Creating the future of transport

Published Project Report
PPR280

A review of HGV crossover accidents, and the relative costs of steel and concrete barriers (Phase II report)

G L Williams

A Review of HGV Crossover Accidents, and the Relative Costs of Steel and Concrete Barriers

(Phase II Report)

by G L Williams

PPR 280

PUBLISHED PROJECT REPORT

TRL Limited

PUBLISHED PROJECT REPORT PPR 280

A Review of HGV Crossover Accidents, and the Relative Costs of Steel and Concrete Barriers (Phase II Report)

by G L Williams (TRL Limited)

Version: 3

Prepared for:	**Project Record:**	**2/333: Provision of R&D and Consultancy Services for SLVR, TRL Project Number 11105884**
	Customer:	**Highways Agency (Quality Services, Traffic Safety and Environment Division)** **St. Christopher House,** **Southwark Street, London, SE1 0TE.** **Sponsor: Brian Hill**

This report has been prepared for the Safety Standards and Research Department of the Highways Agency, The views expressed are those of the author(s) and not necessarily those of the Highways Agency.

Published Project Reports are written primarily for the Customer rather than for a general audience and are published with the Customer's approval.

This report has been produced by TRL Limited, under a Contract placed by the Highways Agency. Any views expressed are not necessarily those of the Agency.

TRL is committed to optimising energy efficiency, reducing waste and promoting recycling and re-use. In support of these environmental goals, this report has been printed on recycled paper, comprising 100% post-consumer waste, manufactured using a TCF (totally chlorine free) process.

Contents

Contents Contd.

List of Tables

List of Figures

Executive Summary

A Review of HGV Crossover Accidents, and the Relative Costs of Steel and Concrete Barriers (Phase II Report)

by G L Williams, TRL Limited

PROJECT REFERENCE : 11105884
HIGHWAYS AGENCY PROJECT SPONSOR : Brian Hill, Highways Agency
TRL PROJECT MANAGER : Steve Savin

TRL Limited has been commissioned to examine crossover accidents involving heavy goods vehicles (HGVs) on major roads in Great Britain. This report consists of two inter related parts - a review of HGV accidents in which the vehicle restraint in the central reserve has been impacted, and an examination of the whole life costs associated with metal safety fences and concrete safety barriers.

Two distinct types of HGV accident were investigated - those in which an HGV crossed the central reserve, and those in which an HGV struck a safety fence or barrier in the central reserve and was contained and redirected. In order to analyse such accidents, data were extracted from the STATS 19 accident database for the years 1985 to 1998 inclusive. The main findings were as follows:

- Between 1985 and 1998 there was a total of 786 HGV crossover accidents, this being 0.47% of the total number of vehicle accidents in this period. Within these accidents, the most serious casualty was rated as 'fatal' in 125 (16%) incidents, 'serious' in 226 (29%), and the remaining 435 (55%) rated as 'slight'.
- Within the 786 HGV crossover accidents, there was a total of 1686 casualties, these being 0.07% of the total number of casualties resulting from vehicle accidents during this period. Of these casualties, 180 (11%) were rated as 'fatal', 456 (27%) as 'serious injuries', and 1050 (62%) as 'slight injuries'.

These accident statistics show that the HGV crossover accident is rare, and the resulting casualties constitute a small percentage of the total number occurring in vehicle accidents on the major roads of Great Britain.

Fatal HGV crossover accidents were identified using the STATS19 database. Of the 125 fatal accidents, 56 associated fatal files were available and of these, 39 contained enough information to enable the lateral impact energy of the HGV to be calculated. It was found that in 9 cases the HGV may have been contained by a 'very high containment' class of safety fence or barrier, and of these, 6 may have been contained by a higher containment safety fence or barrier.

Fatal accidents in which an HGV was contained and redirected by a vehicle restraint system in the central reserve were then also highlighted using the STATS19 database. When compared to data regarding HGV crossover accidents it was found that there were typically 2.1 casualties involved in an HGV crossover accident, compared with 1.6 casualties in an accident where an HGV is contained and redirected. It was also shown that the probability of a fatal HGV crossover accident is approximately twice that of an accident in which an HGV is contained and redirected.

Following this data analysis, it was decided to compare the relative whole life costs (WLC) of 'normal containment' class safety fences and barriers with that of a greater level of containment, this being the Higher Vertical Concrete Barrier (HVCB). A total of seven items of cost were examined, these being safety fence and barrier installation, general maintenance, repairs (following an accident), removal costs, accident costs, and traffic management and traffic delay costs associated with any works to the vehicle restraint system. These were then consolidated on a whole life costing spreadsheet, to enable the WLC for 1000m of each safety fence or barrier type to be calculated over a service life of 50 years. After a period of 25 years it was assumed that the metal safety fences would be removed from site and replaced with an identical system. There were a number of items of cost excluded from the whole life cost calculations due to their complex

and/or site specific nature. These included the relocation of services (such as lighting columns and signs), the cost of consequential structural damage, and the costs associated with the complete closure of the carriageway during the recovery of vehicles.

If no accidents occur with the safety fence or barrier over its whole life, calculations showed that the WLC for HVCB was approximately twice that for common vehicle restraint systems including the wire rope safety fence (WRSF), double sided tensioned corrugated beam (TCB) and open box beam (OBB). It was further shown that the WLC for 1000m of HVCB would be less than for 1000m (during a service life of 50 years) of:-

- OBB and Vertical Concrete Barrier (precast and slipformed) if approximately 10 accidents occur.
- TCB if approximately 13 accidents occur.
- WRSF if approximately 14 accidents occur.

It was however, assumed in these calculations that the accident rates and severity would mirror those seen in the historical accident data ranging from 1985 to 1998.

IMPLEMENTATION

Following the investigations carried out under this commission further studies are recommended:

- Identify lengths of major road with a high percentage of HGVs or HGV crossover accidents, as the use of very high containment vehicle restraint systems in the central reserve has been shown to be more economically viable where the probability of an HGV impact is high.

- A study of accidents involving vehicles of mass less than 3.5 tonnes crossing the central reserve or being contained and redirected by safety fences or safety barriers.

- Investigate the costs associated with structural consequences resulting from HGV accidents in the central reserve of major roads.

- Investigate the costs associated with relocating services in the central reserve of major roads.

- Compare the whole life costs of safety fences and barriers not included in the current study such as Double Rail Open Box Beam (DROBB), parapets, precast HVCB, two parallel runs of single sided TCB and OBB, and/or safety fences at half post spacing.

A Review of HGV Crossover Accidents, and the Relative Costs of Steel and Concrete Barriers (Phase II Report)

ABSTRACT

TRL Limited has been commissioned by the Highways Agency to examine crossover accidents involving heavy goods vehicles (HGVs) on major roads in Great Britain. This report consists of two inter related parts - a review of HGV crossover accidents resulting in casualties, and the relative costs of steel safety fences and concrete barriers. The report presents the findings from a study of fatal accidents occurring between 1985 to 1998 and contains detailed accounts of these accidents with particular reference to the performance of the safety fence or barrier (where present). A detailed whole life costing survey for the most common types of safety fences and barriers currently in use on the central reserve of major roads, is also included.

CHANGES FROM PHASE I REPORT

- The STATS19 data examined in this report now cover accidents occurring between 1985 to 1998. In the Phase I report, this period was 1988 to 1998.
- The STATS19 data also include information relating to accidents involving HGVs striking a safety barrier in the central reserve (where present) and being contained and redirected back into the same, live carriageway.
- A list of all police files relating to fatal HGV crossover accidents occurring between 1985 and 1998 on major roads in Great Britain has now been incorporated. This list also gives reasons for not being able to obtain some of the police files.
- Material costs taken from the "Spon's Civil Engineering and Highway Works Price Book" have been updated in line with their 2002 publication [1].
- To compliment the costs obtained from the Spon's Price Book, cost data have also been obtained from UK representatives involved with the installation and maintenance of safety fences and barriers, and with the traffic management required during highway works.
- This information has been combined to estimate the likely whole life costs (WLC) of a number of safety fence and barrier designs which are typically installed in the central reserve of major roads. These WLCs include the installation, maintenance, repairs, accident, and removal costs associated with these systems.
- The WLC worksheet has also been introduced in this report.
- The effect of repair frequency and accident severity on the WLC for safety fences and barriers have also been investigated.
- Based on the above information, conclusions and recommendations have been updated as appropriate.

1. INTRODUCTION

1.1 Background

Early in 1999, there was a series of accidents involving heavy goods vehicles (HGVs) veering to their offside, impacting safety fences installed in the central reserve, and entering the opposing carriageway. These are referred to as 'crossover accidents'. Such accidents have caused a number of fatal casualties, and have given rise to this study.

The safety fences and barriers generally installed in the central reserve are known as 'normal' or 'N2' containment. They have been designed to safely contain and redirect errant vehicles of one and a half tonnes in weight, impacting the fence or barrier at one hundred and ten kilometres per hour and at twenty degrees; they were not designed to contain and redirect heavier vehicles. However experience and police files examined as part of this project, have shown that the N2 containment safety fences can, in some instances, contain these heavier vehicles successfully.

Concern within the Highways Agency about HGV crossover accidents prompted the consideration of replacing N2 containment safety fences in the central reserve with fences or barriers of a greater level of containment. For example the higher vertical concrete barrier (HVCB) has shown under controlled full scale impact testing that it can contain and safely redirect heavier vehicles (i.e. a thirty-tonne rigid HGV impact at sixty-five kilometres per hour and at twenty degrees).

TRL Limited has been commissioned by the Highways Agency to report on the containment effectiveness of steel safety fences and concrete safety barriers currently in use in the central reserve during impacts by HGVs. A survey of whole life costs for installing safety fences and barriers of greater containment is also investigated.

1.2 Comparison with other types of vehicle accident

The annual number of *accidents* involving HGVs crossing the central reserve is relatively small when compared with the total number of vehicle accidents occurring on major roads in Great Britain. In the period 1985 to 1998 there were, on average, 120,302 reported vehicle accidents per annum on such roads (see Appendix B, Table B1). In the same period there were, on average, 56 HGV crossover accidents per year (see Appendix C, Table C1), which constitutes 0.47% of the total number of vehicle accidents.

The rarity of the HGV crossover accident is also reflected in the *casualty* statistics. Of the 166,070 casualties occurring, on average, each year on major roads in Great Britain (see Appendix B, Table B2), 120 casualties (0.07%) resulted from HGV crossover accidents (see Appendix C, Table C2).

Again, this trend is shown in the statistics relating to *fatalities*, where those caused by HGV crossover accidents (approximately 13 per year - see Appendix C, Table C2) comprise 0.46% of the total number of fatalities on major roads in Great Britain (approximately 2,844 per year - see Appendix B, Table B2).

2. ACCIDENT ANALYSIS

2.1. Data Collection

The data in this section are based on reports sent to the Department for Transport, Local Government and the Regions (DTLR) by police forces following an accident in which the police have attended and human injury has occurred to one or more persons. The accident report form known as STATS19 is used for such purposes, and is reproduced in Appendix D. The current system of collecting road accident statistics was set up in 1968 [2]. Each year, officers of the 51 police forces in Great Britain complete some 240,000 STATS19 road accident reports. These forms are transferred to magnetic tape and are sent to the DTLR at monthly intervals, where they are added to the annual master file.

The most recent accidents considered in this study took place in 1998, due to police reports generally only being released once a verdict has been reached in any court proceedings arising from the accident.

The search commencement date of 1985 was selected for two reasons:
(i) Before this date the STATS19 database contains less information regarding the specific details of accidents.
(ii) This year saw the introduction of TD19/85: 'Safety Fences and Barriers' [3], which aimed to standardise new and existing safety fences and barriers erected on the main roads of Great Britain.

Hence, it is for these reasons that this report details HGV crossover accidents occurring between 1985 and 1998.

2.1.1 Definition of Accident Severity

Accidents are classed as fatal, serious or slight, depending on the severity of the most seriously injured casualty in the accident:

- *'Fatal accident:* One in which at least one person is killed (but excluding confirmed suicides) within 30 days of the occurrence of the accident. [*Killed:* Human casualties who sustained injuries which caused death less than 30 days after the accident].
- *Serious accident:* One in which at least one person is seriously injured but no person (other than a confirmed suicide) is killed. [*Serious injury:* An injury for which a person is detained in hospital as an ‘in-patient’, or any of the following injuries whether or not they are detained in hospital; fractures, concussion, internal injuries, crushings, burns (excluding friction burns), severe cuts and lacerations, severe general shock requiring medical treatment, injuries causing death 30 or more days after the accident].
- *Slight accident:* One in which at least one person is slightly injured but no person (other than a confirmed suicide) is killed. [*Slight injury*: An injury of a minor character such as sprain, bruise or cut not judged to be severe, or slight shock requiring roadside attention. This definition includes injuries not requiring medical attention].
- Persons who are merely shaken and who have no other injury are not included, unless they receive or appear to need medical treatment.' [4]

2.1.2 Definition of a Heavy Goods Vehicle (HGV)

Research has found that numerous definitions of an HGV exist. In this study, the definition adopted by the DTLR (and hence used in the STATS19 reporting structure) has been used:

'Heavy goods vehicles (HGV):

- *Prior to 1994 these were defined as those vehicles over 1.524 tonnes unladen weight and included vehicles with six or more tyres, some four wheel vehicles with extra large bodies and larger rear tyres and tractor units travelling without their usual trailer.*

- *From 1 January 1994 the weight definition changed to those vehicles over 3.5 tonnes maximum permissible gross vehicle weight (gvw).' [2]*

Hence when analysing details within the police reports (which concerned accidents both before and after 1994), the vehicle's weight was noted to ensure that only vehicles with a gross vehicle weight exceeding 3.5 tonnes were included in the study and subsequent numerical analysis.

Whilst this is an effective method for limiting the weight of an HGV, the variation in the weight of a vehicle defined as an HGV can be great (ranging from 4 to 38 tonnes in this study). The form of the vehicle can also differ considerably under the current definition of an HGV, from a large delivery van to a articulated vehicle with six or more axles. Such differences can make it difficult to treat all vehicles defined as HGVs in the same manner. This in turn makes it difficult to estimate the effects when a vehicle defined as an 'HGV' impacts a safety fence or barrier

2.1.3 Searching on the STATS19 database

In order to assess which of the accidents reported through the STATS19 procedure involved an HGV crossing the central reserve, a search was made on the STATS19 records database. A search can be made for any combination of criteria relating to the information collected on the STATS19 report forms. For the purpose of this report, the following criterion was used between the years 1985 to 1998:

'Accidents on motorways and/or M(A) roads and/or A roads in Great Britain involving at least one HGV crossing the central reserve'

2.1.4 Outputs from the STATS19 Search

The output of the STATS19 search was twofold:

(i) **General accident statistics -** These are examined in detail in Section 2.2, and tabulated in Appendix C.

(ii) **A list of police accident reference numbers relating to fatal accidents -** These are examined in detail in Section 2.3, and tabulated in Appendix E.

2.1.5 Under reporting in the STATS19 database

Whilst the STATS19 database provides accident information on reported accidents, many potentially reportable road accidents and casualties are not reported to the police and therefore, do not appear in the official annual statistics.

A report by Helen James [5] summarised five UK studies to investigate under reporting. Police and hospital, accident and casualty records were compared, and the following Table was reported:

Vehicle occupant	Min-Max % Reported
Fatal	100
Serious	85 - 91
Slight	70 - 82
All injuries	75 - 86

Table 1: Percentage of injuries reported (estimated from hospital-based studies in Great Britain) [5]

In the report (dated 1991), the following observation was made:

'Legally [in Britain], only accidents in which a motor vehicle is involved causing injury to a person other than the driver, and in which exchange of addresses and insurance information has not occurred, must be reported to the police. Thus some accidents are not reported because they do not fall into these requirements, such as single-vehicle accidents where only the driver/rider was injured, or multi-vehicle accidents where names and addresses have been exchanged. Others are not reported because of ignorance of the legal obligation to report, perception that the accident was too trivial, or because the victim did not become aware of their injuries at the scene of the accident.' [5]

In addition, the report also states that:

'Perception of the severity of the injury or accident, and whether it was a road accident, also determined the level of reporting if this was not necessary or was not considered necessary. This meant that rates increased with injury severity and were higher for multi-vehicle compared with single vehicle accidents.' [5]

It can be deduced that due to the greater impact weights, speeds and angles present in HGV crossover accidents, there will generally be a higher level of impact energy. In addition, such accidents often involve more than one vehicle. Hence the number of reported HGV crossover accidents will closely reflect the actual number occurring. As a result, those data used in this report will not be adjusted to account for under reporting. It is also unknown to what degree under reporting plays a part in accidents of this specific type, and so applying a general adjustment factor may be misleading.

2.2 Overview of Statistics

The data collected from the STATS19 database regarding the number and severity of HGV crossover accidents can be found in Appendix C. These data have been used to provide the graphical representations in Figures 1 to 3.

These data indicate that in comparison to other types of accident occurring on the major roads of Great Britain, the HGV crossover accident is rare (being 0.47% of all vehicle accidents on these roads), (refer to Appendix B, Table B1 and Appendix C, Table C1).

2.2.1 The Annual Number of HGV Crossover Accidents

Figure 1 shows the annual number of HGV crossover accidents occurring on major roads in Great Britain between 1985 and 1998.

It shows that the number of HGV crossover accidents per year initially increased quite sharply from 67 in 1985, to 76 in 1986. However, since 1986 the number of accidents has tended to decrease gradually each year. This may be for a variety of reasons, for example an increase in the amount of safety fence or barrier installed on the central reserve. This decrease is not however, due to a reduction in the number of HGVs using these roads, as this value was seen to rise by 47% (from 217 to 320 million vehicle kilometres) between 1985 and 1998 (see Appendix B, Table B3).

After the decrease in the number of HGV crossover accidents between 1986 and 1993, the number of accidents has then fluctuated between approximately 40 and 50 accidents per year between 1993 and 1998.

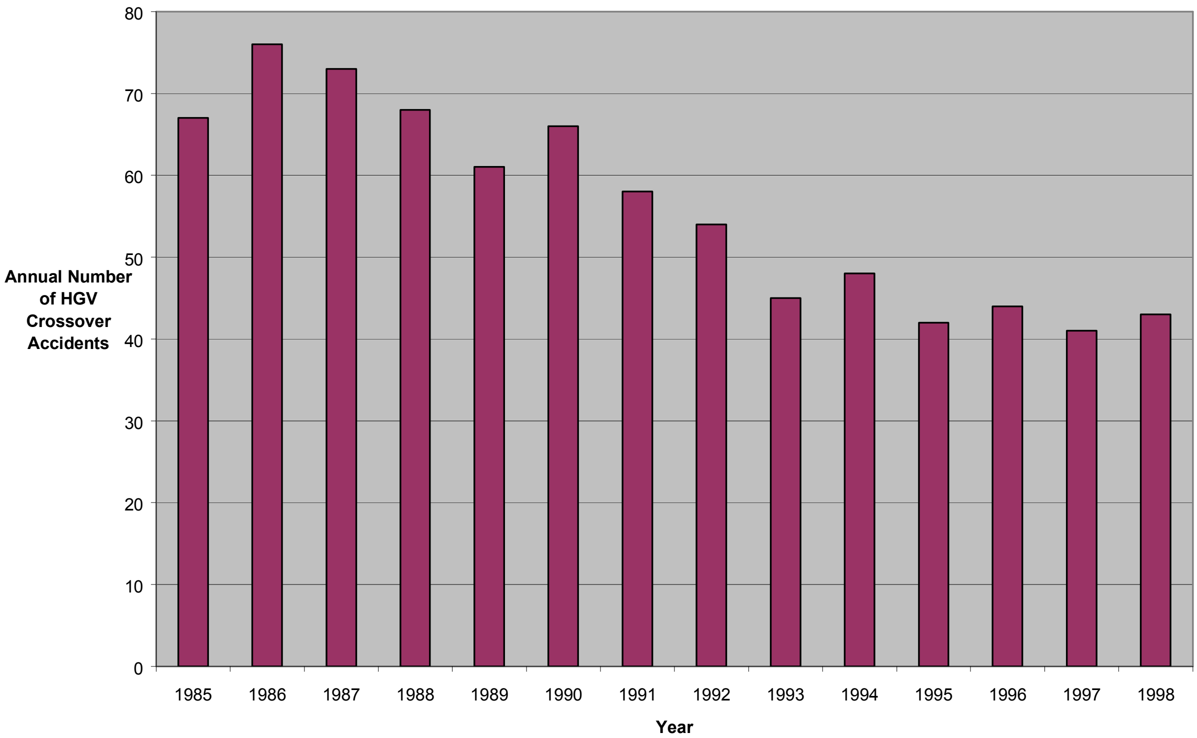


Figure 1: *Annual* Number of HGV Crossover *Accidents* on Motorways, A(M) and A roads in Great Britain (Of All Severity)
(see Appendix C, Table C1)

These small variations may be attributable to secondary factors such as poor weather and/or visibility [6], however it is more likely that they are due to the fluctuations associated with random occurrences.

2.2.2 Breakdown of Annual HGV Crossover Accidents - By Severity

As previously stated, Figure 1 (above) shows the *total* number of HGV crossover accidents occurring in each year on major roads in Great Britain. This total number of accidents is *broken down* into three distinct categories of accident: *fatal, serious and slight*. These categories define the severity of the accident, and are related to the severity of the most seriously injured casualty in the accident (as defined in Section 2.1.1).

Between 1985 and 1998 there was a total of 786 HGV crossover accidents. A breakdown of these accidents by accident severity is displayed in Figure 2. The accident was rated as 'fatal' in 125 (16%) incidents, 'serious' in 226 (29%) incidents, and the remaining 435 (55%) incidents were rated as 'slight' (See Appendix C, Table C1).

Figure 2 shows that between 1985 and 1998, all levels of accident severity have fallen in number, with the exception of fatal injuries which have remained at quite a constant level throughout this period. The number of fatal accidents drops noticeably in 1996 and this may be due to the fact that there were no accidents involving more than one HGV in that year.

It should be noted that the number of fatal accidents is small, and hence this type of graphical representation may magnify any small change in the number of fatal accidents. Between 1985 and 1998, the total number of fatal accidents was 125, varying from a minimum of 3 in 1996, to a maximum of 13 in 1986 and 1990.

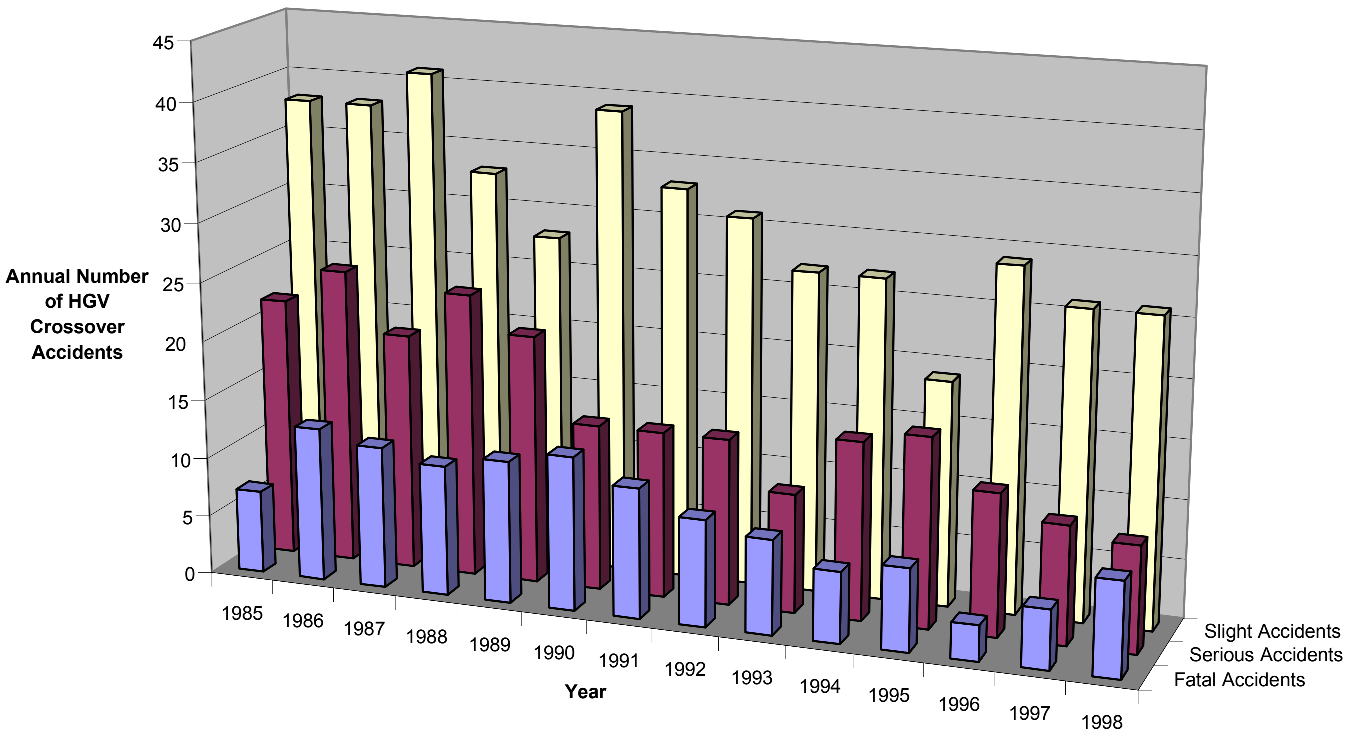


Figure 2: Number of HGV Crossover *Accidents* on Motorways, A(M) and A Roads in Great Britain, *by Severity*
(see Appendix C, Table C1)

2.2.3 Casualties Involved in HGV Crossover Accidents

In addition to examining the number of HGV crossover *accidents* in each year, it is also important to investigate the number of *casualties* resulting from these accidents. These are shown by severity of casualty in Figure 3.

Figure 3 shows a similar trend to that shown in Figure 2 (which considered the number of accidents, by severity). This is not surprising, as one would expect the number of casualties to reflect the number of accidents occurring in each year, unless there are exceptional circumstances. These could include a multiple vehicle accident, and/or an accident involving a vehicle containing a large number of people (such as a coach or a minibus).

Within the 786 HGV crossover *accidents* occurring between 1985 and 1998 on major roads in Great Britain, there were a total of 1686 *casualties*, an average of 2.1 casualties per accident. Of these 1686 casualties, 180 (11%) were fatalities, 456 (27%) were serious injuries, and the remaining 1050 (62%) were slight injuries (see Appendix C, Table C2).

By comparison, these figures represent 0.07% of the casualties (of all severities) occurring on the major roads of Great Britain between 1985 and 1998 (see Appendix B, Table B2 and Appendix C, Table C2). The 180 HGV crossover accidents fatalities represent 0.46% of the total number of fatalities occurring as a result of a vehicle accident. This indicates that the proportion of casualties and fatalities involved in HGV crossover accidents is small when compared to the equivalent total figures for all types of vehicle accidents.

Figure 3 displays a similar pattern of injuries between the different casualty severities in each year. It can be seen that the number of casualties increases from an initial low in 1985 to a peak in 1987, after which it decreases gradually until 1993. The number of casualties then rises slightly in 1994 and 1995, until a drop in 1996. There is a gradual rise in the number of casualties in the final three years.

