RoSy® PMS - not just a pavement management system……

Part II – a report example

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Report Status: Final

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1 CRITERIA FOR ECONOMIC CALCULATION

1.1 METHODOLOGY & APPROACH

1.1.1 Road pavement

Please consult Book 1 for description.

1.1.2 Trip hazard, kerb defects, drainage defects and driveways

Under the heading “Trip hazard” the following defects were collected:
- Crack (m²)
- Settlement (m²)
- Patch (m²)
- Cover (piece)

(Height differences exceeding 15 mm were registered)

Under the heading “Kerb defects” the following defects were collected:
- Separation
- Sinking
- Broken
- Missing

(The length of the defect was registered)

Under the heading “Drainage defects” the data for gullies and manholes was collected separately. The following defects were registered:
- Crack (m²)
- Pothole (m²)
- Settlement (m²)
- Blocked (pcs)
- Protrude (pcs)

(Chainage and roadside were registered for driveways)

The prices listed under section 1.3.5 were applied for the cost calculations.

The final result appears from the summary under sections 2.4 – 2.7 and appendix B. Data is presented as total costs, costs per road class, costs per defect type and costs per road section.

1.2 SYSTEM SET UP:

1.2.1 Construction types:

This defines the physical make-up of the road pavement: The materials and layer thickness employed in its pavement structure. This division is applied for differentiating the deterioration of the pavement defects and road asset (see 1.2.7). For this project two pavement structure types are applied (0. Asphalt and 1. Concrete). The pavement structures of the road network can be divided into more than two types, but this has not yet been done, since knowledge is required of how each of the pavement structure types will deteriorate over time.

1.2.2 Road class:

The road network is grouped into road classes, which are based on the importance of the sections. The road classes are used in the analysis that e.g. differentiates service levels.

Below road class grouping applies:

Road class
1. National Primary
2. National Secondary
3. Regional Primary
4. Regional Secondary
5. Local Primary
6. Local Secondary
7. Local Tertiary

1.2.3 Traffic interval:

Three traffic intervals are applied (SA is 8.2 tonnes Standard axle) for e.g. differentiation of deterioration models and service levels (see 1.2.4 and 1.2.5).

The traffic intervals appear from the table below:

Name	From SA per day	To SA per day
Low traffic	0	1
Medium traffic	1	50
High traffic	50	99999999

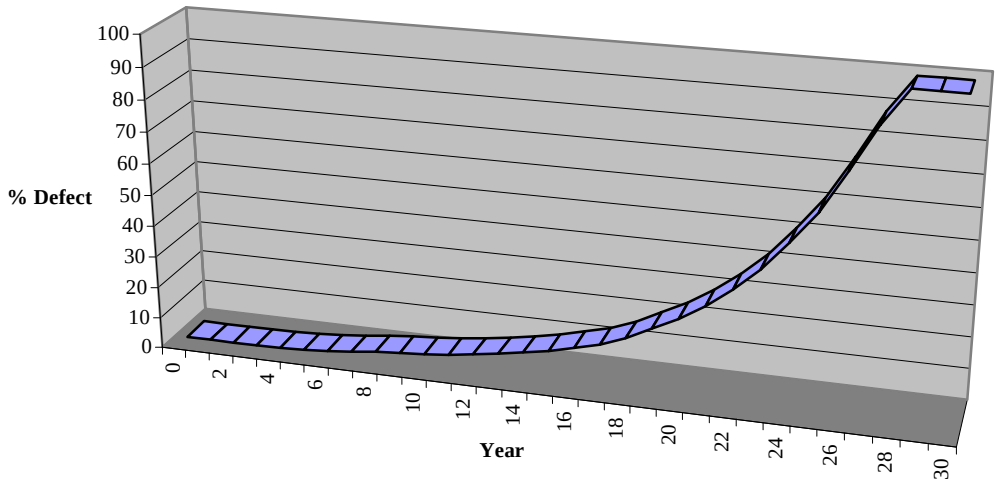
1.2.4 Deterioration models:

These models predict the way in which each defect type (cracking, rutting, etc.) will develop over time. 42 deterioration models are available at present:

Two construction models
Seven defect models

Each model has three traffic intervals. This amounts to 21 models for asphalt and 21 models for concrete. An initial adjustment has been made to the models in cooperation with @@. A future adjustment of the models will, however, still be required.

Example of a deterioration model



1.2.5 Service levels:

The service levels, which appear from in the table below, were applied for the calculation. If any of the defect values of a section exceed these levels due to a constrained budget, then the section will be considered a ‘low standard’ section.

Defect	Traffic (SA)	Service level (%)
Cracks	Low (0-1)	10
Cracks	Medium (1-50)	8
Cracks	High (> 50)	6
Crazing	Low (0-1)	4
Crazing	Medium (1-50)	3
Crazing	High (> 50)	1
Potholes	Low (0-1)	0.3
Potholes	Medium (1-50)	0.2
Potholes	High (> 50)	0.1
Settlements	Low (0-1)	7
Settlements	Medium (1-50)	5
Settlements	High (> 50)	2
Rutting	Low (0-1)	6
Rutting	Medium (1-50)	5
Rutting	High (> 50)	4
Stripping	Low (0-1)	10
Stripping	Medium (1-50)	8
Stripping	High (> 50)	4
Patching	Low (0-1)	20
Patching	Medium (1-50)	15
Patching	High (> 50)	10

In cooperation with @@ we have made a temporary service level for accumulated defects (patches not included). Service levels for the accumulated defects are:

Traffic group ”low” = 15%
Traffic group ”medium” = 12%
Traffic group ”high” = 7%

(If a section has accumulated defects exceeding the above level, then the section will be considered a ‘low standard’ section.)

1.2.6 Traffic growth:

Each road class can be indicated with an annual traffic growth percentage. For this project the percentages appearing from the table below were applied:

Road class	Traffic growth (% per year)
1. National Primary	4.4
2. National Secondary	4.4
3. Regional Primary	4.4
4. Regional Secondary	4.4
5. Local Primary	4.4
6. Local Secondary	4.4
7. Local Tertiary	4.4

1.2.7 Road asset:

The development of the road asset was calculated on the basis of the average values for new roads appearing from the below table:

Construction type	Layer	New value (IEP per m²)
Asphalt	Wearing course	7
Asphalt	Bound base course	12
Asphalt	Unbound base course	5
Asphalt	Sub base	2
Asphalt	Sub grade	2
Concrete	Wearing course	13
Concrete	Bound base course	10
Concrete	Unbound base course	5
Concrete	Sub base	2
Concrete	Sub grade	2

1.2.8 Miscellaneous parameters:

The parameters appearing from the table below were used for the calculation:

Design period	15 years
Minimum kerb height	100 mm
New kerb height	200 mm
Repair period	3 years

1.3 SOURCES OF DATA:

1.3.1 Road reference:

At the first meeting GMCB received basic road data from @@ in the format of an Arc View file. This data formed the basis of the data collection and subsequent linking between road data and the vector mapping of the city.

Example of data received from @@:

1 of 2350 selected

Shape	Entity	Layer	Level	Nslink_dnr	Nslink_of	Mapid	Ro	Road_no	Road_ref	Road_name
PolyLine	Line String	23	23	582	582	100001	L	98539	10	CASTLE AVE
PolyLine	Line String	23	23	583	583	100001	L	10041	20	ROPE WALK
PolyLine	Line String	23	23	584	584	100001	L	10041	10	ROPE WALK
PolyLine	Line String	23	23	585	585	100001	L	10042	10	MEADOWGROVE EST
PolyLine	Line String	23	23	586	586	100001	L	10042	20	MEADOWGROVE EST
PolyLine	Line String	23	23	587	587	100001	L	10042	40	MEADOWGROVE EST
PolyLine	Line String	23	23	588	588	100001	L	10043	10	MEADOWGROVE EST
PolyLine	Line String	23	23	589	589	100001	L	10043	20	MEADOWGROVE EST
PolyLine	Line String	23	23	590	590	100001	L	10043	30	MEADOWGROVE EST
PolyLine	Line String	23	23	591	591	100001	L	10043	50	MEADOWGROVE EST
PolyLine	Line String	23	23	592	592	100001	L	10044	10	MEADOWGROVE EST
PolyLine	Line String	23	23	594	594	100001	L	10046	10	EDEN GROVE
PolyLine	Line String	23	23	595	595	100001	L	10046	20	EDEN COURT
PolyLine	Line String	23	23	596	596	100001	L	10046	30	EDEN COURT
PolyLine	Line String	23	23	597	597	100001	L	10046	40	EDEN COURT
PolyLine	Line String	23	23	598	598	100001	L	10046	80	EDEN COURT
PolyLine	Line String	23	23	599	599	100001	L	10046	70	EDEN COURT
PolyLine	Line String	23	23	600	600	100001	L	10046	60	EDEN GROVE
PolyLine	Line String	23	23	601	601	100001	L	10047	10	CASTLE RD

1.3.2 Data collection:

Geometric data and condition data collected by GMCB and entered into RoSy BASE. (Description in Book 1)

1.3.3 Bearing capacity data:

The list below is a survey of the sections showing signs of poor bearing capacity. FWD measurements were carried out on these sections.

