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Investigation of Fatigue Characteristics of Pavement Quality Concrete Using Building Demolition Waste

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Abstract *:- The country is developing day by day and infrastructure play a very vital role in the development of country. As we know concrete is a main constituent of construction material and play major role in the safety of infrastructure.*

In the concrete Portland cement is used as a main ingredient. Therefore more use of Portland cement impact very badly on environment. So researcher focused on utilizing agriculture and industrial waste as a substituent of Portland cement. Many industrial wastes like blast furnace slag, fly ash and silica fume are used as a substituent cement material.

But nowadays agriculture waste is also a very big issue in our country so researcher looks into this matter and utilizing the sugar cane baggage ash as a cement material to reduce the load on cement and also minimize the pollution.

This paper contains preparation of sugarcane baggage ash as a replacement in cement with a percentage replacement of 5% 10% 20% 30% respectively.

Many industrial wastes like blast furnace slag, fly ash and silica fume are used as a substituent cement material. But nowadays agriculture waste is also a very big issue in our country so researcher looks into this matter and utilizing the sugar cane baggage ash as a cement material to reduce the load on cement and also minimize the pollution.The partial replacement of ordinary Portland cement however by agricultural waste or agro-waste has been seen as an alternative solution for decreasing CO2 emission due to less cement consumption for construction industry.

The residue after combustion presents a chemical composition dominates by silica. Sugarcane bagasse (SCB) is that the waste created after juice extraction from sugarcane. The Sugarcane bagasse ash (SCBA) is acquired through the control burning of sugarcane bagasse. The SCB creates the environmental nuisance thanks to direct disposal on the open lands and forms garbage heaps there in area. Besides SCBA, rice husk ash, palm kernel husk ash, fly ash, ground blast-furnace slag and silica fume have pozollonic properties that can be used in partial replacement of cement.

Key words: *- Sugarcane bagasse, Portland cement, industrial waste, furnace slag, fly ash, silica fume*

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I. INTRODUCTION

Silica fume, also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production. It is extremely fine with particles size less than 1 micron and with an average diameter of about 0.1 microns, about 100 times smaller than average cement particles. Its behaviour is related to the high content of amorphous silica (> 90%). The reduction of highpurity quartz to silicon at temperatures up to 2,000°C produces SiO_2 vapours, which oxidizes and condense in the low temperature zone to tiny particles consisting of non-crystalline silica. During the last three decades, great strides have been taken in improving the performance of concrete as a construction material. Particularly Silica Fume (SF) and fly ash individually or in combination are indispensable in production of high strength concrete for practical application. The use of silica fume as a pozzolana has increased worldwide attention over the recent years because when properly used it as certain percent, it can enhance various properties of concrete both in the fresh as well as in hardened states like cohesiveness, strength, permeability and durability. Silica fume concrete may be appropriate in places where high abrasion resistance and low permeability are of utmost importance or where very high cohesive mixes are required to avoid segregation and bleeding. The history of silica is relatively short, the first recorded testing of silica fume in Portland cement based concretes was conducted in 1952 and it was not until the early 1970‘s that concretes containing silica fume came into even limited use. The early work done in Norway received most of the attention, since it had shown that Portland cement-based-concretes containing silica fumes had very high strengths and low porosities. Since then the research and development of silica fume made it one of the world‘s most valuable and versatile admixtures forconcrete and cementious products.

OBJECTIVE OF THE STUDY

The objectives of the present study are as follows:

- To find the effect of partial replacement of Silica fume on the strength characteristics of concrete.
- Four percentage levels of replacement i.e. 5, 10, 15 and 20 percent are considered for partially replacing cement with silica fume. M20 concrete grade is initially designed without replacement and subsequently cement is partially replaced with silica fume and fly ash.
- To study the cost benefit analysis.
- To determine the carbon foot print of the concrete.

II. LITERATURE REVIEW

1. M. VijayaSekhar Reddy, I.V Ramana Reddy,

Studied the behavior of High Performance Concrete (HPC) which is being the most used type of concrete in the construction industry. They replaced cement with supplementary cementing materials like fly ash, silica fume, and metakaolin.

They concluded that there was a considerable increase in service life of the concrete structure and reduction in heat of hydration by using supplementary cementing materials in concrete. They observed the maximum and minimum percentage of reduction in strength of concrete when concrete was replaced with fly ash were 12.64% and 1.92%.

2. P. SrinivasRao .

Studied the durability characteristics of metakaolin blended concrete by adopting M20 Grade of concrete. An attempt was made with H_2so_4 and HCL. Steel fibres with 60 as aspect ratio at 0%,0.5%,1.0% and 1.5% of volume of concrete are used.