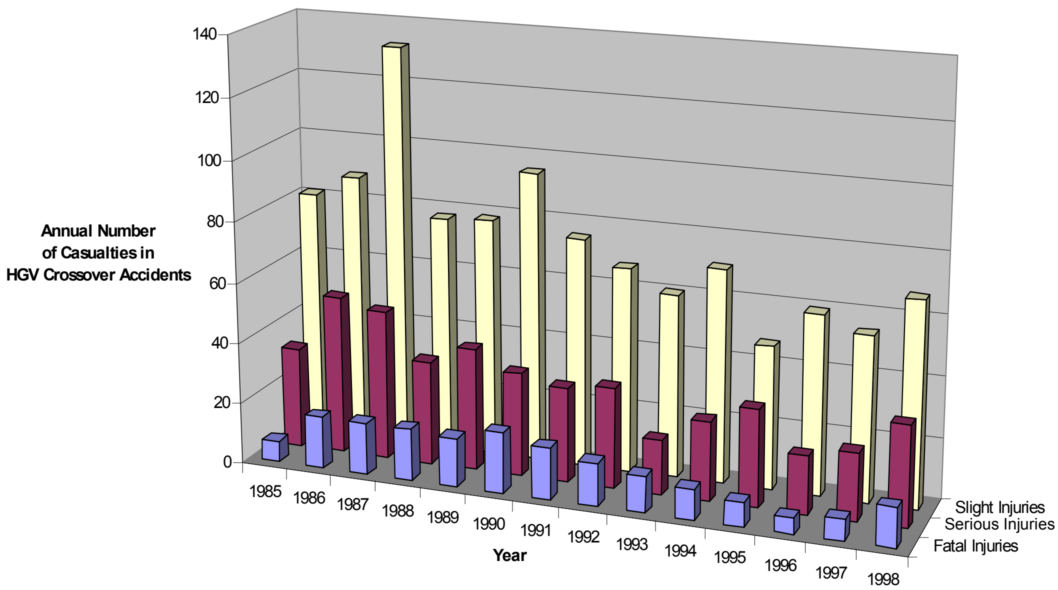


Figure 3: Number of *Casualties* Involved in HGV Crossover Accidents on Motorways, A(M) and A roads in Great Britain, *By Severity.*
(see Appendix C, Table C2)

2.3. Police Fatal Files

The STATS 19 search (detailed in Section 2.1.3) revealed that there were 125 fatal accidents involving HGV crossovers between 1985 and 1998. These accidents were cross-referenced with a list of police files involving fatal accidents, known as 'fatal files'. Some of these files are held at TRL Limited, and 56 of the 125 fatal files were found to be within this file collection. (The collection is jointly funded by the DTLR's Vehicle Standards & Engineering, and Road Safety Divisions).

The fatal files were investigated due to their detailed content, i.e. they will generally include photographs taken at and around the accident site, and drawings/sketches of the scene. From these, the type of safety fence or barrier present at the crossover site can then be identified (if installed). The impacting vehicle's weight, speed and angle are also more likely to be recorded in these fatal files, and this information can be used to assess the level of impact energy imposed on the safety fence or barrier during the accident. This detailed information is more likely to be included in fatal files than in police files relating to non-fatal accidents.

Of the 125 fatal files concerning HGV crossover accidents, 56 were collected during Phase I of this study. A further 69 were identified as possibly containing further useful information. The associated police forces were approached for these outstanding 69 files, however no additional files could be obtained, as explained below:

- 35 files: No correspondence was received from the police force regarding the requested file(s).
- 28 files: The police file(s) had been destroyed as part of a regular file disposal schedule.
- 6 files: The police file(s) was not available for other reasons (e.g. file(s) could not be found, court proceedings, or the accident was not deemed to be a crossover accident by the police force contacted).

The 56 available fatal files were reviewed as part of Phase II of the study and notes relating to the accidents (with particular reference to the safety fence or barrier performance) are included (Appendix E, Table E). From the performance characteristics of the safety systems installed at the site of the accident, conclusions are drawn later in this report with regard to the containment effectiveness of metal safety fences and concrete barriers in the central reserve of major roads.

Figure 4 gives a brief summary of the information available in the police fatal files held at TRL Limited and examined for this commission.

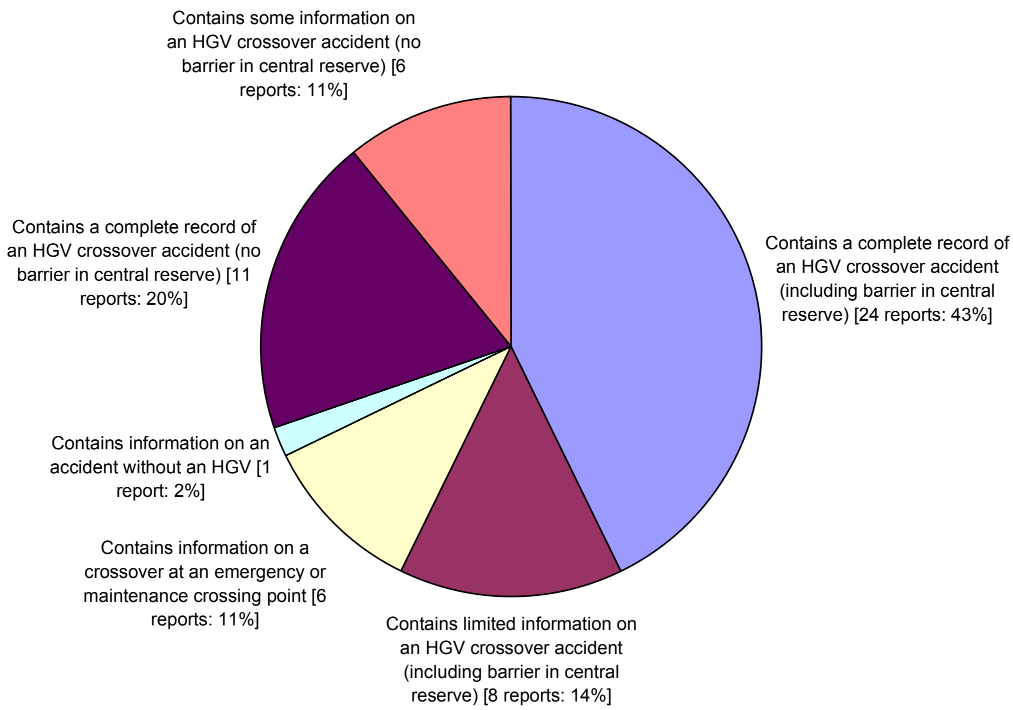
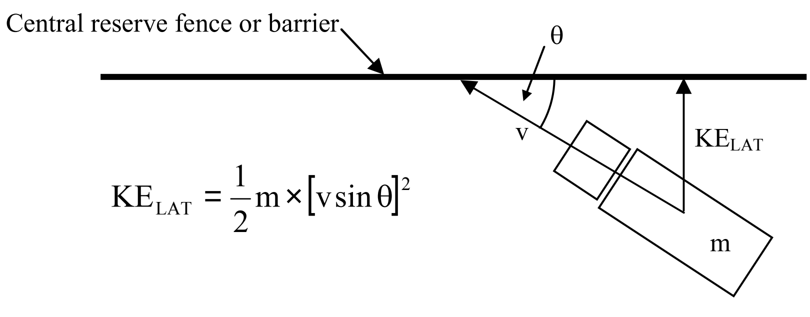


Figure 4: Summary of Information Contained in Fatal Files Held at TRL Limited

Appendix E, Table E gives brief details about each of the accidents included in the 56 fatal files within TRL's possession, and also lists those files which were not available (with reasons why).

2.3.1 Energy Balances

In Appendix E, Table E, an attempt has been made to analyse the impact conditions imposed onto the central reserve by the impacting HGV in each of the accidents, and to use this to try and assess the severity of the impact. This has been effected by calculating the level of lateral impact energy, KE_{LAT}, (resolved at ninety degrees to the central reserve) as follows:



$$KE_{LAT} = \frac{1}{2} m \times [v \sin\theta]^2$$

Figure 5: Calculation of Lateral Impact Energy

This will then take into account the fact that the impacts in accidents will be by HGVs of different weight (m), impacting at different speeds (v) and angles (θ). The level of impact energy (KE_{LAT}) experienced in each of the accidents has then been compared to those levels experienced by a safety fence or barrier in the validation tests specified in BS-EN 1317 1&2 [7] (see Table 2 below):

Test Type	Containment Level	Test Vehicle	Test Weight (kg)	Test Speed (km/h)	Test Angle (degrees)	Lateral Impact Energy, KE_{LAT} (kJ)
$TB32_{MAX}$	Normal containment	Car	1575	115.5	21.5	108,883
$TB41_{MAX}$	Low angle containment	Rigid HGV	10300	73.5	9.5	58,478
$TB42_{MAX}$	Higher containment	Rigid HGV	10300	73.5	16.5	173,165
$TB51_{MAX}$	Higher containment	Bus	13400	73.5	21.5	375,141
$TB61_{MAX}$	Higher containment	Rigid HGV	16500	84	21.5	603,334
$TB71_{MAX}$	Very high containment	Rigid HGV	30900	68.25	21.5	745,897
$TB81_{MAX}$	Very high containment	Articulated HGV	39100	68.25	21.5	943,838

Table 2: Calculated maximum permissible lateral impact energy in standard impact tests (to BS-EN 1317-1&2, 1998) [7]

As can be seen in Table 2, the maximum level of lateral impact energy (i.e. resolved at ninety degrees to the barrier) is 943,838kJ in the TB81 test (this being a 39,100kg HGV impacting a vehicle restraint at 21.5 deg and at 68.25km/h). This is within the speed/angle tolerance envelope of BSEN1317 Part 2 [7], and the vehicle weight is at the maximum limit for this test type. Hence, by using the maximum parameters of a TB81 impact test, the maximum resolved lateral impact energy is approximately 950,000kJ.

Although the load distribution and therefore deformation characteristics of a safety fence or barrier can vary considerably due to the impact angle, it is felt that this purely energy-based approach will provide a basis for a comparison between controlled validation tests and 'real life' accidents, for similar angles of impact.

2.3.2. Energy Balances and the Police Fatal Files - An Estimation of Containment

From a comparison between the lateral impact energy levels experienced in each of the HGV crossover accidents and those conditions undertaken during full-scale testing (see Appendix E, Table E), the following conclusions can be reached:

Of the 56 police fatal files examined relating to fatal HGV crossover accidents:

- 16 (28%) did not contain enough information for an assessment to be made (i.e. vehicle weight and/or impact speed, and/or impact angle have not been recorded).
- 1 (2%) concerned a vehicle less than 3.5 tonnes in weight (i.e. not within the current definition of an HGV).
- 23 (41%) the impact energy *greatly* exceeded 950,000kJ (approximately, the maximum resolved lateral impact energy).
- 7 (13%) the impact energy *slightly* exceeded 950,000kJ.
- 9 (16%) the impact energy *was less* than 950,000kJ, (and hence may have been prevented by the installation of a *very high containment* safety fence or barrier).
  - *Of these 9 accidents*, 6 may have been stopped by a *higher containment* safety fence or barrier.

The average lateral impact energy in these fatal HGV crossover accidents was approximately 3,000,000kJ - over three times that experienced in a $TB81_{MAX}$ controlled impact test (see Appendix E, Table E).

In addition to the impact parameters, details were also collected from the fatal files regarding the type of safety fence or barrier installed in the central reserve at the site of the HGV crossover accidents. The results were as follows:

- Two parallel rows of single sided tensioned corrugated beam were installed in 13 cases.
- Double sided TCB was installed in 13 cases.
- Single sided TCB was installed in 1 case.
- An unspecified type of safety fence or barrier was installed in 6 cases (generally 'metal barrier' was recorded).
- No vehicle restraint system was installed in 22 cases (including 5 at a maintenance or emergency crossing point).
- No details of the safety fence, barrier or central reserve were given in 1 case.

In all of the accidents where the specific type of safety fence or barrier has been identified, TCB has been used. This is either in two parallel rows of single sided TCB, or in single rows of either a single sided or double sided configuration. This is not surprising as TCB is widely used in central reserves in the UK. TCB has been designed to contain and redirect vehicles such as cars and has proven to be effective during full-scale impact testing. It is classified as containment level N2 and is not therefore, designed to contain and redirect vehicles of mass greater than 1500kg, nor at an impact angle exceeding 20°.

In all of the 33 accidents in which a safety fence was struck and the HGV crossed over the central reserve, the combination of impact parameters exceeded those experienced during an N2 containment full-scale impact test. Hence the safety fences performed as one would expect given that the impact conditions at the accident sites were greater than those for which the fences were designed.

It is important to note however, that 22 of the 56 HGV crossover accidents (39%) occurred where there was no provision of safety fence or barrier in the central reserve at the time of the accident. This issue has been addressed since these accidents; emergency crossing points have now been completely closed with safety fences or barriers, and maintenance crossing points are now closed and removable safety devices have been installed in their place.

During the examination of the police fatal files, the width of the central reserve was also noted. This is of particular relevance to a comparison between steel safety fences and concrete barriers because of their different deflection characteristics on impact. Due to their rigid structure, concrete barriers do not deform during impact and hence, can be placed on relatively narrow central reserves. In the case of metal safety fences however, this is not the case as the fence is not rigid and is designed to deform under impact. As an example, for wire rope systems (at the standard 2.4m post spacing), it is recommended that they should not be used on central reserves having a width of less than 3.14m due to their deflection characteristics [8].

2.4 Accidents in which an HGV is contained and redirected

From the detailed examination of police fatal files relating to HGV crossover accidents, one method of reducing the number of casualties caused by such accidents may be to increase the containment level of the safety fences and barriers used in the central reserve. It has been shown in Section 2.3.2 that 9 of the 56 fatal crossover accidents occurring between 1985 and 1998 may have been prevented had a very high containment safety fence or barrier been used in the central reserve. However, there is the possibility that increasing the containment level of the safety fence or barrier may cause additional hazards (and subsequent casualties).

Consideration should be given to the possibility that containing and redirecting HGVs back onto their original carriageway can, in some circumstances, present a greater risk to other road users than if the HGV were allowed to pass through the central reserve and completely traverse the opposing carriageway. A hypothetical example of when such a situation could occur is given below:

Figure 6 shows a simple, single HGV crossover scenario. An HGV is travelling along the carriageway with roadworks ahead. As a result of the roadworks, traffic ahead has slowed on the carriageway and congestion is developing. The driver of the HGV has not anticipated this, and hence brakes sharply, and swerves to the offside to avoid the queuing traffic. The HGV strikes a very high containment safety fence or barrier in the central reserve and is contained and redirected in accordance with CEN validation tests [7]. The HGV is however, redirected towards the queuing traffic, increasing the probability of impact with other vehicles and hence, of casualties. The traffic on the opposite carriageway was light and free moving at the time of the accident. Therefore the number of casualties may have been lower had the HGV been allowed to crossover the central reserve and enter the opposite carriageway, as other drivers may have had enough time to recognise and assess the danger, and take appropriate avoidance action.

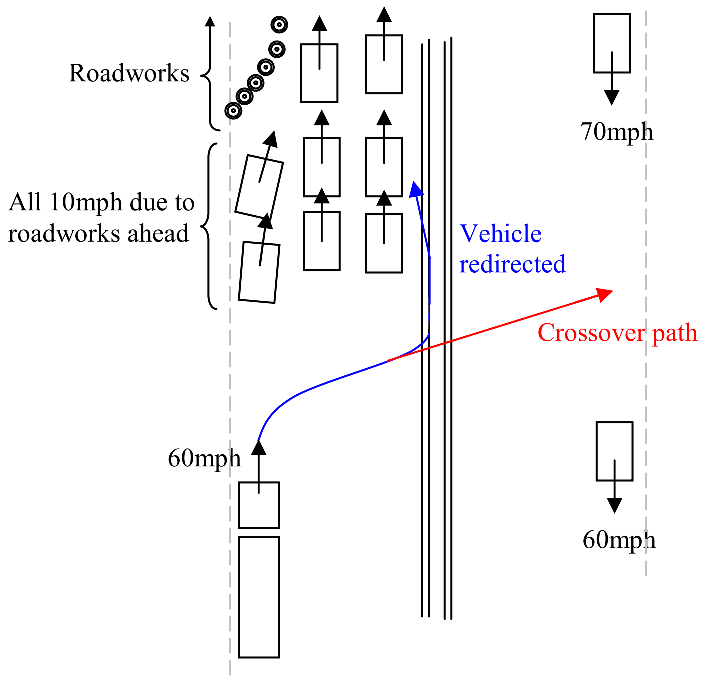


Figure 6: Hypothetical Example of a Single HGV Crossover Scenario where allowing a crossover may reduce the probability of casualties.

To help in the avoidance of this hypothetical example, it is reasonable to expect that warning signs would have been placed sufficiently in front of the roadworks to warn the HGV driver of the roadworks ahead. However for this example, it is assumed that either the HGV driver has chosen to disregard these signs, or that the traffic congestion is long in length and that the road signs have not yet begun, or that the driver has been distracted. The example does however, highlight the point that there may be some instances where allowing a crossover to occur may in fact, reduce the number and severity of casualties.

In the examination of the HGV fatal crossover accident files, notes were made (where information was available) on the traffic flow on both carriageways at the time of the accident and the following was found:

- 11 cases: Traffic flow *less* on the opposite carriageway.
- 4 cases: Traffic flow *greater* on the opposite carriageway.
- 38 cases: *Similar* traffic flow on both carriageways.
- 3 cases: Not enough information was available in the fatal file to make an assessment.

Hence the traffic flow was less on the opposite carriageway in 21% of the fatal HGV crossover accidents where information was recorded. This shows that the hypothetical example of a less severe accident occurring if an HGV is allowed to traverse the central reserve is rare, although the situation is not impossible.

It was decided to investigate further accidents in which an HGV is contained and redirected to try and assess what effect such accidents might have in terms of casualty numbers and injury severity. If the containment level of the safety fence or barrier in the central reserve were to be increased, it is important to understand the safety effects that such a change could have.

In order to assess such accidents, STATS19 data were again collected. The following search criterion was used in the database for the years 1985 to 1998:

'Accidents on motorways and/or M(A) roads and/or A roads in Great Britain involving at least one HGV striking the central reserve and remaining on the same carriageway.'

The data obtained showed that the average number of casualties resulting from an accident in which an HGV is contained and redirected is approximately 1.6. This is less than the rate seen in HGV crossover accidents where the number of casualties per accident is approximately 2.1.

In a similar way to the HGV crossover analysis, accident statistics and police fatal files were obtained (where available), and examined. The accident statistics are summarised in Section 2.5 and tabulated in Appendix G. From the police reports, impact conditions were noted, and the lateral impact energy of the vehicle (i.e. resolved at 90 degrees to the traffic face) was calculated (see Section 2.3.1). These energy values were then compared to those experienced during a controlled full-scale impact test (see Table 2, and Appendix F, Table F).

As the N2 containment safety fences and barriers are designed to contain and redirect vehicles of 1.5 tonnes, it is not really surprising that the number of accidents involving an HGV (of weight exceeding 3.5tonnes) striking a safety fence or barrier and being contained and redirected (439) is 36% less than for accidents where an HGV crosses over the central reserve (786).

Of the 32 reported fatal accidents in which an HGV was contained and redirected on a major road in Great Britain between (1985 and 1998), 12 associated police fatal files were available (the other 20 having mainly been destroyed or unavailable for another reason). Of these accidents, the number of fatal files:

- 3 (25%) did not contain enough information for an assessment of the impact severity to be made.
- *1 (8%)* the impact energy *greatly* exceeded 950,000kJ (approximately, the maximum resolved lateral impact energy).
- *3 (25%)* the impact energy *slightly* exceeded 950,000kJ.
- 5 (42%) the impact energy *was less* than 950,000kJ.
  - Of these 5 fatal accidents, the number of accidents in which the impact energy is less than that experienced in a higher containment TB61 impact test: 4 (80%)

Hence, there were 9 accidents where there was enough information available to calculate the resolved lateral impact energy. Within these fatal accidents, the average lateral impact energy was approximately 110,000kJ - very similar to the 108,883kJ experienced in an N2 containment test, see Table 2, Section 2.3.1. In 2 of the 9 accidents the impact energy was less than that experienced in an N2 containment impact test. The impact energy was greater than this level in the remaining 7 accidents.

During the examination of the fatal files relating to accidents where an HGV was contained and redirected, notes were made regarding the type of safety fence or barrier installed at the accident sites. The results were as follows:
Two parallel runs of single sided TCB: 1
Double Sided TCB: 3
Double Sided Open Box Beam (OBB): 3
3 Rail Double Sided OBB: 1
Unspecific barrier installed: 2
No record of a safety fence or barrier present at the accident site: 2

This shows that whilst N2 containment safety fences (such as TCB and OBB) are not designed to contain and redirect vehicles over 1.5 tonnes, they have been seen to do so during these accidents.

The following Table gives brief details of the impact conditions during each of the accidents where an HGV was contained and redirected by an N2 containment safety fence. It should be noted that the maximum lateral impact energy experienced in an N2 containment impact test is 108,883kJ.

Police Ref. No	Description of barrier at impact	Speed of impact (Km/hr)	Vehicle weight (kg)	Angle of impact (degrees)	Impact Energy
ED00298	D/S TCB	80 (witness)	6300	20 (photo)	181,965
41T1217	D/S OBB	32 (estimation)	7490	30 (sketch)	73,975
7Y43211	D/S OBB	97 (tachometer)	4000	15 (photo)	97,266
9M10139	D/S OBB	32 (estimation)	17000	70 (sketch)	593,042
9M10207	3 rail, D/S OBB	105 (tachometer)	5587	45 (photos)	1,188,206
2046490	D/S TCB	79 (tachometer)	38000	45 (sketch & photos)	4,574,801
0EB3645	Not seen in photos	96 (witness)	16000	Not recorded	Not enough information available in records
0TL0196	D/S TCB	113 (witness)	ERF	20 (witness)	Not enough information available in records
1365891	Two rows of S/S TCB with ditch in between	93 (tachometer)	11700	35 (police report)	1,284,395
A300214	Steel (two runs around a bridge support)	19 (tachometer)	38000	45 (police report)	264,622
Q065993	Grass with trees in central reserve	64 (tachometer)	38000	30 (photos)	1,501,232
X049193	Metal safety fence, Armco	Not in Police Report	17332	Not recorded	Not enough information available in records

Table 3: Impact parameters in accidents where an HGV was contained and redirected.

2.5 A Comparison of HGV Accident Statistics, 1985 to 1998.

Table 4 below displays a comparison between the HGV accident statistics for HGV crossover accidents and those in which an HGV has been contained and redirected. Whilst this comparison indicates that the number of accidents in which an HGV is contained and redirected is less than those involving an HGV crossover, the effects of under reporting should be remembered. As stated in Section 2.1.1, the figures contained within STATS19 are based on those accidents in which human injury has occurred to one or more persons, and the police have attended. In the case of accidents where an HGV has been contained, it is less likely that they will be reported as these will tend to be lower energy impacts and hence, there will be a lower probability that an injury and/or accident damage will occur. Due to the nature of the HGV crossover accident, it is more likely that the majority of these accidents will be reported, as they will generally cause a greater level of damage and disruption to other road users. Whilst the data have not been adjusted to take under reporting into account (as such an adjustment factor would be difficult to obtain), this problem should be acknowledged when comparing the two sets of data. However, all fatal accidents should be reported due to the severity of such injuries, and the subsequent attendance of the emergency services at the accident scene.

The comparison in Table 4 below shows that the probability of a fatal accident involving a contained and redirected HGV is approximately half that of a fatal HGV crossover accident. A similar proportion is also shown by the casualty statistics. This may be partly justified by the fact that the average lateral impact energy in a crossover accident is 1.6 times that experienced in an accident where the HGV is contained and redirected.

Parameter	HGV Crossover Accidents	HGV Contained Accidents
Number of accidents	786	439
%age (number) of accidents: Fatal	16% (125)	7% (32)
Serious	29% (226)	23% (101)
Slight	55% (435)	70% (306)
Number of casualties	1686	689
%age (number) of casualties: Fatal	11% (180)	5% (37)
Serious	27% (456)	22% (150)
Slight	62% (1050)	73% (502)
Average number of casualties per accident	2.1	1.6
Average Lateral Impact Energy (kJ)	3,004,122	1,804,389

Table 4: A Comparison between HGV Crossover Accidents and those in which an HGV was contained and redirected on major roads in Great Britain

In accidents where an HGV is contained and safely redirected, the lower number of casualties may be due, in part, to the mechanism of the accident. Striking a fence or barrier in the central reserve will cause the HGV to slow, as its lateral impact energy is transferred into energy to deform the safety fence (or barrier) in the central reserve. This slowing effect may give drivers following on the carriageway time to observe the problem ahead and slow and/or take evasive action to avoid the accident. Both of which will have the effect of reducing the severity of the accident and the number of casualties involved. This may not be true of an HGV crossover accident where the vehicle may come through the central reserve and/or safety fence or barrier at quite a high speed, giving drivers on the opposing carriageway less time to take appropriate avoidance action. These phenomena may well be due to the difference in load distribution, and hence a higher concentration of energy in the HGV crossover accident. It can be seen from the analysis of the police fatal files that an HGV's angle of impact with a safety fence or barrier is generally greater in an HGV crossover accident than one in which an HGV is contained and redirected. Hence the impact load in an HGV crossover accident will be imposed on the safety fence or barrier over a smaller area. This, in turn, relates to a higher concentration of energy, and hence the greater level of damage in such accidents.

2.6 Summary of the STATS 19 Data Analysis

Accidents involving HGVs passing through the central reserve and entering the opposite carriageway are rare, with approximately 56 reported cases each year on major roads in Great Britain. The number of all reported accidents on such roads each year is approximately 120,000, meaning that *HGV crossover accidents* account for approximately 0.47% of *all accidents*.

The rarity of the HGV crossover accident is also reflected in accident statistics. Of the 166,000 reported casualties occurring on major roads in Great Britain each year in all accidents, 120 *casualties* (0.07%) each year result from HGV crossover accidents.

Again, a similar trend is shown in the *fatality* statistics where those caused by HGV crossover accidents (approximately 13 reported each year) comprise 0.46% of the total number of annual fatalities on major roads in Great Britain.

Accidents statistics suggest that the number of HGV crossover accidents has now begun to 'level off' after decreasing steadily from 1985 to 1993, with only minor fluctuations from year to year, a common phenomenon associated with random events. This is also reflected in the casualty statistics associated with such types of accident.

When compared to HGV crossover statistics, accidents in which HGVs are contained and redirected are less frequent and often have less severe consequences. The probability of such an accident being classed as 'fatal' is approximately half that of a crossover accident. A similar proportion is also reflected in the casualty statistics. Whilst the percentage of serious accidents and casualties is approximately the same for both types of accident, it is the slight category which accounts for the smaller proportion of fatal accidents and casualties. It is emphasised however, that the lateral impact energy in HGV crossover accidents is approximately 1.6 times that experienced in accidents where an HGV is contained and redirected.

3. THE WHOLE LIFE COSTING OF STEEL AND CONCRETE BARRIERS

3.1 Whole Life Costing - Introduction

Accident statistics have shown that accidents involving HGVs striking the central reserve and being contained and redirected can have less serious consequences in terms of casualty numbers and severity. This may lead to the suggestion that safety fence and barrier containment in the central reserve could be increased so as to reduce the number of HGV crossover accidents, and subsequently increase the number of accidents where the HGV is contained. However, as the hypothetical example in Figure 6 and some of the accident reports have shown, in some situations the probability of a casualty occurring as a result of an accident may be decreased if HGVs are allowed to cross the central reserve into a lighter trafficked carriageway. However, such situations are rare, and on major roads where HGV crossover accidents did occur, the traffic flow on each carriageway was similar in the majority of cases.

Hence, it was decided to investigate the whole life costs associated with the possible replacement of N2 containment safety fences and barriers in the central reserve with a vehicle restraint system of very high containment (an example of this being the Higher Vertical Concrete Barrier [HVCB]).

Whilst any discussion to increase the containment level in the central reserve should not rely exclusively on monetary concerns, they will have a part to play in such decisions.

Additional factors such as traffic delay and disruption costs are also incorporated into the whole life study, as these will be factors which require consideration during safety fence and barrier installation, maintenance, repair and removal at the end of the system's service life.

3.2 Whole Life Costing - Background

Whole life costing (WLC) provides a method by which alternative solutions to a problem can be compared, in financial terms, over the total life of a structure. Whilst the basis of WLC is relatively simple, the assignment of values to some of the variables involved can be more difficult.

