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

SECTION 2 **SPECIAL STRUCTURES**

PART 4

BD 51/98

PORTAL AND CANTILEVER SIGNS/ SIGNAL GANTRIES

SUMMARY

This Standard sets out criteria and considerations for use in the procurement and preparation of designs for portal and cantilever sign and/or signal gantries for use over highways. It updates and expands upon BD 51/94, which it replaces.

INSTRUCTIONS FOR USE

1. Remove BD 51/94, which is suspended by BD 51/98, and archive as appropriate.

2. Insert BD 51/98 into correct place.

3. Archive this sheet as appropriate.

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Portal and Cantilever Sign/ Signal Gantries

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PART 4

BD 51/98

PORTAL AND CANTILEVER SIGN/ SIGNAL GANTRIES

Contents

1. INTRODUCTION

General

1.1 This Standard replaces BD 51/94. It shall be used in conjunction with relevant Parts of BS 5400, as implemented by the Overseeing Organisations, except where otherwise indicated.

Implementation

1.2 This standard shall be used forthwith on all future schemes for the construction, improvement and maintenance of trunk roads including motorways. It shall also apply to schemes currently in preparation provided that, in the opinion of the Overseeing Organisation, this will not result in significant additional expense or delay progress. Design organisations shall confirm its application to particular schemes with the Overseeing Organisation.

1.3 This standard is intended for use in designing permanent and temporary structures which wholly span or are partially cantilevered over the carriageway, hard shoulder and/or hard strip for the purpose of supporting large signs and/or motorway type signals and/or message signs, such as, but not exclusively, the examples shown in Figure 1, but excluding cantilever or other traffic signal masts which should be designed in accordance with TA13/01.

Scope

1.4 This Standard specifies criteria and advice for the design of sign and signal gantries of portal and cantilever types (for use on motorways and all purpose roads), where any part of the sign or motorway signal and their supporting structure is mounted over the carriageway, central reserve, hard shoulder and/or hard strip. They may be constructed of steel, aluminium, concrete or composite metal and concrete. Other materials may also be considered in accordance with paragraph 4.3.

1.5 The selection of suitable sign and signal configurations are outside the scope of this standard.

Function of Gantries

1.6 Structures to support signs and signals are provided to perform some or all of the following functions:

i) Support directional signs, usually of fixed legend, but occasionally for variable message signs.

ii) Support signals, including motorway matrix signals; motorway signals Mark 2; 420 and 320 enhanced message signs; controlled motorway indicators; speed enforcement equipment; closed circuit television cameras; and associated equipment.

iii) Where required support other equipment, such as microwave aerials; tolling equipment; and traffic detection equipment.

Procurement

1.7 The procurement of sign/signal gantries will normally be carried out under contracts incorporating the Specification for Highway Works (MCHW1). In such cases products conforming to equivalent standards and specifications of other member states of the European Economic Area and tests undertaken in other member states will be acceptable in accordance with the terms of the 104 and 105 Series of Clauses of that Specification. Any contract not containing these Clauses must contain suitable clauses of mutual recognition having the same effect regarding which advice should be sought.

Definitions

1.8 The meaning and definition of terms used shall generally be in accordance with BS 6100, unless otherwise defined below:

Carriageway

1.9 For the purposes of this Standard, the carriageway width is taken to be the running surface which includes all traffic lanes, hard shoulders, hard strips and marker strips, between raised kerbs. In the absence of raised kerbs it is the width between safety fences, less the amount of set-back required for these fences, being not less than 0.6m nor more than 1.0m from the traffic face of each fence. The carriageway width shall be measured in a direction at right angles to the line of the raised kerbs, lane marks or edge marking.

Gantry

1.10 Generic term for structure supporting signs or signals, includes single or multiple portals, single and double cantilevers and combinations of same.

Live Load

1.11 Imposed load due to maintenance activities.

Outreach of Cantilever

1.12 Length of cantilever from traffic face of support to tip.

Sign

1.13 A device carrying directional or other informational message, eg route information at the approach to a junction.

Signal

1.14 A device which uses lights to give advisory or mandatory instructions, eg stop, or 30 mph speed restriction.

Supports

1.15 Vertical or near vertical structural member supporting horizontal member, sign, signal and/or associated equipment.

Variable Message Sign

1.16 Sign capable of displaying a variety of text, messages and/or symbols including the use of the following technologies:

a) Rotating prism
b) Reflecting cells
c) Light emitting cells

Vehicle Restraint System

1.17 Installation to provide a level of containment for errant vehicles to limit damage or injury to users of the highway.

2 GENERAL PRINCIPLES

Siting

2.1 Once the need for sign and/or signal portal and cantilever gantries is established, the siting of the structures shall accord with TD 9, TD 18 and TD 33 (DMRB 6.1.1, 9.1.2 and 8.2.2 respectively), together with TA 74 (DMRB 8.1) and Chapter 5 of this Standard. This shall include consideration of visibility by the approaching traffic. Where possible these structures should not be located on under-bridges.

Technical Approval

2.2 The designs for construction, alteration and re-positioning of sign/signal portal and cantilever gantries shall comply with the requirements of BD 2, Part 1 (DMRB 1.2). The Design organisation shall give consideration to the appropriate procedure for the procurement of sign gantries in accordance with the requirements of SD 4 (MCHW 0.2.4).

Layout

2.3 All elements shall comply with TD 27 (DMRB 1.2) after allowing for deflections due to dead, live, wind, snow loads and temperature in the serviceability limit state combinations 1 to 5. On portal type gantries the ends of the beam shall be at the same level.

Access

2.4 Unless otherwise agreed with the Technical Approval Authority (TAA), provision shall be made for the maintenance and inspection of signs and signal equipment, as appropriate. Where electrical (other than lighting), optical or mechanical plant is fitted over the carriageway, a walkway or platform shall be provided.

Equipment

2.5 All signs, signals and associated equipment shall be securely attached to the structure using vibration resistant fixings. The structural design shall make adequate provision for the attachment of equipment. Any subsequent modifications to structural members shall only be carried out with the approval of the TAA in accordance with BD 2, Part 1 (DMRB 1.2).

2.6 Any loose equipment such as doors etc, shall be fitted with a safety chain etc attached to a fixed element to safeguard the road users and vehicles on the carriageway below.

Connections

2.7 Main structural metal elements shall be site connected by means of bolts.

Control of Vandalism and Theft

2.8 Measures shall be taken to reduce the risk of theft of materials, such as aluminium alloy and copper, and to minimise the risk of vandalism to equipment.

Adaptability

2.9 Structural holding down bolt arrangements shall be designed such that subsequent removal and replacement of the gantry structure may be readily undertaken.

2.10 Consideration shall be given in the design to the possibility that in the future it may be necessary to revise, alter or increase the sign area; reposition or add signals; or relocate the gantry structure for reuse elsewhere, [see paragraph 2.2]. Designs which unreasonably constrain the position of signals on the structure shall be avoided.

Identification

2.11 In England and Wales the structure site identification marking of gantries shall be in accordance with Departmental Standard BD 45 (DMRB 3.1.1). In Scotland the National Roads Directorate shall be consulted.

2.12 Where it is intended that gantry super-structures will be dismantled and reused elsewhere, each main structural element capable of being dismantled, such as girders, beams, cantilevers and supports, shall be identified by means of a permanently fixed metal plate or inscription. These shall be visible by positioning between 1 and 1.5 metres above the base plate of the support and on the girder, beam or cantilever adjacent to the usual point of access. The text shall include the following information.

i) Name and location of the manufacturer.
ii) Year of manufacture.
iii) A unique serial number for each element.
iv) All up self weight of member plus attached equipment but excluding the weight of any variable message sign.

The characters shall not be less than 10 mm high nor more than 20 mm high.

Use of dissimilar metals

2.13 Where dissimilar metals are to be used, the connections shall be designed to avoid the risk of galvanic corrosion. The electrical bonding of all metal components must nonetheless be maintained.

Protection for Road Users and Structure

2.14 Vehicle restraint systems in accordance with the Overseeing Organisations' requirements shall be provided at gantry supports. The performance of the system required in terms of the Specification for Highway Works (MCHW1) shall be the intermediate level of vehicle containment given in Clause 401.1(c). Examples of some acceptable arrangements are shown in Figure 2. Details of the vehicle restraint system shall be agreed with the Overseeing Organisation.

2.15 Where the gantry support is located behind a high containment bridge parapet to BS 6779 or BD 52 (DMRB 2.3.3), further vehicle restraint systems are not required.

2.16 Where gantry supports are positioned in recesses in retaining walls provision must be made to give continuity to vehicle restraint across the recess and afford access, if required, to the gantry support and any control equipment. Possible means of achieving this are shown in Figure 3.

3. LOADINGS

Loads to be considered

3.1 Loadings shall be in accordance with BD 37 (DMRB 1.3.13), as modified here.

3.2 For the purpose of calculating stresses and stability the following loads shall be considered.

i) Dead load (DL)
ii) Superimposed dead load (SDL)
iii) Wind load
iv) Temperature effects
v) Snow load
vi) Differential settlement
vii) Earth pressure
viii) Live loading
ix) Vehicle collision with supports

Application of loads

3.3 Each element and the structure as a whole shall be considered under the effects of loads in each combination as given in Table 3.

Superimposed Dead Loads

3.4 For fixed signs initial values for nominal superimposed dead loads may be based on the densities of the materials given in BS 648. Nominal loading of a fixed sign shall not be less than 0.5 kN per metre of span of gantry or outreach of cantilever.

3.5 In the case of the variable message signs, signals and associated equipment, the nominal superimposed dead load initially assumed shall in all cases be accurately checked with the actual weights of the items to be used and, where necessary, adjustments shall be made. The calculated nominal superimposed dead loading shall not be less than 1.25 kN per metre of span of gantry or outreach of cantilevers.

Adverse Effects of SDL

3.6 The factor γ_{fL} for design load, to be applied to all parts of the superimposed dead load, having an adverse effect, shall be taken for all six combinations as follows:

Established by	For the ULS	For the SLS
Calculation	1.50	1.20
Weighing	1.20	1.00

Beneficial Effects of SDL

3.7 Where, in accordance with BD 37 (DMRB 1.3.13), a component of superimposed dead load has a relieving effect, γ_{fL} shall be reduced to the following values:

i) Fixed elements, such as walkways, ladders, handrails etc $\gamma_{fL} = 1.0$
ii) Removable items, such as all sign, signal and electrical equipment etc γ_{fL} = zero

Environmental Effects

3.8 The return period for wind and temperature effects in service may be taken as 60 years by adopting the following:

i) Wind coefficient K, taken as 0.96 (see BD 37, DMRB 1.3.13)
ii) Minimum and maximum shade air temperatures taken for a 120 year return period and adjusted by an addition of 1.7°C and a subtraction of 1.7°C respectively (see BD 37, DMRB 1.3.13).

Wind Load

3.9 Gantries shall not be located less than two times their maximum height clear of any overbridge.

Flat Sign Faces

3.10 The following drag coefficients shall be taken for flat surfaces, such as sign faces, in directions both parallel and normal to the sign:

Rectangles	2.2 x modification factor as given in Table 1
Circles	1.15

TABLE 1 Modification factor of drag coefficients for rectangular plates

max dimension / min dimension	Factor
∞	1.00
20	0.75
17	0.70
10	0.64
8	0.63
4	0.59
2	0.57
1	0.55

L Shaped Cross-Sections with Solid Walkways

3.11 Where a solid walkway, or other impervious horizontal surface is placed abutting the lower edge of a vertical sign face or other impervious face, a vertical downward component of the wind force P'_v acts concurrently with the horizontal one, P_t blowing into the 'L' as shown in Figure 4.

3.12 The nominal vertical wind load P'_v shall be taken as acting at the centroid of the appropriate area and shall be derived from:

$P'_v = 2qA_4$ x modification factor as given in Table 1

where A_4 is the solid area of the horizontal surface on the windward side of the vertical solid face.

Longitudinal Wind Load

3.13 The longitudinal wind load P_L shall be calculated on the side elevation of the structure including any individual members not effectively shielded.

Wind Load Combinations

3.14 The transverse, longitudinal and vertical wind loads P_t, P_L and P_v shall be combined as follows:

i) P_t alone
ii) P_t in combination with $\pm P_v$ and/or $-P'_v$, whichever is worse
iii) P_L alone
iv) 0.5 P_t in combination with P_L and 0.5 ($\pm P_v$ and/or $-P'_v$).

Note

Where P_t and P_v are as defined in BD 37 (DMRB 1.3.13) and P_L and P'_v in 3.12 and 3.13 above.

3.15 For design loads the factor g_{fL} shall be taken as follows:

For combination	Effect	For the ULS	For the SLS
2	Adverse	1.40	1.00
	Relieving	1.00	1.00
3 & 5	Adverse	0.70	0.50
	Relieving	0.50	0.50

Snow Load

3.16 Nominal snow load of 0.75 kN/m² in projected plan area shall be applied to all surfaces.

3.17 For design snow loads the factor γ_{fL} shall be taken as follows:

For the ULS	For the SLS
1.10	1.0

Earth Pressures

3.18 In all conditions and limit states of design, earth pressures generating from any retained fill will need to be considered. These shall be calculated in accordance with BS 8002.

3.19 For the ultimate limit state of the structural elements the partial load factor γ_{fL} for earth pressure generated by the backfill itself shall be taken as 1.5 (1.0 for relieving effects).

3.20 For the serviceability limit state of the structural elements the partial load factor γ_{fL} for earth pressure generated by the backfill itself shall be taken as 1.0.

3.21 For the ultimate strength and serviceability conditions of the soil 'active' earth pressure shall be used in the design. Partial load factors are not required for these conditions since BS 8004 design method is based on overall factors of safety.

Live Loading

3.22 On gantries of the portal and cantilever types, nominal live load shall consist of at least 0.5 kN per metre run of the useable length of walkway.

3.23 Cantilevers with an outreach of less than 7.5m, shall be checked for nominal live load consisting of two 1.0 kN point loads acting vertically downwards spaced 0.5m apart and positioned at any point on the walkway or maintenance platform.

3.24 Walkways and maintenance platforms shall be designed for the local effects of two 1.0 kN nominal point loads acting vertically downwards spaced at 0.5m apart and applied at any point.

3.25 For design live load γ_{fL} shall be taken as follows:

For combination combination	For the ULS	For the SLS
1	1.50	1.20
5	1.25	1.00

Vehicle Collision Loads

3.26 When any part of the sign or structure is over the carriageway, hard shoulder or hard strip supports within 4.5m of an edge of the carriageway (para 1.9) these shall be designed to withstand the vehicle collision loads in Table 2, dependent on the type and set out of restraint system provided as in Figure 2(a).

