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Robust Solution For Road Rehabilitation

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Abstract: The focus today is on the construction of long-term performing pavement, since pavements are the costliest component of Highways. Most of our roads have bituminous pavements with thin binder course. Bituminous pavements are showing early sign of distresses worldwide, due to increasing loads, intensity of traffic, high tyre pressure etc. The rutting, cracking and ageing etc are quite common. Reflective cracking is another form of distress in bituminous overlay. These distresses get more pronounced in hot climatic regions like India since bitumen is highly sensitive to temperature. Performance of bituminous pavements in hot climatic regions is thus becoming somewhat doubtful. Concrete on the other hand is known to be a relatively stiffer material and is relatively less sensitive to high temperature. Accordingly, concrete pavements are being increasingly adopted as an alternative to traditional bituminous pavements. Even in terms of rehabilitation and repair the use of concrete is replacing traditional bituminous overlay because of better performance against rutting and cracking. This is the current international trend.

Keywords: UTWT- Ultra thin white topping, ACC Speedcrete 24 , ACC Speedcrete 8

1. Introduction

1.1 General

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 the demand 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 centers and minor ports. Their total length was about 1,37,711 km as at the end of March 2002.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 centers harbouring backwardness. A majority of these roads do not have traffic worthy pavement. 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 roads exhibit, in general, the following deficiencies:

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

Under the present rehabilitation programs 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 bediscarded. White Topping is a way of strengthening or rehabilitating deteriorated asphalt pavements by Plain Cement Concrete (PCC) overlay with or without fibres. It shall have less failures and will act as good base layer for the overlay which will be a best option as the life of the pavement will be more when compared with bituminous overlay.[3]

2. Detailed Literature Review

2.1 Introduction

Portland Cement Concrete (PCC) overlay on an existing bituminous pavement is commonly known as White topping. The principal purpose of an overlay is either to restore or to increase the load carrying capacity or both, of the existing pavement. In achieving this objective, overlays also restore the ride-ability of the

existing pavements which have suffered rutting and deformations, in addition to rectifying other defects such as loss of texture[3]. The increasing truck weights and tyre pressures on pavements in recent years have pushed the demand on the performance of 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 which is a cement concrete layer placed over an existing asphalt pavement. 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.

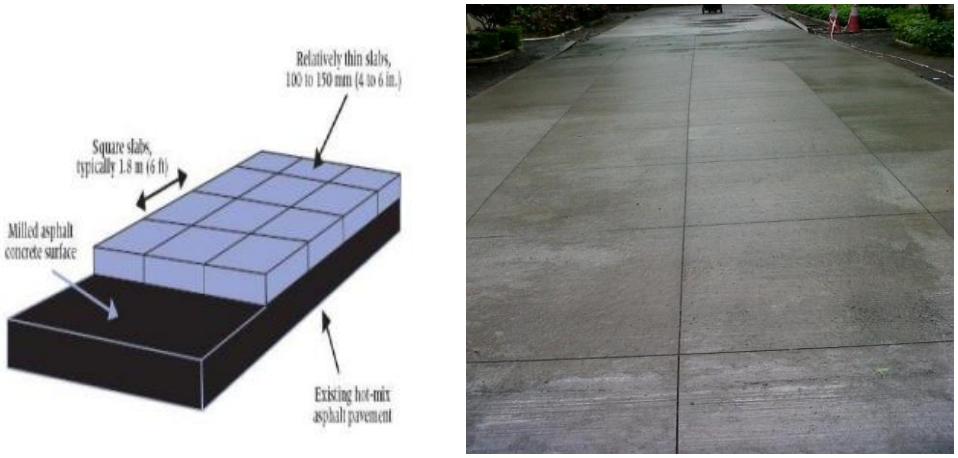

Fig 2.1 Shows the White topping

2.2 Background of White topping

The first white topping project constructed in the United States was in 1918 in Terre Haute, Indian. It was reported that, from 1918 to 1992, approximately 200 white topping projects were done. Among them, 158 were jointed plain concrete pavement, 14 continuously reinforced plain concrete pavement,10 fiber-reinforced concrete, and seven were jointed reinforced concrete pavement[3].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, India and the Netherlands have undertaken recent projects with white topping .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.[3]