The basis of WLC is that all costs associated with a solution to a problem, over its total life, can be added together to represent a total or 'whole life' cost for that solution. Future costs can be normalised to a present value using the following formula:

$$\text{Present Value} = \frac{C}{(1+r)^t} \qquad [9]$$

where:

C is the cost at current prices
r is the test discount rate
t is the time in years to when the cost is incurred

Once the whole life cost has been calculated, it can then be used to compare different solutions (for example the replacement of N2 containment safety fences and barriers in the central reserve with those of a higher or very high containment level). Reduced maintenance frequency and/or improved performance under impact may justify any extra first cost.

To carry out the whole life costing for a possible solution, the following information is required: first cost, test discount rate, frequency and cost of maintenance, and the proposed service life of the structure.

3.2.1 First Cost

These are the initial installation costs for a green field site which, in the case of safety fences and barriers, will include materials, labour and plant costs. These will also include traffic management and traffic delay costs associated with the installation of the fences or barriers, and/or any resurfacing of the central reserve and/or the provision of additional drainage. Costs for the relocation of services (such as lighting columns, signs, and communications cables) have not been included, as these considerations can be extremely site-specific and would be very difficult to incorporate into the assessment of more general WLCs. <u>These could be investigated on a case study basis, and the commencement of this work is one of the recommendations from this report.</u> It is generally thought that these costs would be considerably higher for concrete barrier installations due to the foundations required for this type of vehicle restraint system.

3.2.2 Test Discount Rates

The test discount rate represents the fact that money not spent now could be invested (or at least not borrowed), and would therefore be worth more in the future.

In the UK, the test discount rate used by the DTLR and recommended by the Treasury is 8%. This percentage is also recommended in Highways Agency Document BA 28/92: 'Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures' [10]. Hence a test discount rate of 8% has been used in the WLC analysis.

<u>Due to the long-term nature of WLC, the final cost figures calculated cannot be considered as absolute values, and must be used for comparative purposes only.</u>

3.2.3 Frequency and Cost of Maintenance

It is possible to estimate the maintenance and repair costs associated with typical N2 containment and higher or very high containment safety fences and barriers. Metal safety fences are designed to deform in order to contain and redirect an errant vehicle, and hence any impact with such a fence will generally require a greater level of repair, and/or maintenance, than a concrete barrier. Damage to rigid higher or very high containment concrete barriers will generally be less, as such systems are designed not to deflect when impacted. This has been shown during controlled full-scale impact testing.

In addition to the repairs and maintenance required by safety fences and barriers after impact, consideration has also been given to the detailed maintenance and inspection of vehicle restraint systems. Within the WLC, detailed inspection frequencies have been timetabled in accordance with the requirements of BS7669: 3: 1994: 'Guide to the installation, inspection and repair of safety fences', i.e.

Detailed inspection frequencies:
Steel components:-
Less than 10 years old: every 5 years
More than 10 years old: every 2 years

Concrete components:-
Less than 15 years old: every 5 years
More than 15 years old: every 2 years [11]

Once the maintenance strategy for the fences or barriers has been decided, the likely disruption costs incurred then need to be addressed. The Department of Transport has developed a computer model (QUeues And Delays at ROadworks - QUADRO) to calculate the delay costs incurred when disrupting traffic. These costs, and any associated traffic management costs, can often overwhelm the cost of maintenance procedures. Such costs will be incurred during maintenance work and during the installation, repair and removal of the safety fence or barrier.

Prediction of the cost and frequency of maintenance requires engineering judgement. Estimations of the frequency with which a safety fence or barrier in the central reserve of a major road will be impacted, and the resulting length of damage will have to be made.

The length of accident damage will, obviously, depend on the circumstances of the accident. For example, an HGV striking an N2 containment safety fence or barrier at twenty degrees and at ninety-five kilometres per hour will generally cause a greater length of damage than a small car (such as a Ford Fiesta) impacting at the same speed and angle. This is because in the case of the HGV impact, the impact parameters are greater than those for which the N2 containment safety fence or barrier is designed. The interaction between the vehicle and the safety fence or barrier will also play a part in the length of accident damage, and hence this will depend on the type of vehicle striking the barrier (e.g. a car or an HGV) and the angle at which the impact occurs.

The length of accident damage can be estimated through the results of controlled full-scale impact tests and through information obtained from police fatal files. However, such police files have shown that tensioned corrugated beam (TCB) constitutes the majority of the safety fence in the central reserve, and hence information on the in-service performance of other types of fence or barrier is limited.

3.2.4 Service Life of Structure

If costing is to be carried out over the service life of the safety fence or barrier then by implication, this should be defined. Factors that may influence this decision are:

- Type of safety fence or barrier
- Quality of materials, manufacture and installation
- In-use conditions
- The external environment
- Maintenance conditions

These factors can either increase or decrease the standard service life to give a 'predicted service life'.

Within this study, a predicted service life of 50 years has been estimated for concrete safety barriers, and 25 years for metal safety fences. Both of these figures have been received from contacts within the relevant manufacturing industries. Due to the fact that one service life is twice that of the other, the vehicle restraint installed in the central reserve will require replacement after a period of 50 years, no matter whether a metal safety fence or concrete safety barrier is installed in the first instance.

3.3 The Whole Life Costing Worksheet

To estimate the whole life costs associated with a number of different common safety fence and barrier types, a worksheet was developed (in Excel format). Cells highlighted in yellow on the worksheet indicate values which can be altered, and which have been obtained from a third party (e.g. the Spon's Price Book or a safety fence or barrier manufacturer). Cells highlighted in red on the worksheet have been estimated due to a lack of appropriate information.

Sheets from the worksheet are reproduced in Appendix H.

In order to calculate the WLC associated with steel safety fences and concrete safety barriers, the following information was collected:

3.3.1 Initial Installation Cost (Appendix H, Table H1)

In the WLC worksheet, the initial installation costs have been sourced almost exclusively from the Highway Works section of the "Spon's Civil Engineering and Highway Works Price Book 2002" [1]. Some concern has been raised that whilst such prices are appropriate for comparative purposes (such as is required for this report), the prices in the price book are traditionally a little high. Hence to validate these claims (or otherwise), a comparison between costs received from industry, and those in the price book are given in Appendix I, Table I. The Table shows that while the Price Book costs are a little high in some areas, they are also low in others. Hence overall, the prices are 'about right' and suitable for use within the whole life costing exercise. This Table also highlights the differences that can arise in quotation from different companies. It should also be noted that in many cases, the monetary amount quoted by a particular contractor could differ according to the length of works undertaken and it is for this reason that the lengths quoted for are noted underneath Table I.

Costs concerning the installation of extruded concrete barriers have been received from Extrudakerb and SIAC Construction. Such costs are not included in the Spon's Price Book. Of these, the Extrudakerb values have been used in calculations as they compare more favourably with information received from the Highways Agency's Contracts Department.

The quantity of materials required to construct each length of safety fence or barrier has been calculated in accordance with Drawings available in the Highway Construction Details [12].

The initial installation costs quoted include the cost of materials, labour and plant, but not the delivery of the parts to site as this could vary greatly depending on the location of, and access to, the works site. As a result, safety fence and barrier manufacturers contacted were unable to provide costs for such activities.

It is assumed that the original carriageway meets all the requirements of a straight dual, three-lane motorway with a relatively flat, grassed central reserve. The definition used for a 'straight' road in the context of this report is that quoted in the Spon's Price Book, i.e. that the road is curved and 'exceeding a 120m radius' [1]. Curves with a radius tighter than this would incur additional costs due to the difficulties arising during the installation. In a more general sense, the definition of a straight road is usually that quoted in TD19/85, i.e. those roads with a radius greater than or equal to 850m [4].

It is also assumed that no safety fence or barrier currently exists at the site and hence there is no need to connect into an existing system. The cost associated with two end terminals is, therefore, included in the calculations. It is also assumed that the Spon's Price Book definition of a 'terminal' includes all parts specified under the phrase 'terminal' in the HCD Drawings (i.e. they include the angled beam and concrete haunch in the case of steel fences, and tapered concrete terminals (to Drawing SB/23 [12]) for concrete barriers). Intermediate and end anchorages are included in the whole life cost calculations for the wire rope safety fence.

Costs for the relocation of services (such as lighting columns, signs, and communications cables) have not been included, as these considerations can be extremely site-specific and would be very difficult to incorporate into the assessment of more general WLC. These could be investigated on a case study basis, and the commencement of this work is one of the recommendations from this report.

However, the costs associated with surfacing the central reserve and the provision of additional drainage for concrete barriers have been included as these may introduce significant cost differences between concrete safety barriers and steel safety fences.

The Spon's Price Book also estimates the time required to install the elements of the safety systems, and hence the period of time required for traffic management and the subsequent traffic delay costs can be calculated for each type of fence or barrier. For such costs, a working day of 24 hours is assumed for simplicity.

3.3.2 Traffic Management Costs (Appendix H, Table H2)

No cost information was available regarding the hiring of traffic management equipment in the Spon's Price Book, and hence requests for information were sent to a number of UK traffic management companies. The only quote received was from Class One Traffic Management. Hence this means that unlike the initial installation costs, these prices have not been compared to quotations from similar companies to assess how closely they reflect prices throughout the industry.

Whilst costings for Temporary Vertical Concrete Barriers (TVCB) and VarioGuard (a temporary metal fence) have been received, it is the TVCB costs which have been used when estimating traffic management costs. This is purely due to the need to remain consistent with the style of temporary vehicle restraint employed, as including calculations for both TVCB and VarioGuard may complicate the issue. It is thought that TVCB is currently the more common type of temporary vehicle restraint used at roadworks.

It is assumed that the TVCB quoted for is designed for a speed limit of 110kph (i.e. it is of the TVCB (110) designation), and hence there is no requirement for a reduction in speed limit from 110kph (70mph) to 80 kph (50mph) throughout the works. This would cause additional complications when attempting to calculate QUADRO traffic delay costs associated with the works.

The layout of the temporary barriers has been costed so as to be in accordance with the requirements of HA Document IAN 24: 'Use of Temporary Safety Barriers at Road Works'. This requires that 'in addition to the work zone, 39m of temporary safety barrier is required before the works and 21m beyond the end of the works' [13].

The traffic management costs also include an allowance for the provision of cones and signage before the works, these being in accordance with Chapter 8 of the Traffic Signs Manual [14].

Traffic management costs assume the closure of the lanes to the offside of each carriageway, as would be required during works in the central reserve, i.e.

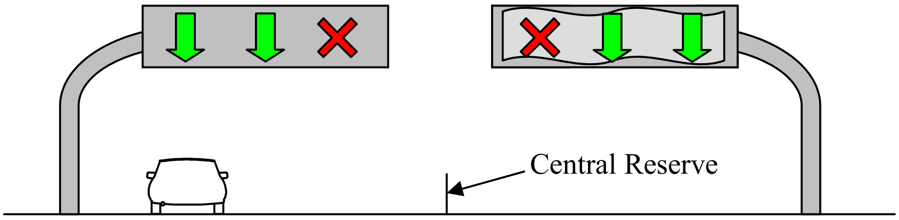


Figure 7: Assumed Lane Closures Due to Repair and/or Maintenance Work

To simplify the whole life costing workbook, a detailed breakdown of the traffic management cost is only shown for works during the installation of the fences or barriers. For traffic management relating to repairs and the removal of the safety systems, these calculations are not detailed, but have been carried out using the same process as for the initial installation.

3.3.3 Maintenance Costs (Appendix H, Table H5)

There are three types of maintenance cost that will generally be incurred during the whole life of the safety fence or barrier:

(i) Routine Maintenance

This concerns the more frequent (i.e. daily or weekly) 'drive-by' inspection of safety fences and barriers that will identify areas requiring attention from maintenance crews. Such a task will incur similar costs for the different types of fence or barrier and hence, has not been included in the whole life costing exercise. In addition, the inspection of the restraint systems will not be the sole task of the 'drive-by' inspections and hence, assigning a cost to this particular exercise would be difficult. This cost would also be relatively small when compared to other areas associated with the process of whole life costing, and the other areas of maintenance.

(ii) Detailed Maintenance

These are the costs necessary to maintain the performance characteristics of the safety fence or barrier for any reason other than a vehicular impact (for example the checking and if necessary, re-tensioning of tensioned systems).

As stated in Section 3.2.3, the detailed maintenance frequencies are taken from BS7669: 3: 1994 'Guide to the installation, inspection and repair of safety fences' [11].

A nominal cost of £500 was selected for the routine inspection of the fences or barriers, this being raised slightly to £750 for tensioned systems (where a small amount of retensioning may be required in the system). These values were derived from staff at TRL Limited specialising in highway maintenance. Spon's Price list quotes the cost of employing a safety fencing gang at £43.76 per hour, so £500 will approximate to eleven hours work. This seems realistic for the detailed inspection of 1km of safety fence or barrier to the requirements of BS7669 [11].

In addition to the maintenance costs, a figure has also been included in the calculations for the painting of the safety fences and barriers with protective coatings. These have been calculated in accordance with the costs quoted in BD36/92: 1: 1992: 'Evaluation in Maintenance Costs in Comparing Alternative Designs for Highway Structures' [15], and have been allocated at the intervals quoted in this standard.

(iii) Repairs Maintenance

Refer to Section 3.3.5.

3.3.4 Traffic Delay Costs (Appendix H, Table H5)

The DTLR has developed a computer model (QUeues And Delays at ROadworks - QUADRO) to calculate the delay costs incurred when disrupting traffic. These costs, and any associated traffic management costs can often overwhelm the cost of the maintenance procedures.

Such traffic delay costs have been included in the whole life costing for the disruption caused during the installation, repair (following an accident) and removal of the safety fence or barrier system. They have not been included for the time required to clear the carriageways of vehicles and debris following an accident as this will depend greatly on the accident and the number of vehicles involved.

Due to the predicted change in traffic flow from year zero to year fifty, it can be seen on the WLC worksheet that the associated hourly QUADRO costs increase yearly during the whole life of the fence or barrier.

These costs are incorporated into the WLC via equations in the WLC Worksheet. The equation calculates the total amount of time required for each of the works, and multiplies this by the QUADRO cost per hour. These costs are then added to the parts and traffic management costs to give the costs shown in the 'Additional Cost of Works' and 'Cost of Repair' columns in Table H5 (see Appendix H).

3.3.5 Repair Costs (Appendix H, Table H4)

These have been estimated by examining the results of controlled full-scale impact tests on safety fences and barriers, and evaluating the components required for the repair of the system following the test. The cost of the replacement parts has then been extracted from the initial materials costs.

It is assumed that accident repairs are carried out whilst the carriageway is open to the travelling public, and not during the period immediately after an accident when the carriageway may be closed whilst accident debris is cleared.

Repair costs have been evaluated for both car and HGV impacts however it is only those figures relating to HGVs which have been used for the whole life costing exercise.

3.3.6 Accident Costs (Appendix H, Table H5)

In addition to the repair costs associated with an accident, other accident costs (such as road closures, remedial repair measures and the like) will be incurred following an accident. These costs are estimated to be:

- £1,000,000 per fatal casualty.
- £19,000 per serious casualty.
- £380 per slight casualty. [5]

An item of accident cost not included in the whole life costing exercise is that associated with structural consequences. In the case of safety fences and barriers, they are positioned to protect road users from exceptional local hazards. If the vehicle strikes this hazard there is a possibility that the hazard itself may be damaged (for example, an HGV striking a bridge pier causing the bridge to collapse, or an HGV striking a lighting column). In each case, repair work will need to take place to rectify the damage and this will incur costs. It is these costs which have not been considered as part of the WLC exercise, due to their complex and site specific nature.

3.3.7 Removal Costs (Appendix H, Table H3)

These are listed in the Spon's Price list for metal safety fences, however they do not appear for concrete barriers. Hence, removal costs for metal systems are as quoted in the Spon's Price Book, and values for concrete barrier removal have been estimated using the costs quoted for the installation of the barriers as a guide. This will give some indication of the time, and plant required for the movement and handling of the barriers.

Traffic management and traffic delay costs have also been incorporated into this part of the calculation, as they will be incurred during this time.

3.3.8 Whole Life Costs (Appendix H, Table H5)

This combines the individual costs and calculates the whole life cost of safety fences and barriers over a 50 year period. This includes the initial installation, any subsequent repairs, maintenance and removal, and the associated traffic management and traffic delay costs. Accident costs have also been incorporated into the calculations.

3.4 Summary of the Information used to calculate the WLCs.

It is assumed that the original carriageway meets all the requirements of a straight dual, three-lane motorway with a relatively flat, grassed central reserve. The definition of a 'straight' road is as detailed in Section 3.3.1.

It is also assumed that no safety fence or barrier currently exists at the site and hence there is no need to connect into an existing system. The cost associated with two end terminals are, therefore, included in the calculations. Intermediate and end anchorages are included in the whole life cost calculations for wire rope safety fence.

Costs for the relocation of services (such as lighting columns, signs, and communications cables) have not been included, as these considerations can be extremely site-specific and would be very difficult to incorporate into the assessment of more general WLC. These could be investigated on a case study basis, and the commencement of this work is one of the recommendations from this report.

However, the costs associated with surfacing the central reserve and the provision of additional drainage for concrete barriers have been included as these may introduce significant cost differences between concrete safety barriers and steel safety fences.

It is also estimated that the average annual daily two-way flow (AADT) of traffic is 60,000. This value has been quoted by TRL's Traffic Count Department for a 'typically busy' dual three-lane motorway.

A sample length of 1000m was selected as some of the quotes sent by contractors were based on such a length, and hence selecting the same length would increase consistency in the pricing. Due to the post spacing being different between some of the safety fences, the lengths constructed will only approximate to 1000m and will not be exact.

It is also assumed that HGVs contribute 8% of the traffic on the road. This is taken from DTLR Traffic data for 2000 where HGVs contribute 8% of all motor vehicles on major roads (See Appendix J).

3.5 An Examination of Whole Life Costs for Safety Fences and Barriers

The WLC worksheet was used to calculate the cost associated with safety fences and barriers at damaging strike intervals of once every five, ten, fifteen, twenty or twenty five years, and if they were not struck at all during their whole life. This was completed over a whole life period of fifty years for HGV only impacts. The results are shown in Appendix K, Table K.

3.5.1 Rate of Damaging Accidents and Repairs

The calculations have shown that if no damaging impacts occur on a 1000m length of safety fence or barrier during its whole life, then the associated whole life costs are as follows (also see Appendix K, Table K):

	No damaging impacts during a whole life of 50 years	
WRSF (2.4m post spacing)	£ 306,000	Metal Safety Fences
D/S TCB (3.2m post spacing)	£ 329,000	
D/S OBB (2.4m post spacing)	£ 395,000	
Precast VCB (3m units)	£ 420,000	Concrete Safety Barriers
Slipformed VCB	£ 411,000	
Slipformed HVCB	£ 617,000	

Table 5: Costs incurred for 1000m of safety fence or barrier if it is undamaged during a whole life of 50 years.

Table 5 shows that the whole life cost associated with concrete barriers is greater than that for metal safety fences. This can be attributed to the higher initial installation cost of concrete barriers which has been shown (in Appendix H, Table H1) to be almost three times greater than the cost of some metal safety fences.

Controlled full-scale impact tests have shown that flexible metal safety fences will require repair after each impact. Repairs to rigid concrete barriers are not required for the generally superficial and non-structural damage caused by HGV impacts.

If the costs associated with these repairs are incorporated into the whole life cost calculations, it can be seen that the cost of concrete safety barriers is still greater than that for metal safety fences (see Appendix K, Table K).

This is equally applicable at the extremities evaluated in Table K, Appendix K. If a 1000m length of higher vertical concrete barrier is installed in the central reserve and requires no repairs during its whole life, its WLC will still be greater than for a normal containment safety fence or barrier requiring repair at the most frequent of the intervals (fifteen times during its whole life).

3.5.2 Rate of Fatal Casualties and Associated Accident Costs

A value of £1,000,000 has been used as the accident cost associated with a fatal casualty with the values for serious and slight casualties being £19,000 and £380 respectively (refer to Section 3.3.6)

As a result, the costs resulting from an accident will far outweigh the initial installation costs, especially if a fatal casualty has occurred.

One fact which will also be incorporated into WLC calculations (in Section 3.5.3) is that not all accidents involving a vehicle striking a safety fence or barrier in the central reserve will result in fatal injuries. This is substantiated by the figures collected from the STATS19 database which showed that for HGV crossover accidents 11% of the accidents were classed as 'fatal', as opposed to 5% in accidents where an HGV was contained and redirected.

3.5.3 Summary of Whole Life Costs

Factors discussed in Sections 3.5.1 and 3.5.2 have been taken into account during the calculation of the WLCs. The values are summarised in Table 6 (overleaf).

The following descriptions explain how the WLCs were derived:

Column 1: Only information relating to HGVs has been included as details relating to accidents involving vehicles under 3.5 tonnes are not part of this study. It is a recommendation of this report that crossover accidents involving vehicles under three and a half tonnes in weight are investigated to provide further detailed information.

Column 2: It is first assumed that the safety fence or barrier is struck five times during its whole life (i.e. once every ten years). The exercise is then repeated with ten strikes during the whole life (i.e. once every five years).

Column Number:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Safety Barrier Type	Impacting Vehicle	Number of Accidents during WL	Number of Fatal Injuries	Number of Serious Injuries	Number of Slight Injuries	Column 3 x £1M: Accident Cost	Column 4 x £19K: Accident Cost	Column 5 x £380: Accident Cost	Average Accident cost	Number of Repairs required during whole life (estimated)	WLC (installation, maintenance and removal) - from WLC Worksheet	**TOTAL WLC (including accident costs)**	%age difference to D/S TCB (3.2m p/s)
WRSF (2.4m p/s)	HGV	5	5 x 0.11	5 x 0.27	5 x 0.62	£550,000	£25,650	£1,178	£115,366	5	£336,744	**£547,073**	-3.80
D/S TCB (3.2m p/s)	HGV	5	5 x 0.11	5 x 0.27	5 x 0.62	£550,000	£25,650	£1,178	£115,366	5	£358,331	**£568,661**	0.00
D/S OBB (2.4m p/s)	HGV	5	5 x 0.11	5 x 0.27	5 x 0.62	£550,000	£25,650	£1,178	£115,366	5	£423,485	**£633,815**	11.46
Precast VCB (3m units)	HGV	5	5 x 0.11	5 x 0.27	5 x 0.62	£550,000	£25,650	£1,178	£115,366	3	£436,988	**£647,317**	13.83
Slipformed VCB	HGV	5	5 x 0.11	5 x 0.27	5 x 0.62	£550,000	£25,650	£1,178	£115,366	3	£426,041	**£636,370**	11.91
Slipformed HVCB	HGV	5	5 x 0.05	5 x 0.22	5 x 0.73	£250,000	£20,900	£1,387	£54,457	1	£619,246	**£718,529**	26.35

Table 6a: WLC incurred for 1000m of safety fence or barrier if there are 5 accidents during a whole life of 50years

Column Number:	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Safety Barrier Type	Impacting Vehicle	Number of Accidents during WL	Number of Fatal Injuries	Number of Serious Injuries	Number of Slight Injuries	Column 3 x £1M: Accident Cost	Column 4 x £19K: Accident Cost	Column 5 x £380: Accident Cost	Average Accident cost	Number of Repairs required during whole life (estimated)	WLC (installation, maintenance and removal) - from WLC Worksheet	**TOTAL WLC (including accident costs)**	%age difference to D/S TCB (3.2m p/s)
WRSF (2.4m p/s)	HGV	10	10 x 0.11	10 x 0.27	10 x 0.62	£1,100,000	£51,300	£2,356	£115,366	10	£357,458	**£710,934**	-2.85
D/S TCB (3.2m p/s)	HGV	10	10 x 0.11	10 x 0.27	10 x 0.62	£1,100,000	£51,300	£2,356	£115,366	10	£378,287	**£731,763**	0.00
D/S OBB (2.4m p/s)	HGV	10	10 x 0.11	10 x 0.27	10 x 0.62	£1,100,000	£51,300	£2,356	£115,366	10	£443,176	**£796,653**	8.87
Precast VCB (3m units)	HGV	10	10 x 0.11	10 x 0.27	10 x 0.62	£1,100,000	£51,300	£2,356	£115,366	6	£448,338	**£801,861**	9.58
Slipformed VCB	HGV	10	10 x 0.11	10 x 0.27	10 x 0.62	£1,100,000	£51,300	£2,356	£115,366	6	£436,215	**£789,691**	7.92
Slipformed HVCB	HGV	10	10 x 0.05	10 x 0.22	10 x 0.73	£500,000	£41,800	£2,774	£54,457	2	£633,038	**£799,892**	9.31

Table 6b: WLC incurred for 1000m of safety fence or barrier if there are 10 accidents during a whole life of 50years

Columns 3 to 5: As stated previously, not every accident involving damage to the central reserve safety fence or barrier will result in fatal injuries. Therefore historical data have been used to estimate the number of fatal, serious and slight accidents which may occur during the fifty-year whole life period. STATS19 data (refer to Table 5) have shown that for HGV crossover accidents (which are more likely to occur with vehicle restraint systems of N2 containment classification):

- 11% can be classed as fatal.
- 27% can be classed as serious.
- 62% can be classed as slight.

These data have also shown that for accidents in which an HGV has been contained (which are more likely to occur with vehicle restraint systems of higher or very high containment classification):

- 5% can be classed as fatal,
- 22% can be classed as serious.
- 73% can be classed as slight.

From these figures, the number of accidents in each severity class can be calculated by multiplying the total number of accidents by these percentages.

It is very difficult to estimate the number and severity of injuries occurring as a result of HGV impacts as none of the fatal accidents examined occurred at a site with very high containment safety fences or barriers installed. Hence, those data concerning accidents in which an HGV has been contained and redirected may give some indication of approximate levels of accident severity. However it must be emphasised that for such accidents there is generally a lower level of lateral impact energy than in a crossover accident.

Columns 6 to 8: The accident cost can be approximated by multiplying the estimated number of accidents (from columns 3 to 5) by the cost data from Section 3.3.6.

Column 9: This column calculates the average accident cost using the values derived from columns 6 to 8.

Column 10: Each impact with a metal safety fence will require repair to some extent. This may not be true for every impact with a concrete safety barrier. Both of these factors have been shown in controlled full-scale impact test. It is for this reason that column 10 uses the information in the test reports to predict the number of repairs which will be required on the 1000m length of safety fence or barrier if it is struck five or ten times during its fifty year service life.

Column 11: This figure is derived from the WLC worksheet, with the number of repairs being inserted as in column 10, and distributed equally throughout the fifty year period (See Appendix H, Table H5). The figures quoted are 'present value' figures (see Section 3.2) and hence the costs will vary according to the year in which they occur. For example, a £1000 cost in year zero will appear as a £21 cost after fifty years. This emphasises the need to spread equally the repair costs throughout the whole life of the vehicle restraint system.

Column 12: In a similar way to the repair costs in column 11, the average accident cost has also been distributed equally throughout the fifty-year period. Perhaps more importantly, this column indicates the likely whole life costs for the safety fences and barriers if installed on a central reserve over a period of fifty years. The figures are repeated in Table 7 below, for clarity. Whilst these costs show that WRSF is the more economically viable design of vehicle restraint system (when costs are being assessed on a whole life basis), this should not lead to the conclusion that this safety fence should be installed in the central reserve of all major roads. There are a number of other factors that must be taken into consideration, and these include:

- Installation considerations (including the presence of services, road geometry and access to the installation site).
- The deflection characteristics and clearance available at the rear of the system.
- Consequential damage (and therefore costs) which may determine whether a vehicle restraint with a higher or very high containment capability is required.
- The transition to other vehicle restraint systems already installed in the central reserve.

Column 13: This column compares the WLC for the safety fence and barrier types given with that for double sided TCB at 3.2m post spacing. As previously noted, the police fatal files have shown this safety fence to be present at the site of many of the HGV crossover accidents.

