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An analysis to set long term maintenance strategy for Bangladesh

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Abstract

An analysis was done using the HDM-4 model to derive long term pavement maintenance strategies and budget for 20 years in Bangladesh. It was observed that the maintenance demand is consistent with the Road Master Plan. The impact of budget and unconstrained work programs were also derived. It is believed that these results can help decision makers in planning and strategy setting for main road network.

Keywords: Maintenance Strategy, HDM-4 model, Maintenance Standards and Demand

1. Introduction

Regular and timely maintenance is the key for efficient road preservation. Maintenance strategies are a long-term plan which should be implemented so that road network is at good condition. It can help decision makers understanding the road network and budget scenario.

In Bangladesh, pavement maintenance strategies were not properly addressed till the Road Master Plan (RMP) was formulated in 2007 (RHD, 2007). However, the RMP has got the following limitations in setting maintenance strategies for the road network.

- The RMP analysis was not detailed,
- No maintenance standards were set prior to obtain strategies and backlog was also considered in setting maintenance strategy.

Theoretically there should not have any backlog if roads are maintained on time and with appropriate treatments. Therefore, strategically it is not wise to defer maintenance and accumulate backlog. It is always advisable to remove backlog at first. Khan (2005) and RHD (2007) also emphasized to remove backlog in the initial years.

Khan (2005) set optimum maintenance standards for Bangladesh assuming backlog is removed at first. The road network was clustered into 48 groups based on surface type, traffic volume and pavement width. It was observed that these groups were set appropriately. The RMP considered traffic volume and road condition while grouping the major road network in Bangladesh (RHD, 2007); however it indicates incorporation of backlog (due to poor roads) which is not advisable in the strategy analysis. Therefore, the RMP results need to be reviewed.

Though, Khan (2005) developed the standards for the whole road network, but maintenance strategies and demand were not possible to determine in that study, which is a vital for a road network. Therefore, this paper addressed to determine the long term maintenance strategies for Bangladesh and also to see the impact of different budget scenarios using the HDM-4 (Highway Development and Management) model.

2. Objectives

The followings were the key objectives of the current analysis.

- To derive long term maintenance strategies using the set standards by Khan (2005), and
- To assess different budget scenarios.

3. Approach of the Analysis

It was mentioned earlier that Khan (2005) set 48 road groups for main road network of Bangladesh based on 2 surface types (ST = Surface Dressing and AC = Asphalt Concrete), 3 traffic volume types (LT: Low Traffic $\leq$ 2050 AADT/lane; MT: Medium Traffic = 2050 – 4200 AADT/lane and HT: High Traffic $\geq$ 4200 AADT/lane) and 8 pavement width types (ST: Single Lane Two Way $\leq$ 4 m two way; IT: Intermediate Lane Two Way = 4 – 5.5 m two way; TT: Two Lane Two Way = 5.5 – 9 m two way; WTT: Wide Two Lane Two Way = 9 – 12 m two way; FT: Four Lane Two Way $\geq$ 12 m two way; TO: Two Lane One Way = 5.5 – 9 m one way; FO: Four Lane One Way $\geq$ 12 m one way and MO: Multi Lane One Way).

However, it was noticed that FO and MO road groups are absent at the moment in Bangladesh, which may be considered in future to upgrade the network and manage increased traffic volume. Therefore, ultimately, total road groups considered in the current analysis was 36.

The HDM-4 model was considered for the strategy analysis to review the demand and unconstrained works programme. Strategy analysis help in analysis the whole road network using representative road groups. Also, budget optimization was done to see the impact on budget scenarios. The following objectives were chosen in the analysis where Objective 1 is to obtain minimum costs keeping the road at a set IRI (International Roughness Index), Objective 2 was to only improve the road condition when fund is sufficient and Objective 3 is to obtain results by getting more economic benefits.

- Objective 1: Minimize cost at target IRI,
- Objective 2: Minimize IRI (improving road condition), and
- Objective 3: Maximize NPV (Net Present Value).

The obtained results were then compared with the RMP and Annual Needs Report of the Roads and Highways Department of Bangladesh (who deals with the main road network), and conclusions were derived. The flow chart of the steps considered can be seen in Figure 1.

