Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

# CD 355
# Application of whole-life costs for design and maintenance of highway structures

(formerly BD 36/92 & BA 28/92)

Revision 0

**Summary**
This document covers the application of the whole life costs analysis at the design development stage of new structures and the design of maintenance interventions.

**Application by Overseeing Organisations**
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

**Feedback and Enquiries**
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

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# Release notes

| Version | Date | Details of amendments |
|---|---|---|
| 0 | Jul 2019 | CD 355 replaces BD 36/92 including BA 28/92. The full document has been rewritten to make it compliant with the new Highways England drafting rules. |

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# Foreword

## Publishing information

This document is published by Highways England .

This document supersedes BD 36/92 and BA 28/92, which are withdrawn.

## Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

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# Introduction

## Background

The purpose of this document is to present a common procedure for estimating the whole-life cost of alternative designs or maintenance interventions and to give a client an estimate of the cost of ownership of an asset throughout its life. It should also provide a basis for the management of the asset and planning of maintenance activities.

There has been much development in the understanding of deterioration modelling and the use of life-cycle plans for good asset management since the publication of BD 36/92 and BA 28/92. For the case of new or substantially altered structures this document outlines the methods to be adopted to evaluate the life-cycle costs of different options and the production of a life-cycle management plan for the adopted solution. In the case of maintenance interventions a similar approach is outlined, with the aim of considering the effect of different intervention options on the whole life cost of the asset. It is intended that these can be reviewed and updated throughout the life of the asset, following a principal inspection.

## Assumptions made in the preparation of the document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

References in this document to BS EN documents include their UK National Annexes and all associated Published Documents (PDs).

## Mutual Recognition

Where there is a requirement in this document for compliance with any part of a British Standard or other technical specification, that requirement may be met by compliance with the mutual recognition clause in GG 101 [Ref 2.N].

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# Abbreviations

**Abbreviations**

| Abbreviation | Meaning |
|---|---|
| AADT | 24-h annual average daily traffic |
| AMP | Asset management plan |
| DMRB | Design Manual for Roads and Bridges |
| DR | Discount rate |
| GI | General inspection |
| LGV | Light goods vehicle |
| OGV | Other goods vehicle |
| PI | Principal inspection |
| PV | Present value |
| TM | Structure's share of traffic management costs for a scheme |
| UD | Structure's share of traffic user delay costs for a scheme |

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# Terms and definitions

**Terms and definitions**

| Term | Definition |
|---|---|
| Base price year | The year at which prices are based. |
| Design organisation | The organisation contracted or obliged to undertake the design of structures or intervention schemes for structures. |
| Discount rate | The rate at which future costs are discounted to the present value year. This is set by Government and can be found in the Green Book produced by HM Treasury at the time of writing. |
| Evaluation period | The period over which the life-cycle cost appraisal is to be undertaken. Normally 60 years, or the design life of the structure if less than 60 years. |
| Life-cycle management plan | A plan for managing a structure comprising a schedule of all construction, routine maintenance, inspection, and maintenance activities together with associated costs on a structure over the evaluation period. After a number of alternatives have been appraised in accordance with this document the life-cycle management plan is the outcome for the preferred option. |
| Maintenance action | Individual maintenance activity undertaken on a structure or an element in a particular year, which may include works, inspection or monitoring. |
| Maintenance organisation | The organisation contracted or obliged to undertake the maintenance of structures. This organisation may also undertake the design of intervention schemes for structures. |
| Prelims | Structure's share of preliminaries costs for the construction contract |
| Present value | The value of costs incurred at future dates when discounted to the present value year. |
| Present value year | The year to which all costs are discounted in a whole-life costing exercise. |
| Routine maintenance | Work of a minor nature which needs to be carried out at regular intervals to ensure the safety of the structures stock, to keep the stock in good order, and to minimise deterioration. Routine maintenance includes, for example, cleaning of drains and channels, removal of debris from bearing shelves, greasing bearings, tightening nuts & bolts, removal of graffiti or vegetation from an element or structure. |
| Scheme or project | A plan or arrangement which includes the construction of a new structural asset or undertaking of activities to repair or replace elements of existing structures. |

