Ultra Thin White Topping: Modern Rehabilitation Technique

Mr. Prathmesh S. Saraf[1]

[1]Master of Technology

[1]Civil Engineering (Transportation Engineering and Planning)

[1]Sandip University, Nashik, India.

---***---

Abstract - Improved and dependable infrastructure, particularly the road network has been given a high priority by the Government. The asphalt pavements have a design period of 5 to 10 years and they require maintenance from time to time. They are susceptible to cracking, rutting, etc. under extreme conditions of weather, daily traffic and loading. Concrete roads have a long life of 30 years or more and do not develop ruts or potholes. They are also not adversely affected by floods and other vagaries of weather. Apart from constructing new roads, it would be in the country's interest to renew worn out or damaged bitumen pavements, by putting a layer of concrete on top. This is known as WHITETOPPING. The deteriorated bituminous pavements can be rehabilitated using the white topping technology. The type of white topping includes conventional, thin and ultrathin white topping depending upon the thickness of the road. In this paper, we will study about the rehabilitation of existing asphalt pavements using Ultrathin White Topping. It is a 50-100mm thick cement concrete overlay on distressed asphalt pavement. In this project, 3 trial mixes were tested by using IS code and IRC recommendations on the quantity of cement and chemical admixtures to enhance performance and achieve certain economy in construction of pavement. The quality testing of the trial mixes was also carried out. The trial mix giving the optimum results was checked for achieving economy in construction.

***Key Words*:** Construction sites, JSA (Job Safety Analysis), Materials, Manufacturing etc.

1.INTRODUCTION

Road traffic is increasing over the years. This is an international phenomenon. An international forecast predicts that such a rise will continue in near future. Even within the case of developed countries, there's a shortage of funds required for brand spanking new infrastructure projects, both for constructing them and for his or her maintenance and repairs. The position within the context of a developing country like India is clearly far worse. As a result, more and more roads are deteriorating, and therefore the existing pavement structure as an entire is usually found to be inadequate to cope up with this traffic. The deterioration of pavement generally takes place due to the combined action of traffic, weather changes, drainage, environmental factors, etc. Flexible pavements generally deteriorate at a more rapid rate when compared to rigid pavements. Flexible pavements continue to deteriorate at a slower rate even without the traffic movement on the surface, due to climatic and environmental factors. Rate of deterioration of bituminous pavements increases rapidly when water is retained in the void spaces of bituminous pavement layers.

The problems currently faced by pavements are:

- Formation of potholes, reveling and cracks.
- Formation of unevenness including depressions along the longitudinal profile of pavement surface.
- Formation of longitudinal ruts along wheel paths.
- Formation of large waves along the longitudinal profile, which affects high-speed travel.
- The earth slopes of road embankments and cuts may get damaged due to soil erosion.
- The earth shoulders of the highway may get eroded between pavement edge and shoulders resulting in formation of edge drop leading to inconvenience and danger to traffic along with reduction in roadway capacity.

Cement concrete overlay on top of an existing bituminous surface is commonly known by the term “White-topping”. White-topping can be further classified into:

i. **Conventional White-topping**

It consists of a PCC overlay of thickness 200 mm or more (on top of existing bituminous layer) which is designed and constructed without consideration of any bond between the concrete overlay and underlying bituminous layer

ii. **Thin White-topping**

PCC overlay of thickness greater than 100 mm and less than 200 mm is classified as Thin White topping. The bond between the overlaid PCC and underlying bituminous layer is often a consideration but is not mandatory.

iii. **Ultra-Thin White topping**

UTWT may be defined as concrete overlay 50 mm to 100 mm thick, with closely spaced joints and bonded to an existing bituminous pavement. UTWT system consist of thin layer of high strength, Fiber reinforced concrete placed over a clean, Milled surface of distressed bituminous concrete pavement, to achieve a full or partial bonding.

II. OBJECTIVE

1. To test different trial concrete mixes by using micro silica and fly ash.
2. Case study of an under construction Ultra-Thin White Topping.
3. To study overlaying technique of UTWT.

