STUDY 3 OF 3

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The British In-situ Concrete Paving Association

BARRIER COST COMPARISON

British In Situ Concrete Paving Association

Concrete Step Barrier Studies

Barrier Cost Comparison: Stage 3

Special Features

August 2008

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EXECUTIVE SUMMARY

Britpave appointed Arup in February 2007 to carry out a comparative costing analysis of Concrete Step Barrier (CSB) and other steel vehicle restraint systems for central reserve application on the highway network.

The Stage 3 report follows, and should be read in conjunction with, both Stages 1 and 2.

This Stage 3 report presents costs associated with the following "special features" which may be included in a steel or concrete barrier installation:

- Transitions
- Connections to structures
- Terminals
- Bifurcation
- Drainage details
- Expansion joints
- Emergency crossing points
- Night working

A summary of the comparative costs for these items is presented in the tables below.

It is important to note that this report is not intended to be used as a pricing tool

Typical costs for linear drainage range from £25/m for a surface water channel to £125/m for a combined surface water channel and carrier.

In the event that CSB is required to be constructed during night hours it is anticipated that the cost of the standard concrete barrier would increase by between £20 and £35 per metre.

The peripheral details of the central reserve construction are broadly common across scenarios regardless of whether steel or concrete barrier systems are installed. Some of the features included in a comparative price, such as central reserve construction, will be true for both CSB and steel barrier options. The rates for the barriers therefore assume a basic construction for the central reserve, and any adjustment would be true for both options. The model used in generating the comparative costs takes account of variability in costs of materials and construction techniques.

The ranges of average costs presented in this report are a "snapshot" of costs provided by industry in March 2007. The costs were provided in the context of the study, and do not relate to any specific project or scheme. Costs are given in pounds Sterling.

This study does not quantify whole life costs over the lifetime of the barrier system, such as those costs associated with repair, maintenance, or replacement. Instead it concentrates on the initial construction costs incurred during barrier installation. The costs used in this report were sourced from industry suppliers and are therefore supplier costs for installation of the barrier system by a specialist installer.

All concrete step barriers costed in this study are surface mounted CSB conforming to the Britpave specification. Details of the CSB and steel barrier systems can be found in the Stage 1 and Stage 2 reports.

Table 1 – Summary of comparative costs for CSB and deformable barrier special features

Concrete Step Barrier		Deformable Steel Barrier	
Item	**Cost £**	**Item**	**Cost £**
Transition to deformable steel barrier	1,500 to 2,000		
Transition at structure/gantry base etc.	3,000 to 4,000		
Expansion joint unit	3,000 to 4,000		
Bifurcation	19,000 to 23,500	Bifurcation (H2)	13,200 to 15,700
		Bifurcation (N2)	9,600 to 10,900
Emergency crossing points	650/m	Emergency crossing points	1000/m
Terminal (verge)	5,250 to 8,000	OBB terminal	3,250 to 5,000
Double sided P4 terminal	9,500 to 10,500	Double sided P4 terminal	8,000 to 8,500
Crash cushion	17,500 to 19,000	Crash Cushion	16,000 to 17,000

1 INTRODUCTION

Britpave appointed Arup in February 2007 to carry out a comparative costing analysis of concrete step barrier (CSB) and other steel vehicle restraint systems for central reserve application.

Stage 1 of this study developed basic costs for the barrier systems under consideration. The Stage 2 study considered the influence of different central reserve layouts, and central reserves where lighting columns are installed. For typical prices per linear metre of concrete step barrier, refer to the Stage 1 report.

The Stage 3 report follows, and should be read in conjunction with, both Stages 1 and 2. These include descriptions of the different barrier systems costed for Britpave.

1.1 Scope and purpose

Stage 3 of the study addresses the cost implications of the following special features which will influence the total cost of the barrier installation:

- Transitions
- Connections to structures
- Terminals
- Bifurcation
- Drainage details
- Expansion joints
- Emergency crossing points
- Night working

These features are present in both steel and concrete barrier installations and so, where appropriate, have been priced for both.

Costs have been built up from first principles considering the individual components of each of the barrier systems, as determined in the Stage 1 costing exercise. Construction methods and installation rates have been included in the analysis.

This report does not consider whole life costs over the lifetime of the barrier system such as those costs associated with repair, maintenance or replacement. Costs given in this report are those for capital costs incurred during barrier installation. Broader whole life and sustainability issues are discussed qualitatively in the Stage 1 report.

