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Regression Models to Evaluate Compressive Strength of Polyethylene Terephthalate (PET) Fibre Reinforced Recycle Aggregate Concrete

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Abstract:-This paper presents the compressive strength of PET fibre reinforced recycles aggregate concrete. The Natural Aggregate (NC) was replaced by recycle aggregate (RA) in the proportion of 25, 50, 75 and 100%. PET fibres were added to the Recycle Aggregate Concrete (RAC) by 1 and 2% volume. Total 45 cubes were cast and tested. The results showed that as the % of RA and volume fraction of PET fibre content increases the strength was decreased. For obtained experimental results three simple Regression Models (RMs) were synthesized and the same are presented in this article.

Key words:- RAC, PET fibres, Compressive strength, Cube, Regression Models.

I. INTRODUCTION

The aggregate occupies about 75 to 80% of the concrete volume and play a substantial role in different concrete properties such as fresh and harden concrete properties, dimensional stability and durability. Conventional concrete consists of sand as fine aggregate and gravel, limestone or granite in various sizes and shapes as coarse aggregate. There is a growing interest in using waste materials as alternative aggregate materials. In this context Demolished Waste Material (DWM) of building or any structure (after completing of its lifespan) or during modernization, waste is generated. This can be utilized in the concrete as RA. Many research works has been carried out on RAC. Now days the plastic is also is a waste and this waste is using for many works as recycle products. Among the plastics family Polyethylene Terephthalate (PET) is one of the major product using by the society in the form of various articles. In this connection a review is presenting below related to PET fibres and RAC.

Marzouk et.al. [1] conducted the experimentation on concrete with plastic waste. The plastic material was used as sand substitution in the concrete. The results showed that the use of plastic bottle waste was effective and it attracts as low cost material. Siddique et.al.[2] investigated the effective utilization of waste products (tires, plastic, glass etc) in concrete. The study showed that the use of waste product in concrete not only makes it economical but also helps in reducing disposal problem. Kou et.al.[3] reported that splitting tensile strength of PVC concrete. From their study it is noticed that as PVC content increases the strength was decreased. Akcaozoglu et.al. [4] investigated the use of shredded waste polyethylene using two types of binders. The authors found that the compressive strengths of mortar with PET aggregate is higher with combination of binders. Kandasamy and Mrugesan [5] reported the behavior of composite material consisting of cement based matrix with an ordered or random distribution of fibre of steel, nylon, polythene. The results showed that the addition of fibres increases the properties of concrete. Baboo Rai et.al.[6] reported the concrete properties produced with waste plastic with and without plasticizer. The study showed that reduction in workability and compressive strength with inclusion of plastic. But they also specified that with addition of Plasticizer the strengths were increased marginally. Bhogayata et.al.[7] presents a comparative study of compressive strength of concrete made by mixing of plastic bags as concrete constituent. The results showed that as increase of plastic the compaction factor and compressive strength decreases. Jianzhuang Xial et.al[8] has given a overview of study on recycle aggregate concrete. In this paper different properties and behavior was described.Xiao.J.Zh. et.al [9] has shown relationships between mechanical properties of RAC. From literature it is observed that there is a little work has been focused on PET fibres with combination of RA. So the authors had planned to evaluate compressive strength (CS) of PET fibre recycle aggregate concrete. To find CS of PET fibre reinforced recycle aggregate concrete 45 cubes were cast and tested in the laboratory.

II. MATERIALS USED

1) ***Cement*****:** Ordinary Portland cement–53 grade was used. The specific gravity of cement was found as 3.15 and it satisfies the requirements of IS: 12269–1987 specifications.

2) ***Superplasticizer:*** To impart the additional desired properties, a super plasticizer (Conplast SP-430) was used. The dosage of superplasticizer adopted in the investigation was 0.85% (by weight of cement).

3) ***Sand:*** Locally available sand collected from river bed was used as fine aggregate. The sand used was having fineness modulus 2.96 and confirmed to grading zone-III as per IS: 383-1970 specification.

4) ***Coarse aggregates:*** The crushed stone aggregates were collected from the local quarry. The coarse aggregates used in the experimentation were 20mm and down size aggregate and tested as per IS: 383-1970 and 2386-1963 (I, II and III) specifications. The specific gravity was observed as 2.65.