2.3There are 3 types of White topping

1. Conventional White topping (CWT)
2. Thin White topping (TWT)
3. Ultra-Thin White topping (UTWT)

a) Ultra – Thin white topping ACC Speedcrete 24 (A product of ACC limited – Concrete Divison)
b) Ultra – Thin white topping ACC Speedcrete8 (A product of ACC limited – Concrete Divison)
c) ACC Supercoat (A product of ACC limited – Concrete Divison)

2.3.1 Conventional White topping

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).These pavements are generally used for pavements subject to heavier traffic loads, and have been designed based on the assumption that the existing asphalt concrete layer does not contribute directly to the load-carrying capacity of the pavement structure. Rather, the asphalt concrete layer is considered to serve as a base layer for the new concrete overlay, and no bond is considered to exist between the overlay and the existing asphalt. A longer joint spacing comparable to those of conventional jointed concrete pavement generally incorporated in conventional white topping [5].

Fig 2.2 shows the conventional white topping

Table 2.1 Mix Design Details & Cost Analysis of Conventional White topping

	Grade of Concrete M40	Rate	
X	Kg/m3	Rs/m3	Cost
Cement – OPC53 Grade	390	5.4	2106
Flyash	150	1.7	255
Water	160	0.1	16
20mm	710	0.6	426
10 mm	240	0.6	144
Crush Sand	830	0.7	581
Admixture	5.85	35	204.75
Density	**2486**	**Raw Material Cost**	**3733**

Here the 28 days compressive strength requirement shall be characterstics strength at 28 days of concrete as per IS 456 :2000

2.3.2Thin White topping (TWT)

Thin white topping which has PCC overlay between 100 – 200 mm. It is designed either where thicker concrete slabs are used. The slab 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[5].Used for low to moderate trafficked corridors [3]

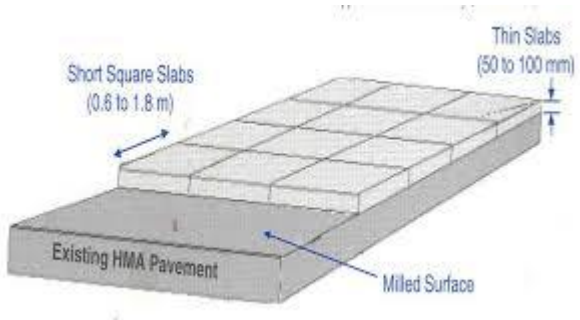

Fig 2.3 shows the thin white topping

2.3.3Ultra -Thin White topping (UTWT)

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 gently chiseled. Joints are provided at a spacing of0.6 to 1.25 m[2].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 [3]

Table 2.2 Mix Design Details & Cost Analysis of Ultra-Thin white topping

	Grade of Concrete M60 UTWT	Rate	
	Kg/m3	Rs/m3	Cost
Cement	480	5.4	2592
Flyash	140	1.7	238
Alcofine	70	13	910
Water	140	0.1	14
20mm	478	0.6	286.8
10 mm	475	0.6	285
Crush Sand	728	0.7	509.6
Admixture	5.88	140	823.2
Accelerator	0.69	60	41.4
Density	**2518**	**Raw Material Cost**	**5700**

Here the 28 days compressive strength requirement shall be characterstics strength at 28 days of concrete as per IS 456 :2000.

There are various Supplementary Cementitious materials used in order to gain quicker strength.

Silica fume, also known as micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide. It consists primarily of very fine smooth spherical silicon oxide particles with an extremely high surface area. Micro-silica particles are 100 times smaller than the average cement particle. Its handling and disposal is a point of concern because of the environment concerns. Silica fume is usually categorized as a supplementary cementitious material. These materials exhibit pozzolanic properties, cementitious properties and a combination of both properties. Due to these properties, it can affect the concrete behavior in many ways.[4]

Manufacturing process of Silica Fume

Micro-silica, also called as silica fumes is produced in electric arc furnace as a by product of the production of elemental silicons or alloys containing silicon.

