VOLUME 1 **HIGHWAY STRUCTURES: APPROVAL PROCEDURES & GENERAL DESIGN**

SECTION 2 **OTHER PROCEDURAL DOCUMENTS**

PART 2

BA 28/92

EVALUATION OF MAINTENANCE COSTS IN COMPARING ALTERNATIVE DESIGNS FOR HIGHWAY STRUCTURES

INTRODUCTION

This Advice Note gives guidance, background information and examples for the evaluation of commuted maintenance costs when comparing alternative designs of highway structures, either at design or tender stage, in accordance with BD 36/92

INSTRUCTIONS FOR USE

1. Insert BA 28/92 into Volume 1, Section 2

2. Archive this sheet as appropriate

Note: New contents pages for Volume 1 containing reference to this document are available with BD 36/92

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THE HIGHWAYS AGENCY BA 28/92

THE SCOTTISH OFFICE DEVELOPMENT DEPARTMENT

THE WELSH OFFICE
Y SWYDDFA GYMREIG

THE DEPARTMENT OF
THE ENVIRONMENT FOR NORTHERN IRELAND

Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures

Summary: This Advice Note gives guidance and background information on the evaluation of commuted maintenance costs in comparing alternative designs for highway structures and alterations to existing structures.

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REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

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PART 2

BA 28/92

EVALUATION OF MAINTENANCE COSTS IN COMPARING ALTERNATIVE DESIGNS FOR HIGHWAY STRUCTURES

Contents

1. INTRODUCTION

Background

1.1 Memorandum 577, issued by the Department of Transport in 1945, carried the theme of economy in the design of highway structures and (on page 25) said:

> "In studying comparative costs of steel and other structures for any site, due allowance should be make for periodic painting costs of the steel structure".

1.2 Technical Memorandum T8/64 drew attention to the need to appraise the respective merits of alternative designs in the case of large structures and BE 7 (1967) extended this to smaller structures. BE 21 (1969) indicated the action necessary in the preparation of alternative designs both in the preliminary and final design stages and the possibility of design work being done by the British Constructional Steelwork Association; it also gave advice on alternative tenders. BE 21 specifically required the estimated future maintenance costs to be converted to present values at a discount rate of 8 per cent per annum and advised:

> "The maintenance of steel and concrete structures may be assumed to differ only in respect of the maintenance of the protective system applied to the steelwork, all other maintenance characteristics being substantially the same.....".

1.3 Technical Memorandum BE 5/76 (DMRB 1.2) updated BE 21, in requiring details of comparisons to be included in Form TA1, Approval in Principle, and increasing the discount rate to 10 per cent.

1.4 BD 36/88 broadened the evaluation of maintenance costs of alternative designs by taking account of maintenance of concrete and the cost to road users of delays arising from maintenance works. Unit costs for maintenance of concrete have been derived from maintenance costs of bridges of up to about 65 years of age. Delays to road users are to be estimated using the program QUADRO. All costs are discounted at the current Test Discount Rate of 8%.

1.5 BD 36/92 (DMRB 1.2.1) is consistent with the current version of the QUADRO Manual.

1.6 BA 28/88 is hereby superseded.

Scope

1.7 This Advice Note gives guidance, background information and examples for the evaluation of commuted maintenance costs when comparing alternative designs of highway structures, either at design or tender stage, in accordance with BD 36/92.

Implementation

1.8 This Advice Note should be used forthwith for all schemes currently being prepared provided that, in the opinion of the Overseeing Department, this would not result in significant additional expense or delay progress. Design Organisations should confirm its application to particular schemes with the Overseeing Department.

2. THE BASIS OF COMPARISON

General

2.1 The objective is to take full and realistic account of the differences in the costs of maintaining bridges of different types and materials over their whole life.

2.2 The cost of scaffolding or other access provisions for maintenance may be significant and should be taken into account including, where relevant, the provision of a permanent enclosure to steelwork.

2.3 The cost of lane or carriageway closures for work on busy trunk roads or motorways is very high but can usually be reduced if work is carried out at times of low traffic flow (at night or week-ends).