They concluded that the percentage weight loss was reduced and compressive strength was increased in the case of fibre reinforced concrete and concrete containing 10% metakaolin replaced by weight of cement when compared to concrete and the percentage weight loss was less when immersed in HCL and $H_2so_{4.}$

3. P. Murthi and V.siva Kumar

Studied the resistance of acid attack of ternary blended concrete by immersing the cubes for 32 Weeks in sulphuric acid and hydrochloric acid solutions. Binary blended concrete was developed using 20% class F fly ash and ternary blended concrete was developed using 20% fly ash and 8% silica fume by weight of cement.

They concluded that the ternary blended concrete was performing better that the ordinary plain concrete. They observed that the mass loss for 28 and 90 days of M20 PCC specimens were 19.6% and 16.1% respectively. They also observed that the time taken for reduction of 10% mass loss when immersed in 5% H_2SO_4 and 5% HCL solutions was 32 weeks.

4. A.K Al- Tamimi and M.sonebi

Studied the properties of self- compacting concrete when immersed in acidic solutions. Workability was obtained using slump cone test, L- box and orimet for SCC mix. Cylindrical specimen of diameter 45mm and length 90mm were casted and cured for 28 days in water after they were immersed in 1% HCL and 1% H_2so_4 solutions by maintaining a ph of 5 regurarly.

They concluded that self- compacting concrete was performing better than control concrete when exposed to 1% sulphuric acid and hydrochloric acid.

They observed that the time taken for 10% mass loss for SCC was 18 weeks and for CC was 6 weeks.

5. Madhusudhan Reddy

Studied the effect of HCL on blended cement and silica fume blended cement and their concretes. Concrete cubes were casted using deionised water with a series pf dosages implanted into water and using only deionized water for comparison. These cubes were tested for determining chloride ion permeability and compressive strength.

They concluded that compressive strength reduction of sugarcane ash blended concrete and silica fume blended concrete was 2 to 19% at 28 days and 90 days.

6. UroojMasood

Studied the behavior of mixed fibre reinforced concrete exposed to acids. A mixture 75% glass and 25% steel fibres were used in mixed fibre reinforced concrete and cubes were casted and cured for 30, 60, 90, 120 and 180 days in acids and sodium sulphate. Test specimen were tested for weight loss and denseness of concrete of exposed and unexposed specimen at all the ages and compressive strength at 180 days.

They concluded that resistance towards the sulphuric acid attack was maximum when 100% steel fibreswas used when compared to other fibres and without any fibres. Mixed fibre reinforced specimen and 100% steel fibre reinforced specimens exhibited more resistance towards the attack of sulphuric acid.

7. G. Siva Kumar

Studied on preparation of Bio-cement using sugarcane baggasse ash and its Hydration behavior.In this study they had used as partial replacement in ordinary Portland cement (OPC) by 10% weight. Compressive strength of the sample was carried out and reported that the cementious material in sugar cane bagasse ash is responsible for early hydration. The pozzolonic activity of bagasse ash results in formation of more amount of C-S-H gel which result in enhances the strength, and hence bagasse ash is a potential replacement material for cement.

8. H.S. Otuoze

Studied had investigated on “Characterization of Sugarcane Bagasse ash and ordinary Portland cement blends in Concrete”. The SCBA is obtained by burning sugar cane bagasse at between 600-700 degrees celcius, since the sum of sio2, Al2o3 and Fe2o3 is 74.44% For strength test, mix ratio of 1:2:4 was used and OPC was partially replaced with 0%, 5%, 10%, 15%, 20%,25%,30%,35%,40% by weight in concrete. Compressive strength values of hardended concrete were obtained at the of 7,14,21,28 days. Based on the test conducted, it can be concluded that SCBA is a good pozzolona for concrete cementation and partial blends of it with OPC could give good strength development and other engineering properties in concrete.

9. Lavanya

A experimental study on compressive strength of concrete by partial replacement of cement with sugarcane bagasse ash. The feasibility of using sugar cane bagasse ash, a finely grounded waste product from the sugarcane industry, as partial replacement for cement in conventional concrete is examined. The test were conducted as per BIS codes as evaluate the stability of SCBA for partial replacement up to 30% of cement with varying water cement ratio. They showed that addition of SCBA results in improvement of strength in all cases and according to the results obtained, it can be concluded that bagasse ash can increase the overall strength of concrete when used up to a 15% cement replacement level with W/C ratio of 0.35, bagasse ash is valuable pozzolonic material and it can potentially be used as a replacement for cement.

