Comparative Study on Cell Filled and Whitetopped Concrete Overlay with Human Hair as Pavement Rehabilitation Methods

Gokul K. L., Satyakumar M.

Abstract: ***During the past two decades, the issue of rehabilitation of the existing pavements using various techniques is gaining momentum. The use of fibre reinforced concrete for rehabilitation purposes is becoming popular. Fibre reinforced concrete is an economical method to overcome flexural failure, micro cracks etc. Human hair is a non-degradable fibre which can be used as a reinforcement material in concrete overlays. Human hair fibre added concrete can be used as a concrete for cell filling and whitetopping concrete pavement rehabilitation methods to overcome the functional deficiencies of existing bituminous pavements. In whitetopping a concrete overlay is provided over the existing deteriorated bituminous pavement. In Cell Filled concrete overlay a mesh of cell is provided and is filled with concrete. In this study the mechanical properties of whitetopped and cell filled concrete overlays incorporated with human hair is being investigated. A field trail of Cell Filled and Whitetopped concrete with and without hair fibre was tried. Conclusions were drawn based on these laboratory and field studies.***

Index Terms: Cell Filling, Human hair, Mechanical properties,Pavement rehabilitation, Whitetopping.

I. INTRODUCTION

Road traffic is increasing steadily over the years. This is an international phenomenon. An international forecast predicts that such increase will continue in near future. Even in case of developed countries, there is a unavailability of funds essential for new infrastructure ventures, both for constructing them and more meaningfully towards their conservation and repairs. The position in the context of a developing country like India is visibly far inferior. As a result, more and more roads are deteriorating and the standing pavement structure as a whole is often found to be insufficient to survive up with the present traffic. Appropriate firming and conservation of roads is immediately essential to certify well-adjusted regional development and mitigation of deficiency as they connect the villages and other small town centresharbouring backwardness. A majority of these roads do not have traffic well-intentioned pavement. [1] The cost of firming and restoration by predictable method of this large network will need enormous resources both physical and financial which are pretty occasional.

Most of the prevailing flexible pavements in the network typically have thin bituminous layers. These bituminous pavements, in overall, have a problem that they get deteriorated with time. Most of our roads exhibit, in general deficiencies like alligator cracking, upheaval, rutting, fatigue cracking, and thermo cracking.

Under the rehabilitation plans, typically the overlays are being placed over such cracked or rutted bituminous stratum without making any significant energies to seal these cracks properly [2]. Occasionally the cracks are so extensive also widespread that it is not even conceivable to fully seal them, with the effect that such recently overlaid surfaces yet again exhibit rutting/cracks in a very squat time. Reflection cracks are one example regularly come across with such overlay repairs. Such conservations do not improve their predictable life and bring avoidable disparagement from the public. Such practices of strengthening by overlaying thus essential to be discarded.

Any alternative technique of strengthening or fixing of roads should, therefore, be based on their permanency reasonably purely by initial cost. The cost assessment for such alternative strengthening/repair methods should be based on the concept of life-cycle cost. Substitute approaches of strengthening/repairs should take maintenance of the deficiencies of current bituminous layers. Rutting and cracking are prodigiously witnessed to be common nature type of distress on furthermost of bituminous pavements. This could be remedied by milling the existing faces. Milling expressively de-stresses the cracked/rutted section. White topping and Cell filled concrete overlay were investigated as rehabilitation methods of moderately distressed bituminous concrete pavements and intersections. Now a day these have much import role for pavement preservation. In this cement concrete overlays over current bituminous pavements have been used as a rehabilitation option for more than 80 years [3]. A cross-section of a pavement displaying concrete overlay over bituminous layer is revealed in fig.1.

Fig. 1. **Cross-section of a pavement shows the concrete overlay over bituminous layer [3]**

II. WHITETOPPING CONCRETE OVERLAY

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White topping (WT) is a technique of strengthening or rehabilitating weakened asphalt pavements by Plain Cement Concrete (PCC) overlay with or without fibers (fig 2). Ultra-Thin White topping (UTWT) and Thin White topping (TWT) are being progressively accomplished in USA and West Europe. Thickness up to 100 mm, it is labelled as UTWT and for thickness more than 100 mm but up to 200 mm; it is called Thin White Topping (TWT) (fig 3). Beyond 200 mm thickness, it is called Conventional White topping identical to our regular PCC pavements. The prevailing design standards are somewhat dissimilar than those of normal concrete pavements. In case of UTWT, the bond between the existing asphalt pavement and Plain Cement Concrete (PCC) overlay is considered compulsory. However, in case of TWT the bonding is necessary but not compulsory. Another alteration is that for these overlays joints are spaced near. Usual spacing of joints is at 0.6 m to 1.2 m besides in some cases it is up to 1.5 m. These joints are generally not dowelled. No tie rods are also provided in the longitudinal joints. The thickness of UTWT is between 75 to 100 mm. [4]

