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Influence of Fine Aggregate Proportion on Both Fresh & Hardened Concrete Properties

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***Abstract*: The fine aggregate content in the concrete mix plays an important role in both fresh & hardened concrete properties. In general while designing the concrete mix, designer of concrete mix is not giving proper attention due to lack of time & also due to committed schedule delivery of design mix for implementation at project site. However the proportions of sand content in total aggregate of concrete mix proportion is having a significant influence on both fresh concrete & hardened concrete properties. In the present research work it has been observed that on reduction of sand content in the mix has reduce the workability of concrete while on increase in sand content of the concrete mix has significantly increase the workability of fresh concrete. The present research work has also revealed that on increase or decrease in sand content beyond the optimum proportion has significantly influence the reduce strength of hardened concrete.**

Keywords: Fine aggregate; workability; Slump; Compressive Strength; Flexural Strength, LSF, SR, AR.

I. INTRODUCTION

The proportion of fine aggregate content in the concrete has significantly influence both fresh concrete & hardened concrete properties. But even knowing the fact & influence of fine aggregate content in concrete properties sufficient attention is not giving by the designer during selection of various ingredient during designing of concrete mix. In general while designing of any concrete mix usually lab trial is conducted mostly by varying the cement content due to shortage of time rather varying the fine aggregate proportion. Because of the lack of sufficient attention towards choosing of adequate fine aggregate content in mix by doing lab trial by varying the fine aggregate proportion along with cement content proper behaviors of both fresh concrete & hardened concrete cannot be ascertain properly. In most cases it has been observed that the recommended mix proportions for any grade of concrete by third party concrete mix designer is found different in both fresh & hardened concrete properties during site trials than recommended fresh & hardened concrete properties in third party laboratory. In the present research work it has been observed that on reducing the fine aggregate content in the mix the workability of fresh concrete got reduced significantly, while on increasing the fine aggregate content in the concrete mix the workability of fresh concrete got increased significantly. The present research work has also revealed that on increase or decrease in sand content beyond the optimum proportion has significantly influence strength of hardened concrete.

II. MATERIAL

The cement used for the present research work was Ordinary Portland cement of CEM-I, as per BSEN-197-1 [1]. & the coarse & fine aggregate used for the present research work is of crushed Basalt rock & river sand having FM of 2.65. The super plasticizer used in this research work was of PCE based superplasticizer of FOSROC brand [2]. The reference grade of concrete used for this present research work was C-30/37 grade concrete with Ordinary Portland cement of CEM-I, 52.5N class cement as per BSEN-197, Part-I. The mix proportion of reference grade concrete is having 435 kg CEM-I 52.5N grade cement with water to cement ratio is 0.4 & coarse aggregate content of 20 mm nominal size having combination of 20 mm 60% & 10 mm 40% by weight of total coarse aggregate. The Fine aggregate content in the reference mix is 685 kg which is 37.49% of total aggregate ratio & the superplasticizer used in the research work is 1% by weight of cement. Thus in the present research work various sample were taken by changing the Fine aggregate proportions keeping other ingredient remain same. The material property of various ingredient of concrete are presented below tables.

Table-I
Properties of Cement

SL No	Test parameters Details	UOM	Properties of Cement CEM-I, 52.5N Class as per BSEN-197, Part-1
1	Sp gravity	-	3.15
2	Blaine Fineness	M2/Kg	343
3	45 micron retain	%	2.5
4	IST	Minute	125
5	FST	Minute	230
6	C_3A	%	8.98
7	C_3S	%	53.11
8	C_2S	%	19.28
9	C_4AF	%	13.38
10	LSF	Ratio	0.92
11	SR	Ratio	2.10
12	AR	Ratio	1.24

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Table-II
Properties of coarse aggregate

Combined graded coarse aggregate 20 mm +10 mm (60:40)			
SL No	**Test parameters Details**	**UOM**	**Properties of Coarse aggregate as per ASTMC-33**
1	**Sp gravity**	**-**	**2.81**
2	**Flakiness Index**	**%**	**27**
3	**Elongation Index**	**%**	**14**
4	**Crushing Strength**	**%**	**18.66**

