Traffic management and concrete safety barriers

by A Chequer, J Mitchell and S Thompson

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TRAFFIC MANAGEMENT AND CONCRETE SAFETY BARRIERS

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Executive summary

This report presents a study that has investigated the issues of mounting signs on concrete safety barriers in the central reserve. The design of concrete safety barriers causes problems for the mounting of existing temporary traffic management signs since traditional sign mounting 'A' frames are considered to be unsuitable due to the height of the safety barrier. 'A' frames (which generally straddle the barrier) cannot touch the ground without modification. Various solutions to these problems have been investigated and are described in this report.

Concrete barriers have been widely used within mainland Europe for many years and have several advantages over steel safety barriers. They are narrower than two parallel rows of safety fence, and also do not deflect upon impact, freeing up valuable space for carriageway widening. Their inherent strength and impact resistance means they do not require repairs after accidents and as such are essentially maintenance free.

The solutions for temporary traffic management signs included the provision of temporary brackets to provide anchor points for conventional 'A' frames, retro-fit square post brackets for vertical type sign frames, eyelets mounted on top of the barrier, square post brackets pre-cast into the barrier during construction and establishing guidelines to make best use of current practice.

Permanent signs, such as matrix signals (MS1's), could be securely bolted down to the top of the concrete barrier using anchor bolts. Small permanent traffic signs could be installed into the top of the concrete barrier by fixing sign mounting posts into small diameter holes which are drilled into the top of the barrier and secured either mechanically or chemically using permanent adhesive.

Of the options discussed in this report, in cases where a wide barrier (approximately three times the width of a normal safety barrier) is used to accommodate lighting columns, vertically mounted sockets, built into the concrete safety barrier, to accommodate mounting posts for temporary traffic management signs is the favoured option, both in terms of ease and safe set up. However, in the cases of a normal width 'step' type safety barrier, a favoured solution is to use especially designed mounting brackets and straps to stabilise the sign mounting frames. An alternative solution is to mount steel eyelets on top of the barrier, to which securing straps could be attached to stabilise the sign frames.

Vertically mounting posts for permanent traffic signs, e.g. warning signs, can be appropriately positioned on top of the concrete safety barrier to allow for the laterally positioned re-enforcing bars in the barrier structure.

This report outlines the research and comprises four main areas:

- A study that has assessed current practice for mounting Temporary Traffic Management (TTM) signing on Vertical Concrete Barriers (VCB)'s. Current practices include the use of conventional sandbags plus webbing straps which tie sign frames to adjacent road furniture.
- A survey of TTM experts to gauge current opinions on the subject. Those consulted include Highways Agency Area Teams, the Traffic Management Contractors Association, Britpave, manufacturers of concrete barriers, and sign frame manufacturers.
- A questionnaire based survey of Highways Agency Area teams to establish the different types of permanent traffic sign located in the central reserve on the motorway and major trunk road network.
- A description and discussion of the various available solutions and recommendations for both permanent and temporary traffic management signs.

1 Introduction

The requirement to increase the capacity on some very busy stretches of motorway by increasing the number of traffic lanes has resulted in a reduction of the physical width of the central reserve. Partly as a result of this action, there has been an increase in the use of concrete safety barriers.

The Highways Agency has also issued an Interim Advice Note (IAN60/05) requiring that on the central reserve of motorways with an AADT greater than 25,000, a concrete safety barrier of H2 containment class, Working Width Class of W2 and with a maintenance free serviceable life of 50 years, must be installed on new schemes where the safety barrier is to be replaced. A particular type of concrete barrier, referred to as the 'Concrete step barrier', will be widely used in future in the central reserve due to its proven H2 containment level.

Safety concerns have been raised about the installation of temporary traffic management signing in the central reserve on existing stretches of motorway where concrete safety barriers are used. There are inherent problems with instability of sign mounting frames ('A'-frames), which are often wedged across the concrete barrier and weighed down using sandbags as ballast. This is illustrated in Figure 1:

Figure 1: Conventional 'A' frame in-situ on concrete barrier

The installation requirements for any vertically mounted permanent signs in the central reserve have also been considered. These signs are usually matrix warning signs (MS1) requiring mains power.

2 Objectives

The objective of the study is to conduct a review with the aim of finding how the erection of temporary traffic management and permanent signing in the central reserve with concrete barriers should be managed. This review covers both wide and narrow central reserves and also considers aspects relating to power supplies and services.

3 Methodology

To address the objectives of this review, the methodology adopted was to:

1. Establish current practice on the HA network by contacting those bodies responsible for the maintenance of motorway sections that include concrete safety barriers. Those bodies would include Highways Agency staff, maintenance agents, and traffic management contractors.

2. Review the new draft standard BS 8422, which specifies the wind loading and stability requirements for sign mounting frames.

3. Establish, from sign frame manufacturers, what products are currently available on the market and to investigate possible ways of modifying current frame design to accommodate the different types of concrete safety barrier.

4. Establish what types of sign mounting arrangements are used in the Netherlands and other EU countries where concrete step barriers in the central reserve have been used for a number of years.

5. Investigate the development of a specification for standard mounting sockets in a concrete barrier to accommodate frame posts for vertically mounted signs. The need for an electrical connection at each socket for any mains powered signs was also investigated.

4 Current practice

4.1 Observations of selected road work sites

Drive-through observations of temporary traffic management signing at a road works site, with concrete safety barriers in the central reserve, were carried out between Junctions 11 to 15 of the M25 where work is currently being completed to widen this stretch of the motorway from four lanes to five.

