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White Topping Revolution for Cost-Effective and Long-Lasting Treatment over the Existing Bituminous Roads

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Abstract:-There are two types of Pavements, namely flexible Pavement and Rigid Pavement. Flexible pavements are constructed with Bituminous Base Course and wearing Coat over the Granular Subbase/ Base course. In Flexible Pavement, grain-to-grain contacts transmit the loads to the subgrade soil. Rigid pavements are constructed with Cement Concrete slabs constructed over a Granular Sub Base (GSB) layer or a levelling course of Dry Lean Concrete (DLC) layer. In Rigid pavement traffic loads are transmitted to the subgrade through the bending action of the concrete slab and hence while designing concrete pavements, the flexural strength of concrete (modulus of rupture) is used rather than its compressive strength, as concrete fails in flexure rather than compression.

In hot climatic regions like India, where heavy truck loads contribute to the deterioration of Bituminous wearing surface resulting in degradation of riding quality, an effective solution is required to rehabilitate the damaged pavement. One such approach involves overlaying the damaged pavement with a fresh Bituminous layer to enhance its strength and rehabilitate the surface. However, rutting of the Bituminous layer remains a common issue, especially in tropical areas like India with significant truck traffic. Adopting Plain Cement Concrete (PCC) Overlay with White Topping technology has proven beneficial to address this problem. This innovative technique offers improved structural strength, enhanced durability, cost-effectiveness, reduced maintenance expenses and a lower life cycle cost in comparison to traditional Bituminous surface overlays. The White Topping technology encompasses various classes, including Conventional White Topping, Thin White Topping (TWT) and Ultra-Thin White Topping (UTWT), each characterized by the thickness of the white topping layer applied over the existing Bituminous surface. This technical paper broadly explains the advantages and disadvantages of White Topping Technology and the Life Cycle Cost comparison between Bituminous overlay, Thin White Topping and Ultra-Thin White Topping overlay to establish the relative cost savings of Thin White Topping Overlays.

I. INTRODUCTION

The implementation of PCC overlay over the existing Bituminous layer has significantly extended the service life of the overlaid pavement by approximately 15 to 20 years with a nominal maintenance cost, compared to the relatively shorter lifespan of traditional Bituminous overlays which typically lasts for four to five years to the maximum. The Ministry of Surface Transport (MoRTH) recommends an overlay of a minimum of 25mm to 30mm thick Bituminous Concrete (BC) in every five years on the existing surface because of the degradation of the bituminous wearing coat exposed to traffic.

II. TYPES OF WHITE TOPPING

White Topping technology is categorized into three distinct types based on the thickness of the overlay applied over the existing Bituminous surface.

- *Conventional White Topping*
- *Thin White Topping (TWT)*
- *Ultra-Thin White Topping (UTWT)*

- *Conventional White Topping*

This involves a Plain Cement Concrete (PCC) overlay of 200 mm thickness or more placed on top of the existing Bituminous layer. The existing Bituminous pavement is treated as a sub-base like Dry lean Concrete (DLC) in this type of construction. In conventional White Topping, polythene sheet or debonding layer is not provided by reducing the joint spacing to less than 12 times the thickness of the Concrete overlay. Separation layer may be provided where the joint spacing is greater than 12 times the thickness of the Concrete overlay. Dowel bars may be provided only where heavy traffic load and wet climatic conditions exist.

There are various methods for surface preparation before overlaying the Conventional White Topping. Either of the below-mentioned options can be adopted depending upon the condition of the existing bituminous surface.

- *Direct Laying*:

The Concrete Overlay is placed directly on the existing bituminous surface after cleaning the surface with a boomer /blower. Ruts, if any, are to be filled with DLC or concrete (PCC).

- *Milling*:

To achieve substantial bonding between the concrete overlay and the bituminous pavement, extensive surface preparation is necessary. Milling is done to remove the surface undulations and ruts. The existing bituminous surface is milled to the tune of 25 to 50mm to obtain a uniform and rough surface to establish an effective bond between the existing bituminous layer and the PCC overlay. However, it is important to avoid excessive roughening of the surface, as it could increase frictional forces.

