Experimental Investigation of Thermal Properties on Multi-Layered PCC Slab

G.Sountharya[1], G.Bairavi[2], A.Anbu thenral devi[3]
[1]Dept of Structural Engineering
[2, 3]Assistant Professor, Dept Of Civil Engineering
[1, 2, 3] SRVEC

Abstract- *Pavement is the actual travel surface especially made durable and serviceable to withstand the traffic load commuting upon it. Road transportation plays a vital role in the development of the country. India has one of the largest highway and road networks on the planet, second only to the road network of the United States. It provides linkages to other modes of transportation like railways, airways and shipping, etc., Present work involves the study of thermal conductivity and thermal expansion of PQC-DLC composite at different source temperature and compare it with that of plain PQC and DLC on similar condition. Prismatic specimens are tested for coefficient of thermal expansion test and cylindrical specimen are used for determining the thermal conductivity. These tests were done under different source temperature. Results were compared and the thermal behavior of both the types of specimens was studied. In expansion the result gives that as the PQC increases in the combination the value of expansion is observed to be higher.*

Keywords- Highways, road networks, pavement layer and thermal expansion.

I. INTRODUCTION

Pavement is the actual travel surface especially made durable and serviceable to withstand the traffic load commuting upon it. Pavement grants friction for the vehicles thus providing comfort to the drivers and transfers the traffic load from the upper surface to the natural soil. Modern pavement design is concerned with developing the most economical combination of pavement layers that will ensure that the stresses and strains transmitted from the carriageway do not exceed the supportive capacity of each layer, or the sub-grade, during the design life of the road. Major variables affecting the design of a given pavement are therefore the volume and composition of traffic, the sub-grade environment and strength, the materials economically available for use within the pavement layers and the thickness of each layer.

II. LITERATURE REVIEW

Armaghani, et al., 2003 carried out study on "Temperature Response of Concrete Pavements," and describe that the thermal effects in concrete pavements based on measurements obtained from instrumented test slabs. Temperature and horizontal and vertical displacement data were obtained with thermocouples and linear variable differential transformers (LVDTs). The effect of dowel bars on slab displacement was also investigated. AThis suggests that doweled joints offer resistance to slab movement, a condition that can induce stresses in the pavement. The authors draw several other conclusions on thermal effects in concrete pavements.

Tang, et al. (2006) discuss the effects of negative temperature gradients in their article "Analysis of Concave Curling in Concrete Slabs." Their analytical approach takes into account that a gap, resulting from curling, may occur between the bottom of the slab and the base. The authors note that there is a critical temperature difference between the top and bottom of the slab, such that when the temperature difference is greater than the critical value, the gap forms. Displacement and stress distributions are also presented.

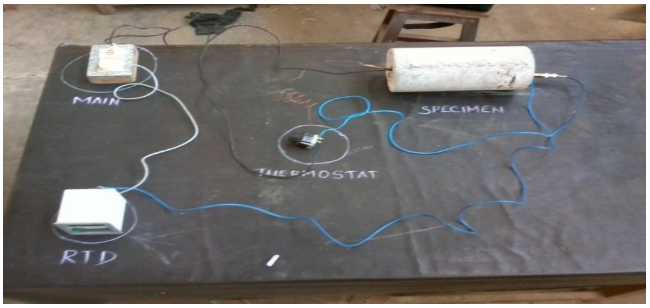
Lakshmi sindhura.A, et al. (2008) proposed to study the behavior of composite rigid pavement slab. These slabs were tested for static and dynamic loading with a sand bed taken as the continuous support. Results obtained from these tests were taken as the basis for comparison of plain and composite slabs. In his study, the work done on the composite pavement slabs having lean cement concrete layer at the middle of the slab, under monotonous and dynamic loading conditions, was shown. It was found that use of composite pavement slabs reduce the cost of construction significantly.