2.4 For night or week-end working full allowance should be made for higher rates of pay, environmental protection (heating and lighting), repeated provision and removal of staging and plant for each shift. Work in a protected environment should be more efficient as there is not standing time for weather, traffic etc. For the purpose of comparing maintenance costs of steel bridges with concrete bridges it is proposed that the appropriate engineering costs should be increased by 50 per cent for working at night, unless better information is available.

2.5 Where alternative designs involve types of structures and use of materials not covered in detail by this document, advice may be obtained from the Bridges Division of the Overseeing Department on deriving present value (PV) costs for maintenance.

Common Elements

2.6 Joints, bearings and concrete substructures are often common to both steel and concrete structures and therefore only need appear in the economic comparison where there are significant differences. For example, the evaluation of simply supported spans requiring more bearings than continuous spans should include the additional commuted replacement cost.

3. MAINTENANCE OF STEELWORK

3.1 Costs are based upon maintenance painting at fifteen year intervals. They allow for 10 per cent of the area being blast cleaned to clean steel quality in each maintenance cycle and replacing primers and undercoats to those areas and two top costs overall.

3.2 Estimates are usually more realistic if the painted area and scaffolding are dealt with separately. For instance, scaffolding will not normally be required for painting parapets.

3.3 Although considerable expenditure has been necessary on certain steel bridges for structural work, in addition to painting, eg repair of welds, this is not taken into account in the estimates for future maintenance because such work is not likely to be required for bridges designed to modern standards.

4. MAINTENANCE OF CONCRETE BRIDGES

4.1 From analysis of a number of concrete bridge decks it has been found that the probability of major maintenance being required on an individual structure is 0.02. This probability has already been taken into account in establishing the works costs given in para 3.2 of BD 36/92 (DMRB 1.2.1). However, the road user delay costs calculated by QUADRO and traffic management costs for individual structures must also be multiplied by this factor to reflect the probability of the delays occurring.

4.2 In deriving the costs for maintenance, the cost of waterproofing decks built before waterproofing became mandatory has not been included; neither have remedial works mainly attributable to lack of waterproofing. Measures to repair, or minimise, damage by alkali silica reaction are not included. New bridges will be built to a specification which will minimise the risk of these problems.

4.3 Future information on frequency and costs of maintenance obtained from the relevant Structures Databases will allow updating of costs.

5. USE OF QUADRO

5.1 The QUADRO program was developed primarily for use in rural areas, and although it can be used for some urban schemes, detailed representation of complex diversion possibilities is not practicable. Schemes where works severely affect junctions are usually not suitable for the program because the QUADRO method is link-orientated and junctions are assumed to provide adequate capacity. The program should not be used for detailed assessment of traffic management arrangements since it is not able distinguish fine differences in site layouts. In the last mentioned situation, advice may be obtained from the Bridges Division of the Overseeing Department.

5.2 Traffic volume and vehicle composition is usually defined for the opening year or year of construction. The QUADRO program will then estimate traffic volume and vehicle composition for the years when the maintenance work is expected to be carried out.

5.3 QUADRO needs details of the number and sequence of lane closures, the length of lane to be closed and the duration of the closures. In the absence of the appropriate local data, the values in Table A of Appendix A may be used.

5.4 Examples of the use of QUADRO showing the recommended methods for adjusting the results taken from the QUADRO printout and for combining works, traffic management and road user delay costs are given in Appendix B. Adoption of the data in Appendix A, the recommended treatment of costs after the year 2025 and the high growth evaluation will allow consistent assessments for all structures.

6. REFERENCES

6.1 QUADRO 2 Manual, April 1982, plus advice issued to all holders of the QUADRO manual in 1989.

6.2 Design Manual for Roads and Bridges Volume 1: Section 2 Other Procedural Documents.

BE 5/76	Evaluation of Highway Structures (DMRB 1.2) (Clause 5 and Appendix 1 are superseded by BD 36/92).
BD 36/92	Evaluation of Maintenance Costs in Comparing Alternative Designs for Highway Structures (DMRB 1.2.1).

