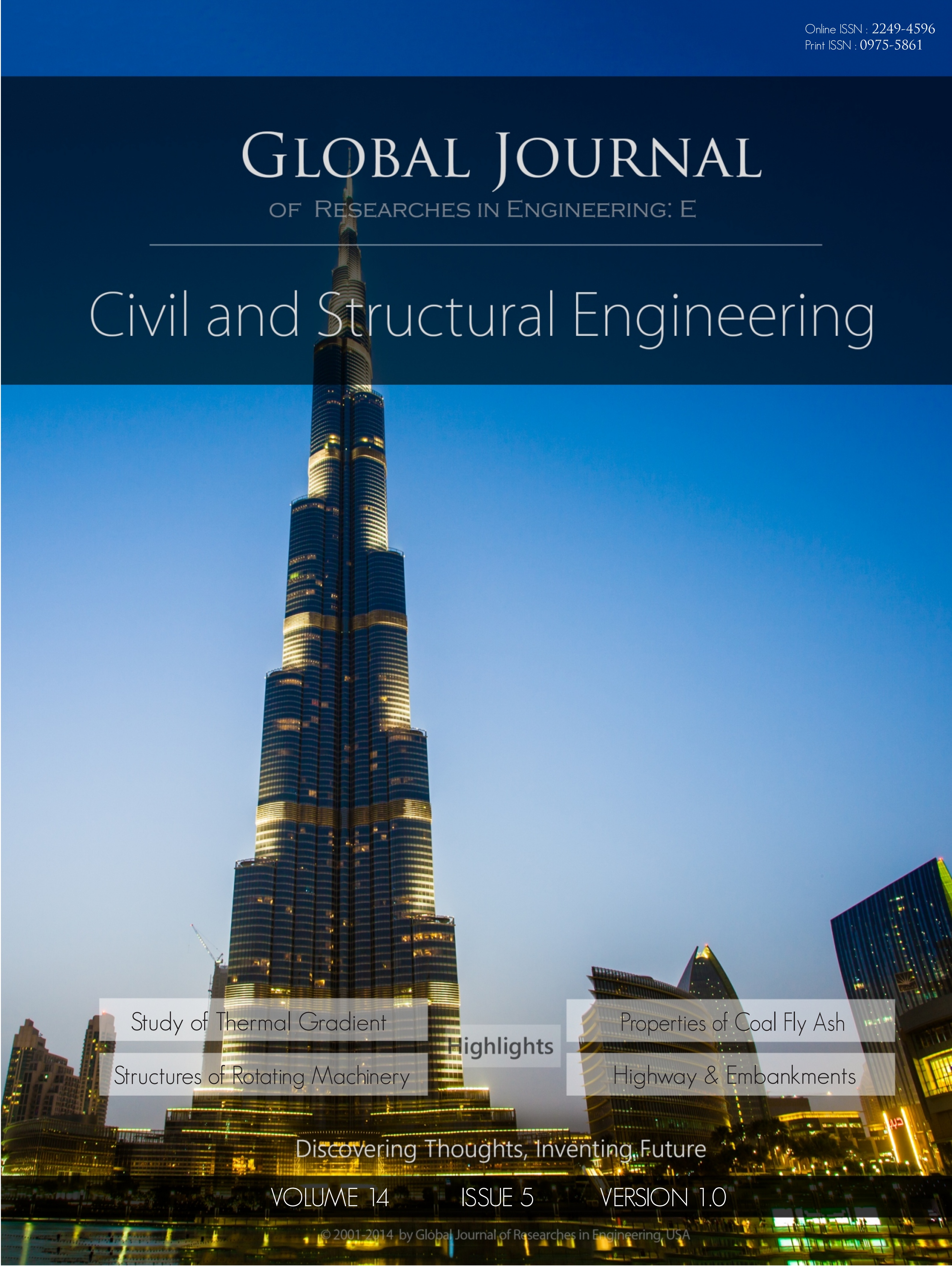
Online ISSN : 2249-4596
Print ISSN : 0975-5861

Global Journal

of Researches in Engineering: E

Civil and Structural Engineering



Highlights

- Study of Thermal Gradient
- Structures of Rotating Machinery
- Properties of Coal Fly Ash
- Highway & Embankments

Discovering Thoughts, Inventing Future

VOLUME 14 ISSUE 5 VERSION 1.0

Global Journal of Researches in Engineering: E
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Civil And Structural Engineering
Volume 14 Issue 5 (Ver. 1.0)

Open Association of Research Society

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USA Tax ID: 98-0673427

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Publisher's Headquarters office

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Wakefield MASSACHUSETTS, Pin: 01880,
United States of America
USA Toll Free: +001-888-839-7392
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Offset Typesetting

Global Journals Incorporated
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Packaging & Continental Dispatching

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Contents of the Issue

Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 14 Issue 5 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Study of Thermal Gradient in Concrete Slabs through Experimental Approach

By Mr. Dhananjay M & Mr. Abhilash K
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Abstract- Millions of tons of cement is used every year that adversely affects environment. Cement is also an important building material for infrastructure development. Cement can be suitably replaced with low cost and so called waste materials like fly ash, marble powder, silica fumes etc... Favoring environment and saving cement. Large length of roads is required to be built in near future over the globe in general and in India in particular. The present technology of making flexible pavements is increasingly becoming unsustainable because of rising life cycle costs and could be suitably replaced with high volume fly ash and high volume marble powder based concrete roads.

The daily and seasonal variation in temperature is an important factor influencing cement concrete pavements. The temperature differential depends on the thickness of slab and the grade of concrete. In this study an effort is made to determine realistic temperature differential and temperature stresses in pavement quality concrete , high volume fly-ash concrete slab and high volume marble powder concrete slab of different thickness. The Concrete slabs of size 500X500 mm of different thickness are instrumented with thermocouples to record the temperature differential between top to bottom of the slabs. Also an attempt is made to Design a Controlled concrete mix and High Volume Fly Ash Concrete and High Volume Marble powder Concrete by replacing 50% of cement by fly ash and 50% of cement by Marble powder respectively, also to find Compressive strength and Static Flexural strength at different periods of curing.

Keywords: pavement quality concrete, high volume fly ash concrete, high volume marble powder concrete, thermocouples, temperature gradient, compressive strength and flexural strength.

GJRE-E Classification : FOR Code: 870301, 290899

STUDYOFTHERMALGRADIENTINCONCRETESLABSTHROUGHEXPERIMENTALAPPROACH

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Study of Thermal Gradient in Concrete Slabs through Experimental Approach

Mr. Dhananjay M [α] & Mr. Abhilash K [σ]

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The temperature is recorded every hour for a period of two days. It was observed that the temperature is more predominate at the top of the slab during day time when compared to bottom of concrete slabs and also observed that the temperature is more at the bottom of the slab during night time when compared to top of concrete slabs. The temperature gradient in concrete slabs achieves equilibrium two times a day i.e. during morning hours and also during evening hours and also actual temperature stresses are calculated.

From these studies, it is observed that the compressive strength in Controlled concrete is higher at 3, 7 and 28 days of curing. Fly-ash admixed concrete has lower compressive strength at 3, 7, 28 days of curing when compares to Controlled concrete, but at 56days the compressive strength of High Volume fly Ash Concrete is more than that of Controlled concrete. Similarly the static flexural strength of fly ash admixed concrete mix is higher than Controlled concrete at 56 days of curing.

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Keywords: pavement quality concrete, high volume fly ash concrete, high volume marble powder concrete, thermocouples, temperature gradient, compressive strength and flexural strength.

I. Introduction

Concrete pavements by far have the best long-term value because of their longer life expectations, durability and minimum maintenance requirements. The rigidity of concrete pavements allows them to keep the riding surface in good condition. Concrete pavements can be designed to last for more than 25 years. Concrete pavements frequently outlast both their designed life expectancy and traffic loads. The durability of concrete minimizes the need for extensive repairs or annual maintenance. When repairs are necessary, they are typically smaller in scope than the asphalt pavements. Concrete's rigid surface makes it easier for wheels to roll, thus reduces operation cost of vehicles.

Pavements are generally subjected to axle loads varying from 30kN to 250kN. While designing the pavements the cumulative damage factor is taken into account in order to incorporate all categories of axle loads applications. Loads of different magnitudes cause different amount of damage to the pavement. Fatigue and fracture has become an important consideration in the design of structures subjected to repeat or cyclic loading conditions. The fatigue performance generally depends on material characteristics, geometry, stress – strain history and environment among other factors which occur at random during the intended life of the structure as a result high performance concrete (HPC) is essential for rigid pavements.

High Performance Concretes produced today contain materials in addition to Portland cement to achieve higher compressive strength and durability. The materials include fly ash, silica fume, ground-granulated blast furnace slag etc. used separately or in combination. At the same time, chemical admixtures such as high-range water-reducers are needed to ensure that the concrete is easy to transport, place and finish. For high-strength concretes, a combination of mineral and chemical admixtures is nearly always essential to ensure achievement of the required strength. The structural deteriorations in cement concrete pavements are noticed in the form of cracks due to combined effects of load stress and warping stress at critical regions.

The stresses developed in rigid pavement include load stress, shrinkage/expansion stress and temperature stress. Temperature stresses develop due to the change in temperature from top to the bottom region of the concrete slab. Temperature along depth of the slab is to be recorded to determine thermal stresses. Thermocouples are used to record the temperature.

Thermocouples are the most popular temperature sensors.

They are cheap, interchangeable, have standard connectors and can measure a wide range of temperatures. Thermocouples are available in different combinations of metals or calibrations. Because thermocouples measure in wide temperature ranges and can be relatively rugged, they are very often used in industry.

a) Need for the study

High Volume Fly ash Concrete (HVFAC) is being used for rigid pavements in recent times, the strength and durability properties of HVFAC and High Volume Marble Powder Concrete (HVMPC) are not the same as conventional Pavement Quality Concrete (PQC). The stresses induced due to temperature may very when compared to PQC. Hence there is a need to analyze the stresses induced due to temperature in HVFAC and HVMPC pavement.

b) Objective of the study

The main objectives of this study are to analyze the temperature stresses induced in CC slabs.

Specific objectives are:

- To design a Controlled concrete mix and High Volume Fly Ash and High Volume Marble powder Concrete mix by replacing 50% of cement by fly ash and marble powder.
- To study the Temperature gradient along the depth of the concrete slabs, i.e. for Pavement Quality Concrete, High Volume Fly ash Concrete and High Volume Marble powder concrete slabs of different thickness.
- To check whether maximum recommended temperature differentials within the concrete roads are as per IRC 58-2002, is within the limits for different slab thickness.
- Comparison of stresses in High Volume Fly ash Cement Concrete Pavement, High Volume Marble Powder Concrete and Pavement Quality Concrete.

II. PRESENT INVESTIGATION

High Volume Fly Ash Concrete, High Volume Marble Powder Concrete and Conventional Pavement Quality Concrete are used in this study to determine the effect of temperature in Concrete pavement slabs. Conventional Pavement Quality Concrete is designed as per IS 10262:2009. Fifty per-cent cement is replaced with by Fly Ash and Marble Powder to get High Volume Fly Ash Concrete and High Volume Marble powder concrete.

Table 1 : Physical properties of materials used in the study

Sl.No	Material	Property	Value
1	Cement	Normal Consistency Initial setting time Specific Gravity	34% 45min 3.045
2	Fly-ash	Specific Gravity Fineness Modulus	2.10 3.325%
3	Granite powder	Specific Gravity Fineness Modulus	2.27 0%
4	Fine aggregate	Specific Gravity Fineness Modulus Water absorption	2.606 3.23% 0.45%
5	Coarse aggregate	Specific Gravity Fineness Modulus Loss Angeles Abrasion Value Aggregate Impact Value Aggregate Crushing value Water absorption	2.86 1.63% 34.96% 17.32% 26.82% 1.4%

a) Casting of Concrete Slabs

Slabs of size 500mmx500mm and thickness 150, 200, and 250mm are cast at the selected site. Marine ply wood moulds are prepared to cast the slabs. Figure 1.

Figure 1 : Moulds for Casting

The location for casting the slab is identified such that it is exposed to sun light. The slab is directly cast on earth surface. The surface is prepared before casting. Thermocouples are fixed to wooden beads of size 10x10mm at 3 levels that is 25mm from top 25mm from bot-tom and at the center of the bead as shown in Figure 2.

Figure 2 : Fixing of Thermocouple on wooden beads

The wooden bead is placed in the mould, Concrete is poured into the mould first around the thermocouple bead and then in three layers and compacted as shown in Figure 3.

Figure 4 : Compaction of Concrete in Moulds

Then all the 9 slabs are cast in a similar way. The slabs are cured for a period of 28 & 56 days by membrane curing by gunny bags.

b) Temperature Recording

Temperatures are recorded after 56 days of casting by using a digital temperature indicator. As shown in figure 5.

Figure 5 : Temperature recording at the site

The temperature indicator has two leads which are connected to the two leads of the thermo-couple. When temperature indicator is activated it displays the temperature directly in degree centigrade. The temperature is recorded every hour for a period of 2-days.

Table 2 : Temperature (°C) Readings in Middle of PQC Slabs

Hours	25 cm Thick			20 cm Thick			15 cm Thick		
	T	M	B	T	M	B	T	M	B
7:00 AM	27.2	27.4	27.6	26.1	26.3	26.5	23.5	24.4	23.8
8:00 AM	27.5	27.4	27.4	26.2	26.2	26.2	25.6	25.2	25.5
9:00 AM	29.6	28.2	27.4	28.2	26.1	25.9	28.2	27.2	26.4
10:00AM	31.6	28.5	27.3	32	29.2	27.8	31.2	28.3	27.1
11:00AM	33.2	27.9	26.5	35.3	31.2	28.1	34.5	32.2	28.2
12:00 PM	36	31.2	27.3	36.1	32	28.6	36.7	28.3	29.2
1:00PM	39.9	32.4	28.5	39.2	33.1	30.3	40.2	34.5	31.2
2:00 PM	43.9	38.6	30.7	43.1	36.8	30.7	44.8	37.2	32.9
3:00 PM	42.5	36.2	32.9	42.7	36.8	34.3	43.5	39.3	35.1
4:00 PM	41.1	38.2	33.1	40.2	36.7	32.8	43.8	40.2	37.2
5:00 PM	39.5	36.8	33.9	39.8	37.1	34.5	42.5	39.7	37.7
6:00 PM	36.2	34.2	33.9	36.1	34.2	33.9	39.3	38.1	37.2
7:00 PM	33.9	33.9	33.9	33.4	33.3	33.4	36.2	36.2	36.3
8:00 PM	32	32.5	32.8	32	32.5	32.7	32.9	33.3	33.5
9:00 PM	31	31.9	32.7	31.2	31.9	32.6	30.3	31.2	31.9
10:00PM	29.8	31.2	32.6	29.3	30.8	31.8	28.5	29.9	30.8
11:00PM	28.8	30.8	32.3	28.3	30.2	31.4	27.2	29.2	30.1
12:00AM	28.3	29.3	31.4	27.8	28.8	30.6	26.3	28.2	28.8
1:00 AM	27.3	28.3	30.1	27.4	28.3	29.9	26.2	27.9	28.5
2:00 AM	27.1	28.2	29.6	27.2	28.3	29.3	25.8	27.2	27.8
3:00 AM	26.9	27.3	29.1	26.9	27.2	28.9	25.6	26.8	27.7
4:00 AM	26.3	26.9	27.8	26.5	27	28	25.5	26.4	26.9
5:00 AM	26.1	26.8	27.1	26.2	26.9	27.1	25.2	25.6	26.1
6:00 AM	25.6	36.1	26.3	25.9	26.2	26.5	24.8	25.1	25.3