10. R. Srinivasan

Experimental study on Bagasse Ash in concrete. They had observed that sugar cane bagasse is fibrous waste-product of sugar refining industry, and causing serious environmental problem which mainly contain aluminium ion and silica. Hear bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%,5%,15%,25% by weight of cement in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken, as well as hardened concrete test like compressive strength. Spilt tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days were done. The results show that the SCBA in blended concrete had significantly higher compressive strength, tensile strength and flexural strength compare to that of the concrete without SCBA. It is found that cement could be advantangeously replaced with SCBA up to maximum limit of 10%. Partial replacement of cement by SCBA increases workability of fresh concrete.

11. U.R. Kawade

Effect of use of bagasse ash on strength of concrete. They had chemically and physically characterized and partial replaced in the ratio of 0%,10%,15%,20%,25%and 30% by weight of cement in concrete. The results show that the SCBA concrete had significantly higher compressive strength compared to that of the concrete without SCBA. It is found that the cement could be advantangeously replaced with SCBA content was achieved with 15% replacement.

12. Padney, Singh, Sharma, &Tiwari,

Calcium hydroxide ($Ca(OH)_2$) which is one of the hydration products of Portland cement and greatly contributes toward the deterioration of cement composites. However, when a pozzolan is blended with Portland cement, it reacts with the lime to produce additional calcium-silicate-hydrate, which is the main cementing compound.

The pozzolanic material therefore reduces the quantity of lime and increases the quantity of calcium-silicate-hydrate which enhanced the cementing quality, when the pozzolan is blended in suitable quantity with Portland cement.

13. Srinwasan&Sathiya,

According to cement could be advantageously replaced with sugarcane bagasse ash up to maximum limit of 10%. also used sugar cane bagasse ash to substitute cement between 0-30% to produce concrete, the findings of their study shows that it is possible to substitute cement with sugarcane bagasse ash up to 20% in concrete without hurting its resistance. investigated the effects of fine bagasse ash on the workability and compressive strength of mortars and concrete and found that the appropriate proportion of clinker replaced by fine sugarcane bagasse ash was 20%, which the highest compressive strength comparing to all ratios between 0-40% of resultant cements and near that of commercial cement.utilised sugarcane bagasse ash as pozzolanic material in concrete and observed that sugarcane bagasse ash can improve the workability, compressive strength and durability of concrete.

14. Apiwaranuwat, Kitratporn, Chuangcham andPunmatharith

looked at the use of sugarcane bagasse ash as a raw material in the production of autoclave light weight concrete and observed that the optimal production conditions for sugarcane bagasse ash containing autoclave light weight concrete were a cement/sand ratio of 65/36, a water/total composition ratio of 0.24, and a curing time of 16 hours.

15. Muthusamy&Kamaruzaman,

Studied that replacing 10% coarse aggregate with laterite soil can produce laterised concrete exhibiting comparable strength with normal concrete. They also added that replacement of laterite aggregate up to 30% is able to produce laterised concrete exhibiting the targeted strength of 30 MPa.

2.3 GAP AREA

Several studies have experiment in various directions on percentage variation of sugarcane ash on various grades. Any of them not experiment on M35 grade of concrete by partial replacement of sugarcane ash.
Boundary of studies is on stages.

1. Through out of study the grade of concrete is not above on M30 grade of concrete.
2. The effect of sugarcane ash with fly ash on some extent.

III. MATERIALS AND METHODOLGY

The required strength or target strength of concrete can be obtained by careful selection of ingredients, correct grading of ingredients, accurate water measurements and adopting a good workmanship in mixing, transporting, placing, compacting, finishing and curing of concrete in the construction work. When a binding material (cement),fine aggregate (sand),coarse aggregate(such as crushed stone, broken bricks, etc.) and water are mixed together in suitable proportions, they form an easily workable mix known as plastic, wet or green concrete. When this plastic concrete becomes hard like a stones, this is termed as hardened concrete or simply as a concrete The properties of material used for making the concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, fine aggregates, water and silica fume. The aim of studying of various properties of materials is used to check the appearance with codal requirements and to enable an engineer to design a concrete mix for a particular strength. The description of various materials which were used in this study is given below: Ordinary Portland cement Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. The function of cement is first of all

to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone , modern equipments, maitaining better particle size distribution, finer grinding and better packing. Although they are little costlier than low grade cement , they offer 10-20% saving in cement consumption and also they offer many hidden benefits . One of the most important benefits is the faster rate of development of strength.