5) ***Recycle aggregate concrete:*** The Recycled coarse aggregate obtained by crushing demolished concrete mass (Figure.1) and the same was used as recycled coarse aggregate in the present investigation. To obtain a reasonably good grading, 50% of the aggregate passing through 20 mm I.S. sieve and retained on 12.5mm I.S. Sieve and 50% of the aggregate passing through 12.5mm I.S. Sieve and retained on 10 mm I.S. Sieve is used. The specific gravity was found as 2.48.

6) ***Water:*** Ordinary potable water, free from organic content, turbidity and salts was used for mixing and for curing throughout the investigation.

7) ***PET Fibres:*** The waste PET fibres were obtained by cutting of unused drinking water bottles. The fibres were cut from steel wire cutter and it is labour oriented. The PET fibres were sieved and found that 10mm size are more in fiber content and the thickness was observed as 1mm. (Figure.2)

Fig.1 Collection of demolished concrete waste

Fig.2 PET fibres

III. CASTING AND CURING

Concrete was prepared by a design mix proportion of 1:1.90:3.09 with a W/C ratio of 0.45 which correspond to M20 grade of concrete. The entire mix was homogeneously mixed with calculated quantity of required materials. The compressive strength test specimens were (cube size is 150 x 150 x 150mm) cast and tested after 28 days of curing as per IS specifications. A total 15 mixes (45cubes) were consider in the investigation and for each mix three cubes are tested. The average value of ultimate load and stress of three cube specimens are presented in Table.1.In the table.1, RAC indicates recycle aggregate concrete , F1 and F2 indicates PET fibre volume fraction of 1 and 2% by volume of cast specimen (cube) and the number 0,25,50,75 and 100 indicates the % of replacement of granite aggregate with recycle aggregate. The RAC-0 considered as reference mix (M20) or Natural aggregate concrete (NAC), in this forth coming content the other mixes were compared with reference mix or NAC.

IV. TEST RESULTS AND DISCUSSION

A. Workability: The workability test results of RAC with and without waste PET fibre is presented in Table 1.0. From the results it is observed that as Recycle Aggregate (RA) content is increases the workability decreases. The decrease in slump may be due to higher water absorption capacity of RA than the Natural Aggregate (NA) The surface texture and angularity of RA may influence the workability performance. The slump test is also conducted for RAC with PET fibres. The design slump during mix designed process was taken as 50mm, where as when it comes to reality it showed the slump in the range of 49 to 19mm. From this it is observed that as the % of fibre increases the workability decreases. This may be due to sharp edge and shape of fibres, which act as barriers to the flow of concrete. The similar trend of decrease in slump is reported by the Frigione[10], Ismail and Al-Hashmi [11] and Kou et.al. [12].

Table 1.0 Workability

S.No.	Nomenclature	Slump (mm)
1	RAC-0 (Reference Mix)	49
2	RAC-25	48
3	RAC-50	46
4	RAC-75	40
5	RAC-100	40
6	RACF1-0	32
7	RACF1-25	31
8	RACF1-50	31
9	RACF1-75	30
10	RACF1-100	28
11	RACF2-0	25
12	RACF2-25	24
13	RACF2-50	23
14	RACF2-75	22
15	RACF2-100	19

B. Compressive Strength: The compressive strength results are presented in Table 2.0 and Figure 3.0. From this table and figure it is observed that as % of RA content increases the compressive strength decreases. For 25 to 75% replacement of RA in conventional mix the strength decrement is about 2 to 14%. The reason may be the bond between recycle aggregate concrete and new cement mortar forms weak links, but it is vice versa for reference mix or NAC. These types of observations were made by Rasheeduzzafar, Khan [13] and Torben C Hansen [14]. From those review articles it is observed that there is about 8 to 24% decrement in compressive strength when compared with NAC.

Table 2.0 Compressive strength

S.No.	Nomenclature	Average Ultimate Load(KN)	Average Ultimate Compressive Strength (N/mm2)	% of Decrease or increase
1	RAC-0 (Reference Mix)	750	33.33	-
2	RAC-25	723	32.13	- 2.89
3	RAC-50	696	30.93	- 7.20
4	RAC-75	673	29.19	-12.42
5	RAC-100	645	28.60	-13.98
6	RACF1-0	680	30.22	- 9.33
7	RACF1-25	647	28.75	-13.74
8	RACF1-50	619	27.51	-17.46
9	RACF1-75	596	26.54	-20.55
10	RACF1-100	577	25.64	-23.07
11	RACF2-0	506	22.48	-32.55
12	RACF2-25	485	21.55	-35.34
13	RACF2-50	467	20.75	-37.74