Safety Barrier Type	TOTAL WLC (5 accidents during 50 year service life) [including accident costs]	TOTAL WLC (10 accidents during 50 year service life) [including accident costs]
WRSF (2.4m post spacing)	£547,073	£710,934
D/S TCB (3.2m post spacing)	£568,661	£731,763
D/S OBB (2.4m post spacing)	£633,815	£796,653
Precast VCB (3m units)	£647,317	£801,861
Slipformed VCB	£636,370	£789,691
Slipformed HVCB	£718,529	£799,892

Table 7: Summary of the WLC for 1000m of the six common types of central reserve safety fences and barriers for a whole life of 50 years

The values in Table 7 show that when accident costs are incorporated into the WLC, the value for HVCB is still greater than for the other steel safety fences and concrete safety barriers.

The Table also shows that the whole life cost associated with HVCB becomes more comparable with the cost of metal systems as the number of accidents with the vehicle restraint increases. This is not surprising given the lower accident and repair costs, and the smaller frequency of repairs required by the HVCB system.

Figure 8 shows how the whole life cost for common safety fences and barriers varies according to the number of HGV accidents that occur with the vehicle restraint during its whole life. It has been constructed using the whole life cost information previously presented in Tables 5 and 7, and from whole life cost figures calculated for 15 accidents with the vehicle restraint over its service life.

It can be seen that the costs during a service life of 50 years for 1000m of HVCB are less than for the same length of:

- OBB and VCB (both precast and slipformed) at a rate of approximately 10 accidents during the service life.

- TCB at a rate of approximately 13 accidents during the service life.
- WRSF at a rate of approximately 14 accidents during the service life.

As can be seen from Table 6 and Figure 8, the whole life cost figures are dominated by the accident costs. These greatly outweigh all of the other costs associated with a vehicle restraint system during its whole life. As a result, the gradient of the lines in Figure 8 are highly dependant on the accident rates derived from historical STATS19 data and subsequently used in Table 6. Hence, it is emphasised that the findings from Figure 8 are only applicable if the accident rate and severity remain consistent with the average figures for the past fourteen years.

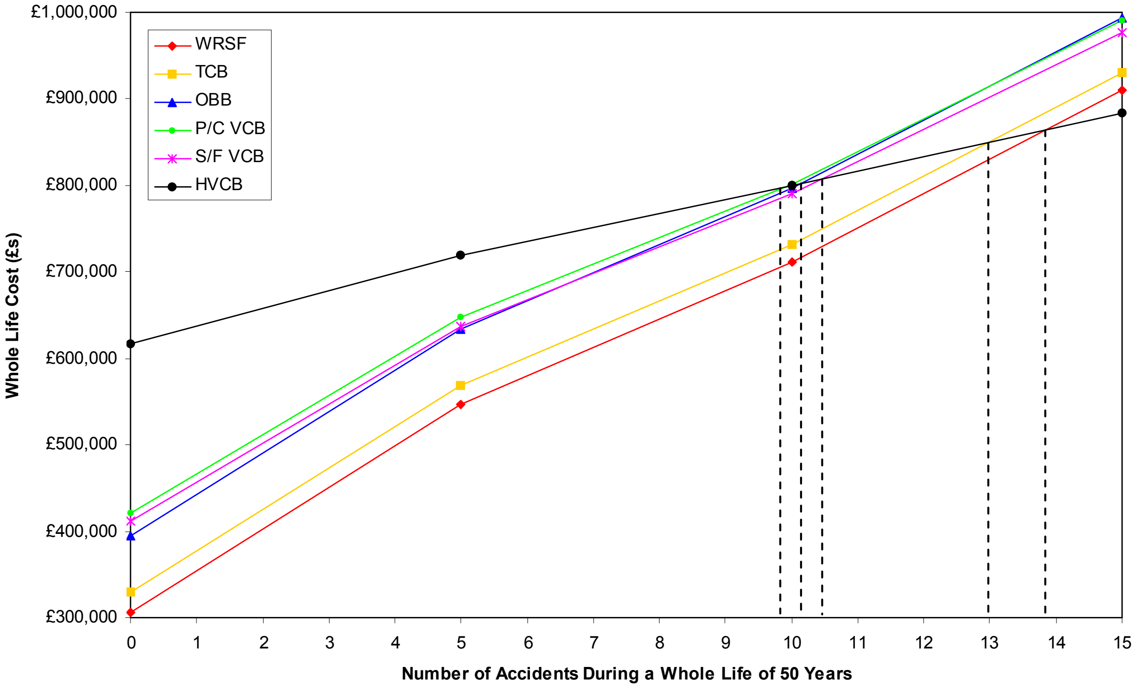


Figure 8: The Changes in WLC due to a Change in the Number of Accidents

Hence, the introduction of safety fences and barriers with a greater level of containment may only be economically viable in areas where the probability of an HGV crossover accident is high. This could be an area with a high volume of HGVs and/or a history of HGV crossover accidents.

<u>It is therefore a recommendation of this study that areas with a high volume of traffic of three and a half tonnes in weight and/or a history of HGV crossover accidents be identified</u>. This could be determined retrospectively (through accident records) or proactively (by examining the traffic flows on particular roads, and identifying those roads with a higher population of HGV traffic).

It has been shown under full-scale impact testing with cars that in terms of vehicle containment and redirection, steel safety fences are just as effective as concrete safety barriers. However, following an impact with a car, it would be expected that the length of repair associated with concrete barriers would be less than for steel fences due to their contrasting deformation characteristics under loading.

However <u>it is a further recommendation that a brief study into the effects of accidents in which cars have crossed the central reserve or have been contained and redirected be considered</u>.

4. CONCLUSIONS

4.1 Accident Statistics

- The annual number of *accidents* involving HGVs crossing the central reserve is relatively small when compared with the total number of vehicle accidents occurring on major roads in Great Britain.
  In the period 1985 to 1998 there were, on average, 120,302 reported vehicle accidents per annum on such roads. In the same period there were, on average, 56 HGV crossover accidents per year, which constitutes 0.47% of the total number of vehicle accidents (Refer to Section 1.2).

- The rarity of the HGV crossover accident is also reflected in the casualty statistics. Of the 166,070 casualties occurring, on average, each year on major roads in Great Britain, 120 casualties (0.07%) resulted from HGV crossover accidents (Refer to Section 1.2).

- This trend is repeated in the statistics relating to fatalities.
  Those fatalities caused by HGV crossover accidents (approximately 13 per year) comprise 0.46% of the total number of fatalities on major roads in Great Britain (approximately 2,844 per annum) (Refer to Section 1.2).

- After a decrease in the number of HGV crossover accidents between 1986 and 1993, the number of accidents has fluctuated between approximately 40 and 50 accidents per year between 1993 and 1998 (Refer to Section 2.2.1).

- Between 1985 and 1998 there was a total of 786 HGV crossover accidents.
  The accident was rated as 'fatal' in 125 (16%) incidents, 'serious' in 226 (29%) incidents, and the remaining 435 (55%) incidents were rated as 'slight' (Refer to Section 2.2.2).

- Within these accidents there were a total of 1686 casualties, an average of 2.1 casualties per accident.
  Of these 1686 casualties, 180 (11%) were fatalities, 456 (27%) were serious injuries, and the remaining 1050 (62%) were slight injuries (Refer to Section 2.2.3).

- Energy calculations have been completed for 39 of the 125 fatal HGV crossover accidents occurring on major roads in Great Britain.
  These indicated that the accident may have been prevented by the installation of a very high containment safety fence or barrier in 9 cases, and of these, 6 may have been stopped by a higher containment safety fence or barrier (Refer to Section 2.3.2).

- The average lateral impact energy in these fatal HGV crossover accidents was approximately 3,000,000kJ - over three times that experienced in a $TB81_{MAX}$ controlled impact test (Refer to Section 2.3.2).

- In all of the 33 accidents in which a safety fence was struck and the HGV crossed over the central reserve, the combination of impact parameters exceeded those experienced during an N2 containment full-scale impact test (Refer to Section 2.3.2).

- Statistics have shown that there are typically 2.1 casualties for HGV crossover accidents, and 1.6 casualties per accident in which an HGV has been contained (Refer to Section 2.5).

- The probability of a fatal accident involving a contained and redirected HGV is approximately half that of a fatal HGV crossover accident. A similar proportion is also shown by the casualty statistics (Refer to Section 2.5).

4.2 Whole Life Costing

- The WLC calculations have shown that if no damaging impacts occur on the 1000m length of safety barrier during its whole life, then the associated costs are as follows (Refer to Section 3.5.1):

	No damaging impacts during a whole life of 50 years	
WRSF (2.4m post spacing)	£ 306,000	Metal Safety Fences
D/S TCB (3.2m post spacing)	£ 329,000	
D/S OBB (2.4m post spacing)	£ 395,000	
Precast VCB (3m units)	£ 420,000	Concrete Safety Barriers
Slipformed VCB	£ 411,000	
Slipformed HVCB	£ 617,000	

- However, if factors such as accident rates, repairs and accident compensation are also incorporated, the WLCs for 1000m of safety fence or barrier more closely resemble the following Table (Refer to Section 3.5.3):

Safety Barrier Type	TOTAL WLC (5 accidents during 50 year service life) [including accident costs]	TOTAL WLC (10 accidents during 50 year service life) [including accident costs]
WRSF (2.4m post spacing)	£547,073	£710,934
D/S TCB (3.2m post spacing)	£568,661	£731,763
D/S OBB (2.4m post spacing)	£633,815	£796,653
Precast VCB (3m units)	£647,317	£801,861
Slipformed VCB	£636,370	£789,691
Slipformed HVCB	£718,529	£799,892

- It can be seen that the costs during a service life of 50 years for 1000m of HVCB are less than for the same length of:
  - OBB and VCB (both precast and slipformed) at a rate of approximately 10 accidents during the service life.
  - TCB at a rate of approximately 13 accidents during the service life.
  - WRSF at a rate of approximately 14 accidents during the service life.

  (Refer to Section 3.5.3).

- Hence, the introduction of safety fences and barriers with a greater level of containment may only be economically viable in areas where the probability of an HGV crossover accident is high (Refer to Section 3.5.3).

5. RECOMMENDATIONS AND IMPLEMENTATION

The overreaching conclusion from this study is that accident statistics have shown that HGV crossover accidents are rare and the resulting casualties constitute a small percentage of the total number occurring on major roads in Great Britain.

There are areas in the study which have been omitted due to their complexity, and other topics which have arisen as requiring further investigation during the study. It is therefore recommended that the following items of work (listed in order of priority) are examined before further conclusions regarding the suitability of increasing the containment capability of safety fences and barriers in the central reserve can be made.

- Initiate a study to identify lengths of major road with a high percentage of HGVs or HGV crossover accidents.
  As stated in the conclusions, the WLC spreadsheet has shown that the use of very high containment safety barrier in the central reserve becomes more viable where the probability of it being struck by an HGV is high. Such lengths of road could be determined either retrospectively (by examining accident records and plotting the accident sites) or proactively (by examining the traffic flows on particular roads, and identifying those roads with a higher population of traffic over 3.5 tonnes). Once areas of HGV population are found which greatly exceeds the DTLR average of 8% of all traffic, the associated cost of installing vehicle restraint systems of greater containment in those areas could then be calculated.

- Initiate a study into accidents involving vehicles of mass less than 3.5 tonnes crossing the central reserve or being contained and redirected by safety fences or safety barriers.
  The report currently investigates those accidents involving HGVs impacting central reserve safety fences and barriers. However HGVs constitute 8% of the motor vehicles on major roads in Great Britain. A far greater percentage (79%) of this traffic is classed as 'cars' (see Appendix J, Table J). Hence it may also be beneficial to undertake an accident statistics study similar to this for those vehicles defined as in the STATS19 database as 'cars'. The containment effectiveness of the central reserve safety fences and barriers can then be assessed for these vehicles. Whole life costs could then be derived using accident data and costs associated with both HGV and car accidents.
  The possible effects of installing vehicle restraint systems with a greater level of containment could also be investigated, although this may be difficult due to the relatively low proportion of concrete barriers currently installed in the central reserve of major roads.

- Initiate a series of case studies investigating the costs associated with structural consequences resulting from HGV accidents in the central reserve of major roads.
  Another item of cost not included in the whole life costing exercise is that associated with structural consequences. Within the accident costs, monetary amounts have been allocated solely on the number and severity of casualties involved in an accident. In the case of safety fences and barriers, they are positioned to protect road users from exceptional local hazards. If the vehicle strikes this hazard there is a possibility that the hazard itself may be damaged (for example, an HGV striking a bridge pier causing the bridge to collapse, or an HGV striking a lighting column). In each case, repair work will need to take place to

rectify the damage to the structure and this will incur costs. It is these costs which have not been considered as part of the WLC exercise, due to their complex and site specific nature.

- Initiate a series of case studies investigating the costs associated with relocating services in the central reserve.
  The main area of cost not included in the whole life costing exercise was a study into the financial penalties associated with relocating services in the central reserve (such as lighting columns, signs, drains and communications cables). This was due to the very site-specific nature of such works and hence, this is likely to be a complex investigation. However, if it were felt necessary, such an investigation could be undertaken as a case study, and carried out in conjunction with maintenance agents.

- Initiate a study to calculate and compare the whole life costs of safety fences and barriers not included in the current study.
  Within this study, whole life costs have been calculated for a number of basic safety fences and barriers. However other types of fence and barrier are available for use on the Highway, and it may be felt necessary that the whole life costs for these vehicle restraints are also required to aid comparison. This may include calculations for Double Rail Open Box Beam (DROBB), parapets, precast HVCB, two parallel runs of single sided TCB, and/or safety fences at half post spacing.

6. REFERENCES

[1] 'Spon's Civil Engineering and Highway Works Price Book 2002', Edited by Davis, Langdon & Everest, 2001.
[2] 'Road Accidents in Great Britain, 1998: The Casualty Report', Department of the Transport, Local Government and the Regions (DTLR), 1999. Also, see [4].
[3] 'TD19/85: Safety Fences and Barriers', June 1985.
[4] Internet site: 'www.transtat.dtlr.gov.uk/tables/tsgb01/4/4text.htm#4.15-4.18'.
[5] 'Under Reporting of Road Traffic Accidents' by Helen F James, Reprinted in Traffic Engineering and Control, December 1991.
[6] 'Crossover Accidents involving Large Vehicles on UK motorways and A Roads', by J. Rutter and S. Gray, TRL Unpublished Project Report PR/TT/164/99, October 1999.
[7] 'BSEN1317', Parts 1 and 2 - Part 1: Road Restraint Systems, Terminology and general criteria for test methods - Part 2: Road Restraint Systems, Performance classes, impact test acceptance criteria and test methods for safety barriers, both 1998.
[8] 'TD 32/93: Wire Rope Safety Fences', December 1993.
[9] 'The Structural Engineer', 1st April 1997, Volume 75, No.7, ISSN 0039-2553.
[10] 'BD28/92: Evaluation of maintenance costs in comparing alternative designs for highway structures', 1992.
[11] 'BS7669 Part 3: Guide to the installation, inspection and repair of safety fences', 1994.
[12] 'Manual of Contract Documents for Highway Works: Volume 3 - Highway Construction Details'.
[13] 'Interim Advice Note (IAN) 24: Use of Temporary Safety Barriers at Road Works', December 1998.
[14] 'The Traffic Signs Manual'.
[15] 'BD 36/92: Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures', August 1992.
[16] 'HA 39/98: Edge of Pavement Details', August 1998.
[17] 'Manual of Contract Documents for Highway Works: Volume 1 - Specification for Highway Works'.
[18] 'HD 36/99: Surfacing Materials for New and Maintenance Construction', August 2001.
[19] 'HD 37/99: Bituminous Surfacing Materials and Techniques', August 1999.
[20] Internet site: 'www.gomaco.com'.
[21] Internet site: 'www.transtat.dtlr.gov.uk/tables/tsgb01/4/download/40901.xls'

7. BIBLIOGRAPHY

Additional reading relating to this subject:

Journal Articles:
'Barrier Grief', Commercial Motor, 6-10 October 1994, pgs 36, 37.
'Barrier Grief', Commercial Motor, 13-19 April 2000, pgs 38 to 40.
'Concrete Advantages', Highways magazine, December 1996, pg 13.
'Case Studies on Vertical Concrete Safety Barriers in the UK', Britpave.

Appendix A: Definitions and Abbreviations

Term or abbreviation	Explanation
• Accident Severity	The severity of the most seriously injured casualty in the accident
• Central Reserve	The strip of land (may be grassed) between two opposing carriageways
• Concrete Safety Barrier	An installation provided for the protection of users of the highway which is continuously in contact with its supporting foundation.
• Crossover Accident	An accident in which one or more vehicle leaves the carriageway on the offside, and enters the opposing carriageway
• DTLR	Department of Transport, Local Government and the Regions
• Fatal Accident	An accident in which at least one person is killed (but excluding confirmed suicides) within 30 days of the occurrence of the accident.
• Fatal Files	A police accident report concerning a fatal accident
• Fatal Injury	Human casualties who sustained injuries which caused death less than 30 days after the accident
• Great Britain	England, Scotland, Northern Ireland and Wales
• HA	Highways Agency
• HGV	Heavy Goods Vehicle: Prior to 1994 these were defined as those vehicles over 1.524 tonnes unladen weight and included vehicles with six or more tyres, some four wheel vehicles with extra large bodies and larger rear tyres and tractor units travelling without their usual trailer. From 1 January 1994 the weight definition changed to those vehicles over 3.5 tonnes maximum permissible gross vehicle weight (gvw).
• Higher Containment	A safety fence or barrier that has been impact tested to and complies with H1, H2 or H3 containment level requirements in BSEN1317, parts 1 and 2 (see Table 2).
• HVCB	Higher vertical concrete barrier - A concrete barrier with a vertical face, 1.2m in height
• Major Roads	Motorways, A(M) Roads and A Roads
• Normal Containment	A safety fence or barrier that has been impact tested to and complies with N1 or N2 containment level requirements in BSEN1317, parts 1 and 2 (see Table 2).
• OBB	Open box beam safety fence
• Safety Fence	An installation provided for the protection of users of the highway consisting of horizontal members mounted on posts
• Serious Accident	An accident in which at least one person is seriously injured but no person (other than a confirmed suicide) is killed
• Serious Injury	An injury for which a person is detained in hospital as an ‘in-patient’, or any of the following injuries whether or not they are detained in hospital; fractures, concussion, internal injuries, crushings, burns (excluding friction burns), severe cuts and lacerations, severe general shock requiring medical treatment, injuries causing death 30 or more days after the accident
• Service Life	The period of time for which an element will continue to perform as intended, operating under design conditions, subject to maintenance in accordance with the manufacturer's written recommendations.
• Slight Accident	An accident in which at least one person is slightly injured but no person (other than a confirmed suicide) is killed
• Slight Injury	An injury of a minor character such as sprain, bruises or cut not judged to be

	severe, or slight shock requiring roadside attention. This definition includes injuries not requiring medical attention
• STATS19	A reporting system in operation in Great Britain for the collection of information at fatal, serious, and slight accidents; organised by the DTLR.
• TCB	Tensioned corrugated beam safety fence
• Terminal	The treatment of the beginning and/or end of a safety fence or barrier. In addition it can provide an anchorage for the system.
• Transition	The interface between two safety fences or barriers of different cross-sections or different lateral stiffness, where containment shall be continuous.
• VCB	Vertical concrete barrier - A concrete barrier with a vertical traffic face, 0.8m in height
• Vehicle Restraint System	System installed on the road to provide a level of containment for an errant vehicle
• Very High Containment	A safety fence or barrier that has been impact tested to and complies with H4a or H4b containment level requirements in BSEN1317, parts 1 and 2 (see Table 2).
• WLC	Whole Life Cost: provides a method by which alternative solutions to a project can be compared, in financial terms, over the total life of a structure
• WRSF	Wire rope safety fence

Appendix B: Data Extracts from DTLR Casualty Reports [2] (1985 - 1998).

Table B1: Total Number of Reported Accidents occurring on major roads in Great Britain (including fatal, serious and slight accidents).

Date	Total Accidents in year (all severity)
1985	122,597
1986	124,561
1987	119,857
1988	123,521
1989	130,581
1990	128,339
1991	116,978
1992	115,913
1993	114,763
1994	117,199
1995	114,820
1996	116,590
1997	119,843
1998	118,668
Average	*120,302*

Table B2: Total Number of Reported Casualties on Motorways and A Roads in Great Britain.

Year	M, A(M) Roads			A Roads			**Total Number of Casualties**			
	Fatal	Serious	Slight	Fatal	Serious	Slight	**Fatal**	**Serious**	**Slight**	
1985	241	1454	5963	3071	35340	118722	**3312**	**36794**	**124685**	
1986	248	1581	6687	3302	33969	122368	**3550**	**35550**	**129055**	
1987	283	1583	7214	3071	32093	118222	**3354**	**33676**	**125436**	
1988	242	1448	7083	3026	31909	123725	**3268**	**33357**	**130808**	
1989	233	1583	8326	3239	31320	132937	**3472**	**32903**	**141263**	
1990	229	1643	8969	3113	29507	132770	**3342**	**31150**	**141739**	
1991	234	1394	8377	2703	25334	122600	**2937**	**26728**	**130977**	
1992	238	1338	9046	2463	24003	123749	**2701**	**25341**	**132795**	
1993	201	1338	9507	2278	21920	124175	**2479**	**23258**	**133682**	
1994	157	1358	10235	2224	22531	127783	**2381**	**23889**	**138018**	
1995	180	1333	10338	2119	22124	124838	**2299**	**23457**	**135176**	
1996	165	1298	11141	2078	21567	128016	**2243**	**22865**	**139157**	
1997	191	1422	12507	2133	20894	132817	**2324**	**22316**	**145324**	
1998	174	1301	12654	1974	20030	131790	**2148**	**21331**	**144444**	
Total	**3016**	**20074**	**128047**	**36794**	**372541**	**1764512**	**39810**	**392615**	**1892559**	**2324984**
Average	*215*	*1434*	*9146*	*2628*	*26610*	*126037*	*2844*	*28044*	*135183*	*166071*

Table B3: Annual Number of Registered HGVs on Major Roads in Great Britain.
(in million vehicle kilometres)

Year	2 axles	3 rigid	4 rigid	3 arctic	4+ arctic	TOTAL
1985	130	11	10	7	59	217
1986	131	11	10	6	62	220
1987	137	12	11	6	70	236
1988	155	15	17	7	82	276
1989	159	17	18	7	95	296

Year	2 axles	3 rigid	4+ rigid	4+ arctic	TOTAL
1990	158	16	17	100	291
1991	160	15	15	100	290
1992	158	14	14	97	283
1993	159	13	15	96	283
1994	162	14	15	104	295
1995	161	15	15	107	298
1996	161	15	14	117	307
1997	165	18	14	122	319
1998	163	19	14	124	320

Please note that the categorisation of vehicles changed after 1989.

Appendix C: Data Extracts from STATS 19 Database (1985 - 1998)

Table C1: Number of HGV Crossover Accidents on Motorways, A(M) and A Roads in Great Britain by Severity of Most Serious Casualty.

Year	Fatal	Serious	Slight	Total Number of Accidents
1985	7	22	38	67
1986	13	25	38	76
1987	12	20	41	73
1988	11	24	33	68
1989	12	21	28	61
1990	13	14	39	66
1991	11	14	33	58
1992	9	14	31	54
1993	8	10	27	45
1994	6	15	27	48
1995	7	16	19	42
1996	3	12	29	44
1997	5	10	26	41
1998	8	9	26	43
Total	**125**	**226**	**435**	**786**
Average	*9*	*16*	*31*	*56*

Table C2: Number of Casualties Involved in HGV Crossover Accidents on Motorways, A(M) and A roads in Great Britain.

Year	M, A(M)			A			**Total Number of Casualties**			
	Fatal	Serious	Slight	Fatal	Serious	Slight	**Fatal**	**Serious**	**Slight**	
1985	4	9	35	3	24	46	**7**	**33**	**81**	
1986	3	22	36	14	30	52	**17**	**52**	**88**	
1987	11	27	75	6	22	57	**17**	**49**	**132**	
1988	10	14	23	7	20	54	**17**	**34**	**77**	
1989	5	19	33	11	21	45	**16**	**40**	**78**	
1990	13	24	51	7	10	44	**20**	**34**	**95**	
1991	12	18	36	5	13	39	**17**	**31**	**75**	
1992	8	16	33	6	17	34	**14**	**33**	**67**	
1993	7	6	22	5	12	38	**12**	**18**	**60**	
1994	9	14	41	1	12	29	**10**	**26**	**70**	
1995	5	15	23	3	17	24	**8**	**32**	**47**	
1996	3	6	36	2	13	23	**5**	**19**	**59**	
1997	7	17	35	0	5	19	**7**	**22**	**54**	
1998	9	29	29	4	4	38	**13**	**33**	**67**	
Total	**106**	**236**	**508**	**74**	**220**	**542**	**180**	**456**	**1050**	**1686**
Average	*8*	*17*	*36*	*5*	*16*	*39*	*13*	*33*	*75*	*121*

Appendix D - An Example of a STATS 19 form [2]

DETR/SO/WO

Accident Record Attendant Circumstances

STATS19 (1999)

1.1 Record Type [1_]

11 New accident record
15 Amended accident record

1.2 Police Force [__]

1.3 Accident Ref No [_______]

1.5 Number of Vehicle Records [___]

1.6 Number of Casualty Records [___]

1.7 Date (Day Month Year) [__|__|__]

1.9 Time of Day (Hours Mins, 24 hour) [__|__]

1.10 Local Authority [___]

1.11 Location
10 digit OS Grid Reference number
Easting [_|____] Northing [_|____]

1.12 1st Road Class [_]

1 Motorway
2 A(M)
3 A
4 B
5 C
6 Unclassified

1.13 1st Road Number [____]

1.14 Road Type [_]

1 Roundabout
2 One way street
3 Dual carriageway - 2 lanes
4 Dual carriageway - 3 or more lanes
5 Single carriageway - single track road
6 Single carriageway - 2 lanes (one in each direction)
7 Single carriageway - 3 lanes (two way capacity)
8 Single carriageway - 4 or more lanes (two way capacity)
9 Unknown

1.15 Speed Limit (mph) [0__]

1.16 Junction Detail [0_]

00 Not at or within 20 metres of junction
01 Roundabout
02 Mini roundabout
03 T or staggered junction
05 Slip road
06 Crossroads
07 Multiple junction
08 Using private drive or entrance
09 Other junction

Junction Accidents Only

1.17 Junction Control [_]
1 Authorised Person
2 Automatic traffic signal
3 Stop sign
4 Give way sign or markings
5 Uncontrolled

1.18 2nd Road Class [_]
1 Motorway
2 A(M)
3 A
4 B
5 C
6 Unclassified

1.19 2nd Road Number [____]

1.20a Pedestrian Crossing - Human Control [_]

0 No crossing facility within 50 metres or physical crossing facility not controlled by authorised person
1 Control by school crossing patrol
2 Control by other authorised person

1.20b Pedestrian Crossing - Physical Facilities [_]

0 No physical crossing facility within 50 metres
1 Zebra crossing
4 Pelican, puffin, toucan or similar non-junction pedestrian light crossing
5 Pedestrian phase at traffic signal junction
8 Central refuge - no other controls
9 Footbridge or subway

1.21 Light Conditions [_]

1 Daylight: street lights present
2 Daylight: no street lighting
3 Daylight: street lighting unknown
4 Darkness: street lights present and lit
5 Darkness: street lights present but unlit
6 Darkness: no street lighting
7 Darkness: street lighting unknown

1.22 Weather [_]

1 Fine without high winds
2 Raining without high winds
3 Snowing without high winds
4 Fine with high winds
5 Raining with high winds
6 Snowing with high winds
7 Fog or mist - if hazard
8 Other
9 Unknown

1.23 Road Surface Condition [_]

1 Dry
2 Wet / Damp
3 Snow
4 Frost / Ice
5 Flood (surface water over 3cm deep)
6 Oil or diesel
7 Mud

1.24 Special Conditions at Site [_]

0 None
1 Automatic traffic signal out
2 Automatic traffic signal partially defective
3 Permanent road signing or marking defective or obscured
4 Roadworks present
5 Road surface defective