Nominal Loads on Supports

3.27 The nominal loads are given in Table 2 and Figure 5 together with their direction and height of application, and shall be considered as acting horizontally on gantry supports. Normal loads shall be considered acting from any adjacent carriageway. All of the loads given in Table 2 shall be applied concurrently. The loads shall be considered to be transmitted from the vehicle restraint system provided at the supports with residual loads acting above the vehicle restraint system.

3.28 Nominal collision loads shall be assumed to be uniformly distributed over a circular contact area, assuming an effective contact stress of 20 N/mm^2. Alternatively, a square contact area may be assumed, using the same effective stress.

Collision Load Combinations

3.29 No associated nominal primary live load is required to be considered on the gantry.

TABLE 2

Collision Loads on Supports to Sign/Signal Structures

[See Figure 5]

Height of Load	Load Component		Point of Application on Gantry Support or Plinth
	Normal to the Carriageway below (kN)	Parallel to the Carriageway below (kN)	
Lower main load component transmitted to support or raised plinth	150	50	Any one point 0.75m above carriageway level
Upper residual load component transmitted to support	100	100	At the most severe point between 1m and 3m above carriageway level

3.30 Vehicle collision loads on supports shall be considered in combination 6 only. Secondary live loads shall be considered separately and are not to be combined.

3.31 For all elements, the effects due to vehicle collision loads on column supports need only be considered at the ultimate limit state. The γ_{fL} to be applied to the nominal loads shall have a value of 1.50.

3.32 For the design of anchorages for holding down bolts, plinths, bases and structural aspects of foundations γ_{fL} shall be taken as 1.75 for ULS and 1.30 for SLS. The purpose of this is to ensure that these have a greater reserve of strength, so that, in the event of a severe impact, they will have survived and a replacement column support can be fitted.

General Combination of Loads

3.33 Six combinations of loads are specified in Table 3 with values of the partial load factor g_{fL} for the ultimate and serviceability limits states. Where any permanent load has a relieving effect g_{fL} shall be taken as 1.0 in both ultimate limit state and serviceability limit state.

Fatigue from High Vehicle Buffeting

3.34 For cantilever structures only, the stress range (s_r) in any part of the structure for fatigue purposes due to high vehicle buffeting shall be calculated by applying a force of 5.4 kN to the end of the cantilever arm vertically upwards and a similar force horizontally against the direction of the traffic. The required endurance shall be 5×10^6 cycles per year of design life.

TABLE 3

Loads to be taken in each combination together with appropriate g_{fL} for ultimate limit state (ULS) and serviceability limit state (SLS)

Clause Numbers		Load	Limit State	γ_{fL} to be Considered in Combination					
BD51/97	BD 37/88 Appendix A			1	2	3	4	5	6
	5.1	Dead: Fabricated metal	ULS SLS	1.05 1.00	1.05 1.00	1.05 1.00	1.05 1.00	1.05 1.00	1.05 1.00
		Concrete	ULS SLS	1.15 1.00	1.15 1.00	1.15 1.00	1.15 1.00	1.15 1.00	1.15 1.00
3.4 to 3.7		Superimposed Dead Established By:							
		Calculation, but not less than specified minimum	ULS SLS	1.50 1.20	1.50 1.20	1.50 1.20	1.50 1.20	1.50 1.20	1.50 1.20
	N/A	Weighing, but not less than specified minimum	ULS SLS	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00
3.7	5.1.2.2 and 5.2.2.2	Reduced load factor for DL and SDL where this has a more severe effect:							
		Fixed	ULS	1.00	1.00	1.00	1.00	1.00	1.00
		Removable	ULS	0.0	0.0	0.0	0.0	0.0	0.0

Clause Numbers		Load	Limit State	γ_{fL} to be Considered in Combination					
BD51/97	BD 37/88 Appendix A			1	2	3	4	5	6
3.8 to 3.15	5.3	Wind:							
		During erection	ULS SLS	- -	1.10 1.00	- -	- -	- -	- -
		In Service	ULS SLS	- -	1.40 1.00	0.70 0.50	- -	0.70 0.50	- -
		Relieving effect of wind	ULS SLS	- -	1.00 1.00	- -	- -	- -	- -
	5.4	Temperature:							
		Restraint to movement, except frictional	ULS SLS	- -	- -	- -	1.30 1.00	- -	- -
		Effect of temperature difference	ULS SLS	- -	- -	- -	1.00 0.80	- -	- -
3.16 to 17	N/A	Snow	ULS SLS	- -	- -	1.10 1.00	- -	- -	- -
	5.6	Differential settlement	ULS SLS	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00
3.18 to 3.21	5.8	Earth pressure retained fill and/or live load:							
		Vertical Loads	ULS SLS	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00	1.20 1.00
		Non-vertical Loads	ULS SLS	1.50 1.00	1.50 1.00	1.50 1.00	1.50 1.00	1.50 1.00	1.50 1.00
		Relieving Effect	ULS	1.00	1.00	1.00	1.00	1.00	1.00
3.22 to 3.25	N/A	Live Load	ULS SLS	1.50 1.20	- -	- -	- -	1.25 1.00	- -
3.26 to 3.32		Vehicle collision on:							
		Column support	ULS	-	-	-	-	-	1.50
		HD bolts, anchorages, base and structural aspects of foundation	ULS SLS	- -	- -	- -	- -	- -	1.75 1.30

Fatigue Due to Wind Gusting

3.35 For cantilever structures only, the stress range (s_r) in any part of the structure for fatigue purposes due to wind gusting shall be taken as 0.2 times the stress in that member due to the design wind only. The required endurance shall be 3.5 x 10^5 cycles per year of design life. Should a more refined calculation be needed, the required endurance may be taken as the natural frequency of the structure in Hz times 1 x 10^5 cycles per year of design life. The factor on the stress due to the design wind may also be recalculated based on the natural frequency of the actual structure together with the log decrement of structural damping.

Design Life for Fatigue Purposes

3.36 The design life for fatigue purposes shall be taken as 60 years. The fatigue effects from high vehicle buffeting and that due to wind gusting shall be combined in a Miner's Sum calculation to give a value of less than unity.

4. DESIGN

Materials

4.1 Steel and concrete gantry structures shall be designed in accordance with the relevant parts of BS 5400, as implemented by DMRB and this Standard.

4.2 Aluminium gantry structures shall be designed in accordance with the relevant parts of BS 8118, as implemented by this Standard.

4.3 When structural materials other than those stated in 4.1 and 4.2 are proposed, the appropriate TAA shall be consulted and design methods and specification agreed. The TAA shall be assured by means of the track record, longevity, ductility, elastic behaviour and availability in acceptable colours of the suitability of the material. The design criteria and limits to be adopted for such a material shall also be agreed with them, before its use is approved for the construction of gantries.

4.4 Where advanced composites are proposed for use as the structural element of gantries, the design criteria must be established against which to assess the design proposed. The advantages of advanced composite materials are high strength and high stiffness to weight ratio, excellent corrosion resistance and fatigue properties. Advantages for gantry structures are lightness for quick erection and replacement and low maintenance. Deflection criteria are likely to dictate the design sections to be used. A draft design code for polymeric structures for the construction industry has been drawn up by EUROCOMP, together with supporting background information in advance of the preparation of a Euronorm. Pultruded structural sections are available in a wide range of sizes and shapes. Joints and connections may be made by various means, including resin adhesives, mechanical key and bolting, or a combination of these. Colour can be specified and included permanently during the manufacture of the sections. With a lower elastic modulus than steel they will have a better performance under impact.

Structural Criteria

4.5 The design life shall be 60 years, unless otherwise required by the TAA.

Deformations

4.6 Structural deformation due to self weight and superimposed dead load shall be counteracted by an appropriate amount of pre-camber.

4.7 In the public's mind even a small downward residual deformation is perceived as uncomfortable and a small upward pre-camber, over and above that allowed for above, is to be preferred. Consideration shall therefore be given to raising the centre of spans of portals or tips of cantilevers by an additional camber above the chord line for portals, or the horizontal for cantilevers.

4.8 In the serviceability limit state under loading combinations 1 to 5 inclusive the deflections and rotations due to wind, temperature, snow and live load **only** shall be limited such that the deformations do not exceed the values given in Table 4.

4.9 The deformation at the extremities of the structural support shall be derived from the sum of the components of the effects of the load in the support posts, cantilever and sign supports, [see Figures 6 and 7]. The height of the post shall be measured from the top of any support plinth to the underside of the structural beam or cantilever.

TABLE 4
Limiting Structural Deformations of Gantries
[See Figures 6 and 7]

Element and Position	Direction of Deformation	Fixed and Variable Message Signs and Signals
Top of Post of Cantilever or Leg of Portal	Horizontal Δx_1 or Δy	1/300 of height
Tip of Cantilever or extremity of structural sign or signal support, [see Figure 6)	Horizontal Δx_2	1/150 of outreach plus heights of post and sign upright
	Vertical Δz	1/300 of outreach plus height of post
Within span of Portal or extremity of structural sign or signal support, [see Figure 7]	Horizontal Δx_2	1/200 of span plus heights of leg and sign or signal support
	Vertical Δz	1/300 of span plus height of post

Minimum Thickness of Metal Sections

4.10 The minimum thickness of structural metal sections shall be as follows:

i) Steel plates and sections other than hollow sections 6 mm

ii) Steel hollow sections effectively sealed by welding, other than a small drain hole 5 mm

iii) Aluminium alloy plates and sections 4 mm

Closed Hollow Sections

4.11 Hollow sections in all materials shall be designed to resist the ingress and retention of water or moisture by gravity flow, capillary action or condensation. For hollow sections made out of metal, the end plates shall be of thickness not less than the lesser of the following:

i) Equal to the thickness of the walls of the hollow section

ii) 8mm

The end plates shall be joined by continuous structural quality welding to the relevant BS. Should there be a possibility of water entering in significant quantity and subsequently freezing, then drain holes shall be provided. Hollow sections in non-corrosive materials or galvanised steel shall be provided with drain holes at all low points and the size of the hole shall be appropriate to the void being drained, but shall not be less than 10mm diameter.

Additional Design Conditions

4.12 The following design conditions, 4.13 to 4.17, are for use with BS 5400, Part 3 and BS 8118.

Circular Hollow Sections

4.13 The shape limitations below are intended to exclude selection of a member which may be susceptible to the onset of unacceptable local buckling of the member.

4.14 In circular hollow sections for all design effects, as defined in the relevant code of practice, the wall thickness to radius ratio shall be limited to a maximum of:

$$\frac{R}{t} \leq 0.06 \left(\frac{E}{f_y}\right)$$

Where:

R = Outer radius
t = Wall thickness
E = Young's modulus
f_y = Yield stress (or 0.2% tensile proof stress)

Combined Effect of Loads

4.15 The combined effects of axial compression, torsion and biaxial bending shall be catered for. These may be checked in accordance with the methods given in *Design of members subject to combined bending and torsion*, Nethercot DA, Salter PR and Malik AS, SCI publication 057, The Steel Construction Institute, 1989.

4.16 As the relevant codes of practice do not contain criteria against which to check the combined effects of bending, axial force, shear and torsion, the equation derived from Gerard and Becker has been adapted. The following interaction equation shall be satisfied at the ultimate limit state:

$$\left(\frac{\sigma}{\sigma_{cr}}\right) + \left(\frac{\tau}{\tau_{cr}}\right)^2 \leq 0.95$$

Where:

σ = Sum of applied compressive stress, due to resultant ULS axial forces and bending moments.

σ_{cr} = Permissible elastic buckling stress, being the lesser of:

Least buckling stress derived from elastic analyses of alternative buckling modes, which allow for the effects of initial imperfections,

or The least permissible code of practice compressible stress for the relevant states of buckling,

reduced by the appropriate design code factors ($\gamma_m.\gamma_{f3}$ for steel and γ_m for aluminium).

τ = Sum of applied shear stresses, due to resultant ULS torsion and direct shear force.

The direct shear stress shall be taken as not less than:

$$\frac{\text{(Resultant ULS shear force)}}{0.6\ \text{(Cross section area)}}$$

τ_{cr} = Permissible elastic shear buckling stress, being the lesser of:

The shear buckling stress derived from an elastic analysis which allows for the effects of initial imperfections,

or, The permissible code shear stress reduced by appropriate code factors ($\gamma_m.\gamma_{f3}$ for steel and γ_m for aluminium).

or, (Material yield stress)/($\sqrt{3}$

All reduced by appropriate code factors.

Local Effects of Impact

4.17 The local effects of vehicle impact load may be considered by using the following:

i) Finite element model
ii) Plastic theory of plate deformation
iii) Paper by Ellinas CP and Walker AC, *Damage on offshore tubular members,* IABSE colloquium, Copenhagen Ship collision with bridge and offshore structures, 1983.
iv) Standard formulae contained in *Stress and strain*, Roark RJ, 4th Edition or later, McGraw-Hill, 1965.

Elements of Structure

Supports

4.18 The design of supports shall be such that, local damage in a section at the point of impact by design collision loading is insufficient to result in collapse of the section as a whole.

4.19 Consideration shall be given to the use of hollow sections for posts, internally stiffened or filled if necessary with a medium that restrains local deformation until repairs or replacement can be carried out.

4.20 In order to achieve the required resistance, it may be necessary to encase or widen the support to form a concrete plinth to a height sufficient to cater for the low level collision loadings and/or position structural members out of the collision zone.

Clearances

4.21 The horizontal dimensional clearances of the structures and safety fences and barriers shall be in accordance with DMRB, including TD 27 (DMRB 6.1) and Figure 2(a). The clear headroom under the gantry shall be 5,700 mm minimum.

Connections

4.22 Sections shall be strengthened at connections as necessary.

4.23 All fillet welds shall have a leg length of not less than 4 mm. All fillet welds, unless contained within a closed member, shall be continuous.

4.24 Consideration shall be given in the design of the mounting arrangements for signs and signals to the possible structural interaction between the enclosure and supporting members where appropriate.

4.25 Vibration resistant fasteners shall be used.

Foundations - Design for Soil - Structure Stability

4.26 The following design principles apply to foundations with spread footings or piles.

Design Conditions

4.27 The foundation and the surrounding soil shall be designed to perform satisfactorily for both the ultimate and the serviceability conditions. The four conditions which are to be considered in the design are described below.

4.28 Ultimate limit state of the structural elements corresponds with the failure of the holding down bolts, plinth, or the base of a foundation, pile cap or pile and is as defined in BS 5400: Parts 3 and 4, as implemented by BD13 and BD24 (DMRB 1.3.13 and 1.3.1 respectively), for steel and reinforced concrete respectively. The structural design and detailing shall be in accordance with those codes.

