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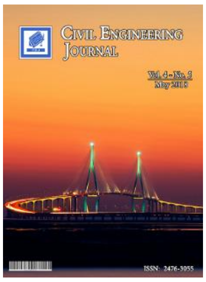
Civil Engineering Journal

Vol. 4, No. 5, May, 2018



Mechanical properties of concrete containing Fly Ash, Rice Husk Ash and Waste Glass Powder

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Received 28 March 2018; Accepted 31 May 2018

Abstract

This paper for the first time investigates the workability, compressive and tensile strength of concrete containing Fly Ash, Rice Husk Ash and Waste Glass Powder. Seventy six cube specimen (150 × 150 × 150 mm were cast with different composition of Fly Ash, Rice Husk Ash ,Waste Glass Powder and steel fibers. The cubes were tested for axial compression and tensile tests. The research also investigated the effect of curing regime on the compressive and tensile strength of concrete cube specimen. The results revealed that the addition of 15 % Rice Husk Ash and 39% Fly Ash increased the workability of 25 % as compared to the controlled concrete. The sample containing 10 % Rice Husk Ash, 10% Waste Glass Powder and 39% micro silica produced worst workability as it decreased the workability up to 5 % of controlled concrete. The results for axial compressive strength shows that the addition of 15% Rice Husk Ash (RHA) and 39% of Fly Ash (FA) in concrete leads to the improvement of compressive strength by 14%. The sample containing replacement of 10% Rice Husk Ash (RHA), 10% waste glass powder (WGP) and 39 % of micro silica (MS) in concrete leads to the improvement by 53.9 for compressive. The replacement of 10% Rice Husk Ash (RHA), 10% waste glass powder (WGP), 39 % of micro silica (MS) 3% steel fiber in concrete leads to the improvement by 37% for compressive strength. It was observed from the results of tensile strength that the samples containing 15% Rice Husk Ash (RHA) and 39 % of Fly Ash (FA) increased the tensile strength by 24% as compared to the controlled concrete. The sample containing replacement of 10% Rice Husk Ash (RHA), 10% waste glass powder (WGP) and 39 % of micro silica (MS) in concrete leads to an increase of 20% as compared to the controlled ones. Also, the replacement of 10% Rice Husk Ash (RHA), 10% waste glass powder (WGP), 39 % of micro silica (MS) 3% steel fiber increased the tensile strength by 40 % as compared to the controlled concrete sample. Finally, it was concluded that the replacement of 10% RHA, 39% micro Silica, 10% WG in concrete was found to be superior for increasing the mechanical properties of concrete.

Keywords: Waste Glass; Rice Husk Ash; Fly Ash; Compressive Strength; Split Tensile Strength.

1. Introduction

Rice-husk (RH) is an agricultural by-product material. It constitutes about 20% of the weight of rice. It contains around 50% cellulose, 25–30% lignin, and 15–20% of silica. At the point when rice-husk is scorched, rice-husk fiery debris (RHA) is created [1].

On consuming, cellulose and lignin are evacuated abandoning silica powder. The controlled temperature and condition of consuming yields better nature of rice-husk fiery debris as its molecule size and particular surface territory are reliant on consuming condition. For each 1000 kg of paddy processed, around 200 kg (20%) of husk is created, and when this husk is singed in the boilers, around 50 kg (25%) of RHA is produced. Totally copied rice-husk is dim to white in shading, while incompletely consumed rice-husk fiery remains are blackish, the composition of silica got after burning of rice husk relies upon the temperature and span of ignition of rice husk. Mehta (1979) proposed that basically

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http://dx.doi.org/10.28991/cej-0309153

shapeless silica can be delivered by keeping up the burning temperature below 500C under oxidizing conditions for delayed periods or up to 680C with a hold time under 1 min.

However, Yeoh et al. (1979) revealed that RHA can stay in the nebulous shape at burning temperatures of up to 900 C if the ignition time is under 1 hour, while crystalline silica is created at 1000C with ignition time more prominent than 5min. Utilizing X-ray diffraction, Chopra et al. (1981) watched that at consuming temperatures to 700 C, the silica was in an indistinct shape. The impact of various consuming temperatures and the substance piece of rice husk (Taiwan RHA) were examined by Hwang and Wu (1989) [2, 3] It was spotted that at 400C, polysaccharides start to depolymerize. Over 400C, drying out of sugar units happens. At 700C, the sugar units disintegrate. At temperatures over 700C, unsaturated items respond together and shape a very receptive carbonic build-up. The X-ray information and concoction investigations of RHA delivered under various consuming conditions given by Hwang and Wu (1989). The previous researches focused on addition of steel fibers and polypropylene fibers in concrete mix. Experimental studies were performed to investigate the effect of addition of steel fibers and polypropylene fibers on the mechanical properties of concrete. The results revealed that the addition of steel fibers improved the mechanical properties of concrete like compressive and split tensile strength [4-6]. Experimental investigations were performed to investigate the mechanical properties of concrete by the replacement of Cement with Rice Husk Ash. The results reported that replacement of Cement by RHA significantly improved the mechanical properties of concrete but the density of concrete decreases. None of these studies include Rice Husk Ash, Fly Ash and Waste Glasses in a single research work [7-9].

The studies also reported using Fly Ash and Waste Glasses as a replacement for Cement and Fine Aggregates respectively. The researches clearly shows the significance of Fly Ash for improving mechanical properties of concrete. The objective was to find best economical mix design for Fly Ash and Waste Glass replacement for concrete. The studies shows that replacement of Cement and Fine Aggregate by 10 percent Fly Ash and 20 percent waste glass respectively proved to be the most economical mix. Further studies are needed to investigate the behavior of concrete having Fly Ash, Rice Husk, Waste Galss and Steel Fibers together in a single research study [10-13].

Demonstrated that the higher the consuming temperature, the more noteworthy the level of silica in the fiery debris. K, S, Ca, Mg and additionally a few different parts were observed to be unpredictable. Rice-husk fiery debris (RHA) is a fine pozzolanic material. The Use of (RHA) as a pozzolanic material in bond gives a few points of interest, for example, enhanced quality and strength properties, lessened materials costs because of concrete investment funds, and natural advantages identified with the transfer of waste materials and to diminished carbon dioxide emanations. Reactivity of RHA is credited to its high substance of nebulous silica, and to its substantial surface region represented by the permeable structure of the particles (Cook, 1984; Mehta, 1992). For the most part, reactivity is supported likewise by expanding fineness of the pozzolanic material. However, Mehta (1979) has contended that crushing of RHA to a high level of fineness ought to stay away from since it infers its pozzolanic action fundamentally from the interior surface zone of the particles. Della et al. (2002) announced that a 95% silica powder could be created after warmth treatment at 700C for 6 hours. What's more, the particular surface area of particles was expanded after wet grinding from 54 to 81 m^2/g [14-16]. In a research study by Ghassan Abood the feasibility of using (RHA) material as a partial substitute for cement was performed using compressive strength tests and found proficient as a pozzolanic material and it's very rich in (amorphous silica) (88.32%). The misfortune on start was comparatively high (5.81%). Expanding RHA fineness builds its reactivity. The outcomes demonstrated that strength of the mixed cement with 10% RHA substitution significantly increases the strength of concrete. The cement can be supplanted by (RHA) up to 20 present without antagonistically influencing the axial compressive strength. It was concluded that increasing the percentage replacement for (RHA) fineness improve the compressive strength of mixed concrete [16].

