International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)

| ISSN: 2395-7852 | www.ijarasem.com | Bimonthly, Peer Reviewed & Referred Journal|

| Volume 2, Issue 6, November 2015 |

Pavement Rehabilitation Using Thin White Topping

Ashish P Alapure [1], Shishir S Ganjale [2], Shrikant S Kulkarni [3], Utkarsha B Ingle [4], Yogesh Y Gore [5], Yogita B Dahatonde [6].

Department of Civil Engineering, JSPM's Rajarshi Shahu College of Engineering, Tathawade, Pune, India[1,2,3,4,5,6]

ABSTRACT: Thin White topping (TWT) is a technology to construct 100-200mm thick cement concrete overlay on distressed asphalt pavement as a rehabilitation technique. There have been several TWT projects completed in India, the first in Pune, subsequently in New Delhi, Ghaziabad, Mumbai, and Thane. All projects have shown good to excellent performance so far, indicating that this rehabilitation strategy can stand up to the Indian climate and traffic conditions. The suitability of TWT rehabilitation for a particular site is dependent on several factors including existing asphalt thickness, volume of truck traffic, base and sub-grade support, and pavement conditions. This paper outlines the state-of practice in India for construction of TWT considering mix traffic, extreme climatic conditions, use of indigenous materials and design aspects as per Indian Road Congress (IRC) guidelines.

KEYWORDS: Deflection, Hot Mix Asphalt, Stress, Thin White Topping.

1. INTRODUCTION

The increasing truck weights and tyre pressures on our pavements in recent years have pushed the demand on the performance of our pavements to a higher level. Many asphalt pavements have experienced rutting while many others have experienced longitudinal cracking. One of the possible solutions to this problem is the use of white topping (WT), which is a cement concrete layer placed over an existing asphalt pavement.

Concrete overlays have been used to rehabilitate bituminous pavements since 1918 in USA. There has been a renewed interest in white topping, particularly on Thin White Topping (TWT) and Ultra-Thin White Topping (UTWT) over Conventional White Topping. Based on the types of interface

i. **Conventional White topping**– which consists of PCC overlay of thickness 200 mm or more, which is designed & constructed without consideration of any bond between existing overlay & underlying bituminous layer (without assuming any composite action).

ii. **Thin White topping (TWT)**– which has PCC overlay between 100 – 200 mm. It is designed either considering bond between overlay & underlying bituminous layer or without consideration of bond. High strength concrete (M 40 or higher) is normally used to take care of flexure requirement. Joints are at shorter spacing of 0.6 to 1.25 m.

iii. **Ultra-Thin White topping (UTWT)**– which has PCC overlay of less than 100 mm. Bonding between overlay & underlying bituminous layer is mandatory. To ensure this, the existing layer of bitumen is either milled (to a depth of 25 mm) or surface scrapped (with a non-impact scrapper) or gently chiseled. Joints are provided at a spacing of 0.6 to 1.25 m.

White topping is stronger than asphalt overlay, and thus more resistant to rutting and surface initiated cracking. Consequently, white topping pavements pose potential economical and technical benefits. However, they need to be effectively evaluated for feasibility and proper application techniques, suitable for India, so that their use can provide the maximum benefits to the road users in particular and Indian economy at large.

Ultra-thin white topping is one of the types of white topping in which a thin layer of concrete varying from 50 to 100mm thick with fibers is placed over a prepared surface of distressed asphalt pavement. In addition to the thickness of the concrete overlay, other factors differentiate UTW from conventional concrete overlays are: (a) a substantial degree of bond between the concrete overlay and the prepared asphalt surface, and (b) much closer joint spacing. Ultra-Thin White topping is an emerging and innovative technology for asphalt pavement rehabilitation in India.

RESEARCH PROBLEM

Design and analysis of Thin White Topping by using excel sheet.

We are going to reduce the layer thickness of topping so as to achieve economy in project.

II. OBJECTIVES OF RESEARCH WORK

1.1. To study the present condition of existing pavement and suitability regarding laying of ultra thin white layer.
1.2. To do various types of testing on existing bitumen pavement to obtain the good design.
1.3. To design the ultra thin white topping with fibers so as study the effect of fibers on strength.
1.4. To design and analysis of ultra thin white topping layer on ANSYS software.
1.5. To do economic analysis to compare and suggest suitable type of overlay.