This report should not be used as a pricing tool. The peripheral details of the central reserve construction are broadly common across scenarios regardless of whether steel or concrete barrier systems are installed. Some of the features included in the comparative prices such as central reserve construction will be true for both CSB and steel barrier options. Although the detail of the central reserve assumes a basic construction, any adjustment would be true for both options. The model used in generating the comparative costs does, however, take account of variability in costs of materials and construction techniques.

1.2 Cost data

Cost data was obtained in March 2007 from the same sources as were used for the Stage 1 basic barrier costs.

The costs used in this report are supplier costs for installation of the barrier system by a specialist installer. No allowance is made for main contractor on costs.

2 SPECIAL FEATURES

The following special features applied to steel barrier and/or concrete step barrier have been priced:

- Transitions
- Connections to structures
- Terminals
- Bifurcation
- Drainage details
- Emergency crossing points
- Expansion joints

These are described in more detail below.

2.1 CSB Transitions

Transitions are provided in concrete step barrier where the CSB connects to a wide profile CSB, a steel barrier system, another concrete barrier profile or at interfaces with structures, gantry bases, etc.

Transitions are formed in situ using formwork.

Figure 2.1.1 shows a typical transition and connection between CSB and open box beam barrier.

Figure 2.1.1 CSB connection to OBB

For the purposes of this cost comparison the in situ concrete transition unit has been priced. However the cradle anchorage and steel barrier system have been excluded from the costs. The cost for these is dependent on the steel barrier system used.

2.2 CSB Terminals

If a terminal is to be provided at the end of a run of CSB then this will typically consist of

a) A transition unit as described above plus a crash cushion;

b) A transition unit as described above, plus a terminating length of deformable steel barrier system.

Crash cushions may be mounted directly at the end of concrete barrier, as shown in Figure 2.2.1, without the need for a connecting length of deformable steel barrier.

Figure 2.2.1 Quadguard Crash cushion on concrete barrier (not CSB profile).

Crash cushions may also be used as a double P4 end terminal. The Highway Care Quest product is approved by HA for this use.

Figure 2.2.2 Highway Care Quest Double P4 end terminal

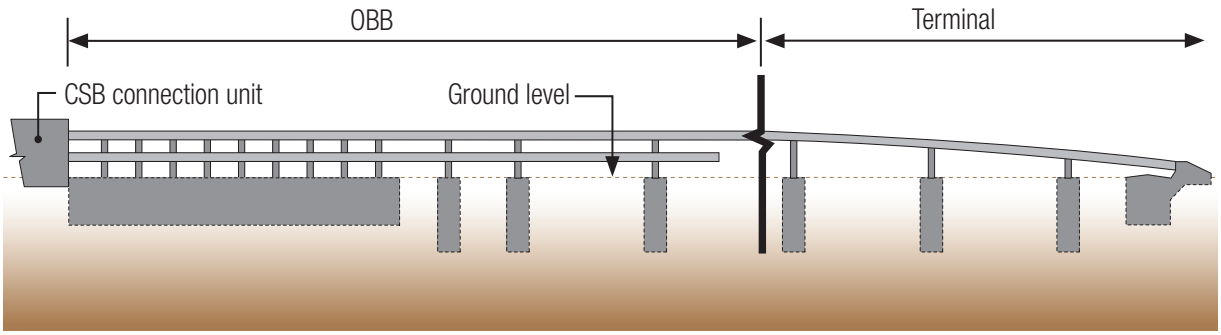

Figure 2.2.3 CSB connection to typical OBB with P1 terminal.

The cost for the terminal is dependent on the steel barrier system used and the length of deformable barrier installed between the CSB and the terminal unit.

2.3 CSB Transitions at structures

Figure 2.3.1 Formwork for in situ transition unit at gantry base

At structures, an in situ transition unit is formed to enable the CSB profile to transition to match the adjoining gantry base or structure. Typically an in situ length of 6 metres is cast (figure 2.3).

2.4 CSB Bifurcation

Bifurcation allows lengths of dual barrier to be constructed, usually to protect bridge piers or other structures in the central reserve. The transition from a single profile to dual standard profiles is cast using traditional fixed formwork. The transition length will vary according to the type of slip form paving mould used to construct the adjacent sections. Typically, a 15m taper is constructed for an asymmetric bifurcation (Figure 2.4.1).

Figure 2.4.1 Formwork for in situ bifurcation taper

The length of dual barrier provided is determined by TD 19/06. For the purposes of this costing exercise a length of approximately 70m slipform paved dual barrier is priced, plus two 15m in situ bifurcation tapers. This allows for construction of 30 metres of dual barrier either side of a hazard, in the central reserve.