Name	No.	Section	Description	Length	Class
BALLYHOOLY NEW RD	614	60	BALLYHOOLY NEW RD - BALLYVOLANE CROSS	502	RP
BEAUMONT LAWN	5004	50	UPPER BEAUMONT DRIVE - BEAUMONT LAWN	279	LS
BLACKROCK RD	1001	80	BLACKROCK RD - MENLOE GARDENS	250	LP
BOREENMANAGH RD	852	50	BOREENMANAGH RD - CEANNCORA LAWN	338	RS
CENTRE PARK RD	1002	20	MARINA WALK	573	LP
CENTRE PARK RD	1002	30	MARINA WALK	542	LP
CENTRE PARK RD	1002	40	MARINA WALK	429	LP
CHURCHYARD LANE	852	60	BOREENMANAGH RD - CHURCHYARD LANE	393	RS
COMMONS RD	1026	20	GREAT WM OBRIEN ST - COMMONS RD	640	LP
COURTOWN DRIVE	5054	10	HARBOUR VIEW RD - COURTOWN DRIVE	511	LS
FAIRFIELD RD	5094	30	FAIRFIELD RD	240	LS
GLEN HEIGHTS RD	50614	10	GLENHEIGHTS RD	270	LT
GLENTHORN RD	5074	10	DUBLIN HILL MIDDLE - GLENTHORN RD	127	LS
GLENWOOD DRIVE	50942	10	LABURNUM GROVE - GLENWOOD DRIVE	238	LT
HORGANS QUAY	8	160	HORGANS QUAY - WATER ST	794	NP
IONA PL	50673	10	IONA RD - IONA PL	187	LT
KILMORE RD LOWER	5054	30	KILMORE HEIGHTS - KILMORE RD LOWER	414	LS
LOWER GLANMIRE RD	8	80	LOWER GLANMIRE RD - ROCKGROVE SQUARE	585	NP
LOWER KILEENS RD	90209	10	COMMONS RD - LOWER KILEENS RD	594	LT
MARINA RD	10011	20	MARINA WALK - MARINA RD	141	LT
MELBOURNE RD	1017	20	MELBOURNE RD - ALLENDALE DRIVE	436	LP
MONAHANS RD	5002	20	BLACKROCK RD	504	LS
MONAHANS RD	5002	30	BLACKROCK RD	334	LS
NORTH RING RD	635	40	NORTH RING RD -SPRING LANE	489	RP
NORTH RING RD	635	70	NORTH RING RD - BALLYHOOLY NEW RD	515	RP
OLD YOUGHAL RD	1029	30	OLD YOUGHAL RD - MURMONT PARK	374	LP
REDFORGE RD	20	90	REDFORGE RD - DUBLIN ST	631	NP
RINGMAHON RD	1004	30	BALLINURE RD - RINGMAHON RD	404	LP
RINGMAHON RD	5007	10	SKEHARD RD - RINGMAHON RD	325	LS
SHANAKIEL RD	1019	20	SHANAKIEL RD - ROPE WALK	331	LP
SILVERCOURT	5088	10	NORTH RING RD - SILVERCOURT	444	LS
UPPER FAIR HILL	5057	30	UPPER FAIR HILL - PARK LANDS	418	LS
UPPER FAIR HILL	5057	40	UPPER FAIR HILL - BLACKSTONE BRIDGE	311	LS
VICTORIA QUAY	5001	10	ALBERT QUAY - VICTORIA QUAY	603	LS

LEGEND			
Road class	1	NP	National Primary
Road class	2	NS	National Secondary
Road class	3	RP	Regional Primary
Road class	4	RS	Regional Secondary
Road class	5	LP	Local Primary
Road class	6	LS	Local Secondary
Road class	7	LT	Local Tertiary

A description of the bearing capacity data processing is found in Book 1.

1.3.4 Traffic data

The traffic data handed out by @@ is listed below: provided:

1. LUTS traffic counts 1999.
2. Traffic flows from the SATURN traffic model.

The traffic data only related to the main routes in @@ City. The traffic flows were indicated in PCU's in two directions between two junction nodes (including junction co-ordinates).

It turned out that the traffic flow sections between two nodes were not identical to the @@ road sections. A traffic flow section could cover 4-5 different road sections.

The traffic flows from both directions were added to a total traffic flow between two nodes and all traffic flows were converted from PCU's into AADT and SA (Standard Axles).

The traffic flows were then projected to the road sections and manually entered into RoSy.

Experience shows that the traffic load for one day can be found by multiplying PCU's per hour by 10 (e.g. AADT). Since the traffic counts are from 1999 a 10% increase has been included.

AADT is thus calculated as the total PCU flow per hour multiplied by 11.

SA is calculated in the following way:

(HGV + BUS) * 11 * 0.2

0.2 is load and the distribution factor (5 HGV = 1 Standard axle).

Example of traffic data:

Junct 1	Junct 2	HGV	HGV total (HGV+BUS)	Cars	Bus	AADT (Cars * 11)	SA (HGV*11*0.2)
3001	4936	88.07	184.07	1252.11	96	13773	404
3001	3026	82.33	166.28	1220.72	83.95	13427	365
3002	4936	71.55	155.48	1029.12	83.93	11320	342
3002	4915	49.64	70.64	755.93	21	8315	155
3002	3003	96.4	192.4	1292.12	96	14213	423
3003	4916	77.35	185.34	720.06	107.99	7920	407
3003	4901	22.96	67.95	879.98	44.99	9679	149
3003	3002	69.23	168.14	955.46	98.91	10510	369
3006	4916	58.74	190.58	777.81	131.84	8555	419
3006	4911	28.75	136.74	557.15	107.99	6128	300
3008	4912	58.67	127.57	881.13	68.9	9692	280
3008	3917	18.55	51.5	450.26	32.95	4952	113
3008	3009	43.43	172.29	749.81	128.86	8247	379
3009	4948	95.11	95.11	825.53	0	9080	209
3009	3010	30.72	165.6	572.34	134.88	6295	364
3010	3012	174.93	339.87	1561.72	164.94	17178	747
3012	4461	10.91	64.89	414.93	53.98	4564	142
3012	3083	28.45	52.44	192.67	23.99	2119	115
3012	3042	183.78	297.76	2082.34	113.98	22905	655

An Arc View theme was generated by means of the junction co-ordinates. From this it was possible to see the traffic flow together with the @@ road network in Arc View. The road sections with traffic flows were identified and the traffic flows were manually entered into the RoSy database.
The traffic model covers approx. 600 sections or approx. 25%. This means almost all sections in road classes 1, 2, 3, 4 and 5.

The sections, for which no traffic data was available, have been given a traffic factor according to their road classes as shown in the table below:

Road class	SA per day
0. Not classified	0.9
1. National Primary	300
2. National Secondary	100
3. Regional Primary	50
4. Regional Secondary	30
5. Local Primary	15
6. Local Secondary	3
7. Local Tertiary	0.9

It is recommendable that the traffic model and the road database work with the same road sections. The advantage is that @@ can update traffic figures in RoSy, when traffic flows change in the future years.

1.3.5 Treatment types and their specifications:

This subject was discussed with staff from @@ and details are found in Book 1.

