNDER LONGITUDINAL LOADING

(i) The product of the minimum guaranteed yield stress and the plastic modulus of an intermediate post, about an axis at right angles to the line of the parapet, shall be not less than $\frac{1}{8}$ of that in the transverse direction.

(ii) The longitudinal strength of an end post shall be equal to its transverse strength, unless it is connected to a safety fence, as described in Clause 201(a)(vi), when its longitudinal strength may be equal to that of an intermediate post.

(h) STRENGTH AND DESCRIPTION OF POST FIXINGS

(i) The base of the post shall be secured by means of a base plate and holding down bolts. The bolts should either screw into sockets contained within the supporting concrete or be capped with domed nuts.

(ii) The holding down moment of the post fixing, in both directions must exceed the appropriate fully plastic moment of the post by at least 50%

(iii) Under these conditions the stress in the holding down bolts, based on the net area at the bottom of threads; shall not exceed the minimum guaranteed yield stress of the bolt material.

(iv) The maximum stress in the supporting concrete shall not exceed two thirds of the 28 day cubic strength.

(j) FIXING LONGITUDINAL MEMBERS TO SUPPORTING POSTS

The fixing of the longitudinal members to their supporting posts shall develop not less than the longitudinal strength requirement of the post.

TABLE II STRENGTH CRITERIA FOR METAL MEMBERS & SUPPORTING POSTS

PARAPET GROUP	LONGITUDINAL MEMBERS	SUPPORTING POSTS
	Product of plastic modulus and yield stress. (Ton in) (See Clause 106(d))	Transverse force F (Tons)) to be applied. (See Clause 106(f))
P.1	$\frac{5L}{6n}$	5
P.2	$\frac{2.5L}{6n}$	2.5
P.3	$\frac{1.7L}{6n}$	1.7

Notes:-

(i) "L" equals the distance between centre line of supports, in inches.

(ii) "n" is the number of effective longitudinal members.

(iii) A plinth which complies with Clause 107(c)(iv) may be considered as one effective longitudinal member.

(iv) In the forms of parapet described in Figs. 1 and 3 of the Appendix, no metal longitudinal member whose centre line is at a height of less than 12" above the adjoining paved surface, shall be regarded as an effective member.

(v) In the form of parapet described in Fig.4 of the Appendix, the upper and lower longitudinal members shall both be regarded as being equally effective, although the centre line of the lower member, in this case, is less than 12" above the adjoining paved surface.

(vi) For pedestrian parapets (Group P.4), and parapets on bridges over railways (Group P.5), see Clauses 204 and 205.

107. PROPERTIES OF REINFORCED CONCRETE PARAPETS AND PLINTHS

(a) MINIMUM CONCRETE STRENGTH

The concrete shall have a minimum 28 day works cube strength of 4,500 lb/sq in.

(b) DESIGN REQUIREMENTS FOR REINFORCED CONCRETE PARAPET WALLS

The strength and other design requirements for reinforced concrete parapets are as shewn in Table III.

When a parapet consists of precast reinforced concrete panels, the minimum length of each panel shall be 4'0".

TABLE III STRENGTH OF REINFORCED CONCRETE PARAPETS

ITEM NO.	REQUIREMENT	PARAPET GROUP		
		P.1	P.2	P.3
1	Minimum ultimate moment of resistance, at base of wall, for bending in the vertical plane, with reinforcement adjacent to the traffic face. (See Note 1)	30 Ton in/ft	15 Ton in/ft	10 Ton in/ft
2	Minimum ultimate moment of resistance for bending in the horizontal plane, with reinforcement adjacent to outer face (See Note 1)	15 Ton in/ft	7.5 Ton in/ft	5 Ton in/ft
3	Minimum ultimate fixing moment of anchorage at the base of a precast reinforced concrete panel.	45 Ton in/ft	22.5 Ton in/ft	15 Ton in/ft
4	Minimum transverse shear load to be transferred at vertical joints between precast panels, or at vertical joints made between lengths of in-situ parapet.	2 Tons per foot of joint	1 Ton per foot of joint	$\frac{2}{3}$ Ton per foot of joint
5	Minimum thickness of R.C. Wall (See Note 2) at top at base	4" 7"	4" 6"	4" 5"

Note 1. In items 1 and 2 above, distribution steel shall be provided where necessary.

2. The minimum cover to all steel shall be $1\frac{1}{2}$".

3. For Group P.4 pedestrian parapets, and Group P.5 parapets for bridges over railways, see Clauses 204 and 205.

(c) DESIGN REQUIREMENTS FOR REINFORCED CONCRETE PLINTHS

(i) HEIGHT

A reinforced concrete plinth, whose height shall be at least 1" above the adjoining paved surface, shall always be provided under a metal parapet.

(ii) FORM

The bottom edge of a reinforced concrete plinth shall lie in the plane of the traffic face of a parapet. The front face of the plinth should preferably lie in this plane, but may be inclined, at not more than 1 in 12 away from the traffic, provided that no part of the face of the plinth shall depart more than 1" from the traffic face of the parapet.

(iii) STRENGTH

The strength of the plinth shall be sufficient to withstand the moment and shear developed by the fixing of the parapet posts. (See Clause 106(h)).

(iv) PLINTH AS AN EFFECTIVE LONGITUDINAL MEMBER

A plinth may be considered as an effective longitudinal member provided its height is at least 12" above the adjoining paved surface, and that it can support a horizontal transverse force of $\frac{F}{n}$ tons applied to its top edge, in addition to the forces induced by the posts. ("F" being the appropriate force given in Table II, and "n" the number of effective longitudinal members).

(v) PRECAST SECTIONS

Where a plinth is built of precast concrete sections, they shall be not less than 4'0" long. The fixing moment of the plinth to the deck shall be not less than the holding down moment of the post fixing, plus $1\frac{1}{2}$ times the moment induced by $\frac{F}{n}$ where appropriate. (See sub para. (iv) above and Clause 106(h)(i)).