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**Terms and definitions** (continued)

| Term | Definition |
|---|---|
| Structural asset (structure) | Bridge, buried structure, subway, underpass, culvert and any other structure supporting the highway with clear span or internal diameter greater than 0.9m, (2.0m or greater in Scotland except that corrugated steel buried structures are included if they have spans of 0.9m or more).<br>Earth retaining structure where the effective retained height is greater than 1.5m (1.0m or greater in Northern Ireland).<br>Reinforced/strengthened soil/fill structure, with hard facings, where the effective retained height is greater than 1.5m (1.0m or greater in Northern Ireland).<br>Portal and cantilever sign and/or signal gantry. |
| Whole life cost | Summation of all the costs incurred in the construction and maintenance of an asset over the evaluation period. |
| Work duration | The time in days that a particular inspection, maintenance, or construction activity could take. |

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# 1. Scope

## Aspects covered

1.1 This document shall be used in the design development stage for new permanent structural assets and the options appraisal of maintenance schemes or alterations to existing permanent structural assets.

1.1.1 This document should be used at other times during a structure's life-cycle to assist in whole life asset management.

## Implementation

1.2 This document shall be implemented forthwith on all schemes involving the whole-life costs analysis at the design development stage of new structures, and the design of maintenance interventions on the Overseeing Organisation's motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 2.N].

1.3 The lowest whole life cost option shall become the recommended solution in an options report, except where other factors override that selection.

*NOTE* *Whole life costs are just one indicator of the most sustainable solution, a full evaluation of which could encompass technical, environmental, social and economic objectives. Each of the alternative options appraised according to this standard is likely to differ in ranking when ordered by either their initial cost or their whole life cost. Whilst the lowest whole life cost option is generally to be preferred, aspects other than costs can be a significant factor in selection.*

1.4 In those cases where an alternative to the lowest whole life cost option is to be recommended, a report summarising the implications of each of the alternatives and justification for the proposed recommendation shall be provided to the Overseeing Organisation.

1.4.1 An options report should include the valuation and summary of the alternative options, and justification for the proposed recommendation.

## Use of GG 101

1.5 The requirements contained in GG 101 [Ref 2.N] shall be followed in respect of activities covered by this document.



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# 2. Evaluation procedure

2.1 The preferred scheme solution shall be determined by an appraisal following the procedure outlined below in clauses 2.2 to 2.9.

2.2 The valid design or maintenance options shall be established.

2.2.1 Design options should allow for the replacement of elements such as bearings and joints in a cost-effective way that will not cause undue disruption to traffic.

2.2.2 Design options should anticipate large scale refurbishment of bridge structures at some stage in their life and avoid designs which would prevent this being undertaken efficiently, e.g. it is recommended that details which would prevent contraflow traffic arrangements being implemented are avoided.

2.3 Anticipated activities for the construction, inspection, routine maintenance, and interventions on the structure for each of the options identified shall be determined for the full evaluation period.

2.4 The timing and duration of each of the anticipated activities for each of the options shall be estimated.

2.5 Construction costs of each alternative and the costs associated with each of the activities identified above shall be estimated using current cost data.

2.6 The cost of traffic management and user delays for all of the activities identified above shall be estimated.

*NOTE* *For information on user delay costs see section 3.*

2.6.1 Where the structure works are part of a larger scheme, some costs should be shared between different assets, and only structure's proportion should be included in the evaluation.

2.7 The present value of all costs for each option shall be calculated, using discount factors for expenditure in the future; this will in effect generate a life-cycle management plan for each option.

*NOTE* *Evaluating activities and calculating their costs can, in effect, generate a life-cycle management plan for each option.*

2.8 The initial and life-cycle costs of the options shall be compared to determine the optimal cost-effective solution.

2.9 The life-cycle management plan for the recommended solution shall be stored with the design documentation for the structure.

2.9.1 The findings of the initial and life cycle cost comparison should be presented to the Overseeing Organisation for a decision on the recommendation.