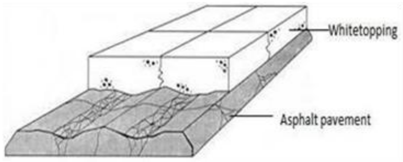

Fig. 2. Schematic diagram of a pavement structure with whitetopping [5]

Fig. 3. Finished TWT pavement

III. Cell Filling Concrete Overlay

As a substitute, for improved structural performance and low preservation, an innovative pavement technology termed Plastic Cell Filled Concrete Block Pavement (PCCBP) was developed in South Africa. Plastic cell formwork has been effectively used for canal lining, reinforced earth treatment, etc. The cells are tensioned and spread across the foundation stratum and concrete is filled and compacted into the cells. (fig.4). Upon compaction, the cell walls get deformed, resulting in interlocking of neighbouring individual concrete blocks. Cell Filled Concrete (CFC) overlay is one of cast-in-situ block pavement Deformed walls of plastic sheet behave like a hinge and the blocks can undergo limited rotation. Thus, flexibility is introduced into the cement bound (rigid) surfacing. Cell filled concrete overlay is also a better choice for the rehabilitation of village roads [6].

Fig. 4. Cell filled pavement under construction and compaction of concrete [6]

IV. Human Hair Fibre

Human Hair Fibre (HHF) (fig.5) is considered as a waste material in most parts of the world and is a collective fundamental found in municipal waste streams which cause massive environmental difficulties.. It is also accessible in plenty and at a very little cost. Human hair fibre reinforced concrete can avoid the spalling of concrete. The belongings like high tensile strength, unique chemical composition, thermal insulation etc. makes it seemly to be used as a reinforcing material. [7]

Fig. 5. **Human hair fibre**

V. Research Significance

The work was carried out to study the performance of Cell filled and Whitetopped overlays, represent a new rehabilitation choice to address pavements with surface distress problems and also the use of human hair fibre in concrete overlay to utilize the waste material as a resource.

VI. Experimental Investigations

The first stage is to find the mechanical properties of Cell filled and Thin whitetopped concrete with and without human hair fibre. Second stage include casting field trails of Cell filled and Thin whitetopped concrete overlay with and without human hair fibre.

A. Test on Mechanical Properties

The mechanical properties of CFC and TWT concrete with and without human hair fibre were conducted in laboratory. Test include cube compressive strength, cylinder splitting tensile strength and flexural strength test.In Cube compressive strength test,cube strength were evaluated according to IS 516-1959 [9] The test were conducted on a 2000 kNcompression testing machine. In the case of flexural strength one measure of the tensile of concrete, it is measure of an unreinforced beam to resist failure in bending. The flexural strength is expressed as modulus of rupture in Mpa and is determined by standard third point loading and center point loading according to IS 516 – 1959[9]. For find split tensile strength, cylinder strength were evaluated according to ASTM C496 / C496M – 11 [10], the test were conducted in a 2000 kN compression testing machine.

B. Field Casting of Overlay

Field trail were done to evaluate the performance of CFC and TWT concrete overlays with and without hair fibre.

i. **Rehabilitation by CFC and TWT concrete overlays**: For the present work 6 potholes with a depth greater than 10mm were selected and they are relaid with CFC and TWTC overlays with and without hair fibre.

ii. **Construction of Cell Filling Concrete overlay**:The Constructing region is cleaned after the milling operation. The form work is placed over the surface, to be rehabilitated. It is recommended that a good profile correction were need for CFC overlays. After the placing of form works, the cells are filled with concrete and compacted well. The construction of CFC overlay is shown in fig.7.

Fig. 6. Construction of CFC overlay

iii. **Construction of Thin whitetopping concrete overlay**: The damaged pothole is rehabilitated by placing the Thin concrete overlays as shown in fig.8

Fig. 7. Construction of WTC overlay

VII. Results and Discussions

The result obtained from each experiments and a detailed discussion on it is being presented here.

A. Cube compressive strength results

To investigate the effect of stiffeners on fire resistance, the The compressive strength results were shown in table 1.