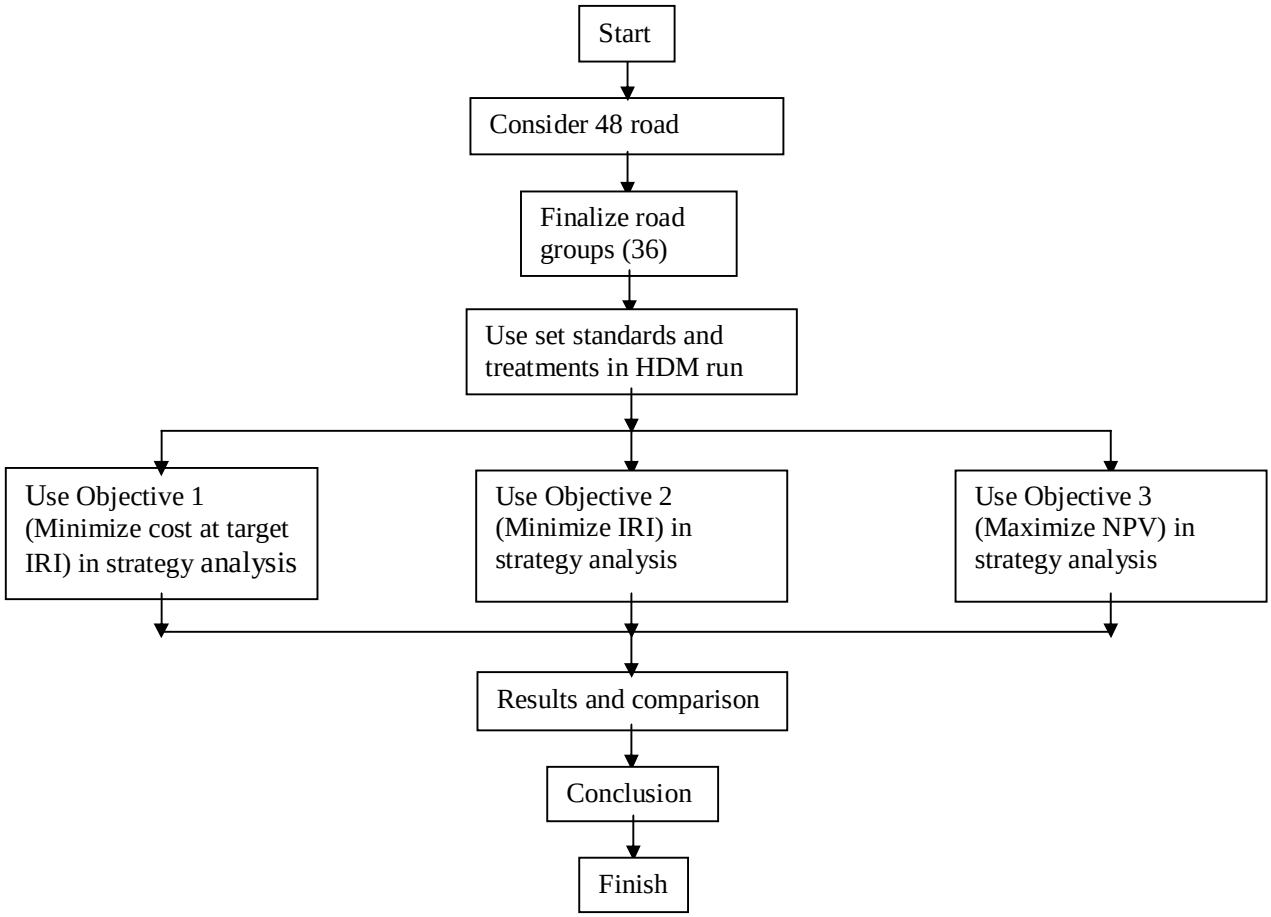

Fig. 1. Methods considered in the Current Analysis

4. Results

It was mentioned that HDM-4 strategy analysis was considered for this analysis. The 36 road groups and their road condition, treatment history, traffic composition and volume, treatment unit costs, etc were extracted from Khan (2005). Calibration factors for the road deterioration, work effects, road user effects models of HDM-4 were also taken from Khan (2005). Set optimum treatment intervention criteria and maintenance standards were considered in the analysis; details can be seen in Khan (2005). Annex 1 show the road groups, set standards and treatments considered.

The detail results can be seen in Figures 2, 3, 4, 5, 6 and 7 and in Annex 2. Figure 2 shows the Routine Maintenance (RM), Periodic Maintenance (PM) and total demand obtained in the analysis for 20 years which are similar to the RMP results. The main difference in PM and total demand between RMP and current analysis is mainly for backlog which was not taken care of in the current analysis. As the RMP considered backlog in their analysis, hence the demand was higher. Figure 3 reveals the percentage in demand. Figures 4 and 5 show the first

5 years demand in different analysis due to availability of first 5 years data in these sources, i.e., current analysis, RMP, Needs Report (2006-07) and Needs Report (2007-08). The result reveals that demands are varying; however, the current results, the RMP and average demand are close. Annex 2 reveals the results for maintenance strategy in different years for all road groups with unconstrained work programme, which may help the decision makers.