To accommodate the additional lanes, a concrete safety barrier has been installed in the central reserve as can be seen in Figures 2 to 4 below.

Drawings showing the different types of concrete safety barrier used in the central reserve on the HA network are to be found in Appendix 1.

The most common types of temporary signs found over the whole length of the site were mounted on 'A' -frames which were stretched across the concrete safety barrier, as can be seen in Figure 2. This is not considered a satisfactory installation arrangement, since the sign sits slanted across the barrier.

Figure 2: Sign mounted on an 'A' frame stretched across a concrete safety barrier

Signs were also observed to be mounted on 'A'-frames which are located on the top of the concrete safety barrier where the top of barriers were wide enough to locate the base of the 'A'; frame (see Figure 3). Again, ballasting in the form of sand bags was used to provide stability for the sign.

Figure 3: Sign with 'A' frame located on the top of a concrete barrier

A number of the ‘A’ frames were observed to be strapped to lamp columns using webbing straps with a plastic buckle to tighten or release the strap. This can be seen in Figure 4 below.

Figure 4: ’A’ frames secured to lamp columns by webbing straps

Also seen in the works area were a small number of temporary traffic management signs, e.g. diagram 610 arrow signs, mounted on vertical posts which are permanently fixed into the concrete barrier, see Figure 5 below.

Figure 5: Temporary traffic management signs mounted on vertical posts in the central reserve

4.2 The Traffic Management Contractors Association (TMCA)

Results are presented in this section for a questionnaire which was sent to the TMCA. Both the questions asked, and the answers obtained, are shown. The questionnaire can be found in Appendix 2 and TMCA contact names can be found in Appendix 4.

1. *TRL: What types of sign (by shape and size) do you use in the central reserve?*

   TMCA: This could be any sign as required by Contract Specification in accordance with Chapter 8 of The Traffic Signs Manual (1991) and Traffic Signs Regulations & General Directions, the signs can be up to 3.5 metres wide if sufficient width is available, and up to 5 metres high.

2. *TRL: What means do you currently use to locate temporary and permanent signs in the central reserve, which have the following types of safety barrier? :*

   - Concrete barriers,
   - Steel beams,
   - Wire rope safety fences.

   TMCA: Quick fit frames, ballasted with sandbags and/or tied with rope/straps to safety fence or lighting columns.

3. *TRL: Are the systems which are currently available for locating temporary and permanent signs to concrete barriers satisfactory? If not, what system would you propose for locating such signs in these circumstances?*

   Note that any systems proposed will need to satisfy the stability requirement of the new British Standard BS 8442 (due to be published at the end of March 2006).

   TMCA: The problem is with the higher concrete barriers, the standard quick fit frames are not suitable without extending the legs and raising the cross-members.

   If appropriate sockets were installed within the concrete barriers then proprietary quick fit barrier frames could be installed. However these frames are only suitable for smaller type signs, not larger than WBM signs (e.g. signs for contra-flow working) required on type A works.

   In some areas, i.e. where motorway widening has occurred, the width of the central reserve limits the size of signs available for use. Some guidance on this aspect is required as Client's/Managing Agents do not fully understand the problems and some are reluctant to extensively vary from The Traffic Signs Regulations and General Directions 2002 (TSRGD, 2002).

4. *TRL: What problems do you currently experience fixing signs to these barriers, beams and fences?*

   TMCA: As above.

5. *TRL: What do you currently do to counteract these problems?*

   TMCA: Purchase/fabricate bespoke sign frames/fixings. On the newly widened M25 Junction 12 – 15, slots have been installed in the central reserve at appropriate locations, which work fairly well with purpose-made frames. However, the maximum width of sign which can be used is 1.8m. (The profile of the slots used is shown in Appendix 5.)

6. *TRL: When external lighting of signs is required, what lighting system(s) and power source(s) do you use?*

   TMCA: Battery operated white lights.

7. *TRL: How often do you experience problems with the stability of the signs and their frames?*

   TMCA: Intermittently, problems are also encountered for nearside signs where little or no verge exists, or if the safety fencing is at limited set-back to rear of hard shoulder.

   Furthermore, the current trend of installing high containment barriers (i.e. Sistema) in front of existing parapets will create increasing future problems in placing nearside signs, as these barriers cannot be straddled with signs/frames.

4.3 The Highways Agency

Results presented in this section are for the questionnaire sent to the Highways Agency. The responses given by each of the area managers for each of the questions asked are tabulated. The questionnaire can be found in Appendix 2 and the list of Highways Agency contacts can be found in Appendix 4.

1. *TRL: What signs (temporary and permanent) are typically used in the central reserve on the HA network?*

The responses given by the area managers are shown in Table 1 below:

HA Response given	HA area
The only permanent signs are the matrix signs that stand alone. Temporary signs are for traffic management and dependant on type (A or B) could be for overnight work or some duration, obviously this would cover a multitude of signs.	1,7, 9
Permanent MS1 matrix signs throughout the network plus fixed text message signs (rotating prism) to facilitate type B tunnel closures at Hatfield, Holmesdale and Bell Common. Similar signs also exist on approaches to the Dartford Crossing. Permanent warning signs are also present on approaches to all tunnels and offside lane drop arrangements at A1(M) Jct 6 Northbound, M1 Jct 5 to 4 Southbound and M11 southbound approach to A406. Type A and B temporary chapter 8 signing employed throughout the network.	5
We put out our normal advanced notice and tapers prior to any concrete walls; it does not cause problems in positioning, stability and manual handling for ourselves.	4
There are also signs associated with lane gain/ lane drop and warning signs such as 'slow lorries' etc.	2