Aggregate Aggregates constitute the bulk of a concrete mixture and give dimensional stability to concrete. To increase the density of resulting mix, the aggregates are frequently used in two or more sizes. The most important function of the fine aggregate is to assist in producing workability and uniformity in the mixture. The fine aggregate assists the cement paste to hold the coarse aggregate in suspension. This action promotes plasticity in the mixture and prevents the possible segregation of paste and coarse aggregate, particularly when it is necessary to transport the concrete some distance from the mixing plant to placement. The aggregates provide about 75% of the body of the concrete and hence its influence is extremely important. They should therefore meet certain requirements if the concrete is to be workable, strong, durable and economical. The aggregates must be proper shape, clean, hard, strong and well graded. Cement

Cement is considered as the best binding material and is being commonly used as a binding material in the construction of various engineering structures these days. Since it sets quickly and provides sufficient strength to heavy and important structures, it is considered as one of the leading enggineering material of modern times. Product

obtained by burning and crushing in powder form, either stone containing 20 to 40% clay and remaining carbonate of lime or an intimate mixture of well proportioned calcareous and argullaceous materials is called natural cement. Natural cement is not as strong as artificial cement. Natural cement is rarely manufactured and used in India.

IV. EXPERIMENTAL INVESTIGAITON

In the present experimental investigation sugar cane bagasse ash has been used as partial replacement of cement in concrete mixes. On replacing cement with different weight percentage of SCBA the compressive strength is studied at different ages of concrete cured in different environments like normal water and HCL diluted solution. The details of experimental investigations are as follows

MIXING

Mixing of ingredients is done in pan mixer of capacity 40 liters. The cementations materials are thoroughly blended and then the aggregate is added and mixed followed by gradual addition of water and mixing. Wet mixing is done until a mixture of uniform color and consistency are achieved which is then ready for casting. Before casting the specimens, workability of the mixes was found by compaction factor test.

Compressive strength test

The most significant test for determining the engineering quality of bricks is their compressive strength. The test was carried out according to IS 3495(Part 1)-1992. At 3, 7, 14, 28, and 54 days after curing, all prepared brick specimens for series A, B, C, and D blends were tested for compressive strength. Due to a lack of time, the 54-day compressive strength test for series E blends was not conducted. At each test age, a minimum of three samples were tested. This test was carried out utilising an automatic Compression Testing Machine (CTM) with a capacity of 5000kN, and a constant progressive load of 0.6 kN/sec was applied (Figure 5.1). The ratio of ultimate failure load to the area of sample perpendicular to the direction of load application was used to compute compressive strength (MPa).

Soundness Test of Brick

Soundness test on bricks is carried out to determine the nature of bricks when subjected to sudden impact. It is a simple test in which two bricks are taken randomly from the stack of bricks. The bricks are then struck against each other. If it emits clear metallic ringing sound; the brick is of good quality.

Shape and Size Test on Brick

To maintain the uniformity in the construction, the bricks must be of proper shape and uniform size. A good brick must have a proper rectangular shape with sharp edges. For this test, about 20 bricks from the stacked bricks are taken. The samples taken are then stacked along the length, breadth and height and duly compared. If all the bricks are of similar size, then they can be used in construction works.

Efflorescence test

As water evaporates, efflorescence forms a fine, white, powdery layer of water-soluble salts on the surface of bricks. This test was carried out according to the IS 3495 (Part 3):1992 requirements. One end of the specimen was immersed in water for this test. 2.5 cm is the depth of immersion in water. The specimen was then placed in a warm (20-30°C) and well-ventilated room until it absorbed all of the water and the excess water evaporated. The arrangement was covered with glass to prevent excessive evaporation

V. RESULTS AND CONCLUSION

This chapter deals with the presentation of results obtained from various tests conducted on concrete specimens cast with and without silica fume is shown here. The main objective of the research program was to understand the strength and durability aspects of concrete obtained using silica fume as partial replacement for cement. In order to achieve the objectives of present study, an experimental program was planned to investigate the effect of silica fume on compressive strength and split tensile strength concrete. The experimental program consists of casting, curing and testing of controlled and silica fume concrete specimen at different ages.

Water absorption test

The fundamental aspect impacting the durability of bricks is water absorption. The less water that gets into the brick, the more durable it is, and the more natural environment resistance it will have. As a result, the internal structure of brick should be solid enough to prevent water entry. The bulk density of brick is defined as the weight of the brick divided by its volume. IS 3495 (Part 2):1992, often known as the 24-hour immersion cold water test, was used to conduct the water absorption test. This test was carried out by placing the specimen in a laboratory oven for 24 hours at a temperature of 100 5°C until it reached a basically constant mass. At a temperature of 27 2°C, the specimen from the oven was immersed in water for 24 hours.

