IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Enhancing Concrete Strength with Fly-Ash and Rice Husk Ash: An Experimental Investigation with Steel Fiber Addition

Ravikant[1], Manish Vishnoi[2] & Ravi Kant Pareek[3]

[1]M.tech Scholar, Department of Civil Engineering, Vivekananda Global University, Jaipur

[2]Assistant Professor, Department of Civil Engineering, Vivekananda Global University, Jaipur

[3]Associate Professor, Department of Civil Engineering, Vivekananda Global University, Jaipur

ABSTRACT

Numerous researchers are currently focusing on enhancing concrete properties by incorporating various types of materials. This study aims to investigate the behavior of M40 grade concrete with a water-cement ratio (w/c) of 0.43 and to determine its compressive strength, flexural strength, and split tensile strength when cement is replaced by fly ash, rice husk ash, and steel fiber. Different replacement levels were considered, including 10%, 20%, and 30% of fly ash and rice husk, as well as combined replacements. The steel fiber content in the concrete was varied from 0% to 1.0%.

The results indicated that the workability of the concrete decreased with increasing percentages of fly ash (FA), rice husk ash (RHA), and steel fiber. Among the various combinations, the maximum compressive strength achieved after 28 days was 53.77 N/mm2 with a 10% replacement of cement by fly ash (FA). Similarly, the maximum flexural strength recorded at 28 days was 5.89 N/mm2 with a 10% replacement of cement by fly ash (FA). Additionally, the maximum split tensile strength attained after 28 days was 4.21 N/mm2 with a 10% replacement of cement by fly ash (FA). The most favorable strength results were observed with a combination of 20% fly ash and 10% rice husk ash, along with 0.75% steel fiber in the concrete.

These findings demonstrate the potential of using fly ash and rice husk ash as partial replacements for cement, along with the inclusion of steel fibers, to improve the strength characteristics of concrete.

Keywords: Fly ash(FA), Rice husk ash(RHA), Steel Fibres(SF), Compressive Strength, Flexural Strength and Split Tensile Strength.

1.INTRODUCTION: Ordinary Portland Cement (OPC) is a crucial but resource-intensive and expensive component in concrete production, which is widely used in construction. The demand for cement is projected to triple to approximately 3.5 billion tonnes by 2015. However, the raw materials needed for cement production are relatively limited. Moreover, the environmental impact of cement production is a major concern due to the emission of carbon dioxide (CO2), a significant contributor to global warming. Studies by Bhanumathidas and Mehta in 2001 estimated that producing one ton of cement consumes around 1.5 tons of earth minerals and emits one ton of CO2 into the atmosphere.

To address these challenges and reduce the impact on the environment, researchers are exploring the use of Supplementary Cementitious Materials (SCMs). SCMs are waste materials that can be blended with cement, reducing the need for OPC. By incorporating SCMs such as fly ash, Ground Granulated Blast furnace Slag (GGBS), silica fume, rice husk ash (RHA), low-calcium (LP) materials, and copper slag into concrete, several advantages can be achieved. These materials often possess pozzolanic properties, enhancing concrete strength and reducing permeability over time. Blending cement with SCMs not only saves OPC but also facilitates waste recycling, improves concrete's physical properties, increases its durability, and reduces greenhouse gas emissions.

In addition to using SCMs, reinforcing concrete with steel fibers enhances its flexural and tensile strength. Steel fibers work by preventing cracks from propagating through the concrete. They exert resisting forces at the crack tips, slowing down their progression and promoting a gradual failure, ultimately leading to increased tensile and flexural strength.

By adopting these sustainable practices, concrete producers can mitigate the environmental impact of OPC production, conserve natural resources, and improve the overall performance and durability of concrete structures.

2. MATERIAL USED

2.1 Cement: For this experimental study, Ordinary Portland cement of 43 grade from J.K SUPER cement was utilized. The selection of the cement was based on an investigation of its strength at 28 days, as per the guidelines of IS 4031-1988.

2.2 Fine Aggregate: The fine aggregate used in this research was locally available river sand that passed through a 4.75mm IS sieve and conformed to grade zone I of IS 383-1970. The sand had a fineness modulus of 2.31 and a specific gravity of 2.89.

2.3 Coarse Aggregate: Coarse aggregates were obtained from a local quarry. The coarse aggregate had a maximum size of 20mm and a specific gravity of 2.89. In this experiment, a combination of coarse gravel with a size of 20mm and crushed aggregates in a 60:40 ratio was used. The physical properties of the coarse aggregate, including fineness modulus and specific gravity, were measured and found to be 2.31 and 2.89, respectively.