According to ASTM C618 the pozzolanic impact relies upon the pozzolanic response and on the physical or filler impact of the smaller particles size of Rice husk fiery debris (RHA) in the blend plan , moreover, a standout amongst the most widely recognized strategies to enhance the pozzolanic movement of mineral admixtures is to diminish their particle size, work by Isaia, Gastaldini and Moraes in 2003 have suggested for the) particle size of (RHA) in the domain of 10e75 mm exhibit satisfactory pozzolanic behaviour [17, 18]. Numerous studies have investigated the efficiency of utilizing pozzolans in (RHA) because RHA has high permeability and the majority of silica. It is significant to note that RHA should be in small particles size to get high and good pozzolanas for use in concrete mixture design. There are many kinds of classes of pozzolan such as class C and F and the stander of these chemical compound SiO2+Al2O3+Fe2O3 should be over 70% as determined by (ASTM C 618). Composition rate and particle size of (PC) and pozzolanic materials, determine the properties of cement-based solidification [19, 20]. Present study has been focused on recycled materials like Fly ash, (RHA) and waste glass as substitute by aggregates in concrete study has investigated that the using of (WG) materials it really has potential to enhance the strength and workability in concrete, waste glass should be crushed into powder like sand particle size, it must be fine more than sand and it can demonstrate the properties materials [21, 22]. When the (particle size) of (RHS) equal or more than the (particle size) of Pozzolanic Portland cement (PPC) the (RHA) cannot achieve the requires in mix design concrete for manufacture high strength and also we cannot substitute cement by (RHS) up to 20% but if the particle size of (RHA) is lower than particle size of cement it can produce the best quality and improve mechanical properties of concrete (RHA) can used as partial substitute up to 15%. The optimum replacing of (RHA) is 10% it also depends on the particle size of (RHA) and water ratio concrete [23-25]. Compressive strength has increased 30.15% by Sathawane compared with control has been reduced by 8.73% at 28 days and the (split tensile strength) has decreased by 9.58% compared with control concrete at 28 days, (RHA) and Fly ash were obtained at combination replacement of 7.5 %, 22.5% by bond in concrete respectively , the use of RHA and Fly ash (FA) in concrete as a Partial substitute to cement as mentioned above can decrease the environmental risks and impacts, produces economic and eco-accommodating concrete [10]. Nurul Nazierah et al. has reported the substitution of bond by 10% Rice husk ash to be the ideal substitution to enhance the strength, moreover, for the solidness list execution, and substitution of cements by up to 50 percent of (RHA) likewise can be accomplished, brought about diminished in control passed and diminished in water ingestion, However, utilizing 10% of Rice husk solicit as a fractional substitution from concrete enhanced the durability execution of concrete. It's observed that (RHA) gave some impact on the compressive, split strength and durability of high strength concrete, due to the contained high quantity of silica compound in (RHA) [26] Khassaf et al. has reported that increasing the quantity of (RHA) in mix design concrete, the workability in fresh concrete was reduced, it was taken out from his results , the compressive and split tensile strength improve with increase of RHA% until 20%, Compressive and split tensile strength were increased of rate 10.5% and 11% respectively, it was the maximum increment, furthermore, when increase of 30% of (RHA) occurs, the results were decreased for compressive and split tensile strength of 17% and 10.5% respectively for 28 days. And also drying shrinkage was decreased about 28% by 30% increase of (RHA) after 90 days of curing period [27].

The objectives of this research are a) Experimental Investigation of using Waste glass powder (WGP), Rice husk ash and Fly Ash (FA) on concrete compressive and split tensile strength. b) Effect of commercially and manual burnt (RHA) on the strength of concrete. c) Investigation of cube split tensile and compressive strength for Curing Period of 7, 14 and 28 days. d) Determination of optimum percentages of Rice husk ash, (WGP) and Fly Ash and for producing best mix of concrete. e) Determination of optimum percentages for Producing (High Strength concrete mix). This innovative research for the first time investigates the mechanical properties of concrete for replacement by Fly Ash, Rice Husk, Waste Glasses and Steel Fibers experimentally.

2. Experimental Program and Material Properties

2.1. Materials

2.1.1. Cement

The cement used was Lafarge Portland cement (53 Grade) with a specific gravity of 3.15. first and final setting time of Lafarge cement was 23 min and 365 min, respectively, conforming to BIS specification IS:12269-1987, this type of cement (53 Grade) achieves higher early strength as compared to other grades of cements, but since of early pickup, does not expand considerably up to 28 days. Nevertheless ,because the hydration process is very fast, the density of (Portland cement) was 1440/m^3, one of the most popular types of (OPC) in China is Lafarge which has been utilized in this research work. Lafarge cement has been introduced by the new cement plant in (Dujiangyan – China). Meeting the most present-day ecological and technological standards, the plant has a yearly generation limit of more than 1.4 million tons of cement. (Lafarge), which has worked in China since 1994, is presently setting up its cement business in Dujiangyan which we mentioned above (Chengdu - Sichuan Province), in the south-west of the country. The chemical composition and some (physical properties) of the Lafarge Portland cement are shown in Table 1 and 2.

Table 1. Physical composition of Pozzolanic Portland cement (PPC)–(Lafarge)

Specific gravity	3.15
Specific surface (m^2/kg)	359

Table 2. Chemical composition of (Pozzolanic Portland cement)–(Lafarge)

Compound	Volume (%)
SiO2	21.84
Al2O3	5.17
Fe2O3	5.25
CaO	70.74
MgO	2.62

2.1.2. Fine and Coarse Aggregates

Fine and Coarse aggregate used in the experiment was produced from China–Sichuan province, the gravels were washed before use and the (particle size) of fine and coarse aggregates were 15-20 mm gravel, 1.81 mm fine respectively.

2.1.3. Rice Husk Ash (RHA)

The required rice husk ash (RHA) was supplied from the south-west of China. This product has a high content of silica (94.51%) by weight and was obtained by burning at relatively high temperatures in the range of (700-1000) C following the recommendations found in the literature. To manufacture a pozzolanic material, the ashes was ground by means of a laboratory grinding by batch ball mill mechanic for 4h. The average (particle size) of (RHA) is 654.3 nanometer (nm), the RHA was considered suitable for the partial replacement of cement. The chemical composition and (physical properties) of Rice husk ash (RHA) as shown in Table 3.

