Behaviour of Tensile Strength Energy to Control Concrete Spalling in Rigid Pavements by using Rice Straw Concrete

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Abstract: **Roads and pavements are very essential for the development of any country. Flexible pavements are used for light weight traffic while rigid pavements are used for the movement of heavy vehicles. Many flaws are erected in rigid pavements by means of historical activity, containing early age microcracks, crazing, spalling and surface erosion. Due to these defective flaws, the durability and serviceability of rigid pavement will be reduced. The spalling of rigid pavements can be controlled by controlling compressive strength, tensile strength and flexure strength of concrete in rigid pavement. The aim of this research is to evaluate the effect of rice straw as reinforcement in concrete. It has been noted that properties of concrete improved by adding rice straw in concrete due to its low density, more ductility, lightweight, and resistant to heat. The general aim of the research is to enhance tensile strength of concrete to control the spalling in rigid pavements through rice straw fibre concrete (RSFRC). The tensile strength of RSFRS and plain cement (PC) concrete has been compared. The design mix ratio of 1:2:4 has been used along with 0.6 water to cement ratio while 5cm rice straw at 0.5% has been added in that concrete. The workability of RSFRS concrete was reduced as compare to PC. The production of cracks was reduced in RSFRS concrete as it can absorb more energy as compare to simple concrete. The toughness index of this concrete has been improved to 27% as compare to ordinary concrete which may help in reducing spalling of concrete in rigid pavement. Future research can be done by adding suitable admixtures in RSFRS to improve more properties of concrete.**

Keywords: **Concrete, Rice straw, plain concrete, split tensile test and toughness index.**

I. INTRODUCTION

The roads and pavement play an essential part in the economy and development of any country. Roads are used to transport the people and goods from one place to other place in the betterment of country. Flexible and rigid pavements are the two basic types of road structures. Bitumen layer is used in the top layer of flexible pavement while concrete is used in rigid pavement. Despite of some advantages of roads structures, there are some flaws are also there in rigid pavements like crazing, concrete spalling and surface erosion (du Plessis, Ulloa-Calderon, Harvey, & Coetzee, 2018). Concrete spalling is caused by concrete infiltration by the reactive aggregates (Xiao & Wu, 2018). The opening of the stratum in the concrete cracks and the expansion in the pavement of transversal crack was changing in width. The extraction of samples from hard road surfaces points that the degradation of concrete preoccupation and depression is an advanced state of these spalling (Papapostolou, Karakosta, & Doukas, 2017). It is imagined, due to stratum, that the detachment take place because of tensions in the layer of delaminated concrete that resulted wheel load movements, the variation of the temperature and the existence of moisture content in the stratum. The complicated base suggests the existence of additional splashes on the side of downstream of transverse cracks / concretes, and that this splash mode is generated from the shear stresses induced by a tire of the vehicle on the pavement rigid slab (Papapostolou et al., 2017). The SFM analysis of static finite elements of the delaminated portion of a rigid pavement slab shows that the force per unit area resulted from tire of vehicle on the pavement may be enough to expand the stratum, which generates splashes. Poor quality concrete or construction technique will result in concrete spalling. Small edges forming a large spalling on the back of the slab and down to the concretes can be observed (Amadi, Sadiku, Abdullahi, & Danyaya, 2018). The main clarity of concrete spalling in rigid concrete pavements are concretes faced to enormous stress due to high loading traffic or by encroach of any incompressible materials, the concrete that is composed with weak concrete, Concrete that brings together with water that outcome shows rapid freezing and thawing Concrete Spalling in Rigid Pavements (Panda & Swamy, 2018).