4.29 Serviceability limit state of the structural elements corresponds with acceptable limits as described in BS 5400: Parts 3 and 4, as implemented by BD13 and BD24 (DMRB 1.3.13 and 1.3.1), for steel and reinforced concrete respectively. The structural design and detailing shall be in accordance with those codes.

4.30 Ultimate Strength of Soil.

i) This condition corresponds with the following failure modes of the surrounding soil and the soil-structure interface:

Sliding
Overturning
Bearing capacity of the foundation soil
Slip failure of the surrounding soil

ii) Design for this condition shall use the design procedures and the overall factors of safety given in BS 8002 and BS 8004. Nominal values of dead earth pressures and live loads as given in Chapter 3 shall be used in the calculations where necessary.

Note: The overturning design criterion given in BD 37 is not applicable to this condition.

4.31 Serviceability Condition of Soil.

i) The adoption of recommended safe bearing capacities for the foundation design should avoid undesirable soil movements due to settlements and tilting of the foundation. Nevertheless a separate assessment of the differential settlements and tilting of the structure is necessary for the design of associated superstructures with in-built redundancy or cantilevers. Such movements can be calculated from a displacement or consolidation analysis. The predicted movements shall be taken into account in the overall design of the structure.

ii) Nominal values of dead earth pressures and live loading as given in Chapter 3 shall be used in the calculations where necessary.

4.32 Caution is necessary if reliance is placed on mobilising resistance due to passive pressure acting on spread footings or pile caps particularly on the downward slopes of embankments or cuttings, filter drains or other disturbed material.

Drainage

4.33 Provision shall be made for the drainage of water from the structure and fixings. All walkways, roofs of enclosures and other surfaces shall have adequate falls to allow water to run off. Where run off can concentrate, it shall discharge clear of the carriageway and hard shoulder/strip and clear of the structure.

4.34 Provision shall be made to drain hollow sections, [see the clause 4.11] above.

Cable Routes

4.35 A structured cable management system shall be devised and incorporated into the structural design of the gantry. The cable route shall be covered and shall include access points on the gantry to accommodate present equipment configurations; it shall be flexible enough to allow for future developments. It shall provide continuous protection from the ducted network in the nearside verge through to the central reserve. Where cable routes are external to the structure, they shall be positioned remote from the usual line of sight, ie on the down stream face, where possible.

4.36 The minimum radius for a cable route shall not be less than twelve times the external diameter of the cable. Entry and exit points to internal ducts shall be sealed by the use of duct plugs in accordance with SHW Clause 1530.7. A draw rope shall be provided in all ducts in accordance with SHW Clause 1530.4.

5. APPEARANCE

General

5.1 The overall appearance is an important consideration for gantries. The gantry design shall be submitted by the TAA to the Agency's Architect/Planner for England and Wales, or to the Overseeing Organisation for Scotland and Northern Ireland, for approval of its appearance at the time of approval in principle.

5.2 When considering the environmental and aesthetic aspects related to the location and detailed design of sign gantries, the designer shall ensure that visual impact and appearance are given full attention to that of the function. The designer shall take into account the following clauses in considering the visual impact and appearance of sign gantries.

Environmental and Aesthetic Considerations

Context

5.3 When locating gantries and signs in their general landscape setting to accord with current European Community legislation in the preparation of Environmental Statements, designers shall consider the environmental advice embodied in DMRB, Volumes 10 and 11. These volumes advise on the Environmental Assessment of highway schemes to identify in particular the visual impact created by the location of highways and highway features including signs and gantries, together with methods of mitigating such impact.

5.4 Visual impact shall be assessed by a combination of the degree to which the feature is prominent in the view, and the quality of the landscape, urban and rural, in which the feature is located. Visual impact will be caused upon the surrounding landscape by gantry construction both during the day, and by any associated lighting during the hours of darkness. These impacts shall be assessed and minimised in relation to:

a) The quality of landscape in which the gantry is proposed. (Designated Landscapes, etc.).
b) The extent of the visual envelope created, day and night.
c) The number of residential properties affected, day and night.

Information collected under a), b) and c) above shall be presented for assessment in the textual and environmental framework format required in DMRB, Volume 11.

5.5 Further assessment of visual impact caused by lighting shall be considered in conjunction with the Department of Transport publication *Road Lighting and the Environment*.

5.6 As a general guide, gantries shall be located low in the landscape, preferably in cutting and not visible above the skyline.

5.7 In practice there are overriding functional constraints which establish the required location and size of signs and gantries in relation to road geometry and proximity to junctions. Although the most effective mitigation is the initial choice of location for a gantry, where standards dictate this is not possible, developing a sympathetic appearance to the structure is the best solution to adopt, accompanied by consideration of physical and vegetative visual barriers which can assist in mitigating the visual impact created.

Form and Aesthetics

5.8 Gantries shall not be perceived as an isolated or "bolt on" element in the design of a road scheme but must be considered an integrated part of a total design solution. Ideally a theme of design should be established which runs through the separate elements of highway development including structures, gantries, signs, fencing, noise barriers and lighting, lending visual sympathy between elements and establishing a continuity to the overall proposal.

5.9 Recent gantries have a somewhat "technical or mechanistic" appearance more appropriate to an urban than in a rural setting, but using modern flexible materials it should be possible to produce a more organic and rounded form of gantry more appropriate to placing in the countryside.

5.10 More satisfactory aesthetics will be achieved, if the gantry design includes the following features:

a) Simplicity and unobtrusiveness.
b) Visually light and uncluttered structures.
c) Continuity of design with other highway elements.
d) Innovative design. Appropriate choice between "technical" and "organic" appearance to gantry design in urban and rural settings.
e) Appropriate use of colour (see also below "Colour").
f) Spanning over several carriageways/slip roads to reduce number of vertical supports.
g) Spanning more than the mere minimum distance between vertical barriers or bunds for a more integrated appearance, [see figure 8].
h) Balancing the visual impact of the need to illuminate signs against endeavouring to reduce the visual impact of lighting when viewed from outside the highway.
i) Proportioning signs in relation to gantry and other highway elements.
j) Creating a "sense of place" with individual designs or sculptural forms. For example, at the beginning of a motorway as it leaves a city, this transition point could be emphasised by a unique design, however, such a feature may be more appropriate for a bridge.
k) Lateral thought and innovation. This is required in conceiving original gantry design, by a combined team of engineers and architects/ landscape architects.
l) Omission of walkways, excessive structure, superfluous retaining walls and concrete plinths and bases, wherever possible.

Colour

5.11 The same aesthetic criteria shall be applied to the use of colour on gantries and signs as is indicated for form, with the added caution that the colour of a gantry shall assist in promoting the function of communication, not compete with it.

5.12 Research suggests that mid to soft grey is most appropriate for the British climate and most acceptable to the representative design bodies, especially when viewing a feature against the sky. BS 4800 Medium Grey 18B21 and BS 381C Camouflage Grey 626 are suitable. Black has been proposed as an alternative, but draws attention to itself in all but dense woodland or avenue settings. Greens are frequently bright and synthetic and fail to match the complex landscape backdrop. Muted grey - green has been successful in Surrey in association with colouring lighting columns. The silver - grey of galvanised steel or weathered aluminium frequently integrates well.

5.13 Generally multi-colours are not found to enhance any particular form, however, designers should not be discouraged from experimentation. In other European Countries innovative use of colour has made a positive contribution to the highway environment and in Britain brighter colours and transparent panels have been successfully utilised on recent noise barrier designs. Illustrations and computer generated impressions will assist construction experimentation with colour options.

Detail

5.14 The visual impact caused by the provision of gantries and signs may be mitigated by the selection of a suitable form of either a vertical barrier, earth bund, dense tree and shrub planting or a combination of these three elements.

5.15 There is frequently a shortage of space within the highway land take, particularly where motorway widening has taken place. Where required sufficient space shall be made available to establish sustainable screen vegetation and allow for good horticultural practice.

5.16 Assessment must be made of the necessary access from the highway to maintain horticultural plots which have the function of screening gantries and signs, with reasonable ease. Access through barriers, bunds and fences has traditionally been spaced at 200 m ensuring none of the landscape maintenance is placed further than 100 m from an access from the highway.

5.17 Forward visibility requirements towards gantries shall be checked to ensure no conflict with planting which has to function as a high dense screen, often as a condition of the mitigation commitment made to adjacent residents.

5.18 Where possible access and cables routes to gantries shall be located to avoid essential planting plots. It is recommended that a procedure be adopted that records existing cables and accesses and mitigates damage where existing horticultural commitments have been identified and recorded.

5.19 Where the screening of gantries by vegetation requires a depth of topsoil sufficient to sustain healthy plant growth, the displacement of topsoil for the construction of gantry bases and cabling shall be fully reinstated.

5.20 Records of long term mitigation commitments shall be established in order to ensure that maintenance regimes accord with the preservation of these undertakings.

6. ACCESS AND SAFETY

Access - General

6.1 Means of access for maintenance of the signs, signal equipment, lighting and the structure is required. This may be fulfilled by one or a combination of the following: mobile hoists, moveable equipment mounted on the structure, or fixed access. Where permanent access is provided, a permanently fixed metal plate or inscription, stating the maximum number of persons and weight of equipment, in characters not less than 10mm high, shall be positioned where it can be clearly read from the usual point of access.

6.2 Where lifting equipment is specified, lifting points and davits shall be provided to carry a safe working load of 100 kg (1 kN). A permanently fixed metal plate or inscription, stating the maximum safe working load, in characters not less than 10mm high, shall be positioned either adjacent to the hook or on the davit. All lifting equipment must be tested in accordance with the current requirements of the Health and Safety Executive. Lifting equipment shall be positioned over the back of the hard shoulder or hard strip, unless otherwise agreed.

6.3 Where circumstances permit, particularly on motorways of four lanes or more, consideration shall be given to using portal gantries as a means of gaining access to the central reserve by the provision of an additional ladder at every other gantry. This will not be required where there is no walkway, nor where there is no central reserve support, nor generally if there are less than four lanes spanned. When this is implemented consideration shall be given to the appropriate control of users of such a facility. The potential for damage to the signals and their associated equipment by users shall be addressed.

Fixed Access

6.4 Where a fixed walkway or platform is required to enable maintenance of signs, signal equipment and/or lighting, to be carried out, the following requirements shall be met:

i) The minimum clear width of the walkway, excluding cable trays and/or working space to maintain equipment, shall be 600 mm. On gantries where several sets of equipment may need to be maintained simultaneously, the clear width of the walkway/platform including cable trays shall be not less than 1,500 mm.

ii) An overhead clearance of not less than 2.1 metres desirable, 1.5 m absolute minimum, shall be provided. Wherever the headroom is less than 2.1 metres, secured protective head gear shall be worn by all operatives mounting the gantry and a notice shall be provided indicating that protective head gear shall be worn.

iii) The walkway surface shall be nominally horizontal. Solid walkways shall be sufficiently inclined to drain surface water.

iv) Unless over a horizontal structural member or within an enclosure, walkways should preferably be of the open mesh type with the minimum possible solidity compatible with openings which will prevent the passing of a ball 5 mm in diameter.

v) The surface of all walkways on gantries shall have a non-slip finish. The surfacing of solid walkways, when new, shall have a slip resistant finish which has a slip resistance against rubber, leather or composite sole material of not less than 65 units under wet conditions. The slip resistant finish shall have an effective life of at least ten years and shall retain a slip resistance of not less than 45 units under wet conditions throughout this period. The slip resistance of solid surfacings should be checked by the portable skid resistance pendulum tester developed by the Transport Research Laboratory. A suitable in situ finish on solid surfaces may be obtained by over sprinkling the surface with calcined bauxite flints with a particle size in the range of 0.17 to 0.50 mm or other materials with an equivalent performance.

vi) Access facilities shall be designed so as to discourage the use of cable trays as walkways.

vii) In Scotland, fixed walkways and platforms shall be enclosed.

Permanent Access for Maintenance of Luminaires

6.5 Where the maintenance regimes envisaged permit, a permanent means of access to gantries supporting only fixed signs shall be avoided if at all possible.

Handrails

6.6 A safety handrail 1.10m high above the walkway or other accessible horizontal surface shall be provided round all walkway surfaces that are not protected by other means of similar height.

6.7 All edges of the walkway shall be provided with the minimum of a solid up-stand at least 150 mm high in the plane of the handrail. To prevent any items falling onto the carriageway those parts of the walkway handrail over the carriageway and at least 1.5m beyond the back of the hard-shoulder/ strip or verge shall be infilled with either solid plate or with mesh with openings which will prevent the passing of a ball 5mm in diameter, or a combination of both.

6.8 Handrails and infill panels shall be in accordance with BS 6180 'Protective barriers in and about buildings'. The category shall be as defined in Table 1 of the BS.

Ladders

6.9 Where access ladders are required, they shall comply with the general requirements of BS 4211 'Ladders for permanent access'; Class B.

6.10 Where the public has pedestrian access to the highway upon which the gantry is located consideration shall be given to the provision of a gate across the bottom of the ladder enclosure or hinged flap with a latch capable of accepting a padlock and the lower length of the enclosure made un-climbable, such as by the provision of mesh infill round at least the lower 2 metres of the ladder enclosure and any ladder supports.

6.11 Experience to date suggests that gantries on motorways are not at risk from unauthorised access, whereas on public highways the risk may be dependent on the locality. Gates or hinged flaps are a possible hindrance to authorised personnel and shall only be fitted where experience indicates they are necessary.

Enclosures

6.12 Enclosures intended to be entered by maintenance personnel may be considered from a health and safety point of view to be enclosed spaces, with all the attendant restrictions and precautions regarding access required by the legislation. Walkways in enclosures shall be provided with natural or artificial lighting. Where translucent panels are used, provision shall be made for cleaning them inside and outside. Enclosures shall have a means of ventilation to provide a safe environment.

Electricity

6.13 Where electrical plant is installed on gantry structures provision must be made to enable the supply to be isolated before work takes place on electrical equipment. It is noted that equipment for motorway communications is a permanent installation. It is therefore based on 240 volts and is installed in accordance with BS 7671 *Requirements for electrical installations*.

Electrical Earth

6.14 All metal components of the structure shall have electrical continuity in accordance with BS 7671. Provision shall be made to allow for the connection of any equipment fitted to the gantry and all individual components of the gantry to be earth bonded and for the base of the structure to be connected to earth by individual earthing rods. The earthing system shall be in accordance with BS 7430 *Code of practice for earthing*.

6.15 By providing electrical connection between the reinforcement in the foundations, holding down bolts and metal gantries it may be possible to achieve adequate earth without the need for earthing rods. Tests shall be made in dry conditions at each location to ensure that this has been achieved.

Lightning Conduction

6.16 A conduction path, to convey lightning strikes from all parts of the structure to earth, shall be provided in accordance with BS 6651.