III. TEST SPECIMEN

Dimension of specimen- For measuring thermal conductivity cylindrical specimen of Diameter 150 mm and height 3oo mm was adopted and for measuring thermal expansion Prismatic Specimen of size 150*100*400 mm was adopted. The details of number of specimens casted for testing have been given below in the table 3.10 and 3.11.

Fig.1 Preparation of Test specimen for Thermal conductivity

Fig.2 Preparation of Test specimen for Thermal expansion



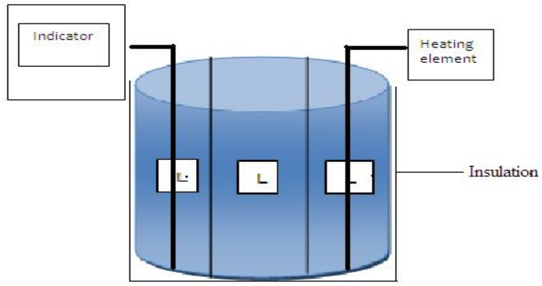


Fig 3: Experimental set-up to measure thermal conductivity

IV. RESULTS AND DISCUSSIONS

Thermal conductivity:

Thermal conductivity gives the heat flux transmitted through a unit area of a material under a unit temperature gradient.Thermal conductivity of aggregate ranges from 1.9 – 3.5 W/m.K. Basalt has least thermal conductivity where as quartzite has maximum thermal conductivity The result obtained in the present study, by two linear parallel probe method, gives the value of thermal conductivity around 2.28 W/m.K.

Table.1 Thermal conductivity values for source temperature (80°C)

Sl. No	Types of combination	Steady state temp °C	Difference in temperature °C	Max Time taken To reach steady state temp (min)	K (W/(m°C))
1	PQC	74	6	110	2.28
2	DLC	74	6	96	2.403
3	PQC+DLC+PQC	77	3	82	2.169
4	PQC+PQC+DLC	76	4	108	2.146
5	PQC+DLC+DLC	76	4	142	2.143
6	1/2PQC+ 1/2DLC	75	5	126	2.41

7	PQC+DLC+PQC (With polythene sheet)	76	4	83	2.148
8	PQC+PQC+DLC (With polythene sheet)	75	5	143	2.107
9	PQC+DLC+DLC (with Polythene sheet)	75	5	92	2.208
10	½ PQC +1/2 DLC (With Polythene Sheet)	74	6	127	2.310
11	DLC+PQC+DLC (with polythene sheet)	76	4	118	2.398
12	DLC+PQC+DLC (without polythene sheet)	75	5	105	2.310

Table.2 Thermal conductivity values for source temperature (100°C)

Sl. No	**Types of combination**	**Steady state temp ºC**	**Difference in temperature ºC**	**Max Time taken To reach steady state temp (min)**	**K (W/(m°C))**
1	PQC	92	8	116	2.22
2	DLC	94	6	107	2.395
3	PQC+DLC+PQC	94	6	131	2.153
4	PQC+PQC+DLC	93	7	158	2.132
5	PQC+DLC+DLC	93	7	131	2.112
6	1/2PQC+ 1/2DLC)	96	4	134	2.4
7	PQC+DLC+PQC (With polythene sheet)	94	6	150	2.127
8	PQC+PQC+DLC (With polythene sheet)	95	5	148	1.993
9	PQC+DLC+DLC (with Polythene sheet)	94	6	172	2.184
10	½ PQC +1/2 DLC (With Polythene	94	6	107	2.250

	Sheet)				
11	DLC+PQC+DLC (with polythene sheet)	95	5	146	2.376
12	DLC+PQC+DLC (with pp sheet)	95	5	120	2.383

Thermal expansion (prismatic specimen)

Thermal expansion is defined as the change in unit length per degree of temperature. become critical factor for crack prevention in mass concrete. The coefficient of thermal expansion of different aggregate from 5 -12 (μ) per ºC. The specimen is cooled to 25°C and then is s slowly heated up till it reaches 95°C. Temperature differential used to study the strain is 60°C (25-95°C)