When a precast concrete plinth acts as an effective longitudinal member, the vertical joints shall be provided with shear keys or dowels which will transfer the appropriate load given in item 4 of Table III.

PART II
SPECIFIC REQUIREMENTS FOR EACH GROUP OF PARAPETS

201. GROUP P.1 VEHICLE PARAPETS, FOR MOTORWAY UNDERBRIDGES

(a) GENERAL

(i) Group P.1 parapets need not be provided at culverts and cattle creeps. Where the omission of the vehicle parapet would cause a hazard for men maintaining the road, (e.g. where the level of the top of the culvert is near road formation level) a light parapet shall be provided for their protection.

(ii) Safety fences on the motorway approaches to culverts and cattle creeps shall be continued over the structure.

(iii) The traffic face of a vehicle parapet shall normally be 2 ft. behind a hard shoulder. The clearance to be provided in cases where a hard shoulder is less than the standard width will need to be considered on its merits.

(iv) On divided structures the traffic face of the off side vehicle parapet where provided, shall be not less than 3 ft. behind the marginal strip. (See Clause 102(ii)).

(v) Where it is desirable to prevent vehicles from standing with their wheels close to the vehicle parapet, (e.g. where edge loading would be critical), a 3" vertical or half-battered kerb may be provided behind the hard shoulder. The "adjoining paved surface" between the hard shoulder and the vehicle parapet shall fall towards the top of the kerb. At the ends of the bridge the kerb shall slope down gradually to the level of the hard shoulders on the bridge approaches.

(vi) To prevent direct impact between a vehicle and the end of the vehicle parapet facing the traffic on the nearside, a safety fence shall be provided on each approach towards the bridge.

The safety fence shall be at least 100 ft. long and shall continue the line of the traffic face of the parapet.

The transition from a highway safety fence to a stiffer vehicle parapet shall be made by progressively reducing the spacing of the supporting posts to half their normal spacing.

The end of the safety fence facing the traffic shall be sloped down and secured to a buried anchorage.

At the end adjacent to the bridge, the safety fence should normally be made continuous with the vehicle parapet by a joint which develops not less than the longitudinal strength of the end post. (See Clause 106(g)(ii))

When the safety fence is not connected to the parapet, it should be arranged to overlap the end of the parapet by not less than 12 inches on the traffic side.

(vii) Where a vehicle parapet is required on the off side adjacent to the fast lane, it shall be protected by a safety fence similar to that described in (vi) above, except that:-

The fence shall be inclined to the line of the road at approximately 1 in 20, but the end of the fence shall not be further from the edge of the carriageway than half the width of the central reservation.

Where there is a risk of the back of the fence being struck by a vehicle leaving the opposing carriageway, the fence shall have a rail on each side of the posts.

(b) FORM

(i) A Group P.1 parapet may consist of a reinforced concrete wall, or precast reinforced concrete panels, as described in Clause 107.

(ii) Alternatively it may consist of at least two effective longitudinal members constructed in accordance with the appropriate provisions of Part I, clauses 106 and 107, and the limiting dimensions given in sub-clause (c) below.

(c) DIMENSIONS OF P.1 PARAPETS CONSISTING OF AT LEAST TWO EFFECTIVE LONGITUDINAL MEMBERS (See Appendix Figs. 1 and 2)

(i) The minimum depth of each longitudinal member, as the depth of its projection on to a vertical plane, shall be 2 in, and the clear gap between longitudinal members shall be not more than 12 in. Sufficient clearance shall be provided around metal members to allow for maintenance.

(ii) Except where a plinth 21" or more in height above the adjoining paved surface is provided, this form of parapet shall have a "main longitudinal member". See Definition, Clause 101(g).

(iii) The front face of a supporting post at its base shall be not less than 6" behind the traffic face of the parapet. This shall apply at whatever height the base may be. The front faces of effective metal longitudinal members should preferably be in the plane of the traffic face and, in no case, may depart from it by more than 1". Below the main longitudinal member, the departure may be only away from the traffic.

For the front face of the reinforced concrete plinth, see Clause 107(c)(ii).

(iv) No longitudinal member, other than the plinth, shall have its centre line at a height of less than 12 in. above the adjoining paved surface.

(v) Supporting posts may be straight or curved, vertical or inclined. When inclined, they shall slope towards the traffic.

202. GROUP P.2 VEHICLE PEDESTRIAN PARAPETS FOR MOTORWAY OVERBRIDGES

(a) GENERAL

(i) Highway bridges (other than those carrying motorways) and accommodation bridges over motorways shall be provided with Group P.2 "Vehicle Pedestrian" parapets. Where the bridge carries a road whose design speed is 70 m.p.h., the strength requirements shall conform with those for Group P.1 parapets.

(ii) When the overbridge carries hard shoulders, the traffic face of the parapet shall be not less than 2 ft outside the edge of the hard shoulder. When it is desirable to prevent vehicles from standing with their wheels close to the parapet, (e.g. where edge loading would be critical), vertical or half-battered kerbs 3" high may be provided at the outside edge of the hard shoulder. The "adjoining paved surface" between the hard shoulder and the traffic face of the parapet shall fall towards the top of the kerb. At the ends of the bridge, if the hard shoulders are not of full width, these

kerbs shall be splayed outwards gradually to meet the back edges of the hard shoulders on the bridge approaches.

(iii) When the overbridge approaches are not provided with hard shoulders, the traffic faces of the vehicle pedestrian parapets shall not encroach on the minimum width required for the paved verges or footways on the bridge. Vertical or half-battered kerbs, not less than 3" high shall be provided over the bridge deck immediately behind the carriageway or marginal strip. Where necessary these kerbs shall be sloped down gradually at the ends of the bridge to the level of the kerbs, if any, or to the level of the carriageway on the bridge approaches.

(iv) On divided structures the traffic face of the offside vehicle pedestrian parapet, where provided, shall be not less than 4 ft from the carriageway. This dimension includes the width of the marginal strip where one is provided. (See clause 102(ii)).