- *Laying of Levelling Course with Fresh BM, DBM Or PCC Layer*:

Sometimes a fresh layer of levelling course of 50mm to 75mm thick Bituminous Macadam (BM), DBM or PCC is laid over the existing bituminous surface. This is done when the existing Bituminous surface is not Dense Bituminous Macadam (DBM) and lots of cracks are developed.

- *Profile Correction with DLC/PCC Levelling Course*:

A profile correction course of 75mm to 125mm thick DLC or PCC(M10) may be laid.

➢ *Thin White Topping (Twt)*

Thin White Topping encompasses a Plain Cement Concrete (PCC) overlay with a thickness greater than 100mm and less than 200 mm. Thin White Topping (TWT) pavement should be analysed as a composite system considering the bond between the overlaid PCC and the underlying bituminous layer. The Bonding consideration may also be ignored in the design.

High-strength concrete with embedded fibres is commonly used, and joints are spaced closely at intervals of 1.00 to 1.50 m, generally in a square shape.

Surface Preparation before Thin White Topping is done as below.

- To develop an effective bond between the existing Bituminous surface and PCC overlay, milling of the existing Bituminous surface is to be done and cleaned properly with a broom and thereafter with a blower.

- The net minimum thickness of bituminous pavement to be retained after milling shall be 75 mm. If the thickness of the existing bituminous pavement is less than 100mm, a profile corrective course of Dense Bituminous Macadam (DBM) of minimum 50mm thickness may be laid over the existing Bituminous surface to maintain a minimum retained thickness of 75mm bituminous layer after milling.

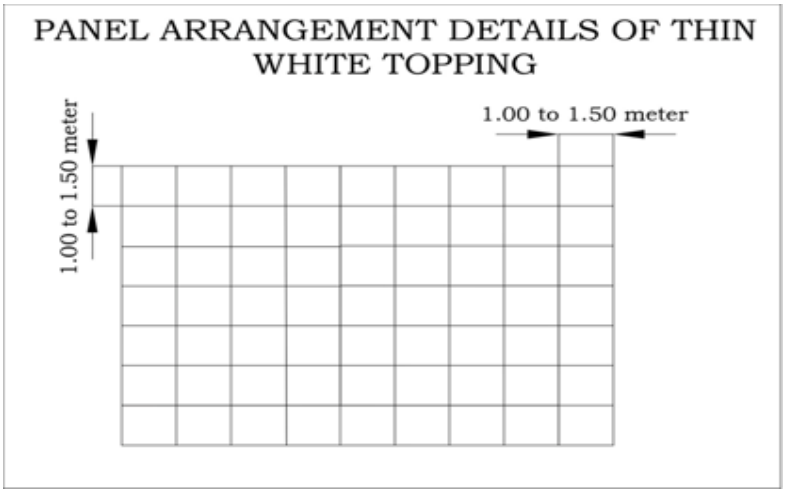

Fig 1 Panel Arrangement Details of Thin White Topping

➢ *Ultra-Thin White Topping (Utwt)*

Ultra-Thin White Topping involves a PCC overlay with a thickness equal to or less than 100 mm. A strong bonding between the underlying bituminous layer and the overlaid PCC layer is essential in this case too. Achieving the necessary bond typically involves milling the existing bituminous surface to an average depth of 25 mm. High-strength concrete with fibres and panel sizes varying between 0.600m to 1.25m is used generally. Square-shaped panels are the construction technique commonly used in creating decorative and functional surfaces. This approach offers several advantages, including enhanced strength, durability, aesthetic appeal, crack control and also allows expansion and contraction of the concrete as explained below.

- *Control of Cracking:*

Joints act as control points for cracks that may develop over time. By spacing them at regular close intervals, you prevent the formation of large, unsightly cracks.

- *Expansion and Contraction:*

Joints allow for the expansion and contraction of the concrete due to temperature fluctuations, reducing the risk of surface damage.

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However, Ultra-Thin White Topping of less than 100 mm thickness is generally not recommended for Highways with heavy traffic even though it is suitable and economical for colony roads and roads having only light vehicle traffic.