2.4 Fly Ash: The fly ash used in the study was sourced from Rajiv Gandhi Thermal Power Plant, Khedar, Hissar, India. Fly ash is a residue generated during the combustion of coal in power generation facilities. Over the years, pollution control regulations have mandated its capture before release. Fly ash is generally stored on-site at most electric power generation facilities in the US. The chemical composition of fly ash varies depending on the source and makeup of the burned coal, but it typically contains significant amounts of silica (both amorphous and crystalline silicon dioxide, SiO2) and lime (calcium oxide, CaO). Fly ash has a whitish gray color and a specific gravity and bulk density of 2.10 and 1120 kg/m3, respectively.

2.5 Rice Husk Ash: The rice husk ash used in the experiment was obtained from a rice mill located in Sirsa. The specific gravity of rice husk ash was found to be 1.99, and its bulk density was measured to be 105.9 kg/m3. Rice husk ash is produced after the burning of rice husk (RH) and possesses high reactivity and pozzolanic properties. While the Indian Standard code of practice for plain and reinforced concrete, IS 456-2000, recommends the use of RHA in concrete, it does not specify specific quantities. The chemical composition of RHA can be affected by the burning process and temperature, and the silica content in the ash increases with higher burning temperatures. Rice husk ash has a light black color.

2.6 Steel Fibre: The investigation utilized steel wire with a diameter of 0.5 mm in the form of steel fibers. The steel fibers had a length of 40 mm and an aspect ratio of 80. All the steel fibers used in the experimental work were straight in shape.

2.7 Water: The water used for mixing and curing the concrete was clean and free from harmful substances such as oils, acids, alkalis, salts, sugar, and organic compounds that could be deleterious to the concrete. According to IS 456-2000, potable tap water was considered suitable for mixing and curing all concrete specimens.

Table 1 CHEMICAL PROPERTIES OF CEMENT (OPC), FLY ASH AND RICE HUSK ASH

Materials	SiO2 (Sillica)	A12O3 (Alumina)	Fe2O3 (iron oxide)	CaO (calcium oxide)	Mgo (Magnisium oxide)	LOI (Loss on ignition)	K2O (Potassium oxide)	Na2O3 (Sodium oxide)	So3 (sulphur tri oxide)
Cement	19.69	5.52	3.69	62.90	2.52	0.9	0.89	0.24	2.73
Fly ash	46.8	23.7	13.2	1.2	1	6.9	0.82	0.95	1.72
Rice husk ash	92.1	0.51	0.40	0.55	0.08	-	1.53	-	0.12

Table No. 2 CHARACTERISTICS PROPERTIES OF CEMENT

Sr. No.	Characteristics	Experimental value	Specified value as per IS:8112-1989
1	Consistency of cement(%)	33%	-
2	Specific gravity	2.98	3.15
3	Initial setting time(minutes)	35	>30 As Per IS 4031-1968
4	Final setting time(minutes)	282	<600 As per IS4031-1968
5	Compressive strength(N/mm2) 3 days 7 days 28 days	 26.56 39.57 47.96	 >23 >33 >43
6	Soundness(mm)	1.00	10
7	Fineness of cement	5%	10% As Per IS 269-1976

3. EXPERIMENTAL PROGRAMME

Experimental programme comprises of test on cement, concrete with partial replacement of cement with FA and RHA with addition of steel fiber.

3.1 MIXTURE PROPORTIONING: The mix proportioning was carried out in accordance with the guidelines specified in IS 10262-1982[11]. The target mean strength for the OPC control mixture was set at 48.25 MPa (40). Mix design is a process used to determine the quantities of different constituents in the concrete mix, and in our experiment, the Indian standard method was employed for this purpose.

The quantities of cement, coarse aggregate, fine aggregate, fly ash, rice husk ash, and steel fiber were determined using the mix design method. All the constituents were weighed using an electronic weighing machine. The mixing process involved thorough blending of cement, fly ash, and rice husk ash in a dry state. Subsequently, sand was added to the mixture, and coarse aggregate was incorporated. The entire mixture was then manually mixed to ensure proper homogeneity.

Steel fibers were added to the mixture in accordance with the desired weight percentage (ranging from 0% to 1%). Finally, water was added to the dry mixture to achieve the required consistency. After the mixing process, the concrete was molded into specimens, and tamping was done simultaneously during the filling process to achieve proper compaction.