Availability of Silica Fume

The major production of Silica Fume is China as per the graph shown

Fig 2.4 shows the world silicon production & Silica Fume Sample

Chemical Composition of Silica Fume

Higher the strength of Si02 more shall be strength of concrete. Usually the Si02 shall not be less than 85%

Table 2.3 shows the chemical composition of Silica Fume concrete

	Unit	Micro-silica
SiO2	%	90 – 98
CaO	%	0.2 - 0.7
Al2O3	%	0.4 - 0.9
Fe_2O_3	%	1 – 2
Other	%	2 – 3
S.G	Kg/m^3	2200
Bulk density	Kg/m^3	550 – 650
Surface area	m2/kg	20,000

Cost Implication -Generally the replacement of Silica fume shall be less than 10% hence is mostly used in case of high grade concrete to reduce the heat of hydration by reducing the cement content in high grade concrete. The rate is about Rs 26 per Kg[4].

Alcofine- Alcofine 1203 is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. The raw materials are composed primary of low calcium silicates. The processing with other select ingredients results in controlled particle size distribution (PSD). The computed plain value based on PSD is around 12000 cm2 /gm and is truly ultra fine. Due to its unique chemistry

and ultra fine particle size, Alcofine1203 provides reduced water demand for a given workability, even up to 70% replacement level as per requirement of concrete performance. Alcofine 1203 can also be used as a high range water reducer to improve compressive strength or as a super workability aid to improve flow[1]. It is been manufactured in Goa.

Table 2.4 shows the chemical composition of Alcofine 1203

Chemical Analysis	Mass %	Physical analysis	Range
CaO	32-34	Bulk Density	600-700 kg/m3
Al2O3	18-20	Surface Area	12000 cm2/gm
Fe2O3	1.8-2	Particle shape	Irregular
SO3	0.3-0.7	Particle Size, d10	< 2 µ
MgO	8-10	d50	< 5µ
SiO2	33-35	d90	< 9 µ

Cost Implication – The cost of Alcofine1203 is about Rs 13 per Kg. [1]

Various types of special Admixtures used for UTWT concrete. Such ACCadmix 9005 High Range High Strength Water Reducing & Retarding, Polycarboxylate Ether based admixture for Concrete and Mortar of grades M60 to M100. Generally the dosage is about 0.5%-1.5% cementitious content.

Ultra -Thin white topping – ACC Speedcrete 24

ACC SpeedcreteUTWT-24, a "Ultra -Thin White Topping-24"is a highly performing overlay laid in depth ranging from100 -150 for road sections mm and trafficked in 24 Hours. It is a single integrated novel solutions which comprises amorphous materials and contains cement, modified polymers, mineral & chemical admixtures that helps in quickly achieving desire properties of concrete in production under strict control and formulation; deliver in a controlled manner and craftsmanship on placing, finishing, curing etc by specialists and experienced personnel. It is designed as complete solutions from study of raw materials to finish overlay at application site to speedup the overlay of pavement with highly accelerated time span.The grades used is generally is M60. Wherein the one day compressive strength achieved is 40 Mpa while flexural strength achieved is about 4 Mpa

Surface Preparation

The preparatory work assumed the corrected profiling, camber and structurally sound sub base / DLC compacted and levelled according to the standard practices in road construction. Any uneven cracks, joints or holes should be repaired and filled up and profiled area should be properly cleaned for applying ACC Speedcrete UTWT- 24.

a) Methodology

ACC Speedcrete UTWT- 24 integrated solutions is plan construction method. The overlay application site is schedule and construction work carried out after complete study of filler local materials, mix design and its formulation. A controlled mixing & delivery at batch mix plant to accurately batch & mixed by experienced technologist. A delivery of ACC Speedcrete UTWT- 24 raw treated with utmost care and prepared surfaced is laid with ACC Speedcrete UTWT- 24 raw, screeded, fusion finished, textured, cured & joint cutting & filling, site clearing etc. completed by experienced personnel with special techniques before trafficking in 24 hours.