(v) To prevent vehicles on the bridge approaches from falling or running down onto the motorway below, or from striking the end of a vehicle pedestrian parapet, safety fences shall be provided as for Group P.1 parapets.

(b) FORM

A Group P.2. parapet may consist of:-

(i) A reinforced concrete wall, or precast reinforced concrete panels.

(ii) At least two effective longitudinal members constructed in accordance with the appropriate provisions of Part I, Clauses 106 and 107, and the limiting dimensions given in Clause (c) below.

Mesh panels shall be mounted on, or flush with the traffic face of the longitudinal members.

(iii) Closely spaced vertical members, secured top and bottom to effective longitudinal members, mounted on the traffic side of the supporting posts. (For effective members, in this case, see Note (v) to Table II).

(c) DIMENSIONS

(i) REINFORCED CONCRETE PARAPETS

The factors governing the dimensions of reinforced concrete parapets are given in Part I, Clause 107 and Table III.

(ii) PARAPETS WITH LONGITUDINAL MEMBERS AND MESH INFILLING (See Appendix, Fig.3)

The minimum overall depth of each longitudinal member, measured as the depth of its projection on to a vertical plane, shall be 2 in. and the clear gap between longitudinal members shall be not more than 16 in. Sufficient clearance shall be allowed around metal members to allow for maintenance.

Except where a plinth, 21 in. or more in height above the paved surface, is provided, this form of parapet shall have a "main longitudinal member", see definition, Clause 101(g).

The front face of a supporting post at its base shall be not less than 4" behind the traffic face of the parapet. This shall apply at whatever height the base may be.

The front faces of all metal longitudinal members shall be in the plane of the traffic face of the parapet.

For the front face of the reinforced concrete plinth, see Clause 107(c)(ii).

The supporting posts may be straight or curved, vertical or inclined. When inclined they shall slope towards the traffic.

The mesh panels shall be fixed on or flush with the front face of the longitudinal members and the gaps in the mesh shall be contained within a parallelogram having a perimeter not greater than 8".

Due regard shall be paid to the problem of maintenance.

(iii) METAL PARAPETS WITH TWO LONGITUDINAL MEMBERS AND CLOSELY SPACED VERTICAL MEMBERS (See Appendix Fig.4)

The front face of a supporting post, at its base, shall be not less than 4" behind the traffic face of the parapet which, in this case, shall be the vertical plane through the front faces of the two effective metal longitudinal members and the bottom edge of the plinth.

The height of the plinth above the adjoining paved surface shall lie between the limits of 1 inch and 4 inches. In other respects, the plinth shall comply with the requirements of Clause 107(c) where applicable.

The minimum overall depth of the projection of each longitudinal member on a vertical plane shall be not less than 2 inches.

Sufficient clearance shall be allowed around metal members to allow for maintenance.

The vertical members forming the in-filling in this form of parapet shall be either solid bars of square or circular section, having a minimum sectional area of $\frac{3}{4}$ sq in. in mild steel to B.S. 15, or other sections of equivalent strength in steel or other metals. Each end connection shall develop at least half the strength of the bar in bending and the strength of the bar in shear.

The clear space between adjacent vertical members shall not exceed 4 in.

The front face of the vertical in-fill members shall be not more than 2 in. behind the traffic face of the parapet.

203. GROUP P.3 VEHICLE PEDESTRIAN PARAPETS FOR BRIDGES CARRYING ALL-PURPOSE ROADS

(a) GENERAL

(i) Highway bridges (and accommodation bridges) which do not carry a motorway, or a road over a motorway or railway, shall be provided with P.3 parapets.

(ii) The traffic face of the parapet shall not encroach on the minimum width required for the verge or footway on the bridge.

(iii) Where footways are provided over a bridge no additional kerbing is required. Where there is no footway, a vertical or half-battered kerb, not less than 3" high, shall be provided not less than 2 ft. from the traffic face of the parapet. At the ends of the bridge the kerbs shall be sloped down gradually to the level of the carriageway or kerbs on the bridge approaches.

(b) FORM AND DIMENSIONS

(i) Although of lesser strength, the form and dimensions of a P.3 parapet should normally conform with those specified for Group P.2 parapets. (See Clause 202). Exceptionally, other types of parapet of equivalent strength may be considered.

(ii) When vertical members are used to form the in-filling, their strength shall be that required for a P.2 parapet. (See Clause 202(c)(iii)).

204. GROUP P.4 PEDESTRIAN PARAPETS FOR FOOTBRIDGES, OTHER THAN FOOTBRIDGES OVER RAILWAYS

(a) GENERAL

Footbridges (other than footbridges over railways), shall be provided with P.4 Pedestrian parapets. For footbridges over railways, see Clause 205.

(b) CONSTRUCTION

Group P.4 parapets shall be designed for the loading specified in Table I, and shall comply with the appropriate provisions of Part I of this Memorandum.

205. GROUP P.5 PARAPETS OVER RAILWAYS

(a) GENERAL

(i) The statutory requirements for parapets on bridges over railways have been incorporated, where necessary, in the text of this clause.

(ii) Where no effective alternative arrangements exist to prevent a vehicle from leaving the bridge approach and falling onto the railway below, a safety fence shall be provided on each approach towards the bridge, as in the cases of Group P.1 and P.2 parapets.

(b) HEIGHT

(i) On bridges over railways having overhead electrification, the minimum height of a parapet above the adjoining paved surface shall be:-

For bridges carrying motorways from which pedestrians, animals, pedal cycles and vehicles drawn by animals are excluded by Order .....4'0"

For all other bridges .....5'0"

(ii) On all bridges over non-electrified lines, and lines electrified by other than an overhead system, the minimum height of a parapet above the adjoining paved surface shall be:- .....4'0"

(c) FORM OF CONSTRUCTION

(i) MOTORWAY OVER A RAILWAY

On bridges carrying a motorway over a railway, vehicle parapets shall be provided which comply with all the requirements for a P.1 parapet, as described in Parts I and II of this Memorandum, subject to Clause 205(b) and to the following:-

Where a parapet plinth is surmounted by metal posts and horizontal rails, the bottom 2 ft. shall be constructed so as to prevent stones from being projected onto the railway by passing vehicles.