2.9.2 Where the options provide other, non-costed, benefits such as providing different levels of service then these should be clearly stated, especially if the most cost-effective solution is not being recommended.

2.9.3 The life-cycle plan should be reviewed and amended with relevant as-built information and, upon completion on site, stored with the structures records in accordance with the Overseeing Organisation's data and record requirements.

*NOTE* *For an example of the evaluation procedure see Appendix B.*

2.10 The activities that shall be included in the appraisal are those that can be expected to be required during the life of the asset, including:

1) construction of the asset or the maintenance intervention;
2) routine maintenance of the asset;
3) undertaking general, principal and special Inspections;
4) repair and renewal of protective systems to elements;
5) repair and renewal of concrete elements especially in areas of severe exposure;
6) replacement of bearings, joints and other limited life elements;



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7) other future maintenance interventions.

*NOTE* *Future maintenance interventions vary depending upon the form of the structure, materials used, construction details, exposure, and the quality of construction.*

2.11 The costs associated with each of the activities shall be estimated using cost data current at the time of the appraisal.

*NOTE* *The accuracy of the cost information can vary, with the costs of the construction or intervention options that are being considered being well defined. The estimates of future interventions can be based on experience and any available research or guidance on deterioration prediction.*

2.12 Where scheme options have different land or access requirements then the costs of this shall be included.

2.13 The 'present value' of all of the costs identified shall be calculated using discount factors applied to future costs.

2.14 The discounting of future costs shall be undertaken in accordance with the requirements of HM Treasury 'Green Book' [Ref 1.N].

2.14.1 The discount rates that should be applied are currently contained in the 'Green Book' published by HM Treasury [Ref 1.N]; this also contains details of how the rates are applied.

2.15 The life-cycle management plans shall be split into annual intervals and activities with associated costs inserted in the year in which they are anticipated to be required.

2.16 The 'present value' of each of the costs shall be calculated using the discount factor for the year in which they are anticipated to occur.

2.17 The present values shall be totalled for each of the scheme options.

2.17.1 Where the most effective solution in terms of whole life costs is not recommended the reasons for this should be clearly stated at the time of making the recommendation.

*NOTE* *In some cases there can be compelling reasons why the most cost-effective solution cannot be recommended for implementation and these can be due to limited initial budget or other reasons such as aesthetic or political factors.*

2.17.2 Where any such reason exists, it should be taken into consideration when shortlisting the valid options.

2.18 In all cases evidence shall be provided to support the assertions made in the life-cycle management plans.

2.18.1 Evidence may be guidance produced by recognised bodies, research, or experience on the performance of materials or elements in the situation in which they are to be exposed.

*NOTE* *Bodies such as TRL (Transport Research Laboratory), CIRIA ( Construction Information Research and Information Association), The Concrete Society, and Steel Construction Institute publish relevant guidance.*

## Changes to life-cycle plan

2.19 The life-cycle plan of the recommended solution shall be updated with any changes that occur during detailed design that affect the whole life cost of the solution.

2.20 Where significant changes are proposed which increase costs, then these shall be subjected to an analysis of the effects of the proposals on the whole-life costs and compared to the original scheme options.

*NOTE* *During detailed design alternative materials or elements or details can be identified as desirable to benefit the construction cost or programme or to improve the durability or level of service offered by the asset. Where these alternatives are expected to increase the whole-life cost of the asset by more than 10% they can be considered to be significant.*



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2.21 The results of the analysis for the proposed changes shall be reported to the Overseeing Organisation with a recommendation for implementation or otherwise.

2.22 Where changes occur during construction these shall be incorporated into the life-cycle management plan and stored in a format, agreed with the Overseeing Organisation, with the 'as-built' information for the asset in accordance with the Overseeing Organisation's data and record requirements.

*NOTE* *At the construction stage it can not be desirable to reconsider scheme options due to changes that are necessary due to site circumstances.*

2.22.1 However the potential impact on whole-life costs should be a criterion for deciding which changes are to be implemented.