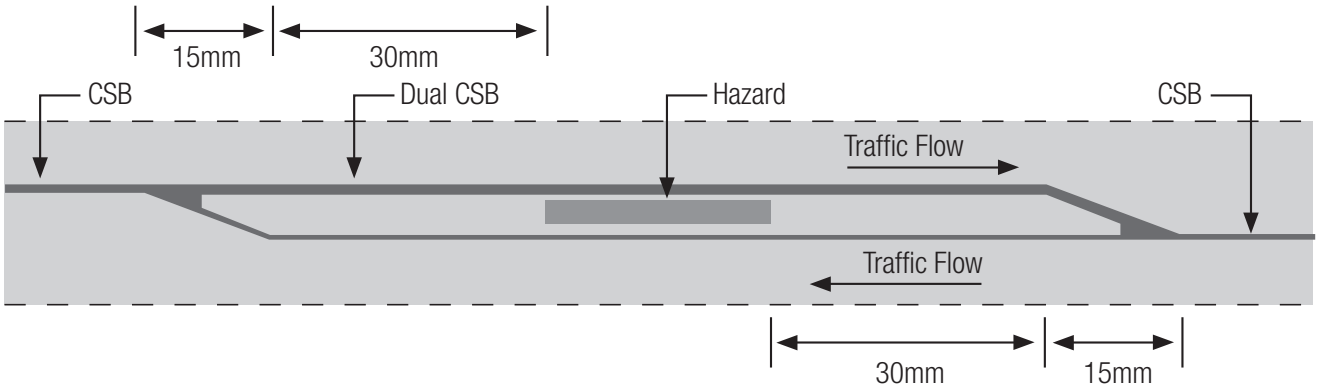

Figure 2.4.2 Typical layout of CSB at bifurcation

2.5 CSB Emergency crossing points

Typical cross sections were drawn up for each of the proposed central reserve layouts. The intention is to provide a typical cost range for a number of scenarios that are representative of central reserve conditions encountered on the UK road network: new build, barrier replacement and motorway widening schemes.

The cross sections are necessarily simplified and generalised; each project will have its own particular constraints and central reserve conditions which will influence the cost.

Costs were calculated for the supply of materials, installation of barriers, and construction of the central reserve.

Figure 2.5.1 Emergency crossing point installation

A typical emergency crossing point (ECP) installed in a length of CSB, will consist of four demountable steel step barrier (SSB) units, connected at either end to CSB via a steel connection unit. This is shown in Figure 2.5.1.

2.6 CSB Expansion joints

CSB expansion joint units are used at structures where movement joints are present. A CSB expansion joint typically consists of 2 No. steel connection units, similar to the ECP installation, joined by slotted plates (Figure 2.6.1).

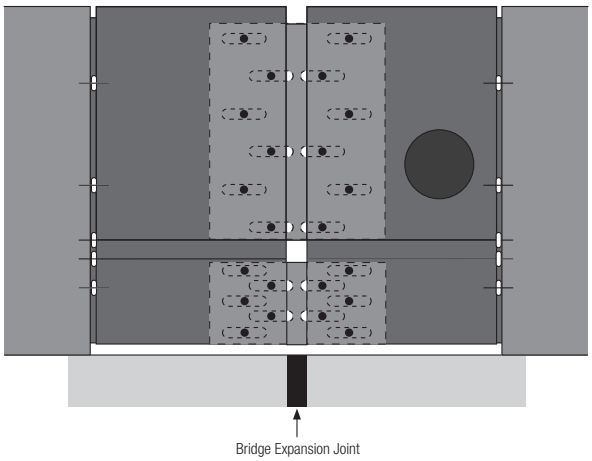

Figure 2.6.1 CSB expansion joint

2.7 Deformable steel barrier special features

Two typical terminal arrangements for deformable barrier systems have been priced for this study: The P1 terminal (Figure 2.7.1) and the P4 terminal (Figure 2.7.2).

Figure 2.7.1 Corus Vetex P1 end terminal at test site (picture from Corus website)

Figure 2.7.2 P4 end terminal (picture from Corus website)

Crash cushions are available for installation with steel barrier systems. Figure 2.7.3 shows the HighwayCare QuadGuard product.

Figure 2.7.3 HighwayCare QuadGuard

Emergency crossing point systems for use with deformable steel barrier systems are available, for example, the Asset Sologuard barrier system (Figure 2.7.4).