7. ENQUIRIES

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

Head of Bridges Engineering
The Department of Transport
St Christopher House
Southwark Street
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Head of Bridges Engineering

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BASIC DATA FOR USE WITH QUADRO

1. TABLE A - TYPICAL QUADRO INPUT DATA (To be used only when local data cannot be obtained)

MAIN ROUTE	UNIT	S2	WS2	D2AP	D3AP	D2M	D3M	D4M
LENGTH	(km)	<-------ALWAYS USE LOCAL DATA--------->						
WIDTH	(m)	<-------ALWAYS USE LOCAL DATA--------->						
HILLINESS	(m/km)	15	15	15	15	15	15	15
SPEED LIMIT	(km/h)	96	96	113	113	113	113	113
BENDINESS	(deg/km)	45	45	30	30	20	20	20
VISIBILITY	(m)	300	300	-	-	-	-	-
ACCESSES	(no/10km)	60	20	-	-	-	-	-
VERGE WIDTH	(m)	3	3	-	-	-	-	-
DIVERSION ROUTE -								
LENGTH	(km)	<-------ALWAYS USE LOCAL DATA--------->						
FLOW	(16 hr)	<-------ALWAYS USE LOCAL DATA--------->						
FREE SPEED	(km/h)		56				78	
REDUCING TO	(km/hr at veh/hr)		44 at 780 25 at 1660				64 at 1055 51 at 1320 35 at 2990	
BREAKDOWN DURATION	(mins)	-	5	40	40	20	20	20
ACCIDENT DURATION	(mins)	-	5	45	45	25	25	25
DISTANCE TO PREVIOUS JUNCTION	(km)	<-------ALWAYS USE LOCAL DATA--------->						

Typical data are given above for the following road types:

Single 2 Lane, Wide Single 2-Lane, Dual 2 All purpose, Dual 3 all-purpose, Dual 2 Motorway , Dual 3 Motorway and Dual 4 Motorway.

Where dashes appear in the above table they indicate either data not required by the QUADRO program, or standard default values will be automatically input eg Verge and Accesses are standardised for dual carriageways and motorways - hence default values apply.

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2. TABLE B - ASSUMED TRAFFIC MANAGEMENT ARRANGEMENTS

SINGLE CARRIAGEWAYS	Normally shuttle working. Two lane working if total carriageway width exceeds 11.5m
DUAL CARRIAGEWAYS	Nearly always contraflow i.e. one carriageway closed. Possibility of single lane closure for short duration work.

3. METHOD OF CALCULATING DISCOUNT FACTORS (for Test Discount Rate of 8%)

3.1 Discount factors may be calculated from the following:

Discount factor = $\frac{1}{1.08^n}$ (where n = number of years from the date of construction)

3.2 Example using discount factors.

The whole life cost of a bearing with a replacement cost of £600 (at 1988 prices) at time of construction would be as follows:

Commuted replacement cost after

25 years 600 x . 146 = 88 (where 0.146 = $\frac{1}{(1.08^{25})}$)

50 years 600 x .021 = 13

75 years 600 x .0031 = 2

£103

Hence whole life cost of bearing = original cost plus replacement cost

= £600 + £103

= £703

4 METHOD OF UPDATING COMMUTED MAINTENANCE COSTS

4.1 For use in comparing total costs, construction plus commuted maintenance costs must be brought to the same price base.

4.2 RPI Values may be used to update commuted maintenance costs to the same year as construction costs - e.g. to change commuted maintenance costs from 1988 to same year as construction costs (say 1990), multiply by a factor of F*.

*Factor F above =

$$\frac{\text{RPI mid-year of construction costs (say 1990)}}{\text{RPI mid-1988}}$$

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EXAMPLES OF THE CALCULATION OF COMMUTED MAINTENANCE COSTS

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EXAMPLES OF THE CALCULATION OF COMMUTED MAINTENANCE COSTS

(Unless otherwise noted references given in the examples relate to BD 36/92).