If the top of the plinth is less than 2'0" above the adjoining paved surface, firmly supported panels of sheet metal or strong, close mesh as described below shall be provided immediately above the top of the plinth, up to a height of not less than 2 ft. above the adjoining paved surface.

The mesh shall be made of round wire, not less than $^{3}/_{16}$" diameter, and the openings in the mesh shall be $\frac{1}{2}$" x $\frac{1}{2}$" square. If made of steel, it is recommended that the mesh panels and their surrounds be heavily galvanised and suitably painted to keep maintenance to a minimum.

Since pedestrians are excluded, footholds on the traffic side are not objectionable. The panels should therefore be fixed behind the horizontal members, where they are less liable to become entangled with an errant vehicle.

(ii) ALL-PURPOSE ROAD OVER RAILWAY

When the road is an all-purpose road, (of whatever class the road may be), vehicle pedestrian parapets shall be provided which comply with all the requirements for a P.2 parapet, as described in Parts I and II of this Memorandum, subject to Clause 205(b) and to the following:-

Except when the parapet is constructed entirely in reinforced concrete (which is preferred in the case of railways with existing or proposed overhead electrification), the area between the top of the plinth and the bottom of the top rail shall be completely filled with firmly supported panels of sheet metal or strong, close mesh as described in Clause 205(c)(i), and so arranged that no footholds and no projections are provided on the traffic side.

(iii) FOOTBRIDGE OVER RAILWAY

Footbridges over a railway shall be provided with pedestrian parapets which comply with the requirements of a P.4. parapet as described in Parts I and II of this memorandum. The parapets must be so arranged that no footholds or projections are provided on the inside face and, if made of steel, it is recommended that all metal parts be heavily galvanised after fabrication.

The parapets shall also comply with the following particular requirements:-

Over railways with existing or proposed overhead electrification footbridge parapets should be of the closed type, but where the footbridge itself consists of an open framework, any openings up to a height of 5 ft. above the surface of the bridge deck shall be

completely filled, preferably with firmly supported sheet metal panels. Alternatively, panels of strong close mesh as described in Clause 205 (c) (i) may be used.

When the railway is not electrified, or is electrified on the 3rd or 4th rail system, any open spaces in the parapet up to a height of 4 ft. above the surface of the deck must be filled either as in the preceding paragraph, or with firmly supported panels of flattened expanded metal mesh not less than 1/32" thick and having openings not exceeding 1¾" x ¾". The weight of the mesh shall be not less than 1.60 lb/sq. ft. if in steel, and not less than 0.58 lb/sq. ft. if in aluminium.

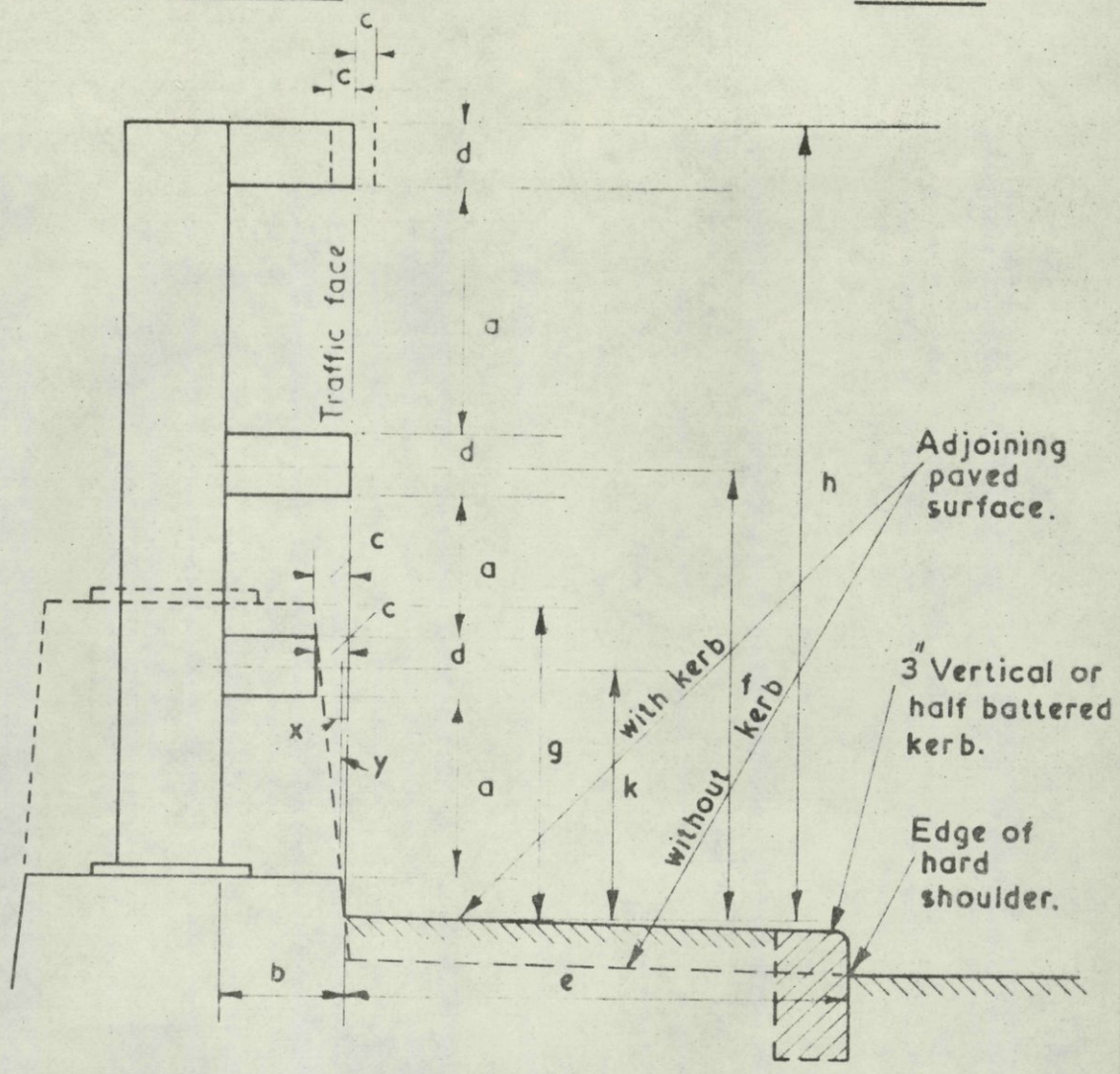
BRIDGES CARRYING A MOTORWAY.