Figure 2.7.4 Asset Sologuard (pictures from Asset Vehicle Restraint System web site)

3 DRAINAGE

The following linear drainage systems are most suitable for installation with CSB and have been priced:

- Slot drain
- Surface water channel
- Combined channel and carrier

Filter drains are often installed with deformable steel barrier systems in soft central reserve. However, these are not recommended for installation with surface mounted CSB, unless in a wide central reserve. For guidance on suitability of drainage systems with CSB refer to the Britpave data sheets.

3.1 Slot drain

Figure 3.1.1a Slot drain under construction

Figure 3.1.1b Paving wide CSB with trough adjacent to slot drain

Slot drains are well suited to situations where the width of the central reserve is limited. The slot drain is slip formed prior to installation of the adjacent CSB (Figures 3.1.1a and b). The slot drain can be formed in the set back zone on the traffic face of the barrier so requiring no additional land-take.

3.2 Surface water channel and combined channels & carriers

Figure 3.2.1 Surface water channel with CSB

Construction of surface water channels adjacent to CSB in the central reserve (Figure 3.2.1) requires more width than slot drain. Channels are typically 600mm to 1 metre wide.

Construction of a combined carrier and channel allows greater capacity. The central reserve width required to install this type of drain is the same as for surface water channel.

3.3 Filter drain

Filter drains or French drains may be used behind the barrier either where embedded CSB is provided with an independent foundation (Figure 3.3.1), or where sufficient land is available in the central reserve to provide the minimum required hardened width beneath surface mounted CSB.

Figure 3.3.1 Filter drain adjacent to embedded CSB

This is the traditional type of drain installed in central reserve with deformable steel barriers. However, it should be noted that installation of French drains in the central reserve does not meet the Highways Agency's aspiration to minimise maintenance in the central reserve.

4 CSB - NIGHT WORKING

In the event that CSB is required to be constructed during night hours it is anticipated that the cost of the standard concrete barrier would increase by between £20 and £35 per metre.

The rates quoted assume that an output of between 200 and 250m can be achieved within the full period of a night shift.

The additional cost is principally due to the overtime payments that would be incurred for providing labour, plant operatives and supervisors to operate the concrete supply plant, delivery (truck mixers) and on-site production (slipform gang).

Although this cost can vary considerably depending on the particular circumstances (supplier, location of supply, number of truck mixers, site conditions etc.) it is estimated that it would typically range between £5000 and £7000 per night shift.

Given that the cost of providing a night time operation once established, is fixed, any reduction in output or scope of work would inversely increase the rate per metre.

5 COSTS

A detailed spreadsheet has been developed from cost data provided by industry. Since the data containment in the spreadsheet is commercially sensitive, only a summary is present in this report.

The costs used in this report are comparative costs given in pounds sterling and were obtained in March 2007 from industry suppliers. They are supplier costs for installation of the barrier system by a specialist installer. No account is taken for main contractor on costs.

The typical cost ranges for untensioned corrugated beam barrier systems and concrete step barrier, are given in section 4 of the Stage 1 report.

All cost ranges presented in this report are based on the average of costs provided by suppliers and installers in the context of this study.

Once again, it is important to note that this report is not intended to be used as a pricing tool.

5.1 CSB Special features

5.1.1 CSB Transitions

Item	Cost £
Transition from CSB to deformable steel barrier (2m length)	1,500 to 2,000
Transition at structure/gantry base etc. (6m length)	3,000 to 4,000

Table 5.1: Costs for transitions

5.1.2 CSB Bifurcations

A bifurcation in CSB constructed in accordance with TD 19/06 will typically consist of two 15 metre bifurcation units plus approximately 70 metres length of dual barrier, i.e. 100m in total. The costs for dual barrier in Table 5.2 below are taken from the Stage 2 report.

Item	Quantity	Rate £	Cost £
Bifurcation (15m length)	2 No.	3,500 to 4,500 each	7,000 to 9,000
Dual barrier	70 m	169 to 207/m	12,000 to 14,500
		Total	19,000 to 23,500

Table 5.2: Bifurcation costs

This gives a total typical cost for bifurcation at a bridge pier of £19,000 to £23,500. More than half this cost is the 70 metre length of dual barrier. Therefore, reducing the length of dual barrier required on the approach to the hazard would give significant cost savings.