Table 1: Permanent and temporary signs in the central reserve on the HA network

2. *TRL: Are you aware of any problems, if so, what have they been?*

The responses given by the area managers are shown in Table 2 below:

HA Response given	HA area
As long as the frames are secured there should not be a problem. The installation and removal does necessitate crossing of the live carriageway and any reduction in that would be welcome	1, 7, 9
Chapter 8 provisions has been problematic within sections of VCB, where socketed sign frame provision has not been made or where reserve width is too narrow to safely accommodate a standard 'wicket' sign. This problem is particularly prevalent on wider sections where TM signing and tapers will have to commence within preceding 4 lane (max) sections. Increasing closure lengths.	5
We have to put out long sites than required. It does not help the travelling public as they have extended sections of the highway with restrictions.	4
There are problems when the centre reservation is of insufficient width to accommodate the signs. This tends to occur on the elevated sections. Typically we try to avoid erecting signs in these situations by extending the length of the TM (increased user effect & reduced working window) by erecting the signs prior to the restricted area. On other occasions we have made special brackets to mount the signs on the parapets.	2

Table 2: Problems occurring with signing in a central reserve using concrete safety barriers

3. *TRL: If so, what safety issues are you aware of?*

The responses given are shown in Table 3 below:

HA Response given	HA area
Only crossing of the carriageway, however, as long as the men are fully trained, certificated and inducted into company method statements and risk assessments, there should not be too much of a problem.	1, 7, 9
In addition to narrow width and encroachment issues adjacent to live lane, the provision of widened sections places increased risk on the TMC activity of setting and removing TM signs through the multiple operative crossings of live lanes.	5
The men are on the network for longer installing/removing extended traffic management.	4
There are risks associated with signs falling/ blowing into the carriageway. Additionally if the barrier can not be easily crossed by the operatives there would be less opportunity to get into positions of safety.	2

Table 3: Safety issues associated with signing and concrete safety barriers in the central reserve

4. *TRL: Similarly, what operational issues are you aware of?*

The responses given by the area managers are shown in Table 4 below:

HA Response given	HA area
Sizes of signs, particularly on elevated sections together with numbers of cones and lamps that need to be carried severely reduce the length of works that can be achieved. Time spent installing and removing traffic management has an impact on the window of working.	1, 5, 7, 9
Increased cost, both time and materials, reduced worksite availability.	4
Theft of traffic Management is sometimes an issue and manual handling issues if the signs need to be lifted too high.	2

Table 4: Operational issues associated with signing and concrete safety barriers in the central reserve

5. *TRL: Are you aware of any possible solutions?*

The responses given by the area managers are shown in Table 5 below:

HA Response given	HA area
In areas where overhead gantries are abundant, greater use of these could be made for lane closures; it is generally thought by the operatives that the travelling public take more notice of them than the wicket signs anyway. Gantries throughout the Birmingham Box are used to assist Traffic Management operations, i.e. Red 'X' over lanes; operatives views are that these red 'X's should remain on throughout the duration of the works. However, current process is they only remain on whilst Traffic Management is installed and removed.	1, 7, 9 9
Provision of fixed text message signs at all cyclic closure sites i.e. tunnels and elevated sections and extend to frequently used safe taper locations. Vertical concrete barrier installations should be socketed at 200m centres.	5
Sign mountings on the wall might be a way ahead. Sockets in wall at appropriate centres.	4
Possibly introduce permanent 'rotating plank' signs at key locations. We believe that this is done on the tunnels in North Wales so that regular maintenance contra-flows can be set up easily.	2

Table 5: Possible solutions to safety and operational issues associated with signing and concrete safety barriers in the central reserve

6. *TRL: One possible solution could be the use of permanent fixtures in the central reserve e.g. sockets and the provision of power points. Do you have any views on this?*

The responses given by the area managers are shown in Table 6 below:

HA Response given	HA area
This would be a good move, however, the main benefit would be in areas of high congestion but this would then present operational problems as we may lose the flexibility that temporary traffic management offers. This is particularly so at strategic junctions where motorways merge and diverge.	1, 7, 9
Unless installed at regular intervals, such points would dictate traffic management taper locations and lead to excessive length of closures. Furthermore the infrastructure would need regular maintenance and testing to reduce the number of closures being cancelled due to power point failures.	5
As above, sockets seem the most sensible solution short term. Ultimately going for remote activated permanent signage for known critical, regular TM sections.	4
With the development of increasingly better standards of reflective sign face materials, it would be advantageous to revisit the TSRGD with a view to removing the requirement to illuminate temporary signs. This would remove a large number of 'issues'. Permanent sockets in the barrier systems to accommodate signs.	2

Table 6: HA managers views on the use of permanent fixtures, such as sockets, in the central reserve

4.4 Permanent signs located in the central reserve

The results of the questionnaire based survey, which was sent to different Highways Agency Area teams, showed that Matrix signals (MS1) are the most common type of permanent sign located in the central reserve of a motorway. They are usually located at 3km intervals, but they can occur more frequently. Where concrete barriers have been installed in the central reserve, the mounting posts for these matrix signals are bolted down on top of the concrete safety barrier using four retaining bolts.

- Fixed text message signs (i.e. rotating prisms) are also present in at least one Highways Agency area; these signs are used to facilitate temporary road closures in both tunnels and bridges.
- Permanent warning signs are also to be found in the central reserve of both motorways and dual carriageways. These signs are often found on the approaches to tunnels and on steep inclines, where they are used to warn of slow moving vehicles.
- Informatory signs, which are often associated with lane drop or lane gain, are also found in the central reserve.