Table 3. Chemical composition of Rice Husk Ash (RHA)

Compound	Volume (%)
SiO2	94.51
K2O	3.95
CaO	1.40
Al2O3	1.91
Si	44.18
P2O5	0.93
K	3.28
Ca	1.10
O	51.44

Rice husk ash is used in concrete construction as an alternative to cement. Types, properties, characteristics and utilizes of (RHA) in constructions is discussed in this (chapter). The Rice husk ash (RHA) industries give the byproduct Rice Husk. Because of the expanding rate of environmental contamination and the thought of manageability factor have created the idea of using (Rice Husk ash). The purposes for the utilization of Rice Husk Ash as an alternative to the bond in concrete industrialization are clarified in the following sections. To have an appropriate thought on the execution of (Rice Husk) in concrete itemized study investigation on its properties should be done. Around (100 million tons) of Rice Paddy manufacture by-products are gotten worldwide. They have a greatly low density of 90-150 kg/m^3.This outcome in a more noteworthy estimation of dry volume. Rice Husk Ash itself has a surface which is rough in nature. These are consequently resistant to natural deterioration. This would bring about uncalled for transfer issues. In this way, an approach to utilize these side-effects to make another item is the best reasonable thought. Among all industries to reuse this item, bond, and concrete assembling businesses are the ones who can utilize rice husk in the best way.

- **Pozzolanic Activity of Rice Husk Ash**

Rice husk contains a considerable amount of SiO2. Good burning and well-ground (Rice Husk Ash) is quite energetic and extensively enhances the durability and strength of concrete and cement. This pozzolanic material with great and consistent properties can be acquired just by combustion (Rice Husk) under well-defined conditions. The affectability of combustion conditions is the essential reason that keeps the common utilization of this material as pozzolanic (Hewlett, 1998; Real et al., 1996). It has been accounted for that corrosive filtering of the (Husk) gets relative unadulterated silica with high particular surface reported by (Inoue and Hara, 1996). It is conceivable to improve the pozzolanic properties and lowering the affectability of combustion states of this material. (Zhang et al 1996) has studied the impact of the combination of (RHA) on the microstructure, hydration, and interfacial zone between the paste and aggregate. Based on the realization, they have concluded that: 1) calcium hydroxide (Ca (OH)2) and calcium silicate hydrates (C-S-H) were the main hydration and reaction products in the RHA paste. Because of the pozzolanic reaction, the paste incorporating RHA had lower Ca (OH)2 content than the control Portland cement paste; and 2) incorporation of the (RHA) in concrete less the porosity and the Ca (OH)2 or Ca+, OH−, quantity in the interfacial area; the width of the interfacial area between the cement paste and aggregate compared with the control Portland cement composite was also reduced. However, the porosity of the rice-husk ash composite in the interfacial area was higher than that of the (silica fume) composite. (Yu et al. (1999) reported that improvement of concrete properties upon addition of (RHA) may be imputed to the creation of more (C-S-H) gel and less Portland in concrete due to the reaction between (RHA) and the (Ca+, OH− ions) or (Ca (OH)2). Cisse and Laquerbe (2000) complemented that (the pozzolanic activity of Rice husk ash) was in charge of the best concrete and execution of (sandcrete) obstructs in correlation with classical mortar blocks. What's more, the utilization of (Rice husk ash) debris can create lightweight (sandcrete) with protecting properties at decreased cost.

- **The Particle Size Allocation of Rice Husk Ash**

The average particle size of (Rice husk ash) is 654.3 nanometer (nm).The RHA samples were mingling with water, tested by (SEM) machine in the chemical lab of Sichuan University. While milled samples presented only monomial distribution which was almost similar with each other, from the results, as 12 minutes given the almost same particles size distributions as obtained in 3-5 and 6 minutes respectively, therefore, the optimal grinding time for reducing the particle size of (Rice husk ash) should be 6 minutes. It can be seen that (RHA) showed a dual-modal distribution, Mehta (1979) has recommended strongly that not grinding the RHA to a fine powder due to its pozzolanic activity is mostly related to the inner surface area of the (RHA) particles. This is related to the micro permeability structure of separate particles. Hwang and Chandra (1996) have pointed out that particle sizes of (RHA) in the 10 to 75 mm range showed acceptable pozzolanic performance. Figure 1 shows the particle size distribution of Rice Husk Ash (RHA). Figure 2 shows Control Burning Rice husk ash up 1000 C by furnace machine in Materials Testing Laboratory, Sichuan University, China.

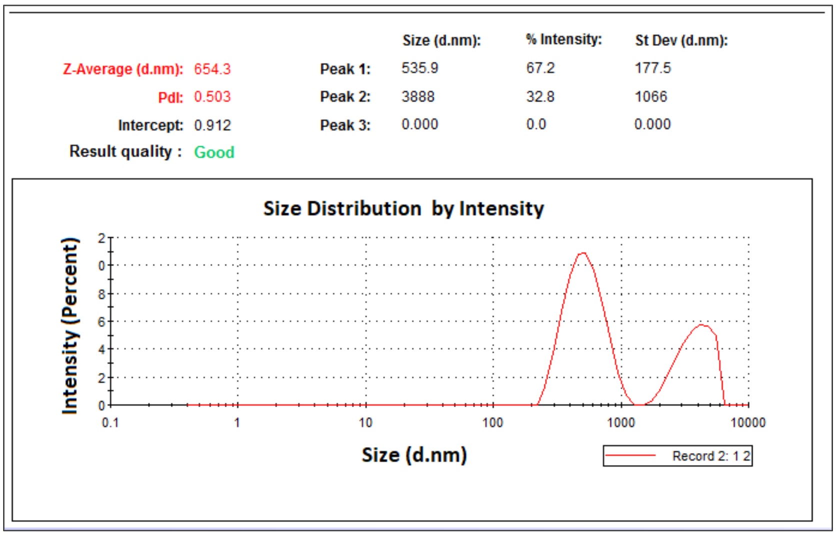

Figure 1. The particle size distribution of (Rice Husk Ash) (654.3 nanometers) the optimum particle size for three graphs in one and time by the SEM machine

Figure 2. Control Burning Rice husk ash up to 1000 ^{0}C by furnace machine in Materials Testing Laboratory, Sichuan University, China

2.1.4. Fly Ash (FA)

Fly ash used in this experiment was obtained as a by-product of coal-fired plants generating stations from the north-west of China, The chemical composition of the fly ash (FA) is given in Table 4, and it meets all the requirements of a Type C fly ash which we have mentioned it up according to CSA A23.5, the national specification covering "Supplementary Cementing Materials.

Table 4. Chemical composition of Fly Ash class C (FA)

Compound	Volume (%)
SiO2	40
Fe2O3	6
CaO	2.0
Al2O3	25
MgO	3.71
LOI	3.0
SO3	1.74
Kn2O	.80
Na2O3	0.94

2.1.5. Waste Glass Powder (WGP)

The fine aggregates in the specimens for Group 3 and 4, were replaced by 10% waste glasses. The waste glass was used after grinding and tested by (batch ball mill) machine in a laboratory for 24h. The average particle size of (waste glass powder) was 2857 nanometer (nm). Figure 2 shows particle size distribution of waste glass. Figure 3 shows the particle size distribution of waste glass powder 2857 nanometer (nm) for three graphs in one and same time by the SEM machine.

