Research Paper

WHITE TOPPING AS A REHABILITATION METHOD: A CASE STUDY OF BUDHEL-GHOGHA ROAD

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ABSTRACT:

White topping is rehabilitation treatment on asphalt concrete. It is defined as Plain Cement Concrete overlay on asphalt concrete. It provides a new innovative method of rehabilitation at a very low cost with very good results and low maintenance cost. This method of rehabilitation/strengthening can be adopted for rural road network and district roads as these roads have low to moderate traffic. Even on the State Highways and some recently declared National Highways, where traffic is moderate, the above method of strengthening has a lot of promise. By adopting proper construction methods, we can rehabilitate large network of roads at reasonable cost and we get additional long life. This paper presents a methodology to adopt white topping as rehabilitation treatment and cost-effective rehabilitation alternative for preserving bituminous pavements on long-term basis.

INTRODUCTION:

Road traffic is increasing steadily over the years. This is an international phenomenon. An international forecast predicts that such increase will continue in near future. Even in case of developed countries, there is a shortage of funds required for new infrastructure projects, both for constructing them and more significantly towards their maintenance and repairs. The position in the context of a developing country like India is obviously far worse. As a result, more and more roads are deteriorating and the existing pavement structure as a whole is often found to be inadequate to cope up with the present traffic. The present total length of NHs is about 66,590 km. The State Highways provide linkages with the National Highways, district headquarters, important towns, tourist centres and minor ports. Their total length was about 1,37,711 km as at the end of March 2002.[1] The proper strengthening and maintenance of roads(is urgently required to ensure balanced regional development and alleviation of poverty as they connect the villages and other small town centres harbouring backwardness. A majority of these roads do not have traffic worthy pavement. The cost of strengthening and repair by Conventional method of this large network will need huge resources both physical and financial which are quite scarce.

Most of the existing flexible pavements in the network broadly have thin bituminous layers.

These bituminous pavements, in general, have a problem that they get deteriorated with time. Most of our roads exhibit, in general, the following deficiencies:

- Rutting
- Fatigue cracking
- Block crack (D-cracking)
- Thermo cracking

Under the present rehabilitation programmes, normally the overlays are being placed over such cracked or rutted bituminous layer without making any significant efforts to seal these cracks properly. Sometimes the cracks are so extensive and widespread that it is not even possible to fully seal them, with the result that such newly overlaid surfaces again exhibit rutting/cracks in a very short time. Reflection cracks are one example frequently encountered with such overlay repairs. Such repairs do not enhance their expected life and bring avoidable criticism from the public. Such practices of strengthening by overlaying thus need to be discarded.

Any alternative method of strengthening or repairing of roads should, therefore, be based on their durability rather purely by initial cost. The cost comparison for such alternative strengthening/repair methods should be based on the concept of life-cycle cost. Alternative methods of strengthening/repairs should take care of the deficiencies of the existing bituminous layers. Rutting and cracking are overwhelmingly observed to be general nature type of distress on most of bituminous pavements. This could be remedied by milling the existing surfaces. Milling significantly de-stresses the cracked/rutted section. However, in isolated stretches, where the pavement is badly distressed due to sub-grade failure etc., full depth repair needs to be resorted to.

White Topping is a way of strengthening or rehabilitating deteriorated asphalt pavements by Plain Cement Concrete (PCC) overlay with or without fibres. Ultra Thin White Topping (UTWT) and Thin White Topping (TWT) are being increasingly practised in USA and West Europe. Demarcation between Ultra Thin White Topping (UTWT) and Thin White Topping (TWT) depends upon the thickness of the Plain Cement Concrete (PCC) overlay and degree to which it is bonded with the existing underneath bituminous layer. For thickness up to 100 mm, it is designated as Ultra Thin White Topping (UTWT) and for thickness more than 100 mm but up to 200 mm; it is called Thin White Topping (TWT). Beyond 200 mm thickness, it is called Conventional White Topping like our ordinary PCC pavements. The governing design principles are somewhat different than those of normal concrete pavements. In case of UTWT, the bond between the existing asphalt pavement and Plain Cement Concrete (PCC) overlay is considered mandatory. However, in case of TWT the bonding is desirable but not mandatory. Another difference is that for these overlays joints are spaced close. Normal spacing of joints are at 0.6 m to 1.2 m and in some cases it is up to 1.5 m. These joints are normally not doweled. No tie roads are also provided in the longitudinal joints. The thickness of UTWT is between 75 to 100 mm. A thickness of up to 150 mm is normally provided even in case of Thin White Topping (TWT). A residual asphalt depth of at least 75 mm is considered essential. [2]