In the case of a double safety barrier, such as is found on some sections of the M25, to accommodate permanent traffic signs, a sign post socket 500mm deep, surrounded by non–reinforced concrete is positioned between the two concrete safety barrier sections. The concrete surrounding the sign post socket also includes longitudinal cable ducts for motorway control signals and mains power for street lighting, etc (a diagram of this arrangement is shown in Appendix 5).

4.5 Britpave/ Extrudakerb

Britpave were aware of the new Highways Agency policy in Interim Advice Note 60/05 requiring safety barriers with H2/W2 performance and a maintenance free life of fifty years on motorways. To implement these new performance requirements the type of concrete safety barrier to be adopted would be of a 'Step' type, which is not currently used extensively on the motorway network (see Appendix 1 for an illustration of the step type of barrier).

For the installation of small permanent traffic signs, e.g. triangular warning signs, to concrete safety barriers in the central reserve, Britpave said that their recommended method of securing the mounting posts for these signs would be to drill small diameter holes in the top of the concrete barrier and fix the mounting posts, either mechanically or chemically using permanent adhesive.

For fixed signs requiring mains power, i.e. MS1 matrix signs, the sign should be mounted to a vertical post on the top of the barrier and mains power would be supplied to the sign via cable ducts as is usually the case for powering external lighting columns.

For signs mounted on 'A' frames, Britpave agreed that frame securing brackets mounted on the top of the barrier could be a satisfactory solution to the frame stability problem. However they would prefer a solution such that the brackets are easily removable at the completion of the works. Britpave do not have any experience of what techniques are used in other countries, for example in France and the Netherlands, where there is a common occurrence of concrete barriers in the central reserve.

4.6 Sign frame manufacturers

UK sign frame manufacturers, some of which are members of The Association for Road Traffic Safety and Management (ARTSM), were approached and asked what sign frames they currently manufactured to mount both temporary and permanent signs to concrete safety barriers located in the central reserve. The manufacturers were also asked if they had any plans for designing and/or making such frames in the future. They were also invited to suggest any possible designs for such a frame. The responses given by each of the sign manufacturers are shown in Table 7 below:

Sign manufacturer	Current situation	Suggested designs or modifications to exiting frames
Altaroute Ltd	Holes are drilled in the sign mounting 'A' frames to accommodate expanding anchor bolts (commonly known as Hilti bolts), which are located into holes drilled into the top of the concrete barrier.	N/a
Morelock Signs Ltd	Morelock are one the major manufacturers of sign mounting 'A' frames and posts for permanent signs in the UK. They do not currently manufacturer any specific sign mounting frames for temporary or permanent signs; however they have designed sign securing brackets for 'A' frames to concrete barriers.	See Section 6 below
Sullivan Holdings Ltd	Sullivan's are one of the major manufacturers of sign mounting 'A' frames in the UK. They were not aware of the problems with installing mounting frames for temporary or permanent signs to/over concrete barriers. The largest frame size they manufacturer ("WMB": 1500mm wide by 3500mm high) have additional locking bars to improve the rigidity of the frame.	Modify the smaller size 'A' frames to accommodate locking bars to improve the rigidity of the frame. No suggestions were forthcoming on how to anchor the frames. There is the need to be aware of any additional cost implications of fixing brackets, etc.

Table 7: Responses given by sign frame manufacturers

4.7 The Netherlands, other EU countries and the United States

A questionnaire, the details of which are shown in Appendix 3, were sent to a number of European government research institutes and other relevant organisations including a private consultant and a Highways authority in the United States. These organisations approached included the Dutch Ministry of Transport, the German Federal Highway Research Institute (BASt), two government bodies in France (Setra and LCPC), a Danish independent consultant, an Italian university and the United States Federal Highways Authority.

The purpose of this questionnaire was, through a number of specific questions, to establish the current practice in each of the countries approached regarding the installation of both permanent and temporary traffic management signs to concrete safety barriers that are located in the central reserve of a motorway and other dual carriageways, highlighting any relevant operational or safety issues.

Unfortunately, despite reminders being sent to a number of the above organisations, no completed questionnaires were received during the timescale of this project.

5 Review of draft standard BS 8442

This new draft standard, BS 8422, specifies that the height of the lower edge of an erected sign (or supplementary plate) should not be less than 300mm above the supporting surface. It also specifies the maximum tilt back angle of the sign from the vertical position, which is 22.5 degrees. It clearly states that if a microprismatic retro-reflective material is used, the sign needs to be mounted vertically.

BS 8442 offers three classes of resistance to wind loads, which are specified via three effective wind speeds: 8.7, 17.6 and 28.3 m/s. The lowest specified wind speed, 8.7 m/s would be appropriate for light breezes and for road works only present for short time durations; the highest wind speed, 28.3 m/s would be appropriate for long-term road works.

The standard states that any sign mounting assembly would need to be designed to allow the use of ballasting, so that the sign assembly is able to resist the specified wind speed classes. The sign frame manufacturer would also be required to indicate both the mass of the ballasting, which is required to resist these wind speed classes, and to indicate the positioning of the ballasting on the sign supports.

Any sign mounting frames, proposed or designed by sign frame manufacturers, would need to satisfy the stability requirement of this new British Standard.

6 Modification of current frame design

After becoming aware of this study, one UK sign frame manufacturing company, Morelock signs Ltd, have designed two alternative types of bracket to secure the sign mounting 'A' frames to concrete safety barriers. Drawings of both types of design of securing bracket are shown in Appendix 6.