1.25 Carriageway Hazards [_]

0 None
1 Dislodged vehicle load in carriageway
2 Other object in carriageway
3 Involvement with previous accident
4 Dog in carriageway
5 Other animal or pedestrian in carriageway

1.26 Place Accident Reported [_]

1 At scene
2 Elsewhere

1.27 DETR Special Projects [____]

DETR/SO/WO

Vehicle Record

STATS19 (1999)

2.1 Record Type [2]

21 New vehicle record
25 Amended vehicle record

2.2 Police Force

2.3 Accident Ref No

2.4 Vehicle Ref No

2.5 Type of Vehicle

01 Pedal cycle
02 Moped
03 Motor cycle 125 cc and under
04 Motor cycle over 125cc
08 Taxi
09 Car
10 Minibus (8 - 16 passenger seats)
11 Bus or coach (17 or more passenger seats)
14 Other motor vehicle
15 Other non-motor vehicle
16 Ridden horse
17 Agricultural vehicle (includes diggers etc.)
18 Tram / Light rail
19 Goods vehicle 3.5 tonnes mgw and under
20 Goods vehicle over 3.5 tonnes and under 7.5 tonnes mgw
21 Goods vehicle 7.5 tonnes mgw and over

2.6 Towing and Articulation

0 No tow or articulation
1 Articulated vehicle
2 Double or multiple trailer
3 Caravan
4 Single trailer
5 Other tow

2.7 Manoeuvres

01 Reversing
02 Parked
03 Waiting to go ahead but held up
04 Stopping
05 Starting
06 U turn
07 Turning left
08 Waiting to turn left
09 Turning right
10 Waiting to turn right
11 Changing lane to left
12 Changing lane to right
13 Overtaking moving vehicle on its offside
14 Overtaking stationary vehicle on its offside
15 Overtaking on nearside
16 Going ahead left hand bend
17 Going ahead right hand bend
18 Going ahead

2.8 Vehicle Movement Compass Point From To

1 N	5 S	Parked:
2 NE	6 SW	not at kerb [0 0]
3 E	7 W	
4 SE	8 NW	at kerb [* 0]

* code 1 - 8

2.9a Vehicle Location at Time of Accident - Road

1 Leaving the main road
2 Entering the main road
3 On the main road
4 On the minor road

2.9b Vehicle Location at Time of Accident - Restricted Lane/ Away from Main Carriageway

0 On main carriageway - not in restricted lane
1 Tram / Light rail track
2 Bus lane
3 Busway (including guided busway)
4 Cycle lane (on main carriageway)
5 Cycleway (separated from main carriageway)
6 On lay-by or hard shoulder
7 Entering lay-by or hard shoulder
8 Leaving lay-by or hard shoulder
9 Footway (pavement)

2.10 Junction Location of Vehicle at First Impact

0 Not at junction (or within 20 metres)
1 Vehicle approaching junction or parked at junction approach
2 Vehicle in middle of junction
3 Vehicle cleared junction or parked at junction exit
4 Did not impact

2.11 Skidding and Overturning

0 No skidding, jack-knifing or overturning
1 Skidded
2 Skidded and overturned
3 Jack-knifed
4 Jack-knifed and overturned
5 Overturned

2.12 Hit Object in Carriageway

00 None
01 Previous accident
02 Roadworks
03 Parked vehicle - lit
04 Parked vehicle - unlit
05 Bridge - roof
06 Bridge - side
07 Bollard / refuge
08 Open door of vehicle
09 Central island of roundabout
10 Kerb
11 Other object

2.13 Vehicle Leaving Carriageway

0 Did not leave carriageway
1 Left carriageway nearside
2 Left carriageway nearside and rebounded
3 Left carriageway straight ahead at junction
4 Left carriageway offside onto central reservation
5 Left carriageway offside onto central reservation and rebounded
6 Left carriageway offside and crossed central reservation
7 Left carriageway offside
8 Left carriageway offside and rebounded

2.14 Hit Object Off Carriageway

00 None
01 Road sign / Traffic signal
02 Lamp post
03 Telegraph pole / Electricity pole
04 Tree
05 Bus stop / Bus shelter
06 Central crash barrier
07 Nearside or offside crash barrier
08 Submerged in water (completely)
09 Entered ditch
10 Other permanent object

2.16 First Point of Impact

0 Did not impact
1 Front
2 Back
3 Offside
4 Nearside

2.17 Other Vehicle Hit
Ref no of other vehicle

2.18 Part(s) Damaged

0 None
1 Front
2 Back
3 Offside
4 Nearside
5 Roof
6 Underside
7 All four sides

2.21 Sex of Driver

1 Male
2 Female
3 Not traced

2.22 Age of Driver
Estimated if necessary
Years

2.23 Breath Test

0 Not applicable
1 Positive
2 Negative
3 Not requested
4 Refused to provide
5 Driver not at time of
6 Not provided (medical

2.24 Hit and Run

0 Other
1 Hit and Run
2 Non-stop vehicle, not hit

2.25 DETR Special Projects

2.26 Vehicle Registration Mark (VRM)
Special codes:
2 Foreign / Diplomatic
3 Military
4 Trade plates
9 Unknown

2.27 Driver Postcode
Special codes:
1 Unknown
2 Non-UK resident
3 Parked and unattended

DETR/SO/WO

Casualty Record

STATS19 (1999)

3.1 Record Type [3][ ]

31 New casualty record
35 Amended casualty record

3.2 Police Force [ ][ ]

3.3 Accident Ref No [ ][ ][ ][ ][ ][ ][ ]

3.4 Vehicle Ref No [ ][ ][ ]

3.5 Casualty Ref No [ ][ ][ ]

3.6 Casualty Class [ ]

1 Driver or rider
2 Vehicle or pillion passenger
3 Pedestrian

3.7 Sex of Casualty [ ]

1 Male
2 Female

3.8 Age of Casualty [ ][ ] Years
Estimated if necessary

3.9 Severity of Casualty [ ]

1 Fatal
2 Serious
3 Slight

3.10 Pedestrian Location [ ][ ]

00 Not a pedestrian
01 In carriageway, crossing on pedestrian crossing facility
02 In carriageway, crossing within zig-zag lines at crossing approach
03 In carriageway, crossing within zig-zag lines at crossing exit
04 In carriageway, crossing elsewhere within 50 metres of pedestrian crossing
05 In carriageway, crossing elsewhere
06 On footway or verge
07 On refuge, central island or central reservation
08 In centre of carriageway, not on refuge, central island or central reservation
09 In carriageway, not crossing
10 Unknown or other

3.11 Pedestrian Movement [ ]

0 Not a pedestrian
1 Crossing from driver's nearside
2 Crossing from driver's nearside - masked by parked or stationary vehicle
3 Crossing from driver's offside
4 Crossing from driver's offside - masked by parked or stationary vehicle
5 In carriageway, stationary - not crossing (standing or playing)
6 In carriageway, stationary - not crossing (standing or playing), masked by parked or stationary vehicle
7 Walking along in carriageway - facing traffic
8 Walking along in carriageway - back to traffic
9 Unknown or other

3.12 Pedestrian Direction [ ]

Compass point bound

1 N
2 NE
3 E
4 SE
5 S
6 SW
7 W
8 NW
9 Unknown
0 Standing still

3.13 School Pupil Casualty [ ]

1 School pupil on journey to or from school
0 Other

3.15 Car Passenger [ ]

0 Not a car passenger
1 Front seat passenger
2 Rear seat passenger

3.16 Bus or Coach Passenger [ ]

0 Not a bus or coach passenger
1 Boarding
2 Alighting
3 Standing passenger
4 Seated passenger

3.17 DETR Special Projects [ ][ ][ ][ ]

3.18 Casualty Postcode [ ][ ][ ][ ] [ ][ ][ ]

Special codes:
1 Unknown
2 Non-UK resident

Appendix E - All Fatal HGV Crossover Accidents 1985-1998, Motorways, A(M) and A Roads

In order to assess which of the accidents reported through the STATS19 reporting procedure involved an HGV crossover, a search was made on the records database. A search can be made on the database for any combination of criteria relating to the information collected on the STATS 19 report forms. For purpose of this report the following search criteria was used for the years 1985 to 1998:

' Accidents on motorways and/or M/A and/or A roads in Great Britain involving at least one HGV crossing the central reserve'

KEY:

Green	Impact energy less than 950,000kJ (that tested for in a TB81 test)
Blue	Impact energy slightly above 950,000kJ (that tested for in a TB81 test)
Red	Impact energy vastly greatly than 950,000kJ (that tested for in a TB81 test)
Grey	Not enough information available in police report

Note: The definition of an HGV changed in 1994:

'Prior to 1994 these were defined as those vehicles over 1.524 tonnes unladen weight and included vehicles with six or more tyres, some four wheel vehicles with extra large bodies and larger rear tyres and tractor units travelling without their usual trailer.
From 1 January 1994 the weight definition changed to those vehicles over 3.5 tonnes maximum permissible gross vehicle weight (gvw).' [2]

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
1099785	1985	A1139	2	Not currently known	1	Cambridgeshire Police: Reports destroyed								
2032185	1985	A45	6	Not currently known	3	Cambridgeshire Police: Reports destroyed								
00H0754	1985	M6	12	Not currently known	2	West Midlands Police: No information returned								
00K3153	1985	M5	9	Not currently known	4	West Midlands Police: No information returned								
BC03802	1985	A82	4	Not currently known	2	Strathclyde Police: Reports destroyed								
C300299	1985	M1	1	Not currently known	1	South Yorkshire Police: No information returned								
D218985	1985	M56	1	Not currently known	1	Greater Manchester Police: No information returned								
1013086	1986	A1	3	Not currently known	3	Cambridgeshire Police: Reports destroyed								
6029093	1986	A1	4	Not currently known	1	North Yorkshire Police: No information returned								
6085078	1986	A1	5	Not currently known	3	North Yorkshire Police: No information returned								
0203015	1986	A448	3	Not currently known	1	West Mercia Police: Report cannot be found								
0C04055	1986	A55	3	Not currently known	1	North Wales Police: Reports destroyed after three years								
0FA1293	1986	A682	1	Not currently known	1	Lancashire Police: Report unavailable								
7S81608	1986	A1	2	Not currently known	2	Nottingham Police: Reports destroyed after ten years								
BC28986	1986	A1	2	Not currently known	1	West Yorkshire Police: No information returned								
GR00857	1986	M5	3	Not currently known	2	Avon and Somerset Police: Reports destroyed after ten years								
P204286	1986	M62	6	Not currently known	3	Greater Manchester Police: No information returned								
QC02306	1986	A74	2	Not currently known	2	Strathclyde Police: Reports destroyed								
QC07812	1986	A74	2	Not currently known	2	Strathclyde Police: Reports destroyed								
XR00005	1986	A40	4	Not currently known	1	Metropolitan Police: Reports destroyed after six years								
TC00486	9-Sep-87	M4	6	4	1	Metropolitan Police: Reports destroyed after six years								
???	12-Sep-87	A38	2	1	2	Staffordshire Police: Reports destroyed								
8M10742	10-Oct-87	M6	3	6	2	Double sided TCB (0.61m high) before and after an MCP (35.7m long). MCP cordoned off with plastic posts.	60mph (witness) 96.6km/h	Light in both directions	6,000	Information not recorded in fatal file	4.2m	A car had faulty lights and broke down in the middle lane. Two gentlemen attempted to clear the car from the carriageway, but got out of the way just as a lorry hit the car. The lorry dragged the car some distance, and they then parted. The lorry then crossed the central reserve at an emergency crossing point. Fatalities occurred as a result of the lorry striking the car in the first instance. Road lighting in the area may have prevented fatalities.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level - Accident also occurred at an Emergency Crossing Point (ECP)
???	30-Nov-87	M6	3	1	1	Staffordshire Police: Reports destroyed								
1127200	1987	A45	3	Not currently known	1	Suffolk Police: Reports destroyed after three years								
00B0262	1987	A127	2	Not currently known	1	Essex Police: Reports destroyed								
00H0242	1987	A454	2	Not currently known	1	West Midlands Police: No information returned								
00H0955	1987	M6	2	Not currently known	2	West Midlands Police: No information returned								
8702230	1987	M90	3	Not currently known	1	Fife Police: Reports destroyed								
BC01987	1987	A1	3	Not currently known	1	West Yorkshire Police: No information returned								
C301652	1987	M18	3	Not currently known	2	South Yorkshire Police: No information returned								
D053047	1987	M1	4	Not currently known	1	Thames Valley Police: Reports destroyed								
TG00361	1987	M25	2	Not currently known	1	Metropolitan Police: Reports destroyed after six years								

Table E (a): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
L112188	5-Apr-88	M6	1	3	2	Two parallel runs of single sided TCBs (0.67m high), with lamp standards in between. Set on grass verge	80.5km/h (tachometer)	Moderate and free flowing in HGV's initial carriageway, but lighter on the opposite carriageway	38,000	20-25deg (estimate from photographs)	3.6m	A tyre burst on an HGV which then hit a car and then crossed central reserve. The HGV then hit another HGV head-on. 40yrds (36.5m) of barrier were damaged in the impact …'as it [the HGV] hit, the barrier seemed to crumple and fold underneath, and the whole vehicle crashed through the barriers.'…'it went through the central reservation and barrier as if it didn't exist'....'It appeared that the barriers had no effect on the vehicle'.	1,111,330	No - Impact energy slightly greater than that tested for in a TB81 test
8062047	13-Apr-88	A1	1	4	2	Grassed central reservation	82km/h (tachometer)	Heavy on initial carriageway, caused by slow moving vehicle ahead, moderate on the opposite carriageway	38,000	50deg (estimated from sketch)	5.4m	A car driver braked suddenly. A following lorry driver did likewise but swerved over the central reserve hitting a roadworks sign, jack-knifed, and then collided with other vehicles.	5,784,738	Accident occurred where there is currently no barrier in the central reserve. Impact energy much greater than that tested for in a TB81 test
41T1086	25-Apr-88	M25	1	6	5	Two metal 'Armco' crash barriers set on soft earth, running parallel, set 1m in from a marginal strip.	106.2km/h	Free flowing, but quite busy, on both carriageways	16,000	80-90deg	2m plus barrier width	A lorry clipped the back of a cement mixer and went through the safety fence in the central reserve. The HGV was then struck by a car, killing its driver. The HGV went 'through the crash barriers quite easily'….'went straight through the barrier, perhaps lifting slightly as it did so'….The HGV cab stopped against the barrier, but the trailer jack-knifed and went through the fence. Both fences were flattened and pushed across into the opposite carriageway.	6,752,067	No - Impact energy much greater than that tested for in a TB81 test
00G0580	9-Jul-88	A25	4	3	1	Two parallel runs of single sided TCBs with lamp standards in between	60mph (driver) 96.6km/h	Quite quiet and free moving - traffic well spaced out.	RAC Dodge recovery truck - HGV Licence not required to drive this type of vehicle	90deg	2m (estimated from photographs)	A Range Rover swerved and struck the RAC vehicle which then crossed the fence in the central reserve. It was then struck by a third vehicle, killing the third vehicle's occupants. When the RAC vehicle struck the barrier in the central reserve 'it appeared to just explode into pieces'.....'appeared to disintegrate on impact with the barrier'. The vehicle overturned on hitting the fence, and landed on its roof. 15m of fence was damaged in the accident.	Not enough information available in the fatal file to assess this quantity	Vehicle considered to be too light to be considered as an HGV.
41T1189	22-Aug-88	M25	2	2	1	Double sided TCB (0.61m high) before and after an ECP. TCB on a grass and shingle verge, and ECP cordoned off with plastic cones	91.7km/h (tachometer)	Moving freely in initial carriageway, and lighter on opposite carriageway	ERF Articulated HGV (petrol tanker)	90deg	4m (estimated from photographs)	An HGV hit the rising edge of ramped end which then launched it. Failure to erect a permanent barrier across the crossing point was seen to be a contributory factor to the accident - Similar accidents occurred on 18/10/87 and on one other day but without fatalities in that case - This accident sparked a meeting of the Traffic Management Meeting who then agreed to remove some emergency cross-over gaps and replace them with temporary barriers.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level - Accident also occurred at an Emergency Crossing Point (ECP)
88W1774	1988	A9	2	Not currently known	1	Tayside Police: Reports destroyed after ten years								
CA12888	1988	M621	2	Not currently known	1	West Yorkshire Police: No information returned								
D88F038	1988	M8	4	Not currently known	2	Lothian and Borders Police: Reports destroyed after ten years								
DA42788	1988	M1	6	Not currently known	3	West Yorkshire Police: No information returned								
NC00410	1988	A80	3	Not currently known	1	Strathclyde Police: Reports destroyed								

Table E (b): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
8282775	28-Mar-89	A19	1	2	1	Grass verge	107.8km/h	Light in both directions	7,500	15deg (calculated)	3.7m	HGV slid on a wet road and drove over the central reserve, striking a road sign in its path. The HGV then struck a car, killing its occupant.	225,245	Accident occurred where there is currently no barrier in place. Requires a central reserve safety barrier with a containment level equal to, or greater than H2 to contain and redirect the vehicle
B13489T	4-Apr-89	A449	1 pedestrian	2	1	Grass verge	72.4km/h	Slowing on initial carriageway and light in both directions	Vauxhall Astra van	10 deg	Information not recorded in fatal file	A caravan was involved in an accident, causing it to spread mud onto the carriageway. A recovery service employee proceeded to pick up the dirt, and was hit and killed by the Astra van. This caused the van to swerve over the central reserve.	Not enough information available in the fatal file to assess this quantity	Accident occurred where there is currently no barrier in place. Not enough information available on this accident to assess impact energy level
00G0597	10-Apr-89	A4123	1 + 1 unborn baby	5	1	Raised concrete kerb	86.9km/h (tachometer)	Fairly light on both carriageways	32,000	75-80deg (estimated from photographs)	1.0m (one slab)	[Accident occurred in a built-up area]. An HGV was overtaking a vehicle turning right through a gap in the central reserve. The HGV then suddenly braked causing it to jack-knife and cross the safety fence, striking a 'keep-left' bollard. The HGV the struck another car (killing the driver) and the driver of the HGV was then thrown from his cab. The HGV then it a further three vehicles. The HGV's rear unit rose approximately 8 to 10 feet after striking the central reserve. One witness states that they managed to avoid getting involved in the accident by driving onto the central reserve.	8,698,449	Accident occurred where there is currently no barrier in place. Impact energy much greater than that tested for in a TB81 test
B051289	14-Jun-89	A1	1	4	2	Grass and shingle verge	60mph (driver) 96.6km/h	Light in both directions	38,000	25-30deg estimate from scale drawing	2m (from scale diagram)	The steering mechanism jammed on an HGV, causing it to cross the central reserve, where it hit a horse box and other vehicles. The HGV and collected vehicles were stopped by OBB and meshed wire fencing which were in place in the verge of the opposite carriageway.	2,443,423	Accident occurred where there is currently no barrier in place. Impact energy much greater than that tested for in a TB81 test
C/1219/89	29-Jun-89	M1	2	3	2	Double sided TCB on grass and tarmac strip	90.1km/h	Quite quiet and free moving	7,490	50-60deg (estimated from photographs)	4-5m (estimated from photographs)	The GPO van hit the nearside S/S TCB and went onto 2 wheels. It then crossed over the central reserve where it was hit by an HGV and other vehicles. This action killed the driver and passenger of the GPO van. The passenger of the HGV was thrown from the cab and killed. The van 'demolished' the central barrier. The van's front was flipped in the air after hitting the barrier, and the proceeded to travel over the barrier.	1,376,587	No - Impact energy slightly greater than that tested for in a TB81 test
1001480	1-Jul-89	A1	3	4	2	Double sided TCB on a scrub verge.	85.3km/h (tachometer)	Quite heavy, but free flowing, in both directions	17,000	20-30deg - estimated from photographs	3m	The HGV slightly hit the safety fence in the central reserve, and then hit the vehicle it was overtaking. The HGV then went over barrier, where cars then ploughed into the vehicle. The HGV's rear unit jack-knifed after hitting the central reservation. The HGV's driver had tampered with tachometer. 55m of barrier required replacement.	558,232	Requires a central reserve safety barrier with a containment level equal to, or greater than H3 to contain and redirect the vehicle

Table E (c): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
1497/89	6-Sep-89	M5	1	3	2	Double sided TCB (1.6m high) on grass scrub.	60mph (driver) 96.6km/h	Very light on original carriageway, light on opposite carriageway	16,000	50-60deg - estimated from skid marks in photograph)	2m (estimated from photograph)	A detached wheel from a vehicle travelling in the opposite direction bounced over the barrier in the central reserve and struck the HGV causing its driver to lose control. The HGV became unstable before hitting the barrier, although the HGV seemed to 'take-off' and land on top of the vehicle containing the deceased. 10 m of barrier damaged in the impact.	3,380,233	Impact energy much greater than that tested for in a TB81 test
1069765	5-Oct-89	A1	2	7	3	Double sided TCB (on a grass verge) before and after an MCP (19m in length)	93km/h (tachometer)	Quite heavy in both directions	37,640	20-30deg - estimated from photographs	4m	An HGV swerved to avoid a car pulling out and rode through a gap in the safety fence at a crossing. It slightly touched the concrete haunch of the ramped end and took off. Other vehicles (including deceased's HGV) then drove into the crossed over HGV. A car swerved to avoid the incident and hit the central reserve barrier - the vehicle's occupants were unharmed, and vehicle was restrained and redirected.	1,469,208	Accident occurred at an Maintenance Crossing Point (MCP) - Impact energy greater than that tested for in a TB81 test
1348789	2-Nov-89	A1101	1	2	1	Lines on road	72.4km/h	Light in both directions	38,000	20deg (estimated from photographs)	0m	Car came round a sharp corner and lost control, skidding due to a burst tyre. It then hit the HGV, causing it to weave over on to the other side of the road and then back again. The car caught light killing the driver.	897,446	Accident occurred where there is currently no barrier in place. Requires a central reserve safety barrier with a containment level equal to, or greater than H4b to contain and redirect the vehicle
9AK2090	20-Nov-89	A(M)1	1	1	1	Metal barrier of height 0.61m	Information not recorded in fatal file	Very light - no witnesses	17,000	Information not recorded in fatal file	Information not recorded in fatal file	The HGV crossed the central reserve and travelled on the opposite carriageway until it hit a parapet in the verge of the opposite carriageway. 120 feet (36.5m of safety fence was damaged in the accident).	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
9D21578	1989	A562	2	Not currently known	1	Cheshire Police: No information returned								
A070589	1989	A57	2	Not currently known	2	Greater Manchester Police: No information returned								
OM10018	12-Jan-90	M6	1	4	2	Single run of 'ARMCO' barrier on a grass verge at an ECP (length of 16m). ECP contained plastic lintels.	96.6km/h	Quite busy in both directions	7,750	45deg (from scale drawing)	4.2m	A car pulled onto the motorway behind a slow moving vehicle. The car then tried to overtake the slow moving vehicle, pulling out in front of an HGV which had pulled out to let them in. The HGV went through an emergency crossing point, but clipped the safety fence and a lamp standard on the way through. The HGV cab lifted about 3 ft off the ground on hitting the barrier. The HGV jack-knifed and the deceased's vehicle drove into the side of the HGV.	1,395,052	Accident occurred at an Emergency Crossing Point. Impact energy greater than that tested for in a TB81 test
OM10126	13-Mar-90	M56	1	5	3	Single run of 'ARMCO' barrier on a grass verge at an ECP (length of 23m). ECP contained plastic lintels.	96.6km/h	Light in both directions	6,850	90deg	4.2m	HGV hit a car, jack-knifed and the cab and trailer became detached…cab clipped the barrier at an emergency crossing point, and then hit other vehicles. Vehicle overturned on hitting the barrier…Trailer became lodged on the barrier.	2,466,095	Impact energy much greater than that tested for in a TB81 test

Table E (d): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
00650	6-Apr-90	A1	2	3	2	Grass verge	75km/h	Light to Moderate	24,000	45-50 deg (estimated from photos and scale drawings)	2m (estimated from photograph)	A car crossed the central reserve and hit an HGV. Another HGV swerved to miss it, although it ended up driving over the top of it. The HGV driver then saw a gap in the traffic on the other carriageway and the central reserve, and drove through it, stopping in a safe place on the opposite carriageway.	2,604,163	Accident occurred where there is currently no barrier in place. Impact energy greater than that tested for in a TB81 test
TG00182	24-Apr-90	A30	1	2	1	Raised kerb covered in gravel	103km/h (tachometer)	Free flowing, but filtering into one lane ahead due to roadworks	30,000	20-30deg - estimated from photographs	1.75m	An HGV's heavy braking caused a suspension spring to fail, causing the HGV's steering to fail. The HGV crossed the central reserve where it was hit by a car coming in the opposite direction. The accident occurred after the brow of a hill. It is recommended by the police (in their files) that due to the large volume of traffic using this road, 'the likelihood of a similar incident occurring, and considering the very high cost attributed to a fatal accident, may consideration be given to improving conditions on this road by the erection of safety barriers, the presence of which would likely have prevented the incident resulting in a fatality'.	1,436,360	Accident occurred where there is currently no barrier in place. Impact energy greater than that tested for in a TB81 test
OM10360	16-Aug-90	M6	4	4	2	Two parallel runs of single sided TCB with lamp standards between. Barrier on long grass verge	HGV1: 66km/h *HGV2: 39km/h*	Heavier on the original carriageway, traffic flow was moderate	HGV1: 22,000 HGV2: *32,520*	HGV1: 45deg *HGV2: 45deg*	3.7m	A car pulled out from the hard shoulder in front of HGV1, causing it to jack-knife and pass through the safety fence in the central reserve. HGV2 then it HGV1 and went through the deformed section of the safety fence, before coming to rest across it. The deceased's car hit both lorries killing all 4 occupants.	1,848,609 *954,145*	No - Impact energy greater than that tested for in a TB81 test
41D0606	3-Oct-90	M1	1	2	1	2 parallel, single sided TCBs (0.75m high) on a scrub and loose clay verge. TCB posts are in concrete blocks	57.9km/h (tachometer)	On original carriageway, heavy and slowing to a standstill, and medium free flowing on the opposite carriageway	38,000	35deg (estimated from scale drawing)	4m (estimated from scale drawing)	An HGV spun and then jack-knifed for unknown reasons. It then struck the safety fence in the central reserve, throwing the driver from his cab. A lamp standard (between the two TCBs) was also knocked down by the HGV. The safety fence in the central reserve had been 'ripped apart'.	1,616,917	No - Impact energy slightly greater than that tested for in a TB81 test
OBI5327	16-Oct-90	M5	1	2	1	Double sided TCB on a grass verge	60mph (witness) 96.6km/h	50mph speed limit zone due to road works. Light on both carriageways and free-flowing.	12,000	55-80 deg (witness)	4.3m	The driver of the HGV had 'blacked out'. The HGV struck the safety fence and was launched landing on top of the deceased's' vehicle. The front offside corner of the HGV skidded along the top of the fence and then rose in the air. The rear axle of the HGV became detached on hitting the fence.	2,898,872	No - Impact energy greater than that tested for in a TB81 test
AC00742	24-Oct-90	A43	3	2	1	Grass verge	87km/h (tachometer)	Light in both directions	Information not recorded in fatal file	40-45deg (estimated from sketch)	5.3m	The accident occurred at a junction. After crossing the grass central reserve, the HGV travelled for 100m on opposite carriageway. Better road lighting at this 'accident black-spot' was recommended.	Not enough information available in the fatal file to assess this quantity	Accident occurred where there is currently no barrier in place. Not enough information available on this accident to assess impact energy level
OLR0335	27-Oct-90	M27	1	2	1	Double sided TCB (from sketch)	16km/h	Quiet and free-flowing	13,200	90deg	4.2m (from scale drawing)	An HGV was turning right through an emergency crossing point in the central reserve when it was hit from behind by a car, killing the car driver.	97,756	Accident occurred at an Emergency Crossing Point (ECP) - Requires a central reserve safety barrier with a containment level equal to, or greater than N2 to contain and redirect the vehicle.