III. LITERATURE REVIEW

1.6. "Ultra-Thin White topping in India: State-of- Practice"
By: D. R. Jundhare, K.C. Khare, and R. K. Jain
This paper outlines the state-of practice in India for construction of UTW considering mix traffic, extreme climatic conditions, use of indigenous materials and design aspects as per Indian Road Congress (IRC) underlines.

1.7. "Assessment of Wisconsin's white topping and ultra thin white topping project"
By: Haifang Wen, PhD, P.E., Xiaojun Li, Wilfung Martono
The primary objectives of this study are to catalog the white topping (WT) and UTW projects in Wisconsin, document pertinent design and construction elements, assess performance and estimate a service life of these projects. A comprehensive literature review was performed. A database of the WT and UTW projects was established covering 18 projects built from 1995 to 2007 in Wisconsin.

1.8. Synthesis of Current Minnesota Practices Of Thin and Ultra-Thin White topping
Author: Chunhua Han, Ph.D., P.E. Braun Intertec Corporation
This paper outlines what has been done and what has been learned:

- When and when not to use thin and ultra-thin white topping,
- Which type of white topping fits best
- How to choose materials, thickness, joint spacing and other physical design
- How to choose construction techniques, and
- Risks associated with this rehabilitation process

1.9. "Pavement Rehabilitation Through Ultra-Thin White topping (UTW) Overlays"
Author: Dave Amos, Intermediate Research Assistant, Missouri Department of trans.
The objective of this study has been to determine the feasibility of placing an ultra-thin white topping (UTW) overlay as a viable pavement rehabilitation method on low to medium volume asphaltic concrete (AC) pavements where rutting or shoving or both have become a problem, particularly at urban intersections. The procedure of milling and overlaying with asphaltic concrete is the least expensive and most commonly used practice in these areas.

1.10. "Performance Evaluation of Ultra-thin White topping in India by BBD Test"
Author: D. R. Jundhare, Dr. K. C. Khare; and Dr. R. K. Jain
This paper give information about performance evaluation of ultra thin white topping in Pune city by using BBD test.

IV. PROJECT SURVEY

1.11. **DETAILS OF SITE**

1.11.1.	Selection of site	:	Date -11/09/2015
1.11.2.	Name of site	:	Infosys chowk to Maangaon (Hinjewadi, Pune)
1.11.3.	Length of road	:	3.0 km
1.11.4.	Length of strip	:	1.5 km
1.11.5.	Carriage way	:	6.0 meters
1.11.6.	Condition of pavement	:	Poor

1.12. **CAUSES TO SELECT THE SITE FOR THIN WHITE TOPPING:**

1.12.1. ROAD CONDITION: Road condition of selected site is poor . During observation it was found that so much rutting of surface course took place. Cracking also observed. During survey potholes also observed. This all shows that existing bitumen road is distressed which is main condition for ultra thin white topping

| ISSN: 2395-7852 | www.ijarasem.com | Bimonthly, Peer Reviewed & Referred Journal|

| Volume 2, Issue 6, November 2015 |

1.12.2. TRAFFIC DENSITY: By observation it is observed that lots of heavy vehicles are going every day and there are lots of commercial vehicles also going on that road.

1.12.3. INDUSTRIAL AREA: Several small scale industries present around the road due to that number of Commercial vehicles using the road is increasing day by day.

1.12.4. MAINTENANCE: Due to heavy vehicles and regular traffic, road is distressing periodically and Which directly increasing the maintenance cost. So to reduce the maintenance cost and increase the durability there is need to adopt some new rehabilitation techniques is needed that is Ultra thin white topping.

V. PHYSICAL FEASIBILITY SURVEY

Before starting the work or designing the ultra thin white topping layer what is needed to first observe the condition of road. For this our project group conducted the physical feasibility survey. The length of road considered for the survey is 1.5 km. We took details for every 60.00 m chainage. In which data is collected on the basis of distress on existing road pavement. In the physical feasibility survey we observes the distress like rutting, cracking, potholes e and classify as major, medium and minor etc.

VI. TRAFFIC DATA COLLECTION AND ANALYSIS

From this point actually design procedure starts ie. Collection of traffic data and its analysis. For this project we conducted 3 days survey of traffic in which only commercial vehicles counted. Traffic data collected in terms of only commercial vehicles per day (CPVD) and then it is converted into PCU.