14	RACF2-75	452	20.08	-39.97
15	RACF2-100	436	19.37	-41.88

The Compressive strength of RAC with fibres is in the range of 30 to 19 MPa. As the % PET fibre increase the compressive strength decreases. The design compressive strength of 20MPa is plotted in the Figure 3.0. This value touches the 2% of PET fibre RAC at 75% replacement of RA. This indicated that, RAC with 1% fibre volume and upto 100% replacement of RA is effectively utilized, but the RAC with 2% fibre upto 75% replacement of RA is permitted for the designer/engineer in charge at site. The decrease in compressive strengths for RAC with PET fibres may be due to low bond strength between the surface of plastic waste and cement paste as well as the hydrophobic nature of plastic waste, which can inhibit cement hydration reaction by restricting water movement and another reason may be particle size and shape between natural and plastic fibre. Frigione [10] was reported this type of trend for natural aggregate concrete with plastic waste.

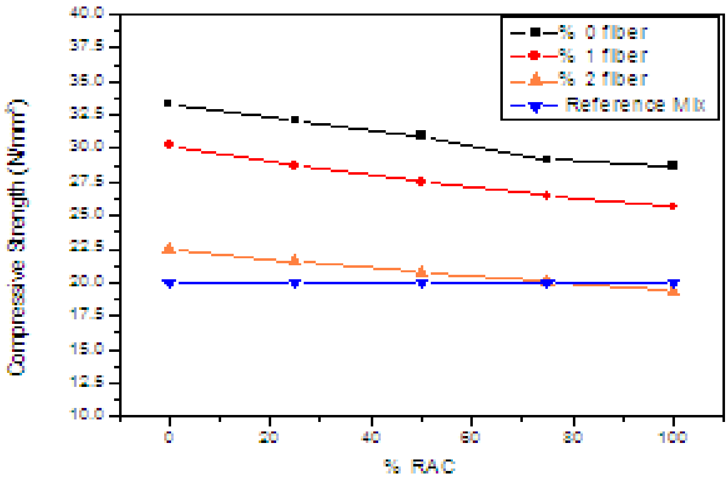

Fig 3.0 Compressive strength vs % of RAC

V. REGRESSION MODELS

From Jianzhuang Xiao et.al [8] is observed that the compressive strength of the RAC decreases with increase of RA content in the mix. This statement is once again ascertained in the present experimental work. From Figure.3 it is observed that, the relation between compressive strength and % of RAC exhibits approximately a linear relationship. A statistical regression analysis is undertaken to establish the empirical relationship between the compressive strength and % of RAC where a linear regression modal is used. The result is given by

f_{ck}= A (%RAC)+B

Where A and B are regression coefficients

f_{ck} is compressive strength in MPa

% RAC is percentage of recycle aggregate content in the mix

Thus the relation between the compressive strength and % of RAC can be established for 0, 1 and 2% of PET fibres is

f_{ck}=33.30-0.050(%RAC)------------------- for 0% PET fibre

f_{ck}=30.00-0.045(%RAC)------------------- for 1% PET fibre

f_{ck}=22.38-0.030(%RAC)------------------- for 2% PET fibre

The correlation coefficient of R^2 for 0, 1 and 2% PET fibre RAC is 0.982, 0.990 and 0.995 respectively.

The experimental and regression model (RM) analysis results are presented in Table 3.0 and Figure 4.0. From the results it is observed that the ratio between experimental (EXP) and regression model (RM) is about 0.98 to 1.00. This indicates the proposed regression models well suited to experimental values.