The concrete spalling can be avoided by using good construction techniques, or by using natural fibres such as rice straw fibre. Precursory analysis has chiefly concentrated to rice fibre and complete rice straw composites. Kamel ascertained rice straw fibre with pulp polymer forming joint agent. The acquire compound shows superior properties, the area of advanced development in behaviour properties and stability of tension members be controlled through the treatment of fibres e.g. rice straw, wholly directed rice straw and complex polymer. The consideration was on temperature and pressure of rice fibres (Guo, Huang, Wang, Yu, & Hou, 2018). Minor reform kinds of research have been done yet conducted exploitation varied rice straw parts to strengthen chemical compound composites. Thus, properties of compound and individual benefaction of varied rice straw parts are of the first analysis interest during this analysis study (Guo et al., 2018). Plain concrete (PC) is not advisable for the execution of structures like rigid pavements (Gao & Wu, 2018). In Rice straw fibre reinforced concrete, fibre reduces the plastic attributes in fresh concrete, increase surface erosion endurance, resistance to fatigue and Impact loading. Distinct types of fibres were ascertained by researchers for enhancing mechanical properties. The performance of plain concrete in rigid pavements has got enhanced by computing natural fibres (Tataranni et al., 2018). Untreated rice straws are selected in this study research to establish initial premises of rice straw fibre concrete. In material rice straw, cement, fine sand, aggregates were used. These materials are used in three layers in the mixer machine to perform concrete mix design. Rice straw fibre, if it is used as reinforcement in plain concrete, it can play a vital role in increasing the toughness index of concrete that will reduce the Concrete spalling flaw issues resulted from the tensile failure (Esfandiarpour & Shalaby, 2018). This Research paper is carrying research on the use of rice straw fibres in concrete specially to control concrete spalling in rigid pavements. To the best of my knowledge, such research on rice straw has not been carried out till to-date (Ji, Wang, Suo, Xu, & Xu, 2018).

II. EXPERIMENTAL PROCEDURE

A. Raw Material

The raw materials used for plain cement concrete (PC) and rice straw fibre reinforced concrete (RSFRC) consist of ordinary Portland cement, fine and coarse aggregates from Lawrencepur and Marghalla, portable water and rice straw fibres.

B. Mix design and casting procedures

The basic and preliminary results were obtained from the preliminary tests performed on all the raw materials of concrete. For the preparation of RSFRC rice straw size of size 5 centimetres were used. These materials are used in three layers in a mixer machine to prepare concrete mixture. For preparing RSFRC, the ingredients of concrete along with fibres were put in the mixer layer by layer to prevent from balling effect, this will make the mixture more workable (Guo et al., 2018). The water to cement ratio was kept 0.6 in the all concrete mixtures. All the samples were poured into moulds and prepared as per standards and guidelines. Specimens were de-moulded after pouring of 48 hours. The cylinder specimens were stored in water at room temperature for 28 days before testing. ASTM C143/C143M-15a standards are used for mixing and casting procedure, which may yield the better test results near to original filed conditions (Hengl, Kluger-Eigl, Blab, & Füssl, 2018).

C. Specimens

Cylinders of 4 inches in diameter and 8 inches in height were prepared for PC and RSFRC. Total 32 cylinders were prepared as per ASTM Standards C138/C318M-16 including 16 cylinders each for plain cement concrete and RSFRC. These samples were prepared to find out the rate of gain of strength at different ages like 3-Days, 7-Days, 14- Days and 28-Days which will clearly show the effect of addition of rice fibre straw on properties of concrete.

D. Split Tensile Strength Energy

In order to find out the split cylinder strength of both types of samples, ASTM standard C496/C496M-11 was used. The curve of load time was recorded in the machine along with the perception of cracks. The crack developing mechanism during split tensile energy test of PC and RSFRC are shown in Figure-1. In left side figure, the crack developing mechanism can be observed while in the right-side figure, the graph of tensile energy to time was shown.

It is clear from the figure that there are more percentage of aggregate failure in RSFRC than that of plain cement concrete. In RSFRC the aggregate damage percentage is around 0.95% while in PC it was only 0.5% in PC. It may be due to the internal reaction between rice straw fibres with any ingredient of concrete. This fact needs to be investigated in future research.