Figures 6 and 7 reveal the impact of budget, which show that if 100% budget is allocated as needed, the road network will be at average 6 IRI in the next 20 years and at 4.5 IRI in the first 10 years. Therefore, it is obvious that government has to make sure availability of the entire necessary budget. It can be said that the network cannot be maintained appropriately between 11 and 20 years even at 100% budget, which reasons may be as follows:

- Intervention years of the set treatments intervention criteria,
- Calibration factor for roughness progression was very high (3.3), which was derived from Khan (2004), and
- For LT (Low Traffic) roads no treatments were suggested by HDM-4 assuming less road deterioration, and as a result pavement performances were affected.

However, these results are still acceptable as they are similar to the RMP. It is worth mentioning that Objectives 2 and 3 results are shown as example in Figures 6 and 7 as Objective 1 provides the similar impact.

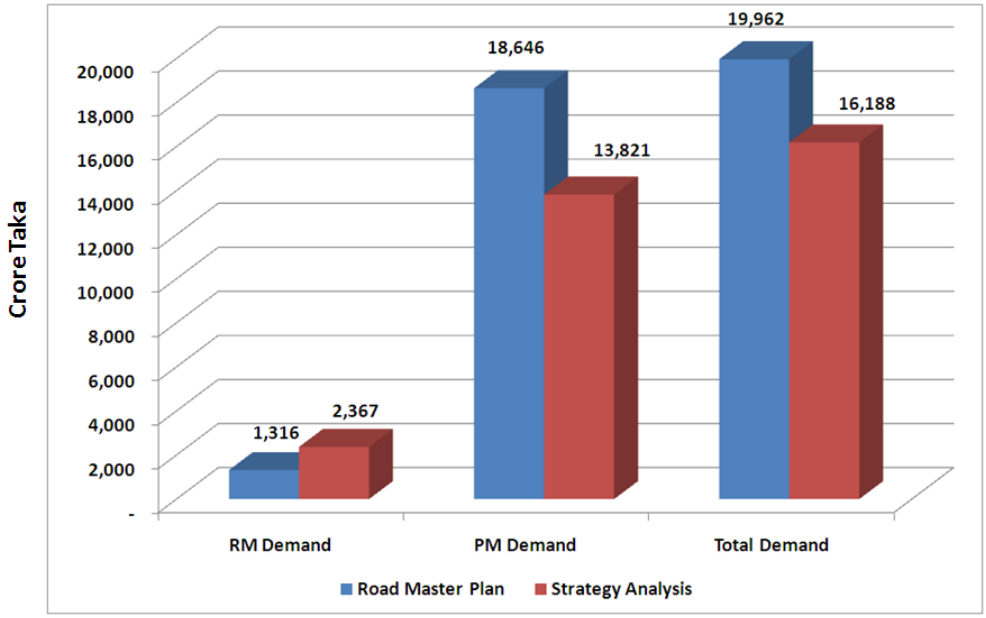

Fig. 2. Demand results (for 20 years) (1US$ = 68 taka)

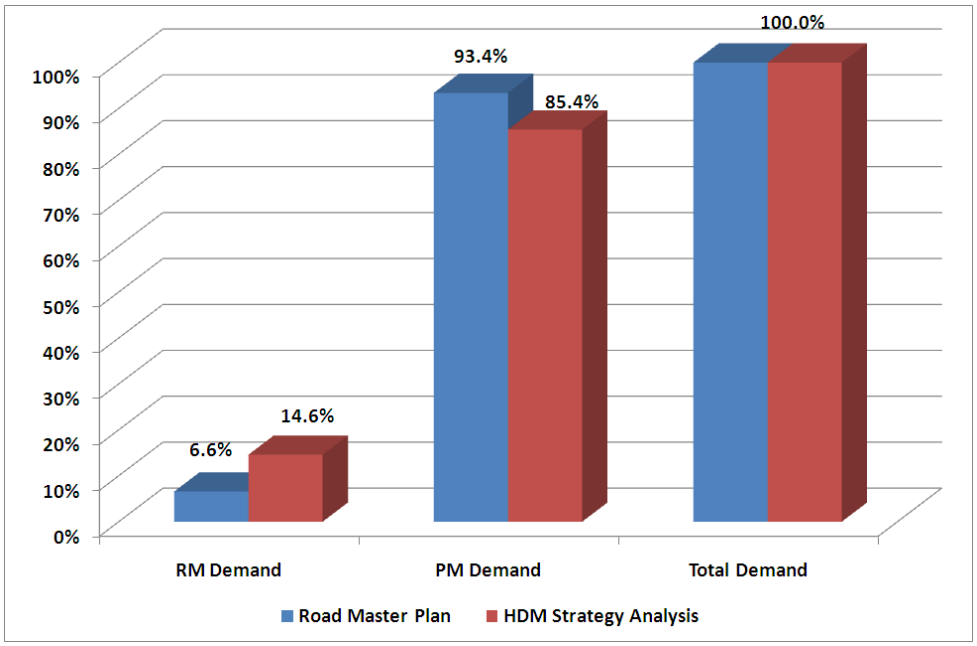

Fig. 3. Demand results in percentage (for 20 years)