*NOTE* *Changes to design, details or materials required to overcome difficulties encountered on site can have a significant impact on the whole life cost of the asset.*

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# 3. Traffic delay costs

3.1 An assessment of traffic delay costs shall be undertaken throughout the assessment period for the asset for the following:

1) the initial construction or maintenance activities;
2) the subsequent inspection, maintenance, and renewal activities.

*NOTE* *The traffic management required for the initial construction or maintenance activity can probably be well defined. However for subsequent activities the traffic management requirements and their duration could be less clear. Due to this lack of precision a sophisticated traffic delay analysis is not warranted in most cases.*

3.2 The assessment of traffic delay costs shall be undertaken using a methodology that includes each of the following:

1) characteristics of the roads affected;
2) predicted traffic flows;
3) characteristics of the lane closures;
4) potential diversion routes.

3.2.1 The carriageways that are to be affected by the activities should be identified from the location and extent of the activity to be undertaken.

3.2.2 The AADT traffic flows for the length of route that can be affected by the activities should be determined from available sources.

*NOTE 1* *Available primary sources of AADT flows include Traffic counts [Ref 2.I]; Webtris webtris.highwaysengland.co.uk/ [Ref 4.I]; and https://opendatani.gov.uk/dataset/northern-ireland-traffic-count-data www.opendatani.gov.uk/dataset/ [Ref 1.I].*

*NOTE 2* *The cost of user delays can be established from the online data provided in WebTAG Unit A3 [Ref 3.I] Department for Transport (UK).*

3.2.3 The impact of the scheme option activities on the affected carriageways should be assessed to determine:

1) the number of lanes available at pinch points which have the greatest potential to cause delay to traffic;
2) the length over which the restrictions apply;
3) any temporary speed limits;
4) length of diversion routes and probable speed of travel (if diversions applicable).

*NOTE* *An example of an acceptable approach to calculating traffic delay costs is given in Appendix A. Where activities on a structure form part of a larger project for which a detailed analysis is required then the more detailed analysis can be used to determine the traffic delay costs.*



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# 4. Normative References

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

| | |
|---|---|
| Ref 1.N | HM Treasury. "The Green Book: appraisal and evaluation in central government" |
| Ref 2.N | Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges' |

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# 5. Informative References

The following documents are informative references for this document and provide supporting information.

| | |
|---|---|
| Ref 1.I | Northern Ireland Department for Infrastructure. OpenData NI. www.opendatani.gov.uk/dataset/, 'Northern Ireland Traffic Count Data' |
| Ref 2.I | Department for Transport (UK). Traffic counts, 'Road traffic statistics https://roadtraffic.dft.gov.uk' |
| Ref 3.I | Department for Transport (UK). WebTAG Unit A3, 'WebTAG Unit A1.3 user and provider impacts' |
| Ref 4.I | Highways England. webtris.highwaysengland.co.uk/, 'WebTRIS' |

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# Appendix A. Guidance on traffic delay cost

## A1 Traffic delay cost

In the absence of a more refined method the following has been devised as a quick, though unrefined, method of calculating traffic delay costs due to restrictions imposed on the network. As the calculation can largely be applied to situations where the extent, duration and timing of lane closures may be estimated values, this is reflected in broad banding of timings of the restrictions. This may only be used for the purpose of calculating user delay costs associated with works included within the scope of this document for inclusion within a life-cycle costing analysis.

**Equation A.1 Total Vehicle Delay (TVD)**

$$TVD = \frac{(DTc + CRDc) - (DTn + CRDn)}{60} \times EV \times EF$$

where:

| | |
|---|---|
| TVD | is total vehicle delay in vehicle hours |
| DTc | is the expected drive time in lane closure conditions over the length of the restriction (min) |
| DTn | is the expected drive time in normal conditions over the length of the restriction (min) |
| CRDn | is the Capacity Related Delay time in normal conditions (min) |
| CRDc | is the Capacity Related Delay time in lane closure conditions (min) |
| EV | is the expected equivalent hourly volume of traffic for each period |
| EF | is an economic factor to be applied to the cost to take account of the extent of planning and forewarning that has been provided prior to imposition of the lane closure(s). |