Table E (e): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
OTL0196	31-Dec-90	M27	2	4	2	Double sided TCB on a 100mm raised area	129km/h	Moderate and in heavy weather	7,500	45deg	Information not recorded in fatal file	A medium goods van loses control and crosses the central reserve, causing the van to become airborne and overturn, landing on top of a car, killing both the driver and passenger. An Articulated HGV then hit the medium goods van. A second car then swerved to miss the accident, struck with the safety fence, and was slowed and redirected safely. The safety fence did not slow or redirect the medium goods van, this vehicle damaging 28m of the fence. The fence was also struck by the now slow moving Articulated HGV, and redirected it safely over a 'considerable distance'. Lastly, a fully laden petrol tanker struck the fence at 20deg, and at a slow speed (20mph) and was contained and redirected safely, without rupturing the tank.	2,407,549	No - Impact energy greater than that tested for in a TB81 test
E202210	1990	A580	2	Not currently known	2	Merseyside Police: No information returned								
F294890	1990	M63	6	Not currently known	1	Greater Manchester Police: No information returned								
L391990	1990	M6	17	Not currently known	4	Greater Manchester Police: No information returned								
M074991	2-Apr-91	M56	1	4	1	Metal safety fence	80.5km/h	Medium amount of traffic	16,600	90 deg	Information not recorded in fatal file	The HGV jack-knifed, hit the safety fence in the central reserve and then overturned. Approximately 50m of safety fence was damaged in the accident.	4,150,160	No - Impact energy greater than that tested for in a TB81 test
BS05298	4-Apr-91	A45	1	3	1	Grass Verge	101km/h (tachometer)	Very heavy on initial carriageway, but free flowing on the opposite carriageway	35,000	15-20 deg (from scale diagram)	2.7m	The HGV's steering ceased up meaning that it could only continue in a straight line, with a corner coming up ahead. Soft earth in the central reserve caused the vehicle to jack-knife.	922,715	Accident occurred where there is currently no barrier in place. Requires a central reserve safety barrier with a containment level equal to, or greater than H4b to contain and redirect the vehicle
9102829	19-Apr-91	M1	1	11	4	Double sided TCB on a grass verge	96.6km/h	Heavy in all three lanes and on both carriageways	Information not recorded in fatal file	45deg (from diagram)	2.0m (estimated from photographs)	Minimal accident details available in the police report. Accident investigator: 'The barrier had been damaged over a distance of 15.3m, this consisted of buckling, the metal being ripped from the stantions and an area where it had been knocked over to ground level.'	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
7E80658	23-Apr-91	A1	1	4	3	Grass Verge	80.5km/h	Very quiet in both directions	38,000	30deg (from scale diagram)	4.5m	Double cross-over….A trailer detached from an HGV and crossed through the central reserve. An HGV coming the other way then swerved, but hit the trailer and crossed over, hitting a car. Another vehicle also struck the loose trailer. This was a very dark area of the road, and the trailer was also dark, so difficult to see. The secondary accident (and the fatalities) may have been avoided had lighting been provided, enabling the HGV to slow instead of swerving to avoid the trailer.	2,375,088	Accident occurred where there is currently no barrier in place. Impact energy much greater than that tested for in a TB81 test
EA08611	9-May-91	A2	1	3	2	Gravel strip	124km/h (tachometer)	Light to moderate and free-flowing on both carriageways	Information not recorded in fatal file	45deg (from scale drawing)	1.3m (from scale drawing)	An HGV overtaking another, when the slower HGV pulled across, striking the first and forcing it to pass through the central reserve. The HGV then hit a car, killing its driver.	Not enough information available in the fatal file to assess this quantity	Accident occurred where there is currently no barrier in place. Not enough information available on this accident to assess impact energy level

Table E (f): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
G006221	29-May-91	M4	2	8	2	Two parallel runs of single sided TCB on a slightly raised concrete platform	80.5km/h (tachometer)	Heavy in both directions, but moving freely.	Information not recorded in fatal file	90 deg	3.75m	An HGV was being towed by a recovery vehicle when it worked loose and crossed through the central reserve. The safety fence was partly knocked down, and a lamp standard was struck. The HGV 'took off' on hitting the fence (5-8 feet). The HGV then landed on the roof of a car killing the driver and passenger.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
00F0728	27-Sep-91	M25	5	7	1	Grass, incorporating an Armco barrier -metal	48mph (tachometer) 77km/h	Slower moving, quite quiet, but free flowing on original, heavy and very slow moving on the opposite carriageway.	30,779	45 deg (scale drawing)	Approx 2.25m (from scale drawing)	No accident details recorded at present.	3,520,225	No - Impact energy much greater than that tested for in a TB81 test
00C0960	7-Oct-91	A12	1	3	1	Double Sided TCB on long grass and shingle verge	50mph (witness) 80.5km/h	Reasonably heavy on initial carriageway, but lighter on the opposite carriageway.	24,000	30-40deg (estimate from photograph)	2m (estimated from photograph)	An HGV ran into the back of a slow moving JCB and crossed the central reserve where it hit another vehicle, killing the driver, and overturned. The safety fence did not deviate the path of the HGV, nor did it slow the HGV down.	1,500,056	No - Impact energy greater than that tested for in a TB81 test
M10391	14-Nov-91	M6	1	4	1	Metal safety fence on a grass verge	96.6km/h	Freely moving	32,520	90 deg	Information not recorded in fatal file	An HGV jack-knifed, and the driver claimed that the HGV 'slid along the barrier for about 100 yards before the wagon went over the top'. The lorry was then struck by a car travelling on the opposite carriageway (whose driver was on a mobile phone). 'Went through the barrier as if they were wooden sticks'…'as if the barrier were paper'...'it went straight through the barrier like a knife through butter'. 120ft (36.5m) of safety fence was damaged in the accident.	11,707,652	No - Impact energy greater than that tested for in a TB81 test
911106W	1991	A85	3	Not currently known	1	Tayside Police: Report unavailable								
QC05805	1991	M74	1	Not currently known	1	Strathclyde Police: Reports destroyed								
9201K200042	8-Jan-92	A178	1	2	1	Grass verge.	35mph (witness) 56km/h	Steady traffic flow on original carriageway.	10,000	Information not recorded in fatal file	4m	The accident occurred at a junction where a car pulled out in front of an HGV. The car was struck by the HGV which then mounted the central reserve and struck a lamp post.	Not enough information available in the fatal file to assess this quantity	Accident occurred where there is currently no barrier in place. Not enough information available on this accident to assess impact energy level
11190792	13-Jul-92	A1139	3	6	2	Dense Bushes	64km/h	Heavy traffic flow on both carriageways, in heavy rain conditions	36,000	45 deg	11.0m	An HGV overtook a tractor at the last minute causing the HGV to become unstable, jack-knife and cross the central reserve. The front of the lorry appeared to be airborne on striking the fence (the cab was 3 feet clear of the ground).	2,844,441	Accident occurred where there is currently no barrier in place. Impact energy greater than that tested for in a TB81 test
92K9288	29-Jul-92	M5	2	5	1	Steel safety fence	55km/h (tachometer)	Heavy on the initial carriageway, but light on the opposite carriageway.	30,000	90 deg	1.5m (from scale diagram)	The steering mechanism failed on an HGV's trailer, causing to cross through the central reserve. One lamp standard was struck and damaged. Minor damage to a second vehicle was caused by the safety fence in the central reserve. The safety fence was broken by girders being transported on the HGV in addition to the HGV. 'It [the lorry] went straight through the central crash barrier'. 'the lorry and load did not continue onwards for any significant distance after this impact with the central reservation'.	3,501,157	No - Impact energy greater than that tested for in a TB81 test

Table E (g): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
ED35692	2-Oct-92	M25	1	5	1	Steel safety fence	93km/h (tachometer)	Steady, but not exceptionally heavy on both carriageways	38,000	45-60 deg	3.8m	The HGV 'glided' through the central reservation (according to one witness) but did not overturn. The HGV 'rose up onto the central crash barrier'.	6,339,922	No - Impact energy much greater than that tested for in a TB81 test
01SV9251388	6-Oct-92	A406	1 pedestrian	4	1	Two parallel runs of single sided TCB, a slightly raised concrete platform with a taller pedestrian guardrail between the TCBs.	64km/h (tachometer)	Quiet in both directions	Information not recorded in fatal file	70 deg	3.0m	An HGV 'drove' through a gap in the barrier at a junction, clipped the meshed safety fence in the central reservation, but did minimal damage. The run of TCB was undamaged.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
00D1671	26-Oct-92	M1	3	4	2	Parallel run of two single sided TCBs	88.5km/h (tachometer)	Light and free flowing in both directions.	Information not recorded in fatal file	45-50 deg (from scale drawing)	3.8m	An HGV struck a second HGV before crossing the central reserve. The HGV became airborne after contacting the barrier and damaged a lamp standard on its way through. The HGV then struck a car and overturned. The safety fence became 'flattened' on both sides during the accident.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
0316760	1992	M2	3	Not currently known	1	Kent Police: No information returned								
2M10001	1992	M6	1	Not currently known	1	Cheshire Police: No information returned								
DC03212	1992	A80	2	Not currently known	1	Strathclyde Police: Reports destroyed								
7E80494	15-Apr-93	A620	1 m/c	2	1	Grass verge	71km/h (tachometer)	Light on both carriageways	Information not recorded in fatal file	40-45deg (estimated from scale drawing)	2.0m (estimated from scale drawing)	A motorcycle crossed the central reserve where it impacted an HGV. The driver then lost control and swerved, crossing the central reserve.	Not enough information available in the fatal file to assess this quantity	Accident occurred where there is currently no barrier in place. Not enough information available on this accident to assess impact energy level
B126993	13-Sep-93	M6	2	3	2	Double sided TCB	60mph (witness) 96.6km/h	Moderate on both carriageways	30,800	Unable to ascertain from photos and sketches	3.0m (estimated from sketch and photos)	No accident details recorded at present.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
MU23793	25-Sep-93	A1	2	3	1	Metal ARMCO barrier	80.5km/h (witness) (50mph)	Moderate on both carriageways	Scania Articulated vehicle	Informatio n not recorded in fatal file	Information not recorded in fatal file	No accident details recorded at present.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
0D07144	27-Dec-93	A483	2	4	1	Double sided TCB (0.61m height)	100km/h (tachometer)	Light and free flowing in both directions.	32,000	25-30deg estimate from scale drawing	6.5m	The HGV driver died of natural causes at the wheel. Another vehicle hit the safety fence in the central reserve to avoid the moving truck and its occupants were unharmed. A statement from the police report: From enquiries made, to the Welsh Office, it would appear that the type of crash barrier erected at the scene. is not designated to prevent any Heavy Goods Vehicle transgressing into the opposing carriageway'.	2,205,011	No - Impact energy much greater than that tested for in a TB81 test
3M10192	1993	M62	4	Not currently known	1	Cheshire Police: No information returned								
93J9499	1993	M5	4	Not currently known	1	West Midlands Police: No information returned								
93K9332	1993	M5	5	Not currently known	2	West Midlands Police: No information returned								
BF10885	1993	M876	3	Not currently known	1	Central Police: Reports destroyed after five years								

Table E (h): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
94K9113	10-Mar-94	M6	2	4	1	Metal barrier	82km/h (tachometer)	Light traffic on both carriageways, traffic on opposite carriageway speeding up after being contained in one lane through roadworks	38,000	90deg (witness)	Information not recorded in fatal file	No accident details recorded at present.	9,857,716	No - Impact energy much greater than that tested for in a TB81 test
0915289	1994	A20	2	Not currently known	2	Kent Police: No information returned								
G017394	1994	M4	10	Not currently known	3	South Wales Police: Reports destroyed after five years								
MU07094	1994	M62	5	Not currently known	3	West Yorkshire Police: No information returned								
QB00609	1994	M74	5	Not currently known	2	Strathclyde Police: Reports destroyed								
0177895	12-Apr-95	A14	2	4	2	Grassed with double sided TCB	81km/h (tachometer)	Fairly heavy in both directions	38,000	50 deg (police)	2.6m	No accident details recorded at present.	5,644,507	No - Impact energy much greater than that tested for in a TB81 test
TM05422	1-Sep-95	M1	1	2	1	Open Box Beam on the verge, and two rows of parallel single sided TCB in the central reserve	90kph (tachometer)	Heavy on final, thinner on initial	38,000	80deg (accident investigator)	4m	No accident details recorded at present.	11,516,920	No - Impact energy much greater than that tested for in a TB81 test
GY18767	21-Dec-95	M54	1	3	2	Double sided TCB, 3.2m post spacing	88.5km/h (tachometer)	Light in both directions, but at a reduced speed due to poor weather conditions	7,500	19deg (accident investigator)	3.6m (from sketch)	No accident details recorded at present.	240,213	Requires a central reserve safety barrier with containment level equal to, or greater than H2 to contain and redirect the vehicle
0002153	1995	M6	4	Not currently known	2	Cumbria Police: No information returned								
5M19405	1995	M6	6	Not currently known	3	Staffordshire Police: Reports destroyed								
4M10483	1995	M62	2	Not currently known	2	Cheshire Police: No information returned								
MU03395	1995	M62	3	Not currently known	1	West Yorkshire Police: No information returned								
UA70208	1995	A71	2	Not currently known	1	Strathclyde Police: Reports destroyed								
DH05716	27-Aug-96	A419	1	1	1	Grassed central reserve	50mph (tachometer) 80.5km/h	Light on both carriageways	MAN 3x3 Arctic, 6axles	60deg (witness)	Information not recorded in fatal file	No accident details recorded at present.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
NK00840	1996	A2	5	Not currently known	1	Kent Police: No information returned								
S001126	1996	M1	4	Not currently known	1	Thames Valley Police: Report unavailable								
X036397	25-Jul-97	M62	2	4	3	Information not recorded in fatal file	Information not recorded in fatal file	Information not recorded in fatal file	Information not recorded in fatal file	Information not recorded in fatal file	Information not recorded in fatal file	No accident details recorded at present.	Not enough information available in the fatal file to assess this quantity	Not enough information available on this accident to assess impact energy level
00G0768	16-Oct-97	M25	2	7	3	Two parallel rows of S/S TCB with lighting columns in between	50mph (police) 80.5km/h	Moderate/heavy on both carriageways, though slightly lighter on original, traffic moving well and well spaced out.	6,490	28deg (police)	Approx 4m (from scale drawing)	No accident details recorded at present.	357,618	Requires a central reserve safety barrier with containment level equal to, or greater than H2 to contain and redirect the vehicle

Table E (i): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Police Ref. No.	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at HGV crossing point	Speed of crossover vehicle (tachometer accuracy is +/- 5km/h)	Traffic flow	Vehicle weight (kg)	Angle of impact with safety fence in central reserve	Distance between carriageways	Accident Details and/or Witness remarks about the performance of the safety fence/barrier.	Impact Energy at 90deg to barrier (J)	Would a very high containment barrier have prevented the crossover from happening?
S041117	14-Nov-97	M1	1	4	3	Two parallel rows of S/S TCB with lighting columns in between	55mph (witness) 88.5km/h	Heavier on initial carriageway, though quite quiet on both.	24,000	30deg (from scale diagram)	Approx 4.5m (from scale drawing)	No accident details recorded at present.	1,813,018	No - Impact energy greater than that tested for in a TB81 test
0HP0027	1997	M27	4	1	1	Hampshire Police: Report unavailable								
9701409	1997	M6	2	1	2	Warwickshire Police: Report unavailable								
8B40422	25-Mar-98	A557	1	2	1	Single sided TCB facing towards the opposite carriageway on a raised platform (sloping upwards)	55mph (witness) 88.5km/h	Moderate on opposite, but very heavy and slow moving on original due to roadworks.	38,000	20deg (scale drawing)	2m (from scale drawing)	No accident details recorded at present.	1,343,191	No - Impact energy greater than that tested for in a TB81 test
8M17273	7-Aug-98	M6	1	4	3	Double Sided TCB	55mph (witness) 88.5km/h	Quite quiet on both carriageways	38,000	15deg (scale drawing)	2.6m (from scale drawing)	No accident details recorded at present.	769,178	Requires a central reserve safety barrier with containment level equal to H4b to contain and redirect the vehicle
0212855	21-Oct-98	A57	2	2	1	Grass	36mph (tachograph) 60km/h	Quiet in both directions, though there were many witnesses to the accident.	7,500	45 deg (scale drawing)	Approx 4.5m (from sketch)	No accident details recorded at present.	520,833	Requires a central reserve safety barrier with containment level equal to, or greater than H3 to contain and redirect the vehicle
0022404	1998	M5	3	1	1	Avon and Somerset Police: Report Unavailable								
00T1224	1998	M1	4	1	2	Hertfordshire: No information returned								
KK00070	1998	M1	3	1	2	South Yorkshire Police: No information returned								
MU01598	1998	M62	8	1	4	West Yorkshire Police: No information returned								
MU40698	1998	A1	1	1	1	West Yorkshire Police: No information returned								

Table E (j): All Fatal Accidents involving HGVs Crossing the Central Reserve, 1985 to 1998.

Appendix F: All Fatal HGV Crossover Accidents (with an HGV being contained and redirected) 1985-1998, Motorways, A(M) and A Roads

In order to assess which of the accidents reported through the STATS19 reporting procedure involved an HGV striking the central reserve barrier and being contained and redirected, a search was made on the records database. A search can be made on the database for any combination of criteria relating to the information collected on the STATS 19 report forms. For purpose of this report the following search criteria was used for the years 1985 to 1998:

' Accidents on motorways and/or M(A) roads and/or A roads in Great Britain involving at least one HGV striking the central reserve and remaining on the same carriageway.'

KEY:	
(green)	Impact energy less than 950,000kJ (that tested for in a TB81 test)
(blue)	Impact energy slightly above 950,000kJ (that tested for in a TB81 test)
(red)	Impact energy vastly greatly than 950,000kJ (that tested for in a TB81 test)
(grey)	Not enough information available in police report
*	Impact energy within the limits for a normal (N2) containment barrier

Note: The definition of an HGV changed in 1994:

'Prior to 1994 these were defined as those vehicles over 1.524 tonnes unladen weight and included vehicles with six or more tyres, some four wheel vehicles with extra large bodies and larger rear tyres and tractor units travelling without their usual trailer.
From 1 January 1994 the weight definition changed to those vehicles over 3.5 tonnes maximum permissible gross vehicle weight (gvw).' [2]

Table F: All Fatal Accidents involving HGVs Crossing the Central Reserve and remaining on the original carriageway, 1985 to 1998.

Police Ref. No	Date	M / A(M) or A road	Number of Vehicles involved	Number of Fatalities	Number of HGVs involved	Description of barrier at impact	Speed of impact Km/hr	Traffic flow	Vehicle weight (kg)	Angle of impact with barrier	Crash Details	Barrier performance	Impact Energy
ED00298	3-Aug-88	M25	1	1	1	D/S TCB	80 (witness)	Very quiet on both carriageways	6300	20deg (photo)	An HGV's wheel hub worked loose, causing the driver to lose control of the vehicle.	4 posts and longitudinals were damaged. The vehicle was contained, but rolled over on the original carriageway.	181,965
41T1217	27-Sep-88	M1	6	1	3	D/S OBB	32 (estimation)	Moderate - not heavy	7490	30deg (sketch)	A lorry pulled out in front of an HGV causing it to swerve on a wet road. This induced a skid. The HGV then headed towards verge, and then back across the carriageway, hitting the safety fence in the central reserve. A car then hit the HGV, killing the driver of the car. It was raining heavily at the time of the accident.	3 rails and 4 posts were damaged in the accident	73,975 *
7Y43211	18-Nov-88	A52	3	1	2	D/S OBB	97 (tachometer)	'Normal'	4000	15deg (photo)	An HGV was following closely behind another vehicle, when it attempted to overtake. The HGV and hit safety fence in the central reserve, ran along it, and was redirected into the back of a car. A second HGV then jack-knifed in trying to avoid the accident.	Barrier undamaged (photos)	97,266 *
9M10139	9-Mar-89	M6	47	4	24	D/S OBB	32 (estimation)	Heavy on initial	17000	70 deg (sketch - vehicle rear hit barrier on its side)	An HGV hit an object on the carriageway, rupturing its fuel tank and spilling diesel onto the road. Other vehicles then slid on the diesel.		593,042
9M10207	28-Mar-89	M56	3	1	1	3 rail, D/S OBB	105 (tachometer)	Fairly busy on both carriageways	5587 (car transporter - empty)	45deg (photos)	An HGV driver was distracted and subsequently over reacted to something. This caused him to swerve and hit the safety fence in the central reserve. The HGV was successfully redirected onto the carriageway, however the HGV driver was thrown from his HGV cab.	24m of barrier damaged	1,188,206
2046490	16-Feb-90	A45	2	1	1	Vehicle hit d/s TCB, but this is in parallel with single sided OBB	79 (tachometer) momentum calculation as it hit another vehicle	Light on both carriageways	38000	45deg (sketch and photos)	An HGV driver drove into the back of a digger joining the carriageway from a slip road.	Barrier stopped HGV, although speed may have been less	4,574,801
0EB3645	18-Dec-90	M65	2	1	1	Not seen in photos	96 (witness)	Not mentioned in police report	16000	Not recorded	An HGV collided with an overtaking car, and then hit the safety fence in the central reserve. It then struck the nearside safety fence.		Not enough information available in records
0TL0196	31-Dec-90	M27	4	2	2	D/S TCB	113 (witness)	Moderately heavy on both carriageways	ERF	20deg (witness states 'acute angle')	A car crossed over central reserve, and was struck by an HGV. The HGV then struck the safety fence in the central reserve. Heavy rain at the time of the accident had caused traffic to slow		Not enough information available in records
1365891	16-Dec-91	A1	1	1	1	Two rows of SS TCB with ditch in between	93 (tachometer)	Moderate	11700	35deg	An HGV suddenly veered to the offside (possibly due to it's driver having a heart attack) and hit the safety fence in the central reserve. The HGV went through the first line of safety fence and towards a 2m ditch in the central reserve, and then out again. The HGV then overturned, throwing its driver from the cab and into central reserve.	HGV went through barrier and into ditch in central reserve, stopping the crossover	1,284,395
A300214	1-Feb-92	A1	7	1	4	Steel (two runs around a bridge support) - OBB?	19 (tachometer)	Building up an heavy on initial due to poor weather conditions, accident also occurring on other carriageway.	38000	45deg	The accident occurred in dense fog, causing traffic to slow, and build in density. An HGV was forced towards the safety fence in the central reserve by an impacting HGV.	27m damaged	264,622
Q065993	23-Mar-93	A62	1	1	1	Grass with trees in central reserve	64 (tachometer)	Reasonably quiet on initial	38000	30deg (photos)	A pedestrian ran out in front of an HGV, causing it to swerve and run across the grassed central reserve. Here it struck a lamp standard, went across both lanes of the original carriageway, and came to rest on the verge.	None in place - but driver's ability to control vehicle stopped vehicle fatalities	1,501,232
X049193	21-Apr-93	M56	3	1	2	Metal, Armco	Not in Police Report	Moderate to heavy on initial	17332	20deg (estimated due to accident circumstances)	A breakdown vehicle was preparing to tow away a broken down car on the hard shoulder. An HGV on the carriageway then goes out of control, hits the car and pushes it towards the breakdown vehicle. The HGV then swerves and impacts the safety fence on the central reserve.		Not enough information available in records

Appendix G: Accident Data from STATS19 Search - HGV contained and redirected

Table G1: Number of Accidents in which an HGV is contained and redirected, on M, A(M) and A Roads, 1985 to 1998

Number of Accidents			Total Number
Fatal	Serious	Slight	
2	**4**	**14**	**20**
1	**4**	**15**	**20**
2	**12**	**18**	**32**
6	**3**	**20**	**29**
4	**5**	**27**	**36**
3	**11**	**24**	**38**
1	**10**	**25**	**36**
1	**6**	**24**	**31**
4	**12**	**26**	**42**
1	**2**	**25**	**28**
0	**7**	**23**	**30**
4	**5**	**22**	**31**
2	**14**	**23**	**39**
1	**6**	**20**	**27**
32	**101**	**306**	**439**

Table G2: Casualties in Accidents in which an HGV is contained and redirected

Year	M, A(M)			A			Total Number of Casualties			Total Number
	Fatal	Serious	Slight	Fatal	Serious	Slight	Fatal	Serious	Slight	
1985	2	6	15	0	1	5	**2**	**7**	**20**	**29**
1986	0	7	17	1	1	7	**1**	**8**	**24**	**33**
1987	2	8	15	0	8	9	**2**	**16**	**24**	**42**
1988	4	4	20	2	4	9	**6**	**8**	**29**	**43**
1989	7	8	30	0	3	13	**7**	**11**	**43**	**61**
1990	3	12	26	1	8	15	**4**	**20**	**41**	**65**
1991	0	7	36	1	4	15	**1**	**11**	**51**	**63**
1992	0	8	29	1	2	10	**1**	**10**	**39**	**50**
1993	3	14	29	1	4	19	**4**	**18**	**48**	**70**
1994	0	1	19	1	1	12	**1**	**2**	**31**	**34**
1995	0	3	15	0	4	13	**0**	**7**	**28**	**35**
1996	1	4	13	3	3	29	**4**	**7**	**42**	**53**
1997	2	13	32	1	6	13	**3**	**19**	**45**	**67**
1998	1	4	25	0	2	12	**1**	**6**	**37**	**44**
Total	25	99	321	12	51	181	**37**	**150**	**502**	**689**

Appendix H: Whole Life Costing Worksheets

Table H1: Installation and Materials Costs

Table H1(a): WIRE ROPE SAFETY FENCE (to HCD WR/01 [12])

Price List (From Spon's Price Book 2002[1]):

Part type	Financial Cost	Installation Time (in hours)	Unit
Wire Rope	£4.33	0.03	per metre
Standard intermediate anchor	£207.03	2.00	each
Short deflection post for setting in concrete	£22.59	0.06	each
Concrete foundation for deflection post	£19.87	0.23	each
Standard end anchorage	£207.03	2.00	each
Long driven line posts	£23.54	0.05	each

Cost to install a wire rope system:	
1000	m long
4	ropes at
2.4	m post spacing

Part type	Number of Units	Financial Cost	Installation Time (in hours)
Wire Rope	4000	£17,320.00	120.00
Standard intermediate anchor	1	£207.03	2
Short deflection post for setting in concrete	6	£135.54	0.36
Concrete foundation for deflection post	6	£119.22	1.38
Standard end anchorage	4	£828.12	8.00
Long driven line posts	411	£9,674.94	20.55
TOTAL		**£28,284.85**	**152.29**
Total (per m)		**£28.28**	**0.15**

Table H1(b): DOUBLE SIDED TENSIONED CORRUGATED BEAM (TCB) (to HCD GA/11, GA/12 and GA/13 [12])

Price List (From Spon's Price Book 2002[1]):

Part type	Financial Cost	Installation Time (in hours)	Unit
Double sided corrugated beam (price accounts for both sides)	£37.06	0.12	m
Long driven posts for double sided tensioned corrugated beam	£35.88	0.06	each
Terminal section for double sided tensioned corrugated beam	£467.05	1.7	each

Cost to install a TCB system:	
1000	m long at
3.2	m posts spacing

Part type	Number of units	Financial Cost	Installation Time (in hours)
Double sided corrugated beam (price accounts for both sides)	1000	£37,060.00	120
Long driven posts for double sided corrugated beam	313	£11,230.44	18.78
Terminal section for tensioned double sided corrugated beam	2	£934.10	3.4
TOTAL		**£49,224.54**	**142.18**
Total (per m)		**£49.22**	**0.14**

Table H1: Installation and Materials Costs Contd.