Road pavement treatment types:
See appendix A for printout.

Trip hazards:

Defect type: Cracks, settlements and patches:

Material	Price per m² (if < 2 m²) in £	Price per m² (if >= 2 m²) in £
Concrete	130.00	65.00
Asphalt	90.00	45.00
Paviour	170.00	85.00
Other	140.00	70.00

Defect type: Cover

Material	Price per piece in £ (if <= 0.1 m²)	Price per piece in £ (if > 0.1 m²)
Concrete	40.00	125.00
Asphalt	40.00	110.00
Paviour	40.00	150.00
Other	40.00	120.00

Kerb defects:

Defect type	Price per m (if < 2 m) in £	Price per m (if < 5 m) in £	Price per m (if >= 5 m) in £
Separation	80.00	60.00	40.00
Sinking	80.00	60.00	40.00
Broken	90.00	67.50	45.00
Missing & other	90.00	67.50	45.00

Drainage defects:

	Price per m² in £	Price per m² in £	Price per m² in £	Price per m² in £	Price per piece in £	Price per piece in £
Pavement type	Cracks	Potholes	Settlement	Unknown	Protrude	Blocked
Asphalt	20.00	35.00	30.00	30.00	160.00	50.00
Concrete	80.00	45.00	80.00	80.00	160.00	50.00

If defect type is settlement then + £160 IEP as basic costs

Driveways:

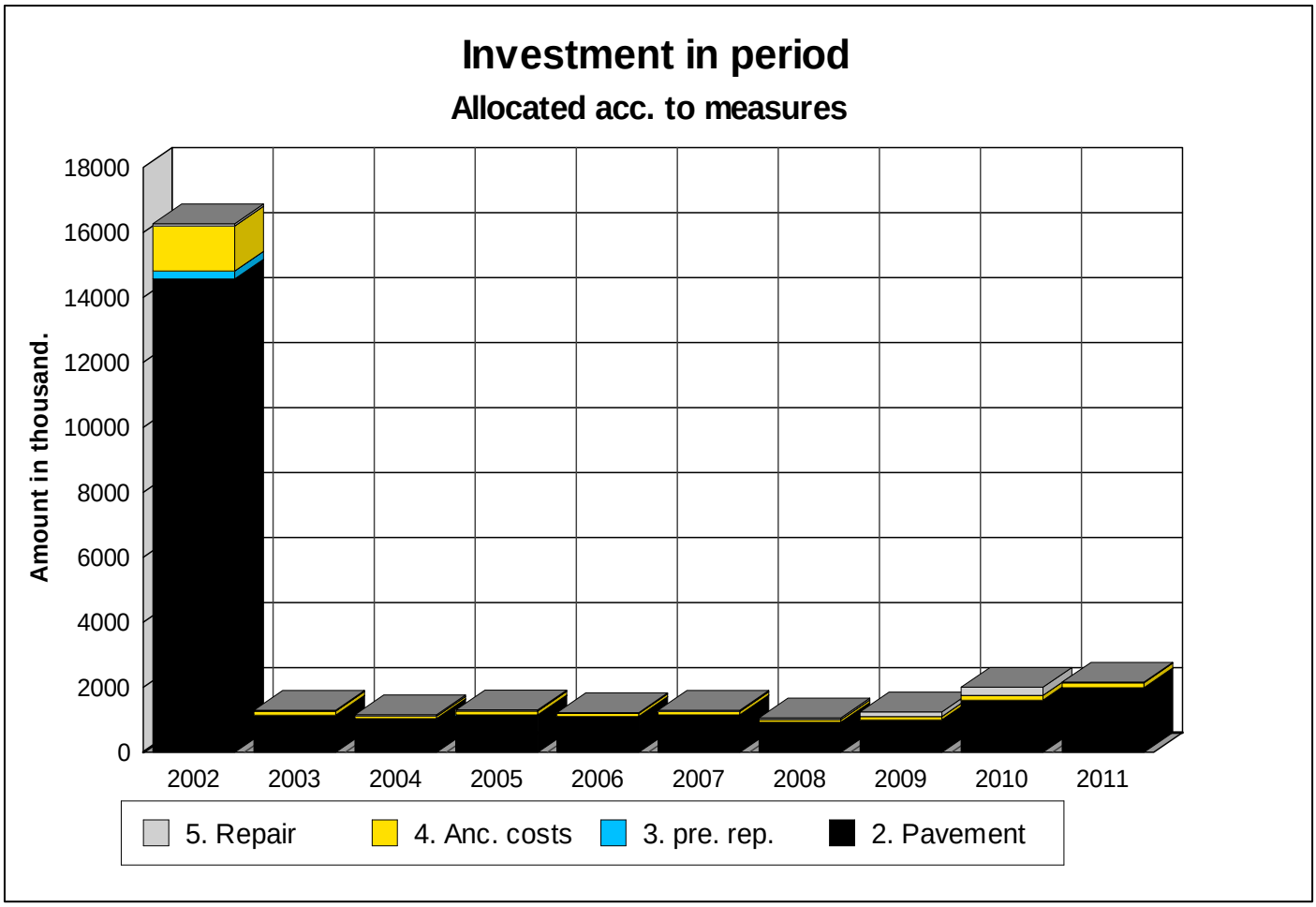
An area of 6 m² has been applied for each registered driveway.
Cost per m² is set to £140.00 IEP. This means that cost per driveway is £840.00 IEP.

2 SUMMARY OF THE ANALYSIS

Please consult appendices A, B, C and the output files stored on the CD ROM for more details.

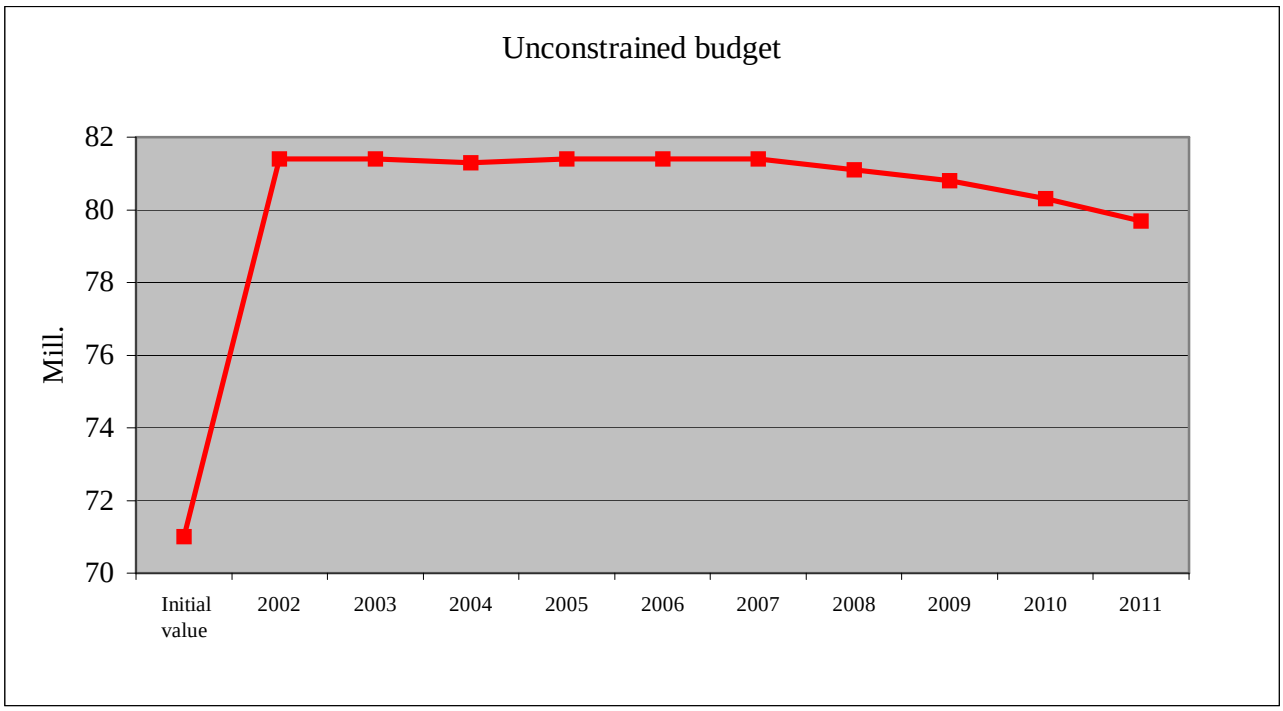
2.1 UNCONSTRAINED BUDGET:

The below graph and table show the investments required for the unconstrained budget plan. The precondition of the plan is that no sections are allowed to fall into the category “low standard” and that the economic optimisation decides which treatment to use and when.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
2. Pavement	14.564	1.137	1.033	1.146	1.097	1.154	924	994	1.600	1.982	25.631
3. pre. rep.	247	8	3	5	3	0	1	2	3	4	276
4. Anc. costs	1.386	120	79	121	96	106	80	104	150	153	2.395
5. Repair	68	28	42	32	24	36	56	143	251	20	700
Total	16.265	1.293	1.157	1.304	1.220	1.296	1.061	1.243	2.004	2.159	29.002

10 year survey, road asset development

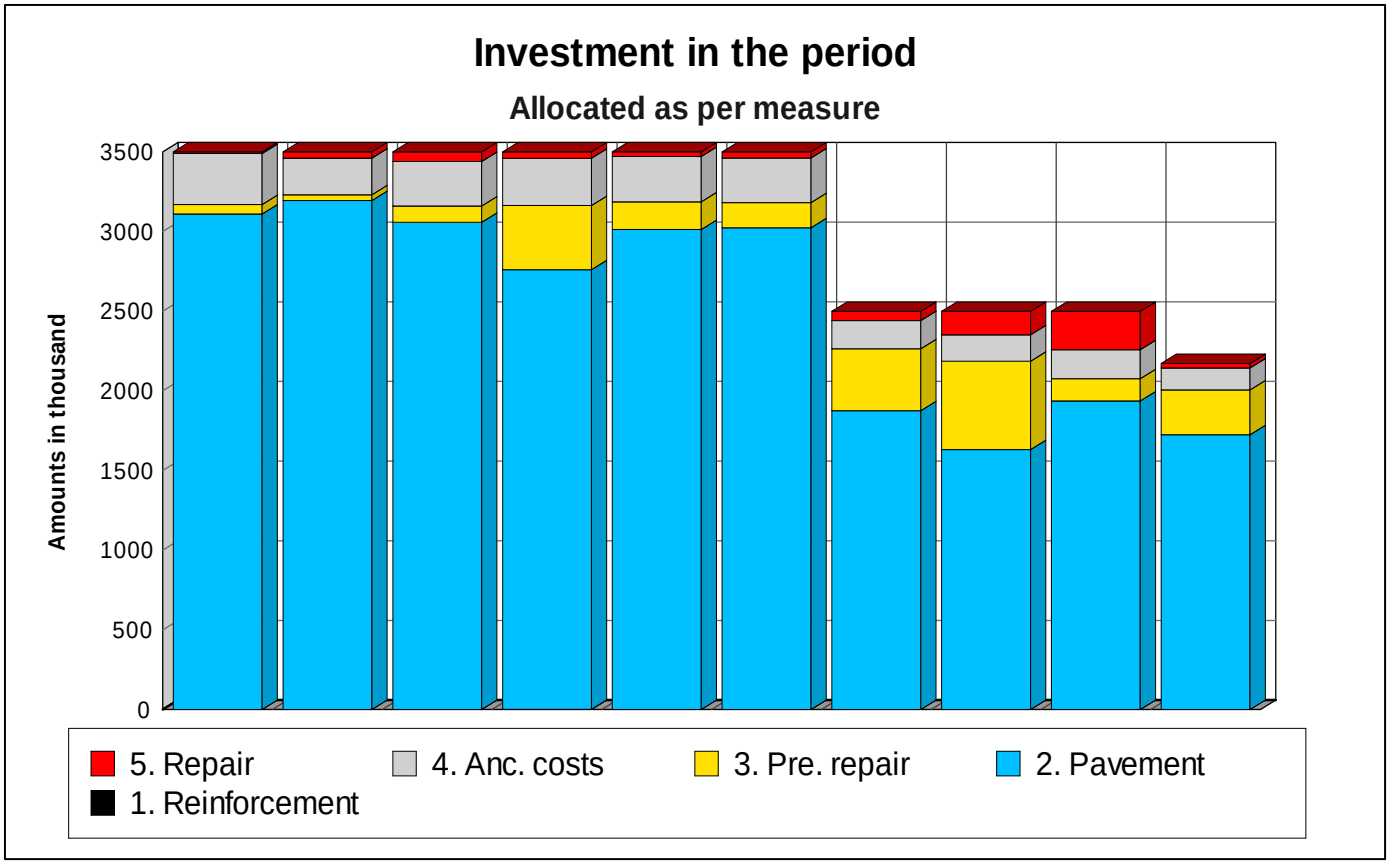


The graph shows the road asset value development.

The “new” road asset value for a completely resurfaced road network without any defects is £84m.

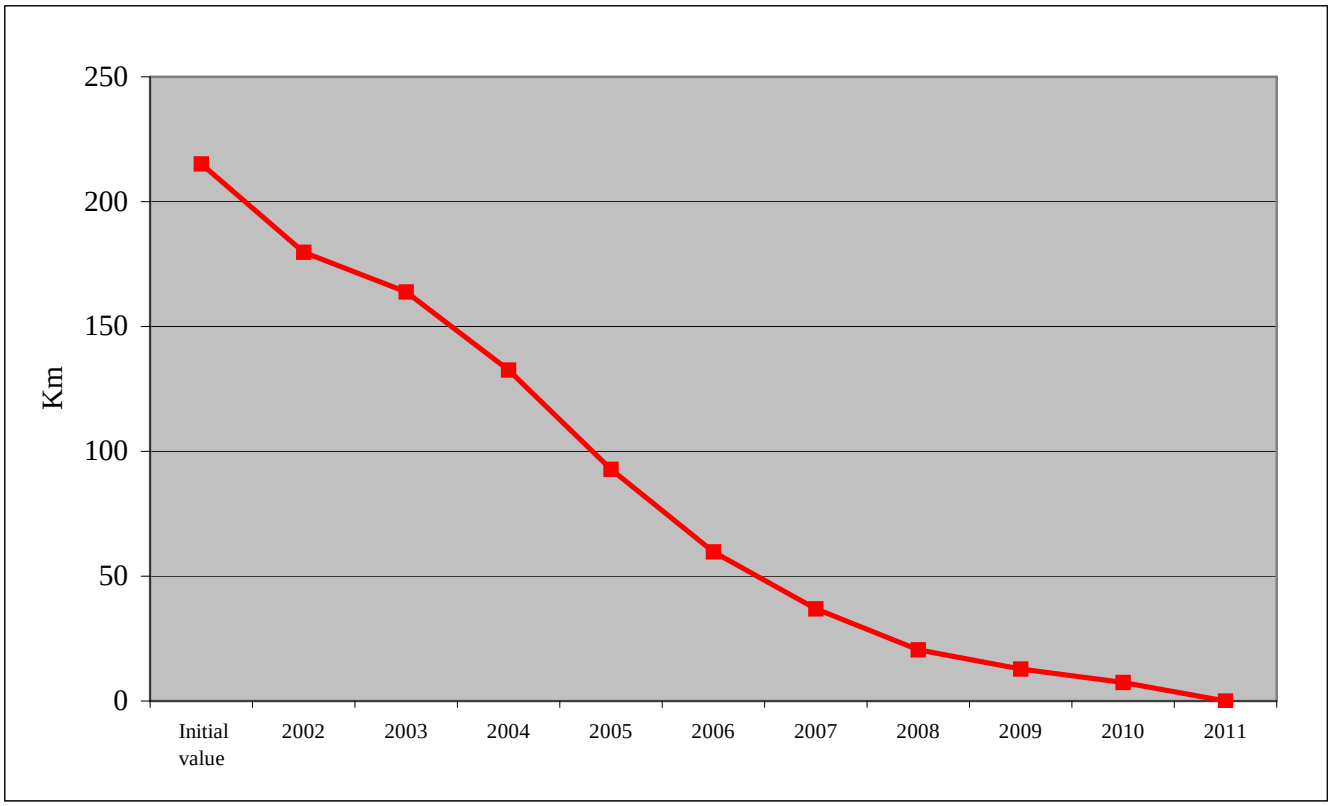
2.2 CONSTRAINED BUDGET (3.5 / 2.5 mill. per year):