Figure 6 below illustrates where both types of securing bracket would be permanently located on the top of a concrete safety barrier.

It is proposed by the manufacturer that the simpler design **type A** bracket would be mounted on the top of the concrete safety barrier and secured using epoxy resin or chemically bolted. The more elaborate **type B** bracket would be fitted over the top of the barrier and screwed securely into place using turnkeys.

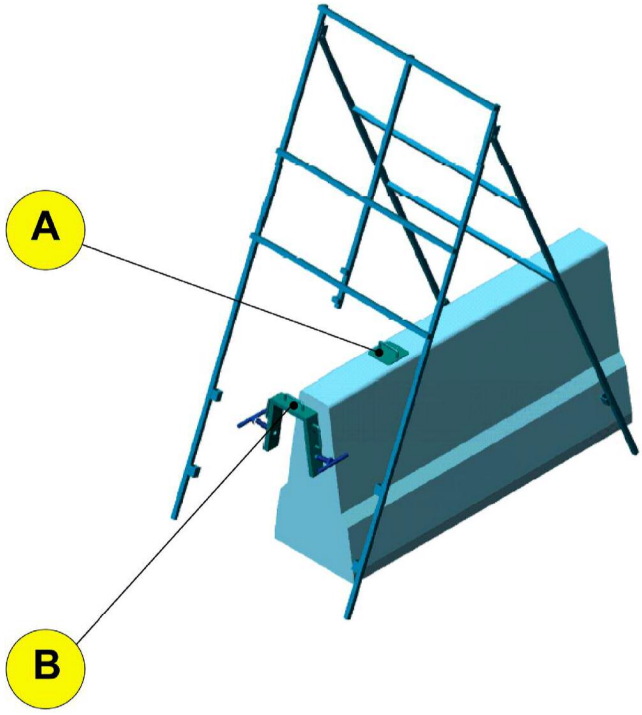

Figure 6: Location of 'A' frame securing brackets on a concrete safety barrier

The sign mounting 'A'-frame would be secured to either type of bracket by means of 'Smartlock' straps. Technical specifications of this type of strap and recommendations for its use are given in the Appendix 7.

Neither type of frame securing bracket have been used so far on a 'live' road works situation and it has been proposed by the manufacturer that these securing brackets be trialled on a live motorway with concrete safety barriers sometime in the near future.

Safety concerns have been raised regarding any incidents which might occur at the location of one of these safety brackets in the central reserve, one particular concern is the risk of a serious injury to a motorcyclist if they hit one of these brackets which has two protruding turnkeys. These safety issues are still outstanding.

7 Retrofit mountings for vertical sign mountings.

TRL's review has established that square-post vertical sign mountings have been in use on VCBs for some time in the United States. As well as cast-in-place post mountings (see Section 9), designs exist for sockets which may be bolted to the top of the barrier as shown in Figure 7 below: The anchor bolts for the retrofit mountings are filled with approved epoxy grout in the drilled holes (either 1.5" or 2" diameter).

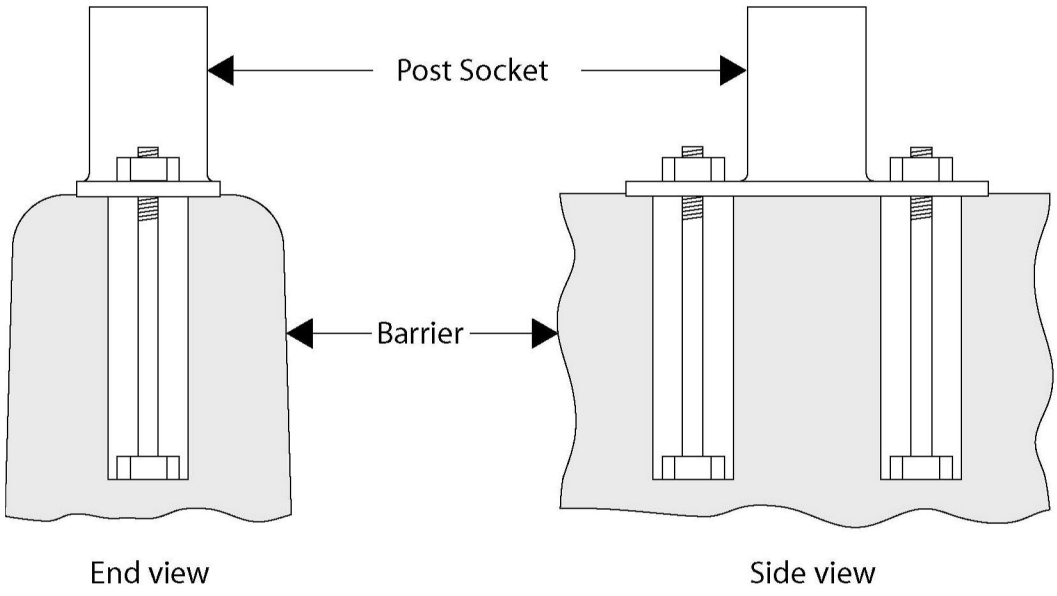

Figure 7: Schematic of a type of retro-fit square post sign mounting in use in the United States

This particular method of mounting traffic signs has been adopted as the current 'best practice' on sections of the M25 where concrete safety barriers are installed in the central reservation.

8 Specification of a standard sign mounting socket

The specification of a standard sign mounting socket should encompass shape, size and minimum depth of insertion. In the absence of extensive research to the contrary, it is logical to base any national standard around the current practice.