STRUCTURE NO.1

STEEL/CONCRETE COMPOSITE BRIDGE DECK

1. DETAILS OF STRUCTURE

The bridge is taken as a 2-span overbridge carrying a single 7300mm carriageway over a dual 2-lane all-purpose trunk road, with steel beam/concrete composite slab deck, plan area 323m^2.

2. ASSUMPTIONS

(i) Maintenance Intervals and Duration of Work

From Table 3/5 of BD 36/92, the interval for repainting steelwork is 15 years. Three examples are considered, representing different methods of working and discounting the works cost.

Example 1.1 Day-time Working - Discounted Works Costs. Works duration: 3 weeks.
Example 1.2 Day-time Working - Undiscounted Estimated Works Costs. Works duration : 3 weeks.
Example 1.3 Night-time Working - Undiscounted Estimated Works Costs. Works duration: 4 weeks.

(ii) Traffic Management

Maintenance repainting will involve one carriageway closure on the road below, (to erect access scaffolding for each half of the bridge) with contraflow working on remaining carriageway.

Example 1.1 Day-time Working. Assume traffic management cost of £7,650 (1988 prices).

Example 1.2 Day-time Working. Assume traffic management cost of £7,650 (1988 prices).

Example 1.3 Night-time Working only (including Sat/Sun) between 7pm - 7am, and involving repeated provision and removal of staging and plant for each shift. Assume traffic management cost of £7,650 x 1.5 for night working (para 2.4 of this Advice Note) = £11.500.

(iii) Traffic Flow

In the following examples the assumed traffic flow is 25,000 AADT* (with 10% HGV) in the year of construction, 1990.
*AADT = Annual average daily traffic.

(iv) QUADRO Input Data

In the following examples QUADRO has been used to evaluate the cost of delays to road users caused by maintenance repainting of steel beams in a composite steel/concrete bridge. In the absence of more detailed local information, the QUADRO input data given in Appendix A of this Advice Note for dual 2-lane, all purpose trunk road, have been used.

Main Route	
Length: (local data)	4.0 km
Width: (local data)	14.6 m
Hilliness:	15 m/km
Speed Limit:	113 km/h
Bendiness	30 deg/km
Diversion Route	
Length: (local data)	7 km
16 hr flow: (local data)	630 veh
Free Speed:	56 km/h
Reducing to:	44km/h at 780 veh/h
	25km/h at 1660 veh/h

(v) Undiscounted Maintenance Costs for Repainting Steelwork

On the basis of a number of recent contracts, undiscounted costs for maintenance repainting of steelwork are estimated to be as follows:

Scaffolding	£4.00/m^2 of deck area
Plus:	
Cleaning down	£1.50/m^2 of painted area
10% blast cleaning at £7.0/m^2	£0.70 " "
10% initial costs at £3.0/m^2	£0.30 " "
Two coats	£3.00 " "

	£5.50/m^2

Note: Costs are undiscounted at 1988 prices.

3. EXAMPLE 1.1 - DAY-TIME WORKING - USING DISCOUNTED WORKS COSTS

(i) Road User Delay Costs

QUADRO was run for the years 2005, 2020 and 2025, see para 3.9(ii) of BD 36/92.

(a) Maintenance work duration of 7 days. For this example the actual works duration was assessed as 3 weeks, see Table 3/5 of BD 36/92. The 7-day QUADRO results were multipled by 3.

(b) Zero works cost. (Works and traffic management costs will be added later, see para 3 (v) Appendix B of this Advice Note).

QUADRO results:

Undiscounted user cost of traffic queueing delays and possile diversions

= £89,500 in the year 2005 (at 1979 prices for 3 weeks work)

£323,200	"	2020	"
£491,700	"	2035*	"
£491,700	"	2050*	"

*£491,700 is the undiscounted user cost in the year 2025, see para 3.9 (ii) of BD 36/92.