Hoists

6.17 Lifting eyes shall be provided on all items of equipment that cannot be readily moved by hand and provision made for hoisting larger items up to walkway level. Permanent hoists are not recommended because of the need to maintain large numbers out on the network, but maintenance teams could be provided with them for use as the occasion demands.

7. DESIGN CONSIDERATIONS

General

7.1 Attributes required of any gantry structure include the following:

i) Good appearance.

ii) The means afforded to attach signs and/or signals shall permit maintenance and enable the maximum flexibility in position and size, including re-configuration during the life of the structure.

iii) Simplicity in construction and ease of erection.

iv) Use standard interfaces at points of connection.

v) Minimum maintenance.

v) Suitable for easy dismantling and possible reuse elsewhere.

Design Standards

7.2 To be flexible in use any standard design of gantry shall satisfy the following objectives:

i) Maximise the potential use of the design at a wide variety of sites and applications for minimum extra structural cost.

ii) Be capable of reuse for revised configurations of signs and/or signal equipment, or future re-positioning to a new site with minimal alteration.

iii) Have standard interfaces between various structural components, equipment and foundations, to permit replacement or reuse.

Overloading of Information

7.3 Overloading of information to be observed by the driver is a function of his speed, the number of destinations displayed and the 'x' height of the letters used on signs, together with consideration of other information presented to him by means of enhanced message signs and signals. These shall be limited in accordance with appropriate design guidance, such as Local Transport Note No 1/94, to a maximum of six destinations or their equivalent, unless otherwise agreed as a departure from standards by the Overseeing Organisation.

Separation of Functions

7.4 The functions of displaying signs and signals on gantries shall be separated, except in Scotland, and designs for each function developed. When a design to accommodate both functions is required for reasons of limited space and economic considerations, this shall be agreed as a departure from standards by the Overseeing Organisation.

Sign Alone Gantries

7.5 To reduce overcrowding of information and visual impact of the gantry structure, dedicated structures to support signs alone, preferably without need for permanent access, shall be considered. The elimination of the walkway can be achieved for example by using micro-prismatic retro-reflective sheeting where appropriate, to avoid the need for lighting; by internal lighting with remote luminaires; or light systems requiring only infrequent maintenance. By placing the beam member at the centre of the sign area, torsional loading on the structure can be reduced. Nonetheless, a risk assessment shall be undertaken to determine whether the operation of setting up and removing traffic management for those occasions when access is still required is acceptable, before agreeing to eliminate the fixed access.

Signal Alone Gantries

7.6 To diminish overloading of information and visual intrusion of the gantry structure, dedicated structures to support signals alone shall be considered. Unless integral with the signal enclosure, these should preferably have an open topped walkway with facilities to mount signals of various kinds on the leading edge and speed enforcement equipment on the rear. Depending upon the eventual requirements, these might also be suitable for motorway tolling equipment. The constraints on cross section of gantries supporting signals alone are shown [on Figure 9].

Combined Sign and Signal Gantries

7.7 To mitigate against the possibility of driver sign overload and to simplify structural requirements, it is desirable to avoid gantries carrying both signs and signals. From an aesthetic point of view structures to support separate functions are to be preferred. However, in Scotland and where operational requirements call for both signs and signals, and subject to satisfying [7.5], designs to support both may be used. The constraints on cross section of gantries supporting both signs and signals are shown [on Figure 9].

Directional Signs

7.8 The layout of the sign shall be in accordance with The Traffic Signs Regulations and General Directions.

Size of Sign to be Allowed for

7.9 The size of sign to be allowed for in design depends on the legend to be placed on the sign panel. The basis of design of sign layouts is given in Local Transport Notes 1 and 2/94 *The Design and Use of Directional Informatory Signs* and *Directional Informatory Signs Interim Design Notes* respectively. The size of the panel is influenced by the following:

i) The 'x' height adopted
ii) The number of destinations
iii) The layout, such as spacing, and the need for arrows and panelling of destinations where appropriate

The 'x' height is by far the greatest influence and needs to be such that the sign is legible to the driver for sufficient time to be able to read and act upon the message as he approaches. This is governed by the approach speed of the vehicle and hence the siting distance.

7.10 The sign shall be visible from the maximum distance at which it can be read, depending on vehicle speed and the letter 'x' height as defined by Local Transport Note 1/94, and the minimum distance given by a maximum upward angle of view by the driver of 10 degrees from the line of travel.

Micro-Prismatic Retro-Reflective Sheeting

7.11 Micro-prismatic retro-reflective sheeting is recommended for use in appropriate situations.

Illumination of Signs

7.12 As regulations currently stand, motorway gantries are required to be lit.

External Lighting

7.13 Where required, it is preferable to position luminaires below the sign face and they shall be positioned at a focal distance sufficient to achieve the level of luminance required by BS 873, Part 5 in order to obtain acceptable levels and distribution of illumination over the whole area of the sign face.

Internal Lighting

7.14 Where internal illumination is envisaged, consideration shall be given to the adoption of translucent micro-prismatic retro-reflective sheeting in front of a light box, with light distribution tubes to the luminaire positioned to one side of the sign. This will allow the luminaire to be maintained without the need to provide permanent access.

Variable Message Signs

7.15 Where required, gantry designs shall allow for the mounting of variable message signs and their associated control equipment, together with their subsequent removal for maintenance and replacement. A permanent means of access for maintenance is likely to be justified. The enclosures for variable message signs are likely to be sufficiently heavy to warrant the provision of lifting eyes.

Maintenance of Signs

7.16 TD 25 (DMRB 8.2.2) requires that traffic signs are cleaned as required and at intervals not exceeding three years. In industrial areas, however, annual cleaning is preferred to prolong the life of the sign, which should be in the order of 15 years. Consideration shall be given to the bulk replacement of lamps for illuminated signs to minimise the out of course maintenance visits. Rotating prism variable message signs have a high maintenance requirement and shall be considered in the same manner as signals. Consideration shall be given to specifying road luminaires to IP65 enclosure rating to reduce the need for cleaning to the same intervals as lamp changing.

Mounting of Signs

7.17 Where appropriate signs shall be mounted at a small inclination to the vertical to improve visibility. The structural member to which the sign is to be attached shall be flush faced and suitable for use with bands or clamps to fasten the signs. Projecting bolt heads and cover plates, that prevent the sign from being fixed in one plane, shall be avoided. The design of the sign support members shall be such that subsequent resigning can be implemented, possibly to a different sign size, without major disruption to the main members of the gantry. The sign support members shall be readily capable of removal and replacement to suit revised sign configurations.

7.18 Where signs are to be mounted on the top of a beam or girder and a light screen independent of the sign panel is to be provided, the screen shall have a horizontal straight top edge after allowing for any pre-camber and/or deflection under self weight. The sign support members shall be plumb in elevation. To achieve the latter, header rails are advisable.

Motorway Signals

7.19 The other main purpose of gantry structures is to support motorway signals over the carriageway. The standards for motorway signals are detailed in TD 46 (DMRB 9.1.1). Descriptions of the different types of signals and design guidance for their implementation is given in TA 74 (DMRB 8.1)

7.20 The types of signal currently in use in England are:

i) Matrix Signal (MS);
ii) Motorway Signal Mark 2 (MS2) - consisting of an EMI and EMS;
iii) Enhanced Matrix Indicator (EMI);
iv) Enhanced Message Sign (EMS) - not actually a Signal, but a variable message sign;
v) Controlled Motorway Indicator (CMI).

Other types maybe in use in the rest of the UK and may be developed.

Matrix Signals

7.21 A Matrix Signal (MS) comprises a matrix (13 x 11) of light emitting display cells, four red 'Stop' lanterns and four amber lanterns mounted on a backing board. The matrix element is used to display speed restrictions, lane restrictions by the use of lane divert arrows, 'Fog' warnings and 'End'. The provisions to be made to accommodate MS are similar to those shown on Drawing No MCX 0144 in TRH 1239 *National Motorways Communications System Installation Drawings*.

7.22 On gantries, MS are usually attached to a vertically pivoted mounting frame so that they project through an opening in the fascia or girder web plate and are capable of being rotated through approximately 180 degrees to enable maintenance to be carried out (refer to Drawing No MCX 0043). The matrix signals can also be arranged to shine through a transparent sheet and fold backwards and downwards to enable maintenance to take place from the rear, often within an enclosure.

Motorway Signals Mark 2

7.23 A Motorway Signal Mark 2 (MS2) comprises two elements:

i) An EMI, a matrix signal which can display various aspects; and
ii) An EMS.

MS2 are usually mounted on cantilever structures. The combined enclosure measures 8190 x 2535 x 500 (max) mm. The implementation of MS2 is discussed in TRH 1642.

Enhanced Matrix Indicator

7.24 The next generation of MS with improved optical performance consists of a 20 wide by 14 high matrix of display cells, lanterns and backing board capable of displaying a range of signals including wickets for up to 4 lanes and speed limits. This is always used in conjunction with a 420 mm high EMS, see below, and often mounted together within one enclosure.

Enhanced Message Sign

7.25 A Enhanced Message Sign (EMS) is a variable message sign with two lines of 12 characters. Each character is formed on a 5 x 7 matrix of display cells. EMS are mounted on a display board with amber lanterns, and have the capability to display a large number of messages to support, for example, speed restrictions shown on matrix signals, and provide other traffic or travel information. The means of mounting provides for adjustment to the vertical alignment in both cases and horizontally as well when on a gantry.

7.26 EMS can be mounted on gantries in conjunction with MS, CMI (see below), or with an Enhanced Matrix Indicator (EMI) to form an MS2. The character height is normally 420 mm, but with the approval of the Overseeing Organisation as a departure from standards

may be reduced to 320 mm. The enclosure for 420 EMS for MS2 measures 6370 x 2535 x 500 (max) mm. The enclosure for 320 EMS measures 4410 x 1755 x 500 (max) mm. For standard interfaces for the mounting arrangements, see Drawing Nos MCX 0583, 0584 and 0604 in TRH 1239 *National Motorways Communications System Installation Drawings*.

Controlled Motorways

7.27 Controlled motorway schemes provide for controlled motorway indicators (CMI), a new generation of lane signal with improved optical performance and incorporating red rings to implement mandatory variable speed limits. CMIs comprise a matrix signal surrounded by a red ring, which signifies a mandatory speed restriction. This allows the setting of variable, mandatory, speed limits in order to delay or prevent the breakdown in traffic flow during busy periods. To impose these speed limits, enforcement equipment is also installed on the gantries over each lane. CMI are mounted either on gantries or posts as shown on Drawing Nos MCX 0731 and 0730 in TRH 1680 *Controlled Motorway - Equipment installation drawings*.

7.28 The implications of this system include:

i) The replacement of each Matrix Signal on a gantry by a CMI. The CMI enclosure measures 1840 x 1480 x 400 (max) mm and its alignment must be capable of adjustment to suit site conditions.

ii) The mounting of enforcement equipment consisting of a radar unit, flash unit, camera and recording unit. This is contained within a box measuring no more than 1000 x 500 x 500 mm over each lane so that it points towards the rear at the departing traffic.

iii) The fitting of an ambient light monitor (ALM).

iv) The attachment of an antenna for the Rugby clock.

v) The fitting of security devices to gantry ladders to prevent access by unauthorised individuals.

The implementation of Controlled Motorways is discussed in TRH 1681 *Controlled Motorways - Infrastructure Design Guide*.

Strategic Variable Message Signing

7.29 Strategic variable message signing schemes have been implemented to inform drivers of delays or closures on a system of strategic routes and advise drivers of an alternative route. VMS with two lines of 18 characters, similar to 420 EMS, and with 3 lines of 18 characters have been used, however the latter is only standard in Scotland and shall only used in special circumstances and with the approval of the Overseeing Organisation elsewhere.

Closed Circuit Television Cameras

7.30 Where it is required to locate closed circuit television (CCTV) cameras on gantry structures, the position of the camera shall be such that a clear, unimpeded view of the motorway is provided. Where fixed cameras are used, the field of view will depend on the coverage of other cameras within the overall CCTV scheme. 5 metre tall CCTV masts on the walkway of gantries towards the nearside end have been used. Where required, consideration shall be given to making provision for the incorporation of such a mast on the gantry structure. Allowance for maintenance will be required and this will include for the camera to be winched down to walkway level.

Maintenance of Signals

7.31 A permanent means of access is necessary on all gantries over motorways and rural dual carriageways carrying signal equipment. The design of the access space shall allow for sufficient withdrawal and working area in the vicinity of any equipment to be maintained.

7.32 The current design of enforcement equipment requires regular visits by maintenance personnel to change and replace films and also to move cameras between lanes and from one gantry to another. The equipment is mounted on the downstream face of the gantry pointing towards the rear of vehicles.

7.33 Whilst open mesh walkways may reduce the vertical effects of wind loading, there is still the risk of small objects falling onto the carriageway below and in addition it is uncomfortable to work on. Solid walkways are, therefore, preferred. The avoidance of headroom restrictions and the provision of adequate ladder access are considered in Chapter 6.

Signal Control Equipment

7.34 Signal control equipment is currently mounted on gantries. This includes equipment for power distribution, communications links and signal drivers. For maintenance, operational and safety reasons such equipment will remain on the gantry structure, close to the signals themselves.

Mounting of Signal Equipment

7.35 The design of signal apertures shall be such that they can accommodate all types of existing equipment - CMI; MS, Enforcement equipment. Brackets and reduction plates may be necessary to achieve this.

7.36 Consideration shall be given in the design of the gantry to allow for the addition of unspecified equipment at a later date without the need for structural checks and preferably without the need for interference with any structural element. Equipment plates with a matrix of holes or a proprietary racking system could be considered.

7.37 On combined function gantries the design shall ensure that the sign face, including the junction number and distance marker, can be viewed without visual obstruction and that information over-loading will not occur.

Power Distribution

7.38 Consideration shall be given to the provision of power sockets along the walkway for use by maintenance personnel. Typically these would be used for test equipment, power tools, lifting hoist etc.

Third Party Equipment

7.39 The presence of equipment provided and installed by a third party, usually for vehicle detection, shall only be permitted when there is no practical alternative. Efforts shall be made to limit the duplication of any such equipment.

Ground Works

7.40 To support gantry superstructures foundations are required to transmit the reactions from the structure safely into the supporting ground. Spread footings are to be preferred where circumstances permit. Piled foundations may, however, be necessary when either ground conditions are poor, or their use is cost effective by avoiding disturbance of an existing carriageway construction. Reinforced concrete plinths 1,200 mm in height above adjacent road level may be a suitable means of catering for the main vehicle impact loading.