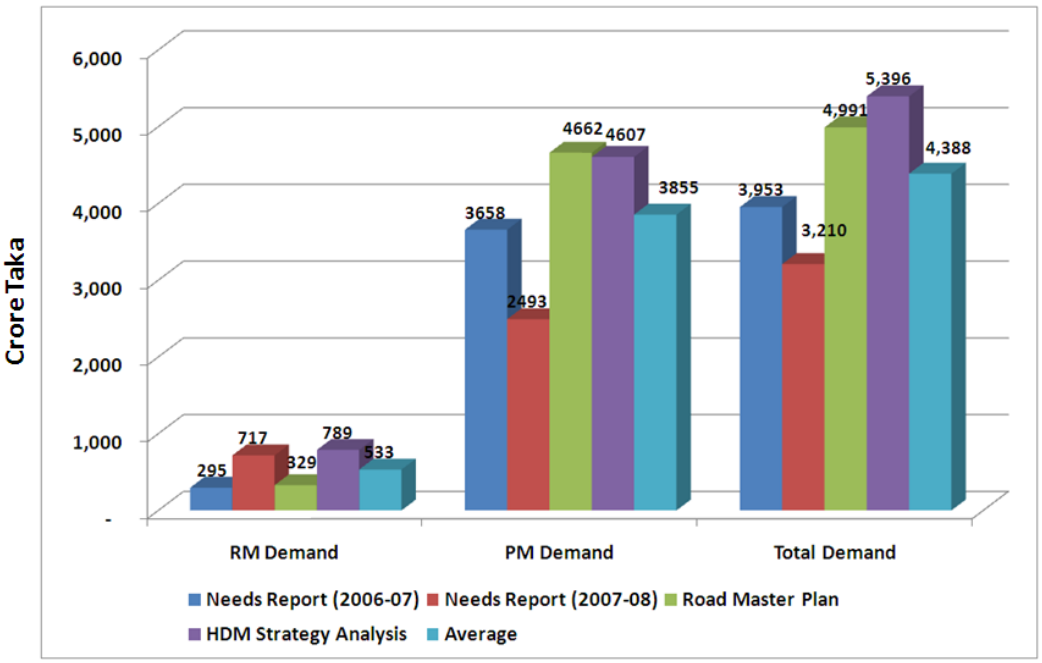

Fig. 4: Demand results (for 5 years)

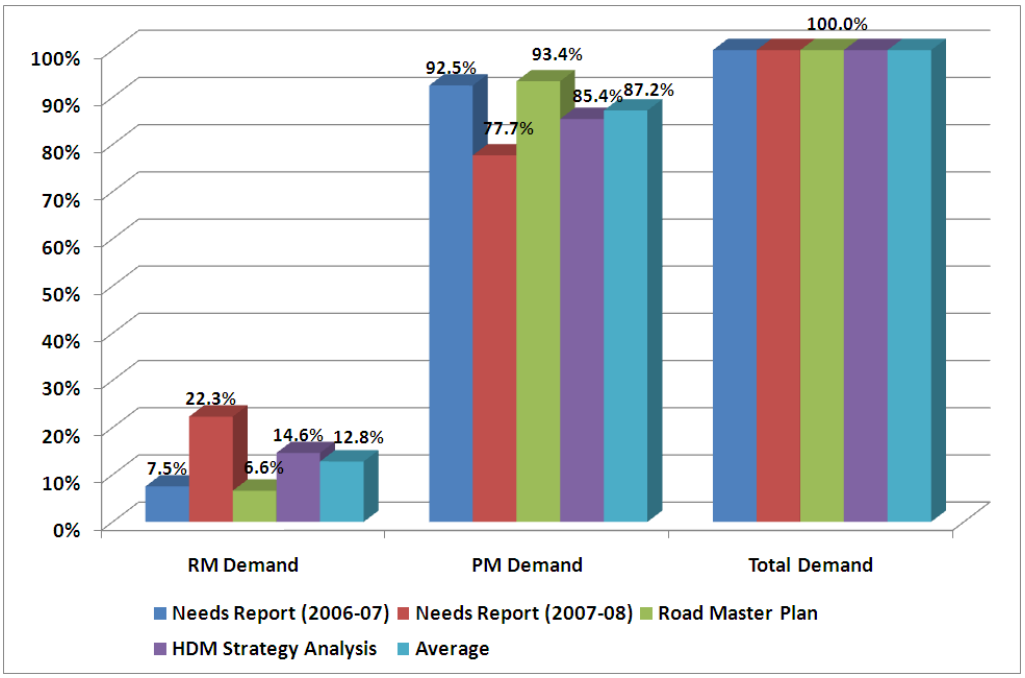

Fig. 5. Demand results in percentage (for 5 years)

