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Review Paper on Effect of Fly-Ash and Rice Husk Ash on Strength Characteristics of Pavement Quality Concrete

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ABTRACT

There is growing interest in the construction of concrete pavements, due to its high strength, durability, better serviceability and overall economy in the long run.

The thrust nowadays is to produce thinner and green pavement sections of better quality, which can carry the heavy loads. High strength concrete is a type of concrete that have characteristic compressive strength greater than 40MPa, also which is made of hydraulic cements and contains fine and coarse aggregates; The present study aims at, developing pavement quality concrete mixtures incorporating fly ash and rice husk ash partial replacement of cement. The aim of this dissertation is to design a slab thickness of Pavement Quality Concrete pavement using the achieved flexural strength of the concrete mixtures. In this study, compressive and flexural strength for pavement quality concrete mixtures for different percentage replacement of cement are reported. It is found in the study that it is possible to achieve savings in cement requirements by replacing it with fly ash.

Keywords:. Fly ash and rice husk ash, High strength concrete, cements, coarse aggregates; pavements,

I INTRODUCTION

A homogenous mixture of binder, a sticky paste, and matrix, which provides the material volume, are the two basic constituents of concrete. Here, the matrix is made up of the appropriate amounts of fine and coarse particles, and the binder is a paste made of cement and water. Water, cement, and additional cementitious or cementing agents are the ingredients that make up the paste. It turns the aggregates—gravel and sand or broken stone—into a rock-like material. To fill in the gaps, the plan is to use sturdy, solid materials. The fine aggregates fill in the spaces left by the coarse aggregates, while cement fills in the spaces left by the fine aggregates. The less voids there were, the stronger the concrete would be. The chemical reaction that takes place when cementitious materials and water come into contact is known as hydration. During this process, paste binds and hardens the aggregates.When compared to the compatibility of other road materials, concrete has the highest modulus of elasticity and stiffness; this results in a reasonable degree of flexural or beam strength for concrete pavement. This characteristic leads to a wider distribution of wheel loads delivered externally. As a result, the sub-grade is under less stress. The concrete layer is the only material that can withstand most of the load. The primary parameters influencing the thickness of the concrete slab are the quantity of wheel or axle loads and the characteristic flexural strength of the proposed concrete. Sub-bases have a minor structural role in stiff pavements.Contrarily, a flexible pavement is a layered structure consisting of multiple layers of bound or unbound materials that may be subjected to various surface treatments to lessen the severity of traffic stress as it falls. The base and sub-base layers of flexible pavements both significantly influence the structural properties of the pavement. Concrete performs more like a bridge over the subgrade. There is significantly less strain on the material beneath the concrete than there is on bituminous pavements. Concrete has been extensively employed for paving roadways, airports, and commercial and residential streets since the first concrete pavement strip was completed in 1893.

CONCRETE PAVEMENTS

A concrete pavement is a structure comprising of a layer of Ordinary Portland Cement Concrete which is usually supported by a sub-base layer on the sub-grade. Depending upon the designer’s preferences of shrinkage crack control technique, rigid pavements can either be unreinforced (plain) or reinforced.