Traffic data in terms of commercial vehicles per day

SR.NO	DAY 1	DAY 2	DAY 3	AVERAGE
1.	10656	10691	11192	10847

Traffic in terms of PCU

SR.NO	DAY 1	DAY 2	DAY 3	AVERAGE
1.	10756.9	10797.6	11595.7	11053.06

6.1 DESIGN TRAFFIC IN TERMS OF CUMMULATIVE REPITITION:

The design traffic is considered in terms of the cumulative number of standard axles to be carried during the design life of the road. Its computation involves estimates of the initial volume of commercial vehicles per day, lateral distribution of traffic, the growth rate, the design life in years and the vehicle damage factor (number of standard axle per commercial vehicle) to convert commercial vehicles to standard axles.

The following equation may be used to make the required calculation:

$$C = \frac{365 * A\{(1+r)^n - 1\}}{r}$$

Where,

C - The cumulative number of standard axles to be catered for in the design

A - Initial traffic, in the year of completion of construction, in terms of the number of commercial vehicles per day duly modified to account for lane distribution.

r - Design growth rate

n - Design life in years for calculations;

r = 7.0 % (Take)

n = 10 years

P= Avg. traffic in PCU

C=58115798.99

Design traffic = 25% of the total repetition of commercial vehicles

= 14528949.75

VII. CALCULATION OF DEFLECTION OF PAVEMEBT BY USING 'BENKLEMAN BEAM' APPARATUS:

Modulus of subgrade reaction (k-value) has been determined by conducting Benkelman Beam Deflection (BBD)on the surface of Hot Mix Asphalt (HMA). The maximum value of deflection obtained from BBD has been used to find out k-value.

Following tables shows observations taken from BBD test.

Mangaon to Infosys

Location	Actual Deflection	Pavement Temp.	Type of soil & PI	Moisture Content (%)	Correction Factor		Corrected Deflection
					Temp.	Moisture	
0	2.182	40	Sandy/r<1300	6.25	-0.05	1.07	2.28
300	2.364	45	Sandy/r<1300	7.4	-0.1	1.04	2.345
600	2.33	47	Clayey/r<1300	17.24	-0.12	1.1	2.431
900	1.344	47	Sandy/r<1300	3.44	-0.12	1.32	1.615
1200	1.468	55	Clayey/r<1300	21.42	-0.2	1.05	1.331
1500	1.224	55	Sandy/r<1300	4.76	-0.2	1.2	1.228
						∑	11.239

Infosys To Mangaon

Location	Actual Deflection	Pavement Temp.	Type of soil & PI	Moisture Content (%)	Correction Factor		Corrected Deflection
					Temp.	Moisture	
0	2.138	40	Sandy/r<1300	6.25	-0.05	1.07	2.234
300	2.062	45	Sandy/r<1300	7.4	-0.1	1.04	2.04
600	1.862	47	Clayey/r<1300	17.24	-0.12	1.1	1.916
900	1.738	47	Sandy/r<1300	3.44	-0.12	1.32	2.135
1200	2.224	55	Clayey/r<1300	21.42	-0.2	1.05	2.1258
1500	2.144	55	Sandy/r<1300	4.76	-0.2	1.2	2.33
						∑	12.78

Maximum deflection = 2.431mm

CALCULATION FOR MODULUS OF SUBGRADE REACTION (K)

Modulus of subgrade reaction (k-value) has been determined by conducting Benkelman Beam Deflection (BBD)on the surface of Hot Mix Asphalt (HMA). The maximum value of deflection obtained from BBD has been used to find out k-value from the graph shown in Figure 1.

K-VALUE FROM BENKELMAN BEAM DEFLECTION (BBD)

BBD test has been conducted as per IRC: 81–1997 guidelines on ten locations as shown in above tables. Maximum deflection from BBD data is 2.431mm and corresponding k-value is 6 kg/cm^2 as obtained from Figure 1 given by Corporation of Engineers and Portland Cement Association (PCA).