Table H1(c): DOUBLE SIDED OPEN BOX BEAM (OBB) (to HCD GA/20, GA/21, GA/22, GA/23 [12]) *Price List (from Spon's Price Book 2002[1]):*			
Part type	Financial Cost	Installation Time (in hours)	Unit
Double sided open box beam (price accounts for both sides)	£68.82	0.22	m
Long driven posts for double sided open box beam	£35.88	0.06	each
Terminal section for double sided open box beam	£721.79	1.78	each
Cost to install an OBB system:			
1000	m long at		
2.4	m post spacing		
Part type	Number of units	Financial Cost	Installation Time (in hours)
Double sided open box beam (price accounts for both sides)	1000	£68,820.00	220
Long driven posts for double sided open box beam	417	£14,961.96	25.02
Terminal section for double sided open box beam	2	£1,443.58	3.56
TOTAL		**£85,225.54**	**248.58**
Total (per m)		**£85.23**	**0.25**

Table H1(d): PERMANENT VERTICAL CONCRETE BARRIER (VCB) - Precast (to HCD SB/20 to SB/24 [12]) *Price List (from Spon's Price Book 2002 [1]):*			
Parts			
Part Type	Financial Cost	Installation Time (in hours)	Unit
Permanent Vertical Concrete Barrier (Type V01 & V02) 3m units [12]	£132.75	0.16	each
Termination Unit (Type V03 & V04) 3m long [12]	£436.12	0.5	each
Additional Costs			
1. Drainage Type A1 (Proprietary precast system with flexible carriageway) [to HCD B17 [12]:Central Reserve - Linear Drainage System with VCB] as required by HA39/98 'Edge of Pavement Details' [16]:			
Narrow Filter Drain Type 9 (average 1m deep) [to HCD F18 & F20] [12]	£23.33	0.17	m
Precast concrete drainage channels (305 x 305 mm - heavy duty)	£39.71	0.1	m
2. Resurfacing of central reserve only:			
Sub base in carriageway, hardshoulder and hardstrip (Granular material DTp specified type 1), 100mm deep	£21.29	0.04	m^3
Road base (Flexible pavement) Dense Bitumen Macadam to DTp Clause 903 (100mm deep) [17]	£4.87	0.02	m^2
Surfacing (wearing course) Dense Bitumen Macadam to DTp Clause 912 (30mm deep) [17]	£3.99	0.01	m^2
Thin carriage overlay (>25 to <40mm) in accordance with HD 36/99 ('Surfacing Materials for New and Maintenance Construction' [18]) and HD 37/99 ('Bituminous Surfacing Materials and Techniques' [19]).			
Cost to install a Precast VCB system on a 4m wide central reserve:			
1000	m long with		
3	m long units		
Part type	Number of units	Financial Cost	Installation Time (in hours)
Permanent Vertical Concrete Barrier (Type V01 & V02) 3m units	331	£43,940.25	52.96
Termination Unit (Type V03 & V04) 3m long	2	£872.24	1
Narrow Filter Drain Type 9 (average 1m deep)	1000	£23,330.00	170
Precast concrete drainage channels (305 x 305 mm - heavy duty)	1000	£39,710.00	100
Sub base in carriageway, hardshoulder and hardstrip (Granular material DTp specified type 1), 100mm deep	400	£8,516.00	16
Road base (Flexible pavement) Dense Bitumen Macadam to DTp Clause 903 (100mm deep)	4000	£19,480.00	80
Surfacing (wearing course) Dense Bitumen Macadam to DTp Clause 912 (30mm deep)	4000	£15,960.00	40
TOTAL		**£151,808.49**	**459.96**
Total (per m)		**£151.81**	**0.46**

Table H1: Installation and Materials Costs Contd.

Table H1(e): PERMANENT VERTICAL CONCRETE BARRIER (VCB) - Slipformed (No HCDs currently available) *Price List (from Spon's Price Book 2002 [12], VCB costs from Extrudakerb):*			
Parts			
Part Type	Financial Cost	Installation Time (in hours) *	Unit
Permanent Vertical Concrete Barrier (800mm high)	£45.00	0.002	m
* 7m/min: Estimated from information on Gomaco web site [20]			
Additional Costs			
1. Drainage Type A1 (Proprietary precast system with flexible carriageway) [to HCD B17 [12]:Central Reserve - Linear Drainage System with VCB] as required by HA39/98 'Edge of Pavement Details' [16]:			
Narrow Filter Drain Type 9 (average 1m deep) [to HCD F18 & F20] [12]	£23.33	0.17	m
Precast concrete drainage channels (305 x 305 mm - heavy duty)	£39.71	0.1	m
2. Resurfacing of central reserve only:			
Sub base in carriageway, hardshoulder and hardstrip (Granular material DTp specified type 1), 100mm deep	£21.29	0.04	m^3
Road base (Flexible pavement) Dense Bitumen Macadam to DTp Clause 903 (100mm deep) [17]	£4.87	0.02	m^2
Surfacing (wearing course) Dense Bitumen Macadam to DTp Clause 912 (30mm deep) [17]	£3.99	0.01	m^2
Thin carriage overlay (>25 to <40mm) in accordance with HD 36/99 ('Surfacing Materials for New and Maintenance Construction' [18]) and HD 37/99 ('Bituminous Surfacing Materials and Techniques' [19]).			
Cost to install a Slipformed VCB system on a 4m wide central reserve:			
1000	m long		
Part type	Number of units	Financial Cost	Installation Time (in hours)
Permanent Vertical Concrete Barrier (Type V01 & V02) 3m units	1000	£45,000.00	2
Narrow Filter Drain Type 9 (average 1m deep)	1000	£23,330.00	170
Precast concrete drainage channels (305 x 305 mm - heavy duty)	1000	£39,710.00	100
Sub base in carriageway, hardshoulder and hardstrip (Granular material DTp specified type 1), 100mm deep	400	£8,516.00	16
Road base (Flexible pavement) Dense Bitumen Macadam to DTp Clause 903 (100mm deep)	4000	£19,480.00	80
Surfacing (wearing course) Dense Bitumen Macadam to DTp Clause 912 (30mm deep)	4000	£15,960.00	40
TOTAL		**£151,996.00**	**408**
Total (per m)		**£152.00**	**0.41**

Table H1: Installation and Materials Costs Contd.

Table H1(f): PERMANENT HIGHER VERTICAL CONCRETE BARRIER (HVCB) - Slipformed (No HCDs currently available) *Price List (from Spon's Price Book 2002 [1], VCB costs from Extrudakerb):*			
Parts			
Part Type	Financial Cost	Installation Time (in hours)*	Unit
Permanent Vertical Concrete Barrier (1200mm high)	£250.00	0.003	m
* 5m/min: Estimated from information on Gomaco web site [20]			
Additional Costs			
1. Drainage Type A1 (Proprietary precast system with flexible carriageway) [to HCD B17 [12]:Central Reserve - Linear Drainage System with VCB] as required by HA39/98 'Edge of Pavement Details' [16]:			
Narrow Filter Drain Type 9 (average 1m deep) [to HCD F18 & F20] [12]	£23.33	0.17	m
Precast concrete drainage channels (305 x 305 mm - heavy duty)	£39.71	0.1	m
2. Resurfacing of central reserve only:			
Sub base in carriageway, hardshoulder and hardstrip (Granular material DTp specified type 1), 100mm deep	£21.29	0.04	m^3
Road base (Flexible pavement) Dense Bitumen Macadam to DTp Clause 903 (100mm deep) [17]	£4.87	0.02	m^2
Surfacing (wearing course) Dense Bitumen Macadam to DTp Clause 912 (30mm deep) [17]	£3.99	0.01	m^2
Thin carriage overlay (>25 to <40mm) in accordance with HD 36/99 ('Surfacing Materials for New and Maintenance Construction' [18]) and HD 37/99 ('Bituminous Surfacing Materials and Techniques' [19]).			

Cost to install a slipformed HVCB system on a 4m wide central reserve:	
1000	m long

Part type	Number of units	Financial Cost	Installation Time (in hours)
Permanent Vertical Concrete Barrier (1200mm high)	1000	£250,000.00	3
Narrow Filter Drain Type 9 (average 1m deep)	1000	£23,330.00	170
Precast concrete drainage channels (305 x 305 mm - heavy duty)	1000	£39,710.00	100
Sub base in carriageway, hardshoulder and hardstrip (Granular material DTp specified type 1), 100mm deep	400	£8,516.00	16
Road base (Flexible pavement) Dense Bitumen Macadam to DTp Clause 903 (100mm deep)	4000	£19,480.00	80
Surfacing (wearing course) Dense Bitumen Macadam to DTp Clause 912 (30mm deep)	4000	£15,960.00	40
TOTAL		**£356,996.00**	**409**
Total (per m)		**£357.00**	**0.41**

Table H2: Traffic Management Costs During Installation

* Traffic Management costs are calculated in the same way for costs during repairs and removal.
* Prices do not include for any traffic management during the erection of the temporary barriers.
* Prices quoted are for an easily accessible site.
* It is assumed that once installed, the barriers will not need to be moved until removal.
* It is also assumed that the offside lane of both carriageways will be closed to traffic.

Price List (from Class One Traffic Management - no prices available from Spon's Price Book)

Temporary Vertical Concrete Barrier (TVCB):		
Installation:	£40.00	per m
Hire	£0.45	per m per 24 hour period
Removal	£40.00	per m
VarioGuard:		
Installation:	£56.66	per m
Hire	£0.40	per m per 24 hour period
Removal	£56.66	per m
Cones and signage:		
Hire	£64.00	per 24 hour period

Table H2(a): WIRE ROPE SAFETY FENCE

Cost to provide traffic management during the installation of a wire rope system:

1000 m long, taking

152.29 hours for installation

Note, in addition to the work zone, 39m of temporary safety barrier is required before the work zone and 21m extend at least beyond the end of the work zone: IAN24 - 'Use of Temporary Barriers at Road Works' [13]

TVCB:	Number of Units	Financial Cost
Installation	2120	£84,800.00
Hire	13452	£6,053.53
Removal	2120	£84,800.00
Cones and signage	12.69	£812.21
TOTAL		**£176,465.74**

Table H2(b): TENSIONED CORRUGATED BEAM (TCB)

Cost to provide traffic management during the installation of a TCB system:

1000 m long taking

142.18 hours for installation

Note, in addition to the work zone, 39m of temporary safety barrier is required before the work zone and 21m extend at least beyond the end of the work zone: IAN24 - 'Use of Temporary Barriers at Road Works' [13]

TVCB:	Number of Units	Financial Cost
Installation	2120	£84,800.00
Hire	12720	£5,724.00
Removal	2120	£84,800.00
Cones and signage	12.00	£768.00
TOTAL		**£176,092.00**

Table H2: Traffic Management Costs During Installation Contd.

Table H2(c): OPEN BOX BEAM (OBB)

Cost to provide traffic management during the installation of a OBB system:

1000 m long taking

248.58 hours for installation

Note, in addition to the work zone, 39m of temporary safety barrier is required before the work zone and 21m extend at least beyond the end of the work zone: IAN24 - 'Use of Temporary Barriers at Road Works' [13]

TVCB:	Number of Units	Financial Cost
Installation	2120	£84,800.00
Hire	23320	£10,494.00
Removal	2120	£84,800.00
Cones and signage	22.00	£1,408.00
TOTAL		**£181,502.00**

Table H2(d): VERTICAL CONCRETE BARRIER (VCB) - Precast

Cost to provide traffic management during the installation of a Precast VCB system:

1000 m long taking

459.96 hours for installation

Note, in addition to the work zone, 39m of temporary safety barrier is required before the work zone and 21m extend at least beyond the end of the work zone: IAN24 - 'Use of Temporary Barriers at Road Works' [13]

TVCB:	Number of Units	Financial Cost
Installation	2120	£84,800.00
Hire	42400	£19,080.00
Removal	2120	£84,800.00
Cones and signage	40.00	£2,560.00
TOTAL		**£191,240.00**

Table H2(e): VERTICAL CONCRETE BARRIER (VCB) - Slipformed

Cost to provide traffic management during the installation of a Slipformed VCB system:

1000 m long taking

408 hours for installation

Note, in addition to the work zone, 39m of temporary safety barrier is required before the work zone and 21m extend at least beyond the end of the work zone: IAN24 - 'Use of Temporary Barriers at Road Works' [13]

TVCB:	Number of Units	Financial Cost
Installation	2120	£84,800.00
Hire	38160	£17,172.00
Removal	2120	£84,800.00
Cones and signage	36.00	£2,304.00
TOTAL		**£189,076.00**

Table H2(f): HIGHER VERTICAL CONCRETE BARRIER (HVCB) - Slipformed

Cost to provide traffic management during the installation of a Slipformed HVCB system:

1000 m long taking

409 hours for installation

Note, in addition to the work zone, 39m of temporary safety barrier is required before the work zone and 21m extend at least beyond the end of the work zone: IAN24 - 'Use of Temporary Barriers at Road Works' [13]

TVCB:	Number of Units	Financial Cost
Installation	2120	£84,800.00
Hire	38160	£17,172.00
Removal	2120	£84,800.00
Cones and signage	36.00	£2,304.00
TOTAL		**£189,076.00**

Table H3: Safety Barrier Removal Costs

Price List (from Spon's Price Book 2002 [1], unless otherwise stated):				
Take down and remove off site - safety fencing on steel posts	£12.46	and	0.17	hours per metre
For concrete systems, the removal costs are estimated as no actual costs could be obtained. Estimations are based on the time required to install the barriers, as this will give some indication of the time required to manoeuvre the barriers.				

Table H3(a): WIRE ROPE SAFETY FENCE		
Cost to remove a wire rope safety fence		
1000 m long		
	Economic Cost	Time required (hrs)
Take down and remove off site	£12,460.00	170
Associated Traffic Management	£177,264.17	

Table H3(b): TENSIONED CORRUGATED BEAM (TCB)		
Cost to remove a TCB system		
1000 m long		
	Economic Cost	Time required (hrs)
Take down and remove off site	£12,460.00	170
Associated Traffic Management	£177,264.17	

Table H3 (c): OPEN BOX BEAM (OBB)		
Cost to remove an OBB system		
1000 m long		
	Economic Cost	Time required (hrs)
Take down and remove off site	£12,460.00	170
Associated Traffic Management	£177,264.17	

Table H3(d): PRECAST VERTICAL CONCRETE BARRIER				
Cost to remove a precast VCB system				
1000 m long				
Take down and remove off site	£75.00	and	0.1	hours per metre
	Economic Cost		Time required (hrs)	
Take down and remove off site	£75,000.00		100	
Associated Traffic Management	£174,108.33			

Table H3(e): SLIPFORMED VERTICAL CONCRETE BARRIER				
Cost to remove a slipformed VCB system				
1000 m long				
Take down and remove off site	£80.00	and	0.15	hours per metre
	Economic Cost		Time required (hrs)	
Take down and remove off site	£80,000.00		150	
Associated Traffic Management	£176,362.50			

Table H3(f): SLIPFORMED HIGHER VERTICAL CONCRETE BARRIER				
Cost to remove a slipformed HVCB system				
1000 m long				
Take down and remove off site	£85.00	and	0.17	hours per metre
	Economic Cost		Time required (hrs)	
Take down and remove off site	£85,000.00		170	
Associated Traffic Management	£177,264.17			

Table H4: HGV Accident Repair Costs

	Parts requiring repair		Cost of Parts Replacement	Length of Repair (m)	Length of traffic management (m)	Duration of Repair (hrs)	Cost of Traffic Management	Accident/Test Number
	Posts	Longitudinal Length (m)						
WRSF								
2.4	17	0	£400.18	40.8	201.6	0.85	£16,135.75	Not Reported
1.2	15	0	£353.10	18	156	0.75	£12,486.19	Not Reported
DSTCB								
3.2	10	52	£1,322.36	26	172	3.72	£14,067.77	Average from Accidents
1.6	13	40	£1,207.64	20	160	3.18	£12,826.50	Average from Accidents
DSOBB								
2.4	10	35	£1,563.15	24	168	4.45	£13,477.75	Not Reported
1.2	9	25	£1,183.17	12.5	145	3.29	£11,626.49	Not Reported
Precast VCB								
3m panels	*N/A*	12	£531.00	12	144	0.64	£11,525.14	D145 & D147 (TB61s)
Slipformed VCB								
N/A	*N/A*	15	£675.00	15	150	0.03	£12,000.24	Not Reported
Slipformed HVCB								
N/A	*N/A*	15	£3,750.00	15	150	0.045	£12,000.37	T0002 (TB42) **1* & V0009 (TB71) **2*

*1 - In this test the HVCB was 100mm smaller in height, though this would have minimal effect on the length of barrier damaged
*2 - In this test the HVCB was an additional 200mm in height, though this would have minimal effect on the length of barrier damaged

Table H5: Whole Life Cost Assessment of Safety Fences and Barriers

Within the WLC assessments for 1000m of safety fence or barrier, the following factors apply:

- Detailed inspection frequency is as required by BS7669:3:1994 [11]
- Additional costs may be incurred due to the presence of services below carriageway level.
- Additional costs may also be incurred if installation is on a curved section of road.
- Exterior Paintworking schedule in accordance with BD 36/92 [15]
- Average Accident Cost (See Table 6, Column 9): £115,366 for normal containment safety fences and barriers, £54,457 for higher vertical concrete barrier (HVCB)
- Base Flow of Traffic: 60,000
- Percentage of HGVs using the road: 8% (based on DTLR traffic data for major roads)

PLEASE NOTE THAT ONLY THE WORKSHEETS FOR TEN ACCIDENTS OCCURING DURING THE WHOLE LIFE OF THE SAFETY FENCE OR BARRIER ARE SHOWN FOR CLARITY.
CALCULATIONS FOR FIVE ACCIDENTS WERE CALCULATED IN EXACTLY THE SAME WAY.

Table H5(a): Wire Rope Safety Fence

	Material Costs		Traffic Management	QUADRO
	Financial (£s)	Time (hrs)	Financial (£s)	
Installation	£28,284.85	152.29	£176,465.74	See Table
Repair (HGV)	£400.18	0.85	£16,135.75	See Table
Removal	£12,460.00	170.00	£177,264.17	See Table

Base Length:	1000 m		
Base Flow:	60,000	**%age HGV:**	8

Intervention Year	Description of Works	Additional Cost of Works	No. Of damaging Impacts (HGVs)	Cost of Repair	Accident Costs	Traffic Flow	Quadro Cost (per hour)	Removal Cost or Exterior Painting	**Undiscounted Cost**		**Present Value**
0	Installation Costs	£ 227,659.65	1	£ 16,663.79	£115,366	60000	£150		£ 359,689.44		£ 359,689.44
1			0	£ -	£0	60960	£153		£ -		£ -
2			0	£ -	£0	61935	£155		£ -		£ -
3			0	£ -	£0	62926	£158		£ -		£ -
4			0	£ -	£0	63933	£160		£ -		£ -
5	Inspection and retensioning	£ 750.00	1	£ 16,674.35	£115,366	64956	£163		£ 132,790.35		£ 90,374.88
6			0	£ -	£0	65995	£165		£ -		£ -
7			0	£ -	£0	67051	£168		£ -		£ -
8			0	£ -	£0	68124	£171		£ -		£ -
9			0	£ -	£0	69214	£174		£ -		£ -
10	Inspection and retensioning	£ 750.00	1	£ 16,685.79	£115,366	70322	£176		£ 132,801.79		£ 61,512.92
11			0	£ -	£0	71447	£179		£ -		£ -
12	Inspection and retensioning	£ 750.00	0	£ -	£0	72590	£182		£ 750.00		£ 297.84
13			0	£ -	£0	73751	£185		£ -		£ -
14	Inspection and retensioning	£ 750.00	0	£ -	£0	74931	£188		£ 750.00		£ 255.35
15	Exterior paintworking		1	£ 16,698.17	£115,366	76130	£191	£453.56	£ 132,517.72		£ 41,775.11
16	Inspection and retensioning	£ 750.00	0	£ -	£0	77348	£194		£ 750.00		£ 218.92
17			0	£ -	£0	78586	£197		£ -		£ -
18	Inspection and retensioning	£ 750.00	0	£ -	£0	79843	£200		£ 750.00		£ 187.69
19			0	£ -	£0	81121	£203		£ -		£ -
20	Inspection and retensioning	£ 750.00	1	£ 16,711.57	£115,366	82419	£207		£ 132,827.57		£ 28,497.92
21			0	£ -	£0	83737	£210		£ -		£ -
22	Inspection and retensioning	£ 750.00	0	£ -	£0	85077	£213		£ 750.00		£ 137.96
23			0	£ -	£0	86438	£217		£ -		£ -
24	Inspection and retensioning	£ 750.00	0	£ -	£0	87821	£220	£227,155.37	£ 227,905.37		£ 35,940.53
25	Installation Costs	£ 238,818.85	1	£ 16,726.08	£115,366	89227	£224		£ 370,910.93		£ 54,159.64
26			0	£ -	£0	90654	£227		£ -		£ -
27			0	£ -	£0	92105	£231		£ -		£ -
28			0	£ -	£0	93578	£235		£ -		£ -
29			0	£ -	£0	95076	£238		£ -		£ -
30	Inspection and retensioning	£ 750.00	1	£ 16,741.78	£115,366	96597	£242		£ 132,857.78		£ 13,203.05
31			0	£ -	£0	98142	£246		£ -		£ -
32			0	£ -	£0	99713	£250		£ -		£ -
33			0	£ -	£0	101308	£254		£ -		£ -
34			0	£ -	£0	102929	£258		£ -		£ -
35	Inspection and retensioning	£ 750.00	1	£ 16,758.79	£115,366	104576	£262		£ 132,874.79		£ 8,986.93
36			0	£ -	£0	106249	£266		£ -		£ -
37	Inspection and retensioning	£ 750.00	0	£ -	£0	107949	£271		£ 750.00		£ 43.49
38			0	£ -	£0	109676	£275		£ -		£ -
39	Inspection and retensioning	£ 750.00	0	£ -	£0	111431	£279		£ 750.00		£ 37.29
40	Exterior Paintworking		1	£ 16,777.20	£115,366	113214	£284	£453.56	£ 132,596.75		£ 6,103.55
41	Inspection and retensioning	£ 750.00	0	£ -	£0	115025	£288		£ 750.00		£ 31.97
42			0	£ -	£0	116866	£293		£ -		£ -
43	Inspection and retensioning	£ 750.00	0	£ -	£0	118736	£298		£ 750.00		£ 27.41
44			0	£ -	£0	120635	£302		£ -		£ -
45	Inspection and retensioning	£ 750.00	1	£ 16,797.13	£115,366	122565	£307		£ 132,913.13		£ 4,163.89
46			0	£ -	£0	124527	£312		£ -		£ -
47	Inspection and retensioning	£ 750.00	0	£ -	£0	126519	£317		£ 750.00		£ 20.14
48			0	£ -	£0	128543	£322		£ -		£ -
49	Inspection and retensioning	£ 750.00	0	£ -	£0	130600	£327		£ 750.00		£ 17.27
50			0	£ -	£0	132690	£333	£246,279.06	£ 246,279.06		£ 5,250.97
									£ 2,275,214.70		**£710,934.13**

Table H5(b): Double Sided Tensioned Corrugated Beam Safety Fence (TCB)

	Material Costs		Traffic Management	QUADRO
	Financial (£s)	Time (hrs)	Financial (£s)	
Installation	£49,224.54	142.18	£176,092.00	See Table
Repair (HGV)	£1,322.36	3.72	£14,067.77	See Table
Removal	£12,460.00	170.00	£177,264.17	See Table

Base Length:	1000 m		
Base Flow:	60,000	**%age HGV:**	8

Intervention Year	Description of Works	Additional Cost of Works	No. Of damaging Impacts (HGVs)	Cost of Repair	Accident Costs	Traffic Flow	Quadro Cost (per hour)	Removal Cost or Exterior Painting	**Undiscounted Cost**		**Present Value**
0	New Construction	£ 246,704.75	1	£ 15,949.73	£115,366	60000	£150		£ 378,020.48		£ 378,020.48
1			0	£ -	£0	60960	£153		£ -		£ -
2			0	£ -	£0	61935	£155		£ -		£ -
3			0	£ -	£0	62926	£158		£ -		£ -
4			0	£ -	£0	63933	£160		£ -		£ -
5	Inspection & retensioning	£ 750.00	1	£ 15,995.95	£115,366	64956	£163		£ 132,111.95		£ 89,913.18
6			0	£ -	£0	65995	£165		£ -		£ -
7			0	£ -	£0	67051	£168		£ -		£ -
8			0	£ -	£0	68124	£171		£ -		£ -
9			0	£ -	£0	69214	£174		£ -		£ -
10	Inspection & retensioning	£ 750.00	1	£ 16,046.00	£115,366	70322	£176		£ 132,162.00		£ 61,216.58
11			0	£ -	£0	71447	£179		£ -		£ -
12	Inspection & retensioning	£ 750.00	0	£ -	£0	72590	£182		£ 750.00		£ 297.84
13			0	£ -	£0	73751	£185		£ -		£ -
14	Inspection & retensioning	£ 750.00	0	£ -	£0	74931	£188		£ 750.00		£ 255.35
15	Exterior Paintworking		1	£ 16,100.17	£115,366	76130	£191	£3,384.85	£ 134,851.02		£ 42,510.67
16	Inspection & retensioning	£ 750.00	0	£ -	£0	77348	£194		£ 750.00		£ 218.92
17			0	£ -	£0	78586	£197		£ -		£ -
18	Inspection & retensioning	£ 750.00	0	£ -	£0	79843	£200		£ 750.00		£ 187.69
19			0	£ -	£0	81121	£203		£ -		£ -
20	Inspection & retensioning	£ 750.00	1	£ 16,158.82	£115,366	82419	£207		£ 132,274.82		£ 28,379.33
21			0	£ -	£0	83737	£210		£ -		£ -
22	Inspection & retensioning	£ 750.00	0	£ -	£0	85077	£213		£ 750.00		£ 137.96
23			0	£ -	£0	86438	£217		£ -		£ -
24	Inspection & retensioning	£ 750.00	0	£ -	£0	87821	£220	£227,155.37	£ 227,905.37		£ 35,940.53
25	New Construction	£ 257,123.13	1	£ 16,222.32	£115,366	89227	£224		£ 388,711.45		£ 56,758.83
26			0	£ -	£0	90654	£227		£ -		£ -
27			0	£ -	£0	92105	£231		£ -		£ -
28			0	£ -	£0	93578	£235		£ -		£ -
29			0	£ -	£0	95076	£238		£ -		£ -
30	Inspection & retensioning	£ 750.00	1	£ 16,291.06	£115,366	96597	£242		£ 132,407.06		£ 13,158.26
31			0	£ -	£0	98142	£246		£ -		£ -
32			0	£ -	£0	99713	£250		£ -		£ -
33			0	£ -	£0	101308	£254		£ -		£ -
34			0	£ -	£0	102929	£258		£ -		£ -
35	Inspection & retensioning	£ 750.00	1	£ 16,365.47	£115,366	104576	£262		£ 132,481.47		£ 8,960.32
36			0	£ -	£0	106249	£266		£ -		£ -
37	Inspection & retensioning	£ 750.00	0	£ -	£0	107949	£271		£ 750.00		£ 43.49
38			0	£ -	£0	109676	£275		£ -		£ -
39	Inspection & retensioning	£ 750.00	0	£ -	£0	111431	£279		£ 750.00		£ 37.29
40	Exterior Paintworking		1	£ 16,446.04	£115,366	113214	£284	£3,384.85	£ 135,196.89		£ 6,223.24
41	Inspection & retensioning	£ 750.00	0	£ -	£0	115025	£288		£ 750.00		£ 31.97
42			0	£ -	£0	116866	£293		£ -		£ -
43	Inspection & retensioning	£ 750.00	0	£ -	£0	118736	£298		£ 750.00		£ 27.41
44			0	£ -	£0	120635	£302		£ -		£ -
45	Inspection & retensioning	£ 750.00	1	£ 16,533.26	£115,366	122565	£307		£ 132,649.26		£ 4,155.62
46			0	£ -	£0	124527	£312		£ -		£ -
47	Inspection & retensioning	£ 750.00	0	£ -	£0	126519	£317		£ 750.00		£ 20.14
48			0	£ -	£0	128543	£322		£ -		£ -
49	Inspection & retensioning	£ 750.00	0	£ -	£0	130600	£327		£ 750.00		£ 17.27
50			0	£ -	£0	132690	£333	£246,279.06	£ 246,279.06		£ 5,250.97
									£ 2,313,300.82		**£731,763.29**