III. LITERATURE SURVEY

Shanna, 2012. In this paper review the author, Ankit Shanna has explained the design and construction of UTWT for the rehabilitation of Roads. As per the author, there has been increased in demand for Highway Industry. The newer materials should be tried for the Road Construction for the optimization of the lifecycle, reduce the abrasion and reduce the maintenance cost of the Road. The Ultra-Thin White Topping (UTWT) is one of best solution for the rehabilitation of the Roads. According to the Author, UTWT is a FastTrack process and it has been adopted by some countries like US, India, etc. Many laboratory tests are carried out throughout the research institutions in India for the UTWT's on field behavior.

Ankush Kumar Sehgal and S.N. Sachdeva, *2015*, In this paper, Author Ankush Kumar Sehgal have considered that the Ultra-thin White topping overlays are considered more environmentally and economically sustainable as compared to asphalt pavements. These concrete overlays do not require maintenance or repair for a longer duration and, therefore, consume fewer raw materials over time. Energy savings also are realized, since rehabilitation and reconstruction efforts consume energy. Even more importantly, congestion is reduced by using long-lasting concrete overlays because of less frequent construction zones that impede traffic flow. Construction of thin white topping do not produce any waste material, rather it utilizes the underlying asphalt layer to form a composite structure, thus reducing overall thickness of the pavement and making the project economical.

U. Sivaramkrishna, 2016, In this paper, Author has confirmed that Ultra thin white topping can be considered as best overlay alternative as it reduces life cycle cost, improves life term when compared with bituminous overlay for rural roads. From the literature considering optimum joint spacing taking into account wheel load position is most important. From the design calculations it is observed with increase of joint spacing thickness of the pavement has to be increased under constant traffic and other design parameters.

Sagar P. Gawande, Ankush R. Malviya and Feroz H. khan, , Jan. 2017,After studying about both fibers and concrete overlays authors has concluded that, The UTWT is a new and emerging pavement rehabilitation technique in which concrete overlay is provided on top of distress pavement. By using polypropylene fiber, the flexural strength ofM40 concrete is calculated by conducting third point load test as 59.50 kg/cm2. For UTWT pavement the square panel of size lm x lm has been provided. The stress ratio for 100 mm thick UTWT pavement is 0.47 the fatigue life N for stress ratio 0.47 is 3901855. Fatigue consumed by pavement due to repetition of vehicles is 38 % less than 100 %.

Vinay H N, Sunil S, May-201-l in this paper Author Vinay H N has done comparative study about flexible & rigid pavements and concluded that Rut is the major distress affecting the selected road stretches. Based on PCI and IRI values all road sections require 'Resurfacing'. Based on deflection data and existing crust details, it is found out that the existing flexible pavements are structurally inadequate keeping in mind the present traffic condition. Hence the selected roads need structural overlay. The white topping design data shows that, R6 with shorter joint spacing and thinnest overlay has resulted in highest critical stress combination while R4 with thickest overlay and shorter joint spacing has resulted in lowest critical stress combination.

IV. METHODOLOGY

1. Cement

Preference should, however, be to use 43/53 Grade cement as the grade of required concrete is M40 or more than M40. Lesser cement content means less water and, therefore, less chances of shrinkage cracks.

Following are the some advantages of use of OPC 43/53 grade:

- High compressive strength in the early stages.
- Low alkali content provides better protection against alkali-aggregate reaction.
- High early strength facilitates speedy construction.
- Superior resistance to sulphate attack due to less C3A.

While using 53 Grade Cement, fly ash up to 20% by weight of cementations material may be added (to facilitate cutting too many saw joints with some Additional time).

Fig. 1: Cement

2. Fly Ash

The use of fly ash in Portland cement concrete has many benefits and improves concrete performance in both fresh and hardened state. Fly ash use in concrete improves the strength and durability of hardened concrete. Fly ash use is also cost effective. When fly ash is added to concrete, the amount of Portland cement is reduced. The spherical shaped particles of fly ash acts as miniature ball bearings within concrete mix, thus providing a lubricant effect. Replacement of fly ash reduces water demand for given slump. When fly ash is used at about 20% of the total cementations, water demand is reduced by approximately 10% .one of the primary benefits of fly ash is its reaction with available lime and alkali in concrete.