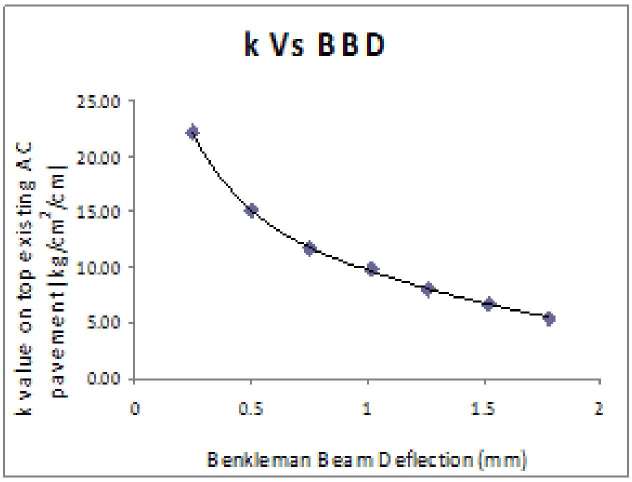

Figure 1. Relation between BBD and k-value
[Source: Corporation of Engineers and PCA]

VIII. DESIGN OF THIN WHITE TOPPING

Percentages of axle road for design of TWT

Single Axle Loads		Tandem Axle Loads	
Axle Load Class, tons	Percentage of axle loads	Axle Load Class, tons	Percentage of axle loads
15-17	0.7	26-30	0.2
13-15	1.0	22-26	0.2
11-13	34.3	18-22	0.3
9-11	33.0	14-18	0.1
Less than 9	28.2	Less than 14	2.0
Total	97.2	Total	2.8

Trial thickness =20cm
Subgrade reaction (k) =6 kg/cm^3
Design period = 10yrs
Modulus of rupture =45kg/cm^2
Load safety factor =1

Axle load in tons (1)	Stress in kg/cm^2 *0.65 (2)	Stress ratio (3)	Expected repetitions (4)	Fatigue life(N)*0.75 (5)	Fatigue life consumed (4/5)
Single axle					
16	24.05	0.53	101702.64	171845.54	0.59
14	21.45	0.47	145289.49	3901855.38	0.037
12	18.2	0.40	4983429.76	infinity	0
10	16.25	0.36	4794553.41	infinity	0
<10	13.65	0.30	4097163.83	infinity	0
Tandem axle					
28	17.55	0.39	29057.89	infinity	0
24	15.27	0.33	29057.89	infinity	0
20	13.32	0.29	43586.84	infinity	0
16	10.05	0.24	14528.14	infinity	0
<16	8.45	0.18	290578.99	infinity	0
				$\sum$	0.627

The cumulative life consumed both by single and tandem axle is being less than 1.Therefore the design is safe for traffic proposed from fatigue consideration.

CHECK FOR STRESSES

1. TEMPERATURE STRESSES

Edge warping stresses= $\dfrac{CE\alpha\Delta t}{2}$

Where,
E= Modulus of elasticity, kg/cm^2
C= Bradbury coefficient (fig. No. 2 from IS58-2002)
∝= thermal coefficient
Δt= temperature difference

Edge warping stress=0.342kg/cm^2
Total Edge warping stress and the highest axle load stress=0.342+24.05=24.392kg/cm^2 < 45kg/cm$^{2.}$ hence thickness is safe.

2. CHECK FOR CORNER STRESSES

Corner stress= $\dfrac{3P}{h^2}\left[1-\left(\dfrac{a\sqrt{2}}{l}\right)^{1.2}\right]$

Where,
l=radius of relative stiffness
a=radius of area of contact of wheels
P=load in kg=6000
h=thickness of overlay=20cm
μ=Poissons ratio=0.15
s=c/c distance between two tyres=31cm
q=tyre pressure=8kg/cm^2

$$l = \sqrt[4]{\frac{Eh^3}{12\left(1-\mu^2\right)k}}$$

l =76.41cm

$$a = \left[0.8521\times\frac{P}{q\Pi}+\frac{s}{\Pi}\left(\frac{P}{0.522\times q}\right)^{0.5}\right]^{0.5}$$

= 24.02cm

Corner stress=27.98kg/cm^2

The corner stress is less than the flexural strength of the concrete i.e. 45kg/cm^2.

Hence overlay thickness is safe.

IX. MIX DESIGN

The type of concrete mix for a particular UTW project has been selected on the basis of traffic conditions, desired concrete strength and opening to traffic. In this project M40 grade of concrete along with polypropylene fibers has been used for UTW overlay by carrying out the mix design as per IS 456, IS 19262, IRC:44-2008 and MORTH guidelines. These fibers were inserted to strengthen the concrete, reduce shrinkage cracking, and provide reinforcement across cracks.

The quantity of various ingredients required per cum of concrete for achieving 0.39 water cement ratio has been given in Table VI shows material requirements per cubic meter of concrete.