III. ADVANTAGES OF WHITE TOPPING AND THIN WHITE TOPPING

The application of white topping over the existing bituminous pavement offers numerous advantages over conventional bituminous overlay alternatives. Some key benefits include:

- Extended lifespan
- Reduced maintenance needs
- Lower Life Cycle Cost
- Improved safety and environmental benefits
- Diminished occurrence of rutting and cracking
- Enhanced structural capacity of the pavement
- Reduced maintenance frequency and lane closures
- Cost-effectiveness in managing budget constraints and high traffic levels
- Reflective surface contributes to improved lighting and reduced heat absorption
- Lower fuel consumption on concrete roads compared to bituminous roads

IV. USE OF WHITE TOPPING IN HIGHWAY IMPROVEMENT PROJECTS

In the last two decades, White Topping in its various forms has been used in various parts of the USA, Europe and India on a large scale to improve the performance, durability and riding quality of the deteriorated bituminous pavement surface.

V. BEHAVIOUR OF CONVENTIONAL WHITE TOPPING, TWT AND UTWT

The basic concept of the design of Thin White Topping (TWT) is the composite action between the existing Bituminous Pavement and the proposed overlay. Hence it is mandatory to establish an effective bond between the PCC overlay and the existing bituminous pavement to enhance the performance of TWT. For all forms of white topping, it is crucial to ensure the continuity of subgrade or sub-base support. To maintain this mandatory criterion a minimum thickness of 75mm bituminous layer is to be retained after milling and the retained Bituminous surface shall be sound. So White topping should only be carried out in areas where the availability of consistent support of bituminous base/DLC base free from cracks, and without any deterioration or material-related distress can be assured.

VI. DESIGN CRITERIA

➢ *Conventional White Topping*

The design and construction of Conventional White Topping are generally designed and constructed as Plain Jointed Cement Concrete Pavement as per IRC:58 and IRC:15 respectively treating the overlay as a new rigid pavement without assuming any composite action between the concrete overlay and the underlying Bituminous Pavement.

➢ *Thin White Topping (TWT)*

TWT overlays are generally designed on the principle of a composite pavement which distributes traffic and temperature stresses. The Pavement Design is carried out as per the guidelines of IRC: SP:76-2015 as a composite pavement. In a bonded system of concrete and flexible layer, the neutral axis shifts downward causing a significant portion of the PCC slab area to be under compression (Refer figure 1) and lesser thickness is required to carry the load than in the conventional PCC. The other factor contributing to the requirement of lesser thickness is that the spacing of joints is considerably reduced due to which the curling and warping stresses are much less.

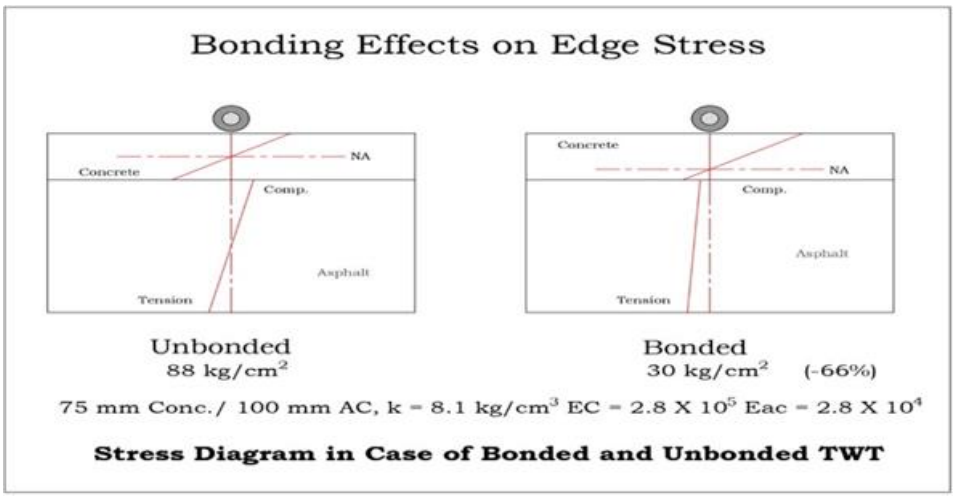

Fig 2 Bonding Effects on Edge Stress

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VII. MIX PROPORTIONING AND STRENGTH OF CONCRETE

The following designed concrete mixes may be used for the construction of both Conventional and Thin White Toppings:

- Conventional Cement Concrete
- Fibre Reinforced concrete using fibres viz. polypropylene, polyethylene, nylon, polyester, steel (IRC: SP:46) etc.
- High-performance concrete using silica fume up to 3-10% by weight of cementitious material with and without using fly ash (up to 20%) or slag up to 70% by weight of cement (Refer IRC: SP:70)
- High-performance fibre-reinforced concrete using specified fibres and mineral admixtures as per IS: 456 using a dose of chemical admixture @ up to 2.0% by weight of cement.