Background:

The first white topping project constructed in the United States was in 1918 in Terre Haute, Indiana (Hutchinson, 1982). According to McGhee (1994), from 1918 to 1992, approximately 200 white topping projects were done. Among them, 158 were jointed plain concrete pavement, 14 continuously reinforced concrete, 10 fibre-reinforced concrete, and seven were jointed reinforced concrete pavement. Construction of white topping is not limited to the U.S. only. Other countries including Belgium, Sweden, Canada, Mexico, Brazil, the Republic of (South) Korea, Japan, France, Austria, and the Netherlands have undertaken recent projects with white topping (Rasmussen and Rozycki, 2004). Agencies are widely expected to use white topping as it is a cost-competitive technique, can be constructed with minimal interruption of the travelling system, as well as be a means of green construction compared to asphalt concrete overlay.

Life-cycle cost (LCC) analysis of white topping and AC overlays (Asphalt Concrete) were conducted by Lowey (2005). From the analysis, it was found that initial cost of white topping is much higher than an AC overlay. When user cost with initial cost is considered however, white topping is cheaper than AC overlay as white topping requires less maintenance during its service life.[3] (sultana, 2007)

METHODOLOGY FOR PROPOSING WHITE TOPPING:

White Topping can be categorised as below:

1. Ultra thin white topping: Bonding mandatory, milling required, thickness up to 100 mm, minimum thickness of the existing bituminous surface 75 mm (net after milling), with short joint spacing. It cannot be used on badly cracked bituminous surfaces. Substantial surface preparation is involved Cost-efficient for intersections, check-posts, parking lots and low volume roads frequent with rutting problems due to stop/start conditions.
2. Thin white topping: Bonding desirable, though not mandatory, milling desirable but thin bituminous overlay of 25-50 mm in lieu of milling can be used, thickness between 100 to 200 mm, with short joint spacing. Used for low to moderate trafficked corridors.
3. Conventional white topping: Similar to a new concrete pavement. It can be directly laid on the existing bituminous pavement without much surface preparation. Thickness usually is equal to or more than 200 mm. However, Thin White topping and Conventional White topping do not have a very rigid demarcation line and a thickness between 150 mm to 250 mm is quite common.

The following procedure needs to be adopted for implementing White Topping as maintenance strategy [4] (Nasvik, 2004)

- Design life--should be at least 15 years; 25 to 30 years is often projected for city streets.
- Cost alternatives--define initial construction costs, maintenance costs, and the design life of the topping.
- Drainage considerations - define the elevation of crown sections to ensure good drainage.
- Pavement patching--identify areas that require sub grade repair after the milling operation
- Thickness design--considers the thickness of the asphalt pavement, the thickness of the topping, traffic loads, and panel layout.
- Longitudinal and transverse joints--determine joint spacing by the overlay pavement thickness and the geometrics of the area to be paved. Normal practice is to saw the joints in the new pavement; tooled joints are also permitted for some areas.
- Profile correction--determine joint spacing by the thinnest concrete profile and carry this spacing throughout the project.
- Surface texture--texture is specified in relation to the speed of traffic. Drag (burlap or boom) textures are good for low-speed facilities; high-speed facilities should use more aggressive textures.
- Traffic control--traffic can be detoured, shifted, or otherwise accommodated during construction, but there must be a plan before construction starts.
- Construction staging--stage the construction to cause the least disruption.

CASE STUDY:

V.K. SINHA, SATANDER KUMAR & R.K. JAIN have represented white topping as cost-effective rehabilitation alternative for preserving bituminous pavements on long-term basis.

Cost effectiveness of the white topping alternative in Indian context is proposed by them for analysis.