## A2 Tabulated values

Tabulated values are given on the following pages for each of the above variables to allow a quick assessment of cost. Different values apply if the lane closures are to be imposed on a weekday, weekday night, weekend day or weekend night. The approximate length of the restriction needs to be estimated and the AADT for the carriageway where the works are to be be located is needed. (At time of writing traffic flow data is available at http:// webtris.highwaysengland.co.uk/ [Ref 4.I], www.opendatani.gov.uk/dataset/ [Ref 1.I], Traffic counts [Ref 2.I]. The speed limits that will be applicable in normal and lane closure conditions are also needed. For full carriageway closures the tabulated values do not apply and the delays due to use of diversion route(s) have to be evaluated by assessment of the length of the diversion(s), the volume of traffic and the likely speed of travel.

## A3 Monetary cost

To give a monetary cost to the delay, the data from WebTAG Unit A3 [Ref 3.I] (or equivalent at time of calculation) for the average vehicle cost per hour for cars:goods vehicle ratio of 85:15 can be used. For 2018 values of £13.55 for a car and £17.81 (average goods vehicles) for a goods vehicle gives £14.20 used in the example.

## A4 Example

Network length with 60,000 AADT on 3-lane carriageway with speed limit of 113 km/h.

Restricted to 2 lanes for 6 hrs during a weekday daytime with speed limit of 80 km/h.

Length of restriction of 1.0 km (incl tapers)

From Tables : DTn= 0.53; CRDn=0.0587; DTc= 0.75; CRDc=1.2293

EV = 60,000(AADT) x 0.062 (for weekday daytime) = 3720



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EF = 0.3 for planned works with advance warning to road users

$TVD = \frac{(0.75+1.2293)-(0.53+0.0587)}{60} \times 3720 \times 0.3 = 25.9$

Cost per vehicle per hour = £14.20, so user delay cost per hour = £368

Total user delay cost for 6 hours of restriction = £2208

## A5 Tables of values

EF = 0.3 for planned works with advanced notice to users

**Table A.1 DTn Expected drive time in normal conditions (in min)**

| Speed (km/h) | Length of restriction (including tapers) (km) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 2.0 |
| 80 | 0.45 | 0.60 | 0.75 | 0.90 | 1.05 | 1.20 | 1.35 | 1.50 |
| 97 | 0.37 | 0.49 | 0.62 | 0.74 | 0.87 | 0.99 | 1.11 | 1.24 |
| 113 | 0.32 | 0.42 | 0.53 | 0.64 | 0.74 | 0.85 | 0.96 | 1.06 |

EF = 1.0 for unplanned works, e.g. required to rectify defects

### A5.1 Weekday days

For hours 06:00 - 22:00 Mon-Fri EV = 0.062 x AADT

**Table A.2 DTc Expected drive time in lane closure conditions (in min)**

| Speed (km/h) | Length of restriction (including tapers) (km) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 2.0 |
| 48 | 0.75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 |
| 64 | 0.56 | 0.75 | 0.94 | 1.13 | 1.31 | 1.50 | 1.69 | 1.88 |
| 80 | 0.45 | 0.60 | 0.75 | 0.90 | 1.05 | 1.20 | 1.35 | 1.50 |

**Table A.3 Capacity related delay in normal conditions (in min) CRDn**

| No. of lanes | AADT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 |
| 2 | 0.0068 | 0.0587 | 0.3132 | 1.2293 | 3.9062 | 10.6340 | 25.7242 | 56.6922 |
| 3 | 0.0003 | 0.0028 | 0.0150 | 0.0587 | 0.1867 | 0.5082 | 1.2293 | 2.7092 |
| 4 | 0 | 0.0003 | 0.0017 | 0.0068 | 0.0216 | 0.0587 | 0.1421 | 0.3132 |