The ingredients of Concrete are to be so proportioned that the mix generally produces concrete of minimum characteristic compressive strength of M40 Grade Concrete or more than M40 Grade Concrete at 28 days.

High-performance concrete of compressive strength M50 is normally preferred. High-strength high-performance concrete is essential for fast-track construction which is achieved by using early-setting cements with micro silica as an essential additive.

UTWT/TWT projects are generally constructed with concrete mix having water/cement ratio of less than 0.40. It is, however preferable to have a water-cement ratio between 0.30 to 0.38. The workability/slump requirement (25-50 mm) may be conveniently achieved by using high-range water reducers (superplasticizers). The mixes may have high cement content (but not greater than 450 kg/m^3).

Extra precautions are required while using very high cement content with about the heat of hydration. The higher strength is derived not by increasing the cement content but by reducing the water content.

The mixes shall be designed as per the guidelines of IRC:44 or IS:10262. The minimum flexural strength or modulus of rupture (Third point loading) of the concrete shall be 4.5 MPa which corresponds to the concrete of M40 Grade concrete at 28 days. It is, however, preferred to have a flexural strength of 5.0-6.0 MPa (Third Point Loading).

VIII. LIFE CYCLE COST(LCC) COMPARISON BETWEEN BITUMINOUS OVERLAY AND THIN WHITE TOPPING (TWT) OVERLAY

A detailed Life Cycle Cost comparison of a segment of Highway having four-lane configuration, incorporating three alternative overlays—one with Bituminous overlay, the second one with Thin White Topping (TWT) and the third one with Ultra-Thin White Topping overlay—has been conducted. The cost per kilometre length of the highway has been calculated for each type of overlay, taking into account the following data.

- The carriageway width is 7.50 meters including kerb shyness and paved shoulders of 2.50 meters width on either side of the central median of varying width.
- The analysis period of twenty years starting from 2023 is used for the sample calculation. A discount rate of 12% is considered and an inflation rate of 5.50% is considered for the price increase of Materials. Actual overlay Design thicknesses of various layers of Bituminous pavements and Thin White Topping are to be designed as per the guidelines of IRC:81-1997 and IRC: SP:76-2015 respectively. However, for an approximate idea of cost comparison, the thickness of the Bituminous layers and TWT layer considered for the cost comparison are as under.
- The thicknesses of the Bituminous overlay considered for the costing are as follows,

✓ A strengthening layer of 75mm thick DBM (including levelling course) and 40mm thick Bituminous Concrete (BC) are considered for overlay treatment at the time of the first Overlay Treatment. The same strengthening courses are proposed to be repeated after ten years of the initial overlay (i.e. in the 11th year) since the life of the Flexible pavement is to the tune of 10 to 15 years only.

✓ An Overlay treatment of 30mm thick Bituminous Concrete (BC)in every five-year gap in the remaining period on the existing wearing coat is considered because of the degradation of the wearing coat exposed to traffic as per the Ministry's Circular. Accordingly, 30mm thick BC overlay is considered in the 6th year,16th year and 21st year.

- The procedure for execution of Thin White Topping (TWT) and thickness of overlay used for the calculation are as under.

✓ Milling of the existing Bituminous surface in varying thicknesses of 25mm to 50mm to bring a uniform surface after retaining a minimum Bituminous thickness of 75mm.

✓ Thin White Topping Overlay of 150 mm thickness

- The methodology for execution of Ultra-Thin White Topping (UTWT) and thickness of overlay used for calculation are as under.

✓ Milling of the existing Bituminous surface in varying thicknesses of 25mm to 50mm to bring a uniform surface after retaining a minimum Bituminous thickness of 75mm.

✓ Ultra-Thin White Topping Overlay of 100 mm

- The Rates used for the calculation are the Schedule of Rates of Maharashtra (State), India for the year 2022-23.