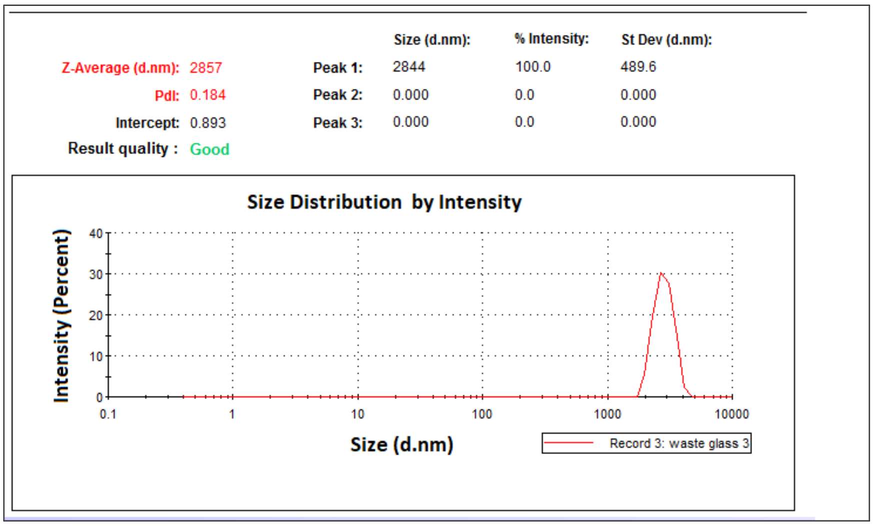

Figure 3. The particle size distribution of waste glass powder 2857 nanometer (Nm) for three graphs in one and same time by the SEM machine

Figure 4 in the following text shows the ball mill machine for grinding (RHA) and (WG) (24 hour duration) whereas Figure 5 shows the Types of materials which has been used in experiment Waste glass (WG), Steel fiber (SF) and Fly ash (FA). Rice husk ash (RHA), Superplasticizers (SP), Cement and sand.

Waste glass is also considered suitable for the partial substitute of sand aggregate. Table 5 shows the chemical composition and some physical properties of) waste glass powder).

Table 5. chemical composition and some physical properties of) waste glass powder)

Compound	Volume (%)
SiO2	72.62
MgO	3.83
Na2O	13.57
CaO	9.98
O	46.54
Na	10.07
Mg	2.31
Si	33.94
Ca	7.13

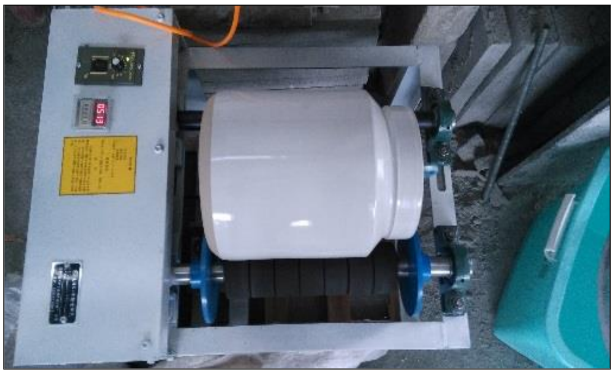

Figure 4. The ball mill machine for grinding (RHA) and (WG) (24-hour duration)

Figure 5. Types of materials used in experiment: Waste glass (WG), Steel fiber (SF) and Fly ash (FA).Rice husk ash (RHA), Superplasticizers (SP), Cement and sand

2.1.6. Steel Fiber

Commercially available steel fibers were procured from North China having particle diameter and length in the range of 0.30 to 0.80 mm and 35 to 45 mm respectively. The tensile strength and density of (steel fibers) which we have used in the experimental study were 600 MPa and 7900 kg/cum respectively. Floor-slab construction is one of the largest applications for steel fiber reinforced concrete in addition to its complement to structural reinforcement in other application is in increasing demand [28].

2.1.7. Superplasticizers

Superplasticizers constitute a relatively new category and improved version of plasticizers. They are chemically different from normal plasticizers. Use of superplasticizers permits the reduction of water to extend up to 30% without reducing workability in contrast to the possible reduction up to 15% in case of plasticizers.

2.1.8. Silica Fume

An admixture "Silica fume" was utilized in the concrete mixes for achieving higher target concrete strengths. Figure 6 shows Casting of specimens in laboratory.

Figure 6. Casting of specimens in laboratory

2.1.9. Mix Proportions

The standardly sized cubes (150 × 150 × 150 mm) were utilized for this research program. The samples in the research study were divided into 4 groups namely (G1, G2, G3, and G4) respectively. Group G1 was the control group, G2 samples comprised the addition of 15% RHA and 39% FA. G3 samples used a substitute of Cement, and fine aggregate, by 10% of RHA and 10% of Waste Glass Powder (GWP) respectively. The last group G4 comprised samples with the addition of Steel Fibers in the samples for Group 3. The mix proportions were carried out as per the guidelines of ACI Committee 211-93 and suggestions from Mohammad Abdur Rashid et al. (2009). The 28 days target strength was selected from 35 to 65 MPa. The total cement content, fine and coarse aggregates were taken as 486, 661, and 1112 kg/m^3 respectively. The w/c ratio was kept in the range of 0.40 to 0.45. The superplasticizer was added to the concrete cubes of Group 3 and 4 only. The mixing time for one batch of the concrete mix was approximately 5 minutes followed by casting procedure. The concrete cubes were cast in Concrete Testing Lab of civil engineering Department, Sichuan University at room temperature and left for 24h before de-molding. The samples were placed for curing in the curing tank for 7, 14 and 28 days respectively. The casting and curing of samples were done as per ASTM C3. The concrete specimens during casting and curing procedure can be seen in Figure 6 The detailed mix design for the specimens for G-1, G-2, G-3, and G-4 are shown in Table.3.4.1 It is proved from the Table that the w/c ratio was kept in the range of 0.40 to 0.5.

2.1.10. Different Proportion of RHA, Cement, Fly Ash, Steel Fiber, Waste Glass and Silica Fume for Testing

In this research study, the cement has been partially replaced by 10% of RHA in group 3, Fly ash (FA) was used in group 2, 3, 4. The same percentage as additional materials and the fine aggregates were added to the concrete for group 3 and replaced by 10% in group 4. The water-cement ratio in groups 2, 3, and 4 was 0.45, 0.35, and 0.4 respectively. Table 6 shows the mix properties of the specimen.

Table 6. Mix properties of the specimen

Sr.No	Strength (MPa)	Slump (mm)	W/C	Mix Ratio
G1	30	50	0.5	1:1.3:2.3
G2	35	77	0.45	1:1.3:2.3
G3	65.02	46	0.35	1:1.5:2.5
G4	47.68	55	0.4	1:1.5:2.5

3. Experimental Program and Testing Procedure

In order to do compressive strength test, cube specimens have a dimension of 150 × 150 × 150 mm and they permeated with different materials which we mentioned them in Mix Proportioning procedure. They go through vibration for 20-25 seconds by vibration table in the lab of civil engineering department Sichuan University to achieve the top of the cube mixture flat surface. The concrete specimens were vibrated and left to dry for 24 hours followed by curing regime of 7, 14, and 28 days. The concrete specimens were tested in axial compression till failure. The guidelines from Standard ASTM C39 code were followed for compression testing by universal testing machine (UTM) [29]. Figure 7 shows Specimens and During Testing specimens under compression by (UTM).