Table 1 Compressive strength of CFC and WTC specimens without HHF

SL.NO	Compressive strength 28th day (N/mm^2)			
	CFC	Average	WTC	Average
1	48.5	48.46	49.6	49.7
2	48.2		49.5	
3	48.7		50	

Table 2 Compressive strength of CFC and WTC specimens with HHF

SL.NO	Percentage of HHF by weight of cement	Compressive strength 28th day (N/mm^2)	
		CFC with HHF	WTC with HHF
1	0	48.46	49.7
2	0.5	48.48	50.13
3	1	49.51	53.2
4	**1.5**	**52.7**	**56.8**
5	2	49.3	50.2
6	2.5	48.6	49.6
7	3	47.8	48.3

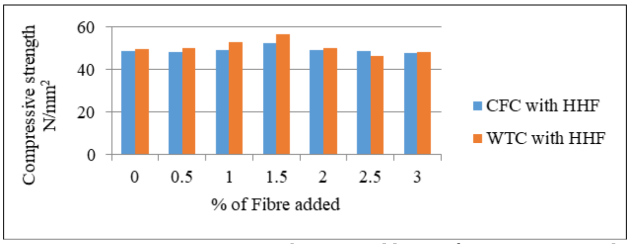

Fig. 8. Compressive strength VS. % addition of HHF on CFC and WTC specimens with HHF

From table 1 and 2 it is clear that WTC specimens achieved higher compressive strength than CFC specimens. The maximum compressive strength value obtained for CFC and WTC specimen at a fibre content of 1.5 %, the value obtained were 52.7 and 56.8 N/mm2 respectively. It is seen that the compressive strength of CFC and WTC with fibre were higher than that without. Also the characteristic compressive strength achieves a value more than 50 N/mm2 at 1.5 % of fibre (fig.9).

B. Split tensile strength results

Table 3Split tensile strength of CFC and WTC specimens without fibre

SL.NO	Split tensile strength 28th day (N/mm^2)			
	CFC	Average	WTC	Average
1	3.73	**3.89**	4.22	**4.41**
2	3.75		4.52	
3	4.2		4.49	

Table 3 shows the split tensile strength of CFC and WTC without HHF. It is clear that average split tensile strength is higher for WTC than CFC.

Table 4 Split tensile strength of CFC and WTC specimens with HHF

SL.NO	Percentage of HHF by weight of cement	Split tensile strength 28th day (N/mm^2)	
		CFC with HHF	WTC with HHF
1	0	3.89	4.41
2	0.5	3.9	4.43
3	1	4.0	4.45
4	**1.5**	**4.3**	**4.68**
5	2	3.8	4.2
6	2.5	3.73	3.84
7	3	3.3	3.76

Table 4 Shows in the results of split tensile strength of CFC and WTC with HHF. Here also it can be seen that the split tensile strength of WTC is higher for a percentage fibre content of 1.5 by weight of cement.The above results are shown in fig.10

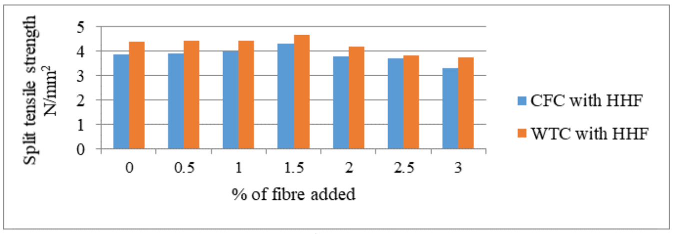

Fig. 9. Split tensile strength of CFC and WTC specimens with HHF

C. Flexural strength results

Flexural strength results of CFC and WTC specimens are shown in table 5 below.

Table 5 Flexural strength of CFC and WTC specimens without HHF

Specimen	Flexural strength 28th day (N/mm^2)			
	CFC	Average	WTC	Average
1	4.51		4.67	
2	4.52		4.65	

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3	4.50	**4.51**	4.69	**4.67**

Table 5 shows the flexural strength results of CFC and WTC without HHF. From this table it is clear that WTC specimen gives better results than CFC specimen.

Table 6 Flexural strength of CFC and WTC specimens with HHF

SL.NO	Percentage of HHF by weight of cement	Flexural strength 28th day (N/mm^2)	
		CFC with HHF	WTC with HHF
1	0	4.51	4.67
2	0.5	4.54	4.73
3	1	4.63	5.11
4	1.5	4.83	5.23
5	**2**	**5.22**	**5.45**
6	2.5	4.51	4.9
7	3	4.21	4.4

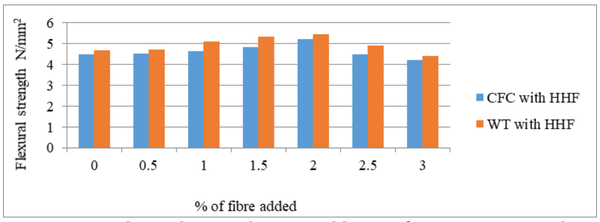

Fig. 10. Flexural strength Vs % addition of HHF on CFC and WTC specimens with HHF

Table 6 shows the results of flexural strength of CFC and WTC with HHF. From the table it is clear that 2% of HHF shows a higher flexural strength for both CFC and WTC. Here also WTC with 2% HHF shows higher value than CFC. The results are shown in fig.11.