The molded specimens were transferred to vibrators, where they were vibrated for 1-2 minutes to ensure uniform compaction. After 24 hours, the demolding of specimens took place, and the specimens were placed in curing tanks for curing periods of 7 and 28 days.

4 EXPERIMENTAL METHODOLOGY:

To evaluate the compressive strength of the concrete, standard cubical molds with dimensions of 150mm × 150mm × 150mm were used. These molds were made of cast iron and provided a stable and consistent shape for the concrete specimens.

Concrete specimens were cast in these molds and allowed to cure for the specified periods, i.e., 7 days and 28 days. After the curing period, the specimens were carefully removed from the molds, ensuring that they maintained their shape and integrity.

The testing of compressive strength was performed using a Compression Testing Machine (CTM). Each cured specimen was placed between the loading plates of the CTM, and a gradually increasing load was applied until the specimen failed or fractured.

The maximum load applied to the specimen just before failure was recorded, and the compressive strength was calculated by dividing this maximum load by the cross-sectional area of the specimen. The compressive strength was expressed in N/mm^2, and the results were documented for further analysis and comparison.

To determine the compressive strength we casted cubes with different percentage of fly ash, rice husk ash and steel fiber in the concrete. After that the specimen are tested at 7 days and 28 days at compression testing machine (CTM) as per I.S. 516-1959[17].

4.2 To assess the flexural strength of concrete with different proportions of fly ash, rice husk ash, and steel fiber, beams of dimensions 150mm × 150mm × 700mm were cast. The beams were designed for a two-point load test due to the relatively small span between the supports.

The effective length of the beam was considered to be 640mm. This means that the distance between the two points of support where the load was applied was 640mm.

After casting the beams, they were allowed to cure for the specified durations, i.e., 7 days and 28 days, to attain the required strength.

The flexural strength test was carried out using a testing setup designed for two-point loading. The beam specimen was placed horizontally on the supports, with the load applied at two points on the top surface of the beam. The load was gradually increased until the beam failed or fractured.

During the test, the load and corresponding deflection were recorded. The flexural strength was calculated using the formula:

Flexural Strength (N/mm^2) = $3PL / (2bd^2)$

Where:

P = Maximum load applied (in N)

L = Span length between supports (in mm)

b = Width of the beam (in mm)

d = Depth of the beam (in mm)

The obtained flexural strength values were documented for further analysis and comparison.

4.3 Split Tensile Strength**:** To determine the split tensile strength of concrete with different percentages of fly ash (FA), rice husk ash (RHA), and steel fiber, cylindrical specimens of dimensions 300mm × 150mm were cast.

The cylindrical specimens were prepared to have a diameter of 150mm and a height of 300mm. These specimens were specifically designed to evaluate the split tensile strength of the concrete.

After casting the cylindrical specimens, they were subjected to curing for the specified durations, i.e., 7 days and 28 days, to achieve the desired strength.

The split tensile strength test was performed using a Compression Testing Machine (CTM) with a capacity of 1000 KN (kilonewtons). The cylindrical specimen was placed horizontally on the CTM, and two compression plates were carefully aligned on opposite sides of the specimen.

The load was applied vertically to the specimen, resulting in a diametrical compressive force. As the load was increased, the specimen experienced tensile stress perpendicular to the applied load, which caused the concrete to crack along the diameter.

During the test, the load and corresponding crack width were measured and recorded. The split tensile strength was calculated using the formula:

Split Tensile Strength (N/mm^2) = $2P / (\pi * D * t)$

Where:

P = Maximum load applied (in N)

D = Diameter of the specimen (in mm)

t = Thickness of the specimen (in mm)

The split tensile strength values obtained were documented for analysis and comparison.

5. TEST RESULTS

TABLE 3: COMPRESSIVE STRENGTH RESULTS

Sr. No	Fly ash	Rice husk ash	% of steel fiber	Compressive strength after 7 days N/mm2	Compressive strength after 28 days N/mm2
1	0%	0%	0%	39.55	52.66
2	10%	0%	0%	40.22	53.77
3	20%	0%	0%	39.99	53.73
4	30%	0%	0%	37.55	50.36
5	0%	10%	0%	38.81	51.99
6	0%	20%	0%	37.33	48.22
7	0%	30%	0%	35.77	45.99
8	10%	10%	0%	37.32	50.73

9	20%	10%	0%	36.95	49.47
10	20%	10%	0.25%	37.55	51.33
11	20%	10%	0.50%	38.29	52.33
12	20%	10%	0.75%	38.66	53.10
13	20%	10%	1.0%	37.03	49.33
14	20%	10%	0%	33.92	45.77