7.41 Where signals are installed on gantries or lighting is provided, electrical cabinets are usually required adjacent to the gantry. Ducts for electric supply and communication cables shall be provided from the cabinet to the base of the superstructure and cable routes along the highway. Electrical cabinets shall be located so as to be unobtrusive and integrated with the landscape design where possible. Details of cabinets and duct routes for use on Motorway Signal Mark 2 schemes at gantry sites are shown on Drawing No MCX 0582 and 0811 of TRH 1239 *National Motorway Control Systems, Installation Drawings*.

7.42 A hard standing at the base of the gantry ladder and between the ladder, cabinet and point of entry from the highway shall be included, with steps and hand railing as appropriate. Where practical, provision shall be made in the vicinity for a car or light van to drive off the highway clear of other road users. Where space permits, the provision of an adjacent vehicle lay-by behind a gap in any safety fencing for the use of maintenance staff would reduce the risk from vehicle collision while stopped on the hard shoulder.

Construction on Site

7.43 Consideration shall be given to minimising disruption on site. As much of the gantry structure as possible should be constructed off site. Foundations should be constructed in advance of the erection of the superstructure. Where practical, spread footings are usually selected on economic grounds, but piles may be necessary in poor ground conditions, or preferred if their use would avoid disruption of the carriageway surfacing and/or minimise traffic management on highways in use. Templates for both position and alignment of the holding down arrangements should be used, especially when the gantry superstructure is to be erected on foundations constructed by others.

7.44 Significant traffic management is necessary for both the construction of foundations, and the erection of the superstructure and fitting out of gantries to be installed on existing highways. As much assembly of the signs and signals as practicable shall be undertaken on the ground, either at the fabrication shop or nearer the site, prior to erection of the main span member.

Protection of Steelwork

7.45 Steel structures shall be protected by a high specification metal spray and a multi-coat paint system. The protection shall not require any minor maintenance and major maintenance only at intervals of between 12 and 15 years. High build paints will help in reducing the number of coats to be applied under traffic management.

7.46 Hot dip galvanising of steelwork is not generally considered suitable because, in the aggressive environment found along highways, once the zinc coating has reached the end of its life (usually within 15 years), the maintenance work then required is more demanding than for the above mentioned metal spray and paint system. Weathering grades of steel are unacceptable because of their unsatisfactory appearance for such high profile structures.

Corrosion of Holding Down Arrangements

7.47 The area of the holding down bolts shall be designed to be free draining. Consideration shall be given to protecting the tops of bolts by plastic caps filled with an anti-corrosion compound.

Vandalism

7.48 Where it is recognised that gantries are generally at risk from unauthorised entry, particularly where the legs are adjacent to retaining walls, or the possibility exists that the enforcement equipment might be the target of vandalism, a risk assessment shall be undertaken. Where necessary gantries shall be fitted with doors across the bottom of the safety enclosure to the ladder to prevent access to all but the very determined. In Scotland, doors shall be fitted across all access ladders to prevent illegal entry.

7.49 The methods adopted to secure gantries include one or more of the following:

i) Install gates or doors across the bottom of the safety cage on the access ladders
ii) Stop the access ladder short of the ground to which it is necessary to attach a temporary ladder brought to site by the operative
iii) Provide a plank or sheet of metal that can be installed and locked across the rungs of the lower part of the ladder

Use of Over-Bridges

7.50 When the need to support signs and/or signals over the highway can be arranged to coincide with an over-bridge, or possibly a tunnel portal, consideration shall be given to utilising that structure to support them. The feasibility and desirability of doing so will, however, depend on the type, size and layout of bridge to which it is proposed to attach signs or signals, together with the size of the latter. Footbridges and other slim bridges can be dwarfed by large signs. On the other hand, signals can readily be attached beneath the overhang provided on a larger and deeper bridge with a cantilevered walkway.

7.51 The means of attachment to the bridge structure will depend on the form of the bridge, particularly its cross section. Access for maintenance of signal equipment can present a problem and particular attention needs to be paid to preventing unauthorised access. This has the attendant risk of vandalism to both the signs and signals and could afford a place hidden from view from which to drop obstacles onto the carriageway below.

7.52 Before agreeing such a solution, an assessment of the risk of unauthorised access shall be carried out to determine whether the proposal to attach signs and/or signals to an over-bridge should be approved.

Gantries on Elevated Structures

7.53 Occasionally it is necessary to mount gantries over roads that are on elevated structures. This can lead to difficulties in accommodating the holding down arrangements on the bridge or viaduct deck. On new designs of elevated structure this may be achieved by constructing a sponson or blister on the edge of the deck.

Urban Environments

7.54 Gantries in an urban environment present special difficulties, including the following:

i) Space is often restricted
ii) Verges are replaced by footways and the public is close at hand
iii) Buried services are often present to obstruct the construction of foundations
iv) There is an increased risk of vandalism
v) If vehicle speed is below 50mph (80kph) a vehicle restraint system is not required but may be necessary in some situations.
vi) Bulky concrete plinths are highly intrusive in the street scene

Smaller ‘x’ heights may be applicable, resulting in smaller sign areas. Lighter forms of gantry, including cantilevers, may be more appropriate in an urban environment. The implications of traffic management for maintenance on urban roads may be less severe than for motorways. For this reason and because of the higher risk of vandalism consideration shall be given to eliminating the need for a fixed means of access from ground level for both sign and signal gantries.

Features to be incorporated in Design

7.55 The above design considerations provide the user with the opportunity to pick those features for immediate and possible future use needed on the scheme under consideration. A check list of the items that might be included is given in Annex B. By this means many of the necessary requirements can be described and against which new designs submitted for approval can be evaluated.

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BD 15 General principles for the design and construction of bridges. Use of BS 5400: Part 1 : 1988 (DMRB 1.3.2)

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TD 9 Road layout and geometry - Highway link design (DMRB 6.1.1)

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Specification for highway works, SO

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9. ENQUIRIES

All technical enquiries or comments on this Departmental Standard should be sent in writing as appropriate to:

The Quality Services Director
The Highways Agency
St Christopher House
Southwark Street
London SE1 0TE

J A KERMAN
Quality Services Director

The Deputy Chief Engineer
The Scottish Office Development Department
National Roads Directorate
Victoria Quay
Edinburgh EH6 6QQ

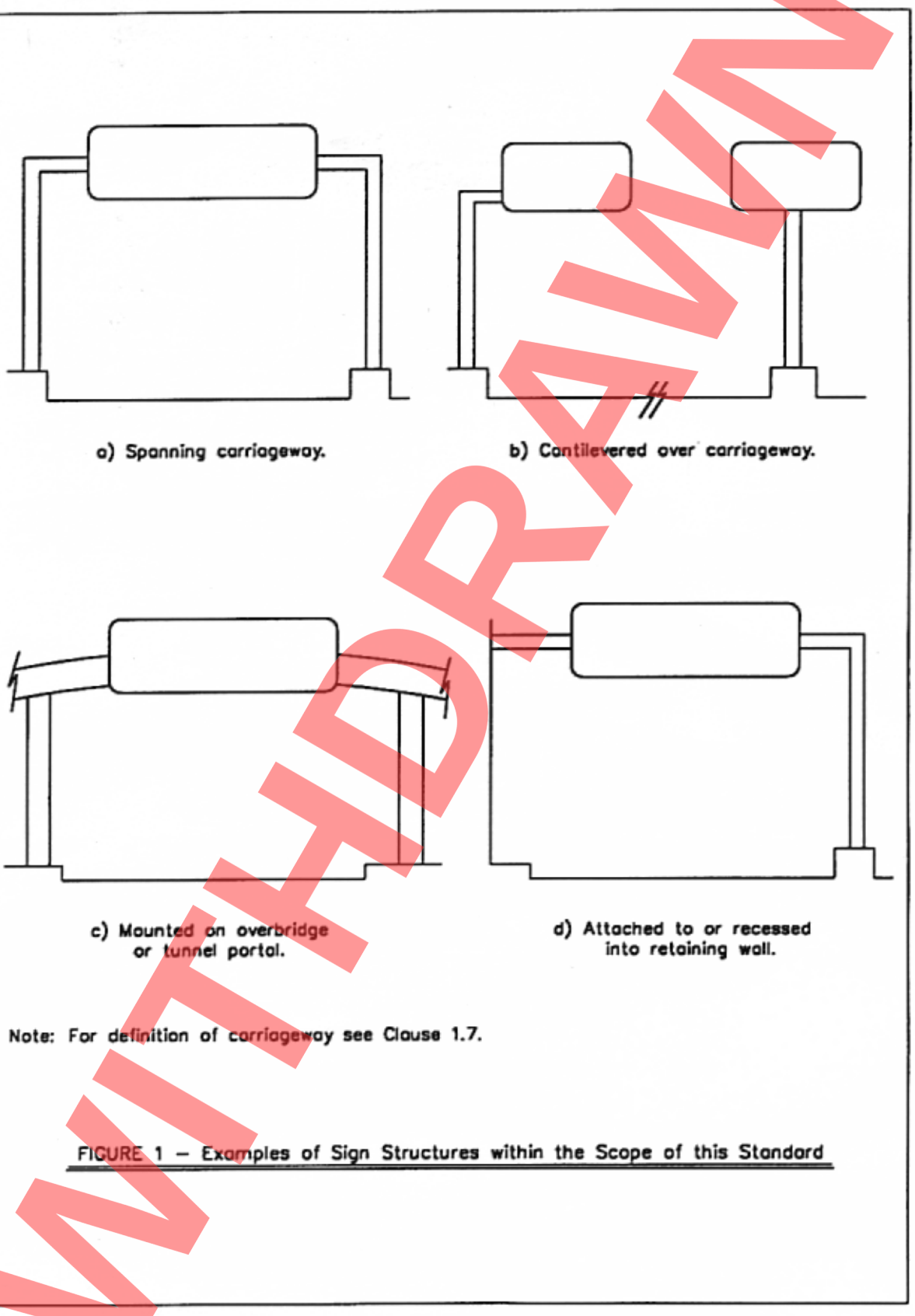
N B MACKENZIE
Deputy Chief Engineer

The Director of Highways
Welsh Office
Y Swyddfa Gymreig
Crown Buildings
Cathays Park
Cardiff CF1 3NQ

K THOMAS
Director of Highways

The Technical Director
Department of the Environment for
Northern Ireland
Roads Service
Clarence Court
10-18 Adelaide Street
Belfast BT2 8GB

V CRAWFORD
Technical Director



Note: For definition of carriageway see Clause 1.7.

FIGURE 1 – Examples of Sign Structures within the Scope of this Standard

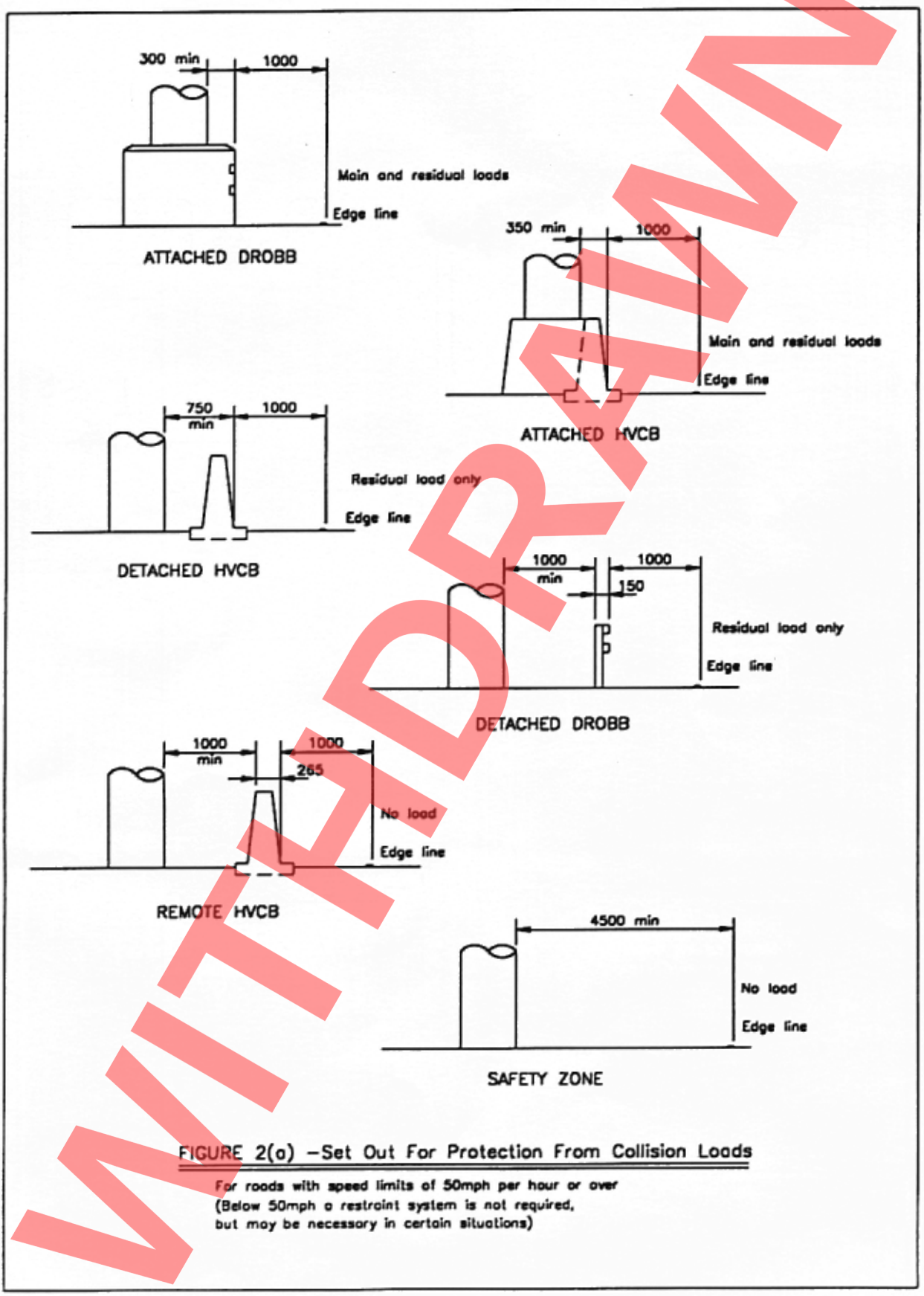
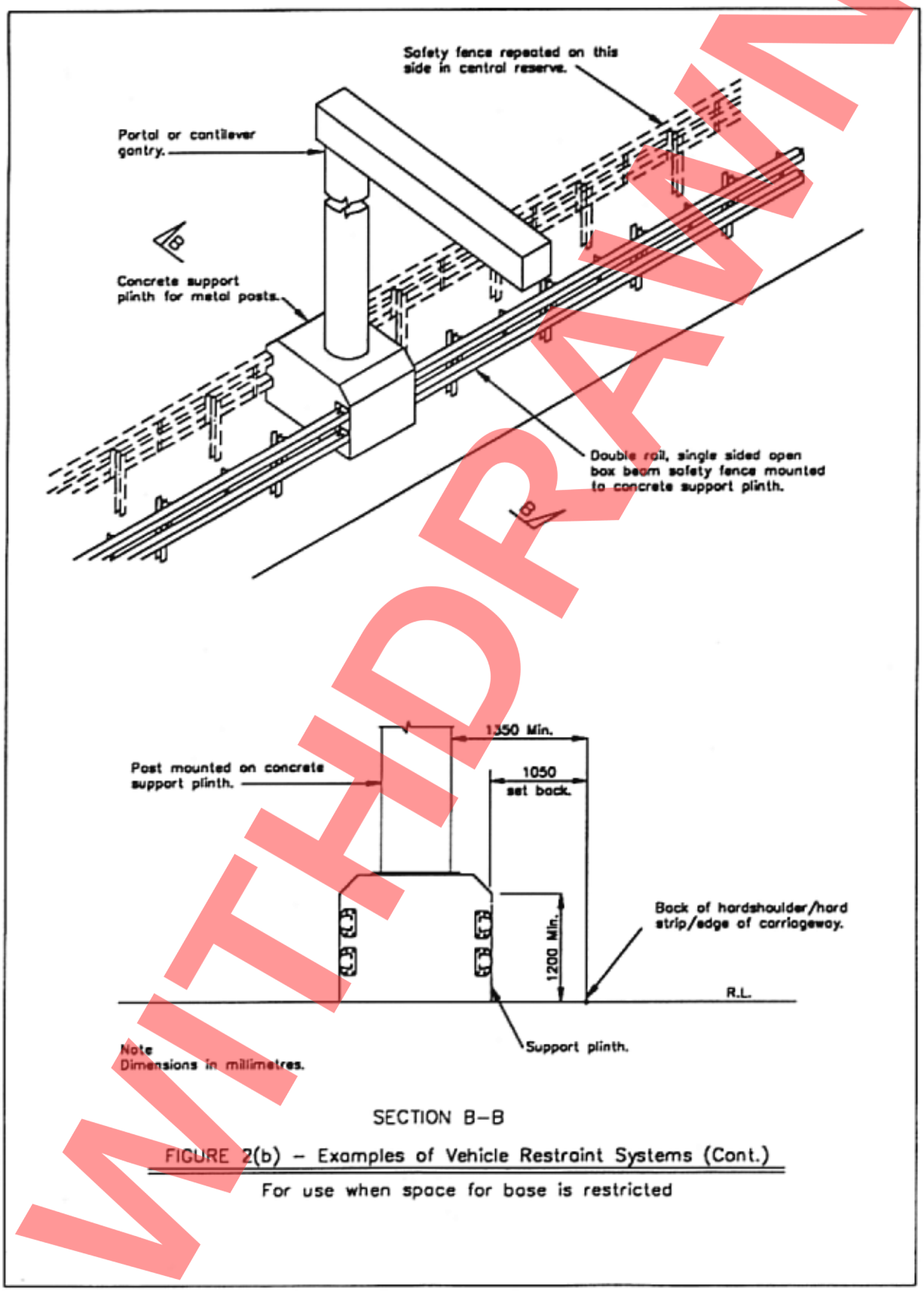