3. **Admixtures**

Admixtures conforming to IS:6925 and 15:9103 may (up to 2% by weight of cement as per IS: 456) be used to improve workability of the concrete or extension of setting time, on satisfactory evidence that they will not have an adverse effect on the properties of concrete with respect to strength, volume change and durability. For ultra-thin white topping super plasticizer Sp-430 is used as admixture. The main objective of using the admixture is to increase the workability at low water content to gain the required concrete strength

4. **Fibers**

These shall be of steel/ polypropylene polyester polyethylene nylon fibers and shall be uniformly dispersed in the concrete mass. These shall be added at the time of preparation of concrete. The synthetic fibers are slender and elongated filaments in the form of bundles, networks, strands of manufactured material that can be distributed thoroughly in the freshly mixed concrete, (as per ASTMC 1116). The diameter of polymeric fibers normally varies from 10-70 micron and specific gravity is in the range of 0.91-1.34. The melting point of these fibers shall not be less than 160°C. The aspect ratio generally varies from 200-2000. Fiber reinforced concrete shall be free from fiber balls when delivered.

5. **Aggregates**

Aggregates for pavement concrete shall be natural material complying with IS:383 with a Los Angeles (LA) Abrasion Aggregate Impact Value (AIV) not more than 35%. The limits of deleterious materials shall not exceed the requirements set out in IS:383. The aggregates shall be free from chart, flint, chalcedony or silica in a form that can react with the alkalis in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06% by weight and the total sulphate content expressed as sulphuric (SO_3) shall not exceed 0.25% by weight of dry aggregates. There are two types of aggregates: a) coarse aggregates b) fine aggregates.

6. **Mineral admixtures**

In case of Conventional White-topping, Ultra-Thin White topping and Thin White topping following materials may be added as mineral admixtures as per their availability:

(i) Fly ash grade I (as per IS 3812-2003)

(ii) Granulated blast furnace slag (as per IS: 12089)

(iii) Silica fume (as per IS: 15388-2003 and 15:456-2000. IRC:SP:70)

The silica-fume as per design is used where high performance concrete is the requirement of the design. It shall be added in suitable dozes normally @ 3-10 by weight of cementations material.

To improve the ductility and fatigue resistance of high strength concrete, polymeric fibers may be added in concrete 0.2%-0.4% by weight of cement and/or steel fibers as per IRC:SP:46.

IV. LABORATORY TESTING

1. **Sieve Analysis Test:**

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) - 1963. In this we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

Fig 2: Sieve Analysis Test

2. **Aggregate Impact Value Test:**

For determination of the aggregate impact value of coarse aggregate, which passes 12.5 mm. IS sieve and retained on 10 mm. IS sieve. IS: 2386(Part IV)-1963 Methods of test for aggregate for concrete Part IV Mechanical Properties.

Fig 3: Aggregate Impact Value Test

3. **Aggregate Crushing Value Test**

For determination of the aggregate crushing value of coarse aggregate, which passes 12.5 mm. IS sieve and retained on 10 mm. IS sieve. IS: 2386 (Part IV)-1963 Methods of test for aggregate for concrete Part IV Mechanical Properties.

Fig 4: Aggregate Crushing Value Test

4. Shape Tests

Shape tests on coarse aggregates such as flakiness index and elongation Index, its importance in concrete construction, methods of determination are discussed.

Shape Tests On Coarse Aggregates:

Following tests are conducted on coarse aggregates under shape tests:

- The elongation index of the given aggregates,
- The flakiness index of the given aggregates.

Fig 5.: Shape Tests

5. Compressive Strength Test

Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether concreting has been done properly or not. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommend concrete cylinder or concrete cube as the standard specimen for the test.