Figure 7. Specimens and During Testing specimens under compression by (UTM)

4. Results and Discussions

4.1. Workability (Slump) Test

The workability of fresh concrete was observed from Slump Cone test. The workability of control concrete specimen and specimen with a combination of Fly Ash (FA), Rice Husk Ash (RHA), Waste Glass (WG) and Steel Fibers (SF) were found out. The guidelines from standard ASTM C143 code were used for measuring the Workability from Slump Cone Test. The Figure 8 shows the workability for Group 1 to Group 4 as shown in the Figure below.

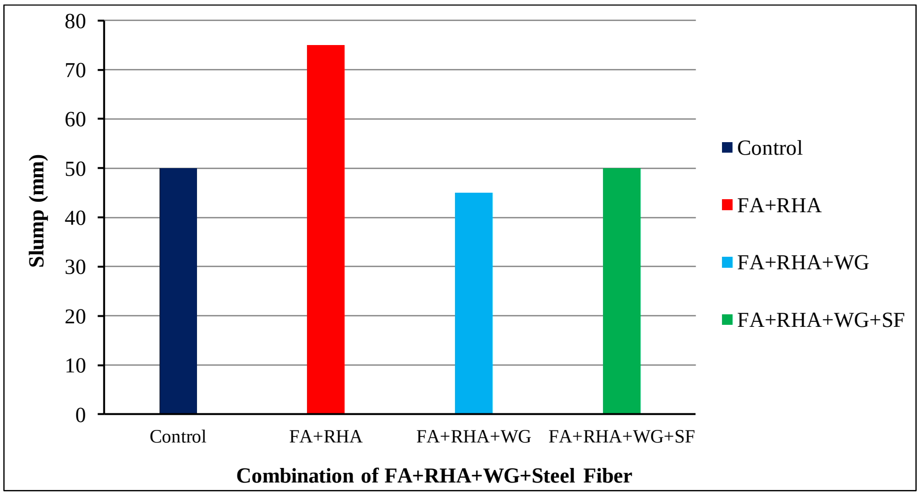

Figure 8. Workability of concrete using slump cone test

The Figure 8 shows the comparative effect of the addition of FA, 15% RHA, WG, and 3% SF on the workability of fresh concrete specimens. As shown in Figure 7 the addition of Fly Ash increases the workability of concrete up to 25.4% as compared to control concrete. The reason of increased workability can be referred to the very low binding property of Fly Ash. Furthermore, the addition of Rice Husk Ash decreased the workability up to 5.8% as compared with the controlled specimen. The apparent reason for decreased workability can be the water absorption capability of Rice Husk Ash. Moreover, the addition of steel fibers in group 4 specimens did not affect the workability of concrete as compared to the controlled sample.

4.2. Compressive Strength

4.2.1. Addition of Rice Husk Ash (RHA) and Fly Ash (FA) in Concrete

Figure 9 shows the comparison of results for G2 specimens with control concrete specimens of compressive strength with the addition of FA and RHA % at 7, 14, and 28 days of curing. It was observed that 7 day curing results in an increase of 8.8 % as compared to the G-1 samples. Moreover, 14 day curing results in increased strength i.e. 17 % as compared to the control group specimen. 28 days compressive strength results show 14% increment in strength as compared to the control samples of G-1.

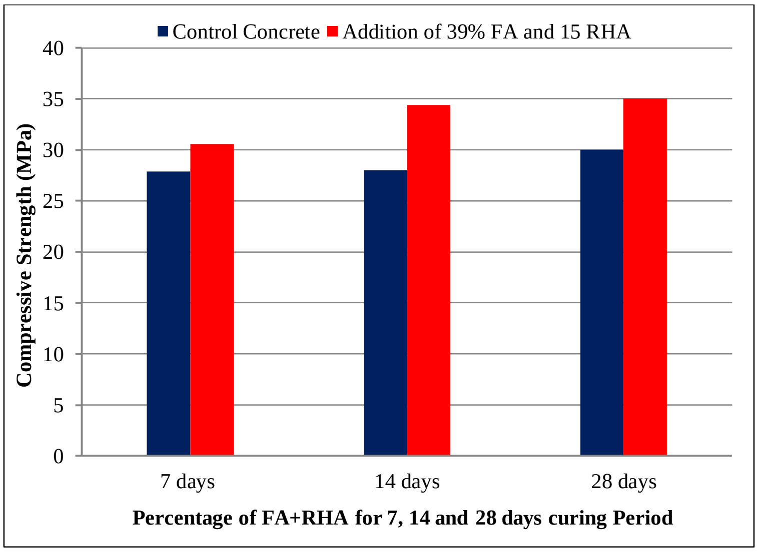

Figure 9. Comparison of compressive strength for addition % of FA and RHA

4.2.2. Replacement of Cement by Rice Husk Ash (RHA), Waste Glasses Powder (WGP), and the Addition of Fly Ash Material

It was observed that 7 day curing results in an increase of 46 % as compared to the G1 samples. Furthermore, for 14 day curing results in increased strength i.e. 51 % as compared to the control group specimen. 28 days compressive strength results show 53% increment in strength as compared to the control samples of G1. The G3 results show that the prediction.

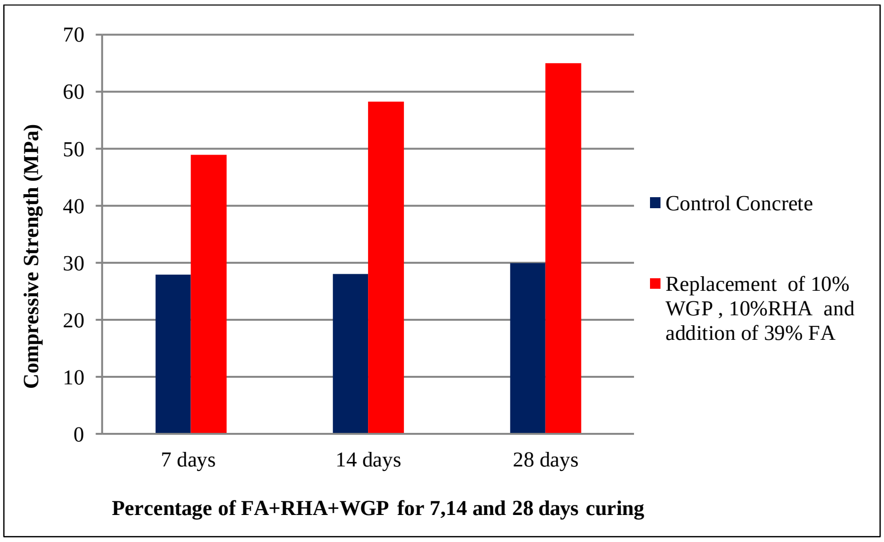

Figure 10. Comparison of compressive strength for replacement %RHA and WG addition % of FA

Was very close to the experimental results not only close it's very higher than the control concrete results for strength due to the mixing of waste glasses with Rice Husk Ash materials together in concrete. The combination of WGP and RHA was very reactive and also very rich in silica compound. Figure 10 shows the comparison of results for G3 specimens with control concrete specimens of compressive strength with replacement of waste glasses powder (WGP), RHA % and addition of Fly ash material at 7, 14, and 28 days of curing.