International Journal of Advanced Research in Arts, Science, Engineering & Management (IJARASEM)

| ISSN: 2395-7852 | www.ijarasem.com | Bimonthly, Peer Reviewed & Referred Journal|

| Volume 2, Issue 6, November 2015 |

Sr. No.	Material	Percentage	By weight (kg)	Quantity (kg/m^3)
1	Cement (43 grade OPC)	-	50	425
2	Coarse aggregate a)20 MM b)10MM	 30 25	 75 62	 598 499
3	Fine aggregate A)River Sand b)Crushed Sand	 23 22	 57 55	 459 439
4	Steel Fibre	-	0.225	1.80

X. JOINTS IN TWT

In case of UTW, contraction joint, expansion joint, construction joint and longitudinal joints are provided with slight modification from conventional rigid pavement because of small size panel and bonding of TWT layer with sub-base layer. Pavement is divided into relatively short panels by contraction joints which are so spaced to prevent formation of intermediate cracks. No expansion joints are required in case of TWT, however at every 15 m length, a wooden board of width 10 mm may be used as construction butt joint with 3 tie bars of 10mm diameter and of length 300mm at spacing of 30cm c/c in each panel with maximum joint spacing of 1.0m. Timely joint cutting (within 6-18 hours of placing of TWT) prevent cracking, minimize curling and warping stresses. An approved high quality sealant shall be used to seal joint reservoirs and prevent moisture and incompressible infiltration into overlay system. Runner beam of concrete grade M 40 without any reinforcement may be provided. For drainage consideration in the longitudinal direction, normal concrete curb stone of grade M 40 may be provided along the length of the beam at a height of 25-30cm above the top level of TWT generally as water table for drainage.

XI. CONCLUSION

International experience on white topping is encouraging. Countries like France, Belgium, U.S.A., U.K. etc. Have successfully designed and constructed white topping and their performance is satisfactory. But for the country like India this is an upcoming technology, therefore it is necessary to construct few trial sections using indigenous materials and techniques. Carrying out long term performance evaluation of the same is necessary to develop this technique for Indian traffic and climatic conditions. We are suggesting the thickness of UTW/TWT by use of manual design and software.

REFERNCES

1. D. R. Jundhare, K.C. Khare, and R. K. Jain "Ultra-Thin White topping in India: State-of- Practice"(2012) vol. 2
2. Haifang Wen, PhD. , P.E., Xiaojun Li, Wilfung Martono "Assessment of Wisconsin's white topping and ultra thin white topping project" (2010)
3. Chunhua Han, Ph.D., P.E. Braun Intertec Corporation "Synthesis of Current Minnesota Practices Of Thin and Ultra-Thin White topping"
4. (2005)
5. Dave Amos, Intermediate Research Assistant, Missouri Department of trans "Pavement Rehabilitation Through Ultra-Thin White topping (UTW) Overlays"
6. J. Roesler, A. Bordelon, A. Ioannides, M. Beyer, D. Wang "Design and Concrete Material Requirements for Ultra-Thin White topping"
7. B.N. Skandakumar, Suhas, Bhavan "Performance Evaluation On Thin-White Topping"
8. SudarshanRajan, Jan Olek , Thomas L. Robertson, Khaled Galal "Analysis Of Performance Of The Ultra Thin White Topping Subjected To Slow Moving Loads In An Accelerated pavement Testing Facility"

9. Dr. V. Ramachandra, Zonal Head (Tech), Ultra-Tech Cement Ltd., Bangalore "WHITETOPPING – A Viable & Sustainable Option for Rehabilitation of Urban Roads"
10. D. R. Jundhare, Dr. K. C. Khare; and Dr. R. K. Jain "Performance Evaluation of Ultra-thin White topping in India by BBD Test"
11. V.K. Sinha, Satandar Kumar& R.K. Jain "White Topping -A Cost effective Rehabilitation Alternative For Preserving Bituminous Pavement Long Term Basis"
12. "IRC 81-1997"- Guide lines for the Benkelman Deflection test.
13. "IRC SP-76:2008-Tentative guidelines for conventional, thin white topping and ultra thin white topping.
14. AlapureAshishP.[1] Dahatonde Yogita B.[2] Ganjale Shishir S.[3] Gore YogeshY.[4] Ingle Utkarsha B.[5]KulkarniShrikant S.[6], S.P.Shinde[7] IOSR Journal paper on "ULTRA THIN WHITE TOPPING" e-ISSN;2278-1684, p-ISSN:2320-334X, PP123-132.