(MOTORWAY UNDERBRIDGES.)

APPENDIX.

FIG. 1.

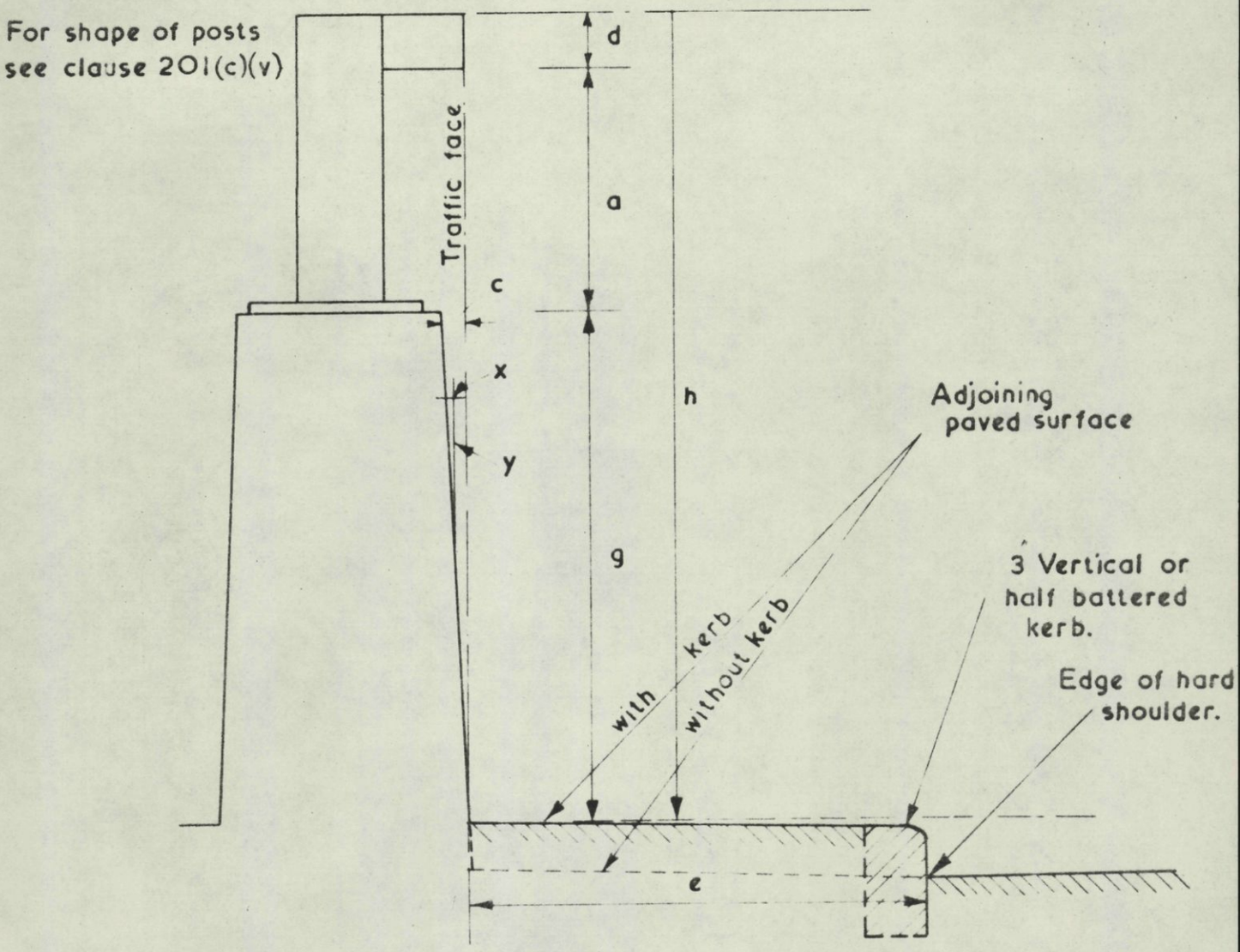
For shape of posts see clause 201(c)(v)



DIMENSION	DESCRIPTION	MAX	MIN
a.	Clear distance between longitudinal members, or between top of plinth and the longitudinal member above. The dimension is not necessarily constant within the barrier.	12"	See Clause 201(c)(i)
b.	The distance between the traffic face of the parapet and the front face of supporting post at its base, at whatever height the base may be.	-	6"
c.	Distance between the front face of a metal longitudinal member, or the top edge of a plinth, and the traffic face of the parapet:-		
	(i) Above the main longitudinal member	±1"	-
	(ii) Below the main longitudinal member (+ = towards the traffic. - = away from traffic)	-1" +0"	-
d.	The overall **depth** of a longitudinal member	-	2"
e.	The distance between edge of hard shoulder and traffic face of parapet.		24"
f.	The height of the centre line of the "Main" longitudinal member above the adjoining paved surface.	27"	21"
g.	Height of plinth, for which this diagram applies, above the adjoining paved surface.	21"	1"
h.	Height of top of upper longitudinal member above the adjoining paved surface. Note. For bridges over railways the height shall be as in Clause 205(b)	-	39"
k.	Height of the centre line of the lowest longitudinal member, other than the plinth, **above the adjoining paved surface.**	to comply with a	12"
x. y	Batter on front face of plinth, subject to limit imposed by "c" above.	1/12	0

DIMENSIONS OF 'P.I.' VEHICLE PARAPET WHERE HEIGHT OF PLINTH IS LESS THAN 21 INCHES.