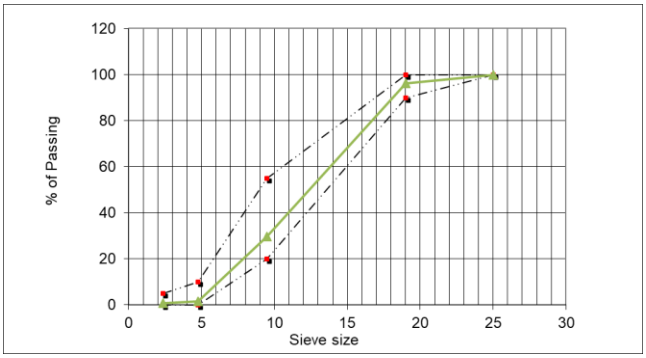

Fig-1: Combined graded coarse aggregate sieve analysis

Table-III
Properties of fine aggregate

SL No	Test parameters Details	UOM	Properties of Fine aggregate as per ASTMC-33
1	**Sp gravity**	**-**	**2.63**
2	**Fineness Modulus**	**-**	**2.61**
3	**75 micron passing**	**%**	**2.9**

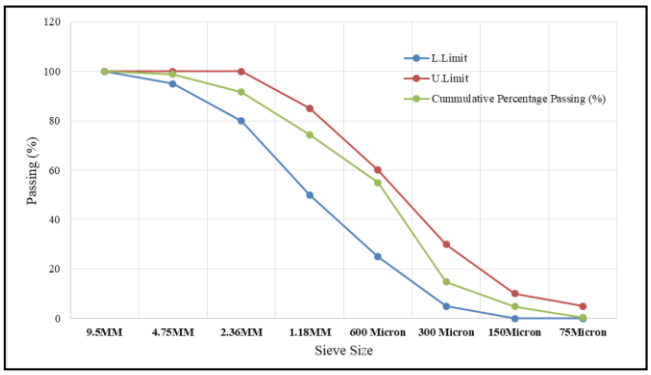

Fig-2: Combined graded fine aggregate sieve analysis

Table-IV
Mixing water test results

SL No	Test parameters Details	UOM	Mixing water test results as per ASTMC-1602
1	**pH**	**-**	**7.2**
2	**Chloride content**	**ppm**	**45**
3	**Sulphate content**	**ppm**	**235**
4	**Alkalies**	**ppm**	**145**

III. EXPERIMENTAL DETAILS

In this present research work a reference grade of concrete C-30/37 were used having cement content of 435 kg per cum with water to cement ratio of 0.4 and fine aggregate proportion of 37.49% of total aggregate combination. The study was conducted mostly by changing the fine aggregate proportion keeping the total aggregate mass, cement content, w/c ratio and superplasticizer doses in the mix were kept constant. In this experiment the 150 mm sizes concrete samples were prepared for 3-days, 7-days, 28-days compressive strength & 250 mm x 250 mm x 500 mm size beam samples were prepared for flexural strength of concrete at 28-days respectively. The following numerical expression are used to find out the packing density, voids content in the aggregate combination.

1. Packing density (Maximum) = (Bulk density) x Weight fraction / Sp gravity
2. Void content = 1- Packing density.

Table-V
Mixing proportions of various Sample ID

SL No	Ingredient Details	UOM	Quantity in different sample ID				
			Sample ID S-0	Sample ID S-1	Sample ID S-2	Sample ID S-3	Sample ID S-4
1	**Cement**	**Kg**	**435**	**435**	**435**	**435**	**435**
2	**Water**	**Kg**	**174**	**174**	**174**	**174**	**174**
3	**w/c ratio**	**ratio**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**
4	**Coarse Aggregate**	**Kg**	**1142**	**1187**	**1096**	**1005**	**913.5**
5	**Fine Aggregate**	**Kg**	**685**	**640**	**730.8**	**822**	**913.5**
6	**% Fine Aggregate**	**%**	**37.49**	**35.03**	**40.00**	**44.99**	**50.00**
7	**% Coarse Aggreagte**	**%**	**62.51**	**64.97**	**60.00**	**55.01**	**50.00**
8	**Superplasticiser**	**Kg**	**4.35**	**4.35**	**4.35**	**4.35**	**4.35**

Fig-3: Mixing & slump test of concrete

Fig-4: Preparation of cube sample

Fig-5: Beam samples for flexural strength

Fig-6: Compressive & Flexural strength test.