To convert to mid-1988 prices:

YEAR	UNDISCOUNTED USER COST 1979 PRICES (FROM PHASE 9 OF QUADRO OUTPUT)	ADJUSTMENT FACTOR (SEE TABLE 3/4 BD 36/92)	UNDISCOUNTED USER COST IN 1988 PRICES
2005	£ 89,500	2.22	£ 198,690
2020	£323,200	2.58	£ , 833,860
2035	£491,700	2.76	£1,357,090
2050	£491,700	2.76	£1,357,090

(ii) Maintenance Costs

Plan area of deck = 323m^2; assume ratio steelwork painted area/deck area = 1.
Using the commuted works costs given in Table 3/2, the calculation for maintenance works cost becomes:

(2.53 + 1.84) x 323 = £1.412)

(iii) Traffic Management Costs

Traffic management cost of £7,650 is assumed (Average 1988 prices).

(iv) Combining and Discounting

Method of discounting and combining QUADRO user delay costs and traffic management costs:

Year

1990	2005	2020	2035	2050	
A x 0.315 B_{15} x 0.315 <-15 years--->					£ 2,410 £62,590
A x 0.100 B_{30} x 0.100 <-30 years---------->					£ 770 £83,390
A x 0.031 B_{45} x 0.031 <-45 years---------->					£ 240 £42,070
A x 0.010 B_{60} x 0.010 <-60 years---------->					£ 80 £13,570
Total Traffic Management Costs*					£ 3,500
Total Road User Delay Costs*					£201,620

*Average 1988 prices, discounted to year of construction, 1990

Where:

A = Traffic management cost, average 1988 prices = £7,650
B_{15} = Undiscounted QUADRO user costs for works in year 2005
B_{30} = " " " " 2020
B_{45} = " " " " 2035
B_{60} = " " " " 2050

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(v) Summary

The present value of repainting steel beam at 15 yearly intervals if day-time working is used is therefore:

Discounted maintenance works cost	£ 1,412
Discounted road user delay cost	£201,620
Discounted traffic management cost	£ 3,500
	£206,532

4. EXAMPLE 1.2 - DAY-TIME WORKING - USING UNDISCOUNTED ESTIMATED WORKS COSTS

(i) Road User Delay Costs

QUADRO was run for the years 20, 2020 and 2025, as example 1.1 above.

(a) Maintenance work duration of 7 days. For this example, the actual works duration was assessed as 3 weeks, see Table 3/5 BD 36/92. The 7-day QUADRO results were multipled by 3.

(b) Zero works cost. (Works and traffic management costs will be added later, see para 4 (v) Appendix B of this Advice Note).

Year

1990 2005 2020 2035 2050

A x 0.315 B_{15} x 0.315 C x 0.315 <-15 years--->	£ 967 £62,590 £ 2,410
A x 0.100 B_{30} x 0.100 C x 0.100 <-30 years---------->	£ 307 £83,390 £ 770
A x 0.031 B_{45} x 0.031 C x 0.031 <-45 years---------->	£ 95 £42,070 £ 240
A x 0.010 B_{60} x 0.010 C x 0.010 <-60 years---------->	£ 31 £13,570 £ 80
(Average 1988 prices, discounted to year of construction, 1990)	£206,520

QUADRO results: as for example 1.1, see para 3 (i) of Appendix B of this Advice Note.

(ii) Maintenance Costs

Plan area of deck = 323m^2; assume ratio steelwork painted area/deck area = 1.

Using the undiscounted costs (1988 prices) from para 2 (v) Appendix B of this Advice Note, the calculation for maintenance works cost becomes:

(5.5 + 4.0) x 323 = £3,070

(iii) Traffic Management Costs

Traffic management cost of £7,650 is assumed (1988 prices).