Compressive strength test

For all ages, compressive strength falls as the fraction of stone dust replaced with pond ash increases. The total replacement of stone dust from the foundation mix (fly ash-stone dust-lime-gypsum) leads in a 50% drop in compressive strength at the age of 56 days, as illustrated in Figure 5.3, with the goal of using pond ash instead of stone dust. It's similar to pond ash in that it's permeable and finer than stone dust. Furthermore, stone dust is a powerful material that serves as aggregates in the brick system and might cause voids if replaced alone. It could also be explained by the fact that the system's initial porosity grew from 3.29 percent to 14.26 percent. It's worth noting that the compressive strength has increased significantly from 28 to 56 days.

Efflorescence test

The efflorescence results were really satisfying and encouraging. For series A, B, C, and E, the bricks created in this investigation showed no efflorescence. Because the white or grey deposits were less than 10%, slight efflorescence was noticed in series D brick specimens.

Summary

The study looked into ways to use various hazardous and non-hazardous industrial wastes in the production of non-structural, unfired bricks in a safe and profitable way. Paper sludge, pond ash, and other novel raw materials were offered to the brick business. a method for examining/selecting or formulating an effective feed mixture incorporating a new solid-waste material for making unfired bricks using coal cinder and marble dust for brick manufacturingInitially, physical and chemical parameters such as specific gravity, loss on ignition, and water absorption were used to classify all of the collected industrial waste. Blaine's air permeability equipment was used to determine the specific surface area. Following successful characterisation, the proportions of several mixes for casting specimens were determined.

5.1 GENERAL

The result of experimental practices and analysis are presented in this chapter section 5.2 provides the result of compressive strength of M35 grade of concrete after partial replacement of cement with SCRB at various percentage and about effect of HCL on compressive strength.

5.2 CONCLUDING REMARKS

The experimental test conducted on the cube (150×150×150 mm), results are obtained as following.

1. Compressive strength of concrete cube with 0% SCBA for 7 days has been obtained as 35 MPa.
2. Compressive strength of concrete cube with 0% SCBA for 14 days has been obtained as 44MPa.
3. Compressive strength of concrete cube with 0% SCBA for 28 days has been obtained as 52.39MPa.
4. Compressive strength of concrete cube with 5% SCBA for 7 days has been obtained as 38MPa.
5. Compressive strength of concrete cube with 5% SCBA for 14 days has been obtained as 47.6MPa.
6. Compressive strength of concrete cube with 5% SCBA for 28 days has been obtained as 48.6MPa.
7. Compressive strength of concrete cube with 10% SCBA for 7 days has been obtained as 38.5MPa.
8. Compressive strength of concrete cube with 10% SCBA for 14 days has been obtained as 52.4MPa.
9. Compressive strength of concrete cube with 10% SCBA for 28 days has been obtained as 54.5MPa.
10. Compressive strength of concrete cube with 15% SCBA for 7 days has been obtained as 36.5MPa.
11. Compressive strength of concrete cube with 15% SCBA for 14 days has been obtained as 47.6MPa.
12. Compressive strength of concrete cube with 15% SCBA for 28 days has been obtained as 51.65MPa.
13. Compressive strength of concrete cube with20% SCBA for 7 days has been obtained as 32.64MPa.
14. Compressive strength of concrete cube with 20% SCBA for 14 days has been obtained as 43.82MPa.
15. Compressive strength of concrete cube with 20% SCBA for 28 days has been obtained as 46.5MPa.
16. Compressive strength of concrete cube with 25% SCBA for 7 days has been obtained as 33.85MPa.
17. Compressive strength of concrete cube with 25% SCBA for 14 days has been obtained as 44.65MPa.
18. Compressive strength of concrete cube with 25% SCBA for 28 days has been obtained as 41.3MPa.

Series	Mix ID	Water absorption (%)
A	PA-0% (BM)	15.4%
	PA-12.5%	16.1%
	PA-25%	18.2%
	PA-37.5%	19.1%
	PA-50% (RM)	19.8%

VI. CONCLUSION

The experimental study seen that the compressive strength of concrete increases with help of SCBA, if use in partially replacement of cement in concrete, after that the compressive strength gets decreases it's also seen that use of HCL for curing of cube in place of normal water is also helpful in the enhancement of compressive strength. Following conclusion is summarized as per experimental study.

1. By increasing the percentage of SCBA in mix design there is gradual decreases of compressive strength for 7 days.
2. After 14 days compressive strength of cube is increases for a certain percentage.
3. Maximum compressive get by the experiment is at 28 days after the replacement of 10% cement with SCBA.
4. Compressive strength is reduced very low acid attack after cured of 28 days.

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