Fig 2.5 Shows the ACC speedcrete concreting work

Ultra -Thin white topping ACC Speedcrete – 8

ACC Speedcrete, a "Ultra -Thin White Topping -8" is a highly performing overlay laid in depth ranging from 100mm - 150 mm for road sections repaired and trafficked in 8 Hours. It is a single integrated high performing novel solutions which comprises amorphous materials and contains cement, modified polymers, mineral & chemical admixtures that helps in quickly achieving desire properties of concrete in production under strict control and formulation; deliver in a controlled manner and craftsmanship on placing, finishing, curing etc by specialists and experienced personnel. It is designed as complete solutions from study of raw materials to finish overlay at application site to speedup the overlay of pavement with highly accelerated time span.

a) Surface preparation

The preparatory work assumed the corrected profiling, camber and structurally sound sub base / DLC compacted and levelled according to the standard practices in road construction. Any uneven cracks, joints or holes should be repaired and filled up and profiled area should be properly cleaned for applying ACC Speedcrete

b) Methodology

ACC Speedcrete integrated high performing novel solutions is plan repair method. The overlay application site is schedule and construction work carried out after complete study of filler local materials, mix design and its formulation. A controlled mixing & delivery at batch mix plant to accurately batch & mixed by experienced technologist. A delivery of Speedcrete raw treated with utmost care and prepared surfaced is laid with Speedcrete raw, screeded, fusion finished, textured, cured site clearing etc. completed by experienced personnel with special techniques before trafficking in 8 hrs.

ACC Supercoat

ACC Supercoat is a cementitious based concrete floor repair solution that is designed to gain high flexural strength and toughness to the Concrete surface within 24 hour of application. Thus reduces the traficking time & an effective cost saving solution.

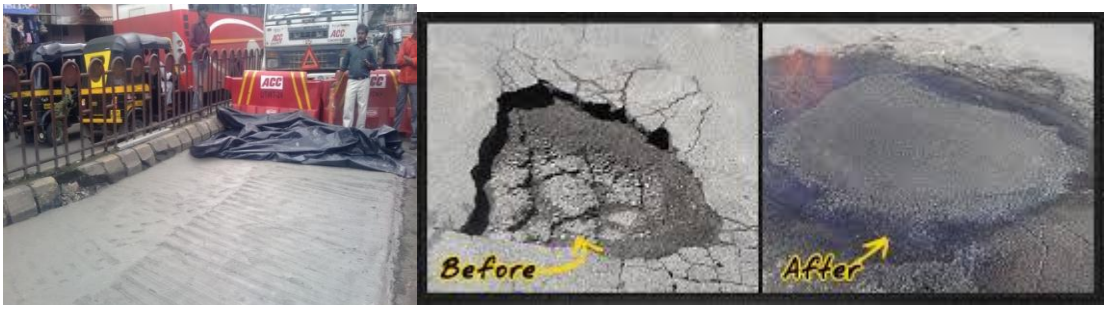

Fig 2.6 shows the ACC supercoat used to fill the potholes in roads

Methodology

The repair surface is cleaned and bonding agent is applied to it. Over that ACC supercoat is laid over it. After finishing within 8-12hours its opened to traffic.

2.4Methodology for proposing white topping

The following procedure needs to be adopted for implementing White Topping as maintenance strategy
a) Design life should be at least 15 years; 25 to 30years is often projected for city streets.
Cost alternatives-define initial construction

b) Cost alternatives -define initial construction costs, maintenance costs, and the design life of the topping.

c) Drainage considerations - define the elevation of crown sections to ensure good drainage.

d) Pavement patching - identify areas that require sub grade repair after the milling operation

e) Thickness design- considers the thickness of the asphalt pavement, the thickness of the topping, traffic loads, and panel layout.

f) 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.

g) Profile correction--determine joint spacing by the thinnest concrete profile and carry this spacing throughout the project.

h) Surface texture- texture is specified in relation to the speed of traffic. Drag (burlap or boom) textures are good for low-speed facilities; highspeed facilities should use more aggressive textures.

i) Traffic control-traffic can be detoured, shifted, or otherwise accommodated during construction, but there must be a plan before construction starts.

j) Construction staging--stage the construction to cause the least disruption[3].