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The above sample overlay thicknesses are derived from the Pavement Design Reports prepared for the stretch of the Road between Rahate Colony (km 2+200) to Khapri ROB (km 8+200) of Nagpur-Wardha Road (Old NH-44) in Nagpur (District) of Maharashtra (State), India. The Traffic volume considered for the Pavement Design is 2700 numbers of Commercial Vehicles Per Day (2700CVPD) based on the Traffic survey conducted on this road in the year 2022. The major length of this existing bituminous road is reconstructed with Conventional PQC (150 mm thick DLC+260 mm thick PQC) and some of the stretches and junctions are constructed with Thin White Topping overlay of 150mm thickness on a trial basis. Some of the stretches treated with TWT on Nagpur -Wardha Road are the side road towards Narendra Nagar Bridge from Jaiprakash Nagar Metro Junction, Airport Junction, side road at Ajni Junction in front of Mount Carmel School, Service Roads at Ajni & in front of Sonegaon Police Station etc

Fig 3 Thin White Topping Work Done on The Side Road at Ajni Square on Nagpur -Wardha Road

The cost of the overlay on the existing bituminous surface with different provisions, as explained above, is tabulated in various tables below.

➢ *Cost with Bituminous Overlay*

- *The Cost of Bituminous Overlay in Every Ten Years (1st year and 11th year)*

The cost of Bituminous Overlay with 75mm thick DBM&40mm thick BC at the start of the work and after Ten Years (1st Year&11th year) is tabulated in Table 01

Table 1 Cost of Bituminous Overlay in Every Ten Years

Overlay Layer	Length (m)	Width (m)	Thickness (m)	Qty	Unit	Rate (Rs)	Cost in Rs
Tack Coats (2 Coat)	1000	20	NA	40000	Sqm	18.00	7,20,000.00
DBM	1000	20	0.075	1500	Cum	9664.00	1,44,96,000.00
BC	1000	20	0.040	800	Cum	12770.00	1,02,16,000.00
Total Cost for Strengthening with (75mm DBM+40mm) BC in 1st year and 11th year							2,54,32,000.00

- *The Inflated Cost of Bituminous Overlay in the 1St Year& 11th Year*

The inflated Cost of Bituminous Overlay (with 75mm thick DBM& 40mm thick BC) in the 1st year and 11th year is given in Table 02.

Table 2 Inflated Cost of Strengthening in 1 St Year And 11 Th Year.

Details	Initial Cost of Overlay in Rs	Inflated Cost@5.5% in Rs
Cost in First Year	2,54,32,000.00	NA
11th year (strengthening with 75mm DBM +40mm BC)	2,54,32,000.00 (Strengthening Course)	4,58,30,814.00

- *Periodic re-surfacing cost on Bituminous Surface in every 5 years*

Periodic resurfacing costs with a 30mm thick BC on the existing bituminous surface are tabulated in **Table 03** for every 5 years, i.e., the 6th year, 16th year, and 21st year.

Table 3 Re-Surfacing Cost in Every 5 Years I.E.In 6th Year,16th Year & 21st Year

YEAR	Basic Maintenance Cost in Rs	Inflated Cost@5.50% in Rs
6th YEAR (30mm thick BC)	80,22,000.00	1,04,84,433.00
16th Year (30mm thick BC)	80,22,000.00	1,79,08,926.00
21st Year (30mm thick BC)	80,22,000.00	2,34,06,251.00

- *Inflated Cost of Periodic re-surfacing with 30mm thick Bituminous concrete overlay every 5 years*

The inflated Cost of Periodic re-surfacing with 30mm thick BC on the existing bituminous surface in every 5 years is tabulated in Table 4

Table 4 Inflated Maintenance Cost over the Bituminous Overlay

Pavement Layer	Length (m)	Width (m)	Thick (mm)	Qty	Unit	Rate in Rs	Amount in Rs
Tack Coat	1000	20	-	20000	Sq.Mtr	18.00	3,60,000.00
BC (30mm thick BC)	1000	20	0.030	600	Cum	12770	76,62,000.00
Total cost for Resurfacing every 5year with 30mm thick BC in Rupees							**80,22,000.00**

➢ *Cost of Overlay with 150mm thick Thin White Topping*

- *Cost of Construction of Thin White Topping Overlay*

The cost of 150mm thick Thin White Topping Overlay is tabulated in Table 05.