(iv) Combining and Discounting

Method of discounting and combining QUADRO user delay costs, maintenance works cost and traffic management cost:

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Where:

A = Maintenance works cost, average 1988 prices = £3,070
B_{15} = Undiscounted QUADRO user costs for works in year 2005
B_{30} = " " " " 2020
B_{45} = " " " " 2035
B_{60} = " " " " 2050
C = Traffic management cost, average 1988 prices = £7,650

(v) Summary

The present value of repainting steel beams at 15 yearly intervals if day-time working is used is therefore:

Discounted maintenance works cost	£ 1,400
Discounted road user delay cost	£201,620
Discounted traffic management cost	£ 3,500
	£206,532

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5. EXAMPLE 1.3 - NIGHT-TIME WORKING - USING UNDISCOUNTED ESTIMATED WORKS COSTS

(i) Road User Delay Costs

QUADRO was run for the years 2005, 2020 and 2025, see para 3.9 (ii) of BD 36/92.

(a) Maintenance work duration of 7 nights. For this example, the actual works duration was assessed as 4 weeks, see Table 3/5 in BD 36/92. The 7-night QUADRO results were therefore multiplied by 4.

(b) Zero works cost. (Works and traffic management costs will be added later, see para 5(v) Appendix B of this Advice Note).

QUADRO results:
Undiscounted user cost of traffic queueing delays and possible diversions

= £10,300 in the year 2005 (at 1979 prices for 4 weeks work)
£27,000 " 2020 ")
£43,200 " 2035* ")
£43,200 " 2050* ")

*£43,200 is the undiscounted user cost in the year 2025, see para 3.9 (ii) of BD 36/92.

To convert to mid-1988 prices:

YEAR	UNDISCOUNTED USER COST 1979 PRICES (FROM PHASE 9 OF QUADRO OUTPUT)	ADJUSTMENT FACTOR (SEE TABLE 3/4 BD 36/92)	UNDISCOUNTED USER COST IN 1988 PRICES
2005	£10,300	2.22	£ 22,870
2020	£27,000	2.58	£ 69,660
2035	£43,200	2.76	£119,230
2050	£43,200	2.76	£119,230

(ii) Maintenance Costs

Plan area of deck = 323 m^2; assume ratio steelwork painted area/deck area = 1.

Using the undiscounted costs (1988 prices) from para 2(v) Appendix B of this Advice Note, multiplied by 1.5 for night working, the calculation for maintenance works cost becomes:
(5.5 + 4.0) x 1.5 x 323 = £4,600

(iii) Traffic Management Costs

Traffic management cost of £11,500 is assumed (average 1988 prices).

(iv) **Combining and Discounting**

Method of discounting and combining QUADRO user delay costs, maintenance works cost and traffic management cost:

Year		
1990		
2005	A x 0.315	£ 1,449
	B_{15} x 0.315	£ 7,200
	C x 0.315	£ 3,620
	<-15 years--->	
2020	A x 0.100	£ 460
	B_{30} x 0.100	£ 6,970
	C x 0.100	£ 1,150
	<-30 years---------->	
2035	A x 0.031	£ 143
	B_{45} x 0.031	£ 3,700
	C x 0.031	£ 360
	<-45 years---------->	
2050	A x 0.010	£ 46
	B_{60} x 0.010	£ 1,190
	C x 0.010	£ 120
	<-60 years---------->	
	(Average 1988 prices, discounted to year of construction, 1990)	£ 26,408

Where:

A = Maintenance works cost, average 1988 prices = £4,600

B_{15} = Undiscounted QUADRO user costs for works in year 2005

B_{30} = " " " " 2020

B_{45} = " " " " 2035

B_{60} = " " " " 2050

C = Traffic management cost, average 1988 prices = £11,500

(v) Summary

The present value of repainting steel beams at 15 yearly intervals if night-time working is used is therefore:

Discounted maintenance works cost	£ 2,098
Discounted road user delay cost	£19,060
Discounted traffic management cost	£ 5,250
	£26,408

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STRUCTURE NO.2

POST-TENSIONED CONCRETE BRIDGE DECK

6. DETAILS OF STRUCTURE

The bridge is taken as a 2-span overbridge carrying a single 7300mm carriageway over a dual 2-lane all-purpose trunk road, with concrete deck comprising post-tensioned concrete main members, and reinforced concrete deck slab.