4.2.3. Replacement of Cement by Rice Husk (RHA), Waste Glass, 39% Micro Silica (MS) and Addition of Steel Fiber Material

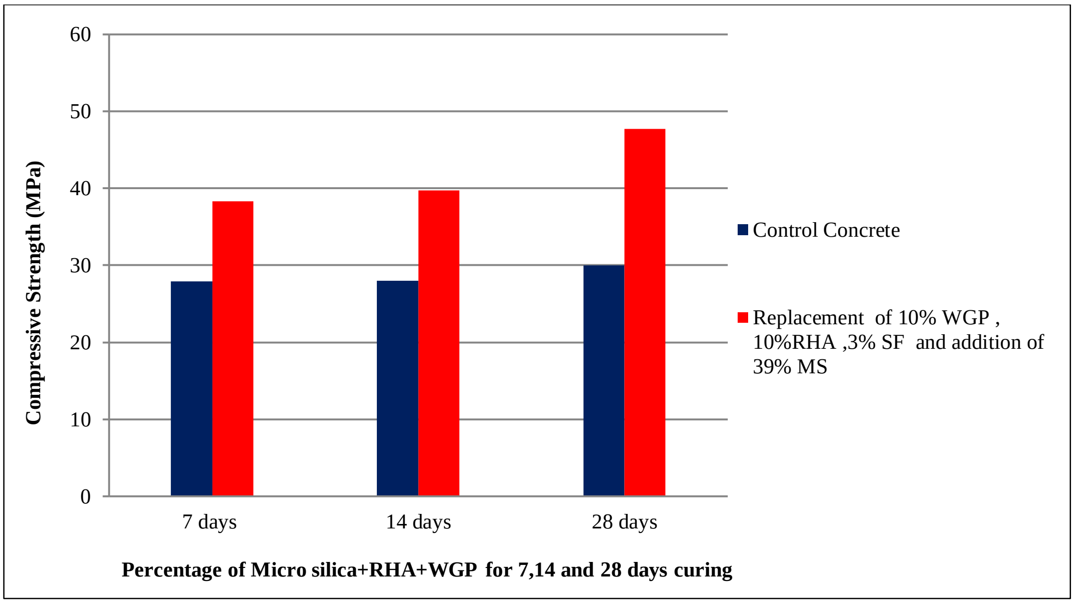

Figure 11. Replacement of cement by, Rice husk ash (RHA), Waste glasses and addition of steel fiber and Micro silica (MS) materials in concrete

It was observed that 7 days of curing results in an increase of strength of 29% as compared to the G1 samples. Furthermore, for 14 days curing results in increased strength i.e. 30% as compared to the control group specimen. 28 days compressive strength results show 37% increment in strength as compared to the control samples of G-1. The results of G4 show the prediction to be very close to the experimental results not only close its higher than the control concrete results for strength due to the mixing of waste glasses, Rice Husk Ash, and steel fiber materials together in concrete very rich and also very rich in silica compound. The combination of WGP and RHA was very reactive. Figure 11 shows the comparison of results for G4 specimens with control concrete specimens of compressive strength with the replacement of waste glasses powder (WGP), RHA % and the addition of steel fiber and micro silica materials in concrete at 7, 14, and 28 days of curing.

4.2.4. The Effect of Different Curing Regimes (7, 14 and 28 days)

From Figure 12 Group 3 (G3) it was observed that results of compressive strength are increase of 65.02 MPa at 28 days curing period as compared to other groups for different percentage of cement, FA, Waste glass and RHA. However, the control group has given 30 MPa for compressive strength at 28 days of curing period. In reference to the comparison of all Groups, the G2 and G4, results show the minimum compressive strength that is achieved by mixing of waste glass, RHA, FA and silica fume which was larger than the conventional concrete. Furthermore, Group (G3) has improved the compressive strength due to the mixing of Rice husk ash with Waste glass and silica fume which was larger than the control concrete and greater than G-2 and G-3. In G-2 and G-4 results were observed that 35 and 45.68 MPa compressive strength was increased as compared to the control concrete specimen at 28 days curing period.

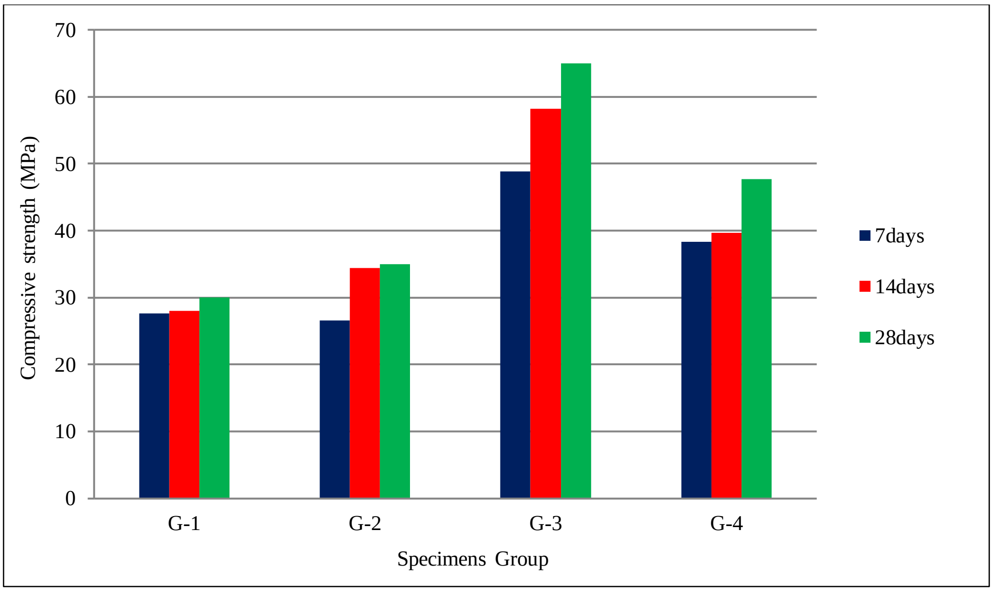

Figure 12. Compressive Strength for G1, G2, G3 and G4 with different curing regimes (7, 14 and 28 days)