The below graph and table show the investments required for the constrained budget plan. The precondition of this plan is of course the constrained budget (£3.5m the first six years and £2.5m in the last four years). The solution chosen for each section is the optimum one provided that the constrained budget allows it. When the constraining limit is reached in the individual year then the system will try to find other saved solutions in other years (different treatment/other treatment year). This will of course result in a number of sections falling within the category "Low standard" (see next page) due to the progress of the deterioration.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
1. Reinforcement	0	0	0	2	0	0	0	0	0	0	2
2. Pavement	3.111	3.195	3.059	2.759	3.013	3.024	1.876	1.632	1.937	1.725	25.331
3. Pre. repair	59	36	102	403	174	158	389	554	140	282	2.297
4. Anc. costs	320	231	280	295	284	281	177	166	180	138	2.351
5. Repair	10	39	60	40	29	37	58	148	241	28	690
Total	3.500	3.500	3.500	3.500	3.500	3.500	2.500	2.500	2.499	2.172	30.670

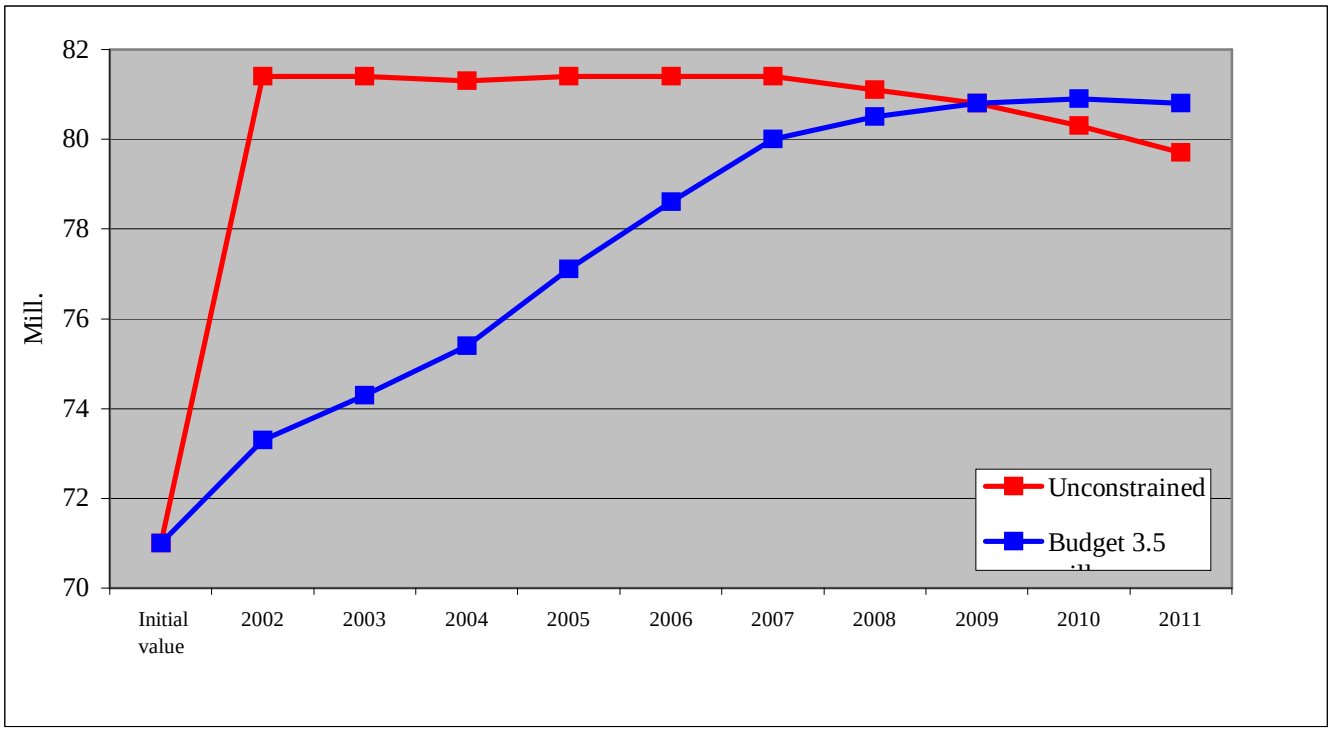
Accumulated lengths of road with "Low standard"



Below totals are in km.	Init.	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1. National Primary	10.3	0	0	0	0	0	0	0	0	0	0
2. National Secondary	0.9	0	0	0	0	0	0	0	0	0	0
3. Regional Primary	10.3	3.5	0.7	0.2	0.2	0	0	0	0	0	0
4. Regional Secondary	12.5	9.5	3.8	2.1	0.3	0	0	0	0	0	0
5. Local Primary	37.4	24.4	9.7	2.6	1.2	0.8	0.7	0.7	0.7	0	0
6. Local Secondary	44.6	43.4	39.2	27.3	8.7	4.2	2.5	1.4	0.7	0.5	0
7. Local Tertiary	99.2	99.0	110.5	100.3	82.3	54.7	33.8	18.5	11.4	7.0	0
Total:	**215.2**	**179.8**	**163.9**	**132.6**	**92.7**	**59.7**	**37.0**	**20.6**	**12.8**	**7.5**	**0**

The above graph and table show the accumulated lengths of roads within the category "Low standard". The table specifies the lengths for each road class. Please note that after treatments in year 2011 no sections falls within the category "Low standard".

10 year survey, road asset development



The above graph shows the development in the road asset value for both calculated plans. The graph very clearly reflects the differences in the investments.

The “new” road asset value for a completely resurfaced road network without any defects is £84m.

2.3 ROSY OUTPUT DESCRIPTION:

In Appendix 1A, reports recommending measures needed in order to obtain the required road standard at a given time. The recommendations and the investment needs are presented for the individual road sections and as a total survey of the entire road network. In addition to this comes the possibility of spreading a total of 10 years investment over the entire calculation period or to have this indicated per year in the period. Whilst the maintenance programme is for 10 years there is an advantage in the optimisation calculations being made with a calculation horizon of 15 to 20 years, while the result period is still presented with a 10 years "window".

Below follows a description of how calculations and reports can be generated on the basis of the monitoring and condition survey:

The geometric data, functional and structural condition data collected on the road network is stored in an open structured relation database (RoSy® BASE). Maintenance methods, products and traffic loads are stored in the same way. Furthermore, the service level that @@ requires as a minimum for the roads has been set up as well as deterioration models for each defect type selected for recording. On the basis of this RoSy® PLAN will run through the following processes:

- ***One homogenous section:*** A visual defect condition section chosen as a result of the condition survey.
- ***Sectioning:*** The defect section is automatically divided into maintenance/calculation sections if differences in bearing capacity or traffic exceed the user-defined tolerances.
- ***Calculate section the first year:*** Data as area, amount of defects, traffic, bearing capacity are linked to the calculation section. All the data is actualised up to date, according to the progression / deterioration model to each set of data.
- ***Calculate Section xx year:*** The different data types are progressed inside the calculation period using the different models.
- ***Repair calculation:*** Calculation of repair combinations over a period of up to 5 years, and the 5 years are calculated floating during the period.
- ***Safety calculation:*** During the period of repair combinations (5 years) eventual day-to-day safety maintenance is calculated e.g. patching of potholes.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Comb. 1										
Comb. 2	Repair									
Comb. 3	Repair	Repair								
Comb. 4	Repair	Repair	Repair							
Comb. 5	Repair	Repair	Repair	Repair						
Comb. 6	Repair	Repair	Repair	Repair	Repair					
Comb. 7		Repair	Repair	Repair	Repair	Repair				
Comb. 8			Repair	Repair	Repair	Repair	Repair			
Comb. 9				Repair	Repair	Repair	Repair	Repair		
Comb. 10					Repair	Repair	Repair	Repair	Repair	
Comb. 11						Repair	Repair	Repair	Repair	Repair
Comb. 12							Repair	Repair	Repair	Repair
Comb. 13								Repair	Repair	Repair
Comb. 14									Repair	Repair
Comb. 15										Repair

Repair means possible repair in the actual year (for each combination there are 32 sub combinations).