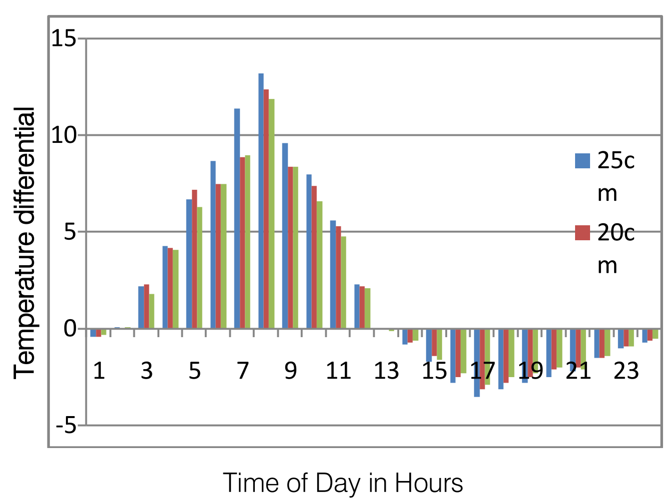

Figure 6 : Actual Temperature Differential at middle of PQC Slabs

Table 3 : Temperature (°C) Readings in Middle of HVFAC Slabs

Hours	25 cm Thick slab			20 cm Thick slab			15 cm Thick slab		
	T	M	B	T	M	B	T	M	B
7:00 AM	25.7	25.9	26.1	25.8	25.9	26.1	25.7	25.8	26
8:00 AM	25.9	25.8	26	26.9	26.9	26.9	26.4	26.3	26.3
9:00 AM	29.6	28.2	27.5	28.9	27.8	27.2	27.9	26.9	26.1
10:00AM	34.2	31.3	29.7	33.2	30.5	28.5	31.9	29.1	27.8
11:00AM	36.5	31.8	29.6	36.2	32.9	29.7	34.2	31.1	28
12:00 PM	41.2	35.4	31	41.2	35.2	32.1	37.6	33.9	30
1:00PM	41.1	35.2	30.2	41.7	36.2	31.6	38.9	35.2	30.2
2:00 PM	46.3	39	34.2	48.1	42.2	37.4	46.3	42.2	37.1
3:00 PM	45.5	37.2	33.3	45.8	40.4	35.5	43.7	39.3	37
4:00 PM	43.2	40.2	35.5	43.9	40.8	36.3	42.3	39.3	37.1
5:00 PM	41.6	38	35.1	41.6	39.1	36.2	40.4	38	36.8
6:00 PM	39.2	37.2	35.5	38.3	36.8	35.9	36.3	35.8	34.9
7:00 PM	35.3	35.4	35.4	35.4	35.4	35.4	32.8	33	32.9
8:00 PM	35.1	35.4	35.8	33.6	33	34.2	32.2	32.5	32.8
9:00 PM	33.8	33.9	35.2	32.6	33.4	33.9	31.5	32.1	32.8
10:00PM	32.5	34.2	34.8	31.3	32.8	33.2	30.4	31.9	32.1
11:00PM	31.2	33.2	34.1	31.1	32.8	33.9	29.6	30.8	31.8
12:00AM	30.9	32.3	33.4	30.7	31.2	33	28.9	30.1	31.2
1:00 AM	30.4	31.8	32.6	29.2	30.2	31.2	28.2	29.3	30.2
2:00 AM	29.8	30.8	31.7	28.8	29.6	30.5	27.9	28.9	29.5
3:00 AM	28.5	29.2	30.2	28.2	28.9	29.7	27.7	28.3	29
4:00 AM	28.3	29.3	29.5	27.9	28.5	28.9	27.2	27.2	28.2
5:00 AM	28.1	28.2	29.1	27.1	27.6	28.1	26.9	27.5	27.6
6:00 AM	27.7	27.9	28.3	26.9	27.2	27.4	26.4	26.6	26.9

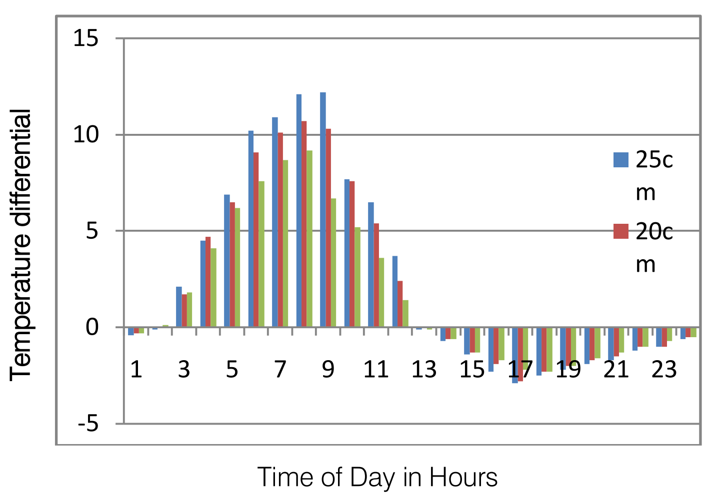

Figure 7 : Actual Temperature Differential at middle of HVFAC Slabs

Table 4 : Temperature (°C) Readings in Middle of HVMPC Slabs

Hours	25 cm Thick slab			20 cm Thick slab			15 cm Thick slab		
	T	M	B	T	M	B	T	M	B
7:00 AM	26.2	26.3	26.5	25.3	25.4	25.6	26.2	26.5	26.8
8:00 AM	26.5	26.5	26.5	28.1	28	28	27.9	27.8	27.8
9:00 AM	29	27.9	26.7	30.1	28.4	28.2	28	26.9	26.4
10:00AM	33.8	30.5	29.3	35.2	30.9	30.5	33.2	31.2	28.7

11:00AM	38.2	35.1	31.2	37.8	36.9	31.7	37.9	34.1	32.4
12:00 PM	38.8	34.3	30.1	38.8	34.3	31.2	40	36	32.3
1:00PM	41.9	37.5	32	39.9	34	31.3	44.5	38.2	35.8
2:00 PM	46.4	38.4	34.2	46.8	42.2	36.2	49.5	43	39.9
3:00 PM	45.1	39.1	35.2	44.9	41.1	36.7	46.2	41.6	38.4
4:00 PM	43.3	39.9	35.8	43.8	40.4	37.2	44.4	41.4	39.3
5:00 PM	43	40.5	36.9	42.3	40.8	37.4	42.8	41.2	39.1
6:00 PM	38.9	37.5	36.8	38.7	37.6	36.9	39.8	36.9	37.9
7:00 PM	37.5	37.5	37.5	36.3	36.3	36.4	34.3	34.3	34.2
8:00 PM	36.5	36.7	37.4	34.2	34.5	34.8	31.4	31.7	32
9:00 PM	33.8	34.8	35.3	32.7	33.2	34	30.2	30.8	31.2
10:00PM	31.9	33.2	34.3	30.1	31.2	32.3	28.5	30.3	30.4
11:00PM	30.3	32.3	33.2	28.8	30.3	31.5	27.5	29.3	29.9
12:00AM	30.3	31.3	32.8	28.5	29.3	30.7	27.5	28.9	29.4
1:00 AM	29.5	30.3	31.6	27.5	28.8	29.3	27.2	28.2	29
2:00 AM	29.2	30.1	31	27.4	27.9	28.8	26.5	27.3	28
3:00 AM	28.8	29	30.2	26.9	27.6	28.2	26.2	27.2	27.3
4:00 AM	28	28.4	29	26.5	27.1	27.4	26.2	26.8	27
5:00 AM	27.2	27.6	28	26.2	26.5	26.9	25.9	26.1	26.5
6:00 AM	26.9	27.1	27.5	26.1	26.4	26.5	25.5	25.9	26.2

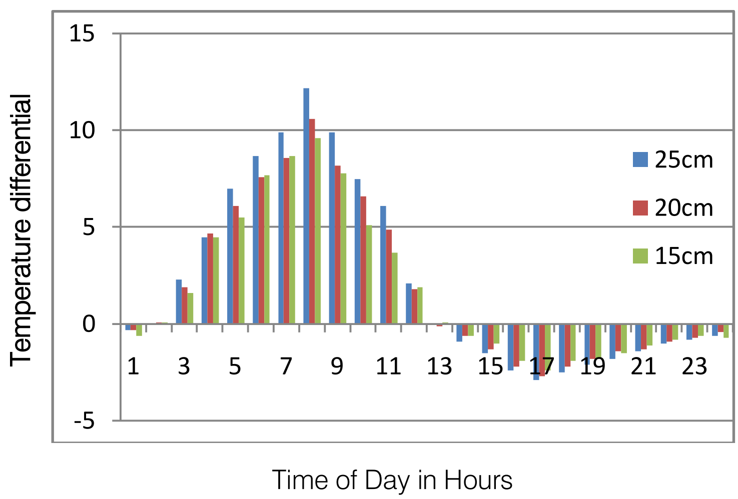

Figure 8 : Actual Temperature Differential at middle of HVMPC Slabs

Table 5 : Temperature (°C) Readings in Edge of PQC Slabs

Hours	25 cm Thick		20 cm Thick		15 cm Thick	
	T	B	T	B	T	B
7:00 AM	25.9	26.2	25.3	25.5	24.1	24.2
8:00 AM	27.2	27.2	26.6	26.7	25.8	25.9
9:00 AM	30.2	28.4	29.3	27.5	30.8	29.1
10:00AM	36.6	30.9	34.4	29.2	33.8	29.1
11:00AM	37.7	29.8	38.4	31.8	36.4	30.9
12:00 PM	40.1	32.7	40.9	33.8	38.2	31.2
1:00PM	40.9	33	42.9	35.2	39.2	32
2:00 PM	48.3	36.9	47.8	37.6	43.5	33.2
3:00 PM	44.3	35.9	44.3	36.5	41.9	34.8
4:00 PM	41.5	35.2	41.8	35.4	41.4	35.2
5:00 PM	39.3	35.2	39.4	35.3	39.7	35.8

6:00 PM	37.3	35.2	36.7	34.9	37.3	35.8
7:00 PM	34.1	34.2	33.4	33.3	33.7	33.7
8:00 PM	31.2	31.9	30.2	30.8	31.4	31.9
9:00 PM	29.8	31.5	29.3	30.8	29.6	31
10:00PM	29	31.3	28.9	30.7	28.3	30.1
11:00PM	28.5	31.5	28	30.4	27.2	29.5
12:00AM	28.2	30.7	27.8	29.7	26.4	28.4
1:00 AM	27.9	30.1	27.5	29.2	26.5	28.2
2:00 AM	27.5	29.2	27.2	28.9	26.3	27.9
3:00 AM	27.3	28.6	26.9	28.1	25.9	27
4:00 AM	26.9	27.9	26.5	27.4	25.5	26.4
5:00 AM	26.5	27.3	26.4	27.1	25.4	26
6:00 AM	26.4	27	26.1	26.6	24.9	25.4

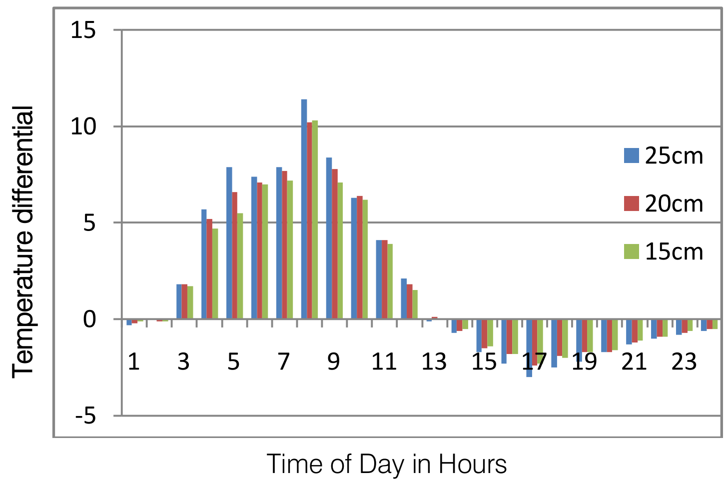

Figure 9 : Actual Temperature Differential at edge of PQC Slabs

Table 6 : Temperature (°C) Readings in Edge of HVFAC Slabs

Hours	25 cm Thick		20 cm Thick		15 cm Thick	
	T	B	T	B	T	B
7:00 AM	27.4	27.8	27.1	27.5	25.1	25.4
8:00 AM	27	27.1	27.1	27	26.3	26.3
9:00 AM	28.8	26.8	28.9	27.2	28.4	26.8
10:00AM	33.9	29.2	33.8	29.7	34.1	29.9
11:00AM	37.7	30.8	37.6	31.5	35.6	30.2
12:00 PM	42.3	33.1	42.1	33.3	38.7	30.9
1:00PM	42.5	31.9	42.4	32.4	42.2	33.1
2:00 PM	45.1	33.9	47.3	37.5	42.9	34.2
3:00 PM	44.1	34.3	45.6	36.9	43.4	35.2
4:00 PM	42.1	34.5	43.2	36.2	41.9	35.1
5:00 PM	39.1	34.1	39.7	35.1	39.4	34.6
6:00 PM	35.9	33.2	36.5	34.2	36.2	34.2
7:00 PM	33.4	33.5	33.2	33.2	33.4	33.4
8:00 PM	32.7	33.4	32.9	33.6	31.2	31.8
9:00 PM	31.3	32.8	31.4	32.8	30.2	31.3
10:00PM	30.8	32.5	30.6	31.9	29.7	30.3
11:00PM	30.2	32.7	29.2	31.4	28.7	30.8
12:00AM	29.6	31.6	28.9	30.7	28.3	29.9
1:00 AM	29.3	31.2	28.2	30	28.1	29.6

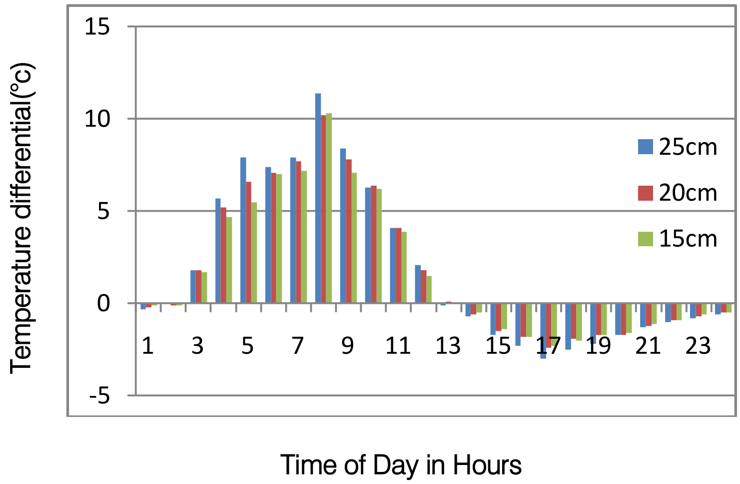

Figure VIII : Actual Temperature Differential at edge of PQC Slabs

Table VI : Temperature (°C) Readings In Edge Of HVFAC Slabs

Hours	25 cm Thick slab		20 cm Thick slab		15 cm Thick slab	
	Top	Bottom	Top	Bottom	Top	Bottom
7:00 AM	27.4	27.8	27.1	27.5	25.1	25.4
8:00 AM	27	27.1	27.1	27	26.3	26.3
9:00 AM	28.8	26.8	28.9	27.2	28.4	26.8
10:00AM	33.9	29.2	33.8	29.7	34.1	29.9
11:00AM	37.7	30.8	37.6	31.5	35.6	30.2
12:00 PM	42.3	33.1	42.1	33.3	38.7	30.9
1:00PM	42.5	31.9	42.4	32.4	42.2	33.1
2:00 PM	45.1	33.9	47.3	37.5	42.9	34.2
3:00 PM	44.1	34.3	45.6	36.9	43.4	35.2
4:00 PM	42.1	34.5	43.2	36.2	41.9	35.1
5:00 PM	39.1	34.1	39.7	35.1	39.4	34.6
6:00 PM	35.9	33.2	36.5	34.2	36.2	34.2
7:00 PM	33.4	33.5	33.2	33.2	33.4	33.4
8:00 PM	32.7	33.4	32.9	33.6	31.2	31.8
9:00 PM	31.3	32.8	31.4	32.8	30.2	31.3
10:00PM	30.8	32.5	30.6	31.9	29.7	30.3
11:00PM	30.2	32.7	29.2	31.4	28.7	30.8
12:00AM	29.6	31.6	28.9	30.7	28.3	29.9
1:00 AM	29.3	31.2	28.2	30	28.1	29.6
2:00 AM	28.2	29.8	27.3	28.8	27.3	28.6
3:00 AM	27.8	29.1	27	28.2	26.9	28
4:00 AM	27.2	28.3	26.4	27.3	26.4	27.3
5:00 AM	26.3	27.2	26.1	26.9	26.3	27
6:00 AM	25.9	26.6	25.9	26.5	26.2	26.7