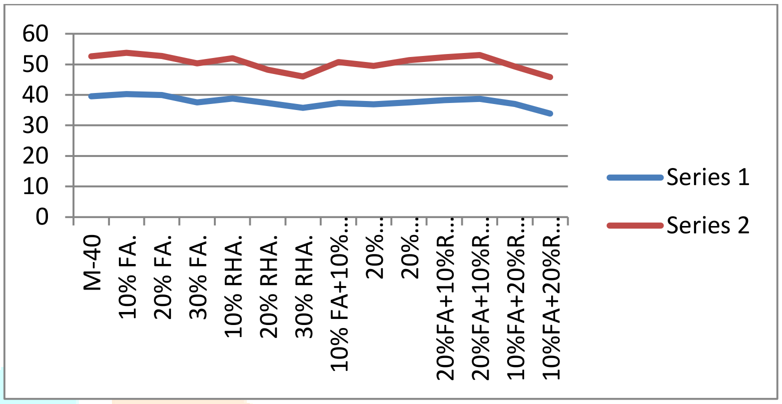

Fig. 1 VARIATION OF COMPRESSIVE STRENGTH AT DIFFERENT AGES

TABLE 4: FLEXURAL STRENGTH RESULTS

Sr. No	Fly ash	Rice husk ash	% of steel fiber	Flexural strength after 7 days N/mm2	Flexural strength after 28 days N/mm2
1	0%	0%	0%	3.73	5.86
2	10%	0%	0%	3.76	5.89
3	20%	0%	0%	3.35	5.48
4	30%	0%	0%	3.15	5.26
5	0%	10%	0%	2.98	4.81
6	0%	20%	0%	2.48	3.96
7	0%	30%	0%	2.40	3.35
8	10%	10%	0%	2.48	3.91
9	20%	10%	0%	2.42	3.85
10	20%	10%	0.25%	2.54	4.04
11	20%	10%	0.50%	2.61	4.1
12	20%	10%	0.75%	2.69	4.16
13	20%	10%	1.0%	2.63	4.09
14	10%	20%	0%	2.27	3.39

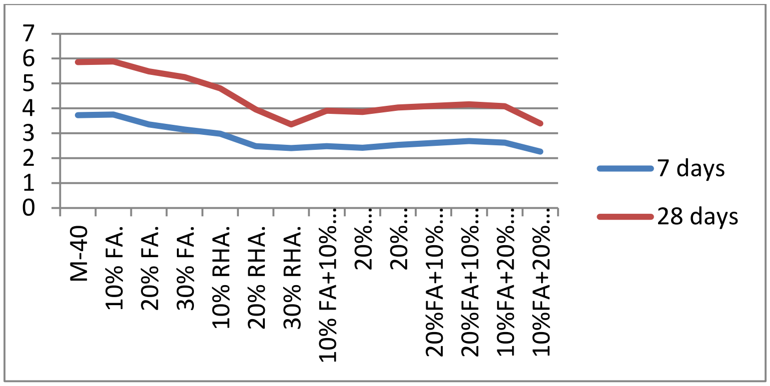

Fig. 2 VARIATION OF FLEXRUAL STRENGTH AT DIFFERENT AGES

TABLE 5: Split Tensile Strength Results

Sr. No	Fly ash	Rice husk ash	% of steel fiber	Split tensile strength after 7 days N/mm2	Split tensile strength after 28 days N/mm2
1	0%	0%	0%	2.6	4.19
2	10%	0%	0%	2.68	4.21
3	20%	0%	0%	2.53	3.69
4	30%	0%	0%	2.35	3.46
5	0%	10%	0%	2.12	3.11
6	0%	20%	0%	1.90	2.87
7	0%	30%	0%	1.59	2.68
8	10%	10%	0%	2.19	2.89
9	20%	10%	0%	2.04	2.72
10	20%	10%	0.25%	2.15	2.97
11	20%	10%	0.50%	2.33	3.11
12	20%	10%	0.75%	2.61	3.41
13	20%	10%	1.0%	2.35	3.18
14	10%	20%	0%	1.66	2.35