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IV. RESULTS AND DISCUSSIONS

From the experimental results it has been observed that on increasing the fine aggregate proportion in total aggregate combination the packing density of the aggregate combination get increased & thus reduce the void volume in the aggregate combination get reduced. The research work also revealed that on increase in paste volume to void ratio of the aggregate combination both compressive strength & flexural strength get reduced. From the experimental outcome it has been observed that the strength of concrete is increasing for 1.15 to 1.20 paste to aggregate void volume ratio & on further increasing the paste to aggregate void volume ratio the strength of the concrete is decreasing. Because of the higher paste volume in concrete the hydration of coarser cement particles might be suspended due to shielding effect by finer cement particles hydration product on coarser cement particles. In addition to that the reduction of strength of concrete on increasing the paste to aggregate void volume ratio leads to formation of internal thermal cracks in gel structure because of elevated heat of hydration of CEM-I, 52.5N grade cement [1], higher fineness (343 m2/kg), higher percentage of C3S (53.11%) and C3A (8.98%) [3]. On the other side the research work also revealed that on increasing the fine aggregate proportion from 35 to 37.5% the strength of the concrete get increased & beyond 37.5% the strength of the concrete is gradually decreasing. This may be because of increasing fine aggregate proportion after certain optimum proportion like 37.5% the surface area of the aggregate get increased & resulting formation of weak interfacial transition zone (ITZ) [2]. The experimental results also shows that on increasing the fine aggregate proportion the workability of fresh concrete get increased due to reduction internal friction between the aggregate particles. In the present research work it is also observed that the strength of concrete at 3-days & 7-days are very high due to higher Lime saturation factor (LSF = 0.92) and higher Silica ratio (SR = 2.1) in the cement composition. The higher the Lime saturation factor in the cement indicate that calcium silicate present in the cement composition are mostly in the form of Tri-calcium silicate (C_3S) and higher Silica Ratio (SR) indicate that more calcium silicate are present in the clinker and less aluminate and ferrite [5]. The detail experimental results of different concrete samples with varying proportion of fine aggregate content in total aggregate combination are hereby represented in Table-VI.

Table-VI
Test results of various Sample ID

SL No	Testing parameter	UOM	Test results of different sample ID				
			Sample ID S-0	Sample ID S-1	Sample ID S-2	Sample ID S-3	Sample ID S-4
1	Fresh concrete Density	Kg/m3	2564.5	2647.6	2548.4	2551.4	2435.3
2	Hardened concrete Density	Kg/m3	2551.7	2622.2	2529.19	2537.93	2415.7
3	Initial Slump	mm	140	135	165	220	240
4	Bulk Density of 20 mm aggregate	Kg/m3	1718	1718	1718	1718	1718
5	Bulk Density of 10 mm aggregate	Kg/m3	1696	1696	1696	1696	1696
6	Bulk Density of fine Aggregate	Kg/m3	1541	1541	1541	1541	1541
7	Combined Bulk Density 20 mm +10 mm + fine agg	Kg/m3	2067	2081	2084	2085	2096
8	Combined packing Density of 20 mm +10 mm + fine agg	m3	0.74	0.73	0.75	0.76	0.77
9	Void in aggregate combination	m3	0.26	0.27	0.25	0.24	0.23
10	Paste volume	m3	0.31	0.31	0.31	0.31	0.31
11	Paste volume to void ratio	Ratio	1.20	1.16	1.25	1.30	1.36
11	3-Days compressive Strength	Mpa	40.56	34.8	37.73	33.62	29.11
12	7-Days compressive Strength	Mpa	50.11	42.42	42.42	45.69	36.18
13	28-Days compressive Strength	Mpa	60.56	52.76	49.24	46.58	41.64
14	28-Days Flexural Strength	Mpa	5.52	5.24	4.98	4.83	4.63

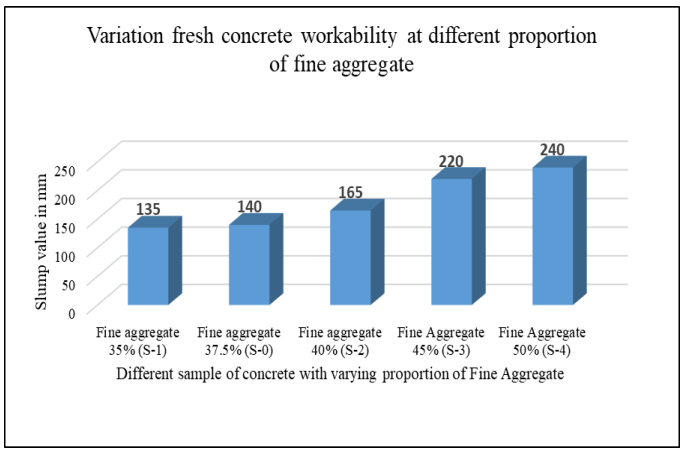

Fig-7: Influence on fresh concrete properties due to increasing in fine aggregate proportion.