Table 5 Cost of 150mm Thick Thin White Topping Overlay

Item	Length (m)	Width (m)	Thickness (m)	Qty	Unit	Rate in Rs	Cost in Rs
Milling of Existing Bituminous Surface	1000	20	25mm to 50mm	20000	Sq.mtr	44.00	8,80,000.00
Thin White Topping (150mm thick)	1000	20	0.150	3000	Cum	7346.00	2,20,38,000.00
Joint Cutting and filling	30000	NA	NA	30000	Mtr	311.00	93,30,000.00
Total Cost for TWT overlay in Rupees							**3,22,48,000.00**

- *Periodic Maintenance Cost Over Thin White Topping Surface*

Three types of periodic maintenance are required over the Thin Topping Surfacing as explained below and tabulated in Tables 6,7 and 8.

✓ *Joint re-filling cost in every five-year interval per kilometre length of a four-lane Highway having a carriageway width of 20.00 Meters*

It is expected that about 25% of the total joint length is damaged and to be cleaned and refilled every 5 years.

The total length of longitudinal joints per kilometre length with a grid spacing of 1.25m c/c=14nos of longitudinal jointx1000meter=14000mtr

The total length of Cross Joints per kilometre length with a proposed grid spacing of 1.25mtr c/c =800nos of cross jointsx20.00 metres=16000metres

Estimated Length (25%) of longitudinal joints to be cleaned and refilled in every ten years =25% of 14,000meters=3500.00meters

Estimated Length of cross joints to be cleaned and refilled every ten years= 25% of 16,000meters=4000.00meters

50% of the SSR Rate for the combined item of Joint cutting and filling is considered for cleaning and refilling the joint with polysulphide since the joint-cutting cost is not involved here.

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Table 6 Joint Re-Filling Cost in Every Five-Year Intervals Over Twt&Utwt Overlays

Details of Joints to be cleaned and Re-filled	Length in meter	Unit	Rate in Rs	Amount in Rs
The Longitudinal Joint to be cleaned and Refilled	3500	meter	155.50	5,44,250.00
The Contraction Joint to be cleaned and refilled	4000	meter	155.50	6,22,000.00
Total Cost for Joint Refilling in Every Five Years (6th,11th,16th and 21st Year)				**11,66,250.00**

Table 7 Inflated Joint Re-Filling Cost in Subsequent Years Over Twt&Utwt Overlays

Year	Basic Cost in Rs	Inflated Cost @5.50 % in Rs
6th Year	11,66,250.00	15,24,242.00
11th Year	11,66,250.00	19,92,123.00
16th Year	11,66,250.00	26,03,626.00
21st Year	11,66,250.00	34,02,835.00

✓ *Cost of repairs to spalled joint after 10 years (11th year) of construction*

It is assumed that 10% of the concrete is damaged in a width of about 25 cm on either side of the joint every 10 years. The cost of repairs to the spalled joint with epoxy concrete is taken as Rs 2000.00 per square meter as per the current market rate since the corresponding rate for Joint Repair is not available in SSR 2023. The Basic cost for repairs to the spalled joint and the inflated cost in the 11th year is tabulated in Table 08.

Table 8 Cost of Repairs to Spalled Joint after 10 Years (11th Year) of Construction

Total Joint Length in Meter	10% of Joint length =30000x10% (in Meters)	Area of repairs to be done (3000x0.500=1500) square meter	Rate Per Square meter (Market Rate) in Rs	Present Cost in Rs per Square	Inflated Cost@5.5% in 11th year in Rs
30,000.00	3000.00	1500.00	2000.00	30,00,000.00	51,24,434.00

✓ *Cost of Re-texturing to the old thin white topping surface after 10 years using diamond grinding*

The surface texture of the Concrete gets lost and becomes smooth and the friction between the concrete surface and the tyres of the vehicles is reduced over time and with a result the road surface becomes smooth and slippery during the monsoon season. Hence Re-texturing is required to be done almost after ten years of construction to avoid skidding of vehicles in the rainy season. The rate of Retexturing has been taken as Rs 200 per square meter area as per the current market rate since the rate for this item is not available in the SSR 2023.