5.1.3 CSB Emergency Crossing Points

Item	Quantity	Rate £	Cost £
Demountable section (5.4m in length)	4 No per emergency crossing	2,500 to 3,250 each	10,000 to 13,000
End sections	2 no per emergency crossing	1,500 to 2,000 each	3,000 to 4,000
		Total	13,000 to 17,000

Table 5.3 Costs for ECP

The total cost for a typical ECP installation consisting of four demountable units and two end sections is £13,000 to £17,000, or approximately £650 per metre length of ECP provided. This is the cost for the installed ECP demountable barrier system and does not include the cost of the central reserve surfacing installed at the ECP.

5.1.4 CSB Expansion joints

Item	Cost £
CSB expansion joint unit	3,000 to 4,000

Table 5.4 Cost for expansion joint units

5.1.5 CSB Terminals and crash cushions

The costs in Table 5.5 below assume that CSB is connected to OBB safety fence. The costs will vary if an alternative deformable system such as Corus Vetex or Hill & Smith Flex Beam is assumed. Table 5.5 assumes installation of single sided P1 and P4 terminals; this is the application in a verge.

Item	Cost £
CSB transition unit (2m length)	1,500 to 2,000
Transition between CSB and OBB	500 to 750
1 No. Single sided double rail OBB safety fences (assumes 20 metres length)	2,000 to 2,750
P1 end terminal (single sided)	1,250 to 1,500
P4 end terminal (single sided)	2,000 to 2,500
Total P1	5,250 to 7,000
Total P4	6,000 to 8,000

Table 5.5 Costs for connection to single sided terminal (verge)

Table 5.6 gives a summary of costs for crash cushions with CSB. The Quest crash cushion is approved by HA for use as a double sided P4 end terminal, in central reserve. The profile of the transition unit will vary depending on the type of crash cushion to be installed.

Item	Cost £
CSB transition unit (2m length)	1,500 to 2,000
Crash cushion (Quadguard)	16,000 to 17,000
Double sided P4 terminal (Quest)	8,000 to 8,500
Total Crash cushion	17,500 to 19,000
Total Double P4	9,500 to 10,500

Table 5.6 Costs for connection to double sided crash cushion (central reserve)

5.2 Deformable steel barrier special features

5.2.1 Bifurcations

The cost of creating a bifurcation in a deformable steel barrier system is taken as the provision of a length of dual single sided barrier for approximately 100 metres at a hazard. Rates for deformable barrier systems are taken from the Stage 2 report.

Item	Rate £	Cost £
2 No. H2 deformable single sided barriers, 100 linear metres	132 to 157/m	13,200 to 15,700
2 No. N2 deformable single sided barriers, 100 linear metres	96 to 109/m	9,600 to 10,900

Table 5.7 Costs for bifurcation in deformable barrier

It should be noted that the costs given are for the barriers. No allowance has been made for strengthening bridge piers or other hazards to withstand impact.

5.2.2 CSB Emergency crossing points

The cost of the ECP will vary depending on the length of opening required. The costs in Table 5.8 below were provided by the supplier for a 16 metre long opening. This is the cost for the installed barrier system and does not include the costs of the central reserve surfacing installed at the ECP.

Item	Cost £
Removable barrier ECP (16 metres long)	15,500 to 19,000

Table 5.8 Costs for 16 metre long ECP

Demountable ECP systems used with deformable steel barrier typically cost around £1000 per linear metre.

5.2.3 Terminals and crash cushions

Table 5.9 gives typical costs for single sided OBB safety fence terminal units.

Item	Cost £
1 No. Single sided double rail OBB safety fences (assumes 20 metres length)	2,000 to 2,500
P1 end terminal	1,250 to 1,500
P4 end terminal	2,000 to 2,500
Total P1	3,250 to 4,000
Total P4	4,000 to 5,000

Table 5.9 Costs for OBB terminal units (single sided)

Table 5.10 gives typical costs for crash cushions for use with deformable steel barrier systems. The cost will vary depending on the type and specification of crash cushion to be installed and the type of safety fence used.

Item	Cost £
Crash Cushion	16,000 to 17,000
Double sided P4 terminal	8,000 to 8,500

Table 5.10 Costs for crash cushions

5.3 Drainage

Typical costs for linear drainage are given in Table 5.11 below.

Item	Dimension	Cost (per linear metre of drain) £
Slot drain	100 to 150mm diameter	75 to 100
Surface water channel	600 x 200mm	25 to 35
Combined surface water channel and carrier	Carrier 300mm dia.	75 to 125
Filter drain	300mm dia.	75 to 125

Table 5.11 Costs for linear drainage

For the carrier and filter drains, an average depth of 1.5 metres is assumed with a chamber approximately every 75 metres.

