TO STUDY VARIOUS LAYER OF HIGHWAY RIGID PAVEMENTS

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ABSTRACT: Development of country depends on the connectivity of various places with adequate road network, the road are the major channel of transportation for carrying goods and passengers.The construction and improvement of high quality roads plays an important role. In this research paper, Chi-Square hypothesis is performed to study different parameters for designing rigid pavements. The hypothesis performed includes relationship between time and deflection for different truck speed and effect on compressive and flexural strength with steel fibers in rigid pavements. Study of compressive strength with eco-friendly material like fly ash is carried out in rigid pavements. Hypothesis reveals cost benefits in pavement if UFS (Used Foundry Sand) are used as an ingredient for M-20 mix design concrete. Relationship between various physical-mechanical characteristics of recycled aggregates and calculation of relationship between nodal deflection and pavement thickness are also studied.

INDEX TERM- Rigid pavements, chi-square, hypothesis, recycled, compressive strength

1. INTRODUCTION-A highway pavement consist of superimposed layers of processed materials above the soilsub-grade, whose basic function is to distribute the applied load to the sub-grade. The pavement structure should be able to provide a surface of good riding quality, adequate skidresistance, favorable light reflecting characteristics and low noise pollution. The ultimate aimis to insure that the induced stresses due to wheel load are sufficiently reduced .The rigidpavement structure consist of a cement concrete slab, below which a granular base or subbasecourse may be provided. Providing a good base or sub-base course layer under thecement concrete slab, increases the pavement life and therefore works out more economic in longer run . Due to rigidity and high tensile strength, a rigid pavement tends to distributethe load over a relatively wide area of sub-grade and the major portion of structural capacityis supplied by the slab itself. The rigid pavements are used for heavier loads and can beconstructed over relatively poor sub-grade.Due to increase in demands and decrease in availability of aggregate for production of concrete in road construction there is need toidentify new source of aggregate from Recycled (waste) materials. In previous years the useof recycled materials has been considered in road construction with great interest in many industrialized and developing countries because it reduces the environmental impact and economize cost. Such waste materials include coconut shell; scrap tire, recycled aggregate, crushed bricks etc. For proper designing of pavements all such parameters are needed to be studied carefully so that better economy is achieved.

2. METHODOLOGY AND CALCULATIONS

Chi-Square hypothesis is carried out to examine relationship between the time and deflection for different truck speeds.Null hypothesis is made on the basis that there is relationshipbetween time and strain wherein strain is directly proportional to deflection. No relationshipexistsbetween time and strain will be the alternative hypothesis. Some critical values of chisquare for specified degree of freedom are checked on the basis of 1%, 5% and 10% level ofsignificance.

Table- 1 Time history strain responses for different truck speeds.

TIME (sec)	STRAIN
0	-1.00 x 10-6
4	2.50 x 10-6
8	3.00 x 10-6
12	4.00 x 10-6
16	-3.00 x 10-6

Expected value = Σ (observed value/5) = 5.5x10-6; O= Observed value, E= Expectedvalue.
Σ (O-E) 2/ E = 1.65x10-3 with four degrees of freedom
$\chi 4^2$=7.779@α=10%,$\chi 4^2$=9.488@α=5%,$\chi 4^2$=13.277@α=1%.
Null hypothesis is accepted.

Hypothesis is carried out to study the relationship of compressive strength with curingtime.Null hypothesis is made on the basis that there is relationship between compressivestrength and curing time.

Table -2 @ 0.4 % steel fibers

Days	Average Compressive Strength (N/Mm2)
7	23.15
28	32.83

Expectedvalue = Σobserved value/2 = 27.9; O= Observed value, E= Expected value
Σ (O-E) 2/E = Σ1.672; with one degree of freedom
$\chi1^2$=2.706@α=10%, $\chi1^2$=3.841@α=5%,$\chi1^2$=6.635@α=1% .Null hypothesis isaccepted.

Table -3 @ 0.5 % steel fiber

Days	Average Compressive Strength (N/Mm2)
7	22.57
28	34.18

Expected value = Σobserved value/2 = 28.375 ; O= Observed value, E= Expected value
Σ (O-E)2/E = Σ2.374 with one degree of freedom
$\chi1^2$=2.706@α=10%, $\chi1^2$=3.841@α=5%, $\chi1^2$=6.635@α=1% .
Null hypothesis is accepted.
Hypothesis is carried out to study the relationship of flexural strength with curing time. Null hypothesis is made on the basis that there is relationship between flexural strength and curing time.

Table 4 @ 0.4 % steel fiber

Days	Average Flexural Strength (N/Mm2)
7	3.73
28	4.69

Expected value = Σobserved value/2 = 4.46, O= Observed value, E= Expected value
Σ (O-E) 2/E = Σ0.056 with one degree of freedom.
$\chi1^2$=2.706@α=10%, $\chi1^2$=3.841@α=5%, $\chi1^2$=6.635@α=1%.

Null hypothesis is accepted.
Null hypothesis is made to examine relationship between flexural strength, slab thickness and corner stresses.

Table 5 @ 0.5 % steel fiber

Days	Average Flexural Strength (N/Mm2)
7	4.10
28	4.82

Expected value = Σobserved value/2 = 4.46, O= Observed value, E= Expected value
Σ (O-E) 2/E = Σ0.056 with one degree of freedom.
$\chi1^2$=2.706@α=10%, $\chi1^2$=3.841@α=5%, $\chi1^2$=6.635@α=1%.
Null hypothesis is accepted.
Null hypothesis is made to examine relationship between flexural strength, slab thickness and corner stresses.