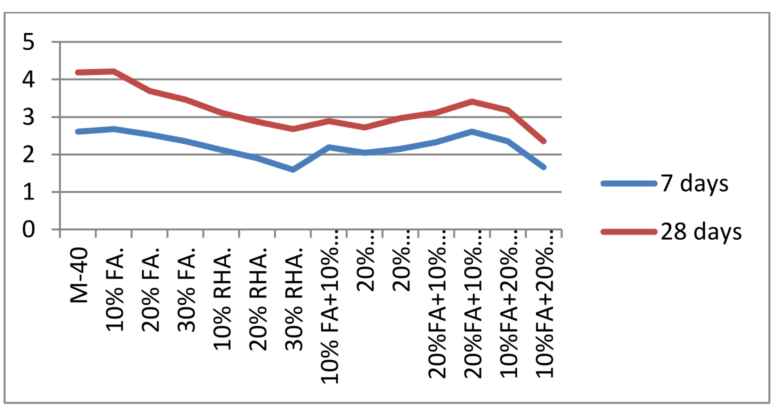

Fig No.3

VARIATION OF SPLIT TENSILE STRENGT AT DIFFERENT AGES

The experimental investigation aimed to study the behavior of M40 grade concrete with different replacements of cement by fly ash (FA), rice husk ash (RHA), and the addition of steel fibers. The compressive strength, flexural strength, and split tensile strength of the concrete were tested after 7 days and 28 days of curing.

1. Compressive Strength Results:
    - The compressive strength of the control mix (0% fly ash, 0% rice husk ash, and 0% steel fiber) after 28 days was 52.66 N/mm².
    - Replacement of 10% cement with fly ash resulted in a maximum compressive strength of 53.77 N/mm² after 28 days.
    - As the percentage of fly ash and rice husk ash increased, the compressive strength showed a decreasing trend.
    - The combination of 20% fly ash + 10% rice husk ash, along with 0.75% steel fiber, provided optimum compressive strength results.
2. Flexural Strength Results:
    - The flexural strength of the control mix after 28 days was 5.86 N/mm².
    - Replacement of 10% cement with fly ash showed the maximum flexural strength of 5.89 N/mm² after 28 days.
    - The addition of steel fiber in the concrete mix improved the flexural strength compared to plain mixes.
    - The combination of 20% fly ash + 10% rice husk ash, along with 0.75% steel fiber, provided the highest flexural strength.
3. Split Tensile Strength Results:
    - The split tensile strength of the control mix after 28 days was 4.19 N/mm².
    - Replacement of 10% cement with fly ash resulted in the highest split tensile strength of 4.21 N/mm² after 28 days.
    - The addition of steel fiber enhanced the split tensile strength of the concrete.

- The combination of 20% fly ash + 10% rice husk ash, along with 0.75% steel fiber, provided the highest split tensile strength.

Overall, the test results showed that incorporating fly ash and rice husk ash in concrete mixtures, along with the addition of steel fibers, improved the mechanical properties of the concrete. The combination of 20% fly ash + 10% rice husk ash, along with 0.75% steel fiber, provided the most favorable results for compressive strength, flexural strength, and split tensile strength. These findings highlight the potential of using supplementary cementitious materials and steel fibers to enhance the performance of concrete while reducing the environmental impact associated with cement production.

CONCLUSION

In conclusion, the experimental investigation on M40 grade concrete with varying proportions of fly ash, rice husk ash, and steel fibers showed promising results. The replacement of 10% cement with fly ash demonstrated the highest compressive and split tensile strengths after 28 days. The addition of steel fibers further improved the flexural and tensile properties, enhancing crack resistance and ductility. The combination of 20% fly ash + 10% rice husk ash, along with 0.75% steel fiber, provided the most optimal strength results. These findings highlight the potential of using supplementary cementitious materials and steel fibers to enhance the mechanical performance of concrete while promoting sustainable practices and reducing environmental impact. Further research is warranted to validate these outcomes in practical applications.

REFERENCES

[1] Rinki .K. Khot1, R. S. Deotale2, Abhijeet .R. Narde3,2014. To Study The Partial Replacement Of Cement By FA & RHA And Natural Sand By Quarry Sand In Concrete.IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE),Volume 11,e-ISSN: 2278-1684,p-ISSN: 2320-334X

[2] Satish H. Sathawanea*,VikrantS.VairagadebandKavita S Kenec,2013. Combine Effect of Rice Husk Ash and Fly Ash on Concrete by 30% Cement Replacement. www.sciencedirect.com

[3] R. S. Deotale, S. H. Sathawane, A.R. Narde,2012. Effect of Partial Replacement of Cement by Fly Ash, Rice Husk Ash with Using Steel Fiber in Concrete. Volume 3 ISSN 2229-5518