- ***Paving calculation xx years:*** In this step each section will be combined and calculated over a 10-20 year period, with all the possible combinations of available treatment products. The different repair and paving products (treatments) have many user defined parameters such as:

- Different unit costs at different areas.
- Different service life at different levels of traffic flows.
- Treatment types dedicated to specific road class/classes.
- Treatment only to be used if condition is inside a specified limit.
- Prior repair of specified defects.
- The treatments influence on existing bearing capacity, etc.

- ***Output from basic calculation:*** With a calculation period of e.g. 15 years, minimum 17 solutions (maintenance strategies) are saved in a file to be used for constrained budget simulations. By choosing no constrains of possible strategies to be stored and many maintenance products possible to be used more than 1000 strategies may be stored per each maintenance section. For each year in the calculation period the optimum solution is saved (first solution: first paving in year 1. Second solution: first paving in year 2 etc.). One solution without paving but with the necessary repair of defect is saved and one solution without investment at all is saved (to be used in the constrained budget simulations when the budget sealing has been reached). With several alternative solutions for each section, it is possible to fit in sections “to maintenance” using the years where the budget has not been used.

- **Output from RoSy ® - Examples of report types**

RoSy® BASE :

Various themes can be printed out from the database:

- *Standard road list* (main data about the road section)
- *Road widths*
- *Roadside elements* (kerb, footway, etc.)
- *Traffic load* (ESA)
- *Layers* (information on pavement structure details)
- *Defect sections* (a list with existing homogeneous sections)
- *Visual condition survey* (detailed list for each section)
- *Bearing capacity*

RoSy® BASE/PLAN :

- Repair products
- Pavement products
- Roadside element products

RoSy® PLAN : Unconstrained budget:

3- Economy Analysis list report:

This report is very comprehensive and is well suited for detail study of calculations. Each maintenance section is described on minimum 17 pages with a calculation horizon of 15 years. This means that a calculation of 1000 sections results in 17,000 pages. We therefore recommend using this report only for study of a few sections. 15 of the 17 pages indicate in which years paving is needed. Page 16 gives solutions without paving but with repair and page 17 solutions without any investment at all. Furthermore, general information on the section is given as well such as district, section number, name, lane from and to chainages, road classes, etc.

All years of the calculation period are shown and the status of several parameters and conditions of the section can be followed. The years, in which maintenance is needed (repair of defects or pavement), are indicated with amounts and investment requirements. Years with low standard sections are indicated as well. “Low standard” sections are sections with service levels lower than chosen for the actual road section.

***Constrained and Unconstrained Plan*:**

Investment Allocation Report:

Plans based on constrained and unconstrained budgets are shown in this report with 1 or 2 pages per plan. Data is presented graphically and with figures indicating the total investment requirement for the entire road network over the calculation period. Totals are given for each individual year and the investments are given per product group.

Capital Development Report (asset value):

This report presents 1 page per plan (unconstrained and constrained). The change in road capital value over the calculation period is presented. The average replacement values for each layer in the pavement structure are indicated as well. These values and the model used for calculation of the decline in road capital value are applied for calculation of the actual road capital values.

Unconstrained & Constrained Budget Maintenance plan Report
From the unconstrained plan, the economical optimum solution for each section is printed out.
The constrained plan will suggest the solution that has been chosen (depending on the constrained budget). Information on whether or not it is the optimum solution is indicated and in case it is not, the plan indicates number of years with low standard. The contents of the report are identical with the contents of the analysis report except that the latter report shows the years where maintenance must be done (repair or paving) only. For 1000 sections this report generates approx. 600 pages.

Specification per road Report:
This report focuses on the first year of the calculation. For each section recommendations for the first year are presented, but only for the sections requiring maintenance. The Report for the constrained budget also lists the sections where the solutions are not the optimal ones and the years with low standard. For 1000 sections the report generates approx. 50-100 pages.

Product Specification Report:
For each product type used in the first year this report will list the sections on which the product is used. Totals for each product are shown as well. For 1000 sections this report generates approx. 20 pages for each plan calculated.

Product totals Report:
Totals for each product type used in the first year are generated in this report.

RoSy® PLAN: Constrained budget:
Load standard roads - report (sections):
The sections with low standard somewhere in the first 10 years of the calculation period are listed in this report. At the same time the report lists the years in which sections are classified as low standard and for how many years they stay low standard. The report is grouped according to road classes. For 1000 sections the report generates approx. 20-30 pages for each plan. This will, however, depend on the constrained budget.

Low standard roads - total report (km total):
This reports lists the total number of kilometres with low standard and is grouped according to road classes. The report generates one page for each budget.

Further information on printouts can be found in the RoSy user manual.

2.4 TRIP HAZARDS:

All the defects causing trip hazards have been registered. Depending on the defect type the quantity has then been multiplied by the unit cost (see section 1.3.5).

Per defect type:

Type	Cost
Cover	£106,590
Crack	£733,801
Patch	£715,214
Settlement	£595,114
Total	**£2,150,719**

Per road class:

Class Name	Cost
1. National Primary	£166,805
2. National Secondary	£22,628
3. Regional Primary	£120,381
4. Regional Secondary	£104,271
5. Local Primary	£438,614
6. Local Secondary	£402,564
7. Local Tertiary	£895,456
Total	**£2,150,719**

See appendix 1B for specification per road section.

2.5 KERB DEFECTS:

The kerb defects have been registered (unit is m). Depending on the defect type the quantity has then been multiplied by the unit cost (see section 1.3.5).

Per defect type:

Type	Cost
Broken	£96,818
Missing	£41,947
Separation	£80,248
Sinking	£133,320
Total	**£352,332**

Per road class:

Class Name	Cost
1. National Primary	£6,920
2. National Secondary	£675
3. Regional Primary	£16,791
4. Regional Secondary	£13,929
5. Local Primary	£63,953
6. Local Secondary	£55,381
7. Local Tertiary	£194,684
Total	**£352,332**

See appendix 1B for specification per road section.

2.6 DRAINAGE DEFECTS:

The defects causing drainage problems have been registered. Depending on the defect type the quantity has then been multiplied by the unit cost (see 1.3.5).

Per defect type:

Type	Cost
Blocked	£52,000
Crack	£832
Pothole	£3,941
Protrude	£67,360
Settlement	£194,963
Total	**£319,095**

Per road class:

Class Name	Cost
1. National Primary	£6,687
2. National Secondary	£1,880
3. Regional Primary	£14,304
4. Regional Secondary	£15,861
5. Local Primary	£68,505
6. Local Secondary	£60,124
7. Local Tertiary	£151,734
Total	**£319,095**

See appendix 1B for specification per road section.

2.7 DRIVEWAYS:

All the driveways have been registered. They are grouped in “ramp up” and “ramp down”. Each driveway recorded is calculated with £840 (see section 1.3.5).

Per defect type:

Type	Cost
Ramp down	£78,120
Ramp up	£1,647,240
Total	**£1,725,360**

Per road class:

Class Name	Cost
1. National Primary	£4,200
2. National Secondary	£0
3. Regional Primary	£1,680
4. Regional Secondary	£8,400
5. Local Primary	£155,400
6. Local Secondary	£237,720
7. Local Tertiary	£1,317,960
Total	**£1,725,360**

See appendix 1B for specification per road section.

3 ROSY® MAP

A linking between data in RoSy® BASE and the road centre lines was made on the basis of data received from @@ (see section 1.3.1).

2100 sections of the approx 2400 sections could be linked without problems. The remaining 300 sections could be grouped into three categories:

1. Sections surveyed but without centre lines.
2. Deviations in length. The actual measurements made by GMCB were used for the linking. The centre lines supplied by @@ were not measured on site but were taken from a road map.
3. Deviations in length in cases where GMCB joined two or more short sections to one section.

Apart from above there were problems with the direction of some of the centre lines delivered by @@. The direction of the individual centre lines indicated by @@ did not always correspond to the section descriptions. The section descriptions were used for the data collection.