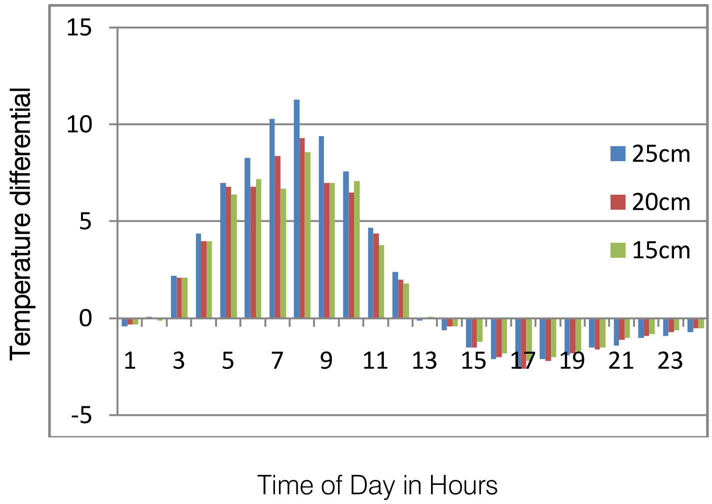

Figure 11 : Actual Temperature Differential at edge of HVMPC Slabs

Table 8 : Temperature (°C) Readings in Corner of PQC Slabs

Hours	25 cm Thick		20 cm Thick		15 cm Thick	
	T	B	T	B	T	B
7:00 AM	25.9	26.2	25.3	25.5	24.1	24.2
8:00 AM	27.2	27.2	26.6	26.7	25.8	25.9
9:00 AM	30.2	28.4	29.3	27.5	30.8	29.1
10:00AM	36.6	30.9	34.4	29.2	33.8	29.1
11:00AM	37.7	29.8	38.4	31.8	36.4	30.9
12:00 PM	40.1	32.7	40.9	33.8	38.2	31.2
1:00PM	40.9	33	42.9	35.2	39.2	32
2:00 PM	47.3	36.9	46.8	37.6	42.5	33.2
3:00 PM	44.3	35.9	44.3	36.5	41.9	34.8
4:00 PM	41.5	35.2	41.8	35.4	41.4	35.2
5:00 PM	39.3	35.2	39.4	35.3	39.7	35.8
6:00 PM	37.3	35.2	36.7	34.9	37.3	35.8
7:00 PM	34.1	34.2	33.4	33.3	33.7	33.7
8:00 PM	31.2	31.9	30.2	30.8	31.4	31.9
9:00 PM	29.8	31.5	29.3	30.8	29.6	31
10:00PM	29	31.3	28.9	30.7	28.3	30.1
11:00PM	28.5	31.5	28	30.4	27.2	29.5
12:00AM	28.2	30.7	27.8	29.7	26.4	28.4
1:00 AM	27.9	30.1	27.5	29.2	26.5	28.2
2:00 AM	27.5	29.2	27.2	28.9	26.3	27.9
3:00 AM	27.3	28.6	26.9	28.1	25.9	27
4:00 AM	26.9	27.9	26.5	27.4	25.5	26.4
5:00 AM	26.5	27.3	26.4	27.1	25.4	26
6:00 AM	26.4	27	26.1	26.6	24.9	25.4

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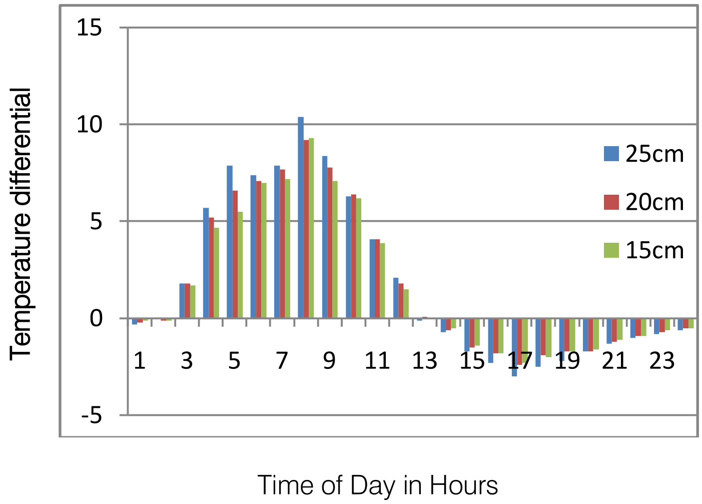


Figure 12 : Actual Temperature Differential at corner of PQC Slabs

Table 9 : Temperature (°C) Readings in Corner of HVFAC Slabs

Hours	25 cm Thick		20 cm Thick		15 cm Thick	
	T	B	T	B	T	B
7:00 AM	26.9	27.2	26.2	26.5	24.2	24.4
8:00 AM	27.1	27	26.5	26.6	26.3	26.4
9:00 AM	29.2	27.1	29.2	27.2	28.7	26.9
10:00AM	35.8	31.3	34.9	30.2	34.6	30.5
11:00AM	38.4	31.9	37.6	31.2	37.1	30.9
12:00 PM	40.1	32.4	41.9	33.7	41.9	34.5
1:00PM	42.8	33.9	42.8	34.3	43.2	35.1
2:00 PM	47.4	37.1	46.8	37.8	47.7	38.8
3:00 PM	44.6	35.9	45.5	37.4	46.1	37.8
4:00 PM	41.8	35.3	43.5	37.2	43.4	36.5
5:00 PM	39.2	35	39.2	35.3	39.9	36.4
6:00 PM	37.1	34.8	36.8	34.8	37.9	36.1
7:00 PM	34.3	34.3	34.2	34.2	34.8	34.7
8:00 PM	32.4	33.4	31.2	32	29.8	30.5
9:00 PM	29.6	31.1	30.4	31.8	28.7	30
10:00PM	28.9	31.1	29.2	31.2	27.8	29.7
11:00PM	28.2	30.8	28.9	30.9	27.6	29.6
12:00AM	28.2	30.4	28.4	30.1	27.3	28.9
1:00 AM	27.3	29.3	28.1	29.8	27.1	28.6
2:00 AM	26.9	28.7	27.8	29.3	26.9	28.9
3:00 AM	26.7	28.3	27.5	28.8	26.8	27.9
4:00 AM	26.2	27.5	26.9	28	26.3	27.1
5:00 AM	25.8	26.9	26.2	27.1	25.8	26.6
6:00 AM	25.4	26.2	25.9	26.6	25.7	26.3

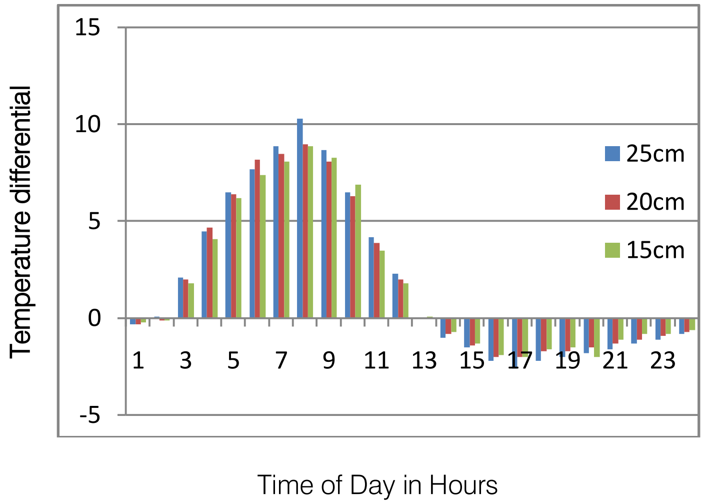


Figure 13 : Actual Temperature Differential at corner of HVFAC Slabs

Table 10 : Temperature (°C) Readings In Corner of HVMPC Slabs

Hours	25 cm Thick		20 cm Thick		15 cm Thick	
	T	B	T	B	T	B
7:00 AM	26.2	26.5	25.2	25.5	25.4	25.6
8:00 AM	27.7	27.7	28.4	28.3	27.4	27.3
9:00 AM	29.2	26.8	30.3	28.2	31.1	29.1
10:00AM	32.2	28.3	35.3	31.5	35.6	31.5
11:00AM	35.2	29.8	38.9	33	37.1	32.3
12:00 PM	39.8	32.3	41.2	34.1	40.9	34.1
1:00PM	43.9	35.3	44.3	35.2	42.3	34.2
2:00 PM	47.4	37.2	47.2	37.6	47.5	38.3
3:00 PM	45.8	37.1	46.9	38.3	46.2	38
4:00 PM	41.7	35.7	43	36.5	45.5	38.1
5:00 PM	39.6	35.5	40.2	36.2	41.9	37.8
6:00 PM	37.2	34.9	37.9	35.8	38.1	36
7:00 PM	34.3	34.3	35.2	35.1	35.2	35.1
8:00 PM	32.5	33.3	31.5	32.2	31.9	32.4
9:00 PM	31.3	32.9	29.8	31.3	29.9	31.2
10:00PM	30.3	32.3	29	30.9	29.3	30.8
11:00PM	29.3	31.7	28.1	30.3	28.5	30.5
12:00AM	28.2	30.3	27.8	29.7	28.1	29.9
1:00 AM	27.9	29.7	27.2	28.8	27.6	29.1
2:00 AM	27.3	28.8	26.8	27.9	27.2	28.8
3:00 AM	26.7	28	26.5	27.8	26.9	28.4
4:00 AM	26.4	27.6	26.1	27.2	26.8	27.8
5:00 AM	26.1	27	25.7	26.5	26.3	27
6:00 AM	25.8	26.4	25.3	25.9	26.5	26.8

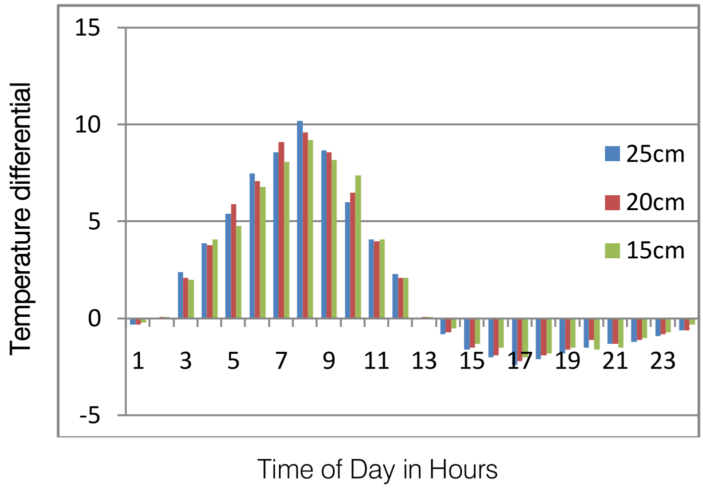


Figure 14 : Actual Temperature Differential at corner of HVMPC Slabs

III. Results and Discussion

The results obtained from the present investigation conducted on HPC slabs and discussions are presented in this chapter.

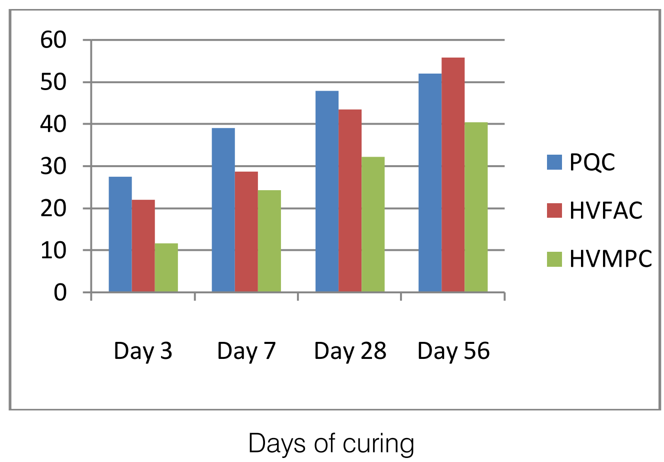
a) Cube Compressive Strength

The cube specimen of PQC, HVFAC & HVMPC mixes is tested for compressive strength at 3, 7, 28 and 56 days of curing. The cube compressive test results for all mixes are shown in Table. It observed that there is an increase in cube compressive strength with increase in number of days of curing. PQC gain early compressive strength compared to HVFAC. From test results it is observed that the compressive strength of HVMPC is lesser than that of PQC & HVFAC at 56 days of curing.

Cube Compressive Strength Test Results of Concrete slabs.

Sl. No	Number of days of Curing	Conventional PQC Mix (N/mm²)	Fly Ash Admixed concrete Mix (N/mm²)	Marble Powder Admixed Concrete mix (N/mm²)
1	3	27.48	22.07	11.70
2	7	39.11	28.74	24.37
3	28	47.41	42.96	32.59
4	56	52.00	55.70	40.44

Comparison of Compressive Strength of PQC, HVFAC and HVMPC Mixes.



Cube Compressive Strength Test Results of Concrete slab.

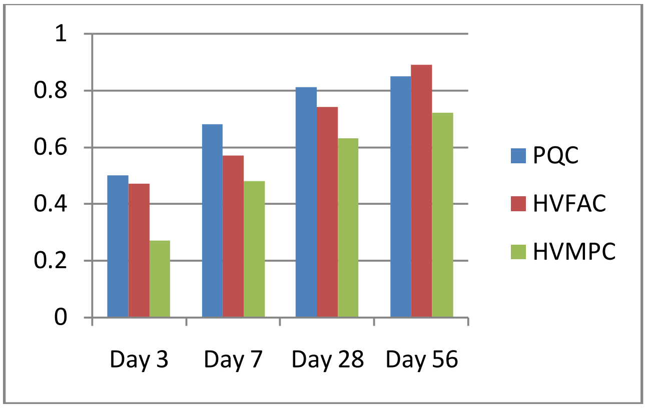
b) Static Flexural Strength

The static flexural strength of PQC and HVFAC beam specimens were determined using two point loading method and the test results are shown in Table.

Static Flexural Strength Test Results of Concrete slabs

Sl.No	Number of days of curing	PQC – Beams		HVFAC - Beams		HVMPC – Beams	
		Load KN	Fcr N/mm²	Load KN	Fcr N/mm²	Load KN	Fcr N/mm²
1	3	11.25	0.5	10.5	0.47	6	0.27
2	7	15.25	0.68	13	0.57	10.75	0.48
3	28	18.25	0.81	16.75	0.74	14.25	0.63
4	56	19.25	0.85	20	0.89	16.25	0.72

Comparison of Flexural Strength of PQC, HVFAC and HVMPC Mixes.



Days of curing

Static Flexural Strength Test Results of Concrete slabs

c) Obtained Temperature Differentials in Concrete slabs

The temperature is recorded for a period of two day in all the slabs. The maximum positive & negative temperature differential occurred during a day in each slab is shown in tables below.

Positive Temperature Differential in different types of concrete Slabs.

1. At Centre

Thickness (mm)	Maximum positive Temperature differential in °C		
	PQC	HVFAC	HVMPC
150	11.9	9.2	9.6
200	12.4	10.7	10.6
250	13.2	12.2	12.2

2. At Edge

Thickness (mm)	Maximum positive Temperature differential in °C		
	PQC	HVFAC	HVMPC
150	10.3	9.1	8.6
200	10.2	10.0	9.3
250	11.4	11.2	11.3

3. At Corner

Thickness (mm)	Maximum positive Temperature differential in °C		
	PQC	HVFAC	HVMPC
150	9.3	8.9	9.2
200	9.2	9.0	9.6
250	10.4	10.3	10.2

Negative Temperature Differential in different types of concrete Slabs

1. At Centre

Thickness (mm)	Maximum negative Temperature differential in °C		
	PQC	HVFAC	HVMPC
150	-2.9	-2.3	-2.4
200	-3.1	-2.8	-2.7
250	-3.5	-2.9	-2.9

2. At Edge

Thickness (mm)	Maximum negative Temperature differential in °C		
	PQC	HVFAC	HVMPC
150	-2.3	-2.1	-2.2
200	-2.4	-2.2	-2.6
250	-3.0	-2.5	-2.6

3. At Corner

Thickness (mm)	Maximum negative Temperature differential in °C		
	PQC	HVFAC	HVMPC
150	-2.3	-2.0	-2.0
200	-2.4	-2.0	-2.2
250	-3.0	-2.6	-2.4

d) *Maximum positive temperature differential for different thickness of CC slabs*

Thickness (mm)	Type of concrete			As per IRC:58-2002
	PQC	HVFAC	HVMPC	
150	11.9	9.2	9.6	17.3
200	12.4	10.7	10.6	19
250	13.2	12.2	12.2	20.3

e) *Obtained temperature stresses in concrete slabs Positive temperature stresses in different types of concrete slabs*

1. At Centre

Thickness (mm)	Maximum positive Temperature stresses in N/mm^2		
	PQC	HVFAC	HVMPC
150	0.225	0.174	0.182
200	0.234	0.202	0.200
250	0.250	0.231	0.231

2. At Edge

Thickness (mm)	Maximum positive Temperature stresses in N/mm^2		
	PQC	HVFAC	HVMPC
150	0.166	0.146	0.138
200	0.164	0.161	0.150
250	0.184	0.180	0.182

3. At Corner

Thickness (mm)	Maximum positive Temperature stresses in N/mm^2		
	PQC	HVFAC	HVMPC
150	0.1095	0.1013	0.1047
200	0.094	0.0918	0.0979
250	0.098	0.0968	0.0958

Negative Temperature stresses in different types of concrete Slabs.