2.5 Summary

The significant increase in the number of automobiles observed in the recent years hascreated a need not only for the construction of new highways but also for the maintenance and rehabilitation of existing highway networks.Pavements are prone to damage due to the repeated wheel loads as well as temperature and other environmental effects. White topping has emerged as a fast growing technology for pavement rehabilitation. In the above chapter various types of white topping and its methodology is discussed.

3 Case Studies

3.1 Introduction

Due to rapid urbanization and growth of industries the traffic flow is increasing day by day resulting in heavy loading on existing road network of the country. During last three decades, there is sufficient increase in the road infrastructure resulting in increase of the total length of roads in the country. The road network in India carries more than two third of the freight traffic. Due to repetition of wheel loads, variation in temperature and other environmental effects most of pavements get damaged. Covering of asphalt pavement with a layer of cement concrete is termed as White topping. On the basis of thickness of the concrete layer it can be divided into bonded and unbonded or conventional White topping. When the thickness of the concrete layer is 200 mm or more and not bonded to the asphalt it is called unbonded or conventional White topping. Bonded White topping is of thickness of 50 mm to 150 mm bonded to Asphalt pavement layer and is of two types, thin and ultrathin. The bond is made by texturing the asphalt. Thin white topping is a bonded layer of concrete of thickness 100 mm to 150 mm while an ultrathin layer is 50 mm to100 mm thick. The use of ultra-thin white topping is preferred for deteriorated asphalt pavements with fatigue and rut distress. The actual thickness of ultra-thin white topping is reliant on traffic loading, existing asphalt pavement thickness and grading of concrete.

3.2 Case Study on Tembhi Naka Thane

In the year 2013 , a stretch of 40 m was taken up at Tembhi Naka Thane, to be repaired by overlay. The existing road was first milled down to get a rough surface so that bond between the existing subgrade and the concrete overlay was achieved. UTWT-24 was laid on the road which had properties as detailed.

Initial Setting Time - 6 hours 45 min
Final Setting Time - 9 hours 35 min
Water permeability @ 28 days is 0mm

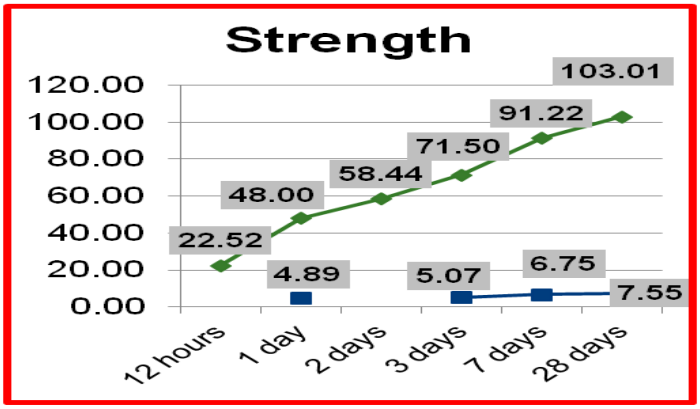

Fig 3.1 shows the paper cutting and road done with UTWT -24

3.3 Case Study on Vadodara Enviro Channel

VECL (Vadodara Enviro Channel) is a quasi-government organisation led by eminent leader SatishPanchal. The organisation is engaged in the treatment of industrial effluents from various industries in the industrial belt. The industries dispose of the effluents into the VECL channeland VECL then treats them and finally disposes of them into the sea. Due to the presence of harmful chemicals in the effluents, the channel itself made of concrete and constantly facing deterioration, requires frequent repairs.A parallel service road to the channel gives access to VECL engineers to repair and maintain it.The road also is used by heavy industrial vehicles and villagers; in fact, though built for servicing the channel, the road is used by everyone as there is no other option. The entire service road is 55 km long and has been in service since the 1970s. The organization annually spends more than Rs 1 crore on repair of the road. After the launch of UTWT-24, VECL came forward to implement the technology. The road has random stretches which are damaged, and many potholes. It was decided that instead of going for patchwork and repairing only the potholes, a stretch of the worst affected portion would be repaired. The road was constructed for a stretch of 500 m and a stretch of 50 m was taken up at a time and UTWT 24 was used in the year 2015.