Consultation with several manufacturers of vertical mount frames has revealed that the sign frames currently in use have a common size and shape of 60mm (outside diameter) square. The sockets that accompany these posts are also square in cross-section and have an internal dimension of 70mm. This 10mm clearance is considered to be adequate to facilitate easy insertion in adverse conditions, without being excessively loose.

A minimum depth of insertion should be specified, though consideration should be given to the height of the barrier locally. As a rule, the stability of the sign will increase with insertion depth. If the barrier is particularly high at any point, a greater insertion depth should be considered to bring the sign face closer to the surface of the carriageway. A minimum insertion depth of 500mm has been suggested by one of the manufacturers

There would be difficulties in using this type and size of sign mounting socket, particularly in the case of a 'step' type safety barrier, where the width of the top of the barrier is only 200cm. The steel reinforcing bars (20mm diameter), inside the barrier structure are located only 150mm below the top of the concrete safety barrier.

It might be possible to offset the sign mounting socket, so as to avoid the reinforcing bars, but there would be little room for error and also such a large structure (70mm square profile) might cause the concrete to fracture, this weakening the barrier's properties.

There are cases, however, where a much wider barrier with a top width of 600cm are used, for example, where lighting columns have to be installed on top of the barrier. With this extra width available, it might be suitable to install the mounting sockets during the slip form process.

The specification of a Standard for vertical sign mounting is shown in Table 8 below:

	Sign Post	**Sign Socket**
Shape	Square	Square
Size	60mm (outer dimension)	70mm (inner dimension)
Depth of insertion	500mm min.	

Table 8: Specification of a Standard for a vertical sign mounting

8.1 A proposed built-in socket design

One solution which is proposed by TRL, and discussed above, is the provision of a standardised socket which is built into the barrier during its construction. This is technologically feasible as the slip form process used to construct the concrete barriers already allows the insertion of round conduits for lamp standards.

It is proposed that a square post could be set into the ground in the path of the slip form machine and that the barrier can then be formed around the posts. It is shown schematically in Figure 8 below:

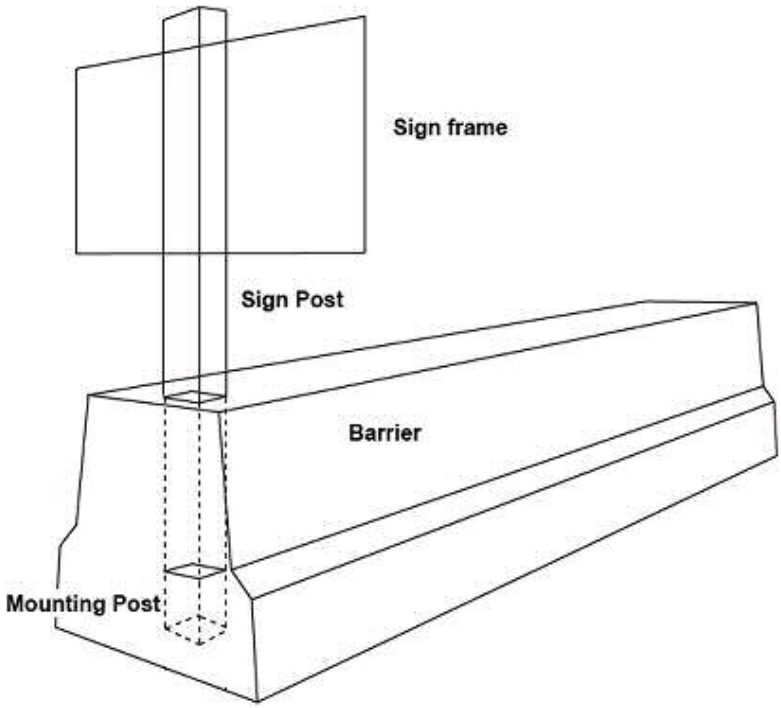

Figure 8: Proposed built-in sign post

As discussed above, this particular arrangement could be beneficial in the case of very wide safety barriers, usually where lighting columns are required. In these situations, where the width of the top of the barrier may be up to 600mm, traditional A-frames may be unstable if placed on top the barrier.

Morelock signs Ltd have produced engineering drawings of a suitable set-in post. This is shown in the Appendix 8. It is proposed that these posts be set into the barrier at 50 metre intervals. This should provide enough flexibility for most applications - Chapter 8 of the Road

Signs Manual features dimensions between signs not less than 50m. In special circumstances - for example, complex junctions or heavily curved sections of carriageway, the frequency of the fitments could be increased.

9 Steel eyelet fittings on top of the concrete safety barrier

For securing temporary traffic management signs, one option is to mount steel eyelets on top of the concrete safety barrier. This could take place during the slip form process, where the eyelets can be pushed into the wet concrete. One possible arrangement could be two eyelets positioned either side of the centre line of the barrier with spacing between them of, say 50cm (see Figure 9 below). This arrangement could be repeated at 50 metre intervals along the top of the barrier.