4.3. Split Tensile Strength

4.3.1. Addition of Rice Husk Ash (RHA) and Fly Ash (FA) in Concrete

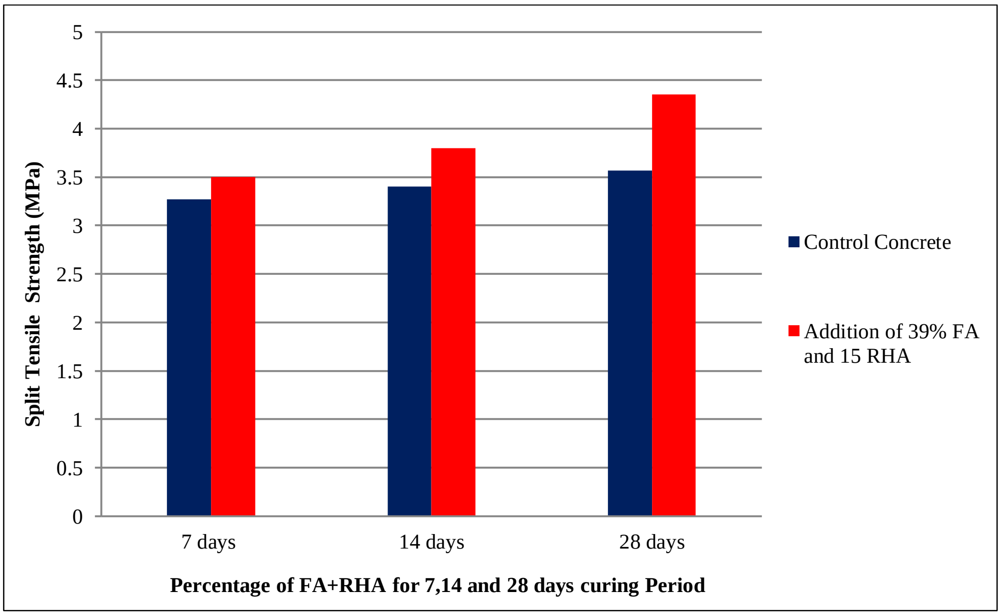

Figure 13. Comparison of split tensile strength for replacement %RHA and WG addition % of FA

It was observed that 7 day curing results in an increase of 8.5% as compared to the G1 samples. Moreover, 14 day curing results in increased strength i.e. 5.2% as compared to the control group specimen. 28 days split tensile strength results show 1.8 % increment in strength as compared to the control samples of G1. Figure 13 shows the comparison of results for G2 specimens with control concrete specimens of split tensile strength with the addition of FA and RHA % at 7, 14, and 28 days of curing.

4.3.2. Replacement of Cement by Rice Husk Ash (RHA), Waste Glasses Powder (WGP), and the Addition of Fly Ash Material

It was observed that 7 days curing results in an increase of 8.5 % as compared to the G1 samples. Furthermore, for 14 days curing results in increased strength i.e. 1.2 % as compared to the control group specimen. 28 days split tensile strength results show 1.8% increment in strength as compared to the control samples of G1. The G3 results show the prediction to be very close to the experimental results not only close, but even higher than the control concrete results for strength due to the mixing of waste glasses with Rice Husk Ash materials together in concrete. The combination of WGP and RHA was very reactive and very rich in silica compound. Figure 14 shows the comparison of results for G3 specimens with control concrete specimens of split tensile strength with the replacement of waste glasses powder (WGP), RHA % and the addition of Fly ash material at 7, 14, and 28 days of curing.

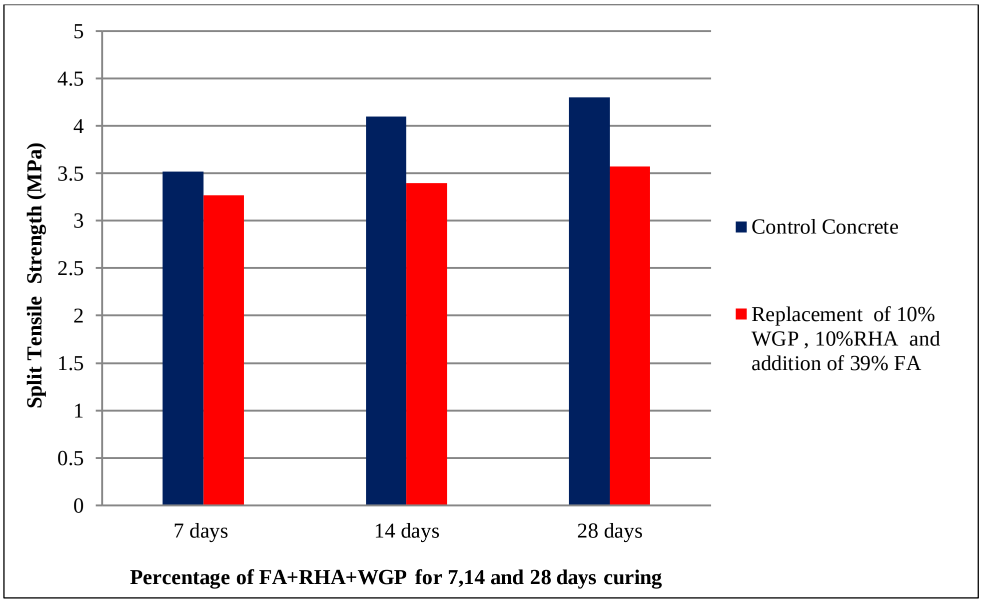

Figure 14. Comparison of split tensile strength for replacement of Cement and Fine Aggregates by RHA and WG plus addition of Micro Silica

4.3.3. Replacement of Cement by Rice Husk Ash (RHA), Waste Glasses, 39% Micro Silica (MS) and the Addition of Steel Fiber Material

It was observed that 7 days curing results in an increase of 8.5% as compared to the G1 samples. Furthermore, for 14 day curing results in increased strength i.e. 7.6% as compared to the control group specimen. 28 days split tensile strength results show 3% increment in strength as compared to the control samples of G1. The results of G4 shows the prediction to be very close to the experimental results not only close, but higher than the control concrete results for strength due to the mixing of waste glasses, Rice Husk Ash and steel fiber materials together in concrete are very rich in silica compound. The combination of WGP and RHA are very reactive. Figure 15 shows the comparison of results for G4 specimens with control concrete specimens of split tensile strength with the replacement of waste glasses powder (WGP), RHA % and the addition of steel fiber and micro silica materials in concrete at 7, 14, and 28 days of curing.

