EFFECT OF POZZOLONIC MATERIAL ON FUNCTIONAL CHARACTERSTICS OF WHITE TOPPING

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Abstract - Traditionally, Cement concrete has been perceived as a material for new pavement construction, in particular for streets with heavy axle loads. However, with respect to pavement rehabilitation, agencies many a times consider bituminous overlays as the first option, regardless of the condition of the existing pavement structure. It is in this environment that Ultra-Thin White Topping (UTW) gaining popularity. The urban streets exhibit well stabilized base due to the repeated wheel load applications, but the riding quality of these streets are not satisfactory due to the deterioration of the surface layer, hence it is required to rehabilitate these pavements. Everyone concentrate only on structural properties of the pavement and the functional properties are ignored so, this paper is to determine the skid resistance of Pavement Quality Concrete and Pozzolonic Cement Concrete and compare the skid resistance values

Key Words: White Topping, Flyash, Skid Resistance, Pavement Quality Concrete, Pozzolonic Cement Concrete

1. INTRODUCTION

1.1. Thin and Ultra Thin Topping :

Although thin white topping (TWT) and ultra-thin white topping (UTW) overlays have been constructed for decades, their recent popularity is largely the result of a renewed demand for longer-lasting but cost-effective solutions for bituminous pavement rehabilitation. A white topping overlay is constructed when a new portland cement concrete layer is placed on top of an existing bituminous pavement system. The concrete thickness for a UTW is equal to or less than 100 mm. A TWT is greater than 100 mm but less than 200 mm. Conventional white topping is an overlay of 200 mm or more. In most cases, a bond between the new concrete and existing bituminous layers is not only assumed during design, but specific measures are taken to ensure such a bond during construction. The success of this bond, leading to composite action, has been found to be critical to the successful performance of this pavement-resurfacing alternative. Ultra-Thin White topping (UTW) is a relatively new pavement rehabilitation technique that is used mainly for the repair of deteriorated asphalt pavements. Typically, UTW is constructed by milling the distressed, top portion of the asphalt pavement, and placing a thin (not more than 100mm thickness) concrete overlay on top of the milled surface. Based on U.S. experience, ultra-thin white topping can be defined as a concrete overlay 50 mm to 100 mm thick with closely spaced joints, bonded to an existing bituminous pavement. For an existing bituminous pavement nearing the end of its structural or functional life, the selection of the most appropriate rehabilitation alternative can be based on some specific criteria and a number of others. In many cases, the selection of the most appropriate strategy will be made by balancing several competing factors. Common factors include the following, Projected traffic loading

- Existing pavement – Condition, Layer thicknesses, Drainage
- Costs – Overlay construction cost, Total LCC, User delay costs, Vehicle operating costs
- Time factors – Number of construction operations, Total construction time, Repair and maintenance time, Frequency of repair and maintenance, Initial performance period
- Corridor impact – Noise level, Excess pollution level, Accident rate (vis-à-vis skid resistance), Ride quality (smoothness)
- Material availability – Cement, Asphalt binder, Aggregates
- Contractors – Availability (capacity), Experience, Competition (number of bidders).

Quite often, the design and constructability of the various overlay alternatives will contribute too many of the factors. Therefore, a need exists to assess some degree of engineering design in the planning and selection stages. For example, one potential pitfall in selecting a UTW or TWT alternative is the result of the oversimplified characterization of the properties of the existing bituminous pavement. Depending on these properties, the UTW or TWT can have a widely varied performance. It has been shown that all else being equal, the stiffness of the bituminous layers can have a significant impact on the performance of these types of overlays(Conversely, a bituminous overlay is sometimes prone to the redevelopment of certain distresses, such as shoving at intersections and reflection cracking). This consideration has been specifically cited in the survey responses, as well as in the literature, as a reason to select a white topping alternative.

Another consideration that is commonly reported in the literature pertains to the benefits of a more reflective surface as a result of the lighter color of concrete. The increased reflectivity has been reported to have a number of benefits, including

- Increased reflection of headlights and aircraft landing lights, improving safety
- A lower demand for external lighting, reducing operational costs and
- A cooling effect owing to lower absorption of solar energy, with environmental benefits.

Finally, another reported benefit is the resistance to fuel spillage, which is a possible consideration in the construction of parking lots, fueling stations, and aircraft aprons.

1.2 Fundamental behavior of Ultra-thin white topping

UTW and TWT overlays provide a unique pavement structure that is fundamentally different from other pavement types. UTW and, in most cases, TWT overlays are designed and constructed with consideration of a sound bond between the PCC and bituminous materials. The result is a composite structure that distributes traffic and environmental loading differently than more conventional PCC or bituminous pavement structures.