Table 3.1 shows the design mix and cost details

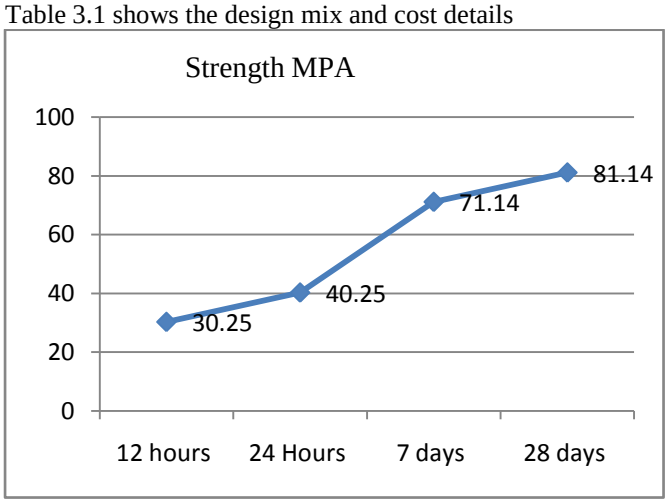

Fig 3.2 shows the strength details

Grade of Concrete M60		Rate	
	Kg/m3	Rs/m3	Cost
Cement	500	4.6	2300
Flyash	130	1.3	169
Alcofine	35	13	455
Water	140	0.1	14
20mm	485	0.55	266.75
10 mm	490	0.55	269.5
Crush Sand	715	0.65	464.75
Admixture	5.88	140	823.2
Accelator	0.67	60	40.2
Density	**2502**	**Raw Material Cost**	**4802**

3.4 Case Study On Chennai Nandanam

At Chennai Nandanamfor GRT Road Utwt 24 was supplied quantity 29 cubic meter in the year 2015 .The existing road was of bituminous with a stretch of 60 km ACC Utwt 24 was used.The one day strength achieved was 48.20 Mpa.

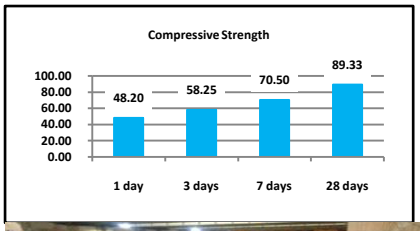

Fig 3.2 shows the strength and concreting works

3. 5 Case Studyon Vadodara

The site was a Industrial Road Construction inside Factory located at Vadodara in the year 2014 Daily 200-300 heavy truck movement happened inside the factory for Loading & unloading. Requirement was of normal M25 Concrete to all Roads inside factory but for Entry/Exit Portiontheirwas a problem of transportation for 3 days or 7 days.So the Product UTWT 24 was supplied ofqty around 40 m3. The stretch was 65 m long.Strength achieved at 24 hours = 39.22 Mpa. With this high strength it was opened to traffic.

3.6 Summary

Here various case studies has discussed which shows that the white topping can be considered as best overlay alternative as it reduces life cyclecost, improves life term when compared with bituminous overlayfor rural roads.

4. Summary of White Topping

4.1 Introduction

White-topping is the covering of an existing asphalt pavement with a layer of Portland cement concrete. White-topping is divided into types depending on the thickness of the concrete layer and whether the layer is bonded to the asphalt substrate. Unbonded white-topping, also called conventional white-topping, uses concrete thicknesses of eight inches or more that is not bonded to the asphalt. Bonded white-topping uses thicknesses of two to six inches bonded to the asphalt pavement and is divided into two types, thin and ultrathin. The bond is made by texturing the asphalt. Thin white-topping uses a bonded layer of concrete that is four to six inches thick while an ultrathin layer is two to four inches thick. Ultrathin white-topping is suitable for light duty uses, such as roads with low traffic volume, parking lots and small airports. Fiber reinforced concrete is used in some thin white-topping overlays and almost all ultrathin white-topping overlays.