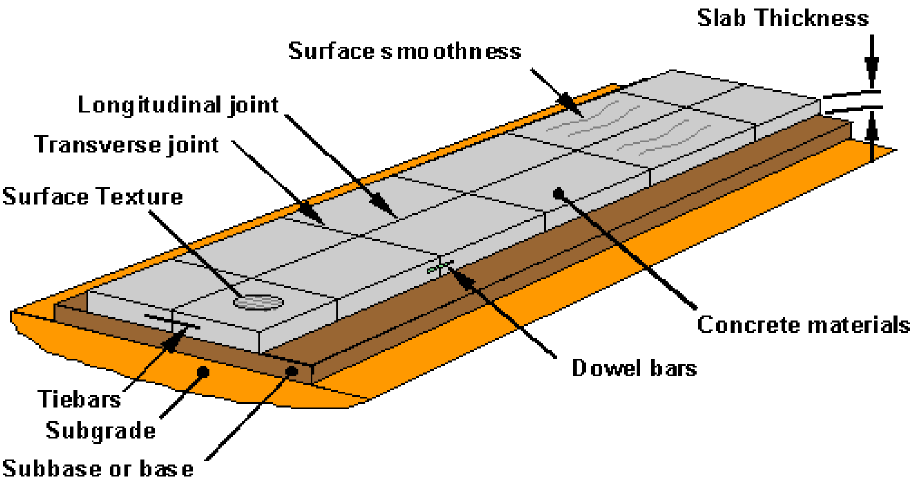

Figure 1 Concrete Road Pavement Structure

Types of Concrete Pavements

1) Jointed Plain (unreinforced) Concrete Pavement – JPCP
2) Jointed Reinforced Concrete Pavement – JRCP
3) Continuously Reinforced Concrete Pavement – CRCP
4) Steel Fiber Reinforced Concrete Pavement – SFCP

II. LITERATURE REVIEW

The relevant literature pertaining to the use of Fly-Ash(FA) and Rice Husk Ash(RHA) in concrete carried out in India and abroad has been reviewed and presented as under:-

FLY-ASH

Fresh Properties:

Low calcium Class F fly ash normally acts as a fine aggregate of spherical form in early stages of hydration whereas high calcium Class-C fly ash may contribute to the early cementing reactions in addition to its presence as fine particulate in the concrete mix. Hydration of cement is an exothermic reaction and the released heat causes a rise of temperature of fresh concrete.

Brown, J.H. (1982) conducted studies on fly ash substitution in concrete, replacing cement and fine aggregate at levels of 10-40% by volume. He observed that each 10% ash substitution for cement resulted in a change in the compacting factor similar to increasing the water content by 3-4%. When fly ash substituted for sand or total aggregate, workability increased to a maximum value at about 8% ash by volume of aggregate, beyond which workability rapidly decreased.

Gebler and Klieger (1983) investigated the air void stability of concrete with Class-C and Class-F fly ashes. They reported that concretes with Class C fly ash generally required less Air Entraining Agent (AEA) than those with Class F fly ashes. The study also highlighted the influence of total alkalies and SO3 contents in fly ash on air entrainment.

Owens (1989) reported increased water demand when using fly ash with a large fraction of particles coarser than 45µm or high unburned carbon content.

Sivasundram et al. (1990) studied the setting time of high-volume fly ash concrete mixes, finding that the initial setting time was comparable to control concrete, while the final setting time was extended by about 3 hours.

Carette and Malhotra (1983) studied the effect of Canadian fly ashes on compressive strength, showing that compressive strength continued to increase with age, indicating pozzolanic action.

Joshi and Lohtia (1993) tested fly ash concrete mixes, reporting that, at 7 days, the fly ash concretes obtained strength between 27.9 and 41.0 MPa compared to 44.1 MPa for control concrete. At 28 days, the strength ranged from 37.6 to 50.7 MPa against 58.7 MPa for control concrete.

Lohtia et al. (1996) studied the creep of fly ash concrete, finding that replacement of 15% of cement with fly ash was optimum for strength, elasticity, shrinkage, and creep. Creep coefficients were similar for fly ash content in the range of 0–25%.

Saraswathy et al. (2003) investigated the influence of activated fly ash on concrete strength, concluding that activation of fly ash improved concrete strength, with chemical activation showing positive effects.

Siddique (2003) studied the effect of fine aggregate replacement with Class F fly ash on concrete properties, reporting higher compressive, splitting tensile, and flexural strengths with fly ash replacements at all ages.

Atis et al. (2004) assessed the drying shrinkage of mortar mixtures containing high calcium non-standard fly ash, noting a reduction in shrinkage with the use of fly ash.

Demirboga et al. (2007) investigated the thermal conductivity of high-volume fly ash (HVFA) concrete, finding a decrease in thermal conductivity with increasing fly ash content.