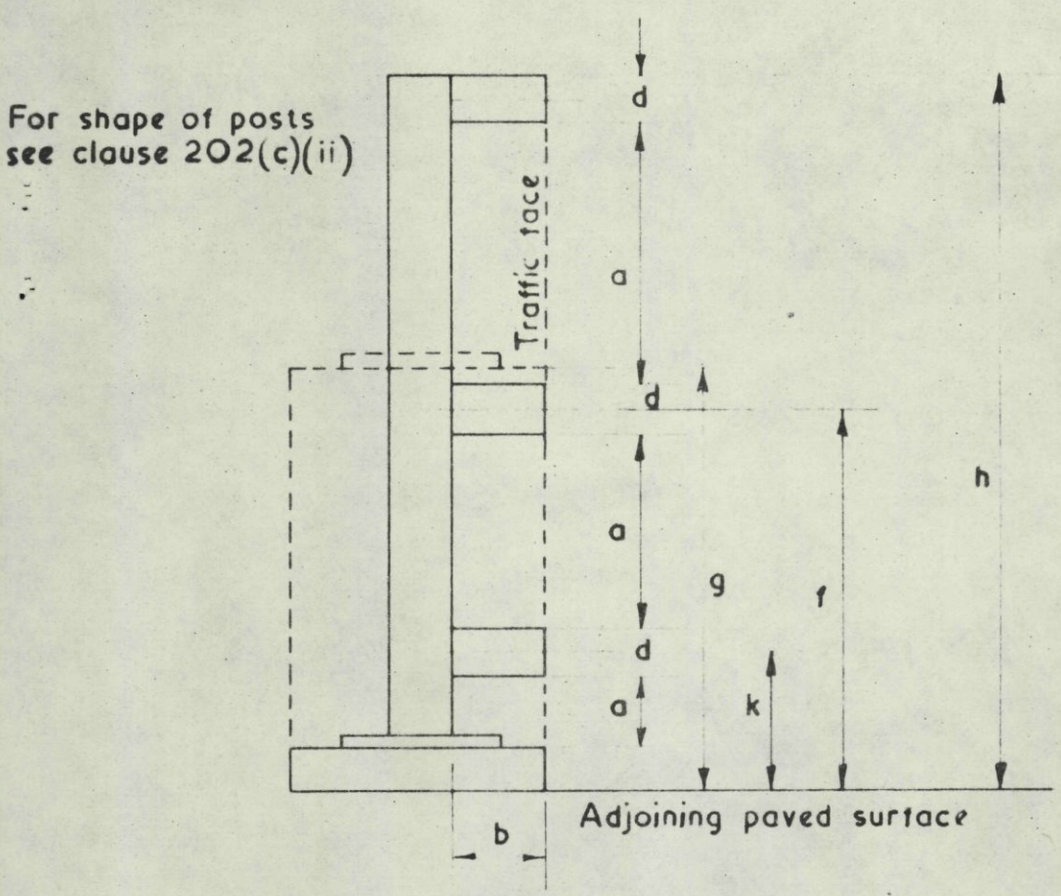
Diagrammatic sketch. not to scale.



Dimension	Description	Max.	Min.
a	Clear distance between longitudinal members or between top of plinth and longitudinal member above. The dimension is not necessarily constant within the barrier.	12"	See Clause 201(C)(i)
b	The distance between the traffic face of the parapet and the front face of the supporting post at its base, at whatever height the base may be.	-	6"
c	Distance of top edge of plinth, or front face of metal longitudinal member, behind traffic face.	1"	0
d	The overall **depth** of a longitudinal member.	-	2"
e	The distance between the edge of the hard shoulder and the base of the plinth	-	24"
g	Height of plinth above adjoining paved surface for which this diagram applies.	-	21"
h	Height of top of upper longitudinal member above adjoining paved surface. Note for bridges over railway the height shall be as in Clause 205(b)		
$\frac{x}{y}$	Batter on plinth (see also 'c' above.)	$\frac{1}{12}$	0

DIMENSIONS OF 'P.I.' VEHICLE PARAPET WHERE HEIGHT OF PLINTH IS 21 INCHES OR MORE.

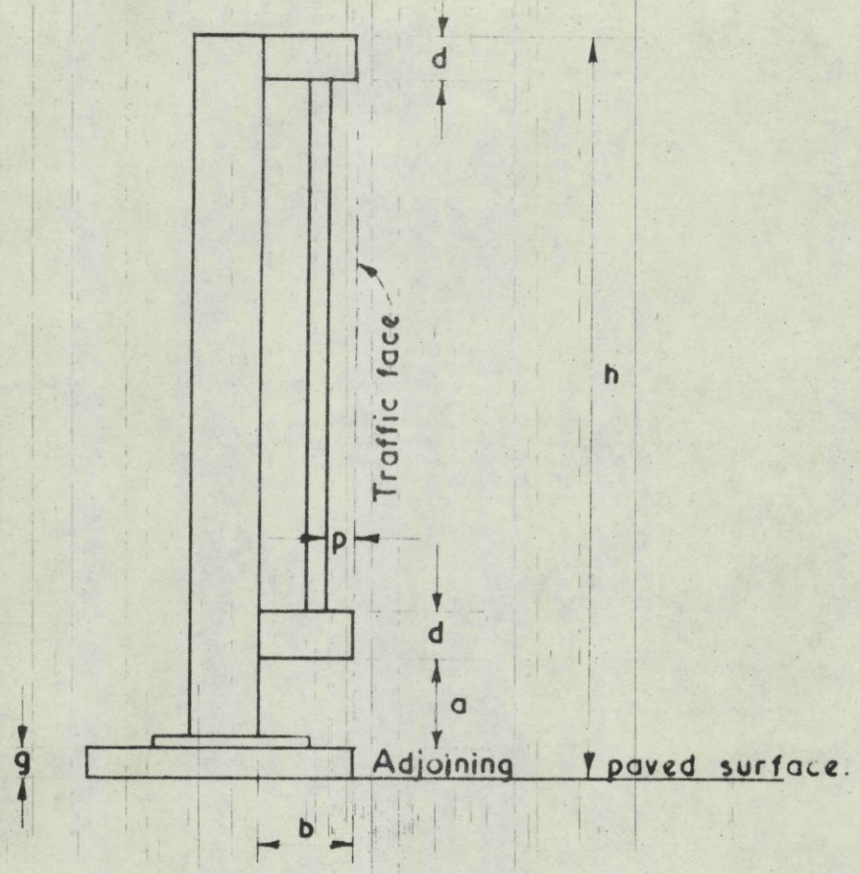
Diagrammatic sketch. Not to scale.