Table 9 Cost of Re-Texturing of Thin White Topping after 10 Years (11th Year) of Construction

Total Length of Retexturing in meter	Width in meter	Area of Retexturing in Square Meter	Rate of Re-texturing in Rs	Basic Cost of Retexturing	Inflated Cost @5.5% in 11th year in Rs
1000.00	20.00	20000.00	200	40,00,000.00	68,32,578.00

The total inflated maintenance Cost in the 11th year will be equal to the sum obtained by adding the Joint refilling Cost, repairing cost to the spalled joint and re-texturing cost as given in Table 10.

Table 10 Inflated Cost for Joint Re-Filling, Repairs to Spalled Joints and Retexturing Over the TWT & UTWT Overlays in 11 Th Year

Inflated Joint Refilling Cost in 11 th year	Inflated Cost of Repairs to Spalled Joint in 11th year	Inflated Retexturing Cost in the 11th year	Total Inflated Maintenance Cost @5.5%in 11th year
19,92,123.00	51,24,434.00	68,32,578.00	**1,39,49,135.00**

Cost of the overlay with 100mm thick Ultra-Thin White Topping (Construction Cost)

- *The cost of the overlay with 100mm thick Ultra-Thin White Topping*

The Cost Of The Overlay With 100mm Thick Ultra-Thin White Topping Is Tabulated In Table No.11 Below.

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Table 11 Cost of Overlay With 100mm Thick Thin White Topping

Item	Length (m)	Width (m)	Thickness (m)	Qty	Unit	Rate in Rs	Cost in Rs
Milling of Existing Bituminous Surface	1000	20	0.05	20000	Sq.mtr	44.00	8,80,000.00
UTWT of 100mm thick	1000	20	0.1	2000	Cum	7346.00	1,46,92,000.00
Joint Cutting and filling	30000	NA	NA	30000	Mtr	311.00	93,30,000.00
Total Cost of 100mm thick TWT overlay							**2,49,02,000.00**

- *The cost of periodic Maintenance of Ultra-Thin White Topping*

The cost of maintenance of Ultra-Thin White Topping are same as that of Thin White Topping and hence the maintenance costs are not repeated since the already worked out maintenance costs under TWT, tabulated in Table Nos.6,7,8,9 and 10 are applicable for the maintenance items of UTWT also.

All the Overlay Costs and Maintenance costs worked out above are derived using the SSR rates of Maharashtra for the year 2022-23. The summary of life Cycle Cost (LCC) analysis of the Bituminous overlay, Thin white Topping and Ultra-Thin White Topping overlays is given in Table No:12 for comparison of LCC of different types of overlays.

Table 12: Life Cycle Cost Comparison (Net Present Value) of Bituminous Overlay, Thin White Topping and Ultra-Thin White Topping (UTWT) Overlay

NPV of Bituminous Overlay					NPV of TWT Overlay				NPV of UTWT Overlay			
Sl no	Year	Construction/Maintenance Cost in Rs	(1/1.12)^ n	NPV	Year	Construction/Maintenance Cost in Rs	(1/1.12)^n	NPV	Year	Construction/Maintenance Cost in Rs	(1/1.12) ^n	NPV in Rs
1	2023	2,54,32,000	1	2,54,32,000	2023	3,22,48,000	1	3,22,48,000	2023	2,49,02,000	1.00	2,49,02,000
2	2024		0.89		2024		0.89		2024		0.89	
3	2025		0.8		2025		0.8		2025		0.80	
4	2026		0.71		2026		0.71		2026		0.71	
5	2027		0.64		2027		0.64		2027		0.64	
6	2028	1,04,84,433	0.57	59,76,127	2028	15,24,242	0.57	8,68,818	2028	15,24,242	0.57	8,68,818
7	2029		0.51		2029		0.51		2029		0.51	
8	2030		0.45		2030		0.45		2030		0.45	
9	2031		0.4		2031		0.4		2031		0.40	
10	2032		0.36		2032		0.36		2032		0.36	
11	2033	4,58,30,814	0.32	1,46,65,860	2033	1,39,49,135	0.32	44,63,723	2033	1,39,49,135	0.32	44,63,723
12	2034		0.29		2034		0.29		2034		0.29	
13	2035		0.26		2035		0.26		2035		0.26	
14	2036		0.23		2036		0.23		2036		0.23	
15	2037		0.2		2037		0.2		2037		0.20	
16	2038	1,79,08,926	0.18	32,23,607	2038	26,03,626	0.18	4,68,653	2038	26,03,626	0.18	4,68,653
17	2039		0.16		2039		0.16		2039		0.16	
18	2040		0.15		2040		0.15		2040		0.15	
19	2041		0.13		2041		0.13		2041		0.13	
20	2042		0.12		2042		0.12		2042		0.12	
21	2043	2,34,06,251	0.10	23,40,625	2043	34,02,835	0.10	3,40,284	2043	34,02,835	0.10	3,40,284
		Total NPV		**5,16,38,219**				**3,83,89,478**				**3,10,43,478**