Durability Properties:

In the study by Ho and Lewis (1983), titled "Carbonation of concrete incorporating fly ash or a chemical admixture," three types of concrete mixes were investigated: plain concrete, concrete containing a water-reducing admixture, and concrete in which fly ash replaced part of the cement. Accelerated carbonation was induced by storing specimens in an enriched CO2 atmosphere. The study concluded that concretes with the same strength and water-to-cement ratio do not necessarily carbonate at the same rate. Concrete containing fly ash exhibited significant improvement in quality with extended curing, especially when curing was extended from 7 to 90 days.

Virtanen (1983), in "Freeze–thaw resistance of concrete containing blast furnace slag, fly ash or condensed silica fume," found that air content has the greatest influence on the freeze–thaw resistance of concrete. The addition of fly ash had no major influence on freeze–thaw resistance if the strength and air content were kept constant.

Naik et al. (1994) explored the permeability of concrete containing large amounts of fly ash. They observed that chloride permeability decreased with age. The 50% fly ash concrete mixture showed lower permeability compared to the no-fly ash concrete, and the 70% fly ash mixture performed better than the no-fly ash concrete after 3 months.

Mehta (2000) concluded in his paper "Sulfate Attack on Concrete" that fly ashes, especially Class F type, significantly increase the life expectancy of concrete exposed to sulfate attack. However, the situation with Class C fly ash differs, as some studies indicated that it might reduce sulfate resistance.

Siddique (2003), in "Effect of fine aggregate replacement with Class F fly ash on the abrasion resistance of concrete," studied abrasion resistance with various levels of fly ash replacement. The results showed that as the fly ash content increased, the depth of wear decreased, indicating improved abrasion resistance, attributed to increased compressive strength with age.

Chalee et al. (2007) investigated the effect of water-to-cement ratio on the covering depth required against steel corrosion in fly ash concrete exposed to a marine environment. They found that fly ash concrete with 35% and 50% replacements provided good corrosion resistance, and a lower water-to-cement ratio reduced the covering depth required for initial corrosion.

Moving on to Rice Husk Ash (RHA), Zhang and Malhotra (1996) studied its influence on air-entraining admixture (AEA) requirements and found that AEA requirement increased with higher RHA content. Bui et al. (2005) investigated the workability of concrete with different water-to-binder ratios and RHA replacements, observing a decline in slump with increasing RHA content.

Ganesan et al. (2008) reported that the consistency of RHA-blended cement increased with RHA content, and the standard consistency with 35% RHA content was higher than that of control OPC. Khani et al. (2009) found that water penetration depth decreased significantly with increasing RHA content and curing period.

Givi et al. (2010) assessed the workability of RHA-blended concrete and observed acceptable workability with high slump values for all investigated RHA-blended mixtures.

Habeeb et al. (2010) investigated the workability, fresh density, and superplasticizer content of RHA concrete and found that finer RHA resulted in denser concrete and increased superplasticizer content to maintain workability.

Uduweriya et al. (2010) studied the compressive strength of concrete containing RHA and found a considerable reduction in surface water absorption in RHA concrete.

Tashima et al. (2010) evaluated the influence of different RHA contents on physical and mechanical properties, including surface water absorption, and found that higher RHA content resulted in lower water absorption.

Nagrale et al. (2012) studied the workability of concrete with 15% RHA replacement and found a decrease in slump, indicating a less workable mix.

In terms of hardened properties, Zhang et al. (1996) reported that RHA concrete had somewhat higher compressive strength than control concrete up to 180 days. Bui et al. (2004) observed that RHA-blended concrete had higher compressive strength than plain cement concrete, and the effect was more pronounced at later ages.

Khani et al. (2009) found that RHA concrete had higher compressive and splitting tensile strengths at various ages compared to control concrete.

Rukzon et al. (2010) reported that the compressive strength of mortar containing RHA was influenced by the fineness of RHA, with finer RHA resulting in higher strength.

Habeeb et al. (2010) investigated the compressive strength of RHA concrete and observed that finer RHA concrete exhibited higher strength than coarser RHA concrete at 28 days.