1. At Centre

Thickness (mm)	Maximum negative Temperature stresses in N/mm^2		
	PQC	HVFAC	HVMPC
150	-0.055	-0.0435	-0.045
200	-0.059	-0.0530	-0.0151
250	-0.066	-0.055	-0.055

2. At Edge

Thickness (mm)	Maximum negative Temperature stresses in N/mm^2		
	PQC	HVFAC	HVMPC
150	-0.037	-0.033	-0.035
200	-0.038	-0.035	-0.042
250	-0.048	-0.040	-0.042

3. At Corner

Thickness (mm)	Maximum negative Temperature stresses in N/mm^2		
	PQC	HVFAC	HVMPC
150	-0.026	-0.022	-0.0228
200	-0.024	-0.020	-0.0225
250	-0.028	-0.024	-0.0226

f) *Maximum positive temperature stress for different thickness of CC slabs*

Maximum positive temperature stress for different thickness of CC slabs

Thickness (mm)	Type of concrete		
	PQC	HVFAC	HVMPC
150	0.225	0.174	0.182
200	0.234	0.202	0.200
250	0.250	0.231	0.231

IV. Results

1. At Centre

a) The maximum positive and negative temperature differentials in pavement quality concrete slab are +13.2 ^{0}C and -3.5 ^{0}C respectively.

b) The maximum positive and negative temperature stress in pavement quality concrete slab are 0.250 N/mm^2 and -0.066 N/mm^2 respectively.

c) The maximum positive and negative temperature differentials in high volume fly-ash concrete slab are 12.2 ^{0}C and -2.9 ^{0}C respectively.

d) The maximum positive and negative temperature stress in high volume fly-ash concrete slab are 0.23 N/mm^2 and -0.055 N/mm^2 respectively.

e) The maximum positive and negative temperature differentials in high volume marble powder concrete slab are 12.2 ^{0}C and -2.9 ^{0}C respectively.

f) The maximum positive and negative temperature stress in high volume marble powder concrete slab are 0.231 N/mm^2 and -0.055 N/mm^2 respectively.

2. At Edge

a) The maximum positive and negative temperature differentials in pavement quality concrete slab are 11.4 ^{0}C and -3 ^{0}C respectively.

b) The maximum positive and negative temperature stress in pavement quality concrete slab are 0.184 N/mm^2 and -0.048 N/mm^2 respectively.

c) The maximum positive and negative temperature differentials in high volume fly ash concrete slab 11.2 ^{0}C and -2.5 ^{0}C respectively.

d) The maximum positive and negative temperature stress in high volume fly ash concrete slab are 0.180 N/mm^2 and -0.04 N/mm^2 respectively.

e) The maximum positive and negative temperature differentials in high volume marble powder concrete slab are 11.3 ^{0}C and -2.6 ^{0}C respectively.

f) The maximum positive and negative temperature stress in high volume marble powder concrete slab are 0.182 N/mm^2 and -0.042 N/mm^2 respectively.

3. At Corner

a) The maximum positive and negative temperature differentials in pavement quality concrete slab are 10.4 ^{0}C and -3 ^{0}C respectively.

b) The maximum positive and negative temperature stress in pavement quality concrete slab are 0.1095 N/mm^2 and -0.02 N/mm^2 respectively.

c) The maximum positive and negative temperature differentials in high volume fly ash concrete slab are 10.3 ^{0}C and -2.6 ^{0}C respectively.

d) The maximum positive and negative temperature stress in high volume fly ash concrete slab are 0.1013 N/mm^2 and -0.024 N/mm^2 respectively

e) The maximum positive and negative temperature differentials in high volume marble powder concrete slab are 10.2 ^{0}C and -2.4 ^{0}C respectively.

f) The maximum positive and negative temperature stress in high volume marble powder concrete slab are 0.1047 N/mm^2 and -0.0228 N/mm^2 respectively.

V. Conclusion

- High volume fly-ash concrete slabs are found to gain compressive strength in gradual pattern. The compressive strength is more at higher curing ages i.e. 56 days & 90 days.
- The compressive strength of High Volume marble Powder Concrete is less at all curing ages i.e. 3,7,28 & 56 days when compared to PQC.
- The obtained temperature differentials for HVFAC & HVMPC are lower than suggested values and temperature difference by IRC 58–2002 for the design of concrete pavements.
- Initial cost of construction or maintenance for concrete overlays is more compared to bituminous overlays. But over a period of time concrete overlays prove more economical.
- Lesser the temperature difference in the HVFAC & HVMPC shows that warping stress in HVFAC & HVMPC pavement will be least than normal PQC.
- Since the compressive strength of HVMPC is less, therefore HVMPC is not recommended for construction of new pavements.
- Thus it can be concluded that HVFAC can be used for construction of new pavements when there is no restrictions for time limits.
- The reduction in total stresses in the pavements, hence the thicknesses will be less than conventional concrete pavements.
- Environmental parameters are to be considered to get realistic temperature differential in HPC pavements.

VI. Acknowledgment

I express my sincere gratitude to Dr. D. S. Suresh Kumar, Director, CIT, I also thanks to Prof. M. Dhananjay for continuous guidance without which I would not come up with this paper, I also thanks to all teaching, non teaching staff of CIT College.

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Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 14 Issue 5 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Effect of Soda Lime Glass Dust on the Properties of Clayey Soil

By Md. Nuruzzaman & Dr. Md. Akhtar Hossain
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Abstract- The research was carried out with an intention to observe any sign of improvement of clayey soil due to the addition of soda lime glass dust with it. In this thesis work clayey type soil has been chosen. The reason behind choosing clay is that it has some problems. The main problem is that it undergoes consolidation settlement due to the application of long term loading. Another problem is it shrinks significantly if it is dried and expands significantly if it absorbs moisture which exerts much pressure on the substructure. Glass dust is chosen to check the improvement because it is cohesionless material. Addition of cohesionless material to the cohesive soil means it will lessen the consolidation settlement and expansive nature of soil. To investigate the effect traditional methods of analyzing the effect of additives on soil has been adopted i.e. conducting several tests of untreated soil and soil treated with glass dust and then comparing the results. The tests that were carried out in this study are Compaction test, Atterberg test, Consolidation test, Unconfined compression test. Before this to know the type of soil grain size analysis and specific gravity tests were performed. From the test results it is observed that the maximum dry density increases, optimum moisture content decreases, liquid limit decreases, plastic limit increases, plasticity index decreases, compression index and swell index decreases with the addition of glass dust with soil. Unconfined compressive strength decreases at zero day and after curing for some days the unconfined compressive strength increases with the addition of glass dust with soil.

Keywords: clayey soil, glass dust, conventional tests, improvement.

GJRE-E Classification : FOR Code: 090599

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Strictly as per the compliance and regulations of :

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I. Introduction

It is necessary for designers to take into consideration local economic factors as well as environmental conditions and project location in order to make prudent decisions for design and construction. Soil modification may have to be considered in many projects. Soil index properties get transformed by adding additives. This leads to the alteration of the physical and chemical properties of the soil. Soil improvement, in the broadest sense, is the alteration of any property of a soil to improve its engineering performance. It also comprises any process which increases or maintains the natural strength of the soil. Although soil stabilization was originally done to increase the strength or stability of soil, gradually, techniques of soil treatment have been developed until soil stabilization is now used to increase or decrease almost every engineering property of soil. The necessities to improve soil properties for construction works result in the use of various stabilizers. Some of these stabilizers are either costly or scarce. For example, cement stabilization was adjudged the most viable due to its abundance; however the growing cost of cement has limited its use. It therefore became necessary to utilize the excellent properties of the common materials. There is a wide range of material available for the construction industries. The choice and sustainability of a particular material depends largely on its availability, nature of project, individual preference, durability, proximity and economic consideration. Solid wastes are inevitable by products of human activities. Due to increase in population, urbanization, industrialization and change in lifestyle, there has been a radical change in the quantity and characteristics of the solid wastes. Hence solid wastes become more hazardous to environment and demands careful disposal practices. Waste materials having qualities to improve engineering properties of soil may be used as admixtures. Broken pieces of glass are waste products. Glass dust is a cohesionless material which can improve the quality of soil.

II. Literature Review

A lot of research work has been done in the past to improve engineering properties of soil using additives. The additives used in the past were lime, cement, saw dust, fly ash, rice husk ash etc. Chemical additives were also used to improve the quality of soil and induce binding action in soil like Sodium Bentonite. A list of researchers is given below who have used certain additives to improve soil. Emad Akawwi and Atef Al-Kharabsheh (2000) has shown the influence of lime on optimum moisture content and consistency index. According to them optimum moisture content of soil treated with lime may increase or decrease depending upon the type of soil. But they have not shown any effect of lime on the compressive strength of soil. Anagnostopoulos and Maria Chatziangelou (2008) worked on compressive strength of cement stabilized soils and have shown that cement admixture increases the unconfined compressive strength of soil significantly. They have also developed a non linear regression model

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to predict the behavior of cement stabilized soil. Their work was limited only to the compressive strength of cement stabilized soil. Brooks has shown that the unconfined compressive strength of clayey soil increases with the addition of fly ash upto a certain limit and then it decreases. He has also shown the swelling index variation of clayey soil due to the addition of fly ash. It has been found that fly ash decreases the swelling index of soil. He has performed CBR test using fly ash and rice husk ash both mixed with soil. His finding was an optimum value of rice husk ash and fly ash for CBR. Brooks (2009) has shown that the unconfined compressive strength of clayey soil increases with the addition of fly ash upto a certain limit and then it decreases. He has also shown the swelling index variation of clayey soil due to the addition of fly ash. It has been found that fly ash decreases the swelling index of soil. He has performed CBR test using fly ash and rice husk ash both mixed with soil. His finding was an optimum value of rice husk ash and fly ash for CBR. Henry Tolulope (2012) has shown that saw dust additive changes properties of soil. It increases maximum dry density and optimum moisture content and decreases unconfined compressive strength of clayey soil. He has also perfomed CBR test and shown that CBR is also improved considerably due to the addition of saw dust. However, no research has done yet using glass dust as an additive to improve the quality of soil. This study is based on the technique used by other researchers to study the improvement caused due to the addition of additive

III. Materials and Procedures

For this research work soil sample was collected from Godagarithana of Rajshahi district. The soil sample was collected at 2ft below the ground level so as to ensure that particles other than soil are not included in the soil sample. If this occurs then there will be error in the results of the experiment done on the original soil sample as well as on the treated soil sample. The color of the soil sample was brown and was different from other types of soil in Rajshahi. When the soil was mixed with water it formed a paste like material and felt very sticky in between fingers. Visual identification of the soil showed no sign of gravel in the soil. The glass was collected from a vangri shop in Vodra at a rate of 7 taka Per kg for small scale purchase which were broken pieces of waste glass. Then the broken pieces of glass were washed and dried to remove foreign materials in it. After that it was crushed to dust by using mortar and hammer. This is done for a small scale laboratory tests. But if glass is to be crushed to dust on a large scale then crusher machine should be used. Otherwise it will be risky to do the job manually. The glass dust was obtained by crushing it into dust and passing it through 300 μm sieve. Glass is an amorphous (non-crystalline) solid material. Glasses are typically brittle and optically transparent. The most familiar type of glass, used for centuries in windows and drinking vessels is soda-lime glass composed of silica 72% + sodium oxide (Na_2O) 14.2% + magnesia (MgO) 2.5% + lime (CaO) 10.0% + alumina (Al_2O_3) 0.6%. Soda-lime glasses account for about 90% of manufactured glass. It has a high thermal expansion and poor resistance to heat (500–600 °C). It is used for windows, containers, light bulbs, tableware etc. Silica is the main composition of sand which is cohesionless. When glass is crushed to dust it acts as a cohesionless material. And when this glass dust is mixed with cohesive and expansive fine grained soil it will improve the consistency of soil. Also glass dust contains 10% of lime in it. This will provide with some extra strength to the soil if hydrated.

To investigate the effect of glass dust on soil sample tests were done on

a) Untreated soil Sample
b) Treated soil sample with different percentages of glass dust

In the work physical identification test, grain size distribution test, specific gravity test, Atterberg limit test, compaction test, consolidation test, unconfined compression test were performed for the untreated soil sample as well as for treated sample except grain size distribution test which was performed for various percentages of glass dust mixed with soil sample. To identify the maximum dry density and optimum moisture content standard proctor test was. For treated soil the percentage of glass dust content were 3%, 6%, 9% and 12%.

IV. Results and Discussion

a) Properties of Soil Sample

The grain size analysis of soil is shown in the figure 1 and the basic engineering properties are shown in the table 1.

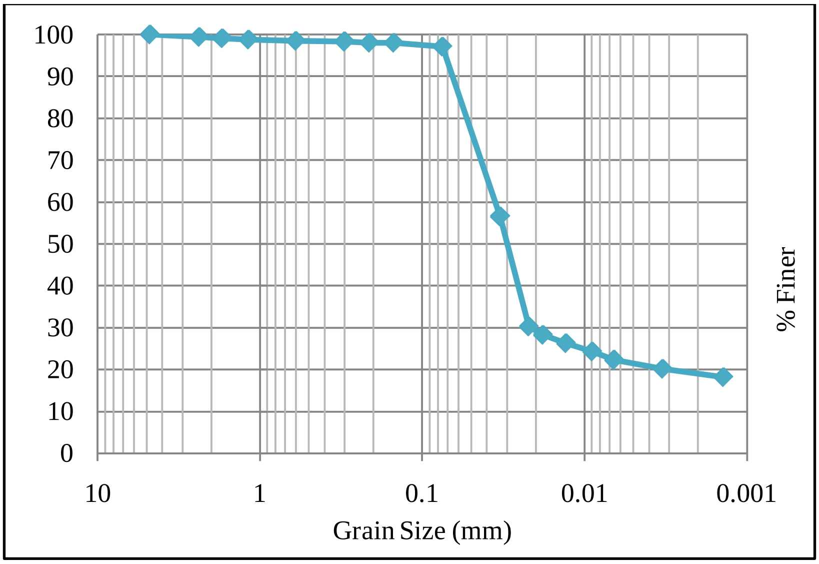

Figure 1 : Grain Size Distribution Curve of Soil

According to Unified Soil Classification System the soil type is Clayey. The group symbol of soil is CL where C stands for clayey and L stands for low plasticity.

Table 1 : Properties of Soil Sample

Specific Gravity	2.49
Maximum Dry Density	1.79 gm/cm^3
Optimum Moisture Content	14.6%
Liquid Limit	27.38
Plastic Limit	15.76
Plasticity Index	11.62
Type of Soil	Clayey (Unified Soil Classification System)

b) Variations

i. *Compaction Characteristics*

The test performed to determine the compaction characteristics of untreated and treated soil was Standard Proctor Test. The variations of maximum dry density and optimum moisture content are shown in figure 2 and 3 respectively.