From the above table of Life Cycle Cost analysis, it can be inferred that the percentage Cost of TWT Pavement compared to Bituminous Overlay is only = (383.89/516.38) x100%/=74.34% (Say 75%) and that of UTWT overlay compared to Bituminous Overlay is = (310.43/516.38) x100%=60.11% (Say 60%) thereby a net saving of 25% in the case of TWT overlay and 40% in the case of UTWT overlay respectively. These percentage savings tally with the savings worked out in similar types of analysis available in various technical literatures.

It may be noted that the exact percentage saving will vary with the overlay thicknesses worked out depending upon the pavement design carried out based on the traffic intensity on the Highway, Subgrade CBR, Lane configuration (Single Lane, two lanes or four lanes) etc

IX. CONCLUSION

It has been established with the help of the Life Cycle Cost Comparison as per the guidelines of IRC: SP:30-2009(Economic Evaluation of Pavements) between Bituminous Overlay and Thin White Topping Overlay that the Net Present Value (NPV) of Thin White Topping overlay with 150mm thickness is only about 75% of that of Bituminous Overlay, thereby a saving of about 25% in overall Life Cycle Cost. When it comes to the comparison between the Bituminous overlay and Ultra-Thin White Topping overlay of 100mm thickness, the saving in Life Cycle Cost will be to the tune of 40% as explained in the above analysis. Hence Thin White Topping and Ultra-Thin White Topping overlays are considered to be very economical and durable treatments compared to bituminous overlays to rehabilitate

the deteriorated existing Bituminous pavement. It may also be noted that the UTWT overlay is generally not recommended for State Highways and National Highways having heavy traffic intensity and it is suitable only for colony roads and low-traffic volume roads.

SCOPE FOR FUTURE STUDY AND RESEARCH

Since Thin White Topping (TWT) and Ultra-Thin White Topping (UTWT) overlays are cost-effective, there is ample scope to undertake case studies to determine the actual cost savings and durability of these overlays by conducting sample studies. The results of such studies can be further extended to establish the cost and durability of TWT and UTWT overlaid pavements on various categories of roads (Colony Roads, Major District Roads, State Highways, National Highways with different configurations, etc.) which can be useful for the preparation of tender documents of such categories of roads in future.

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REFERENCES

[1]. IRC: SP:76-2015 Guidelines for Conventional and Thin White Topping (First Revision)
[2]. IRC:58-2015 Guidelines for the design of plain jointed Rigid Pavements for Highways (Fourth Revision)
[3]. IRC:15-2011 Standard Specifications and code of practice for Construction of concrete Roads (Fourth Revision)
[4]. IRC:81-1997 Guidelines for strengthening of Flexible Road Pavements using Benkelman Beam Deflection technique
[5]. IRC: SP:30-2009 Manual on Economic Evaluation of Highway Projects in India
[6]. Shirole Pratik Ashok, Patil Ashwini R "Life Cycle Cost Analysis of Flexible Pavements and Rigid Pavements in Urban Areas" International Journal of Innovative Science and Research Technology ISSN No: -2456-2165
[7]. Bageshwar Prasad "Life Cycle Cost Analysis of Cement Concrete Roads VS Bituminous Roads (Indian Roads Congress (IRC) Technical Papers (2007)
[8]. Patel Karan M., Dr.L.B. Zala, Prof. A. A. Amin "Life Cycle Cost analysis for selecting the Pavement maintenance alternatives, A case Study of Kota-Barun Road (NH-27)" International Journal of Advance Research in Engineering, Science and Technology.