Fig 6.: Compressive Strength Test

V. MIX DESIGN CALCULATION FOR M40

1. Target Mean Strength = 40 + (5 X 1.65) = **48.25 MPa**
2. Selection of water cement ratio:-

   Assume water cement ratio = **0.4**
3. Calculation of cement content:-

   Assume cement content **400 kg / m^3**
4. Calculation of water:-

   400X0.4= 160 kg

   Which is less than 186 kg (As per Table No. 4, IS: 10262), Hence o.k.
5. Calculation for C.A. & F.A.: As per IS : 10262 , Cl. No. 3.5.1

V = [W + (C/Sc) + (1/p). (fa/Sfa)] x (1/1000)

V = [W + (C/Sc) + {l/(l-p)} . (ca/Sca)] x (1/1000)

Where

V = absolute volume of fresh concrete, which is equal to gross volume (m^3) minus the volume of entrapped air,

W = mass of water (kg) per m^3 of concrete,

C = mass of cement (kg) per m^3 of concrete,

Sc = specific gravity of cement,

(p) = Ratio of fine aggregate to total aggregate by absolute volume,

(fa), (ca) = total mass of fine aggregate and coarse aggregate (kg) per m^3 of

Concrete respectively, and

Sfa, Sea = specific gravities of saturated surface dry fine aggregate and Coarse aggregate respectively.

As per Table No. 3 , IS-10262, for 20mm maximum size entrapped air is **2% .**

Assume FA. by % of volume of total aggregate = **36.5 %**

0.98 = [160+ (400/3.15) + (1 / 0.365)(Fa/ 2.61)] (1 /1000)

=> Fa = **660.2 kg**

Say Fa = **660 kg.**

0.98 = [160+ (400/3.15) + (1 / 0.635)(Ca/ 2.655)] (1 /1000)

=> Ca= **1168.37 kg.**

Say Ca = **1168 kg.**

Cement = **400 kg**

Water = **160 kg**

Fine aggregate = **660 kg**

Coarse aggregate = **1168 kg.**

Admixture = 0.6 % by weight of cement = **2.4 kg.**

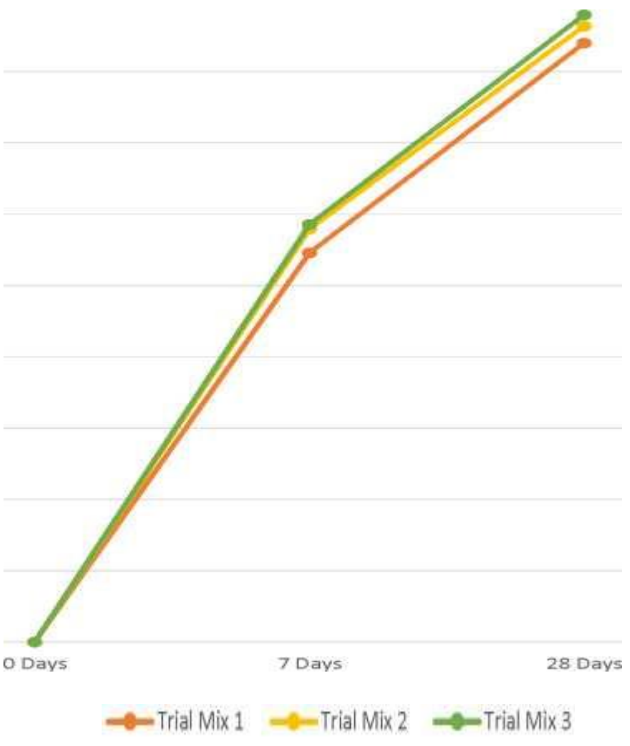
W: C : F.A.: C.A. = 0.4: 1: 1.38: 2.51

VI. RESULT ANALYSIS

Table 1: Test Results

Sr.no.	Tests	Result
1.	Aggregate Impact Value test	12.63%
2.	Aggregate Crushing Value test	15.07%
	Shape Tests	
	For 10mm aggregate 1.Flakiness Index = Wi/W X 100 2.Elongation Index = W2 / W X 100 =	 12.07% 11.94%
	For 20mm aggregates 1. Flakiness Index = Wi/ W X 100 2. Elongation Index = W2 / W X 100 =	 11.72% 10.13%