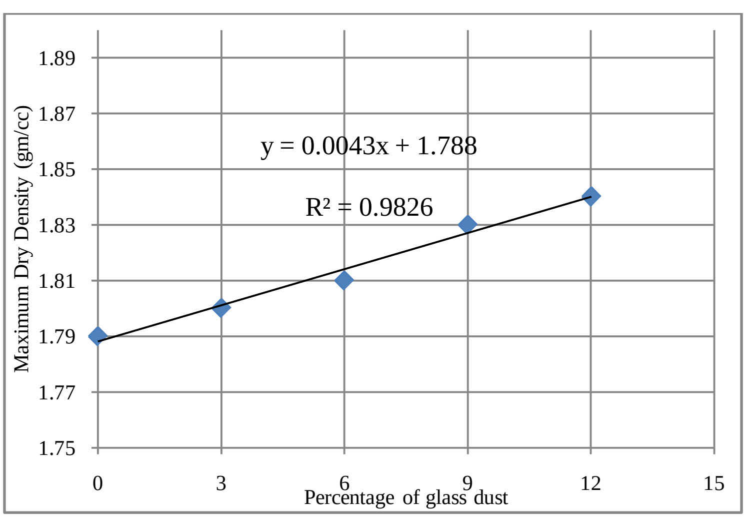

Figure 2 : Variation of Maximum Dry Density with Percentage of Glass Dust

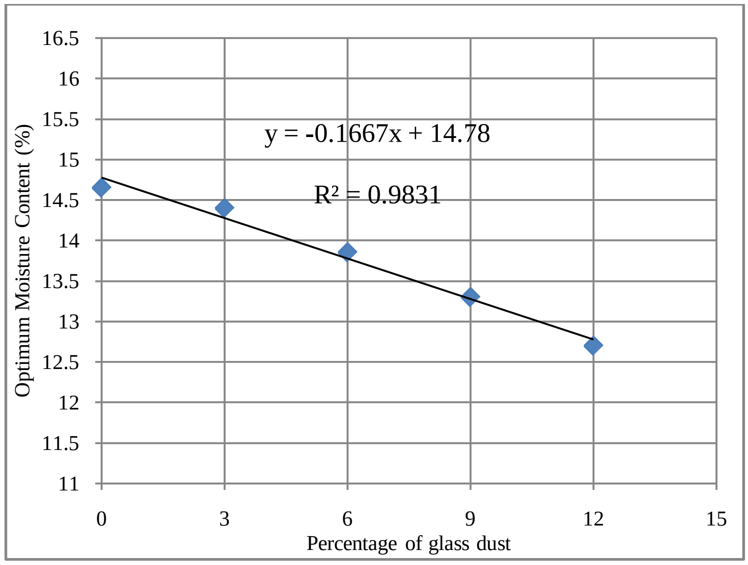

Figure 3 : Variation of Optimum Moisture Content with Percentage of Glass Dust

From the data obtained by standard proctor test for untreated soil and soil treated with different percentage of glass dust it has been found that the maximum dry density of soil increases with the addition of glass dust. Also it has been found that the optimum moisture content decreases with the addition of glass dust. The reason behind the result is the higher specific gravity of glass dust than soil and the fineness of glass dust.

ii. *Plasticity*

The variation of plasticity index of soil after mixing with glass dust is shown in the figure 4 by performing Atterberg limits test.

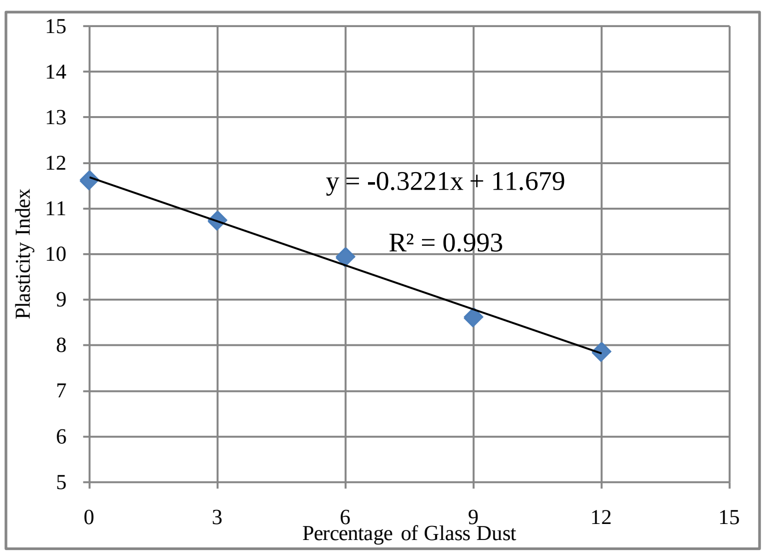

Figure 4 : Variation of Plasticity Index with Percentage of Glass Dust

Plasticity index of soil decreases due to the addition of glass dust and a decrease in plasticity index of soil is a sign of improvement of soil. As glass dust is cohesionless it was expected that it would reduce the plasticity index of soil and the result satisfies the expectation.

iii. *Consolidation Properties*

The amount of settlement of a particular type of soil depends upon its consolidation properties. In the figures 5 and 6 the variation in these properties obtained by mixing glass dust with soil for different percentages are shown.

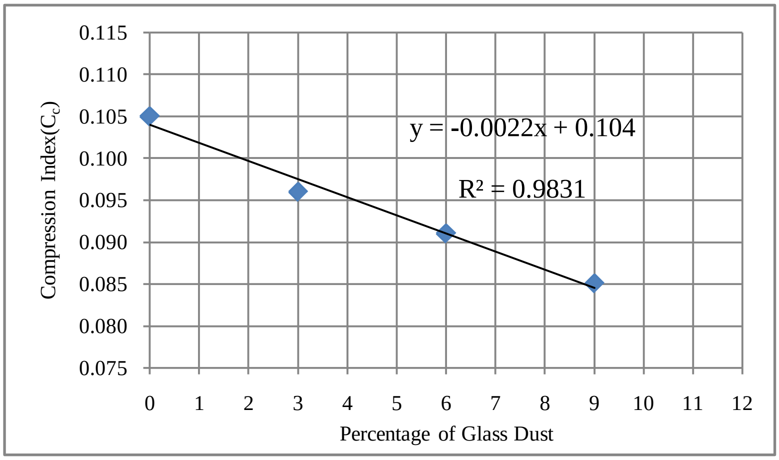

Figure 5 : Variation of Compression Index with Percentage of Glass Dust

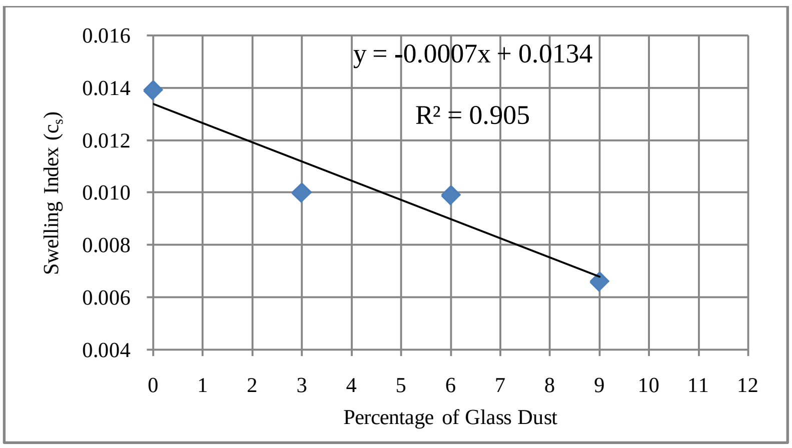

Figure 6 : Variation of Swelling Index with Percentage of Glass Dust

Consolidation test yields that both the compression index and swell index decreases with the addition of glass dust. Decrease in these two indices means that the property of the clayey soil has been improved. The non-cohesive property of glass dust reduces these two indices.

iv. *Unconfined Compressive Strength*

The variation in the unconfined compressive strength of untreated and treated soil is shown in the figure 7.

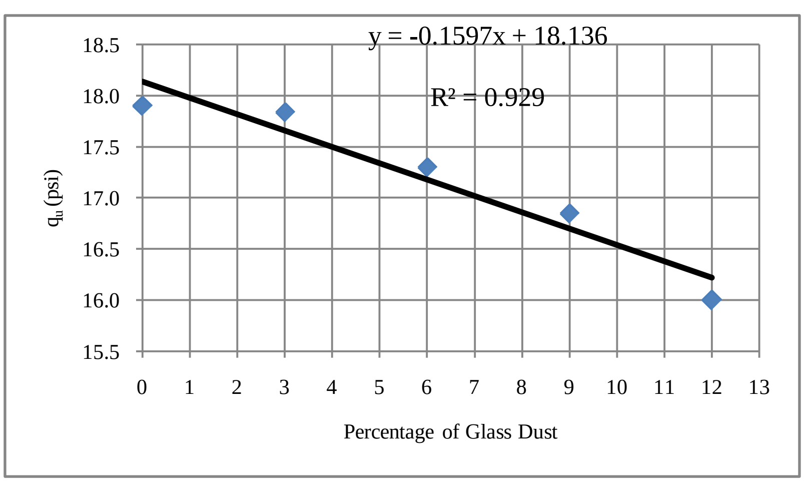

Figure 7 : Variation of Unconfined Compressive Strength with Percent Glass Dust

Global Journal of Researches in Engineering (E) Volume XIV Issue V Version I Year 2014
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From the results of unconfined compression test it has been found that the unconfined strength of soil decreases with the addition of glass dust with no curing.

All the variations of these properties have been found to follow a linear relationship as the regression value is so very clos to 1. So no optimum amount of glass dust could be found in this work. It will depend upon the degree of improvement required and cost of glass dust stabilization.

V. Conclusions

After conducting several tests of untreated soil and the glass dust treated soil for different percentages the following conclusions can be drawn.

- From the test results it is clearly seen that properties of soil has been improved by the addition of glass dust to the soil by comparing the behavior of treated and untreated soil. The improvement of these properties are not drastically and also it is not insignificant.
- The results of the tests also draw another conclusion that the more percentage of glass dust we add to the soil the properties of clayey soil improves more rapidly.

VI. Recommendation for Future Study

The following recommendations can be made for future research:

a) Soil sample from other places can be tested to have a better knowledge about the behavior of soil with glass dust.
b) Soil can be heated with glass dust at a temperature of the melting point of glass and the change in strength properties of soil can be tested.
c) The cost of glass dust stabilization of soil can be assessed and compared with other stabilizing agents.

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Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 14 Issue 5 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Effect of Freezing and Thawing on the Strength Characteristics of Slurry Infiltrated Fibrous Ferrocement using Steel Fibers

By G. S. Sudhikumar, K. B. Prakash & M. V. Seshagiri Rao
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Abstract- The concrete composites play an important role in the field of concrete. The addition of fibers to concrete enhances the strength properties and ductility characteristics. Ferrocement is light weight and versatile material having high cracking, ductility and fatigue resistance and is additionally impermeable to make it far superior than reinforced concrete. It is used for prefabricated residential units, marine and industrial structures. Slurry infiltrated fiber concrete (SIFCON) could be considered as a special type of fiber concrete with high fiber content. The matrix consists of cement slurry or flowing cement mortar. This composite material withstands blast loading and can be used for pre-stressed concrete beams and safe vaults. Slurry infiltrated fibrous ferrocement (SIFF) is a combination of SIFCON and ferrocement and can overcome the limitations of latter. SIFF can be used for the structures like runways in aerodromes, industrial floors etc.

This paper deals with an experimental investigation on the strength characteristics of SIFF using 1% by volume of steel fibers of aspect ratio 25 when subjected to 90 cycles of freezing and thawing (1cycle of freezing and thawing means 24 hours of immersion of specimens in freezer at a temperature of -14°C and then keeping the specimens in open atmosphere for 24 hours). The results indicated that with the addition of 0.8% steel fibers yield higher compressive strength, flexural strength, toughness indices and impact strength.

Keywords: ferrocement, fibers, fiber reinforced concrete; slurry infiltrated fibrous ferrocement (SIFF), welded mesh, chicken mesh, compressive strength, flexural strength, impact strength.

GJRE-E Classification : FOR Code: 290899

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I. Introduction

Today, concrete fiber composite is the most promising and cost effective material used in the construction. Many researchers have shown that the addition of small closely spaced and uniformly dispersed fiber to concrete transforms the brittle cement composite into a more isotropic and ductile material called fiber reinforced concrete (FRC).

FRC can be used in the preparation of various precast building units such as cladding sheets, window frames, roofing units, floor tiles, manhole covers and advanced applications in highway pavements, air field, machine foundations, industrial floorings, bridge deck overlays, sewer pipes, earthquake resistant structures and explosive resistant structures (like MX missile silos etc).

Similar to FRC, the ferrocement has also many advantages and its applications are rapidly increasing in the precast construction industry. Ferrocement make use of different types of steel meshes for its construction. Ferrocement also suffer from limitations. It cannot be employed where high impacts, vibrations, wear and tear are expected. The strength of the ferrocement increases with the increase in steel content. But when the reinforcement is more, the mortar cannot be easily forced inside without forming voids. Thus strength of ferrocement reduces.

The fibrous ferrocement, which is a combination of fibrous concrete and ferrocement, can overcome all the above said limitations to some extent and can be employed with assurance where high impacts, vibrations, wear and tear are expected. In this new material the advantage of both ferrocement and fiber reinforced concrete are combined. The fibrous cement is becoming a promising material for bridge overlays and industrial floorings where high impacts, high vibrations and high wear and tear are expected. The reinforcements used in fibrous ferrocement are of three kinds. The first type reinforcement is welded mesh where smaller diameter bars (approx. 12 G) are kept closely in both directions and are spot welded. This mesh gives stability and shape to the structure. The second type reinforcement is chicken mesh. This is mesh of similar wires (approx 20G) which are interwoven to different openings. The spacing between the wires of chicken mesh is small. This mesh mainly distributes the stresses evenly and the cracks will be minimized. The third type of reinforcement is fiber. The fibers may be of steel, carbon, glass, polypropylene, GI etc. These fibers act as crack arresters and are randomly distributed in the concrete.

Depending upon the shape required, the cage is prepared out of welded mesh and chicken mesh. The cage can be prepared by tying the chicken mesh over the welded mesh at regular intervals by using binding wires. The calculated quantities of fibers are placed in the mould. The mortar is then infiltrated into the mould to form SIFF.

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II. Materials and Method

Main objective of this experimentation is to study the strength characteristics of slurry infiltrated fibrous ferrocement with steel fiber of aspect ratio 25. Different strength parameters considered for study are compressive strength, flexural strength and impact strength.

Ordinary Portland cement of 43 grade and locally available sand (passing 1.18 mm and retained on 150 micron IS sieve) with specific gravity 2.64 was used in the experimentation. To impart additional workability a super plasticizer (Conplast SP 430), 1% by weight of cement was used. The welded mesh (WM) used in the experimentation was square opening of 25 mm x 25 mm. The chicken mesh (CM) used was having a hexagonal opening with 0.5 mm diameter. The cement mortar with a proportion of 1:1 was used with a water cement ratio of 0.45.

To study the effect of steel fibers on the strength properties of SIFF, the compressive strength specimens, flexural strength specimens and impact strength specimens were casted. For compressive strength test, specimens of dimensions 150 x 150 x 150 mm were cast. For flexural strength test, specimens of dimensions 100 x 100 x 500 mm were cast. Flexural strength specimens were tested under two point loading over an effective span of 400 mm. The impact strength test specimens were of 152.4 mm in diameter and 63.5 mm thick. An ASTM D 1557 drop hammer was used (drop hammer weighs 4.5 Kg and falls at 457 mm per blow, each blow represents 20.2 N-m of energy). The number of blows required to cause the first crack and final failure were noted.

Initially, the cages of size 130 x 130 x 130 mm, 480 x 80 mm and 140 mm diameter were prepared by welded mesh, upon which chicken mesh was tied by using binding wire for cube, flexure and impact specimens respectively and is as shown in the figure The cement – sand slurry was prepared with a mix proportion of 1:1 with a w /c ratio of 0.45, and a super plasticizer dosage of 1% (by weight of cement). Initially a small quantity of the slurry was poured into the mould as cover and then the cage is placed into the mould. Then the fibers were placed in different percentages such as 0%, 0.2%, 0.4%, 0,6%, 0.8%, 1.0%, 1.2% and 1.4% into the mould. Now the slurry was infiltrated into the mould upto brim level and was compacted through table vibrator. Then the moulds were covered with wet gunny bags for 12 hours. After 12 hours, the specimens were demoulded and kept in water for 28 days curing. After 28 days of curing, the specimens were subjected to freezing and thawing for 90 cycles (1cycle of freezing and thawing means 24 hours of immersion of specimens in freezer at a temperature of -14°C and then keeping the specimens in open atmosphere for 24 hours). After 90 cycles, the specimens were tested for their respective strengths.