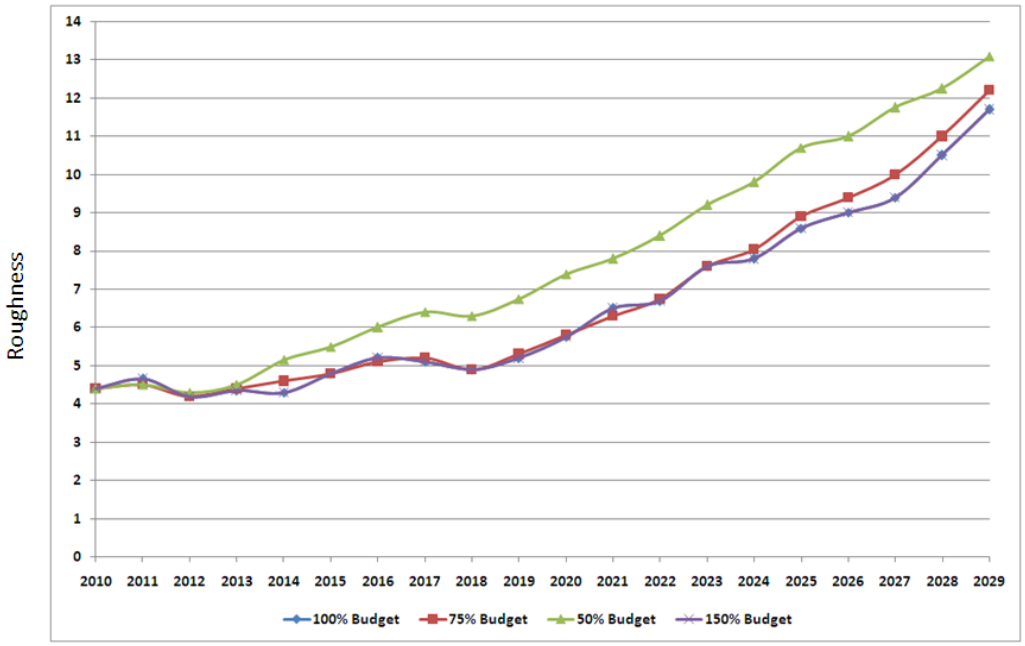

Fig. 6. Budget scenario (objective 2)

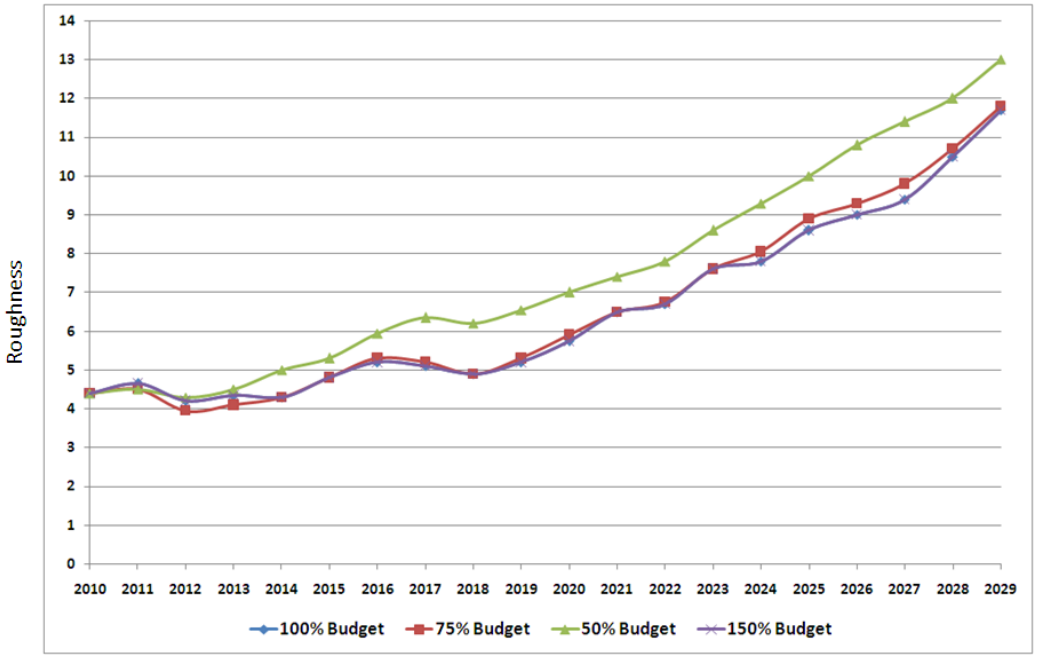

Fig. 7. Budget scenario (objective 3)

5. Conclusions

This analysis considered the reliable inputs for HDM-4, e.g., 36 road groups, set standards and treatment intervention criteria and calibration factors. Hence, the results are justifiable. Moreover, the demands obtained in the current analysis are similar to the RMP. It is believed that the decision makers will use the results in future strategy setting.