The remaining 300 sections were linked on the basis of information received from @@.

4 TRAINING

In December 2000 @@ had the first version of RoSy® installed. Minor training sessions were held during the project and these were closed with 2 x 2 days of training in use of the RoSy modules.
The following participated in the training:

Rosy® Dig	@@	-T/Exec
All Rosy & plan	@@	-Senior
All Rosy & plan/dig	@@	-Senior
All Rosy plan	@@	-Exec
Rosy® plan	@@	-Exec
Rosy® plan	@@	-Exec
Rosy® Dig	@@	-Exec

5 CONCLUSION AND RECOMMENDATIONS

Road Pavement Analysis

The unconstrained budget plan shows that a total investment of £29m is required for the road network in the 10-year period starting in year 2002.

The investment of £16 mill required in year 2002 indicates a maintenance backlog.

During the 10-year period the road asset value is reported to increase from £71m to £80m compared with the investments of £29m.

Before any treatment is done in year 2002 215 km of road falls within the category "Low Standard" (roads falling below minimum standards of condition). By definition the unconstrained plan does not allow "Low Standard" sections. This is the reason for the high capital requirement in year 2002.

The constrained budget plan (£3,5m per year in the first six years and £2,5m per year in the last four years) shows that the total investment in the 10-year period is £30m.

During this period the road asset value increases by £10m to £81m. The costs during the plan period will be the difference between the total sum invested and the benefits arising from the increased road asset value (£30m - £10m = £20m).

The effect of constraining the budget is that some road sections fall below the minimum standards of condition set by the user. With the calculated constrained budget initially 215 km of roads fall in the category of "Low Standard". An investment of £3,5m in year 2002 means a reduction to 175 km roads in the category "Low Standard". After 10 years the roads in the category "Low standard" are eliminated.

The above analysis indicates that the applied budget is sufficient to eliminate the "Low standard" roads within the calculation period.

Trip hazards, kerb and drainage defects and driveways

Road pavements can be optimised or calculated for several years. This is, however, not possible for road side area elements at the moment in RoSy PMS. This facility is under development at the moment. The defects are registered on the day the condition survey took place and cost calculations are made for repair of the defects. The below should thus be regarded as an up-to-the-minute account.

Total cost for repair appears from the table below:

Defect type	(£)
Trip hazards	2,150,719
Kerb defects	352,332
Drainage defects	319,095
Driveways	1,725,360

Footpath / Footways

In 2001 @@ spent £1.575m for maintenance of the footpaths. The calculated cost for repair of the present defects regarding footpath is £2.5m (this figure does not include reconstruction of footpath sections but only repair of the present defects).

The budget spent on footpaths does not eliminate the backlog. Our experience with maintenance and reconstruction cost for footways tells us that the total cost of eliminating the backlog (including reconstruction of footpath sections with too high defect levels) is approx. five times higher than the repair costs. This means that the cost of eliminating the maintenance backlog of the footpaths is about £12m.
Taking into account that the net deterioration of the footpaths will decrease while the backlog is being eliminated, we recommend increasing the annual budget with £1.5m to £3.0m over the next 6 years (an extra £9m) and then reduce the budget to £1.0m.

Bearing Capacity Analysis

During the condition survey only few sections showed signs of poor bearing capacity. A total of 34 sections were measured with a Falling Weight Deflectometer and only 10 of the sections needed reinforcement (10-50 mm). This result indicates, that the bearing capacity of the roads in @@ City is generally good.

RoSy® MAP

The roads in RoSy® Base have been linked to road centrelines and can now be visualised in RoSy® MAP.
This means that all sorts of data can be seen for the road network if constructed on the basis of the data stored in RoSy® BASE and RoSy® DIG. Data calculated with RoSy® PLAN can be visualised as well, for example all roads with high traffic density, all roads with a certain kind of defects, all roads with trench works, all roads paved with a certain kind of maintenance pavement in year 2002.

Recommendations

A complete implementation of an open and flexible Pavement Management System as RoSy® PMS may take several years. During this process the calculation models and parameters will be adjusted, which will improve the analyses made.

Deterioration models are improved over time simultaneously with the gathering of experience with the deterioration of the various defect types on the various pavement types subjected to various traffic loads.

Service levels can be adjusted. This will influence on both costs, development in road asset value and number of km below standard.

Treatment types can be adjusted and updated so that they are used correctly.

Miscellaneous parameters can be adjusted – e.g. minimum kerb height.

Road section data can be improved (traffic data). We recommend introducing a system in order to secure that changes on road sections are updated in the RoSy road database (annual resurfacing). A routine for condition surveys should also be introduced. It is recommended to select 20-30% of the road network each year, so that the entire road network has been surveys after 3-5 years.

We recommend @@ to designate persons, who will then become responsible for the individual phases in the pavement management process so that the system is kept up to date and running.

Furthermore, we recommend that @@ receive follow up training in order to maintain and update the knowledge of RoSy PMS. To improve this it is recommended that @@ enters into an agreement with GMCB so that new versions of RoSy® PMS is received automatically and to have the possibility of hotline service.

6 EXAMPLES OF REPORTS GENERATED FROM ROSY BASE

Below we have listed a number of reports that can be generated from RoSy BASE and PLAN. Reports can be generated from all RoSy modules.

RoSy BASE contains a number of standard reports, which are listed below. RoSy BASE can be expanded with the report generator, Crystal Report, allowing editing of standard reports or new ones.

Reports printable from RoSy BASE:

BASE folder **Report name and field contents:**	**Sorting order:**	**Filename:**
Standard road list: Road No., Road class, road name, chainage 0, update date, old road No., length, area, remark/description	District – road No.	1-Roadlist.rpt
Road area: Contains width data on each road: Road No., road class, road name, chainage 0, update date, old road No., length, area, remark/description	District – road No.	2-Roadarea.rpt
Roadside area elements: Road No., road class, road name, chainage 0, lane, update date, from ch., to ch., from width, to width, add. area	District – road No. – lane – from ch. – to ch. - position	3-Roadsideareael.rpt
Roadside area element totals: Show roadside area element types with totals of number of metres and area for each product.		4-Roadsidearea.Totals.rpt
Pavements: Road No., road class, road name, chainage 0, lane, update date, from ch., to ch., thickness, poduct, paved	District – road No. – lane – from ch. – to ch.	5-Pavements.rpt
Traffic data: Road No., road class, chainage 0, lane, update date, from ch., to ch. AADT, SA, rec. method	District – road No. – lane – from ch. – to ch.	6-Traffic.rpt
Condition survey scheme: Visual condition survey for data collection		7-ConditionScheme.rpt
Condition survey: Survey of conditions per section	District – road No.	8-ConditionSurvey.rpt
Bearing capacity results: Road No., road class, road name, chainage 0, lane, update date, from ch., to ch., survey date, traffic, service life before, reinforcement, extra tonnes	District – road No. – lane – from ch. – to ch.	9-BearingCap.rpt
Register control		A-RegisterCheck.rpt

DOCU folder **Report name and field content**	**Sorting order:**	**Filename:**
Repair products All data on all repair products	Product name	1-RepairProducts.rpt
Repair Products (compact) All data on all repair products	Product name	2-RepairProducts_Survey.rpt
Pavement Products All data on all pavement products	Product name	3-PavementProducts.rpt
Pavement Products (compact) All data on all pavement products	Product name	4-PavementProducts_Survey.rpt
Road side area element products All data on road side area element products	Product name	5-RoadSideAreaElPro.rpt
Road side area element products (compact) All data on road side area element products	Product name	6-RoadSideAreaElPro_Survey.rpt
Condition limits (defects)	Road class – distress class – traffic class	7-ConditionLimits.rpt

EXTRA Folder **Report name and field content:**	**Filename:**
Notes per category	1-Notes.rpt
Winter service – road name order	2-WinterServices.rpt
Winter service – route order	3-WinterServices_Route.rpt
Gulleys and Manholes – additional register	4-GulleysManholes.rpt
Marking – additional register	5-Marking.rpt
Signs – additional register	6-Signs.rpt
Light posts – additional register	7-LightPosts.rpt
Road furniture – additional register	8-RoadFurniture.rpt
Defects on road side area elements – additional report	9-RoadSideAreaDefects.rpt
Condition level survey – additional report	A-ConditionLevelSurvey.rpt
Condition percentage survey – additional report	B-ConditionPercentSurvey.rpt
Survey for byroads pr. road	C-Byroads.rpt

REPAIR Folder **Report name and field content:**	**Filename:**
Sealing Repair report for small cracks	1-Sealing.rpt
Jointing Repair report for large cracks	2-Jointing.rpt
Crazing Repair report for crazing (alligator cracking)	3-Crazing.rpt
Spalls and potholes Repair report for spalls and potholes	4-SpallsPotholes.rpt
Leveling Repair report for settlements and hanging shoulders	5-Leveling.rpt
Emulsion SD (Surface Dressing) Repair report for loss of chippings	6-EmultionSD.rpt
Verge and ditch Repair report for verge regulation and pruning of ditches	7-VergeDitch.rpt

7 EXAMPLES OF REPORTS GENERATED FROM ROSY PLAN

RoSy PLAN contains a number of standard reports.