**Table A.4 Capacity Related Delay in lane closure conditions (in min) CRDc**

| No. of lanes | AADT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 |
| 1 | 1.229 | 10.634 | 56.692 | 222.53 | 707.10 | 1924.97 | 4656.58 | 10262.38 |
| 2 | 0.007 | 0.059 | 0.313 | 1.229 | 3.906 | 10.634 | 25.724 | 56.692 |
| 3 | 0.000 | 0.003 | 0.015 | 0.059 | 0.187 | 0.508 | 1.229 | 2.709 |

### A5.2 Weekday nights

For Hours 22:00 - 06:00 Mon-Fri EV = 0.011 x AADT



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**Table A.5 Capacity Related Delay in normal conditions (min) CRDn**

| No. of lanes | AADT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 | 0.0001 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table A.6 Capacity Related Delay in lane closure conditions (in min) CRDc**

| No. of lanes | AADT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 |
| 1 | 0 | 0 | 0.0001 | 0.0005 | 0.0016 | 0.0045 | 0.0109 | 0.0239 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 | 0.0001 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### A5.3 Weekend days

For Hours 06:00 - 22:00 Sat-Sun EV = 0.048 x AADT

**Table A.7 Capacity Related Delay in normal conditions (in min) CRDn**

| No. of lanes | AADT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 |
| 2 | 0.0010 | 0.0086 | 0.0459 | 0.1803 | 0.5730 | 1.5598 | 3.7732 | 8.3156 |
| 3 | 0 | 0.0004 | 0.0022 | 0.0086 | 0.0274 | 0.0745 | 0.1803 | 0.3974 |
| 4 | 0 | 0 | 0.0003 | 0.0010 | 0.0032 | 0.0086 | 0.0208 | 0.0459 |

**Table A.8 Capacity Related Delay in lane closure conditions (in min) CRDc**

| No. of lanes | AADT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 |
| 1 | 0.1803 | 1.5598 | 8.3156 | 32.6403 | 103.718 | 282.354 | 683.028 | 1505.289 |
| 2 | 0.0010 | 0.0086 | 0.0459 | 0.1803 | 0.5730 | 1.5598 | 3.7732 | 8.3156 |
| 3 | 0 | 0.0004 | 0.0022 | 0.0086 | 0.0274 | 0.0745 | 0.1803 | 0.3974 |

### A5.4 Weekend nights

For Hours 22:00 - 06:00 Sat-Sun EV = 0.010 x AADT

**Table A.9 Capacity Related Delay in normal conditions (in min) CRDn**

| No. of lanes | AADT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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**Table A.10 Capacity Related Delay in lane closure conditions (in min) CRDc**

| No. of lanes | AADT | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30000 | 40000 | 50000 | 60000 | 70000 | 80000 | 90000 | 100000 |
| 1 | 0 | 0 | 0.0001 | 0.0003 | 0.0008 | 0.0022 | 0.0053 | 0.0117 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0001 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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# Appendix B. Example of lifecycle appraisal

## B1 Example of output of an appraisal

In the output illustrated please note the following :

1) Due to space limitations a 20-year extract of an evaluation is shown to illustrate the principles only; a 60-year period is normally required.
2) Relatively small value activities, such as annual routine maintenance, have been 'rolled up' and included in PI (Principal Inspection) costs.
3) Years where there are zero costs have not been shown.
4) Discount factors are based on a discount rate of 3.5% for years 1-30 and 3.0% thereafter. Rates applicable at the time of the appraisal should be used.
5) Costs in the table are in 000's.
6) 'Link' should provide a reference or link to where build ups of the values entered in the table can be found.
7) The costs used are for illustration only and do not reflect actual estimates as these depend on bridge type, span, obstacles crossed etc.