[4] Vasudev r, dr. B gVishnuram, 2013. studies on steel fibre reinforced concrete- a sustainable approach ”international journal of scientific & engineering research, volume 4, issue 5, may-2013 1941 issn 2229-5518 ijser

[5] T.Subramani , K.S.Ramesh2,2015. Experimental Study On Partial Replacement Of Cement With Fly Ash And Complete Replacement Of Sand With M sand. International Journal of Application or Innovation in Engineering & Management (IJAIEM) Volume 4, ISSN 2319 – 4847

[6] RohitSiwacha,S.S. Kajalb,Nikita Rajpalc,2015.Effect Of Fly Ash And Rice Husk Ash On Strength Characterstics Of Pavement Quality Concrete.International Journal of Science, Engineering and Technology Research (IJSETR),Volume 4,ISSN: 2278 – 7798

[7] M. Sivakumar1,T. Manikandan2,2014. An Experimental Study on Strength Development of Concrete Containing Composite Ash(Flay Ash-F & Rice Husk Ash). International Journal of Engineering Research & Technology (IJERT) Vol. 3, ISSN: 2278-0181

[8] Tarun Sama1, Dilip Lalwani2, Ayush Shukla3, Sofi A.4,2014. Effect of Strength of Concrete by Partial Replacement of Cement with Flyash and addition of Steel Fibres. Journal of Civil Engineering and Environmental Technology Volume 1, ISSN: 2349-8404

[9] Apoorv Singh*, Prof. R.D Patel**, Khalid Raza*** ,2014.A Comparative Study on Compressive and Flexural Strength of Concrete Containing Different Admixtures as Partial Replacement of Cement,Vol. 4 ISSN : 2248-9622

[10] Alvin Harison*, VikasSrivastava and ArpanHerbert.Effect of Fly Ash on Compressive Strength of Portland Pozzolona Cement Concrete.Journal of Academia and Industrial Research (JAIR),Volume 2,ISSN: 2278-5213

[11] Godwin A. Akeke, Maurice E. Ephraim, Akobo, I.Z.S and Joseph O. Ukpata,2013. Structural Properties Of Rice Husk Ash Concrete. International Journal of Engineering and Applied Sciences vol 3 ISSN2305-8269

[12] T. Phani Madhavi1, V.Sampathkumar2, P.Gunasekaran3,2013. partial replacement of cement and fine aggregate byusing fly ash and glass aggregate. International Journal of Research in Engineering and Technology, eISSN: 2319-1163 | pISSN: 2321-7308

[13] Amit Rana1, 2013. Some Studies on Steel Fiber Reinforced Concrete. International Journal of Emerging Technology and Advanced Engineering, Volume 3, ISSN 2250-2459

[14] IS 10153-1982. Guidelines for utilization and disposal of fly ash. Bureau of Indian Standard, New Delhi.

[15] Indian standard Code of Practice for Plain and Reinforced Concrete, IS- 456: 2000, 4th Revision, Bureau of Indian Standards, New Delhi.

[16] Indian standard recommended guidelines for Concrete Mix Design, IS 10262: 2009. 1st Revision, Bureau of Indian Standards, New Delhi.

[17] Indian standard Recommended guidelines for Concrete Mix Design, IS 10262: 1982, 5th Reprint 1998, Bureau of Indian Standards, New Delhi.

[18] Indian standard Specifications for coarse and fine aggregates from natural sources for concrete, IS 383-1970, Bureau of Indian Standards, New Delhi.

[19] Kumar, J., Singh, V., **Pareek, R.K**., (2015) “A Study on the Effect of Rice Husk Ash and Fly Ash on Strength Parameters of Pavement Quality Concrete. International Journal on Emerging Technologies; 6(2): 28-34(2015) ISSN No. (Online): 2249-3255, ISSN No. (Print): 0975-8364.

[20] Arun**, Pareek, R.K**., Singh, V. (2015) Effect of rice husk ash & plastic fibre on concrete strength, Int. journal of Civil and Structural Engineering, 6 (1): 2015 ISSN 0976- 4399.

[21] Indian standard method of tests for strength of concrete, IS 516: 1959, Edition (1991-07), Bureau of Indian Standards, New Delhi.

[22] Bansal, R., **Pareek, R.K**., Singh, V. (2015) on Effect on Compressive Strength with Partial Replacement of Fly Ash, Int. Journal on Emerging Technologies, 6(1): 1-6 (2015) (ISSN No. (Print): 0975-8364 (Online): 2249-3255