THE HIGHWAYS AGENCY BA 37/92

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF THE ENVIRONMENT
FOR NORTHERN IRELAND

Priority Ranking of Existing Parapets

Summary: This Advice Note gives criteria for establishing priority rankings for the upgrading of existing parapets on all motorway and other trunk road structures.

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REGISTRATION OF AMENDMENTS

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VOLUME 2 HIGHWAY STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES), MATERIALS

SECTION 3 MATERIALS AND COMPONENTS

PART 2

BA 37/92

PRIORITY RANKING OF EXISTING PARAPETS

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1. INTRODUCTION

1.1. The existing stock of structures on motorways and other trunk roads exhibits a large variety of parapet types; many of these are not adequate to cope with the needs of present traffic as expressed in the current criteria for the design of new bridge parapets, BE 5 (DMRB 2.2) (currently being updated as BD 52/92). As part of the Overseeing Department's programme for the rehabilitation of trunk road structures it is intended that the parapets on existing structures should, where necessary, be brought up to the current design standard on a priority basis with the highest risk sites being tackled first.

1.2. Since it is proposed that all structures in the trunk road system should have a parapet priority ranking assigned to them, the method of establishing that ranking must be reasonably simple to apply, avoiding the need for an elaborate analysis and calculation for each and every structure. At the same time, the method must be sufficiently clear and objective to ensure a reasonable consistency of ranking when used by different assessing engineers.

Scope

1.3. This Advice Note gives criteria for establishing the priority ranking of parapets. It should be applied to all structures including retaining walls in the trunk road stock, taking account of their age, condition and situation. It gives priorities for action to upgrade parapets, regardless of the degree of difficulty of undertaking the upgrading. These difficulties are not discussed in detail here, but must be assessed individually for each structure. It is important that the work of upgrading substandard parapets is co-ordinated with other work so as to minimize costs and disruption to traffic and this may lead to adjustments in programming the upgrading work. These traffic management aspects are not discussed in this Advice Note.

Implementation

1.4 This Advice Note should be used to establish the priority ranking of all existing parapets on trunk road structures. Completion of this ranking should be within a timescale agreed with the Overseeing Department. Advice given in Chapter 7 - 'Remedial Work on Substandard Parapets' - should be referred to when undertaking parapet upgrading.

2. HISTORICAL SURVEY OF PARAPET TYPES

2.1. Parapets can be classified fundamentally into those which were built before the advent of design criteria based on containment in 1967, and those which have been built since that date.

2.2. Pre-1967 parapets include a large number of masonry and brick parapets, generally associated with masonry arch bridges. These rely principally on their mass to keep the stresses in the mortar layers compressive under light to moderate impact loadings. They cannot be relied on to contain heavier vehicles travelling at speed, and secondary incidents may be initiated by falling debris. Masonry parapets can be upgraded by providing a reinforced concrete stem which may be integral with a horizontal slab spanning all or part of the way transversely across the bridge. Such reinforced concrete parapets may be clad with masonry or brick slips to retain their original appearance. Where masonry and brick parapets are provided on older types of bridges other than masonry arch structures, the problems of upgrading them may be more akin to those described below.

2.3. Pre-1967 bridges, other than those arches dealt with above, may have a variety of parapet types, including wrought iron, cast iron, steel, timber, masonry, in situ and precast concrete. The superstructures of these bridges may not have sufficient capacity to transmit the impact forces from parapets of modern containment standards, and, unlike arch bridges, may not have sufficient reserves of dead load capacity to allow additional strengthening members to be added to the structure; partial rebuilding of the structure may therefore be required. The metal parapets usually have little mass compared to masonry parapets, and may be in a deteriorated condition. In such conditions, even minor impacts may lead to penetration. Furthermore, substandard parapets of this type may be provided on relatively modern road schemes on heavily used routes and will attract high rankings in the risk evaluation. However some of the parapets on bridges built before 1967 have already been provided with additional protection often in the form of safety fences, and, when the safety fence conforms to current standards, such provision will justify allotting a lower priority in lists for further remedial action.

2.4. Parapets built since 1967 are not necessarily satisfactory in terms of containment and some will need to be strengthened. The reasons for this include:-

i. parapets incorrectly designed or constructed, eg some early parapets were detailed without proper continuity in the longitudinal members;

ii. parapets designed to lower containment criteria where higher containment is now required;

iii. parapets which have deteriorated; this includes steel members which have corroded (check internal condition of hollow members) and parapet fixings both of which in some cases have lost virtually all their design capacity;

iv. parapets with other material problems, including possible embrittlement in certain earlier aluminium parapet types;

v. parapets which have been damaged and have not been satisfactorily repaired.

3. FACTORS AFFECTING PRIORITY

3.1. It is clear that several factors play an important part in establishing priority ratings for action to upgrade parapets. Among the most important of these are:

i. the nature of the risk associated with the bridge in question which may be sub-divided into the following hazard groups:-

   a. Features below or adjacent to the structure.

   b. Type of highway carried by the structure.

   c. The road geometry and structure layout.

   d. Containment features.

ii. the degree of shortfall in the containment capacity of the parapet.