Table H5(c): Double Sided Open Box Beam Safety Fence (OBB)

	Material Costs		Traffic Management	QUADRO
	Financial (£s)	Time (hrs)	Financial (£s)	
Installation	£85,225.54	248.58	£181,502.00	See Table
Repair (HGV)	£1,563.15	4.45	£13,477.75	See Table
Removal	£12,460.00	170.00	£177,264.17	See Table

Base Length:	1000 m		
Base Flow:	60,000	**% HGV:**	8

Intervention Year	Description of Works	Additional Cost of Works	No. Of damaging Impacts (HGVs)	Cost of Repair	Accident Costs	Traffic Flow	Quadro Cost (per hour)	Removal Cost or Exterior Painting	**Undiscounted Cost**		**Present Value**
0	New Construction	£ 304,121.55	1	£ 15,710.32	£115,366	60000	£150		£ 435,197.87		£ 435,197.87
1			0	£ -	£0	60960	£153		£ -		£ -
2			0	£ -	£0	61935	£155		£ -		£ -
3			0	£ -	£0	62926	£158		£ -		£ -
4			0	£ -	£0	63933	£160		£ -		£ -
5	Inspection	£ 500.00	1	£ 15,765.61	£115,366	64956	£163		£ 131,631.61		£ 89,586.26
6			0	£ -	£0	65995	£165		£ -		£ -
7			0	£ -	£0	67051	£168		£ -		£ -
8			0	£ -	£0	68124	£171		£ -		£ -
9			0	£ -	£0	69214	£174		£ -		£ -
10	Inspection	£ 500.00	1	£ 15,825.47	£115,366	70322	£176		£ 131,691.47		£ 60,998.63
11			0	£ -	£0	71447	£179		£ -		£ -
12	Inspection	£ 500.00	0	£ -	£0	72590	£182		£ 500.00		£ 198.56
13			0	£ -	£0	73751	£185		£ -		£ -
14	Inspection	£ 500.00	0	£ -	£0	74931	£188		£ 500.00		£ 170.23
15	Exterior Paintworking		1	£ 15,890.28	£115,366	76130	£191	£2,408.00	£ 133,664.28		£ 42,136.56
16	Inspection	£ 500.00	0	£ -	£0	77348	£194		£ 500.00		£ 145.95
17			0	£ -	£0	78586	£197		£ -		£ -
18	Inspection	£ 500.00	0	£ -	£0	79843	£200		£ 500.00		£ 125.12
19			0	£ -	£0	81121	£203		£ -		£ -
20	Inspection	£ 500.00	1	£ 15,960.44	£115,366	82419	£207		£ 131,826.44		£ 28,283.13
21			0	£ -	£0	83737	£210		£ -		£ -
22	Inspection		0	£ -	£0	85077	£213		£ -		£ -
23			0	£ -	£0	86438	£217		£ -		£ -
24	Inspection		0	£ -	£0	87821	£220	£227,155.37	£ 227,155.37		£ 35,822.25
25	New Construction	£ 322,336.50	1	£ 16,036.39	£115,366	89227	£224		£ 453,738.90		£ 66,254.00
26			0	£ -	£0	90654	£227		£ -		£ -
27			0	£ -	£0	92105	£231		£ -		£ -
28			0	£ -	£0	93578	£235		£ -		£ -
29			0	£ -	£0	95076	£238		£ -		£ -
30	Inspection	£ 500.00	1	£ 16,118.62	£115,366	96597	£242		£ 131,984.62		£ 13,116.28
31			0	£ -	£0	98142	£246		£ -		£ -
32			0	£ -	£0	99713	£250		£ -		£ -
33			0	£ -	£0	101308	£254		£ -		£ -
34			0	£ -	£0	102929	£258		£ -		£ -
35	Inspection	£ 500.00	1	£ 16,207.65	£115,366	104576	£262		£ 132,073.65		£ 8,932.74
36			0	£ -	£0	106249	£266		£ -		£ -
37	Inspection	£ 500.00	0	£ -	£0	107949	£271		£ 500.00		£ 28.99
38			0	£ -	£0	109676	£275		£ -		£ -
39	Inspection	£ 500.00	0	£ -	£0	111431	£279		£ 500.00		£ 24.86
40	Exterior Paintworking		1	£ 16,304.02	£115,366	113214	£284	£2,408.00	£ 134,078.02		£ 6,171.74
41	Inspection	£ 500.00	0	£ -	£0	115025	£288		£ 500.00		£ 21.31
42			0	£ -	£0	116866	£293		£ -		£ -
43	Inspection	£ 500.00	0	£ -	£0	118736	£298		£ 500.00		£ 18.27
44			0	£ -	£0	120635	£302		£ -		£ -
45	Inspection	£ 500.00	1	£ 16,408.35	£115,366	122565	£307		£ 132,274.35		£ 4,143.88
46			0	£ -	£0	124527	£312		£ -		£ -
47	Inspection	£ 500.00	0	£ -	£0	126519	£317		£ 500.00		£ 13.43
48			0	£ -	£0	128543	£322		£ -		£ -
49	Inspection	£ 500.00	0	£ -	£0	130600	£327		£ 500.00		£ 11.51
50			0	£ -	£0	132690	£333	£246,279.06	£ 246,279.06		£ 5,250.97
									£ 2,426,595.65		**£796,652.54**

Table H5(d): Precast Vertical Concrete Barrier (VCB)

	Material Costs		Traffic Management	QUADRO
	Financial (£s)	Time (hrs)	Financial (£s)	
Installation	£151,808.49	459.96	£191,240.00	See Table
Repair (HGV)	£2,500.00	0.64	£11,525.14	See Table
Removal	£75,000.00	100.00	£174,108.33	See Table

Base Length:	1000 m		
Base Flow:	60,000	**% HGV:**	8

Intervention Year	Description of Works	Additional Cost of Works	No. Of damaging Impacts (HGVs)	Cost of Repair	Accident Costs	Traffic Flow	Quadro Cost (per hour)	Removal Cost or Exterior Painting	**Undiscounted Cost**		**Present Value**
0	New Construction	£ 412,042.49	1	£ 14,121.14	£115,366	60000	£150		£ 541,529.63		£ 541,529.63
1			0	£ -	£0	60960	£153		£ -		£ -
2			0	£ -	£0	61935	£155		£ -		£ -
3			0	£ -	£0	62926	£158		£ -		£ -
4			0	£ -	£0	63933	£160		£ -		£ -
5	Inspection	£ 500.00	0	£ -	£115,366	64956	£163		£ 115,866.00		£ 78,856.45
6			0	£ -	£0	65995	£165		£ -		£ -
7			0	£ -	£0	67051	£168		£ -		£ -
8			0	£ -	£0	68124	£171		£ -		£ -
9			1	£ 14,136.20	£0	69214	£174		£ 14,136.20		£ 7,071.62
10	Inspection	£ 500.00	0	£ -	£115,366	70322	£176		£ 115,866.00		£ 53,668.38
11			0	£ -	£0	71447	£179		£ -		£ -
12			0	£ -	£0	72590	£182		£ -		£ -
13			0	£ -	£0	73751	£185		£ -		£ -
14			0	£ -	£0	74931	£188		£ -		£ -
15	Inspection	£ 500.00	0	£ -	£115,366	76130	£191		£ 115,866.00		£ 36,525.80
16			0	£ -	£0	77348	£194		£ -		£ -
17	Inspection	£ 500.00	0	£ -	£0	78586	£197		£ 500.00		£ 135.13
18			1	£ 14,153.26	£0	79843	£200		£ 14,153.26		£ 3,541.84
19	Inspection	£ 500.00	0	£ -	£0	81121	£203		£ 500.00		£ 115.86
20	Exterior Paintworking		0	£ -	£115,366	82419	£207	£3,160.40	£ 118,526.40		£ 25,429.63
21	Inspection	£ 500.00	0	£ -	£0	83737	£210		£ 500.00		£ 99.33
22			0	£ -	£0	85077	£213		£ -		£ -
23	Inspection	£ 500.00	0	£ -	£0	86438	£217		£ 500.00		£ 85.16
24			0	£ -	£0	87821	£220		£ -		£ -
25	Inspection	£ 500.00	0	£ -	£115,366	89227	£224		£ 115,866.00		£ 16,918.51
26			0	£ -	£0	90654	£227		£ -		£ -
27	Inspection	£ 500.00	1	£ 14,172.93	£0	92105	£231		£ 14,672.93		£ 1,836.86
28			0	£ -	£0	93578	£235		£ -		£ -
29	Inspection	£ 500.00	0	£ -	£0	95076	£238		£ 500.00		£ 53.66
30			0	£ -	£115,366	96597	£242		£ 115,366.00		£ 11,464.77
31	Inspection	£ 500.00	0	£ -	£0	98142	£246		£ 500.00		£ 46.01
32			0	£ -	£0	99713	£250		£ -		£ -
33	Inspection	£ 500.00	0	£ -	£0	101308	£254		£ 500.00		£ 39.44
34			0	£ -	£0	102929	£258		£ -		£ -
35	Inspection	£ 500.00	0	£ -	£115,366	104576	£262		£ 115,866.00		£ 7,836.54
36			1	£ 14,195.63	£750	106249	£266		£ 14,945.63		£ 935.96
37	Inspection	£ 500.00	0	£ -	£0	107949	£271		£ 500.00		£ 28.99
38			0	£ -	£0	109676	£275		£ -		£ -
39	Inspection	£ 500.00	0	£ -	£0	111431	£279		£ 500.00		£ 24.86
40	Exterior Paintworking		0	£ -	£115,366	113214	£284	£3,160.40	£ 118,526.40		£ 5,455.88
41	Inspection	£ 500.00	0	£ -	£0	115025	£288		£ 500.00		£ 21.31
42			0	£ -	£0	116866	£293		£ -		£ -
43	Inspection	£ 500.00	0	£ -	£0	118736	£298		£ 500.00		£ 18.27
44			0	£ -	£0	120635	£302		£ -		£ -
45	Inspection	£ 500.00	1	£ 14,221.81	£115,366	122565	£307		£ 130,087.81		£ 4,075.38
46			0	£ -	£0	124527	£312		£ -		£ -
47	Inspection	£ 500.00	0	£ -	£0	126519	£317		£ 500.00		£ 13.43
48			0	£ -	£0	128543	£322		£ -		£ -
49	Inspection	£ 500.00	0	£ -	£0	130600	£327		£ 500.00		£ 11.51
50			0	£ -	£0	132690	£333	£282,375.92	£ 282,375.92		£ 6,020.60
									£ 1,950,150.18		**£801,860.81**

Table H5(e): Slipformed Vertical Concrete Barrier (VCB)

	Material Costs		Traffic Management	QUADRO
	Financial (£s)	Time (hrs)	Financial (£s)	
Installation	£151,996.00	408.00	£189,076.00	See Table
Repair (HGV)	£675.00	0.03	£12,000.24	See Table
Removal	£80,000.00	150.00	£176,362.50	See Table

Base Length:	1000 m		
Base Flow:	60,000	**% HGV:**	8

Intervention Year	Description of Works	Additional Cost of Works	No. Of damaging Impacts (HGVs)	Cost of Repair	Accident Costs	Traffic Flow	Quadro Cost (per hour)	Removal Cost or Exterior Painting	**Undiscounted Cost**		**Present Value**
0	New Construction	£ 402,272.00	1	£ 12,679.74	£115,366	60000	£150		£ 530,317.74		£ 530,317.74
1			0	£ -	£0	60960	£153		£ -		£ -
2			0	£ -	£0	61935	£155		£ -		£ -
3			0	£ -	£0	62926	£158		£ -		£ -
4			0	£ -	£0	63933	£160		£ -		£ -
5	Inspection	£ 500.00	0	£ -	£115,366	64956	£163		£ 115,866.00		£ 78,856.45
6			0	£ -	£0	65995	£165		£ -		£ -
7			0	£ -	£0	67051	£168		£ -		£ -
8			0	£ -	£0	68124	£171		£ -		£ -
9			1	£ 12,680.45	£0	69214	£174		£ 12,680.45		£ 6,343.38
10	Inspection	£ 500.00	0	£ -	£115,366	70322	£176		£ 115,866.00		£ 53,668.38
11			0	£ -	£0	71447	£179		£ -		£ -
12			0	£ -	£0	72590	£182		£ -		£ -
13			0	£ -	£0	73751	£185		£ -		£ -
14			0	£ -	£0	74931	£188		£ -		£ -
15	Inspection	£ 500.00	0	£ -	£115,366	76130	£191		£ 115,866.00		£ 36,525.80
16			0	£ -	£0	77348	£194		£ -		£ -
17	Inspection	£ 500.00	0	£ -	£0	78586	£197		£ 500.00		£ 135.13
18			1	£ 12,681.25	£0	79843	£200		£ 12,681.25		£ 3,173.47
19	Inspection	£ 500.00	0	£ -	£0	81121	£203		£ 500.00		£ 115.86
20	Exterior Paintworking		0	£ -	£115,366	82419	£207	£3,182.68	£ 118,548.68		£ 25,434.41
21	Inspection	£ 500.00	0	£ -	£0	83737	£210		£ 500.00		£ 99.33
22			0	£ -	£0	85077	£213		£ -		£ -
23	Inspection	£ 500.00	0	£ -	£0	86438	£217		£ 500.00		£ 85.16
24			0	£ -	£0	87821	£220		£ -		£ -
25	Inspection	£ 500.00	0	£ -	£115,366	89227	£224		£ 115,866.00		£ 16,918.51
26			0	£ -	£0	90654	£227		£ -		£ -
27	Inspection	£ 500.00	1	£ 12,682.17	£0	92105	£231		£ 13,182.17		£ 1,650.23
28			0	£ -	£0	93578	£235		£ -		£ -
29	Inspection	£ 500.00	0	£ -	£0	95076	£238		£ 500.00		£ 53.66
30			0	£ -	£115,366	96597	£242		£ 115,366.00		£ 11,464.77
31	Inspection	£ 500.00	0	£ -	£0	98142	£246		£ 500.00		£ 46.01
32			0	£ -	£0	99713	£250		£ -		£ -
33	Inspection	£ 500.00	0	£ -	£0	101308	£254		£ 500.00		£ 39.44
34			0	£ -	£0	102929	£258		£ -		£ -
35	Inspection	£ 500.00	0	£ -	£115,366	104576	£262		£ 115,866.00		£ 7,836.54
36			1	£ 12,683.24	£0	106249	£266		£ 12,683.24		£ 794.28
37	Inspection	£ 500.00	0	£ -	£0	107949	£271		£ 500.00		£ 28.99
38			0	£ -	£0	109676	£275		£ -		£ -
39	Inspection	£ 500.00	0	£ -	£0	111431	£279		£ 500.00		£ 24.86
40	Exterior Paintworking		0	£ -	£115,366	113214	£284	£3,182.68	£ 118,548.68		£ 5,456.91
41	Inspection	£ 500.00	0	£ -	£0	115025	£288		£ 500.00		£ 21.31
42			0	£ -	£0	116866	£293		£ -		£ -
43	Inspection	£ 500.00	0	£ -	£0	118736	£298		£ 500.00		£ 18.27
44			0	£ -	£0	120635	£302		£ -		£ -
45	Inspection	£ 500.00	1	£ 12,684.46	£115,366	122565	£307		£ 128,550.46		£ 4,027.21
46			0	£ -	£0	124527	£312		£ -		£ -
47	Inspection	£ 500.00	0	£ -	£0	126519	£317		£ 500.00		£ 13.43
48			0	£ -	£0	128543	£322		£ -		£ -
49	Inspection	£ 500.00	0	£ -	£0	130600	£327		£ 500.00		£ 11.51
50			0	£ -	£0	132690	£333	£306,263.88	£ 306,263.88		£ 6,529.92
									£ 1,954,652.56		**£789,690.97**

Table H5(f): Slipformed Higher Vertical Concrete Barrier (HVCB)

	Material Costs		Traffic Management	QUADRO
	Financial (£s)	Time (hrs)	Financial (£s)	
Installation	£356,996.00	409.00	£189,076.00	See Table
Repair (HGV)	£3,750.00	0.05	£12,000.37	See Table
Removal	£85,000.00	170.00	£177,264.17	See Table

Base Length:	1000 m		
Base Flow:	60,000	**% HGV:**	8

Intervention Year	Description of Works	Additional Cost of Works	No. Of damaging Impacts (HGVs)	Cost of Repair	Accident Costs	Traffic Flow	Quadro Cost (per hour)	Removal Cost or Exterior Painting	**Undiscounted Cost**		**Present Value**
0	New Construction	£ 607,422.00	1	£ 15,757.12	£54,457	60000	£150		£ 677,636.12		£ 677,636.12
1			0	£ -	£0	60960	£153		£ -		£ -
2			0	£ -	£0	61935	£155		£ -		£ -
3			0	£ -	£0	62926	£158		£ -		£ -
4			0	£ -	£0	63933	£160		£ -		£ -
5	Inspection	£ 500.00	0	£ -	£54,457	64956	£163		£ 54,957.00		£ 37,402.81
6			0	£ -	£0	65995	£165		£ -		£ -
7			0	£ -	£0	67051	£168		£ -		£ -
8			0	£ -	£0	68124	£171		£ -		£ -
9			0	£ -	£0	69214	£174		£ -		£ -
10	Inspection	£ 500.00	0	£ -	£54,457	70322	£176		£ 54,957.00		£ 25,455.72
11			0	£ -	£0	71447	£179		£ -		£ -
12			0	£ -	£0	72590	£182		£ -		£ -
13			0	£ -	£0	73751	£185		£ -		£ -
14			0	£ -	£0	74931	£188		£ -		£ -
15	Inspection	£ 500.00	0	£ -	£54,457	76130	£191		£ 54,957.00		£ 17,324.74
16			0	£ -	£0	77348	£194		£ -		£ -
17	Inspection	£ 500.00	0	£ -	£0	78586	£197		£ 500.00		£ 135.13
18			0	£ -	£0	79843	£200		£ -		£ -
19	Inspection	£ 500.00	0	£ -	£0	81121	£203		£ 500.00		£ 115.86
20	Exterior Paintworking		0	£ -	£54,457	82419	£207	£4,289.11	£ 58,746.11		£ 12,603.87
21	Inspection	£ 500.00	0	£ -	£0	83737	£210		£ 500.00		£ 99.33
22			0	£ -	£0	85077	£213		£ -		£ -
23	Inspection	£ 500.00	0	£ -	£0	86438	£217		£ 500.00		£ 85.16
24			0	£ -	£0	87821	£220		£ -		£ -
25	Inspection	£ 500.00	0	£ -	£54,457	89227	£224		£ 54,957.00		£ 8,024.71
26			0	£ -	£0	90654	£227		£ -		£ -
27	Inspection	£ 500.00	0	£ -	£0	92105	£231		£ 500.00		£ 62.59
28			0	£ -	£0	93578	£235		£ -		£ -
29	Inspection	£ 500.00	0	£ -	£0	95076	£238		£ 500.00		£ 53.66
30			0	£ -	£54,457	96597	£242		£ 54,457.00		£ 5,411.79
31	Inspection	£ 500.00	0	£ -	£0	98142	£246		£ 500.00		£ 46.01
32			0	£ -	£0	99713	£250		£ -		£ -
33	Inspection	£ 500.00	0	£ -	£0	101308	£254		£ 500.00		£ 39.44
34			0	£ -	£0	102929	£258		£ -		£ -
35	Inspection	£ 500.00	0	£ -	£54,457	104576	£262		£ 54,957.00		£ 3,716.99
36			0	£ -	£0	106249	£266		£ -		£ -
37	Inspection	£ 500.00	0	£ -	£0	107949	£271		£ 500.00		£ 28.99
38			0	£ -	£0	109676	£275		£ -		£ -
39	Inspection	£ 500.00	0	£ -	£0	111431	£279		£ 500.00		£ 24.86
40	Exterior Paintworking		0	£ -	£54,457	113214	£284	£4,289.11	£ 58,746.11		£ 2,704.14
41	Inspection	£ 500.00	0	£ -	£0	115025	£288		£ 500.00		£ 21.31
42			0	£ -	£0	116866	£293		£ -		£ -
43	Inspection	£ 500.00	0	£ -	£0	118736	£298		£ 500.00		£ 18.27
44			0	£ -	£0	120635	£302		£ -		£ -
45	Inspection	£ 500.00	0	£ -	£54,457	122565	£307		£ 54,957.00		£ 1,721.69
46			0	£ -	£0	124527	£312		£ -		£ -
47	Inspection	£ 500.00	0	£ -	£0	126519	£317		£ 500.00		£ 13.43
48			0	£ -	£0	128543	£322		£ -		£ -
49	Inspection	£ 500.00	0	£ -	£0	130600	£327		£ 500.00		£ 11.51
50			1	£ 15,765.34	£0	132690	£333	£318,819.06	£ 334,584.40		£ 7,133.75
									£ 1,520,911.73		**£799,891.88**

Appendix I: Summary of Whole Life Costs Derived from Prices Supplied by UK Safety Barrier Manufacturers

	Post Spacing	£/m	£/m	£/m	£/m	£/m	Average Cost £/m	*Standard Deviation*
WRSF (4 ropes)	2.4m	£67.77	£24.00	£28.28	£32.31	-	**£38.09**	*20.08*
WRSF (4 ropes)	1.2m	£78.76	-	£38.08	£47.88	-	**£54.91**	*21.23*
Double Sided TCB	3.2m	£33.58	£39.00	£49.22	£35.29	£43.86	**£40.19**	*6.41*
Double Sided TCB	1.6m	£40.24	£54.00	£60.42	£47.58	£51.99	**£50.85**	*7.52*
Double Sided OBB	2.4m	£60.55	£68.00	£85.23	£63.25	£69.28	**£69.26**	*9.60*
Double Sided OBB	1.2m	£71.34	-	£100.15	£83.27	£88.98	**£85.94**	*11.99*
Precast VCB	3.0m	-	-	£44.81	£52.36	-	**£48.59**	*5.34*
Slipformed HVCB	N/A	£250.00	£260.00	-	-	-	**£255.00**	*7.07*
Slipformed VCB	N/A	£45.00	£127.00	-	£53.98	-	**£75.33**	*44.98*

Costs *include* installation, materials & labour, but *exclude* preliminaries, delivery and VAT

- British Steel (Corus) - based on 1000m run
- Brifen Limited - based on 1000m run
- 1998 TRL Report (unknown title - thorough search has been made) - based on 1000m run
- SPONS (2001) Directory - based on 1000m run
- Extrudakerb - based on 5000m run
- SIAC Construction - based on 83m run
- SIAC Construction - based on 500m run
- Highways Agency - emails from Mark Scroby dated 14/02/00 & 29/11/00
- Lionweld Kennedy - based on 1000m run, dated 01/09/99

Table I: Whole Life Costs from UK Manufacturer's Quoted Prices

Appendix J: Traffic Flow Statistics

					Goods vehicles [1]								
					Rigid by number of axles			Articulated by number of axles					
	Cars and taxis	Motorcycles etc.	Larger buses and coaches	Light Vans	2	3	4 or more	3 + 4	5	6 or more	All Goods vehicles	All motor vehicles	Pedal cycles
Motorways	70.8	0.4	0.6	10.0	3.6	0.4	0.4	0.8	4.1	2.3	12.3	94.1	-
Non built-up major roads:													
Trunk	51.5	0.5	0.4	7.4	2.3	0.4	0.3	0.7	1.9	1.3	6.8	66.7	-
Principal	50.9	0.6	0.5	6.9	1.6	0.3	0.3	0.6	0.5	0.3	3.3	62.1	0.1
All non built-up major roads	102.4	1.1	1.0	14.3	3.9	0.6	0.6	1.2	2.4	1.6	10.1	128.8	0.2
Built-up major roads:													
Trunk	7.6	0.1	0.1	1.0	0.3	0.0	0.0	0.0	0.1	0.1	0.6	9.4	-
Principal	55.3	0.8	1.1	6.8	1.3	0.2	0.2	0.4	0.2	0.2	2.2	66.3	0.5
All built-up major roads	62.9	0.9	1.2	7.9	1.6	0.2	0.2	0.4	0.4	0.2	2.8	75.5	0.5
All minor roads	142.6	2.0	2.1	18.3	2.7	0.3	0.3	0.6	0.3	0.2	4.1	169.1	3.4
All roads	378.7	4.4	4.8	50.5	11.7	1.6	1.5	3.1	7.2	4.4	29.3	467.7	4.0

1 Over 3.5 tonnes gross vehicle weight.

Table J: Traffic Flow Statistics, 2000 (in Billion Vehicle Kilometres) [21]

Appendix K: Accident Frequency and Barrier Containment - Examination of WLC

	Number of accidents during a whole life of fifty years			
	0	5	10	15
WRSF (2.4m post spacing)	£306,330	£336,744	£357,458	£382,627
D/S TCB (3.2m post spacing)	£329,106	£358,331	£378,287	£402,506
D/S OBB (2.4m post spacing)	£394,668	£423,485	£443,176	£467,067
Precast VCB (3m units)	£420,494	£446,265	£463,815	£485,140
Slipformed VCB	£411,239	£434,357	£450,092	£469,216
Slipformed HVCB	£616,945	£645,674	£665,228	£688,994

Table K: Costs incurred for 1000m of safety fence or barrier if repairs are required during its whole life (Accident costs are not included)

Abstract

TRL Limited has been commissioned to examine crossover accidents involving heavy goods vehicles (HGVs) on major roads in Great Britain. This report consists of two inter related parts - a review of HGV accidents in which the vehicle restraint in the central reserve has been impacted, and an examination of the whole life costs associated with metal safety fences and concrete safety barriers.

The main focus of this report is the review of HGV incidents. Two distinct types of HGV accident were investigated - those in which an HGV crossed the central reserve, and those in which an HGV struck a safety fence or barrier in the central reserve and was contained and redirected. These accident statistics show that the HGV crossover accident is rare, but can result in a high number of casualties.

A review of HGV crossover accidents, and the relative costs of steel and concrete barriers (Phase II report)

TRL Limited has been commissioned to examine crossover accidents involving heavy goods vehicles (HGVs) on major roads in Great Britain. This report consists of two inter related parts - a review of HGV accidents in which the vehicle restraint in the central reserve has been impacted, and an examination of the whole life costs associated with metal safety fences and concrete safety barriers.

The main focus of this report is the review of HGV incidents. Two distinct types of HGV accident were investigated - those in which an HGV crossed the central reserve, and those in which an HGV struck a safety fence or barrier in the central reserve and was contained and redirected. These accident statistics show that the HGV crossover accident is rare, but can result in a high number of casualties.

Other recent titles from this subject area

PPR276 Whole Life Cost-Benefit Analysis for Median Safety Barriers, Task 1 – Relocation of Services
G L Williams

PPR277 Whole Life Cost-Benefit Analysis for Median Safety Barriers, Task 2 – Structural Consequences G L Williams

PPR278 Traffic Management and Concrete Safety Barriers
A Chequer, J Mitchell and S Thompson

PPR279 Whole Life Cost-Benefit Analysis for Median Safety Barriers
G L Williams

TRL
Crowthorne House, Nine Mile Ride
Wokingham, Berkshire RG40 3GA
United Kingdom
T: +44 (0) 1344 773131
F: +44 (0) 1344 770356
E: enquiries@trl.co.uk
W: www.trl.co.uk

Published by

IHS
Willoughby Road, Bracknell
Berkshire RG12 8FB
United Kingdom
T: +44 (0) 1344 328038
F: +44 (0) 1344 328005
E: trl@ihs.com
W: www.uk.ihs.com

Price code: 3X

ISSN 0968-4093

ISBN 978-1-84608-727-1

9 781846 087271

PPR280