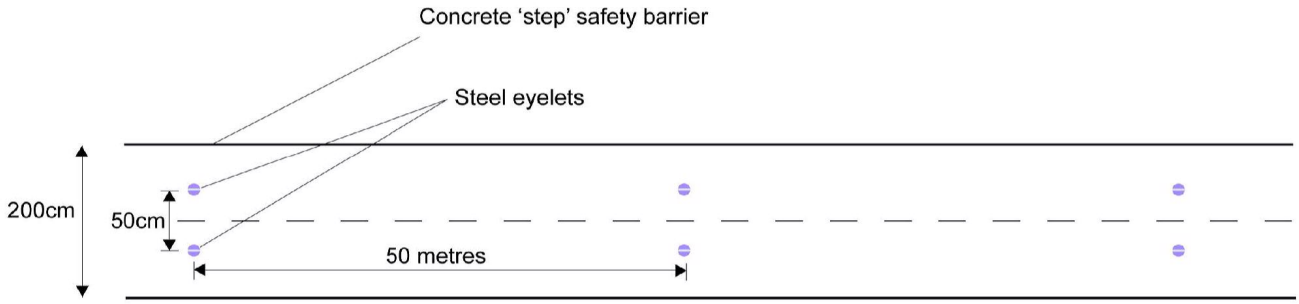

Figure 9: Steel eyelets installed on the top surface of concrete safety barrier (plan view)

One installed, the eyelets can be attached to temporary traffic management 'A' frames by means of tensioning straps.

10 Provision of electrical power sockets for VCB mounted signs

This study has identified a need for a mains power supply on concrete safety barriers. Power may be required for VMS-type signs mounted on a permanent basis, but also possibly on a more temporary basis for the illumination of Temporary Traffic Management (TTM) signing. Consideration also needs to be made for the provision of a mains power supply for permanent external lighting columns in appropriate locations.

Consultation with Britpave has revealed that the concrete safety barrier can be cast with a recess in the top for a wiring conduit. This gives added maintainability and flexibility and supersedes an earlier design where cables were buried in the concrete. These cables would supply mains power for VMS type signs, any Temporary Traffic Management signing requiring illumination and also for external lighting columns. Drawings of the new step type concrete safety barrier, which were supplied by Britpave, have shown that within the concrete barrier structure itself, a vertically mounted cable duct runs from the bottom to the top the barrier in order to distribute mains power to any external lighting column.

There are a variety of industry standard sockets which may be used in this application which will suit permanent VMS-type signs well; however, this may not suit TTM signs unless paired with the cast-in mounting posts discussed in Section 8. Concerns were voiced by Britpave over the cost and maintenance of such a system for TTM and suggested that battery operated

luminaries would be more cost effective and also they would not have to be designed especially for use with a concrete safety barrier.

11 Comparison of temporary and fixed sign mounting strategies

A direct comparison of the properties of current practice, 'A' frames tethered to especially designed securing brackets, built-in vertical sockets and steel eyelets for temporary traffic management signs, are shown in Table 9 below.

	Current practice:- 'A' frame – Tethered and other installation methods **(Section 4)**	**Proposed solution # 1: tethering 'A' frames to especially designed securing brackets (two different designs)** **(Section 6)**	**Proposed solution # 2: built in vertical mountings (socket design)** **(Section 8)**	**Proposed solution # 3: tethering 'A' frames to steel eyelets** **(Section 9)**
Start-up costs	Costs of tethers (reusable), cable ties (non-reusable) and sandbags.	Cost of temporary mounting bracket, not more than £50* for each design of bracket	Estimated £3.5millon** for installation on the whole motorway network	Cost of steel eyelets and securing straps
Costs	Tools, sundries and labour	Tools, sundries and labour	Labour only	Tools, sundries and labour
Positioning	Can be fitted wherever required, but for extra sign stability, it would require a suitable tethering point, such as a fitted bracket or other road furniture (e.g. a lighting column)	In theory, can be fitted wherever required however, one of the options requires more preparation time	Available at fixed points, every 50m, on the carriageway which is sufficient for the demands of Chapter 8 of the Traffic Signs Manual	Available at fixed points, every 50m, on the carriageway which is sufficient for the demands of Chapter 8 of the Traffic Signs Manual
Method of sign installation	The 'A' frame is either stretched across the concrete safety barrier or, if the top of the barrier is wide enough, mounted on the top. Sand bag ballasting is used to provide stability for the signs. If appropriate tethering points are available, 'A' frame is fixed to the permanent feature by straps, ropes or cable ties.	Drilling and/or gluing required for installation of one type of bracket to the top of concrete safety barrier, then install the sign frame and secure using Smartlock straps The other type of mounting bracket would be fitted over the top of the concrete safety barrier and screwed securely into place using turnkeys, then install the sign frame and secure using Smartlock straps	Install vertically mounted sign post into built in socket	Secure the sign mounting frames to the steel eyelets my means of adjustable straps.

	Current practice:- 'A' frame – Tethered and other installation methods **(Section 4)**	**Proposed solution # 1: tethering 'A' frames to especially designed securing brackets (two different designs)** **(Section 6)**	**Proposed solution # 2: built in vertical mountings (socket design)** **(Section 8)**	**Proposed solution # 3: tethering 'A' frames to steel eyelets** **(Section 9)**
Items left over after works	None	For one of the designs, non-removable (e.g. glued) brackets would be left on the concrete safety barrier after the works are complete	None	Non –removable steel eyelets
Sign security	Specification of tethers should be controlled to ensure security.	Specification and application of adhesives, brackets and tethers should be controlled to ensure security.	Sign frames should be secure without recourse to further fastening	Specification and application of steel eyelets and straps should be controlled to ensure security.
Possible safety issues:	Instability of the signs, particularly in the absence of suitable tethering points. This is a major safety issue for larger signs, especially in exposed locations where the wind loading on the sign can be very large. Where wide concrete barriers are found there may be a risk of the frames falling off the barrier.	Assuming good security, the safety of workers would depend on set-up time, which is currently unknown. This might be a safety concern if the set up time takes significantly longer than current practice.	Ease and security of installation ensures that temporary traffic management workers would be in harm's way for the shortest possible time. A preferred option for wider than standard concrete barriers.	Assuming good security, the safety of workers would depend on set-up time, which is currently unknown.
Advantages	Very low installation and material costs Ease of fitting	Low installation costs Flexibility in where the securing brackets are installed for one particular option.	Security of installation – i.e. it is unlikely for the sign plus frame will get dislodged Ease and speed of installation –	Ease of and speed of installation – improving safety for traffic management workers