As a whole it is understood that WTC with HHF is performing better than CFC. Hence WTC with hair fibre can be recommended for pavement rehabilitation works.

D.Field Observation results

Figure 11 andfigure 12 shows the observation made on field on a particular day of WTC and CFC with and without HHF on the Date- 5.03.18 while Figure 13- 15 on the Date-07.04.18

(a) *(b)*

Fig. 11. WTC overlay (a) without hair fibre; (b) with hair fibre

(a) *(b)*

Fig. 12. CFC overlay (a) without hair fibre; (b) with hair fibre

From these figures it is clear that field performance of WTC with HHF was better than CFC. The observation done on 05.03.18, (fig.11-12), shows no visible distress for WTC with HHF. However the specimen that is WTC without HHF, CFC with and without HHF observed on 07.04.18 shows mild defects. In the case of WTC without HHF (fig.13.a) the transverse cracks were observed, which may be due to temperature stress, loading etc. But in the case of WTC with HHF there were no such defects observed. (fig.13.b). So it can summarised that performance of WTC with HHF is better than CFC specimens

(a) *(b)*

Fig. 13. WTC overlay (a) without hair fibre; (b) with hair fibre

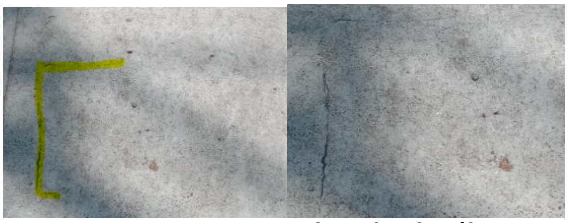

Fig. 14. CFC overlay without hair fibre

Fig. 15. CFC overlay with hair fibre

VIII. CONCLUSION

Following conclusions were drawn:

- Cell filled and whitetopped overlays represent a new rehabilitation choice to address pavements with surface distress problems
- Addition of 1.5 percentage dosage of human Hair fibre gained an optimum value in the compressive strength for CFC and WT concrete
- Addition of 1.5 percentage of hair fibre in concrete achieves an characteristic strength greater than 50N/mm^2
- Whitetopping concrete overlays shows a superior mechanical performance in the lab than that of Cell Filled concrete overlays
- Human hair fibre can reduce the risk of spalling of concrete
- The White Topping pavements show great potential to be a viable rehabilitation method due toeasiness of construction

REFERENCES

1. ModarresA., M. Rahimzadeh. and M. Zarrabi.M, Field investigation of pavement rehabilitation utilizing cold in-place, Resource, Conservation and Recycling, 83, pp. 112-120,(2014).

2. A.G. Karlaftis and A. Badr. Predicting asphalt pavement crack initiation following rehabilitation treatments,Transportation Research Part C, .ELSEVIER, 55,pp. 510-517, (2015)
3. Kambale.A., A.Jadhav., U.Gaikar., S.Gadade and A.D.Chavan, Experimental Study on Ultra-Thin White Topping Use in Village Road, International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET) ISSN : 2394-4099, 4(6), pp.01-06, (2018)
4. K. Ankush and S.N.Sachdeva.: A review of using thin whitetopping overlays for rehabilitation of asphalt pavements, Journal of Basic and Applied Engineering ResearchISSN: 2350-0077, 2, pp. 182-252, (2015)
5. V. K.Sinha., Tia and S. Kumar,Whitetopping A cost-effective rehabilitation alternative for preserving bituminous pavement on long term basic, Journal of Indian Road Congress India, 6(3), pp. .223-240, (2007)
6. R. Subrat, K. Reddy and B..B.Pandey,An Investigation on Cell-filled Pavements, International Journal of Pavement Engineering. 12, pp.21-55, (2010)
7. S. Kaushik, R.C.Reddy and R.V.Mahendar, An Experimental Study on Mechanical Properties of Human Hair Fibre Reinforced Concrete, IOSR Journal of Mechanical and Civil Engineering, 12(4),pp. 65-75, (2011)
8. IS 516 – 1959, Method of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi, India.
9. ASTM C496 / C496M – 11, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens, American Society for Testing and Materials, Philadelphia, Pennsylvania, 2006.
10. IRC: Sp-76: Tentative Guidelines for Conventional,Thin and Ultra-Thin WhietoppingIndian Road Congress,New Delhi, (2008)