A) Cost Computation of Bituminous Overlay

Scenario:

1) Low Volume Road (C/W 7 m without Paved shoulders) Plain Terrain Current traffic =300 CVPD.

2) Projected design traffic at 7.5% annual growth for 10 yrs =2.3 MSA

3) Characteristic BBD (Benkelman Beam Deflection) 1.8 mm*assumed

4) VDF (vehicle damage factor) as per IRC: 81-1997 (T-4) = 1.5

i) Overlay Thickness Computation:

Overlay Thickness has been computed for this scenario table 1 as per IRC: 81-1997[5]

Table 1 Overlay Thickness

Scenario	Computed overlay thickness	Design life for overlay
	90 mm BM	10 years

ii) Basic rates used for analysis:

The basic rates assumed are current (as per analysed tender rates). These are given in Table 2 The rates are applicable and used for computation of the cost of bituminous overlay as well as of White topping.

Table 2 Basic rates

S. No.	Item of works	Rate as on Oct. 2007(Rs)
1	Tack Coat	11.20/sqm
2	BM	4480/cum
3	DBM	4930/cum
4	SDBC	5040/cum
5	BC with CRMB	5820/cum
6	DLC	3490/cum
7	PQC	5330/cum

DBM = Dense Bituminous Macadam
SDBC = Semi Dense Bituminous Concrete
BC = Bituminous Concrete
CRMB = Crumb Rubber Modified Bitumen
PQC = Pavement Quality Concrete

Table 3 Cost of bituminous overlays

Sr. No.	Item of work (with computed quantity/cost)	Cost (Rs in lakh)
1	Tack Coat 7000 x 11.20 x 3 (Two coats of tack coat for addl. crust and one coat for PR)	2.35
2	90 mm BM (7000 x 0.09) 4480	28.22
3	25 mm SDBC on BM (7000 x0.025) x 5040	8.82
4	Periodic Renewal (SDBC @5 yrs) i.e. 5th yr (0.025 x 7000)x 5040 x 1	8.82
5	Routine Maintenance @ Rs.50,000/- year/km 10 x 50,000	5.00
Total amount at current cost Rs.53.21 lakh Say 53 lakh		

B) Cost computation of white topping overlay

Scenario: Ultra Thin White topping

1) Current Traffic= 300 CVPD(Commercial Vehicle Per Day)
2) Design Period= 10 yrs
3) Projected Traffic $(1.075)^{10}$ x 365 x 300) = 225683
4) Design Traffic (0.25 x 225683) = 56420
5) Adopted 57500
6) Thickness provided = 100 mm

i) Design of ultra thin white topping: Thickness adequacy has also been checked for fatigue life for typically assumed axle load distribution vides Table 4 as per IRC 58-2002[6]

Table 4 Design Parameters

Pavement Layer Type and specification	Ultra Thin White Topping(100 mm)
Traffic	300 CVPD
Thickness Designed	100 mm
Life	10 Years
Design Axles (25% of the projected)	57,500
BBD (used as limiting Deflection)	1.8 mm
CBR	6%
Modulus of Sub grade Reaction	4.5 kg/cm3
Modified Modulus of Sub grade Reaction*	5.4 kg/cm3
Temperature Stresses (Delhi)	1.0 kg/cm2
Residual Stresses	66.5 kg/cm2
Edge Load stresses for 6 tones axle load 0.75x 46.29 calculated from IITRIGID Prog	34.71 kg/cm2
Stress ratio (for 6 tonnes axle load)	34.71/67.5 = 0.51
Allowable repetition i.e. 0.75X485000	363750 which is > 57500, hence design is safe for individual axle load of 6 tones

Table 5 Percentage of Axle Load for the Design of UTWT (Assumed Axle Load Distribution)

Single Axle Loads		Tandem Axle Loads	
Axle Load Class, tons	Percentage of axle loads	Axle Load Class, tons	Percentage of axle loads
9-11	0.2	16-18	0.8
7-9	0.5	Less than 16	2.0
5-7	35.0		-
< 5	61.5		-
Total	97.2	Total	2.8

Table 6 Design from Fatigue Consideration Using Programme (Iitrigid)