The total routine and periodic maintenance demand for the primary roads is about 162,000 million taka. The budget scenario reveals that the road network will be at an acceptable standard for the first 10 years and at a fair level in the last 10 years. It indicates a requirement of review of the roughness progression factor and treatment intervention criteria in future.

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Annex 1
Selected optimum maintenance standards for 36 road groups (see Khan, 2005 for details)

Road Group	Description of the Road Group	Selected Optimum Maintenance Standard	Treatments Required at Optimum Standard	Representative Length (km)
STHTST	Surface treatment, high traffic and single lane two-way	5 IRI	RM + Carpeting at 5 IRI	141
STHTIT	Surface treatment, high traffic and intermediate lane two-way	6 IRI	RM + Overlay 80 mm at 6 IRI	141
STHTTT	Surface treatment, high traffic and two-lane two-way	4.5 IRI (Engg. judgment)	RM + Overlay 80 mm at 4.5 IRI	174
STHTWTT	Surface treatment, high traffic and wide two-lane two-way	3.5 IRI	RM + Overlay 80 mm at 3.5 IRI	7
STHTFT	Surface treatment, high traffic and four-lane two-way	3.5 IRI	RM + Overlay 80 mm at 3.5 IRI	4
STHTTO	Surface treatment, high traffic and two-lane one-way	4.5 IRI (Engg. judgment)	RM + Overlay 80 mm at 4.5 IRI	8
STMTST	Surface treatment, medium traffic and single lane two-way	4 IRI (Engg. Judgment)	RM + Carpeting at 4 IRI	1909
STMTIT	Surface treatment, medium traffic and intermediate lane two-way	5 IRI	RM + Overlay 80 mm at 5 IRI	862
STMTTT	Surface treatment, medium traffic and two-lane two-way	4 IRI (Engg. judgment)	RM + Overlay 80 mm at 4 IRI	205
STMTWTT	Surface treatment, medium traffic and wide two-lane two-way	4.5 IRI (Engg. judgment)	RM + Carpeting at 4.5 IRI	8
STMTFT	Surface treatment, medium traffic and four-lane two-way	4 IRI (Engg. judgment)	RM + Overlay 80 mm at 4 IRI	5
STMTTO	Surface treatment, medium traffic and two-lane one-way	4.5 IRI (Engg. judgment)	RM + Overlay 80 mm at 4.5 IRI	9
STLTST	Surface treatment, low traffic and single lane two-way	5 IRI	RM + Carpeting at 5 IRI	8274
STLTIT	Surface treatment, low traffic and intermediate lane two-way	6 IRI	RM + Carpeting at 6 IRI	1566
STLTTT	Surface treatment, low traffic and two-lane two-way	5 IRI	RM + Overlay 60 mm at 5 IRI	257
STLTWTT	Surface treatment, low traffic and wide two-lane two-way	4.5 IRI (Engg. judgment)	RM + Carpeting at 4.5 IRI	10
STLTFT	Surface treatment, low traffic and four-lane two-way	4.5 IRI	RM + Carpeting at 4.5 IRI	6
STLTTO	Surface treatment, low traffic and two-lane one-way	4.5 IRI (Engg. judgment)	RM + Carpeting at 4.5 IRI	11
ACHTST	Asphaltic concrete, high traffic and single lane two-way	5 IRI	RM + Overlay 80 mm at 5 IRI	47
ACHTIT	Asphaltic concrete, high traffic and intermediate lane two-way	5 IRI	RM + Overlay 80 mm at 5 IRI	94
ACHTTT	Asphaltic concrete, high traffic and two-lane two-way	3.5 IRI	RM + Overlay 80 mm at 3.5 IRI	697
ACHTWTT	Asphaltic concrete, high traffic and wide two-lane two-way	5 IRI	RM + Overlay 80 mm at 5 IRI	27
ACHTFT	Asphaltic concrete, high traffic and four-lane two-way	4.5 IRI	RM + Overlay 80 mm at 4.5 IRI	16
ACHTTO	Asphaltic concrete, high traffic and two-lane one-way	4 IRI (Engg. judgment)	RM + Overlay 80 mm at 4 IRI	30
ACMTST	Asphaltic concrete, medium traffic and single lane two-way	5 IRI	RM + Overlay 80 mm at 5 IRI	636
ACMTIT	Asphaltic concrete, medium traffic and intermediate lane two-way	5 IRI	RM + Overlay 80 mm at 5 IRI	575
ACMTTT	Asphaltic concrete, medium traffic and two-lane two-way	3.5 IRI (Engg. judgment)	RM + Overlay 80 mm at 3.5 IRI	819
ACMTWTT	Asphaltic concrete, medium traffic and wide two-lane two-way	5 IRI	RM + Overlay 80 mm at 5 IRI	32
ACMTFT	Asphaltic concrete, medium traffic and four-lane two-way	4 IRI	RM + Overlay 80 mm at 4 IRI	19
ACMTTO	Asphaltic concrete, medium traffic and two-lane one-way	5 IRI	RM + Overlay 80 mm at 5 IRI	36
ACLTST	Asphaltic concrete, low traffic and single lane two-way	5 IRI	RM + Carpeting at 5 IRI	2758
ACLTIT	Asphaltic concrete, low traffic and intermediate lane two-way	6 IRI	RM + Overlay 40 mm at 6 IRI	1044
ACLTTT	Asphaltic concrete, low traffic and two-lane two-way	4.5 IRI	RM + Overlay 60 mm at 4.5 IRI	1028
ACLTWTT	Asphaltic concrete, low traffic and wide two-lane two-way	4.5 IRI (Engg. judgment)	RM + Overlay 40 mm at 4.5 IRI	41
ACLTFT	Asphaltic concrete, low traffic and four-lane two-way	5 IRI	RM + Carpeting at 5 IRI	25
ACLTTO	Asphaltic concrete, low traffic and two-lane one-way	4.5 IRI	RM + Overlay 60 mm at 4.5 IRI	47