7. ASSUMPTIONS

(i) Maintenance Intervals and Duration of Work.

From Table 3/5 of BD 36/92, the interval for concrete maintenance is 20 years. Works duration: 8 weeks.

(ii) Traffic Management

Concrete maintenance will involve one carriageway closure on the road below (to erect formwork and access scaffolding for each half of the bridge) with contraflow working on remaining carriageway. Assume traffic management costs of £10,900 (average 1988 prices).

(iii) Traffic Flow

See para 2 (iii) Appendix B of this Advice Note.

(iv) QUADRO Input Data

See Main Route and Diversion Route data at para 2 (iv) Appendix B of this Advice Note.

8. EXAMPLE 2.1 - DAY-TIME WORKING - USING DISCOUNTED WORKS COSTS

(i) Road User Delay Costs

QUADRO was run for the years 2010 and 2025, see para 3.9(ii) of BD 36/92.

(a) Maintenance work duration of 7 days. For this example, the works duration was taken from Table 3/5 of BD 36/92 as 8 weeks. The 7-day QUADRO results were therefore multiplied by 8.

(b) Zero works costs. (Works and traffic management costs will be added later, see para 8 (vi) Appendix B of this Advice Note).

QUADRO results:
Undiscounted user cost of traffic queueing delays and possible diversions
= £ 391.200 in the year 2010 (at 1979 prices for 8 weeks work)
£1,311,200 " 2030* (")
£1,311,200 " 2050* (")

*£1,311,200 is the undiscounted user cost in the year 2025.

To convert to mid-1988 prices:

YEAR	UNDISCOUNTED USER COST 1979 PRICES (FROM PHASE 9 OF QUADRO OUTPUT)	ADJUSTMENT (SEE TABLE 3/4 BD 36/92)	UNDISCOUNTED USER COST IN 1988 PRICES
2010	£ 391,200	2.34	£ 915,400
2030	£1,311,200	2.76	£3,618,900
2050	£1,311,200	2.76	£3,618,900

(ii) Maintenance Costs

Discounted maintenance works costs from BD 36/92 are used in the absence of more detailed information.

Plan area of deck = 323m^2.

Using the discounted costs given in Table 3/1, the calculation for maintenance works cost becomes:

(0.8 + 2.8) x 323 + £1,163

(iii) Traffic Management Costs

Traffic management cost of £10,900 is assumed (average 1988 prices).

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(iv) Combining and Discounting

Method of discounting QUADRO user delay costs and traffic management cost:

Year		
1990	2010	A x 0.214
		B_{20} x 0.214
		<-20 years--->
	2030	A x 0.046
		B_{40} x 0.046
		<-40 years---------->
	2050	A x 0.010
		B_{60} x 0.010
		<-60 years---------->

A x 0.214	£ 2,330
B_{20} x 0.214	£195,900
A x 0.046	£ 500
B_{40} x 0.046	£166,470
A x 0.010	£ 110
B_{60} x 0.010	£ 36,190
Total Traffic Management Costs*	£ 2,940
Total Road User Delay Costs*	£398,560

*Average 1988 prices, discounted to year of construction 1990

Where:

A = Traffic management cost, average 1988 prices = £10,900
B_{20} = Undiscounted QUADRO user costs for works in year 2010
B_{40} = " " " " 2030
B_{60} = " " " " 2050

(v) Probability Factor

To reflect the probability of repairs being required for the deck elements of concrete structures, the road user delay costs and traffic management costs are multiplied by 0.02, see para 3.7 of BD 36/92 as follows:

Discounted traffic management cost £ 2,940 x 0.02 = £ 60

Discounted road user delay cost £398,560 x 0.02 = £7,970

(vi) Summary

The present value of carrying out concrete repairs at 20 year intervals if day-time working is used is therefore:

Discounted traffic management cost	£ 60
Discounted road user delay cost	£7,970
Discounted maintenance works cost	£1,163
	£9.193