Compressive Strength test graph refer as, On X- Axis- No. of Days On Y- Axis- Compressive Strength in MPa or N/mm^2



Graph 1: Compressive Strength test

VII. CONCLUSIONS

Pavement strengthening and rehabilitation is a problem of immediate concern and white topping technology serves as a promising solution. UTWT has long life, low maintenance, low life cost; it improves structural capacity of existing bituminous pavement. There has been a significant rise in the use of this technology in India over the past few years. Owing to the performance and cost effectiveness, use of this technology is expected to rise in a matter of time. Out of the trial mixes tested, it has been found that trial mix 3 (60% fly ash) shows comparatively higher compressive strength than the other mixes. If this project were to be studied on a larger scope, the mixes adopted could be modified to achieve better performance using different materials and admixtures, targeting for higher compressive strengths.

VIII. REFERENCES

[1] A. Sharma, "Guidelines for the Design and Construction of Ultra-Thin White Topping," *The International Journal of Engineering and Science*, vol. II, no. 01, pp. 269-274, 2012.

[2] P. Raval, D. Belani and P. J. Pitroda, "A Literature Review on UTW pavements in Indian context," *Journal of hiteriiational Academic Research for*

[3] *Multidisciplinary*, vol. I, no. 9, 2013.

[4] Ankush Kumar Sehgal and S.N. Sachdeva, “A Review of using Ultra thin whitetopping overlays for rehabilitation of asphalt pavements” *Journal of Basic and Applied Engineering Research, Volume 2, Number 3; Jamiary-March, 2015, pp. 182-187*

[5] U. Sivaramkrishna, “A Study of concepts of Ultra thin whitetopping for village roads in India” *ELK Asia Pacific Journals - Special Issue ISBN: 978-81-9304115-4*

[6] Sagar P. Gawande, Ankush R. Malviya and Feroz H. khan, ’’Fatigue data analysis of UTWT pavement using fibre reinforced concrete” *JREAS, Vol. 2, Issue 01, Jan. 2017*

[7] Vinay H N, Sunil S, “Rehabilitation of low volume flexible pavements by white topping” *IJRET: International Journal of Research hi Engineering and Technology, Volume: 03 Special Issue: 06 | May-2014*

[8] Mitesh D. Patel, Prof. P S. Ramanuj, Bhavin Parmar, Akash Parmar, “White topping as a rehabilitation method: A case study of Budhel-Ghogha road”, *International Journal of Advanced Engineering Research and Studies, IJAERS Vol. I Issue IV July-Sept., 2012 31-35*

[9] Brajesh Mishra, “A Study On Thin White Topping: An Alternate For Pavement Treatment”, *International Journal of Engineering Research and Development, Volume 11, Issue 11 (November 2015), PP. 07-11*

[10] Vinesh S. Thorat, Rajas T. Mannur, Pranav V. Deshmukh, Kedar R. Joshi, Akshay P. Pasalkar, Nikhil S. Lobhe, “Ultra Thin White Topping”, *International Journal on Recent and Innovation Trends in Computing and Communication, Volume: 5 Issue: 2, pg 44 – 46*

[11] Prof. Shrikant Harle, Prof. Prakash S. Pajgade "White Topping in Roads: Review"

[12] Alapure Ashish P. Dahatonde YogitaB. et. al. "Ultra Thin White Topping" (2015) Page no.123-131

[13] Mr. Shaikh Adil Nooruddin, Mr. Samiullah, Mr. Mohd Safiuddin "Design and Execution of Thin White Topping Road" (APRIL,2017).

[14] Highway Engineering By S. K. Khanna & C. E. G. Justo

[15] Road Development Plan, Vision:2021, Ministry Of Road Transport And Highways, Published By Indian Road Congress, New Delhi, 2001

[16] Report Of The Committee On Norms For Maintenance Of Roads In India, Ministry Of Road Transport And Highways, 2000

[17] Tentative Guidelines For Conventional, Thin And Ultra-Thin Whitetopping, IRC: SP:76- 2008, Indian Road Congress, New Delhi, 2008.