ABSTRACT

Rice straw is an agricultural by-product of paddy cultivation whose production is highest among the agro-residues produced in India. Due to high cost involved in the collection of rice straw and in the absence of alternate uses (in countries like India, Indonesia and China), most of the farmers treat it as waste material and resort to field burning even when it is banned by the government of these countries. The open-air burning of rice straw leads to emission of a greenhouse gas like CO_2. However, researchers say that emission of CO_2 due to the burning of rice straw is not taken into consideration for calculating the net amount of greenhouse gases which affects the atmosphere, based on the hypothesis that the CO_2 will be absorbed again by the rice plants during the next cultivation.

The present investigation is about utilizing rice straw ash (RSA) produced from open-air burning of rice straw at a temperature of 290 ± 5 ^{0}C into the production of pavement quality concrete (PQC) for use in rigid pavements. The probable benefit accrued out of such an initiative would lead to economisation of the rigid pavements, which is about 50% costlier than the conventional bituminous pavements.

Past works state that, open-air burnt RSA has around 80% silica content which is at par with that of an established pozzolan such as microsilica (MS). While MS has been studied extensively in the past, there was a need to explore the potential of RSA for part replacement of OPC in PQC. With this objective in view, the present study explores the level of part replacement of OPC that may be possible by admixing RSA and MS on an individual basis and also in combination for short term (3, 7 and 28 days) and for medium and long term basis (60, 90 and 365 days).

SEM image affirms that the RSA particles were acicular with aspect ratio of 8.5:1 and were 5 times finer than OPC particles. Proportions of RSA (at regular interval of 5% till 30%) and MS (at regular interval of 2.5% till 10%) by weight of OPC in the paste were studied. The mixtures were also prepared by replacing OPC with the combination of RSA (5%, 10%) and MS (5%, 7.5%). Various tests (normal consistency, setting time, soundness test and XRD) were performed on the cementitious paste. The Marsh cone test was performed on the cementitious paste slurry to determine the optimum dosages of high range water-reducer (HRWR) for respective cementitious mortar. It was observed that the admixing of MS did not affect the setting time and

soundness of the cement paste but increased the normal consistency while admixing of RSA remarkably increased all of them.

The effects of RSA and MS on compressive strength and hardened density of cementitious mortar were also observed. It was found that OPC can be replaced by RSA up to 10% and by MS up to 7.5% without any loss of compressive strength.

The proportion of RSA and MS in concrete mixes was finalized based on the test results of cementitious mortar. Different dosages of HRWR for concrete mixes were decided based on the slump test. The compressive, flexural and split tensile strength tests of the M40 grade admixed concrete were found out, and various equations between these parameters were established. The admixing of RSA and MS increased the various strengths of concrete up to 2% and up to 42%, respectively as compared to the control concrete for all curing ages. The results of the strength tests were confirmed by XRD, SEM and Petrography analysis.

The special impetus and emphasis was given to the durability of concrete and to verify whether admixing of RSA into concrete improves its durability properties. It was found that the admixing of MS and RSA had significantly increased the defense mechanism of concrete to water absorption, chloride ion penetration, acid attack and accelerated carbonation curing (ACC). However, MS was more effective as compared to the RSA in improving these durability properties. Also, the relations between durability properties and curing age were formulated based on the experimental results.

The design thickness of the concrete slab of the selected concrete mix was computed as per structural design in accordance with IRC 58:2015. The cost comparison was done on the basis of the total cost of 1 m^3 of admixed concrete and conventional OPC concrete for construction of 1 km of National Highway (one way carriageway of a 4 lane NH).

It is recommended that RSA should be collected carefully and should always be kept in sealed bags. The admixing of 10% RSA into concrete reduces the slab thickness by 11%, cost of 1 m^3 of concrete by 3% and cost of constructing 1 km length of NH by 14% as compared to the control concrete. It is also suggested to use 5% RSA along with 7.5% MS when there is significant concern about the durability of a rigid pavement.