4. RISK EVALUATION

4.1. The degree of risk in terms of the number of people likely to be involved in any secondary accident is affected by certain aspects of the location and purpose of a bridge. When the bridge crosses a busy road, a railway line, or certain other sensitive features, the degree of risk will plainly be greater than if it crosses, say, a minor water course. Even if the bridge is a major high level estuarine crossing, the degree of risk will be relatively low if the risks are confined to the occupants of the penetrating vehicle. For bridges over roads the degree of risk tends to increase in proportion to the volume of traffic on the carriageways below.

4.2. The risk to the traffic on the bridge in the event of full or partial penetration of the parapet is more difficult to define and the rankings given in Annex A have therefore been limited to broad categories of highways.

4.3. The road alignments and clearances on older routes may be substandard in terms of vertical and/or horizontal alignment and this will increase the possibility of parapet collision incidents although the accident record of the site may be quite good.

Clearly a site with a poor accident record, for any reason, will attract a high ranking.

4.4. Certain aspects of the method of providing containment need to be allowed for. In particular, certain through deck bridges rely on the main members to provide vehicle containment and this constitutes a high degree of hazard since a collision could lead to the collapse of the bridge itself.

On the other hand, certain structural members or substandard bridge parapets have already been protected by the installation of additional containment facilities. Where their combined containment capability is adequate, they do not need to be considered for upgrading. Where normal highway safety fences are used, consideration should be given to the clearance provided. If this clearance is less than the minimum given in TD 19/85 (DMRB 2.2) there is a risk that the fence will strike the structure or parapet during vehicle collision.

Where standard systems of safety fence or safety barrier are provided together with the necessary clearance in front of the parapet, this parapet should be excluded from the Ranking System.

Evaluation of Risk from Hazard Group Rankings

4.5. The risk ranking for each hazard group should be determined from the table given in Annex A. The overall risk ranking is to be the sum of the rankings for groups 1, 2, 3 and 4. (Values will range from 2 to 20).

4.6. Certain bridges may have more than one ranking in each group. For example, a structure may cross both a railway and a road. Bridges on older single carriageways may simultaneously be on roads of poor alignment and close to junctions and of reduced parapet clearance. However, for each structure, the worst single ranking from each of the above four groups are to be added together to arrive at an overall risk ranking.

5. CONTAINMENT EVALUATION

5.1. The weaker a parapet is in terms of its containment capacity, the higher the priority that should be assigned to it for upgrading action. However, there are problems involved in trying to assess the strength of certain existing parapets in relation to current design requirements. Although there are design values for the required strengths of new parapets, the final criterion of acceptability is based on a satisfactory performance in dynamic tests. Many existing parapets were constructed prior to the introduction of design criteria based on containment and had been individually designed without the use of dynamic tests.

5.2. In view of this situation, the strength of each parapet, including its fixings and supports, should be assessed for ranking purposes on the basis of engineering judgement, aimed at establishing three broad categories of remnant strength. Full allowance should be made for the condition of the parapet, see paras 2.4 iii, iv and v. To help in achieving a degree of uniformity in these strength assessments, occasional strength checks based principally on the resistance of the existing parapet (ie posts for post and rail parapets, cantilever strength for continuous parapets) should be carried out.

5.3. In situations where present design requirements would indicate the use of a P6 high containment parapet type, then the containment requirement for a high containment parapet will be the basis for assessing the remnant strength category of the existing parapet.

Evaluation of Containment Ranking

5.4. The containment ranking should be determined from the remnant strength of the parapet as a percentage of the current design standard requirement and is given in the table below:

	Containment Ranking
Remnant strength 0 to 33% of full design strength	5
Remnant strength 34 to 66%	3
Remnant strength 67 to 100%	1

6. PRIORITY RANKING

6.1. The priority ranking is obtained from the containment ranking (from para 5.4) multiplied by the overall risk ranking (from para 4.5).

6.2. The priority ranking will be the basis for assessing priorities for the work to upgrade parapets. Sites with high priority ranking will generally be upgraded before those with lower rankings.

7. REMEDIAL WORK ON SUBSTANDARD PARAPETS

7.1. Some of the general principles relating to the remedial work on substandard parapets are described below. Details are not covered here and are outside the scope of this Advice Note. Any remedial work required for the substandard parapets should be assessed and considered individually for each structure.

7.2. The primary function of a parapet is to provide vehicle containment together with safe redirection. However, special consideration must be given to how this can be achieved in structures which are listed or are of historic importance without destroying the character of these structures. The Overseeing Department should be consulted in these cases at an early stage.