Annex 2
Work Programme Obtained in the Current Analysis (Unconstrained by Year)

Year	Section	Road Class	Work Description	NPV/CAP	Financial Costs
2010	STMTST	Tertiary or Local	Carpeting 4 IRI	30.18	229.77
	STHTTO	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	22.18	4.51
	STMTIT	Secondary or Main	Overlay 80 mm @ 5 IRI	18.06	394.60
	STHTWTT	Primary or Trunk	Overlay 80 mm @ 3.5 IRI	17.67	5.73
2011	ACHTWTT	Primary or Trunk	Overlay 80 mm @ 5 IRI	19.96	22.24
	STLTST	Tertiary or Local	Carpeting 5 IRI	18.32	1,026.80
	ACMTFT	Primary or Trunk	Overlay 80 mm @ 4 IRI	15.60	21.74
	STMTFT	Primary or Trunk	Overlay 80 mm @ 4 IRI	7.37	11.63
	ACMTTT	Primary or Trunk	Overlay 80 mm @ 3.5 IRI	5.85	481.43
	STMTTT	Primary or Trunk	Overlay 80 mm @ 4 IRI	4.32	117.31
	ACMTWTT	Primary or Trunk	Overlay 80 mm @ 5 IRI	1.29	27.25
2012	STHTTT	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	32.14	101.08
	STHTIT	Secondary or Main	Overlay 80 mm @ 6 IRI	22.20	66.99
	ACLTST	Tertiary or Local	Carpeting 5 IRI	20.60	342.27
	ACHTFT	Primary or Trunk	110 mm Recon	14.28	45.47
	STHTST	Tertiary or Local	Carpeting 5 IRI	9.29	17.55
2013	ACMTST	Tertiary or Local	Overlay 80 mm @ 5 IRI	25.25	202.37
	STHTFT	Primary or Trunk	110 mm Recon	16.68	11.13
	STLTIT	Secondary or Main	Carpeting 6 IRI	9.63	291.78
	ACHTTT	Primary or Trunk	110 mm Recon	1.37	966.78
2014	ACHTST	Tertiary or Local	Overlay 80 mm @ 5 IRI	35.84	14.87
	ACHTIT	Secondary or Main	Overlay 80 mm @ 5 IRI	32.03	40.75
	ACHTTO	Primary or Trunk	110 mm Recon	24.41	41.11
	ACMTTO	Primary or Trunk	110 mm Recon	15.45	49.63
2015	STHTTO	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	22.18	4.51
	STHTWTT	Primary or Trunk	Overlay 80 mm @ 3.5 IRI	17.67	5.73
	STMTTO	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	13.56	5.70
	ACMTIT	Secondary or Main	75 mm Recon	10.59	631.50
2016	STLTFT	Primary or Trunk	110 mm Recon	289.88	16.70
	STLTWTT	Primary or Trunk	110 mm Recon	241.67	20.03
	ACLTTO	Primary or Trunk	110 mm Recon	161.93	64.40
	STMTWTT	Primary or Trunk	110 mm Recon	106.21	17.04
	ACHTWTT	Primary or Trunk	Overlay 80 mm @ 5 IRI	19.96	22.24
	STLTTT	Primary or Trunk	110 mm Recon	19.86	299.59
	ACMTFT	Primary or Trunk	Overlay 80 mm @ 4 IRI	15.60	21.74
	ACLTTT	Primary or Trunk	Overlay 60 mm @ 4.5 IRI	13.77	492.88
	STMTFT	Primary or Trunk	Overlay 80 mm @ 4 IRI	7.37	11.63
	ACMTTT	Primary or Trunk	Overlay 80 mm @ 3.5 IRI	5.85	481.43
	STMTTT	Primary or Trunk	Overlay 80 mm @ 4 IRI	4.32	117.31
	ACMTWTT	Primary or Trunk	Overlay 80 mm @ 5 IRI	1.29	27.25
2017	ACLTWTT	Primary or Trunk	110 mm Recon	174.85	82.11
	STHTTT	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	32.14	101.08
	STLTST	Tertiary or Local	Carpeting 5 IRI	18.32	1,026.80
2018	STHTIT	Secondary or Main	Overlay 80 mm @ 6 IRI	22.20	66.99
	ACLTST	Tertiary or Local	Carpeting 5 IRI	20.60	342.27
	STHTST	Tertiary or Local	Carpeting 5 IRI	9.29	17.55
2019	STLTIT	Secondary or Main	Carpeting 6 IRI	9.63	291.78
2020	ACHTIT	Secondary or Main	Overlay 80 mm @ 5 IRI	32.03	40.75