RoSy PLAN can be extended with a report generator Crystal Report, which allow adjustment or creation of new reports. If further details are wished about the product, these can be obtained by contacting GMCB or by visiting below homepage.

http://www.seagatesoftware.com/products/crystalreports/default.asp

The following are the reports that can be printed out from RoSy PLAN:

Analysis: 1-UnconstrainedMaintenancePlan.rpt

The report shows all measures in a ten-year period for each individual section. The selected solutions are the economically most optimum solutions. This means the less expensive solutions not resulting in low standard roads. From the list the development in visual remaining service life and residual life (bearing capacity) and reinforcement need appear as well as the actual quantity of defects in per cent per defect. For evaluation of the quality of the solutions the list IRR, BC and the average cost/year/m^2 is shown. In addition to this the total investments in the period and the corresponding capital values are indicated. NB: IRR = Internal Rate of Return, BC = Benefit Cost

Analysis: 2-BudgetMaintenancePlan.rpt

The report shows all measures in a ten-year period for each individual section. The selection of the solutions is based on the BC value, however in relation to years with low standard. The development in visual remaining sercice life and residual life (bearing capacity) and reinforcement appears from the list as well as the actual quantity of defects in per cent per defect. For evaluation of the quality of the solution the list shows IRR, BC and the average cost/year/m2. Furthermore, the total investments during the period and the corresponding capital values are indicated. NB: IRR = Internal Rate of Return, BC = Benefit Cost

Analysis: 3-UnconstrainedAnalysisList.rpt

The report contains all the solutions stored under the calculation. WARNING: Should be used for analysis of one or a very limited number of roads, as the list will otherwise become too comprehensive. ONLY for analysis. The list shows the capital development during the period. The calculated defects development can be followed. This development is created on the basis of the initial condition of the section and the measures carried out. The report asks for a road number in order to limit the list, use this.

Below is an example of page 3 of 11.288 pages (a relatively small calculation). This report used approximately 700 Mb on the harddisk SO BE CAREFUL.

Budget: 1-InvestmentAllocation.rpt

The report lists totals of investments per product group per year. These values are also presented graphically. If more budgets are indicated, these will be listed one after the other. Shoulder/ditch and safety repairs are not part of this budget.

This example shows an increasing expense for safety repairs, an indication that the budget amount is too low.

Budget: 2-CapitalDevelopment.rpt

The report shows the calculated development in capital for the selected road network. If more budgets have been entered when starting the calculation, these will be listed one after the other. The list indicates the current value for all roads, the value of the road network in its present condition (initial value) and the calculated capital value for the individual years in the period (provided that the measures in the budget plan are carried out).
The below example is a typical example of a too low budget, the road capital tends to fall.

Budget: 3-ProductTotals.rpt

Investments and quantities for the first year of the calculation. The list is divided into product groups and then values are indicated per product.

Sort order: Budget, product group, product

Budget: 4-ProductSpecification.rpt

The report lists the individual sections to be maintained the first year. The sections are listed in product order. The products are divided into the following groups: ’Reinforcement’, ’Wearing course’, ’Prior repair’, ’Ancillary costs’, ’Other repair’, ’Safety repair’, ’Roadside area elements’. Totals are given per product, per priority and per district. If district and priority are not applied the three totals will be identical.

Sort order: Budget, product group, product, district, road no./name, chainaging

Budget: 5-SpecificationPerRoad.rpt

The report lists all measures, to be carried out in order to comply with the constrained budget plan for the budget in question. The list contains only sections requiring measures in the first year.
The report asks for a year. Year 2000 could then be indicated, which means that only year 2000 will be studied. By clicking the button OK and accepting the indicated value 9999, all years in the calculation will be studied.

Sort order: Budget, priority, district, road no./name, chainaging

Budget: 6-PavementRepair.rpt

The report lists all roads included in the calculation, which includes roads that will not need any measures in the period. Condition level before the carrying out of any measures is listed. All pavement and repair measures in the calculation period are listed.

Sort order: Budget, priority, district, road no./name, chainaging

Budget: 7-RoadsLowStandardTotal.rpt

The report lists number of km with 'LOW STANDARD' per road class, per priority. If more budgets are indicted, these will be listed one after the other. If no priority is made between the road classes, then only one priority will apply.

The list illustrates well how the limited resources are applied. Among other things it is possible to see for which priorities funds have been allocated (number of roads with low standard does not increase).

Sort order: Budget, priority, road class

Budget: 8-RoadsLowStandard.rpt

The report lists all roads that at one time or the other during the calculation period will have 'LOW STANDARD' status because the condition limits defined for the road class are exceeded. The list indicates in which year a give section will have 'LOW STANDARD' status, and for how many years it has already had this status. Per budget totals for km of road with low standard status will be listed per year, per district and per road class.

Sort order: Budget, priority, district, road no./name, chainaging

Docu: 1-CalculationLog.rpt

The calculation log is shown after a calculation, if any errors and/or warnings were registered during calculation. If errors are registered, these must be corrected and a new calculation must be run. Warnings show incidents that may be of importance but not always are, they should however always be checked.
Errors may be lack of traffic data or products. Warnings may be information on joining of bearing capacity -/ traffic sections.

Docu: 2-DocumentationLog.rpt

The report is a documentation of all parameters with decisive influence on the result that RoSy PLAN delivers.
The list does not contain the applied products. These can be printed out separately (see RoSy BASE manual).

The example only shows the first page:

Economy: 1-InvestmentAllocation.rpt

The report lists totals for investments per measure group per year. These values are also displayed graphically. The basis of the report is the economically optimum solutions for the calculated road network.

The example shows a calculation with a considerable backlog. This means roads with low standard status before the calculation was started. In the unconstrained budget plan the system will compensate all these sections at once (a very large consumption in the first year)

Economy: 2-CapitalDevelopment.rpt

The report shows the calculated development in the capital for the selected road network. From the list the current value for all roads appears, the value of the road network in its present condition (initial value), and the calculated capital value for the individual years in the period (provided that all measures stated in the unconstrained budget plan is complied with).

The example shows the result of a very large investment in year 1 (see previous page).

Ecomomy: 3-ProductTotals.rpt

Investments and quantities for year 1 in the calculation. The list is divided into product groups and then per product.

The list contains quantities that are required to comply with the unconstrained budget plan.

Economy: 4-ProductSpecification.rpt

The report lists the individual sections maintained in year one. The sections are listed in product order. The products are divided into the following groups: 'Reinforcement', 'Wearing course', 'Prior repair', 'Ancillary costs', 'Other repairs', 'Roadside area elements'. Totals are listed per product, per priority and per district. If district and priority are not applied then the three totals are identical.

Sort order: Product group, product, district, road no./name, chainaging

Economy: 5-SpecifikationPrVej.rpt

The report lists all measures to be carried out in order to comply with the unconstrained budget plan. The list contains sections that require measures in year one. The report will ask for a year. It is possible to indicate e.g. that only year 2000 should be studied. When clicking OK and accepting the indicated value 9999, then all years in the period are studied.

Sort order: Budget, priority, district, road no./name, chainaging