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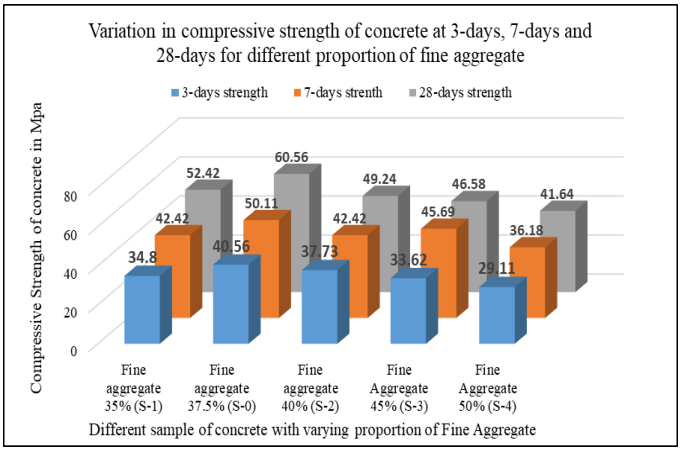

Fig-8: Influence on compressive strength of concrete at different ages due to increasing in fine aggregate proportion.

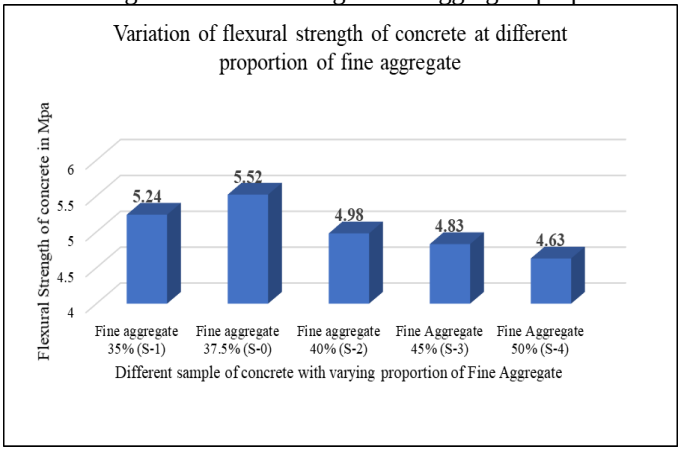

Fig-9: Influence on Flexural strength of concrete at different ages due to increasing in fine aggregate proportion

V. CONCLUSION

The following are the various outcome of present research works.

1. On increasing the fine aggregate proportion in the concrete mix the workability of fresh concrete will get increased. It's because of reduction of internal friction due to increasing fine aggregate content in the mix.
2. On increasing the paste volume of cement in the mix beyond 20% higher than void volume of aggregate will have detrimental effect on strength development of concrete. As higher the paste volume in concrete higher is the heat of hydration & resulting weak ITZ formation due to thermal stresses & its crack formation.
3. At higher LSF of cement composition the early strength of concrete is very high.
4. On increasing the fine aggregate proportion after optimum proportion resulting formation of weak interfacial transition zone (ITZ) of aggregate leading to poor strength of concrete.
5. On increasing the fine aggregate proportion beyond 37.5% both compressive strength & flexural strength of concrete are gradually decreasing.

REFERENCES

[1] BS EN-197, Part-1. Composition, Specifications and conformity criteria for common cements.
[2] Book "Concrete Microstructure, properties & Materials "by P.Kumar & Paulo J. M. Monteiro.
[3] ASTMC-150:2018, Standard specification for Portland cement.
[4] ASTMC-33-08, Standard Specifications for concrete aggregate.
[5] Understanding cement by Nicholas B Winter.
[6] Wong, H. C. H. and Kwan, K. H. A., "Packing density: A key concept for mix design of high performance concrete".
[7] Wong, H. C. H. and Kwan, K. H. A. (2008) "Packing density of cementitious materials: part 2 – packing flow of OPC + PFA + CSF". Materials and structures, 41:773 – 784.
[8] Fennis, S. A. A. M. and Walraven, J. C. (2008) "Measuring the packing density to lower the cement content in concrete".
[9] Glavind, M. and Peterson, E. J. (1999) "Packing calculations applied for concrete mix design". University of Dundee.
[10] Kantha Rao, V. V. L. And Krishnamoorthy, S., "Aggregate mixtures for least-void content for use in polymer concrete".
[11] Powers, T. C. (1968) The properties of fresh concrete. John Wiley and Sons, Inc.. New York.

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