For compressive strength, cubes of dimension 150 x 150 x150 mm were cast and tested as per IS 516: 1959. For flexural strength, the specimens of dimensions 100 x 100 x 50 mm were cast and tested with two point loading as per IS 516: 1959. Impact strength test specimens were of dimension 152 mm diameter and 63.5 mm height. Impact strength test was carried out according to the procedure recommended by Ernest K. Schrader.

a) Test Results

Test results of compressive strength, flexural strength and impact strength for varying percentages of fibers are tabulated in Table 1 and Table 2.The variation in the compressive strength, flexural strength and impact strength for varying percentages of fibers are represented graphically in Figure 1, 2 and 3.

Table 1 : Compressive and flexural strength test results of slurry infiltrated fibrous ferrocement when subjected to freezing and thawing

Percentage addition of fiber	SIFF with steel fiber					
	Compressive strength (MPa)	Percentage increase or decrease of compressive strength w.r.t ref mix	Flexural strength (MPa)	Percentage increase or decrease of flexural strength w.r.t ref mix	Toughness Indices	
					I_5	I_{10}
0 (Ref, mix)	29.33	-	5.84	-	4.74	10.15
0.2	33.63	15	7.09	21	5.26	10.48
0.4	34.81	19	8.08	38	5.45	10.94
0.6	35.26	20	8.24	41	5.87	11.35
0.8	36.15	23	8.27	42	6.14	11.87
1.0	34.22	17	8.37	43	6.51	12.61
1.2	31.56	8	8.48	45	6.74	13.19
1.4	27.11	-8	8.80	51	6.97	14.09

Table 2 : Impact strength test results of slurry infiltrated fibrous ferrocement when subjected to freezing and thawing

Percentage addition of fiber	SIFF with steel fiber			
	Impact strength required to cause (N-m)		Percentage increase or decrease of impact strength w.r.t ref mix	
	First crack	Final failure	First crack	Final failure
0(Ref.mix)	6080.20	6881.47	-	-
0.2	10820.47	14961.47	78	117
0.4	14476.67	19620.93	138	185
0.6	18806.20	21405.27	209	236
0.8	20832.93	23142.47	243	236
1.0	19641.13	22933.73	223	233
1.2	16961.27	20247.13	179	194
1.4	15163.47	18617.67	149	171

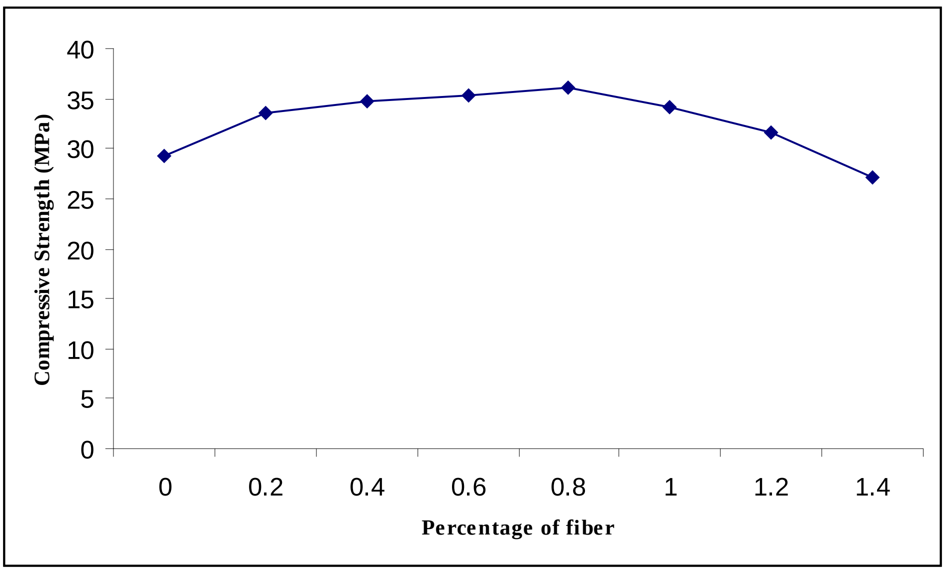

Figure 1 : Variation of compressive strength of SIFF

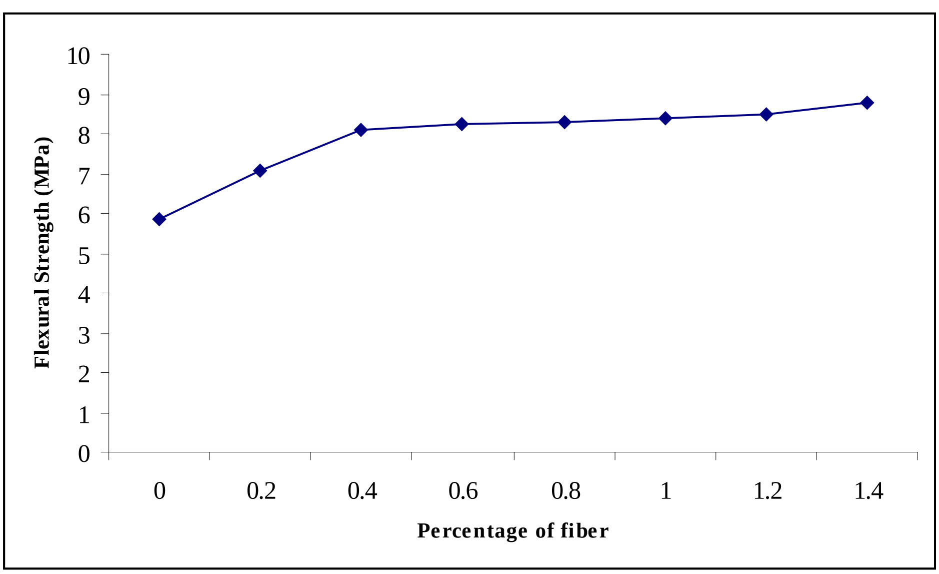

Figure 2 : Variation of flexural strength

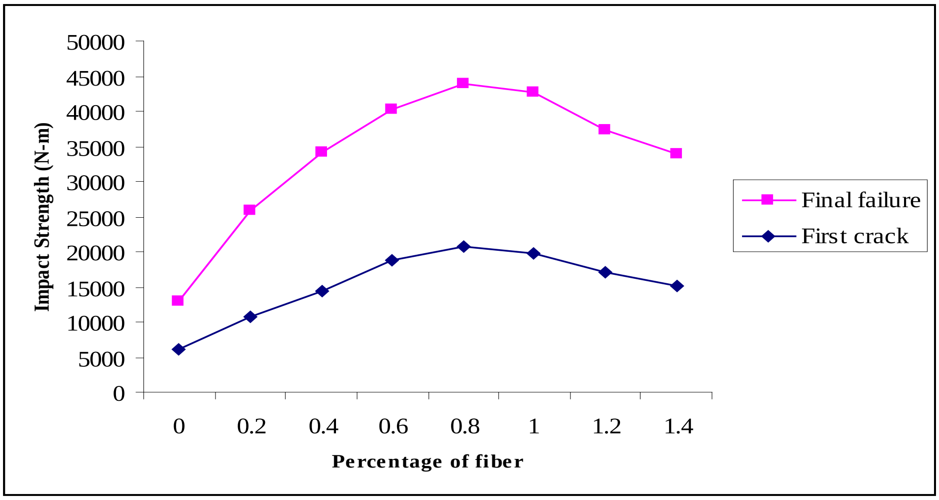

Figure 3 : Variation of impact strength of SIFF

III. Conclusions

Following conclusions can be drawn based on the study conducted on effect of freezing and thawing on the strength characteristics of slurry infiltrated fibrous ferrocement.

a) Addition of 0.8% of steel fibers into slurry infiltrated fibrous ferrocement can result in higher compressive strength when subjected to 90 cycles of freezing and thawing.
b) Addition of 1.4% of steel fibers into slurry infiltrated fibrous ferrocement can result in higher flexural strength and higher toughness indices when subjected to 90 cycles of freezing and thawing.
c) Addition of 0.8% of steel fibers into slurry infiltrated fibrous ferrocement can result in higher impact strength when subjected to 90 cycles of freezing and thawing.

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Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 14 Issue 5 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Dynamic Analysis of Support Frame Structures of Rotating Machinery

By Rafael Marin Ferro, Walnório Graça Ferreira & Adenilcia Fernanda Grobério Calenzani
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Abstract- Adequate dynamic analysis of support frame structures of mechanical equipment is necessary to ensure not only the comfort of the users, but ensure good conditions for the operation of equipment supported. Studies of dynamics structural and equipment see the difficulty performing real models. This paper conducts a performance check of the support frame structures, according to changes in their connections, considering the loads caused by rotating machinery and compared with the limits of displacements of the structures established by standards of equipment and structures. The use of a computational numerical model that represents the most real way possible system to be analyzed is required. This article is to conduct a study establishing a practical application of dynamic loads caused by rotating equipment on supports with different connections structures using computational models with STRAP software. Models of structures with connections rigid, pinned and semi-rigid, will be made, applying loads of rotating machines and viewing which support base has the best performance in relation structure versus dynamic loading in accordance with connections.

Keywords: dynamic analysis; vibration; rotating machinery; support frame structures.

GJRE-E Classification : FOR Code: 290801

DYNAMICANALYSISOFSUPPORTFRAMESTRUCTURESOFROTATINGMACHINERY

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Dynamic Analysis of Support Frame Structures of Rotating Machinery

Rafael Marin Ferro [α], Walnório Graça Ferreira [σ] & Adenilcia Fernanda Grobério Calenzani [ρ]

Abstract- Adequate dynamic analysis of support frame structures of mechanical equipment is necessary to ensure not only the comfort of the users, but ensure good conditions for the operation of equipment supported. Studies of dynamics structural and equipment see the difficulty performing real models. This paper conducts a performance check of the support frame structures, according to changes in their connections, considering the loads caused by rotating machinery and compared with the limits of displacements of the structures established by standards of equipment and structures. The use of a computational numerical model that represents the most real way possible system to be analyzed is required. This article is to conduct a study establishing a practical application of dynamic loads caused by rotating equipment on supports with different connections structures using computational models with STRAP software. Models of structures with connections rigid, pinned and semi-rigid, will be made, applying loads of rotating machines and viewing which support base has the best performance in relation structure versus dynamic loading in accordance with connections.

Keywords: dynamic analysis; vibration; rotating machinery; support frame structures.

I. Introduction

Dynamics of structures studies movements of bodies caused by forces applied to them and also the forces that cause movements in structures. Steel and concrete structures are elements subjected to forces, and these structures must resist in order to maintain the shape similar to the desired settings during the operation. According to Brasil and Silva (2013), the movements of a structure must be sufficiently minor around a projected initial configuration. The adequate dynamic analysis of structures implies the creation of models that allow converting a pre-established entity, in a complex way, into something that the current resources can understand and model. Thus, according to Brasil and Silva (2013), at the beginning the real structure is transformed into a physical (or conceptual) model, by simplifications such as bars, plates, idealized supports, materials of simplified behavior, punctual masses, etc. From then, a mathematical model is constructed, a system of equations relating the characteristics of the structure, and introducing the laws of mechanics. In the final stage, we try to solve these equations by analytical or numerical means. Currently, the processes of mathematical modeling and of numerical solution were transformed by the advent of computing through modeling software.

It is noteworthy that Ferreira (2002) in his elaborated studies indicated that to find the answer in the field of structure's dynamic analysis, analyses can be performed either in the time domain or in the frequency domain, where each analysis must be performed according to the predominance. For instance, in the situation soil-structure the frequency domain analysis prevails.

Vibrations of mechanical equipment such as rotating machinery, should be strictly controlled according to the application and the criteria of existing technical standards and of those that are still being studied, and should be used as basis of the operating conditions of mechanical equipment, especially for predictive maintenance. In his studies, Soeiro (2008) shows that predictive maintenance is a format in which it is considered that equipment or machinery, usually in operation, should have continuous and scheduled monitoring with the objective of detecting flaws such as unbalance, misalignment, widespread clearance, bad fixing, unbalanced electric field, etc.

Premature wear of machine components, unexpected breakage of parts, structural fatigue of the equipment and of its support base, disconnection of parts, and even a possible unplanned stop of the equipment are flaws in machinery that cause excessive vibrations of parts of the equipment and can cause damage to the industrial processes.

Among the above-mentioned essentials of maintenance, in order to control the phenomena of vibration, three different procedures must be followed, considering the latter as the focus of this study: Attenuation of the response: alteration in the structure (reinforcements, auxiliary masses, changing of natural frequency, etc).

II. Considerations for the Design of Steel Frame Support Structures

According to previous researches, it was considered that the effect of dynamic loads on civil structures could be related to the increase of static load. However, in recent researches, it was observed that these studies did not represent correctly the effect of

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dynamic loads on structures, since the analysis of the effects caused by a dynamic load is very different from the analysis of the effects caused by a static load. Thus, characteristics inherent to each type of activity that generates a dynamic excitation should be considered as loads that have frequency, amplitude, and shape, which lead structural systems to different types of disarrangements. Thus, in the REFERENCES we present the main standards used in the research that refer to the analysis of structures subjected to dynamic actions and criteria related to the analysis of human comfort and good performance of mechanical equipment.

III. Considerations on Dynamics of the Rotors of Rotating Machinery

In the numerical simulation of rotor dynamics, the formulation of a mathematical model that represents a rotating system requires prior knowledge of the project parameters such as dimensions and material data. The success of a rotating machine project consists mainly of:

- Avoiding critical velocities, if possible;
- Minimizing the dynamic response in resonance peaks, if necessary;
- Passing through a critical speed;
- Avoiding instability;
- Minimizing vibrations and loads transmitted to machine structure throughout the period of operation.

The critical speeds by which a machine can pass until reaching its operating speed become one of the major inconvenient in rotor dynamics. At these speeds, the machine shaft can reach higher amplitudes of vibration that can cause irreversible damage to the bearings and to other components of the rotor.

In the case of a rotor shaft with conventional materials, the possible ways to reduce the amplitude of critical speeds is to balance the rotor, which means go to the source of the problem – however, it is very difficult to balance a rotor with perfection.

We can also change machine speed rotation to avoid critical speeds, or change the speed by varying the rigidity of the bearings. If the machine has to operate at a critical speed, the solution is to add external damping to the rotor. This property can be used in rotor dynamics, when it is necessary to reduce the amplitudes of vibration if the machine is at a critical speed. It is also necessary to have simplifying hypotheses that make the numerical model practical, without mischaracterizing its behavior.

a) *Handbook of Machine Foundations (1976)*

Another reference found in the technical literature on the theme available – Srinivasulu and Vaidyanathan (1976) – provides a simpler table of limit values of vibration amplitudes for different types of machine that will be used for the validation of the proposed models.

b) *Unbalanced Forces In Rotating Machinery*

According to Brasil and Silva (2013), for an unbalanced force rotating around an axis, the procedure to have this force acting in the vertical plane, pointing to "all" directions, is to apply this force in two orthogonal directions, one in the horizontal with phase t_0 equals zero, and one in the vertical direction with phase t_0 equals ¼ of the period of vibration of this unbalanced force. Thus, as time progresses, there is a variation of two forces so that the composition of them will be the unbalanced force, for one will be multiplied by *sin (ωt)* and the other by *sin (ωt + π/2)*, and while one is maximum, the other is null, and vice versa.

IV. Modelling of the Dynamic Load

The model consists of 2 motor-pump sets (electric motor and hydraulic pump) on a platform (steel frame), Figures 1 and 2, one with its axis oriented transversely to the frame and the second with its axis oriented longitudinally. According to the STRAP program, we are considering the transverse displacements as X3, longitudinal displacements as X1 and vertical displacements as X2.