Givi et al. (2010) found that RHA-blended concrete had higher compressive strength at 90 days compared to concrete without RHA.

Uduweriya et al. (2010) observed a significant increment in tensile strength in concrete containing RHA, with the maximum tensile strength achieved with 20% replacement.

Kishore et al. (2011) studied the compressive strength of high-strength concrete with different levels of RHA replacement and found a decrease in splitting tensile strength with increasing replacement.

In summary, the research on fly ash and rice husk ash reveals their positive impact on various properties of concrete, such as compressive strength, freeze–thaw resistance, and sulfate resistance. The effects are influenced by factors like curing duration, replacement levels, and specific ash characteristics.

Table 1 Compressive Strength of M50 Grade Rice Husk Ash Concrete. (Kishore et al., 2011)

	Compressive strength (MPa) of M50		
Rice husk ash	**7 days**	**28 days**	**90 days**
0	48.31	59.37	62.50
5	42.00	56.40	58.36
10	38.40	53.43	56.40
15	37.37	50.46	52.50

It shows that the splitting tensile strength at 15% replacement decreased by 5.1% for M40 grade of concrete and 9.1% for M50 grade of concrete, when compared with that of the conventional concrete. Maximum value is obtained by M50 grade concrete with 5% replacement. The compressive strength at 7, 28 and 56 days have been obtained. Replacement of cement with Rice Husk Ash leads to decrease in the compressive strength for both M40 and M50 mixes. He observed that for both grade of concretes the flexural strengths were decreased at 15% replacement of rice husk ash with cement, but obtained target strength at 10% replacement.

Khan et al. (2012) in their paper " Reduction in environmental problems using rice-husk ash in concrete " studied the flexural strength of RHAC. Test was carried out on RHAC concrete beams containing 0%, 25%, 30% and 40% of RHA as a replacement of OPC All the concrete beams were cast in 1:2:4 mixture design ratio of Cement: sand: coarse aggregate, respectively. A midpoint loading was applied. The load taken by pure OPC concrete beams was greater than the RHAC concrete beams both at first crack development and failure. The deflection at mid span decreased with the increase of RHA content in RHAC concrete beams both at first crack development and at failure. For 25% RHAC concrete beam the mid span deflection at failure load is 32 mm as compared to 38 mm for OPC concrete beam. For 25% OPC replacement with RHA, the beam performed very well in flexure. The failure load for 25% RHAC is 51 KN which is quite close to 54 KN for OPC concrete beam.

Tashima et al. (2012) in their paper " The Possibility Of Adding The Rice Husk Ash (RHA) To The Concrete " evaluates how different contents of rice husk ash (RHA) added to concrete may influence its physical and mechanical properties like splitting tensile strength. Samples with dimensions of 10 X 20 cm were tested, with 5% e 10% of RHA, replacing in mass the cement. Three mixtures were made i.e. Mixture D (controlled mix) , Mixture E (5% replacement) , Mixture F (10% replacement). All the replacement degrees of RHA researched, achieve similar results in splitting tensile strength. According to the results, may be realized that there is no interference of adding RHA in the splitting tensile strength. There is slight increase in the split tensile strength if compared to controlled mix. The addition of RHA causes an increment in the compressive strength due to the capacity of the pozzolan, of fixing the calcium hydroxide, generated during the reactions of hydrate of cement. All the replacement degrees of RHA increased the compressive strength. For a 5% of RHA, 25% of increment is verified when compared with mixture D.

III. CONCLUSION

Fly ash and Rice husk ash is found to be better-quality to other supplementary materials like slag, and silica fume. RHA used in this study is efficient as a pozzolanic material; it is reach in amorphous silica. Due to less specific gravity of RHA which leads to reduction in mass per unit volume, thus adding it reduces the dead load on the structure and it helps in reducing the environment pollution during the disposal of excess Fly ash and Rice husk ash. Cement is costly material, so the partial replacements of these materials by Rice husk ash and Fly Ash reduces the cost of concrete,

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