4.2 Comparative Summary of White topping

Attempts has been made to summarize the various types of white topping and its recommendations

Parameter	Normal UTWT / Coventional White Topping	Supercoat	UTWT 24 /UTWT 8
Definition	UTW is a technique which involves placement of a thinner (than normal) thickness ranging from 2 to 4 inches with closely spaced joints and bonded to an existing asphalt pavement. The application of UTW has been targeted to rehabilitate deteriorated asphalt pavements with fatigue and/or rutting distress. However the actual depth of UTW depends on the grade of concrete used, intensity of traffic, thickness of existing asphalt pavement after milling etc	ACC Supercoat is a cementitious based concretefloor repair solution that is designed to gain highflexural strength and toughness to the Concretesurface within 24 hour of application	ACC SpeedcreteUTWT- a "Ultra Thin White Topping"is a highly performing overlay laid in depth ranging from100 - 150 for road sections mm mm and trafficked in 24 Hours.
Duration	Duration is normally 7 days	Duration can be varied to 8-24 hours	Duration can be varied to 8- 24 hours
Features	Open to traffic after 7 to 14 days	Open to traffic 8- 24 hours	Open to traffic 8- 24 hours
	As time required is more to open traffic less service to public	High early flexural strength.	Helps in servicing the public
	Losses more in business	Helps in reducing business losses	Helps in reducing business losses
	lower productivity	Helps in higher productivity	Helps in higher productivity
	Reduce maintenance	Reduce maintenance	Reduce maintenance
	Low permeability as per DIN 1480	Low Permeability DIN 1480	Low permeability DIN 1480
	No self levelling property	Self Compacting	Self Compacting
	Curing required for 3-14 days	Limited Curing	Limited Curing
		Attain Environment friendly	Attain Environment friendly
Methodology	Preparation of Base and surface is required	Without preparation of base and Surface , Potholes are repaired	Preparation of Base and surface is required
Cost Impact concrete	Cost is about 6500 per cum	Cost is about 21000 per cum	Cost is about 9000 per cum

4.3 Summary

Roads are the backbone for social, economic, industrial and cultural development of a country. Road infrastructure plays a major role in the economic growth of a developing country like India and every year a lion's share of budget is allocated for the transport sector.Due to budget constraints, many highway agencies are becoming interested in pavement preservation or rehabilitation to ensure the sustainability pavement in serviceable condition. White-topping is a relatively new rehabilitation technology for deteriorated asphalt

pavement in world. ACC speecrete 24 -Ultra thin white topping pavement gains earlier strength at one day about 80% strength as compared with normal conventional topping. Usually high grade concrete M60 above is used for ACC speedcrete 24 as compared with normal conventional concrete.

References

[1]. Ansari U.S, Chaudhri I.M, Ghuge N.P, Phatangre R.R," High Performance Concrete with Partial Replacement of Cement by ALCCOFINE & Fly Ash", Indian Research Transaction Vol. 5, No.2 , Apr-June 2015 EISSN: 2250 – 0804

[2]. B.N. Skanda kumar1, Suhas R2, Bhavan V, "Performance Evaluation of Thin white topping", IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308

[3]. Mitesh D. Patel, Prof. P.S. Ramanuj, BhavinParmar and AkashParmar, "White topping as a rehabilitation method:A case study of Budhel –Ghogha Road ",International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974

[4]. Umesh Sharma, AnkitaKhatri and AbhishekKanoung," Use of Micro-silica as Additive to Concrete-state of Art", International Journal of Civil Engineering Research, Volume 5, Number 1 (2014) ISSN 2278-3652 pp. 9-12

[5]. W.K. Mampearachchi1, J.V. Kosgolla and M. Tia, "Feasibility of whitetopping pavements for resurfacing thin asphalt pavements", J.Natn.Sci.Foundation Sri Lanka 2012 40(4): 293-302