FIGURE 2(a) –Set Out For Protection From Collision Loads

For roads with speed limits of 50mph per hour or over
(Below 50mph a restraint system is not required,
but may be necessary in certain situations)



SECTION B–B

FIGURE 2(b) – Examples of Vehicle Restraint Systems (Cont.)

For use when space for base is restricted

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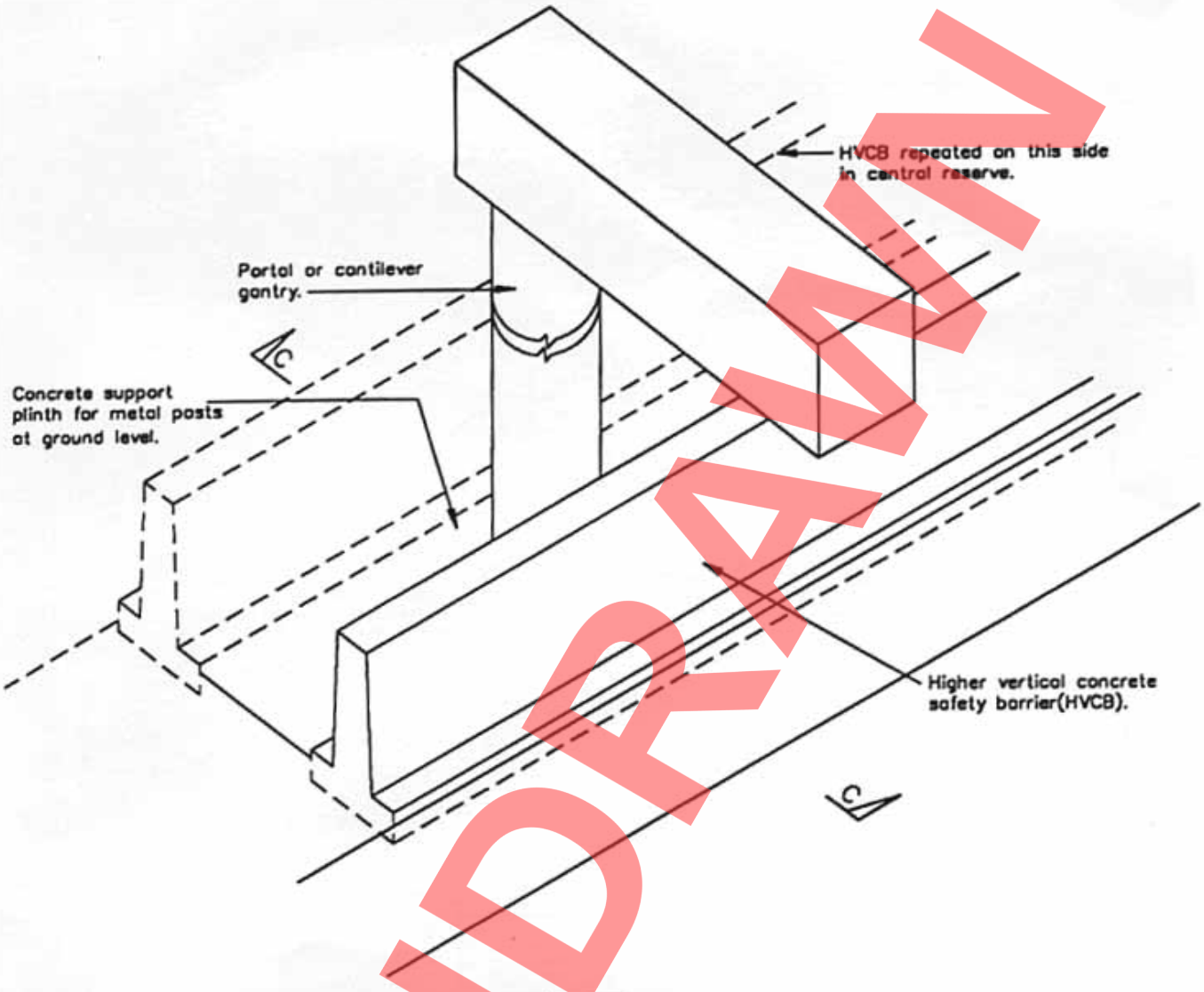

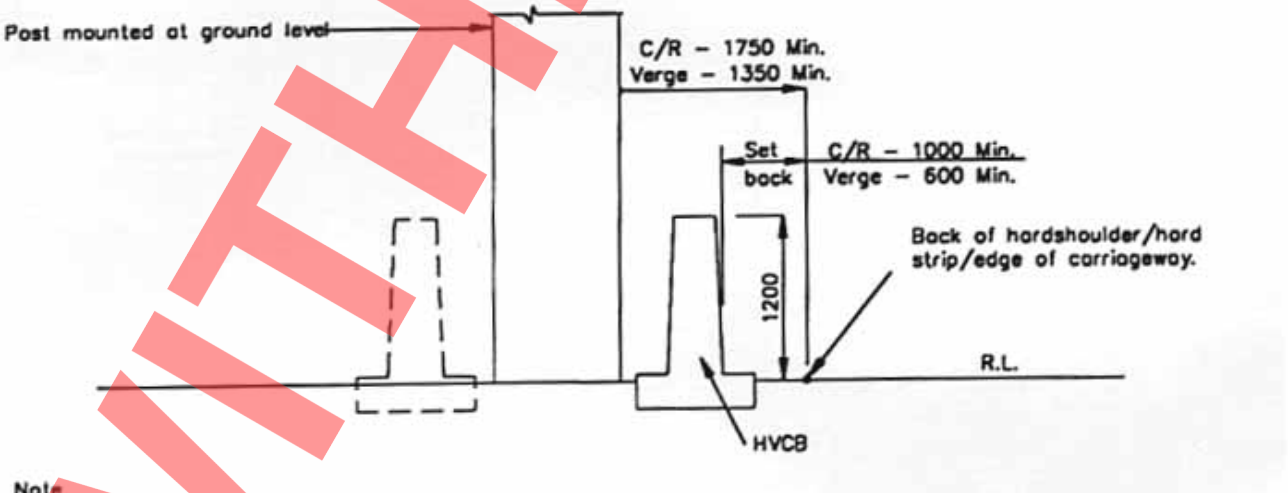

SECTION C–C

FIGURE 2(c) – Examples of Vehicle Restraint Systems (Cont.)

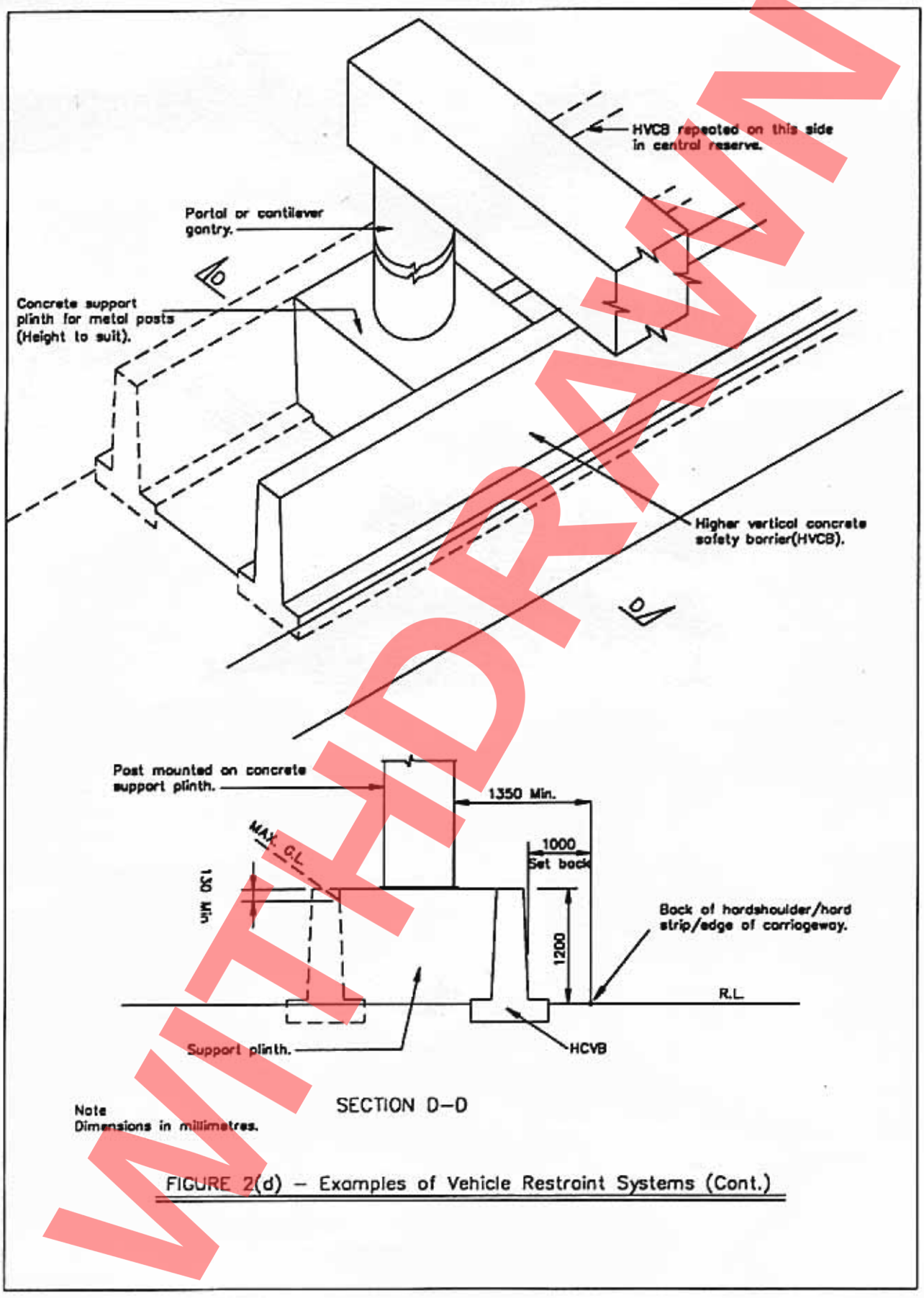

FIGURE 2(d) – Examples of Vehicle Restraint Systems (Cont.)