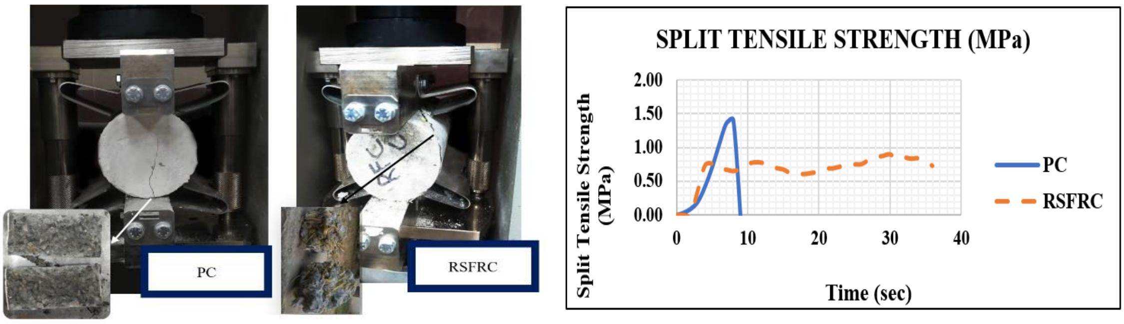

Figure 1: Split Tensile testing of Cylinders in Compression Machine

It is clear from the below figure that the split tensile energy of RSFRC is 1.403 Mpa while that of PC is 0.901 which is 64.3% lesser than that of RSFRC. It means this type of concrete can be used in rigid pavement to avoid the spalling in rigid pavements.

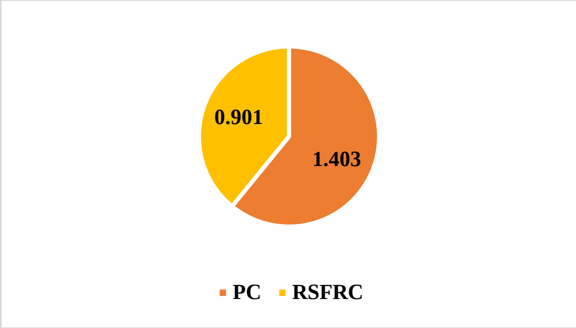

Fig 2: Split Tensile Strengths (Mpa) of PC and RSFRC

E. Total Toughness Index (TTI)

The toughness index is defined as the area under the stress-strain curve of RSFRC up to strain value of 0.006 divided by the area under the stress-strain curve of PC up to a strain value of 0.006. It can also be calculated by the ratio of the total energy soaked up to the energy soaked up till maximum stress. The toughness index increases with the addition of fibres in concrete which act like additional reinforcement in concrete.

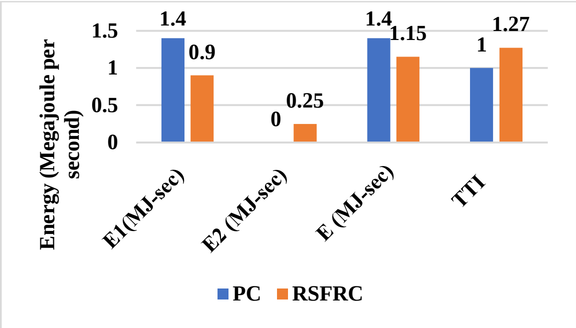

Figure 3: Energy (E) and Total Toughness Index (TTI) of PC and RSFR

In the above graph, E1 is the energy level in Megajoule per second at which the normal plain cement concrete sample was broken down that can be calculated by finding out the area under load time curve up to maximum load while E2 is the extra energy of RSFRC sample that the sample has been absorbed more than the PC that can be calculated by finding out the area under load time curve from maximum load to ultimate load. While E is the sum of both energy levels and TTI is the total toughness index of both types of samples. It is clear form the above figure that the total toughness index of RSFRC is 21.25% more than that of PC which may help this type of concrete in controlling the spalling in the rigid pavement.

III. CONCLUSION

In this research an attempt was made to investigate the effect of use of rice straw fibres in concrete in controlling the spalling of concrete in rigid pavement. After the preliminary tests followed by the concrete mixture design and testing of samples, following conclusions have been extracted for this research work.

1. The workability of RSFRC was reduced as compare to PC. It is because rice straw fibres used to absorb more water as compare to cement.
2. Cracks mechanism was improved of RSFRC as compare to PC.
3. More energy was absorbed by RSFRC as compared to that of PC which may help this type of concrete in controlling the spalling mechanism in rigid pavements.
4. Toughness index observed to be more by 21.25% in RSFRC as compared to that of PC which can improve the over all life of the pavement.

IV. RECOMENDATION

Following are the main recommendations of this research work.

1- There were more damaged in the aggregates of RSFRC as compare to PC. There might be some reaction between rice fibres straw and any ingredient of concrete. This fact must b investigated in future research.
2- RSFRC should be used in rigid pavements to avoid the sapling in the pavement.
3- RSFRC should be used in all types of concrete as it will improve the serviceability of concrete y improvement different concrete properties.
4- Some other properties of RSFRC should also be investigated in future research to get the maximum benefits out of this type of concrete.

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