Table 3 Coefficient of thermal expansion

Sl. No	Types of combination	Differential temp ºC	Strain μ	α ($\times 10^{-8}$/ ºC)
1	PQC	70	7	10
2	DLC	70	4	5.7
3	PQC+DLC+PQC	70	6	8.5
4	PQC+PQC+DLC	70	5	7.1
5	PQC+DLC+DLC	70	5	7.1
6	1/2PQC+ 1/2DLC)	70	2	2.8
7	PQC+DLC+PQC (With polythene sheet)	70	5	7.1
8	PQC+PQC+DLC (With polythene sheet)	70	4	5.7
9	PQC+DLC+DLC (with Polythene sheet)	70	4	5.7
10	½ PQC +1/2 DLC (With Polythene Sheet)	70	3	4.2
11	DLC+PQC+DLC (with polythene sheet)	70	3	4.2
12	DLC+PQC+DLC (without polythene sheet)	70	2	2.8

Table 4 Flexural strength

Sl. No	Types of combination	Modulus of Rupture MPa
1	PQC (Monolithic)	5.3
2	DLC (Monolithic)	2.37
3	PQC+DLC+PQC (Without polythene sheet)	4.02
4	PQC+PQC+DLC (Without polythene sheet)	3.97
5	PQC+DLC+DLC (Without polythene sheet)	1.72
6	1/2PQC+ 1/2DLC (Without polythene sheet)	2
7	PQC+DLC+PQC (With polythene sheet)	4.20
8	PQC+PQC+DLC (With polythene sheet)	3.14
9	PQC+DLC+DLC (with Polythene sheet)	1.84
10	½ PQC +1/2 DLC (With Polythene Sheet)	2.4
11	DLC+PQC+DLC (with polythene sheet)	1.87
12	DLC+PQC+DLC (without polythene sheet)	1.78

Table 5. Compressive Strength:

Sl. No	Types of combination	Compressive strength MPa
1	PQC (Monolithic)	47.61
2	DLC (Monolithic)	14.93
3	PQC+DLC+PQC (Without polythene sheet)	25.30
4	PQC+PQC+DLC (Without polythene sheet)	20.13
5	PQC+DLC+DLC (Without polythene sheet)	8.86
6	1/2PQC+ 1/2DLC (Without polythene sheet)	8.45
7	PQC+DLC+PQC (With polythene sheet)	27.30
8	PQC+PQC+DLC (With polythene sheet)	22.49
9	PQC+DLC+DLC (with Polythene sheet)	9.86
10	½ PQC +1/2 DLC (With Polythene Sheet)	9.73
11	DLC+PQC+DLC (with polythene sheet)	7.10
12	DLC+PQC+DLC (without polythene sheet)	6.25

Thermal conductivity

The effects of temperature on thermal conductivity measurements of PQC, DLC and PQC-DLC composite were examined. It was observed that thermal conductivity decreases a small amount with temperature increases in all the specimens .Concretes were tested 50oC to 100 C and results plotted between thermal conductivity and temperatures are shown in figs .

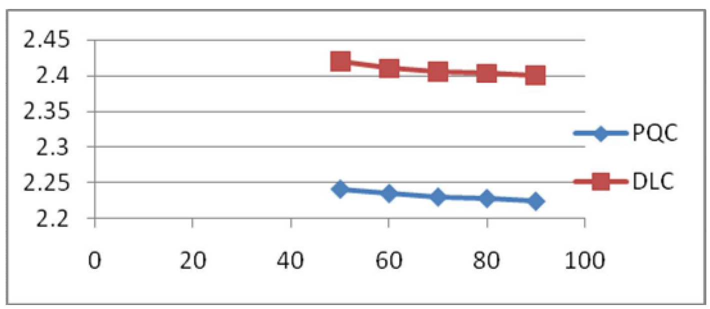


Fig.4 Thermal Conductivity Vs Temperature for PQC and DLC

Comparison of effect of temperature on composite Specimen without polythene sheet