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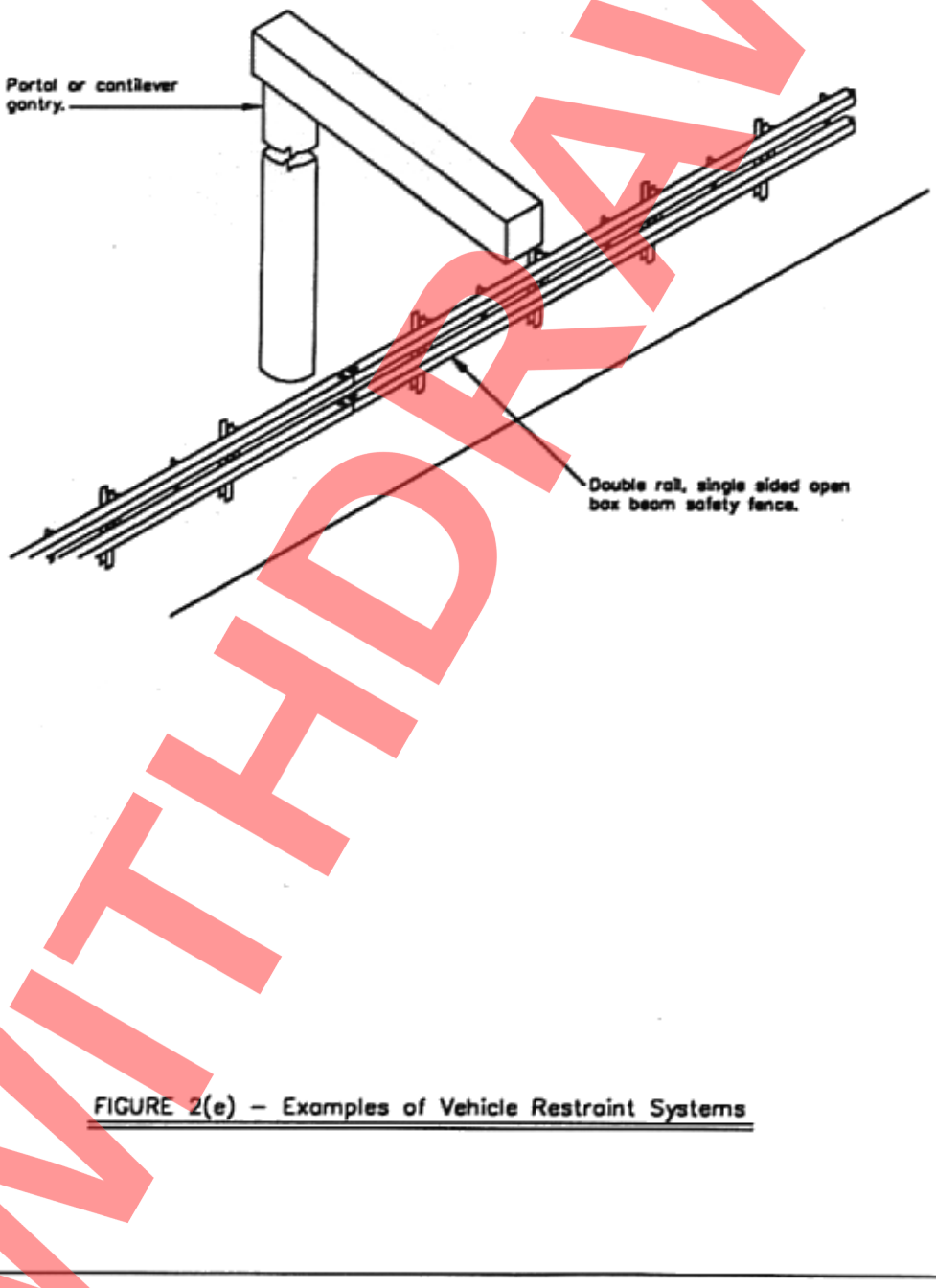

FIGURE 2(e) – Examples of Vehicle Restraint Systems

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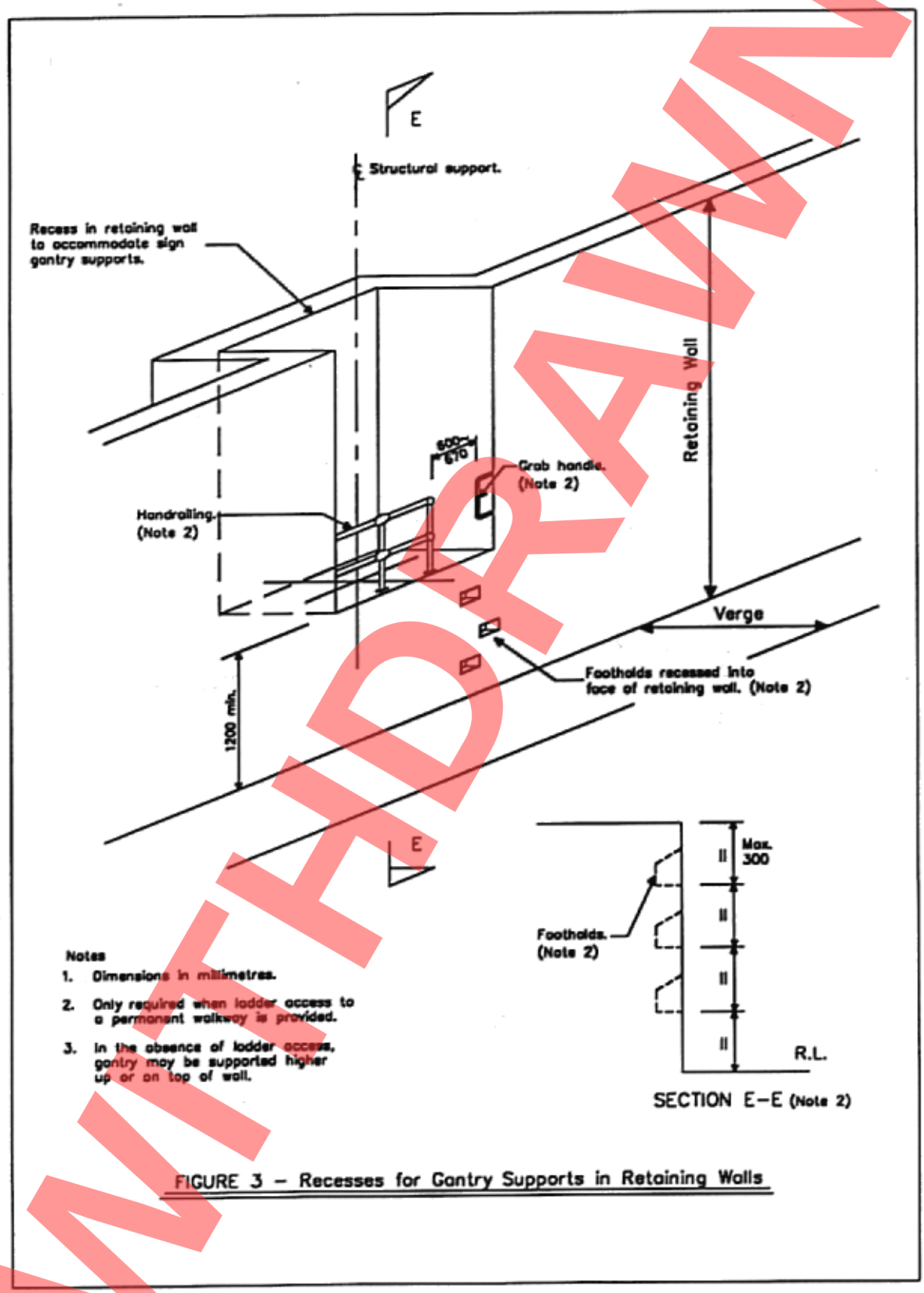
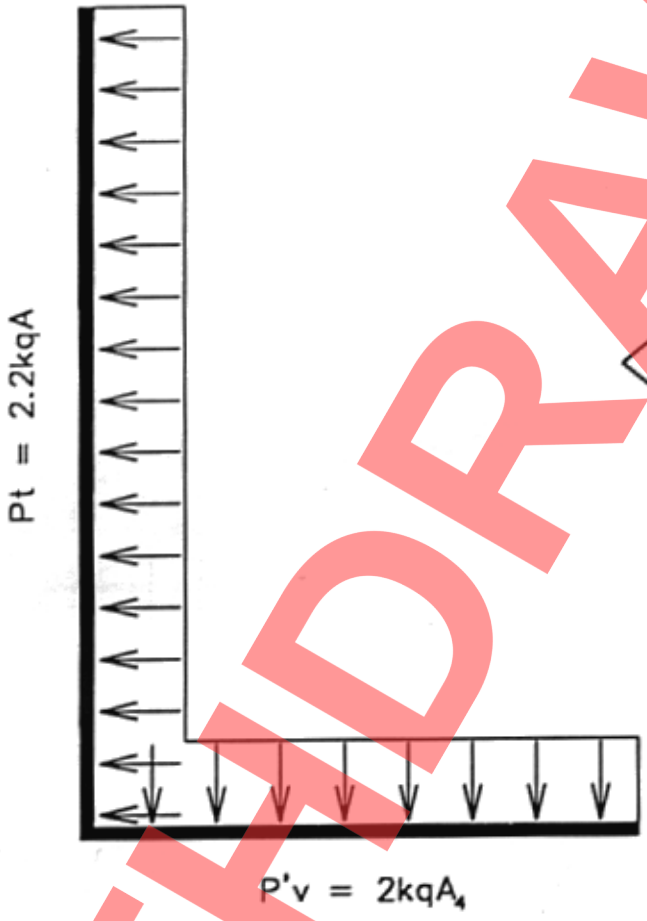


FIGURE 3 – Recesses for Gantry Supports in Retaining Walls



Where k = modification factor as given in Table 1.

FIGURE 4 – Wind Loading on L Shaped Cross Sections with Solid Walkways

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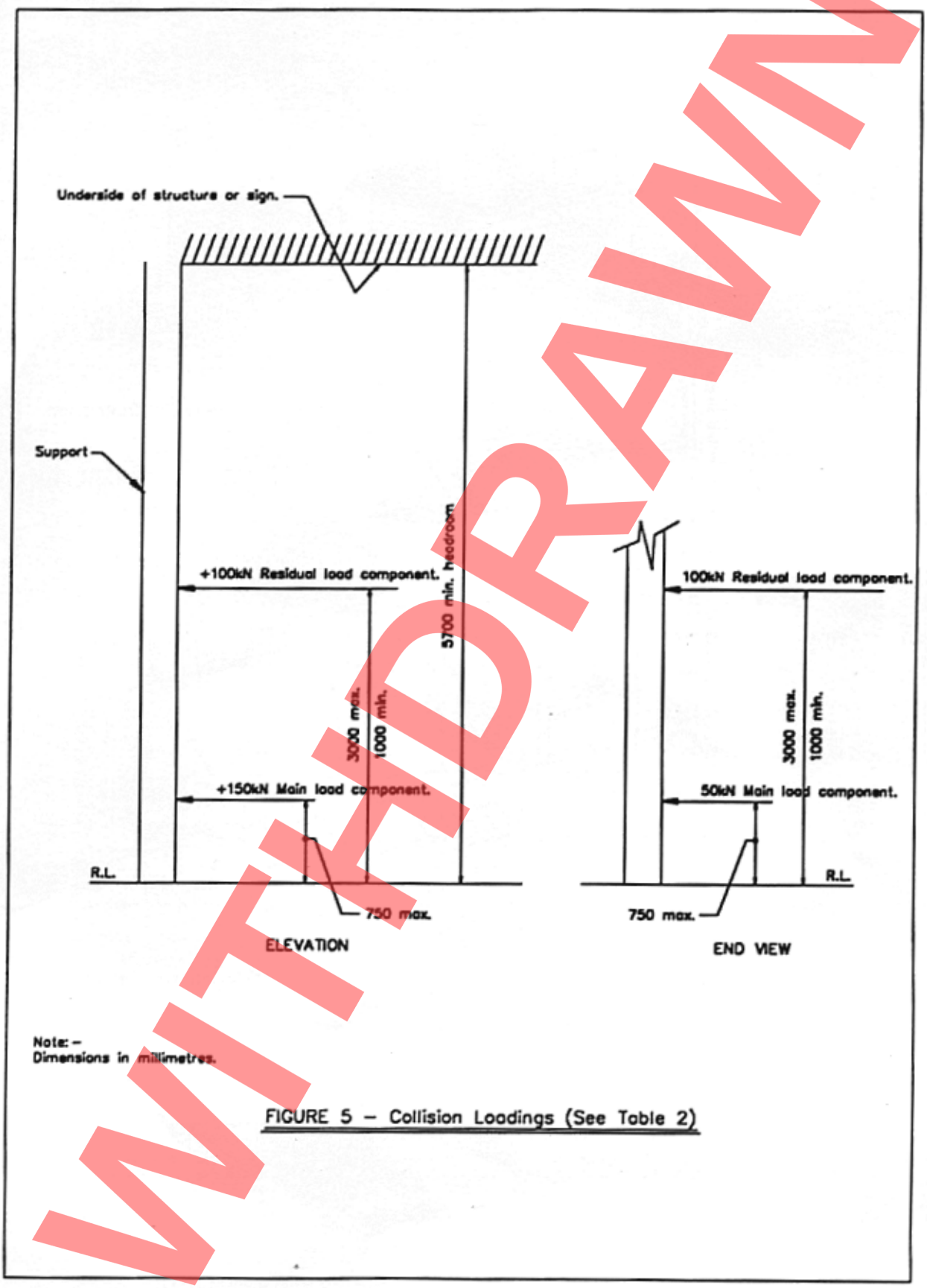

FIGURE 5 – Collision Loadings (See Table 2)

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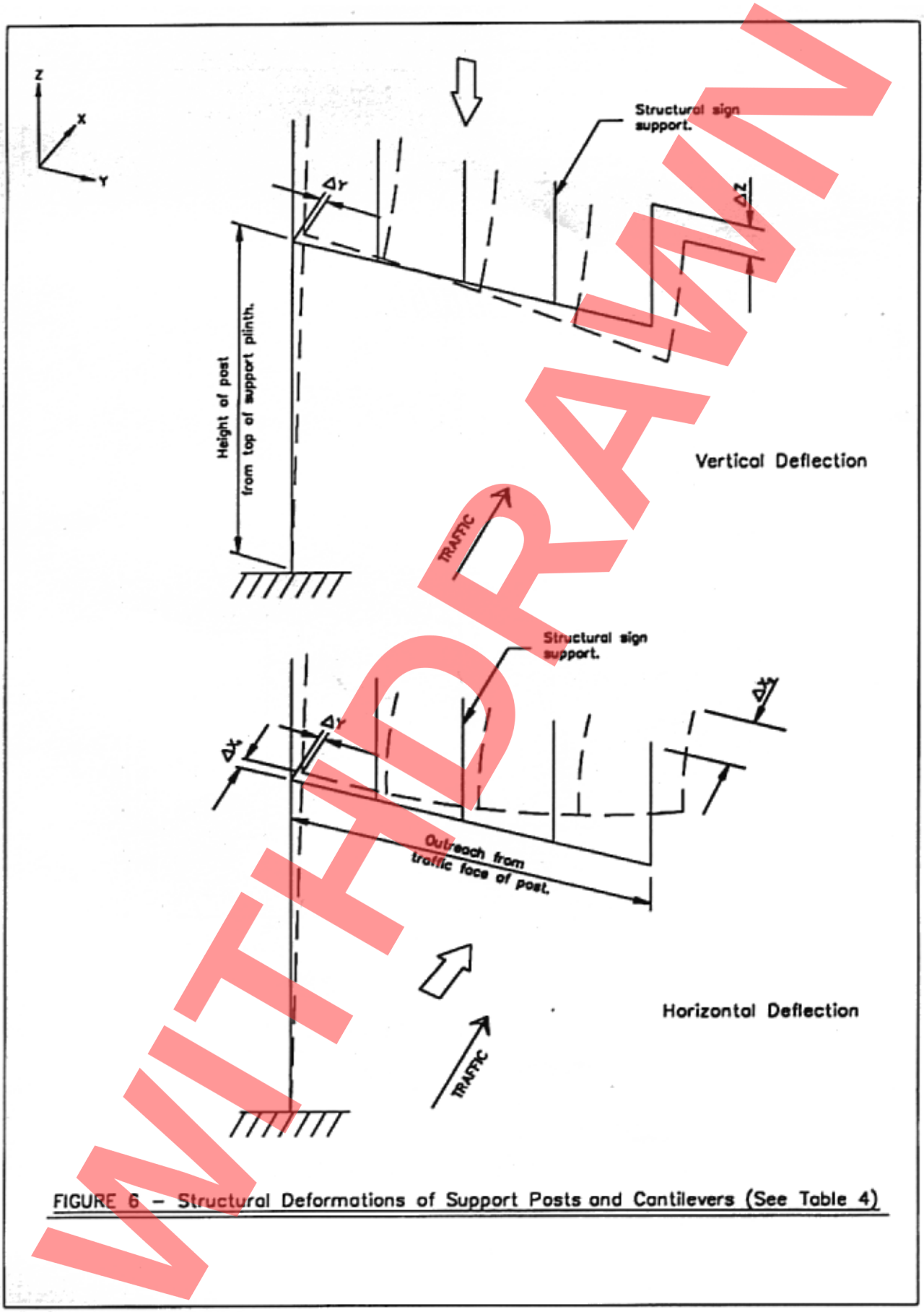