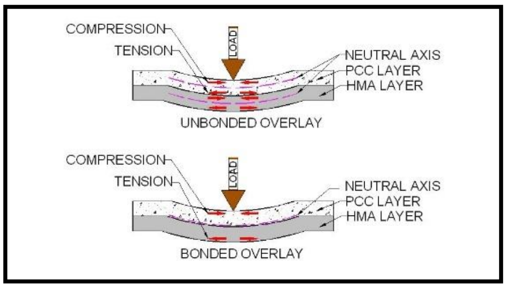


Fig. 1 Effect of composite action on UTW and TWT under loading

As Fig.1 illustrates the stress distribution in a bonded system versus that of an unbonded system can be significantly different. As a result of the composite section, the stresses in the top PCC layer are significantly lower in the bonded than those in the unbonded case. Furthermore, because much of the slab is in compression and because concrete is much stronger in compression than in tension, the design of the slab can be thinner for a bonded case than for an unbonded case.

Although a fully bonded system would be ideal, it has been shown that partial bond is usually realized as a result of a number of factors. In such case, the neutral axis will lie somewhere very much near to the interface of PCC layer and bituminous layer, as illustrated in Fig.1.

A thicker concrete overlay should be considered if the support layers have exhibited poor structural support, by contributing to the deformation and/or cracking of the original bituminous pavement. When designing the UTW or TWT overlay, consideration should be made of the condition of the existing bituminous pavement. The stiffness of the pavement system as a whole (including the bituminous layer and support layers) is known to have a significant effect on the performance of the white topping overlay. As a result, deflection bowls analysis will be required

1.3 Background and Problem Statement.

Sub arterial and residential main streets with considerable high volume of traffic within Bangalore City have been strengthened periodically with bituminous layers. These streets exhibit well stabilized base due to the repeated wheel load applications, but the riding quality of these streets are not satisfactory due to the deterioration of the surface layer, hence it is required to rehabilitate these pavements. At present these pavement are being rehabilitated with a bituminous layer frequently, which is causing hindrance and delay to the traffic and the road user. To overcome this it is advisable to rehabilitate these pavement sections with such rehabilitating methods which will not require repeated maintenance and also provide the road user a better riding quality for a long duration of time.

1.4 Research Significance

It is evident that the performance of UTW and TWT depends on the bond strength between the existing bituminous layer and the PCC overlay. To attain the required compressive strength and to improve the concrete characteristics certain additives like fly ash, micro silica are used as admixtures to concrete. These admixtures can alter the bond strength of concrete overlay on an existing bituminous layer. Hence it is necessary to evaluate the bond strength and study the performance of concrete with admixtures when used as UTW or TWT.

1.5 Experimental Work

The main aim of this experimental work was to study the variation in bond strength due to the addition of admixtures to concrete used as UTW or TWT. As there are no standard testing equipment and procedure available to evaluate these properties a suitable instrumentation was developed and fabricated to suite the requirement further, since the spread of the deflection bowl has a greater influence on the stresses and strains developed in the structural layers of the pavement section, hence it was required to measure the spread of the deflection bowl along with the deflection in the field, which required a modified Benkelman Beam

2. Experimental Procedure

1. Procuring of Materials
2. Basic testing on Materials
3. Mix design for Conventional Concrete and 20%,30%,40% fly ash replaced Concrete

4. Casting of Cubes, Cylinders, Beams and Curing for 28 days
5. Conducting Compression strength test ,Split Tensile test, Flexural test for 7,14,28 days and followed by Abrasion test and Frictional resistance test.
6. Computation and Analysis of test results followed by Conclusion

2.1 Basic test results

1. Cement:

Table-1: Properties of Cement

S.no	Property	Values
1.	Specific gravity	2.58
2.	Fineness	89%

1. Fly ash:

Table-2: Properties of Fly ash

S.no	Property	Values
1.	Specific gravity	1.97
2.	Fineness	92%

2. Fine Aggregates:

Table-3: Properties of fine aggregates

S.no	Property	Values
1.	Specific gravity	2.53
2.	Moisture content	1.97
3.	Fineness modulus	3.324

3. Coarse Aggregates

Table-4: Properties of Coarse aggregates

S.no	Property	Values
1.	Specific gravity	2.62
2.	Los Angeles test	27.4%
3.	Impact test	20.6%

2. 2 Mix Design

Mix design for 1 cubic meter of concrete was calculated according to IS 10262:2009 for conventional concrete,20%,30%,40% fly ash replaced concrete mix

Table -1: Qunatities according to Mix Design

Materials	Conventional concrete	20% fly ash	30% fly ash	40% fly ash
Cement(kg/m3)	437.77	350.23	306.439	262.662
Fine Aggregates (kg/m3)	678	678	678	678
Coarse Aggregates (kg/m3)	1030.96	1030.96	1030.96	1030.96
Water(liter/m3)	197	197	197	197
Admixture(%)	0.87	0.87	0.87	0.87
Water/cement ratio	0.45	0.45	0.45	0.45
Fly ash	--	87.54	131.334	175.108