Dimension	Description	Max.	Min.
a	Clear distance between longitudinal members or between top of plinth and longitudinal member above.	16"	See Clause 202(c)(ii)
b	The distance between the traffic face of the parapet and the front face of a supporting post at its base, at whatever height the base may be.	-	4"
d	Overall depth of longitudinal member	-	2"
f	Height of the centre line of the main member above the adjoining paved surface	27"	21"
g	Height of the plinth above the adjoining paved surface	-	1"
h	Height of top of upper longitudinal member above the adjoing paved surface.	-	39"
k	Height of the centre line of the lowest effective member	to comply with "a"	12"

DIMENSIONS OF "P.2." VEHICLE PEDESTRIAN PARAPET.

Diagrammatic sketch. not to scale.

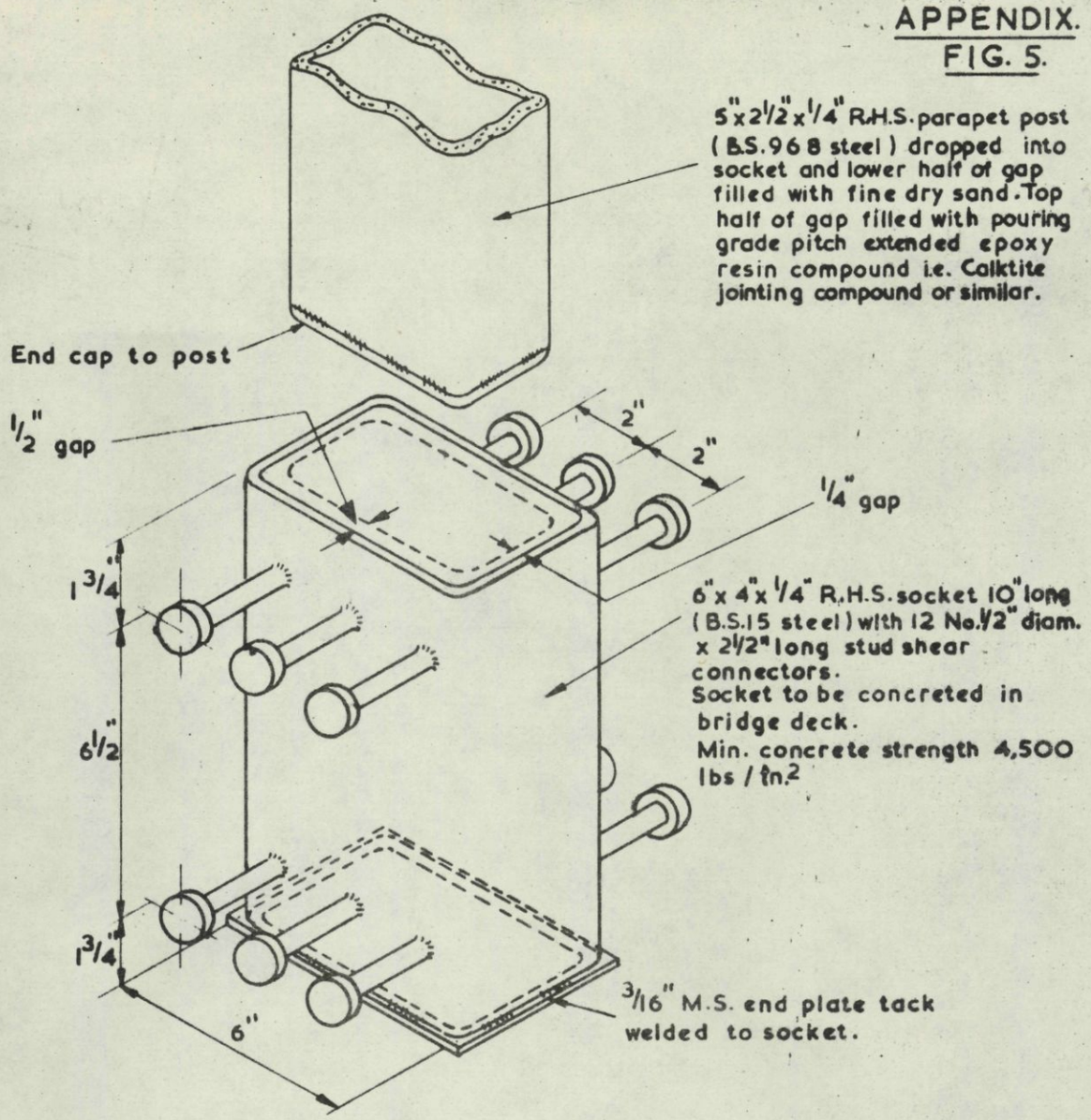


Dimension	Description	Max.	Min.
a.	Clear distance between top of plinth and lower longitudinal member.	4"	See Clause 202(c)(iii)
b.	The distance between the traffic face of the parapet and the front face of the supporting post at its base, at whatever height the base may be.	-	4"
d.	Overall depth of a longitudinal member	-	2"
g.	Height of plinth above the adjoining paved surface	4"	1"
h.	Height of top of upper longitudinal member above the adjoining paved surface.	-	39"
p.	Distance between front faces of the vertical in-fill members and longitudinal members.	2"	0"