5.4 Night working

Item	Cost £
Additional cost for night working operation (typical cost per shift)	5,000 to 7,000

Table 5.12 Additional cost of night time operation

Assuming an output of 200 to 250m per shift can be achieved (typical for the standard CSB), this would add between £20 and £35 per metre.

6 CONCLUSIONS

A summary of the comparative costs for special features used with CSB and deformable barriers is given in Table 6.1. (Figures have been rounded).

This report is not intended to be a pricing tool. The peripheral details of the central reserve construction are broadly common across scenarios regardless of whether steel or concrete barrier systems are installed. Some of the features included in a comparative price, such as central reserve construction, will be true for both CSB and steel barrier options. The rates for the barriers therefore assume a basic construction for the central reserve (further details in Stage 2 report), and any adjustment would be true for both options. The model used in generating the comparative costs takes account of variability in costs of materials and construction techniques.

The ranges of average costs presented in this report are a "snapshot" of costs provided by industry in March 2007. The costs were provided in the context of the study, and do not relate to any specific project or scheme. Costs are given in pounds Sterling.

Typical costs for linear drainage range from £25/m for a surface water channel to £125/m for a combined surface water channel and carrier.

Table 6.1 Summary of comparative costs for CSB and deformable barrier special features

Concrete Step Barrier		Deformable Steel Barrier	
Item	**Cost £**	**Item**	**Cost £**
Transition to deformable steel barrier	1,500 to 2,000		
Transition at structure/gantry base etc.	3,000 to 4,000		
Expansion joint unit	3,000 to 4,000		
Bifurcation (70 metres dual barrier + tapers)	19,000 to 23,500	Bifurcation (H2) (100m long)	13,200 to 15,700
		Bifurcation (N2) (100m long)	9,600 to 10,900
Emergency crossing points	650/m	Emergency crossing points	1000/m
Terminal (verge)	5,250 to 8,000	OBB terminal	3,250 to 5,000
Double sided P4 terminal	9,500 to 10,500	Double sided P4 terminal	8,000 to 8,500
Crash cushion	17,500 to 19,000	Crash Cushion	16,000 to 17,000

6.1 Costs distribution

The costs for these special features will be distributed over a project.

For a simple example, a project approximately 5 km long might be constructed in standard profile surface mounted CSB and have the following special features in the central reserve:

- 2 No. bifurcations at over bridges;
- 1 No. ECP approx. 24 metres long;
- Connection to OBB at each end.

The costs for these items are summarised in Table 6.2 below. (For details of central reserve surfacing options and what is included in the CSB rate, please refer to the Stage 2 report).

Item	Rate £	Quantity	Cost £
Standard profile surface mounted CSB (including central reserve surfacing)	94 to 120/m	4776m	448,944 to 573,120
Bifurcation at over bridges (total length 100m)	19,000 to 23,500	2 No.	38,000 to 47,000
Emergency crossing point (24 metres)	13,000 to 17,000	1 No.	13,000 to 17,000
Connections to OBB	1,500 to 2,000	2 No.	3,000 to 4,000
		Total	502,944 to 641,120

Table 6.2 Example of cost distribution over a 5km project.

For the total barrier system, including special features and central reserve surfacing, the costs distributed over the approximately 5 km long project equate to £101 to £128 per linear metre of central reserve, or an additional 7% over the basic cost of the barrier and central reserve surfacing.

Including a slot drain at £75 to £100 per metre, increases the cost for the total installation to £176 to £228 per linear metre of central reserve.

For night time working an additional allowance of £5000 to £7000 per shift should be made. This equates to an increase in cost to construct CSB of between £20 and £35 per metre.

6.2 Performance and maintenance

The systems and components described in reports for Stages 1, 2 and 3 of the cost study have been compared on the basis of the supply and installation cost only. Whole life costs including product life, maintenance costs and repair costs have not been included. Neither has any allowance been made for the relative performance of the systems in terms of working width or containment class.

Concrete Step Barrier Systems offer H2 containment performance, with low working width. For a cost-benefit analysis in comparison with steel systems, CSB will bring benefits in terms of increased safety for road users and maintenance workers, as well as reduced maintenance requirements and longer lifespan of the product. These issues are discussed qualitatively in the Stage 1 report.

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The British In-situ Concrete Paving Association

BP/39 CONCRETE STEP BARRIER STUDIES

Barrier cost studies Stage 3 of 3

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