2.3 Tests conducted on fresh concrete

We conducted Slump cone test for all the mix proportions i.e, Conventional concrete,20%, 30%, 40% fly ash replaced concrete

Fig 2: Slump cone conduct

	Conventional concrete	20%	30%	40%
Slump	70mm	80mm	80mm	70mm

Table-5: Slump values

2.4 Casting and Curing

Number of Cubes, Cylinders, Beams that were casted

Table-7: Casting

Mix	No of Cubes	No of cylinders	No of Beams
Conventional concrete	9	3	9
20% fly ash	9	2	5
30% fly ash	9	2	5
40% fly ash	9	2	5

Fig-3 :Casting

2.5 Results of Tests on Hardened Concrete

2.5.1 Compressive strength:

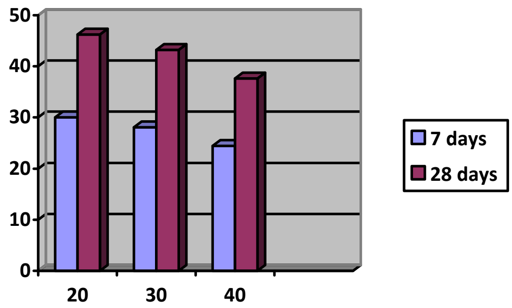
After the casting of cubes, they were placed for curing. Then the cubes were transferred to testing after 7,14,28 days. The maximum load at failure was taken for 3 samples of the same mix. The average compressive strength is calculated by the equation Compressive strength(N/mm2)=load(N)/cross section area of specimen(mm2).

Table-8: Compression strength results

Mix	7 days (N/mm2)	14 days (N/mm2)	28 days (N/mm2)
Conventional concrete	29.549	40.91	45.46
20% fly ash	30.023	41.57	46.19
30% fly ash	28.070	38.86	43.186
40% fly ash	24.434	33.832	37.592

Fig 4: Compression test

Chart-1



X-axis = percentage of fly ash

Y-axis = compressive strength

2.5.2 Split Tensile strength:

After the casting of cylinders, they were placed for curing. Then the cylinders were transferred to testing after 28 days. The maximum load at failure for the samples of the same mix. The average split tensile strength is calculated by the equation Split tensile strength(N/mm2)= 2p/piDL

Where, p=load

L=length

D=diameter

Table-9: Split Tensile

Mix	28 days(N/mm2)
Conventional concrete	3.71
20% fly ash	4.148
30% fly ash	3.629
40% fly ash	3.111

2.5.3 Flexural strength test

After the casting of beams, they were placed for curing. Then the beams were transferred to testing after 7,14,28 days. The maximum load at failure was taken foe the samples of the same mix. The average flexural strength is calculated by the equation Flexural strength (N/mm2)= pL/BD2

Where, p=load, L=length, B=breadth, D=height

Fig 5: Flexural strength

Table-10: Flexural strength

Mix	7 days (N/mm2)	14 days (N/mm2)	28 days (N/mm2)
Conventional concrete	4.591	6.35	7.064
20% flyash	5.220	7.237	8.042
30% flyash	4.5675	6.324	7.026
40% flyash	3.915	5.420	6.0230

2.5.4 Abrasion test

After casting and curing for 28 days, abrasion test was conducted and loss of material(cm3) was noted down at 3000, 7000, 10000 revolutions

Table-11: Abrasion test

Mix	Loss of material in cm3			
	0 revolutions	3000 revolutions	7000 revolutions	100000 revolutions
Conventional Concrete	0.00	14	15.3	17.2
20% fly ash	0.00	14.8	15.6	17.9
30% fly ash	0.00	15.1	16.3	18.5
405 fly ash	0.00	15.5	16.9	19.2

2.5.5 Frictional resistance test

After Abrasion test, Friction test was conducted and the friction pendulum values were noted down

Table-12: Friction test

Mix	Friction pendulum values			
	0 revolutions	3000 revolutions	7000 revolutions	10000 revolutions
Conventional concrete	62	58	49	45
20% fly ash	60	48	41	38
30% fly ash	62	45	40	37
40% fly ash	61	42	36	32

3. Conclusion

In general, the compressive strength is almost same for conventional concrete to 20% replacement. The compressive strength reached a maximum strength at 20% replacement of Cement with Fly ash. On further increase, the strength reduced as percentage replacement increased. This trend is similar at all ages of testing. It is also seen that

- Replacement of cement with Fly ash significantly increased the strength of concrete
- Replacement of 20% of the mass of cement with Fly ash achieved the maximum value of compressive strength.
- Increase in Fly ash replacement decreased the workability of concrete
- Flexural strength of concrete decreases with increase of fly ash
- Friction decreases with increase of Percentage of fly ash.
- Loss of material due to Abrasion increases with increased fly ash content in cement content

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