Single Axle Loads		Tandem Axle Loads	
Load in, tones	Expected Repetition	Load in, tones	Expected Repetition
10	115	17	460
8	287	Less than 16	1,150
6	20,126		
Less than 5	35,362		
Total	55,890	Total	1,610

Table 7 Stress Ratio at Different Axle Loads under the Category of Single Axles

Axle Load (AL) tones	Stress kg/ cm2 from IIT RIGID	Reduced Stress kg/ cm2 from charts 0.75 x Col (2)	Stress ratio* Col (3)/67.5	Expected repetition	Allowable Repetition	Fatigue Life Consumed
-1	-2	-3	-4	-5	-6	(5)/(6)
10	69	52	0.77	115	274	0.42
8	58	44	0.65	287	7,700	0.04
6	46	35	0.52	20,126	3,26,000	0.06
Less than 5	40	30	0.44	35,362	unlimited	0
Total				55,890		0.52

Table 8 Stress Ratio at Different Axle Loads under the Category of Tandem Axle

Tandem Axle Load (AL) tones	Stress kg/ cm2 from charts	Reduced Stress kg/ cm2 Col 2 x 0.75	Stress ratio Col. 3/67.5	Expected repetition	Fatigue life, N	Fatigue life consumed
-1	-2	-3	-4	-5	-6	-7
17	50.4	37.8	0.56	460	94,100	0.01
Less than 16	48.2	36.0	0.53	1,150	2,29,000	0.01
	-			-	Total	0.02

Total fatigue consumed = 0.52 (single axle) + 0.02 (tandem axle) = 0.54 < 0.75 hence design is safe

Table 9 Computed Cost of Ultra Thin White topping

Sr. No.	Item	Rate(Rs.)	Quantity Sq.m	Total Cost in(Rs. Lakh)
1	Scarifying/ milling up to a depth of 40 mm, cleaning, watering etc	30/sqm	7,000	2.10
2	Applying Tack coat as per MOSRTH Sps.	11.20/sq m	7,000	0.78
3	Cost of PQC M 40 Grade concrete including, cost of polymeric/polyolefin fibres, ~ 1kg/cum, form work, placing, laying a thickness of 100 mm, its compaction, finishing, curing, texturing, joint cutting in both directions (at an interval of 1m each upto a depth of 1/3rd of the slab's thickness), use of three tie bars (10 mm dia deformed at an interval 0f 30 cm c/c at butt types of joint in each panel of size 1mX1m, sealing of butt type joints.	5330/ cu m	700 (mm)	37.31
4	Maintenance cost per annum (two lane 1 km)	25,000	10 yrs	2.50
Total initial cost of UTWT in Rs , lakh for two lane		40.19		
Total Life Cycle cost of UTWT, in Rs , lakh for two lane		42.69		

The overlay cost both of bituminous and white topping for 150 mm and 200 mm thickness is shown in table below.

Table 10 Comparative Cost Of Bituminous V/S White topping Overlay (Per Km Basis)

Scenario	Bituminous Overlay thickness	White topping type & thickness	Total cost of bituminous overlay I/c (Rs.)	Total cost of white topping I/c maintenance	Saving in White topping (Rs. Lakh)/ (Rs.) % Saving
I	90 mm BM	100 mm UTWT	53 lakh	42.69 lakh	10.31 lakh(19.04%)
II	150 mm BM	150 mm TWT	107 lakh	85.26 lakh	21.74 lakh(20.32%)
III	200 mm BM	200 mm Conventional	141 lakh	98.64 lakh	42.36 lakh (30.04%)

CONCLUSION:

From the case study it can be concluded that white topping overlay saves:

- For 90 mm bituminous overlay and 100 mm white topping overlay saves 19.04 % cost.
- For 150 mm bituminous overlay and 150 mm white topping overlay saves 20.32 % cost.
- For 200 mm bituminous overlay and 200 mm white topping overlay saves 30.04 % cost.

The cost savings shown on a kilometre basis suggests that, White Topping will have long life and ensured performance at a much lesser cost than that of bituminous pavement. The only disadvantage is long lane closure and perhaps additional provision for diversion of traffic during construction. However one should perform feasibility studies and life cycle analysis before implementation to ensure proper decision making.

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