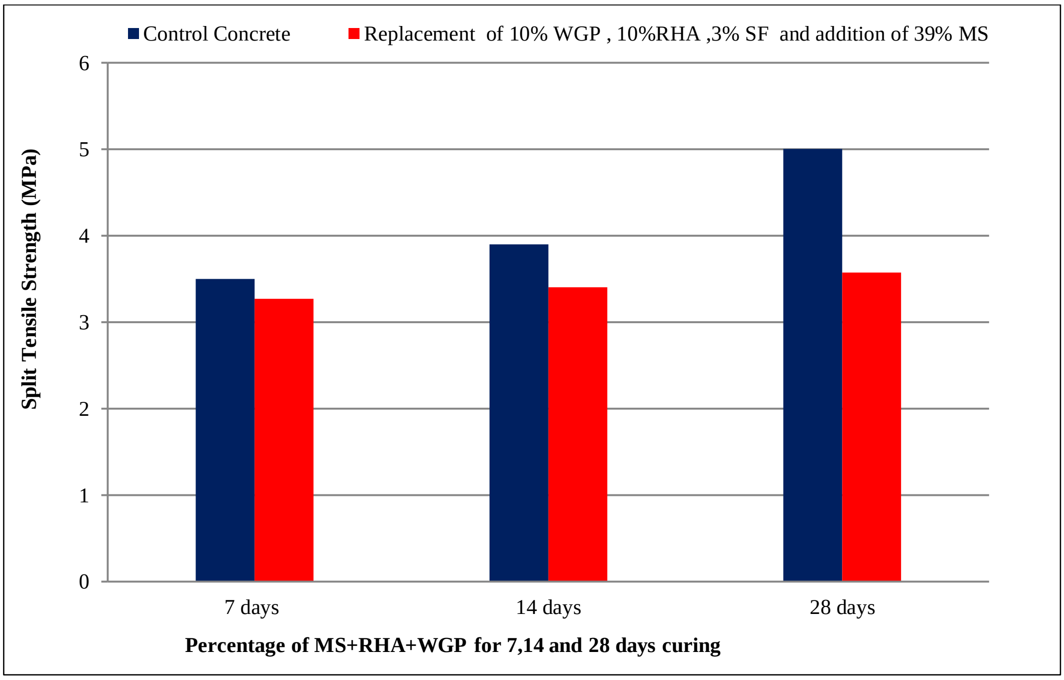

Figure 15. Replacement of cement by, Rice husk ash (RHA), Waste glasses and addition of steel fiber and Micro silica (MS) materials in concrete

4.3.4. The Effect of Different Curing Regimes (7, 14 and 28 days)

From Figure 16 Group 4 (G4) it was observed that split tensile strength is increased of 5 MPa at 28 days curing period.

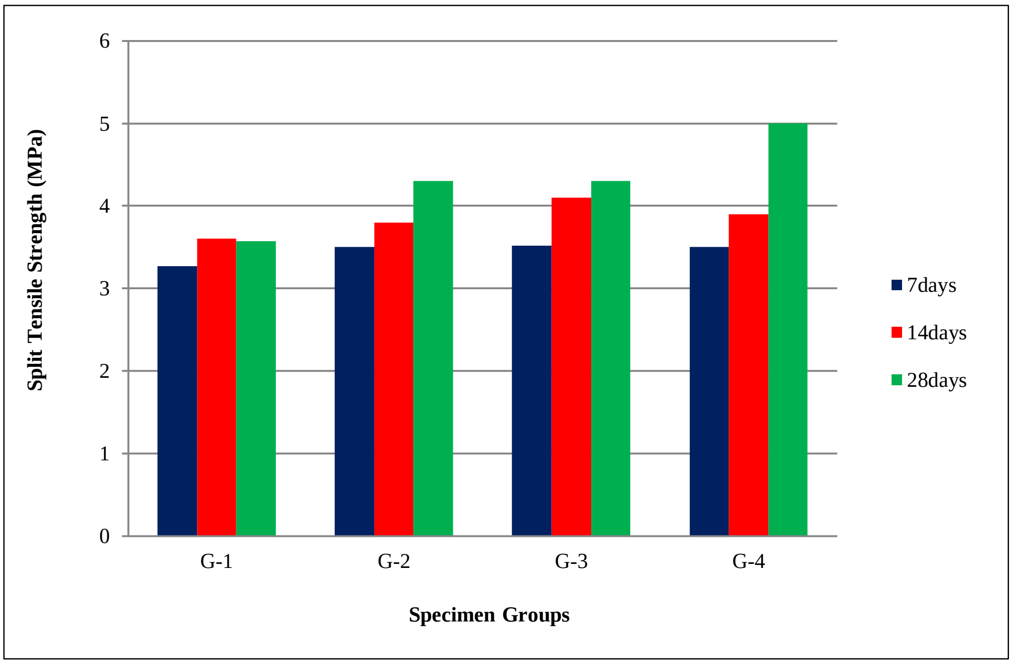

Figure 16. The results of Split tensile strength for G1, G2, G3 and G4 with different curing regimes (7, 14 and 28 days)

Compared to other groups for different percentage of cement, FA, Waste glass, RHA and steel fiber have increased the strength. The reason for increasing the split tensile can be referred to the fibers that reduce the cracks. However, the control group has given 3.75 MPa for compressive strength at 28 days of curing period. In reference to the comparison of all Groups, the G2 and G3, results show the minimum compressive strength that is achieved by mixing of waste glass, RHA, FA, steel fiber and silica fume which was larger than the conventional concrete. Furthermore, Group (G4) has improved the splint tensile strength due to the mixing of Rice husk ash with Waste glass, Micro silica and steel fiber which was larger than the control concrete, and greater than G2 and G3. In G2 and G3 results were observed that 4.3 and 4.3 MPa compressive strength was increased as compared to the control concrete specimen at 28 days curing period.

5. Conclusion

The samples in this research were divided into four groups. Group (G1) was the control concrete. Group (G2) was an addition of 39% FA and 10% RHA, Group (G3) was a replacement of cement by 10% RHA, 10% Waste glass (WG) and 39% silica fume (SF), and Group (G4) was a replacement of cement by 10% of RHA, 10% of Waste glass (WG), 39% silica fume (SF) and 3% of steel fiber. RHA and FA were found to be outstanding to other supplementary materials like silica fume. In the Group (G2) Rice husk ash and fly ash were used as pozzolanic materials which were very effective. Group (G3) improved the compressive strength due to the mix of Rice husk ash with Waste glass and silica fume. On the basis of results presented in the present study, following conclusions can be drawn:

- Adding fly ash to the concrete doesn’t always increase the compressive strength at early age which has been shown in G2 specimens whatever the confined compressive strength in the G2 was achieved The Compressive strength increases with the decrease in the water-cement ratio as shown in the Figure 4.2.3 (G3).
- According to the quantity of RHA that we have used in the concrete we have quantified the percentage of water-cement ratio because RHA is one of the highly porous materials. The maximum compressive and split tensile strength was obtained in the G3 with a combination of 10% Rice husk ash (RHA), 10% of Waste glass (WG) and 39% Silica fume as partial substitute of cement for various curing periods 28 days.
- Addition of Fly Ash in G2 increases the workability of concrete, but Rice Husk Ash has decreased the workability in G3; the apparent reason for decreased workability can be due to the water absorption capability of Rice Husk Ash. In G4, the addition of steel fibers did not affect the workability of concrete as compared to the controlled sample. The environment pollution during the disposal of excess Fly ash and Rice husk ash can be reduced by reusing Rice husk ash, waste glass, and Fly ash, therefore, the partial substitutes of these materials can decrease the cost of concrete.

6. Acknowledgements

I would like to thank my supervisor and the technical staff for all the support and funding.

7. Funding

The project was funded by the Research Grant Committee, Sichuan University.

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