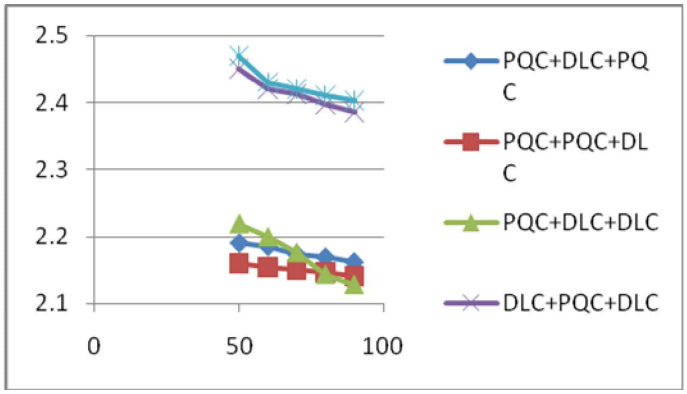


Fig.5 Thermal Conductivity Vs Temperature for Composite Specimen

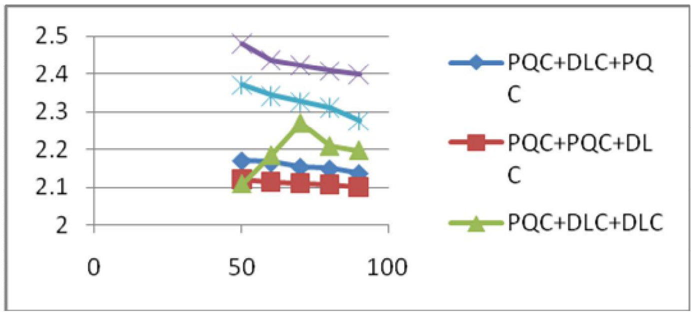


Fig.6 Thermal Conductivity Vs Temperature for composite Specimen with Polythene sheet

V. CONCLUSION

From the studies carried out on composite specimens subjected to different source temperature, the following conclusions are made,

- Use of composite rigid pavement slab for pavement construction is practical and economically feasible as 50% of the cement content gets reduced, which indeed results in the reduction of the cost of construction.
- The compressive strength is drives us to conclude that semi tensile stress cause the failure of DLC and PQC composite. This may be the reason for the composite to record low failure load in compression test..
- In flexural strength the difference between the theoretical and observed value is due to the inconsistency in the behavior of DLC material. This inconsistency is due to the honeycomb nature and low OPC content.
- The Thermal conductivity of composite specimen decreases as the temperature rises.
- DLC specimen shows more thermal conductivity value when compared to that of PQC.

VI. ACKNOWLEDGEMENT

We are thankful to Mr. P.Bharath, Assistant Professors in Department of Civil Engineering, Mr. S.Govindhan, Assistant Professors in Department of Civil Engineering, SRVEC and Ms.R.Rashmiya, Lecturer in Department of Civil Engineering, Sembodai Rukmani Varatharajan Engineering College, to support our research works.

REFERENCES

[1] Armaghani, J. M., Larsen, T. J., and Smith, L. L. (1987), “Temperature Response of Concrete Pavements,” *Transportation Research Record 1121*, TRB, National Research Council, Washington, D.C., pp. 23-33

[2] American Association of State Highway and Transportation Officials (AASHTO) Report, “The Bottom Line: Transportation Investment Needs 1998- 2002,” 1996.

[3] Choketaweekarn P., and Tangtermsirikul S., Prediction of thermal properties of concrete. *Proceedings of the 2nd Asian Concrete Federation Conference*, (2006), 20-21, CMT-228 to CMT-237

[4] Choubane, B. and M. Tia, (1995), “Analysis and Verification of Thermal-Gradient Effects on Concrete Pavement,” *Journal of Transportation Engineering*, Vol.121, No.1, pp. 75-81

[5] Frabizzio M.A. and N.J. Buch (1999), “Performance of Transverse Cracking in Jointed Concrete Pavement,” *Journal of Performance of Constructed Facilities*, Vol.13, No. 4, pp. 172-180