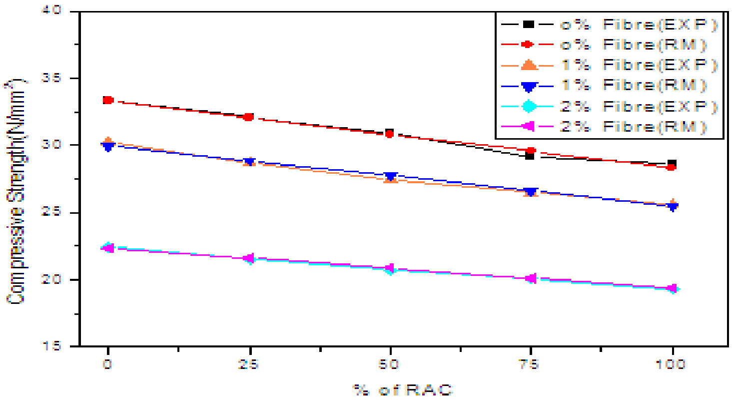

Fig 4.0 Performance of Regression Modal

Table 3.0: Performance of Regression Model for Compressive strength

Sl.No	Nomenclature	Experimental Compressive strength	Regression Model Compressive strength	Experimental compressive strength/ Regression Model compressive strength (EXP/RM)
1	RAC-0 (Reference Mix)	33.33	33.33	1.00
2	RAC-25	32.13	32.08	1.00
3	RAC-50	30.93	30.83	1.00
4	RAC-75	29.19	29.58	0.98
5	RAC-100	28.60	28.33	1.01
6	RACF1-0	30.22	30.00	1.00
7	RACF1-25	28.75	28.87	0.99
8	RACF1-50	27.51	27.75	0.99
9	RACF1-75	26.54	26.62	0.99
10	RACF1-100	25.64	25.5	1.00
11	RACF2-0	22.48	22.38	1.00
12	RACF2-25	21.55	21.63	0.99
13	RACF2-50	20.75	20.88	0.99
14	RACF2-75	20.08	20.13	0.99
15	RACF2-100	19.37	19.38	0.99

VI. CONCLUSIONS

1. As % of Recycle Aggregate (RA) content in the mix increases the compressive strength decreases.
2. The decrease in the compressive strength for RAC is about 3 to 14 % for 25 to 100% of RA content in the design mix when compared to RAC.
3. The compressive strength decrease as % of PET fiber volume increase in RAC.
4. The decrease of compressive strength for 1% and 2% of PET fibre volume is about 9 to 41 % compared to reference mix.
5. The proposed models presented herein are made good compatibility with experimental results.

REFERENCES

[1] Marzouk O Y, Dheilly RM Queneudec M, Valorization of post consumer waste plastic in cementitious concrete composites,Waste Manage,27,pp310-318,2007.

[2] Siddique R,Khatib J, Kaur I ,"Use of recycled plastic in concrete, A review waste management" 28,pp1835-1852,2008.

[3] Kou SC,Poon CS ,"Properties of light weight aggregate concrete prepared with PVC granules drived form scraped PVC pipes", Waste manage (Oxf),29(2),pp621-628,2009.

[4] Akcaozoglu S,Atis CD,Akcaozoglu K, "An investigation on the use of shreadded waste PET bottles as aggregate in light weight concrete",Waste manage (Oxf),32(2),pp258-290,2010.

[5] Kandasamy R and Murugesan R , “Fibre reinforced concrete using domestic waste plastic as fibres”, ARPN journal of Engineering and Applied Sciences,6(3),pp75-82,2011.

[6] Baboo Rai, Tabin Rushad S,Bhavesh KR, Duggal SK , “Study of waste plastic mix concrete with plasticizer”, ID 4692,72,pp1-5,2012.

[7] Bhogayata A,Shah K D, Vyas B A, Arora N K “Performance of concrete by using Non recyclable plastic wastes as concrete constituent”, International journal of Engineering Research and Technology(IJERT),1(4),pp1-3,2012.

[8] Jianzhuang Xiao,Wengui Li,Yuhui Fan, Xio Huang,”An over view of study on recycle aggregate concrete in china (1996-2011)”,Construction and building materials,31,pp364-383,2012.

[9] Xiao J.Zh., J.B. Li. Ch Zhang,”On relationship between the mechanical properties of recycle aggregate concrete:An over view”,Materials and structures,39,pp655-664,2006.

[10] Frigione M, “Recycling of PET bottle as fine aggregate in concrete”, Waste Manage (Oxf),30(6),pp1101-1106,2010.

[11] Ismail ZZ, Al-Hashmi EA,’Use of Plastic waste in concrete mixture as aggregate replacement’, Waste Manage (Oxf) 28(11), pp2041-2047, 2008.

[12] Kou SC, Lee G,Poon CS,Lai WL,”Properties of light weight aggregate concrete prepared with PVC granules derived from scraped PVC pipes” Waste Manage (Oxf) 29(2), pp621-628, 2009.

[13] Rasheeduzzafer, Khan A,”Recycle aggregate concrete a source of new aggregate ,cement, concrete and aggregate(ASTM)” Vol 6,No.1,pp17-27,1984.

[14] Torben C Hansen “Recycle aggregates and recycle aggregate cocncrer second stat-of-the art report developments 1945-1985” RELEM Technical committee-37DRC,pp201-246,1986.