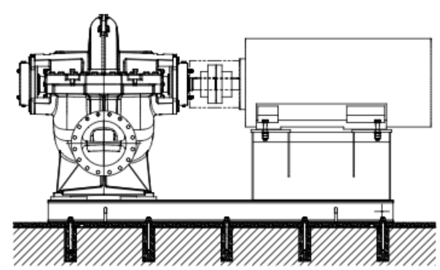


Fig. 1 : Motor-Pump set. Source: KSB Pumps

- Information about the Electrical Motor:

Total Mass: M_{Tm} = 9,448 kg

Quality of the unbalancing: Q = 2.5 mm/s

Operation frequency: f = 60 Hz

Information about the Pump KSB RDLO 350 575:

Total Mass: M_{Tb}= 2,600 kg

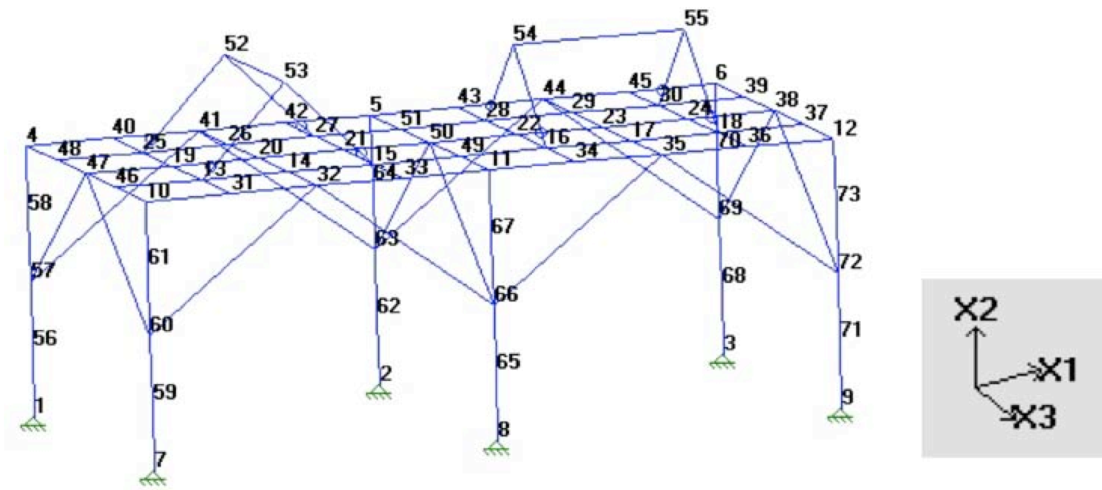
Information about the Structure:

Columns and Principal Beams: Section W410x38.8

Secondary Beams and Braced Frames: Section W380x44.5

Equipment: Rectangular geometric section with steel properties with the total weight of the set

Damping coefficient: 0,8%



Source: Author

Fig. 2 : Indication of the structure nodes

a) Initial Considerations – Application of Nodal Weights And Computational Models

The distribution of the masses of the pieces of equipment depends on the position of the gravity centers of the pieces of equipment, of the rotors, and on how these devices are laid on the structure. In the model, the total mass of each Motor-Pump Set is considered to be of 12,200 kg, whit the application showed in Table 1, and was fully applied on the supporting points of its axis. The mass of the structure was applied on its Nodes as Nodal Weights (the weight of the Sections is considered; however, it is not presented).

Table 1 : Application of Mass on the Nodes of the Motor-Pump Sets

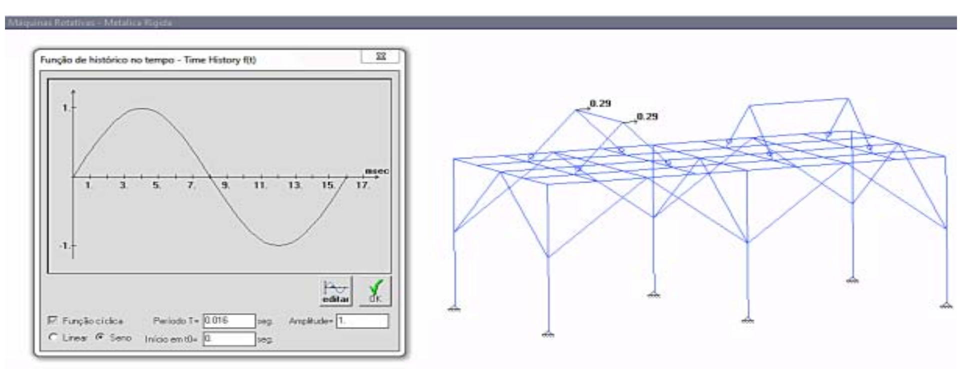
Set	Application point	Mass
CMB1	Node 52 e 53	12,200 kg
CMB2	Node 54 e 55	12,200 kg

Source: Author

b) Description of Dynamic Load – Calculation of the Equipment's Dynamic Forces

The unbalance of the motor-pump set generates a centrifugal force, which depends on the total mass of the set distributed in the two points of the axis, on the eccentricity between the center of gravity of the rotor and the geometric axis of rotation, and on the angular velocity of the set. In this studied was considered the dynamic loads applied to the nodes like the table 2 and showed at Figure 3.

$$F_T = M_{\frac{Cmb}{2}}.Q.\Omega = 6100.(0.0025).(60.2\pi) =$$
$$= 5749.11N \cong 0.58t$$



Source: Author

Fig. 3 : Dynamic Force 1 applied to the model

Table 2 : Dynamic Loads applied to the Nodes

Loads	Force - Nodes	Direction
CMB1-X1 - f=60Hz - T=0.016s - t0=0.00s	0,29 tf - 52/53	X1
CMB1-X2 - f=60Hz - T=0.016s - t0=0.004s	0,29 tf - 52/53	X2
CMB2-X3 - f=60Hz - T=0.016s - t0=0.00s	0,29 tf - 54/55	X3
CMB2-X2 - f=60Hz - T=0.016s - t0=0.004s	0,29 tf - 54/55	X2

Source: Author

V. Results and Discussion

a) Dynamic Analysis of the Structure

Having defined the two orthogonal loads (forces) for each piece of equipment, we combine them in the dynamic analysis module, so that the results are added instant by instant of time of each dynamic load, and never the maximum of them are added as separate loads. After the dynamic load applied into STRAP software, in the Module "Time History", we can view the maximum nodal amplitudes in continuous operation, with answers in the period from 10.0 to 10.1 seconds at nodes 52, 53, 54, and 55, thus verifying which structure has the best performance in the relation load/nodal displacement. It is noteworthy that the machine manufacturers have their limits of displacements, in general, based on the Handbook of Machine Foundations, by Srinivasulu and Vaidyanathan (1976). All amplitude values presented by STRAP software are showed in Table 3.

b) Analysis of the Amplitudes

According to the amplitudes, or displacements, showed in table 3, we observed that the displacement generated in the three models have a small variation between the structures and all within the permitted standards according to Handbook of Machine Foundations de SRINIVASULU e VAIDYANATHAN (1976).

Table 3 : Displacements in Strap Models

Displacements in Strap Models:	Displacements in X1 of combination 1 on Node 52 (mm)	Displacements in X2 of combination 1 on Node 52 (mm)	Displacements in X3 of combination 2 on Node 54 (mm)	Displacements in X2 of combination 2 on Node 54. (mm)
Dynamic analysis of model I – rigid connections:	0,0480	0,0031	0,0238	0,0029
Dynamic analysis of model II – semi-rigid connections:	0,0483	0,0031	0,0244	0,0029
Dynamic analysis of model III –pinned connections:	0,0507	0,0031	0,0253	0,0029

Source: Author.

In the displacement in X1 of combination 1 on node 52, the rigid structure had the best performance, semi-rigid structure second best performance and pinned structure had the worst performance.

In displacements in X2 of combination 1 on node 52, the rigid, pinned and semi-rigid structures had the best performance, equal in this case.

In displacements in X3 of combination 2 on node 54, the rigid structure had the best performance, semi-rigid structure second best performance and pinned structure had the worst performance.

In displacement in X2 of combination 2 on node 54, the rigid, pinned and semi-rigid structures had the best performance, equal in this case.

VI. Conclusion

The structural model studied has a well-sized rigidity. What was observed is that intuitively the use of fully rigid structures may be the best solution from the dynamic structural point of view. However, it was verified that in the three models all the amplitudes are in accordance with Handbook of Machine Foundations, by Srinivasulu and Vaidyanathan (1976), and according to other analysis conducted with STRAP, the results related to velocities – which are not presented in this work – are also in accordance standard Deutsche Norm – Vibrations in Buildings – Part 3: Effects on Structures: DIN 4150-3 (1999).

This article demonstrates that when there are well-founded theoretical basis and adequate computational tools the making of an effective and dynamic calculation of the equipment and structure can be simple and with more capacity of the structural engineer to recommend the best structure considering its connections. Then, considering the software STRAP, which is practical for use in research, the calculations of structural dynamics may be more reliable. Finally, the article is suggested as a reference for future calculations of supporting structures of rotating machinery, and as a suggestion we recommend the actual construction of the models.

VII. Acknowledgments

We thank the colleagues André and Humberto from SAE (Sistemas de AnáliseEstruturalLtda – Systems of Structural Analysis) for the license of the software STRAP 2012 in the period of this research. We also thank the colleagues from IFES for the unconditional support, and the institution for the financial support for the translation of the article. Finally, We thank the Master's Supervisors for the attention.

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Global Journal of Researches in Engineering: E
Civil And Structural Engineering
Volume 14 Issue 5 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Some Geotechnical Properties of Coal Fly Ash and Sand Mixtures with Different Ratio using in Highway & Embankments

By Dilip Kumar, Ashish Gupta & Neetesh Kumar
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Abstract- Fly ash is very effectively used in various civil engineering projects. Fly ash is a by-product of coal burning thermal power plants plant. The quantity of coal ash produced depends upon the quality of coal and the method of burning of the coal. In India less than 20% of ash is used in the manufacture of brick, cement, concrete and other product. Sand particles are much coarser than the fly ash. Here we are using different proportion as 100%S, 80%S+20%FA, 60%S+40%FA, 40%S+60%FA, 20%S+80%FA, 100% FA. Different test like Grain size analysis Specific gravity, Standard proctor test, Permeability test, direct shear test, California Bearing Ratio test were done on different proportions. MDD increases while dry density decreases as Sand increases. Permeability decreases as fly ash content increases. CBR value decreases for both soaked and unsoaked condition as fly ash content increases.

Keywords: *coal fly ash, sand, CBR value, permeability, shear strength.*

GJRE-E Classification : FOR Code: 290801, 290899

Some Geotechnical Properties of Coal Fly Ash and Sand Mixtures with Different Ratio using in Highway & Embankments

Dilip Kumar [α], Ashish Gupta [σ] & Neetesh Kumar [ρ]

Abstract- Fly ash is very effectively used in various civil engineering projects. Fly ash is a by-product of coal burning thermal power plants plant. The quantity of coal ash produced depends upon the quality of coal and the method of burning of the coal. In India less than 20% of ash is used in the manufacture of brick, cement, concrete and other product. Sand particles are much coarser than the fly ash. Here we are using different proportion as 100%S, 80%S+20%FA, 60%S+40%FA, 40%S+60%FA, 20%S+80%FA, 100% FA. Different test like Grain size analysis Specific gravity, Standard proctor test, Permeability test, direct shear test, California Bearing Ratio test were done on different proportions. MDD increases while dry density decreases as Sand increases. Permeability decreases as fly ash content increases. CBR value decreases for both soaked and unsoaked condition as fly ash content increases.

Keywords: coal fly ash, sand, CBR value, permeability, shear strength.

I. Introduction

Fly ash and Sand are very effectively used in various civil engineering projects. The quantity of ash produced depends upon the quality of coal and the method of burning of the coal. In India less than 20% of coal ash is used in the manufacture of brick, cement and other products. Coal fire power plants produce millions of tones of fly ash annually but only a small quantity is used. Consequently thermal power plant coal ash is "negative cost" material. Coal ash has many uses in civil engineering project. Sand is often angular sand and gravel size particles, are employed as aggregate in highway construction and icing control. The main disposal problem is with fly ash, the finer silt size fraction recovered from stack emissions. Fly ash is often a component in concrete mixtures, but it is also used in stabilized road and highway embankment, landfill linear and waste stabilizations.

Fly ash and Sand was collected from Rihandnagar Thermal Power Project (U.P.) and has been used in present investigation. The fly ash and Sand were mixed in different proportions and their physical, chemical and geo-technical characteristics were investigated. Fly ash and Sand fulfill the technical properties required for various use. However experimental inadequate awareness among the user at various levels has resulted in limited use of fly ash and Sand material as fill.

Environmentally safe disposal of large quantities of fly ash and Sand is not only tedious but also expensive. To reduce the problem of disposal of fly ash and Sand great efforts are being made to utilize fly ash and Sand. The properties of fly ash and Sand that is important for use in geotechnical engineering applications.

a) Fly Ash

Fly ash obtained from thermal power station is a by-product available in abundant quantity and ought to be converted into meaningful and useful products. Fly ash is nothing but the finely divided residue resulting from the combustion of powdered coal Fly ash is the by-product of coal combustion thermal power plant. Due to its pozzolonic nature it can be used effectively for variety of purpose.

Coal Fly ash obtained as the by-product from pulverized coal consists of predominantly small spherical particle, which differs in shape and size due to its difference in degree of pulverization of coal and efficiency of collecting system. One of the major factors hindering the utilization of fly ash has been an economic system for collection, handling and transportation of fly ash at thermal power station and facilitate for handling and storage at the user end and its economics.

Coal fly ash has been successfully used as highway road embankment fill material for highway construction projects in a number of different locations throughout the world. When compared with the conventional soil used as embankment.

b) Sand

Sand is a common type of soil, which is having very fine particle size. The physical properties of sand include-It is made of silica, quartz with traces of other substances like titanium It is usually having irregular particle shape. Particle size is usually very small, but not so small that it can pass through a sieve. It is a loose granular substance yellowish brown in colour found

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from the erosion of siliceous and other rocks and forming a major constituent of beaches, river beds, the seabed, and deserts The engineering properties make sand is an ideal material in design construction of dam and for other civil engineering applications. Sand also exhibits a relatively high permeability and grain size distribution that allows the design engineer to use it in direct contact with impervious material. Sand proved to be an economical material because it has demonstrated to have not only good engineering property but also to have constructability benefits.

c) Utilization of fly ash and Sand in India are

- Land Development
- Bricks
- Mine Filling
- Ash Dyke Raising Roads/Embankments
- Concrete
- Fill Matrix

II. Material Used

a) Fly Ash

For the present study the source of fly ash is Anpara Thermal Power Project, Anapara (U.P.). The total production of fly ash at Anpara Thermal Power Project is about 2.5 million tons per year.

Table 3 : Physical Characteristics of Rihandnagar fly ash

Color	Grey
Physical State	Powder with traces of unburnt carbon
Sp. Gravity	2.12
Particles size	-
Clay size particles % (<0.002mm)	2.30%
Silt size particles % (0.002-0.075 mm)	4.65%
Sand size particles % (0.075-4.75 mm)	93.05%

Data as supplied by Rihandnagar Thermal Power Plant Authority.

Table 4 : Chemical characteristics of Rihandnagar fly ash

Constituents	Percentage (by weight)
SiO_2	68.0
Al_2O_3	24.0
$Fe_2O_3 + Fe_3O_4$	2.18
TiO_2	2.64
CaO	1.49
MgO	0.06
SO_4^{--}	Nil
Loss on ignition	1.63

b) Sand

The Sand used in the study was locally available local sand.

Table 5 : Physical Characteristics of sand

Property	Values
Color	Light Yellow Brown
Specific Gravity	2.67
Particle size distribution	
Clay size particle % (< 0.002mm)	0.0%
Silt size particle % (0.002-0.075 mm)	2.5%
Sand size particle % (0.075-4.75 mm)	95.5%
Gravel size particle % (4.75-80 mm)	0.00
Fines	3.00
Liquid Limit	NP
Plastic Limit	NP
Proctor Compaction Test	
Optimum moisture content (OMC) (%)	32 .01
Maximum dry density (MDD) (g/cc)	1.081
Coefficient of Uniformity (C_u)	11.58
Coefficient of Curvature (Cc)	1.45
Angle of internal friction	34^0
Cohesion	0.20

III. Preparation of Fly Ash and Sand Mixture

The following procedure was adopted for preparation of fly ash and Sand mixtures in all tests. The materials were first dried for 24 hrs and brought to room temperature. Fly ash and Sand were then mixed together in the required proportions (by dry weight) in dry form. Different proportions of Rihandnagar fly ash and Sand and their mixed designation are given in table: 3.