Year	Section	Road Class	Work Description	NPV/CAP	Financial Costs
	STHTWTT	Primary or Trunk	Overlay 80 mm @ 3.5 IRI	17.67	5.73
	ACHTFT	Primary or Trunk	110 mm Recon	14.28	45.47
	STMTTO	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	13.56	5.70
2021	ACHTWTT	Primary or Trunk	Overlay 80 mm @ 5 IRI	19.96	22.24
	STHTFT	Primary or Trunk	110 mm Recon	16.68	11.13
	ACMTFT	Primary or Trunk	Overlay 80 mm @ 4 IRI	15.60	21.74
	ACLTTT	Primary or Trunk	Overlay 60 mm @ 4.5 IRI	13.77	492.88
	STMTFT	Primary or Trunk	Overlay 80 mm @ 4 IRI	7.37	11.63
	ACMTTT	Primary or Trunk	Overlay 80 mm @ 3.5 IRI	5.85	481.43
	STMTTT	Primary or Trunk	Overlay 80 mm @ 4 IRI	4.32	117.31
	ACMTWTT	Primary or Trunk	Overlay 80 mm @ 5 IRI	1.29	27.25
2023	STMTIT	Secondary or Main	Overlay 80 mm @ 5 IRI	18.06	394.60
	ACHTTT	Primary or Trunk	110 mm Recon	1.37	966.78
2024	STHTST	Tertiary or Local	Carpeting 5 IRI	9.29	17.55
2025	STHTTT	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	32.14	101.08
	ACMTST	Tertiary or Local	Overlay 80 mm @ 5 IRI	25.25	202.37
	ACHTTO	Primary or Trunk	110 mm Recon	24.41	41.11
	STHTTO	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	22.18	4.51
	STHTWTT	Primary or Trunk	Overlay 80 mm @ 3.5 IRI	17.67	5.73
	ACMTTO	Primary or Trunk	110 mm Recon	15.45	49.63
	STMTTO	Primary or Trunk	Overlay 80 mm @ 4.5 IRI	13.56	5.70
2026	ACHTWTT	Primary or Trunk	Overlay 80 mm @ 5 IRI	19.96	22.24
	ACMTFT	Primary or Trunk	Overlay 80 mm @ 4 IRI	15.60	21.74
	ACLTTT	Primary or Trunk	Overlay 60 mm @ 4.5 IRI	13.77	492.88
	STMTFT	Primary or Trunk	Overlay 80 mm @ 4 IRI	7.37	11.63
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	ACMTWTT	Primary or Trunk	Overlay 80 mm @ 5 IRI	1.29	27.25
2027	ACHTST	Tertiary or Local	Overlay 80 mm @ 5 IRI	35.84	14.87
	ACHTFT	Primary or Trunk	110 mm Recon	14.28	45.47
2028	STHTFT	Primary or Trunk	110 mm Recon	16.68	11.13
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	STLTWTT	Primary or Trunk	110 mm Recon	241.67	20.03
	ACLTTO	Primary or Trunk	110 mm Recon	161.93	64.40
	STHTIT	Secondary or Main	Overlay 80 mm @ 6 IRI	22.20	66.99
	ACMTIT	Secondary or Main	75 mm Recon	10.59	631.50