FIGURE 6 – Structural Deformations of Support Posts and Cantilevers (See Table 4)

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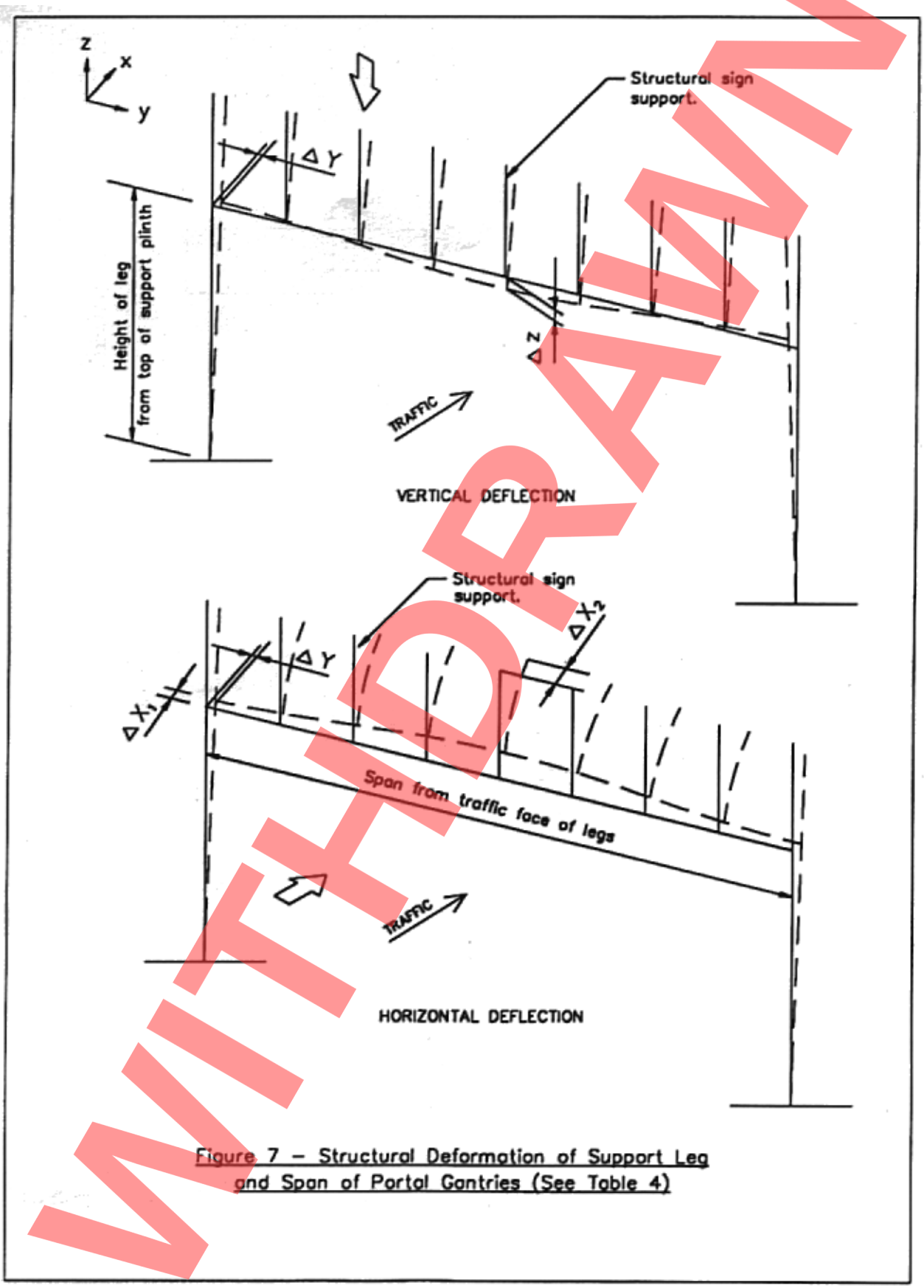

Figure 7 – Structural Deformation of Support Leg and Span of Portal Gantries (See Table 4)

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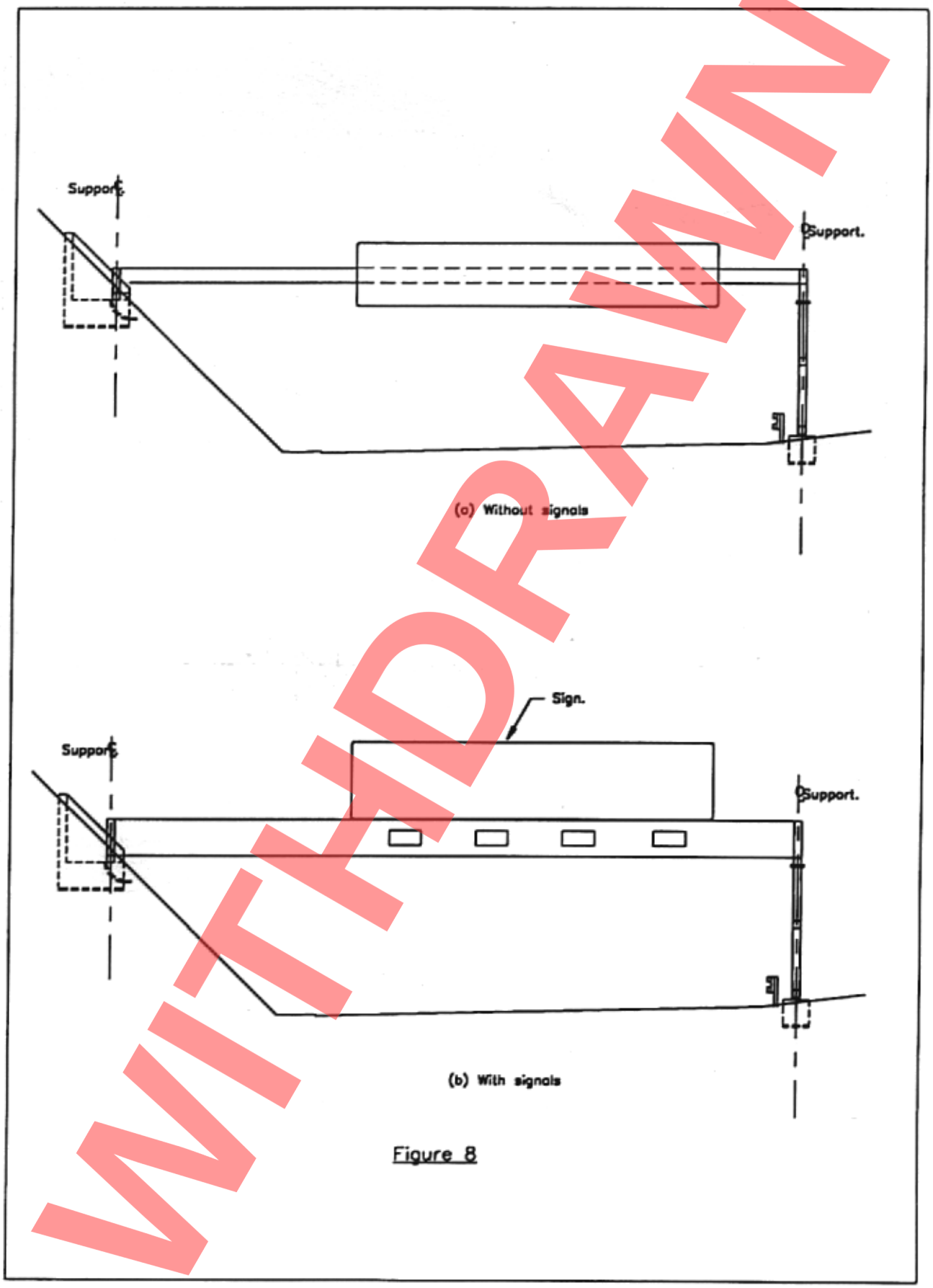

Figure 8

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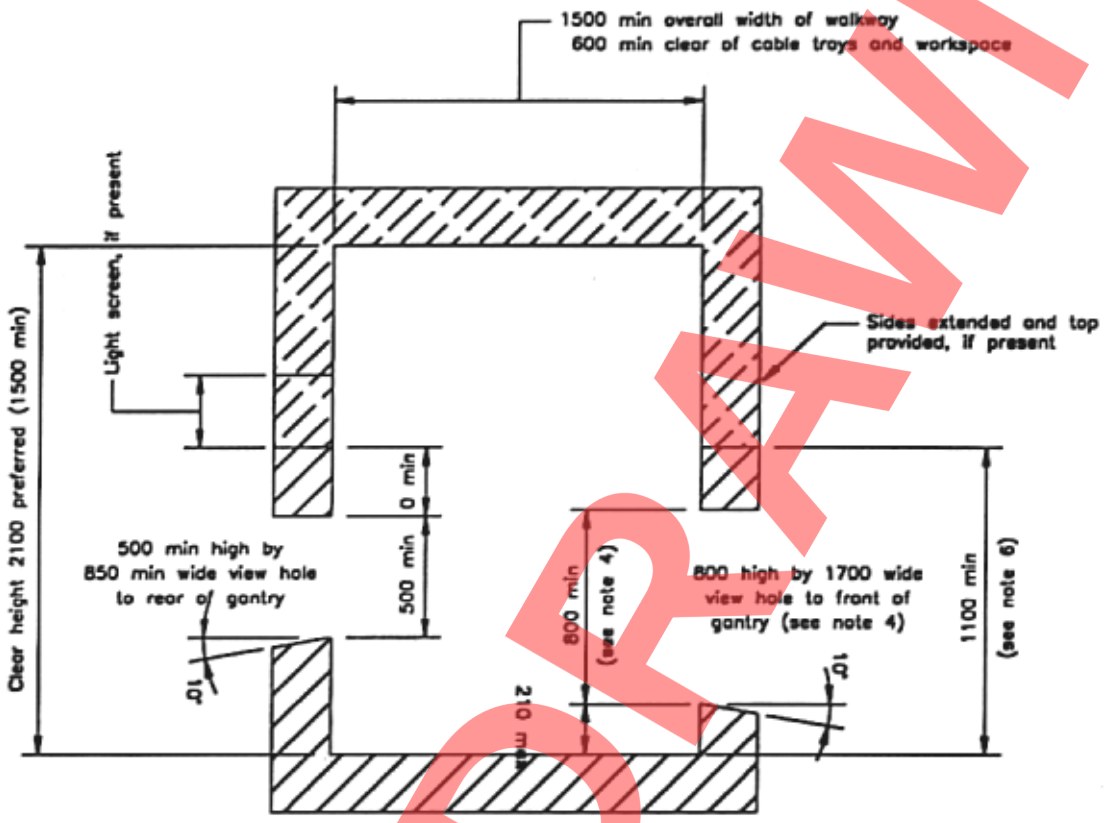

Notes

1. View hole to be positioned centrally over each traffic lane.
2. Structural members of supporting structure to be designed clear of view hole.
3. Width of walkway allows for access beyod opening and for cable trays to be present.
4. Preferably larger for Controlled Motorway Indicators.
5. Dimensions in millimetres.
6. Including to top of luminaires, if present.

FIGURE 9 – Diagramatic Cross Section Of Signal Gantry

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ANNEX B - Check List of Features to be Incorporated in Design

This table may be completed by the design agent for the promoter of the scheme requiring the provision of gantries.

Item No No	Feature	Reference	Requirement
1	Function	1.6	Support signs/signals/other equipment
2	Span arrangement	1.10	Cantilever/single portal/twin portal/other
3	Spans		Specify individual/range (m)
4	Over span	5.10(f & g)	Yes/No
5	Location	5.3 to 5.7	Specify/wind speed for design
6	Signs	2.10, 7.9, 7.10	None/specify No ht x w (m)
7	Illumination of signs	7.12 to 7.14	Specify type: none/external/internal/remote by light tube
8	Retroreflective sheeting	7.11	Specify type, none/type
9	Variable message sign	7.15, 7.25, 7.26, 7.29	None/rotating prism/other
10	Signals	7.20 to 7.28	None/No & position of MS/EMS/EMI/CMI
11	CCTV	7.30	None/location
12	Fixed access walkway/ platform	7.16, 7.31 to 7.33	None/risk assessment/extent/working space/central reserve
13	Ladder access	6.9 to 6.11	None/Yes
14	Access to central reserve	6.3	Yes/No
15	Mounting for signal control equipment	7.34, 7.36	None/location & method
16	Other equipment	7.36, 7.39	None/specify
17	Power distribution	7.38	None/location
18	Lifting facilities	6.2, 6.17	None/location
19	Other parties equipment	7.39	None/specify
20	Security to ladders	7.48, 7.49	None/type
21	Ground works	7.40 to 7.42	None/provision for control/power cabinets/lay by

Item No No	Feature	Reference	Requirement
22	Design life	4.5	No. of years
23	Flexibility in future use	7.17, 7.35, 7.36	Capable of being re-configured and/or re-positioned
24	Use of over-bridge	7.50 to 7.52	No/details
25	On elevated structures	7.53	No/details
26	Colour of structure	5.11 to 5.13	Specify
27	Pull-off for maintenance vehicles	7.42	Yes/No
28	Restraint systems	2.14, 3.26	Yes/No/Dependent on set out (Figure 2a)
29	Other		Specify any other requirement