**Table B.1 Discount Factors (DF) used to convert costs to Present Value (PV)**

| Year | DF | Year | DF |
|---|---|---|---|
| 0 | 1 | 11 | 0.6849 |
| 1 | 0.9662 | 12 | 0.6618 |
| 2 | 0.9335 | 13 | 0.6394 |
| 3 | 0.9019 | 14 | 0.6178 |
| 4 | 0.8714 | 15 | 0.5969 |
| 5 | 0.8420 | 16 | 0.5767 |
| 6 | 0.8135 | 17 | 0.5572 |
| 7 | 0.7860 | 18 | 0.5384 |
| 8 | 0.7594 | 19 | 0.5202 |
| 9 | 0.7337 | 20 | 0.5026 |
| 10 | 0.7089 | | |

### B1.1 Life-cycle cost appraisal for 'Option A' for 'Another Crossing'

Structure Name: Another Crossing

Structure Key/Reference: 99999999

Date of Construction: 2018

Appraisal date: 02/2018 By: An Engineer Role/Company: Designer: ABC Ltd.

Review of Appraisal Due: 02/2024

Appraisal review date: mm/yyyy By: …….. Role/Company:……..

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**Table B.2 Values for Lifecycle Cost Appraisal for OPTION A for 'Another Crossing'**

| Activity | | Yr. 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GI | Works | | 0.3 | 0.3 | | 0.3 | 0.3 | | 0.3 | 0.3 | | 0.3 |
| Link | TM / UD | | 0 | 0 | | 0 | 0 | | 0 | 0 | | 0 |
| PI | Works | | | | 3.5 | | | 3.5 | | | 3.5 | |
| Link | TM | | | | 1.5 | | | 1.5 | | | 1.5 | |
| | UD | | | | 0.4 | | | 0.4 | | | 0.4 | |
| S. Joint | Works | | | | 28 | | | 28 | | | 28 | |
| Link | TM | | | | 6 | | | 6 | | | 6 | |
| | UD | | | | 2.5 | | | 2.5 | | | 2.5 | |
| N. Joint | Works | | | | | | | | | | 60 | |
| Link | TM | | | | | | | | | | 12 | |
| | UD | | | | | | | | | | 4 | |
| Bearings | Works | | | | | | | | | | | |
| Link | TM | | | | | | | | | | | |
| | UD | | | | | | | | | | | |
| Waterproofing | Works | | | | | | | | | | | |
| Link | TM | | | | | | | | | | | |
| | UD | | | | | | | | | | | |
| Deck Conc. | Works | | | | | | | | | | | |
| Link | TM | | | | | | | | | | | |
| | UD | | | | | | | | | | | |
| Parapets | Works | | | | | | | | | | | |
| Link | TM | | | | | | | | | | | |
| | UD | | | | | | | | | | | |
| Supports | Works | | | | | | | | | | 25 | |
| Link | TM | | | | | | | | | | 6 | |
| | UD | | | | | | | | | | 2.4 | |

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**Table B.2 Values for Lifecycle Cost Appraisal for OPTION A for 'Another Crossing'** (continued)

| **Activity** | | **Yr. 0** | **2** | **4** | **6** | **8** | **10** | **12** | **14** | **16** | **18** | **20** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Construction | Structure | 5200 | | | | | | | | | | |
| Link | Prelims | 150 | | | | | | | | | | |
| | TM | 56 | | | | | | | | | | |
| | UD | 20 | | | | | | | | | | |
| Yearly total | | 5425 | 0.3 | 0.3 | 41.9 | 0.3 | 0.3 | 41.9 | 0.3 | 0.3 | 151.3 | 0.3 |
| DF | | 1 | 0.934 | 0.871 | 0.814 | 0.759 | 0.709 | 0.662 | 0.618 | 0.577 | 0.538 | 0.503 |
| PV | | 5425 | 0.3 | 0.3 | 34.1 | 0.2 | 0.2 | 27.7 | 0.2 | 0.2 | 81.5 | 0.2 |

Abbreviations used in the table :

GI = General Inspection; PI= Principal Inspection; DF= Discount Factor TM= Traffic Management; UD= User Delay; Prelims= Cost of Scheme Preliminaries (proportioned to the structure)

For a 20-year evaluation period Option A has a PV of : (5425+0.3+0.3+34.1+0.2+0.2+27.7+0.2+81.5+ 0.2) = £5569.9k

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