Table 3 : Fly Ash and Sand Mix Designation

Mix Designation	% of Fly Ash + % Sand
0%FA+100% S	0% Fly Ash + 100% Sand
20% FA + 80% S	20% Fly Ash + 80% Sand
40% FA + 60% S	40% Fly Ash + 60% Sand
60% FA + 40% S	60% Fly Ash + 40% Sand
80% FA + 20% S	80% Fly Ash + 20% Sand
100% FA+0%S	100% Fly Ash+ 0% Sand

IV. Testing Programme

Since fly ash generate in huge quantity from thermal power plants. mainly work has been done on fly ash not on Sand so in the project we want to investigate that what is the effect of engineering property on mixing of fly ash and Sand in different proportions and how Sand can be safely used with fly ash in geotechnical applications and other civil engineering projects. So following testing is done on fly ash and Sand and its mixtures in different proportions.

- Grain size analysis
- Specific gravity
- Standard proctor test
- Permeability test
- Direct shear test
- California Bearing Ratio test

V. Results and Discussion

This investigation has been carried out to find the effect of fly ash and Sand mixture on optimum moisture content, maximum dry density, permeability, shear strength, particle size analysis and CBR values. In the present investigation fly ash and Sand has been taken from Rihandnagar Thermal Power Plant, Sonbhadra (U.P.) The results of these investigations have been presented in the form of tables and graphs in this chapter. Brief discussions on the laboratory test results are given below.

a) Characteristics of Mix Proportion

Table 5 : Different properties of Fly Ash, Sand and its Mix Proportions

Mix designation	MDD (g / cc)	OMC (%)	Coefficient of Permeability (cm/sec)	Cohesion (c) Kg/cm^2			Angle of shearing resistance (ϕ)	CBR Value (Unsoaked Condition) %	CBR Value (Soaked Condition) %
				Dry	Wet	Dry	Wet		
100% FA	1.40	18.56	5.570×10^{-4}	0.205	0.01	25.7^0	23.0^0	15.75	7.67
80% FA +20% S	1.342	20.90	6.115×10^{-4}	0.255	0.026	33.4°	32.0°	18.10	10.80
60% FA +40% S	1.296	23.12	6.60×10^{-4}	0.250	0.04	34.4°	31.5°	22.05	14.31
40% FA +60% S	1.223	25.96	7.10×10^{-4}	0.230	0.021	30.2°	29°.	24.21	17.42
20% FA +80% S	1.152	28.97	7.410×10^{-4}	0.220	0.005	31.7°	26.5°	27.11	20.69
100% S	1.081	32.01	7.68×10^{-4}	0.205	0.021	36.2°	34.0°	29.61	23.15

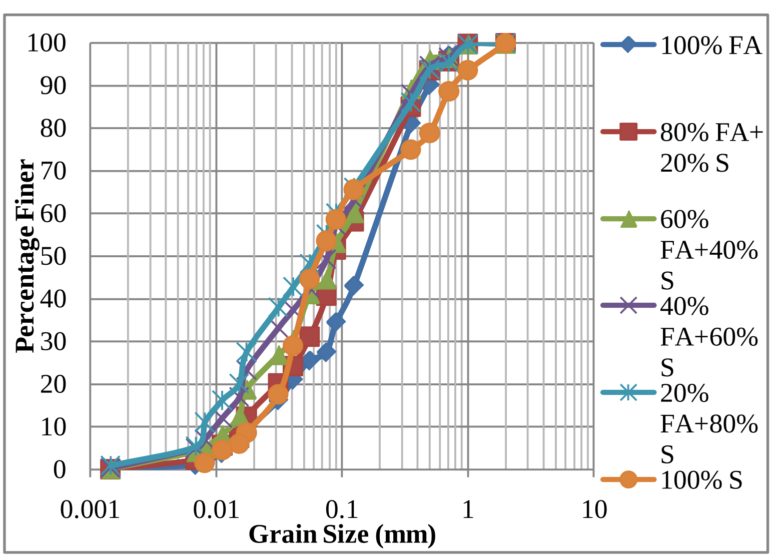

Fig. 1 : Grain Size distribution curve of Fly Ash and Sand mixtures

b) Specific Gravity

The specific gravity was found out for fly ash, Sand, and fly ash and Sand mixtures in different proportions and it is presented in Table 10. The specific gravity of fly ash is 2.15 and for Sand it is 2.27.

Table 10 : Specific Gravity for mixtures of Fly Ash and Sand

Mix designation	Specific Gravity
100% FA	2.10
80% FA + 20% S	2.20
60% FA + 40% S	2.37
40% FA + 60% S	2.45
20% FA + 80% S	2.58
100% S	2.66

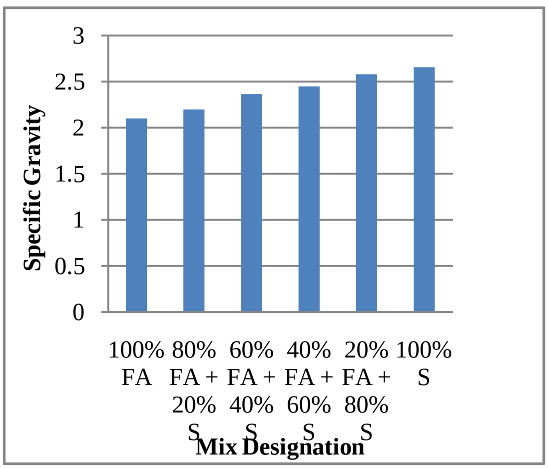

Fig. 2 : Specific gravity of fly ash and Sand mixtures

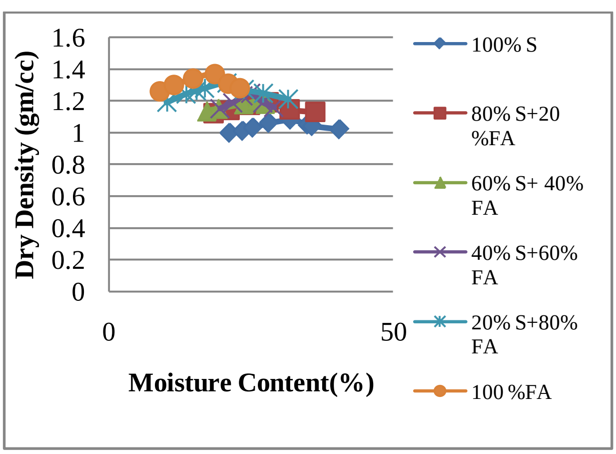

Fig. 3 : Compaction Curve of Fly Ash and Sand Mixtures

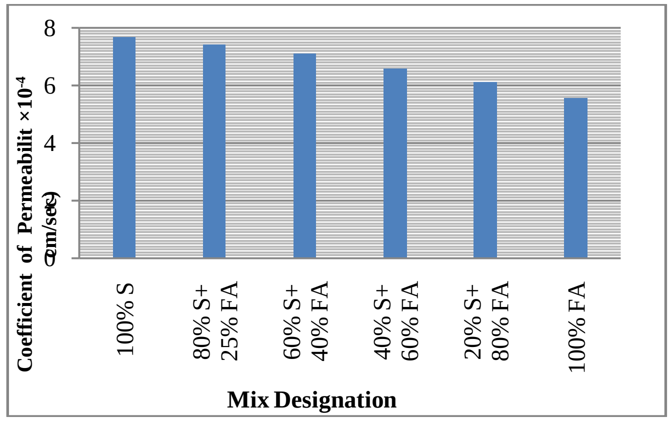

Fig. 4 : Coefficient of permeability of Fly Ash and Sand mixtures

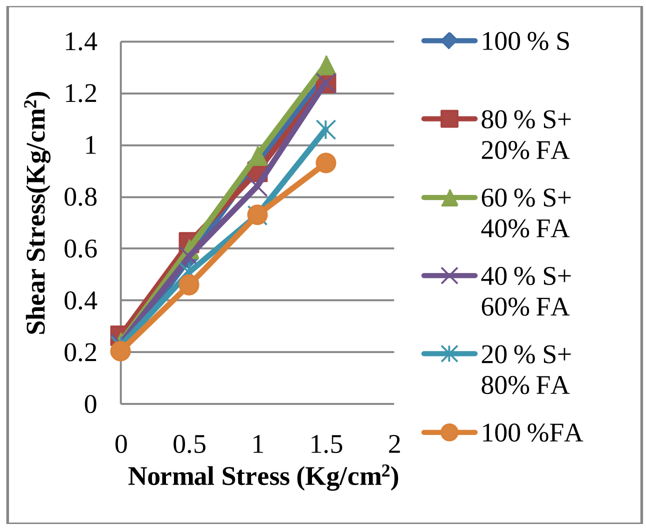

Fig. 5 : Direct shear test of Fly Ash and Sand Mixtures in Dry Condition

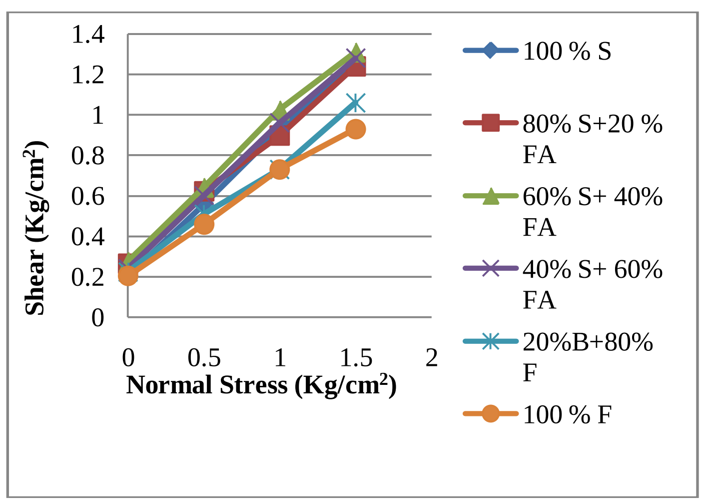

Fig. 6 : Direct shear test of Fly Ash and Sand Mixtures in Wet Condition

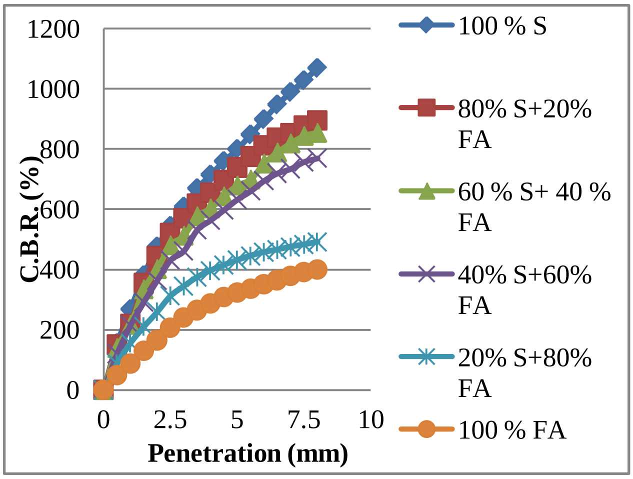

Fig. 7 : CBR value of Fly Ash and Sand Mixtures in Unsoaked Condition

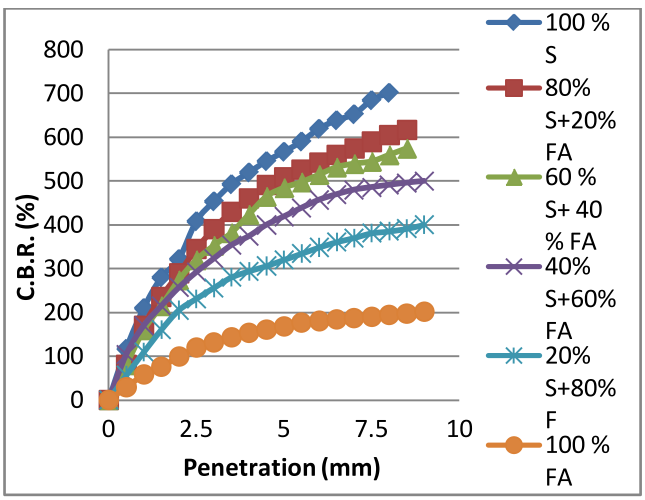

Fig. 8 : CBR value of Fly Ash and Sand Mixtures in Soaked Condition

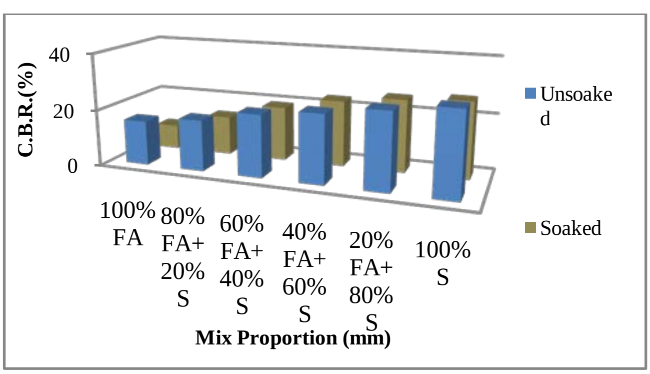

Fig. 9 : CBR value of mixtures of Fly Ash and Sand in soaked and Unsoaked Condition

VI. Conclusions

- Maximum dry density of fly ash and Sand mixture decreases with increasing Sand content while optimum moisture content increases.
- The permeability of compacted coal ash sand mixtures was found to decrease slightly with increasing fly ash content. This may be due to the increasing specific surface with increasing content of the fines, which creates more resistance to flow of water through voids between their particles. Overall range of the values was similar to that of a fine sands/ silts mixture or silts.
- Permeability of fly ash and Sand is 5.570 x 10^{-4} cm/sec and 7.68 x 10^{-4} cm/sec, as such fly ash and sand mixtures can be used as a filling material in core of dyke and mixtures of fly ash and Sand in different proportions can be used in highway embankment as a fill matrix.
- Shear strength parameter of fly ash and Sand shows a variation in cohesion from 0.01 to 0.021 kg/cm^2 and angle of internal friction from 23^o to 34^0 in wet condition it can be safely used in construction of embankment and also body of dyke for water disposal.
- Sand exhibits lower density as compared to fly ash but strength characteristics is better than fly ash under as compacted.
- In soaked condition the CBR value of fly ash and Sand is 7.67 % and 23.15% respectively. While in 80%S+20%FA, 60%S+40%FA, 40%S+60%FA, 20%S+80%FA proportions CBR is 20.69%, 17.42%, 14.31% and 10.80% respectively. The recorded value of CBR for sub-base is 7-20 %. Therefore fly ash and Sand mixtures can be used as sub-base of road construction as well as fill materials for highway embankments.
- Based on the results obtained in this investigation, it is found that high volume coal fly ash mixtures are suitable for use in highway embankment; if proper design and construction procedures are follow. The coal fly ash and Sand mixtures can provide fill materials and fill matrix of comparable strength to most soils typically used as fill materials, while having the advantage of smaller dry unit weights.
- Sand alone or in combination with fly ash at equal or similar proportion can be used as construction material in most geotechnical application where borrow soil is presently used, thus solving an important environmental hazardous problem of disposal of coal fly ash to great extent. Further, this will help reducing degradation of valuable land affected by dumping of unutilized coal ash produced and mining of soil for geotechnical construction.

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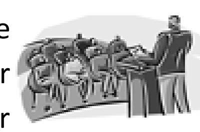

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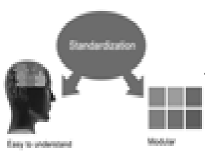

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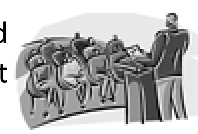

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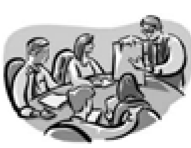

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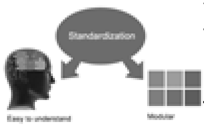

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"

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript’s Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9755861