Table 6 Variation of thickness in concrete cubes.

S.NO	Flexural Strength (kg/cm2)	Slab Thickness	Fatigue Life Ratio	Corner Stress (kg/cm3)	Σ
1.	46.9	31	0.533	17.18	95.61
2.	48.2	29	0.75	19.5	97.45
Σ	95.1	60	1.28	36.68	193.06

Oij= Observed value, Eij= Expected value, Eij= (RixCj)/n
E11= (95.61x95.1)/193.06 =47.09; E12=29.71, E13=0.63, E14=18.61, E21=48, E22=30.28, E23=0.64, E24=18.51. Σ (Oij-Eij) 2/Eij =0.221; with three degree of freedom.
$\chi3^2$=6.251@α=10%, $\chi3^2$=7.815@α=5%, $\chi3^2$=11.345@α=1%.
Null hypothesis is accepted.
Null hypothesis is made on the basis that there exist a relationship between averages Compressive strength and percentage replacement at various failure loads.

Table 7 Compressive strength of fly ash cement concrete cube.

S.NO.	Percentage Replacement	Load at Failure	Average Compressive Strength (N/mm2)	Σ
1.	0.15	111.66	49.62	161.43
2.	0.20	107	47.35	154.55
3.	0.25	99.66	44.29	144.20
4.	0.30	90.30	40.14	130.74
5.	0.35	74	32.88	107.23
Σ	1.25	482.62	214.28	698.15

Oij= Observed value, Eij= Expected value ,Eij= (RixCj)/n, E11= (161.43x1.25)/698.15 =0.28, E12=111.59, E13=49.54, E21=0.27, E22=106.83, E23=47.43, E31=0.25, E32=99.68, E33=44.25, E41=0.23, E42=90.37, E43=40.12, E51=0.19, E52=74.12, E53=32.91.Σ (Oij-Eij) 2/Eij =4.28 with eight degree of freedom.
$\chi 8^2$=13.36@α=10%, $\chi 8^2$=15.507@α=5%, $\chi 8^2$=20.09@α=1%.
Null hypothesis is accepted.
Null hypothesis is made on the basis of relationship between total cost of materials and the consumption of design mix proportions for M-20 concrete.

Table 8 Total cost of materials for M-20 design mix concrete (1:1.48:3:21)

SNO.	c	F.A	C.A	U.F.S	COST / m3	Σ
1.	383.21	569.38	1231.11	-	3441.10	5624.8
2.	383.21	512.44	1231.11	56.94	3418.33	5602.03
3.	383.21	398.56	1231.11	170.82	3372.78	5556.48
4.	383.21	284.69	1231.11	284.69	3327.23	5510.93
Σ	1532.84	1765.07	4924.44	512.45	13559.44	Σ22294.24

C= Cement, F.A= Fine Aggregate, C.A= Coarse Aggregate, U.F.S= Used Foundry Sand
Oij= Observed value, Eij= Expected value, Eij= (RixCj)/n.
E11= (1532.84x5624.8)/22294.24 =386.73
E12=445.32, E13=1242.42, E14=129.29, E15=3421.02, E21=385.16, E22=443.52, E23=1237.39, E24=128.76, E25=3407.17, E31=382.03, E32=439.31, E33=1227.33, E34=127.71, E35=3379.47, E41=378.90, E42=436.30, E43=1217.27, E44=126.67, E45=3351.76. Σ(Oij-Eij)2/Eij =483.52 with twelve degree of freedom.
$\chi 12^2$=18.549@α=10%, $\chi 12^2$=21.026@α=5%, $\chi 12^2$=26.17@α=1%.
Null hypothesis is rejected.
Null hypothesis is done on the basis that there is relationship between the physical mechanical Characteristics with various percentage of recycled aggregate.

Table 9 Physical Mechanical characteristics of recycled aggregates used in rigid pavement Construction.

S.no.	Characteristics	Recycled Aggregate
1.	Sand equivalent (%)	72.84
2.	Activity coefficient	1.04
3.	<0.1mm particle size content (%)	0.2 0.1 0.1
4.	Loss angles wear coefficient (%)	24.25 26.01 27.30
5.	Micro deval wear coefficient (%)	18.80
6.	Dry state density (mg/m3)	2.21 2.30 2.25
7.	Saturated state density(mg/m3)	2.34 2.40 2.37
8.	Absorption coefficient (%)	5.70 4.34

		5.54
9.	Crushing coefficient (%)	81.86 80.75 89.50
10.	Impact wear coefficient (%)	44.27

O= Observed value, E= Expected value, E=ΣO/22 =22.56,Σ (O-E) 2/E =853.98; with 21 degreeof freedom.$\chi21^2$=29.615@α=10%, $\chi21^2$=32.67@α=5%, $\chi21^2$=38.93@α=1%.
Null hypothesis is rejected.

3. CONCLUSIONS

- There is relationship between truck speed and deflection which varies with time.
- Compressive and flexural strength varies with curing time with various percentages of steel fibers. It is hypothesized that there is direct relationship between flexural strength, slab thickness and corner stress.
- Average compressive strength varies with different replacement ratios which subsequently give different failure loads.
- Cost varies with various concrete materials like cement, fine aggregate, coarse aggregate and used foundry sand.
- The recycled aggregate varies with different characteristics like loss angles wear coefficient, microdevalwear coefficient, dry state density, saturated state density, absorption coefficient, crushing coefficient and impact wear coefficient.

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