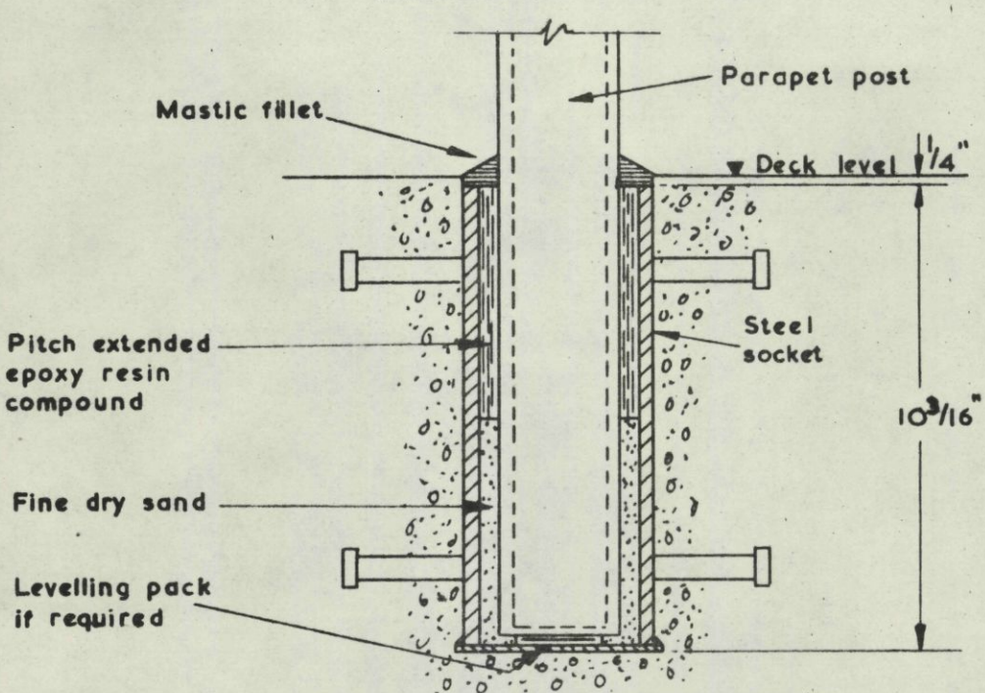
DIMENSIONS OF "P.2" VEHICLE PEDESTRIAN PARAPET.

Diagrammatic sketch. not to scale.

APPENDIX.
FIG. 5.



DETAILS OF SOCKET



SECTION THROUGH SOCKET
AS CAST IN BRIDGE DECK

METHOD OF REPLACEMENT

1. Damaged post burnt off at deck level.
2. Inside of post stub heated with cutting torch to decompose jointing compound.
3. Stub extracted and socket cleaned out.
4. New post reset in jointing compound.

PARAPET POST FIXING FOR TYPE P.I. PARAPET

TECHNICAL MEMORANDUM (BRIDGES) NO. BE 5

THE DESIGN OF HIGHWAY BRIDGE PARAPETS

Amendment List No. 3

(Amendment Lists Nos. 1 and 2 were incorporated in the June 1967 edition of the Memorandum.)

1. AMENDMENTS

(a) In sub-clause 106(e) before "not less than 75%" insert: "with the following exception".

(b) To the end of sub-clause 106(e) add: "Where the allowable movement is 2 inches or more "end posts" complying with sub-clause 106(g)(ii) are to be provided on either side of the expansion joint. The joint in the longitudinal members between these posts need not be designed to transmit tension."

(c) Delete sub-clause 106(h) and substitute the following:

(h) STRENGTH AND DESCRIPTION OF POST FIXINGS

(i) The fixing of the post to the bridge deck shall be either by means of a socket fixing such as that developed by Bridges Engineering and indicated in Appendix Fig. 5, or by means of a baseplate and holding-down bolts. In either case, the fixing shall be capable of developing a moment of resistance about either axis, calculated in accordance with paragraphs (ii) and (iii) below, at least 50% greater than the appropriate maximum fully plastic moment of the post.

(ii) The design moment of resistance of a socket fixing shall be taken as the sum of the moment developed in bearing by the sides of the socket and the moment developed by shear connectors. The design load of shear connectors shall not exceed the ultimate capacity given in Table 2 of CP 117: Part 2. The bearing stress in the concrete shall be assumed to vary linearly over the depth of the post in the socket and shall not exceed two thirds of the twenty-eight day cube strength.

After the post has been positioned the top of the socket shall be sealed with a mastic fillet which will prevent the ingress of water.

(iii) The attachment of a post to a baseplate shall be as strong as the post in bending and shear.

The stress in the attachment of the baseplate to the deck shall be calculated elastically.

The calculated stress in holding-down bolts, based on the net cross-sectional area at the root of the thread, shall not exceed the minimum guaranteed yield stress of the bolt material and the bearing stress in the concrete shall not exceed two thirds of the twenty-eight day cube strength.

The supporting concrete must be additionally reinforced against the bursting associated with any internal forces e.g. those generated by expanding anchorages.

Holding-down bolts should either screw into sockets contained within the supporting concrete or be capped with domed nuts.

(d) Add Appendix Fig. 5 enclosed.

2. EXPLANATORY NOTES

(a) Amendment 1 (a and b)

Joints in longitudinal members designed to accommodate expansion movement can only transmit tension when they come to the end of their travel. It is therefore necessary to decide the amount of travel which is acceptable and to make alternative provision for developing tensile force in longitudinal members when this amount is exceeded.

(b) Amendment 1(c)

The Ministry, up to the present, has been opposed to the setting of parapet posts into concrete, because of the difficulties of removing them if they were damaged, and for preventing a corrosion ring forming at the point of entry of the posts into the concrete. With the development of new materials, further consideration has been given to the problem by the Bridges Engineering Division of the Ministry, which has developed and tested the method shown in the attached Appendix Fig. 5. The detail shown has proved satisfactory for the post of a P.1 parapet and may be adapted as required to take account of different horizontal forces.

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30 April 1968

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