7.3. Among the available methods of upgrading existing parapets, the following options should be kept in mind:-

i. remove old parapet and replace with a new one to current standard;

ii. strengthen existing system by provision of new components only (eg posts, rails, fixings);

iii. strengthen post and rail system by providing additional posts. This is normally achieved by addition of an extra post in the middle of the bay;

iv. provide an additional independent containment facility. This option is only viable if there is sufficient room available to allow for an installation which provides adequate set back from the carriageway edge and deflection under impact. The facility will generally be acceptable in the long term provided that the substandard parapet is adequate for pedestrian containment.

7.4. Before undertaking the strengthening of existing bridge parapets, the structure supporting the parapets must be checked to ensure that there is adequate strength for the additional loadings imposed due to the upgrading of bridge parapets. Where structures are included in the Overseeing Department's bridge assessment programme, their parapets should be assessed at the same time.

7.5. Destruction of a parapet usually takes place when impact forces are substantially in excess of the required containment level and a supporting structure is normally required to accommodate such an event without damage. In cases where the cost and inconvenience of strengthening the supporting structure are excessive (eg long viaduct), it may be economic to accept local damage to the supporting structure as a result of catastrophic failure of the parapet and to effect a repair at the same time as the parapet replacement.

8. REFERENCES

8.1. Design Manual for Roads and Bridges

Volume 2: Section 2 Special Structures

BE 5 - The Design of Highway Bridge Parapets (Fourth Revision) [and Amendment No.2] (DMRB 2.2) *(currently being updated as BD 52/92)*

TD 19/85 - Safety Fences and Barriers (DMRB 2.2)

9. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:-

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RISK RANKING

HAZARD GROUPS

GROUP (1) FEATURES BELOW OR ADJACENT TO STRUCTURE (SEE 4.1)

	Structure either crossing over or lying alongside:	Risk Ranking
a.	Motorway or AP trunk road with traffic flow over 80,000 vpd	5
b.	Motorway or AP trunk road with traffic flow 60,000 to 80,000 vpd	4
c.	Motorway or AP trunk road with traffic flow 40,000 to 60,000 vpd	3
d.	Motorway or AP trunk road with traffic flow 20,000 to 40,000 vpd	2
e.	Motorway or AP trunk road with traffic flow below 20,000 vpd	1
f.	Railway type A (see Annex B)	5
g.	Railway type B (see Annex B)	4
h.	Other areas occupied by people, valuable installation, environmentally sensitive areas such as conservation areas, storage of hazardous materials, etc	1 to 5

GROUP (2) TYPE OF HIGHWAY CARRIED BY THE STRUCTURE

	Structure carrying:	Risk Ranking
a.	Dual 4 or 3 lane motorway or all purpose trunk road	5
b.	Dual 2 lane motorway or all purpose trunk road	3
c.	Single carriageway road	1

GROUP (3) ROAD AND STRUCTURE LAYOUT (see 4.3)

		Risk Ranking
a.	Structure at a location having a poor accident record.	5
b.	Structure carrying a road at or close to junctions/interchanges.	3
c.	Structure carrying a road with inferior horizontal/vertical alignment.	1 to 4
d.	Structure having reduced clearance between carriageway and parapet.	1 to 3
e.	Structure where location or layout does not effect the risk	0

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GROUP (4) CONTAINMENT FEATURES (see 4.4)

		Risk Ranking
a.	Parapet consists, in whole or in part, of members which are also the main structural elements of the bridge.	5
b.	Parapet consists, in whole or in part, of members failure of which would not lead to loss of the bridge or a span.	3
c.	Parapet members not part of bridge structural members.	0

NOTE: Where a range of possible rankings is offered in a group, judgement is required to allocate a ranking according to the greatest severity of the hazards at each location.

HAZARDS BELOW AND ADJACENT TO STRUCTURE - RAILWAY TYPES

TYPE	DESCRIPTION
A	a. High speed railway line (over 160km/h); or b. Busy railway line (with peak intensity of more than six trains an hour each way); or c. Any railway line carrying more than six trains per week conveying more than one wagon containing any of the following hazardous substances: i. FLAMMABLE GASES (Class 2(a)) ii. TOXIC GASES (Class 2(c)) iii. ANHYDROUS HYDROGEN CYANIDE (HYDROCYANIC ACID HCN) or similar products (Class 6.1 (a)); or: d. Any railway carrying more than six "Block" trains per week conveying FLAMMABLE LIQUIDS with a flash point below 21°C (Class 3 (a)); or e. Any railway line running close alongside a road when the rail level is more than 1m below the carriageway surface.
B	Any other railway line

NOTES:

Note 1: The classifications for hazardous substances are defined in Part 3 of the Working Manual for Rail Staff and shall be agreed with the Health and Safety Executive's Railway Inspectorate.

Note 2: "Empty" wagons which have contained any of the hazardous substances mentioned in this Appendix should be regarded as "full" unless the wagon has been purged after discharging the load.

Note 3: Explosives or radioactive substances, because of the way they are transported, are not regarded as "hazardous goods" in the context of this Appendix.

Note 4: A "Block" train is one in which the complete train is made up of wagons carrying the same substance.