	Current practice:- 'A' frame – Tethered and other installation methods (Section 4)	Proposed solution # 1: tethering 'A' frames to especially designed securing brackets (two different designs) (Section 6)	Proposed solution # 2: built in vertical mountings (socket design) (Section 8)	Proposed solution # 3: tethering 'A' frames to steel eyelets (Section 9)
			improving safety for traffic management workers	
Disadvantages	Safety concerns regarding the stability of all temporary traffic management signs, particularly larger signs	Stability issues could remain for very large temporary traffic management signs Possible non-compliance of the use of securing straps Lack of flexibility for the option that requires a permanent mounting on top of the barrier, particularly at strategic junctions, where motorways merge and diverge	Very high initial costs of implementation Can only be adopted where very wide concrete safety barriers are used Lack of flexibility, particularly at strategic junctions, where motorways merge and diverge	High initial costs of implementation Lack of flexibility particularly at strategic junctions, where motorways merge and diverge

* An approximate cost based on prices of similar steel fabrications. Does not include installation costs.

** Based on a network length of 3,500km, a post spacing of 50m and an estimated installation unit cost of £50

Table 9: An estimated comparison of the properties of current practice, tethered 'A' frames using securing brackets, built-in vertical mountings and steel eyelets

12 Potential solutions

Four potential solutions have been identified to overcome the problem of securely mounting temporary traffic management signing to concrete safety barriers located in the central reserve:

1. Clamps or straps to stabilise existing "A" type frames to the concrete barrier.

2. Sockets built into the barriers that accept standardised vertical sign frames.

3. Installing steel eyelets in the top of the concrete safety barrier as anchor points to attach adjustable straps to stabilise existing "A" type frames.

4. Existing methods: refining these procedures to provide a satisfactory solution (e.g. providing guidelines for cable ties / straps / sandbags or the use of extra long A-frames, which may have extra locking bars to improve frame rigidity).

13 Conclusions and recommendations

As can be seen in Table 9, there are both advantages and disadvantages for all of the potential solutions listed in Section 12. However, in the opinion of the project team, all of these solutions are potentially viable in different operational situations.

Of the options presented above, the built-in sockets (potential solution 2) is one favoured solution as they enable secure and easy sign installation for the minimum amount of time TTM operatives are on site. However, this particular solution is only a viable option in the case of very wide concrete safety barriers, which are often used in areas where lighting columns are required.

Where the normal width 'step' type safety barriers are used , the favoured solution is either to use especially designed mounting brackets and straps to stabilise the sign mounting frames or alternatively, to install steel eyelets in pairs at regular intervals along the top of the concrete safety barrier. Of these two options, the mounting bracket/ strap solution is more flexible in terms of sign positioning. However, the steel eyelet/ strap solution should reduce the sign installation time, which has major safety benefits for the temporary traffic management workers.

Recommendations for future work

1. **Temporary traffic management signing**

- Off – road evaluation of all potential solutions

It is recommended that a short evaluation of all potential solutions is performed in a suitable environment, e.g. on the TRL test track. This could involve the construction of a mock-up of a typical concrete barrier section (for example, in wood) to help determine how viable and

usable the new methods are from an operational point of view. Alternatively, a short section of safety barrier could be produced at TRL using the slip form process.

To facilitate this evaluation, it is suggested that experienced temporary traffic management operatives are brought in to provide their input on the new designs using their experience to give a view on their ease of use. The off-road trial would be substantially cheaper than the on – road trial and it would yield valuable data.

- On-road trial

The next stage that is proposed is an on-road trial conducted at the site of a long term road works scheme on a stretch of motorway where concrete safety barriers are present in the central reserve. This would assess the safety benefits in an operational environment.

- Creation of guidelines and standards for securing temporary signs

Following on from the on-road trial, guidelines and standards should be created to define the optimum method(s) for securing temporary signs to be adopted in a range of different road environments.

2. Permanent signing

- Creation of guidelines and standards for the installation of permanent signs

Guidelines and standards should be created for the installation of permanent traffic signs, including matrix signals, to concrete safety barriers in the central reserve.

The current practice of installing matrix signals to the existing concrete safety barriers could be adopted for the new step type of concrete safety barrier, although it should be noted that the width of the top of the step type barrier is slightly narrow compared to the width of the existing concrete safety barriers (200mm, compared to either 240mm or 300mm for a vertical concrete barrier or a higher vertical concrete barrier respectively).

For permanent traffic signs, i.e. warning and informatory signs, in the case of sections of a motorway with a double width concrete safety barrier, which can be found on some parts of the M25, the currently adopted method of installing a 500mm deep sign post socket surrounded by non–reinforced concrete positioned between the two concrete safety barrier sections could be used.

Where only a single width concrete safety barrier exists, small permanent traffic signs, such as triangular warning signs, could be mounted on top of the concrete safety barrier by fixing the sign mounting posts into small diameter holes which are drilled in the top of the barrier and secured either mechanically or chemically using permanent adhesive. However, further work would be required to confirm the safety and effectiveness of this approach.

14 Reference

Figure 7 drawings from “Concrete Barrier Sign Post Installation**”:-**

http://www.dot.state.co.us/S_Standards/S_standard_2000/INDEX6.html.

15 Acknowledgements

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