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AN EXPERIMENTAL STUDY ON M25 GRADE OF SELF COMPACTING CONCRETE USING MANUFACTURED SAND AND FLY ASH WITH DIFFERENT PERCENTAGES OF GLASS FIBERS

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Abstract - *Self Compacting Concrete (SCC) is capable to move steadily and continuously along its intrinsic weight and altogether fill the formwork, similar in the existence of congested reinforcement,without compaction, although enduring homogeneity of the concrete. Compaction is demanding to be accomplished in circumstances as in Conventional Concrete (CC). Present study deals with M25 grade for Conventional Concrete (CC) and Self Compacting Concrete (SCC) both together bear water cement ratio of 0.43. Self Compacting Concrete (SCC) is tested without glass fibers and with glass fibers of different percentages as such 0.00%, 0.25%, 0.50%, 0.75%, 1%, 1.25% and 1.50% to the volume of concrete mix. Fly ash as constant 20% replacement in cement, manufactured sand is used all through the experiment. Tests were organized on workability, strength and durability. For CC of workability like Slump flow test was carried. SCC of fresh properties like Slump flow and T_{50cm}, J-box, L-ring, V-funnel and V-funnel at T5 minutes tests are done to SCC in fresh state for all differences, were within the limits prescribed by EFNARC guidelines. Strength criteria and durability criteria as per IS: 456-2000. Strength tests were organized for CC and SCC of all differences such as Compressive strength, Split tensile strength and durability tests like water absorption and density tests.*

Key Words: *Self Compacting Concrete, Glass Fibers, Manufactured Sand, Fly Ash, Compressive Strength, Split Tensile Strength, Water Absorption, Density.*

1.INTRODUCTION

Self Compacting Concrete (SCC) is one of the radical concrete that does not demand vibration for placing and consolidation. It was developed firstly in Japan in the delayed 1980. This type of concrete was crucial and was focus ahead by Okamura at the time of 1986. SCC basic experiment on concrete workability was performed by ozawa and maekawa over the university of Tokyo. To upgrade the durability and homogeneity concerning concrete was developed in 1988 and first disclosed in 1989. Okamura found SCC in Japan and popularized, extensively practiced chiefly on pre-cast concrete due to cutback in its cost by Okamura and Ozawa in 1994. SCC can be accessed by hiked content in powder with lesser coarse aggregate as correspond to Conventional Concrete (CC); low water to powder ratio, super plasticizer is used for the well-being of the development of fine particles of a immense quantity. Here powder content resembles cement and filler together. Filler used in this experiment was fly ash. Mineral admixture such as fly ash can be partially replaced by cement. Fly ash improves strength and durability characteristics of concrete; it leads early strength due to passive hydration which intern hikes workability in concrete. SCC is of brittle criteria; even glass fibers are added to SCC, this advance in the dissemination of cracks. Super Plasticizer (SP) is of high range water reducers and hikes the fluidity by the same period. To overcome bleeding Viscosity Modifying Agent (VMA) was used. As per modified Nan-Su method SCC was designed. The outcome of different percentages of glass fibers with fly ash, on the characteristics of SCC have been studied along with the comparison of CC. Nan Su et. al.,[1] this investigation made the innovative mix design for SCC, in order to achieve flowability, self consolidating characteristics and other required SCC characteristics. Here voids of the aggregates are packed by the paste of binders. Super plasticizers to be used are determined. Characteristics of fresh state like slump flow, U-box, L-flow and compressive strength tests were well to check the performance of manufactured SCC. As it is simple to implement, saving cost, saves time consuming and needs less quantity of binders. Gonclaves et. al.,[3] in this investigation, manufactured sand is owing to high fines, it commit for hike in plastic viscosity. There is no variation in workability as of river sand, makes cement mortar of 23% lower absorptive and hikes nearly 23% of strength. The mechanical and durability characteristics are recorded to be notably enhanced by the use of manufactured sand. Dr S Deepa Shri et al.,[4] in this research, main constituents such as cement, fly ash, manufactured sand (M-sand) and coarse aggregate made SCC. Different proportion fly ash and cement had been done, this fresh state properties are checked within deadline of EFNARC. Here water absorption hikes due to behavior of fly ash and hike percentages as correlated to Conventional Concrete at the initial ages. During the mechanism of fly ash reaction takes place then there is noticeable hike in percentage of water absorbed at 28 days. Hike in percentage of fly ash outcomes in a moderate cutback in sorptivity. As less fly ash content of 15% noticed to get water absorption by capillary action is virtually similar as Conventional Concrete. Aijaz Ahmed Zende et al.,[5] did present research for SCC and did contrast with Conventional Concrete. This study suggests that SCC gives good environment to overcome by placing and outcome complication like segregation, honey combing and it does not commit consolidation. Enhance in the durability and quality of concrete can be concluded. Vilas V Karjinni et al.,[6] in this study SCC of contrast mineral admixtures such as fly ash, metakaolin, etc, using Nan Su method and modified Nan Su method. Features of fresh and hardened state of SCC are studied; requirement of this study is to know the behavior of SCC with different percentages of fly ash as filler. Vanita Aggarwal et al., [11] did study on SCC by partial replacement of cement from contrast percentage of fly ash and studied strength contrast at early and later stages of it. It is noticed that the minimized water binder ratio and hike in percentage of replacement of fly ash, it influence hike in compressive strength. By this study 40% substitution is optimum and strength characteristic at 28 days is more and it achieve high strength at later age. Sahana Sheril P T et al.,[12] did comparison on fresh and hardened properties of M20 and M30 grades of concrete mixes of SCC and Glass Fiber Reinforced Self Compacting Concrete (GFRSCC). In this research Cem-Fil Anti-crack glass fiber was used. 25% of fly ash is replaced in cement for both SCC and GFRSCC. 5 mix proportions of SCC and GFRSCC of both M20 and M30 grade concrete were done. Admixture used was Glenium B233. The dosage of Glenium used for M30 and M20 grade are 1.1% and 1.2% respectively. Analyzing the specimen of 0.05%, 0.1%, 0.15% and 0.20% of glass fibers on total volume of mix makes hike in compressive strength by 8.2%, 9.2%, 7.02% and 3.5% respectively than the SCC without glass fibers, M20 grade mixes and specimen with 0.05%, 0.1%, 0.15% and 0.20% of glass fibers has hike in compressive strength of 5.1%, 7.1%, 5% and 2.3% respectively. Split tensile strength was developed ranging from 3.7 Mpa to 4.75 Mpa for M20 grade and for M30 grade from 4.53 Mpa to 4.8 Mpa. Asha Deepthi et al.,[17] investigations on CC and SCC was done for M30 grade of concrete mix. CC and SCC was designed by IS code and Nan Su method respectively. Admixture of fly ash with different percentages at 10%, 20% and 30% by using suitable dosage of super plasticizer and viscosity modifying admixture. Fresh state properties of SCC were checked. M30 grade of SCC was designed without mineral admixture; it gives less strength when compared with CC of M30 grade of concrete mix. Fly ash at 30% in SCC appears the hike in compressive strength and split tensile strength at 30 % of fly ash. Thus, hike in compressive strength and split tensile strength at 30% of fly ash in M30 grade of SCC is 23.89% and 18.77% higher than that of SCC without admixture. Miao Liu et. al.,[18] in this study made contrast of CC and SCC. SCC usually has more powder content than CC. Thus, it is required to substitute some of the cement by fillers to achieve budgetary and durable concrete.

2.PRESENT WORK

2.1 Objective and Scope

The objective of the present work is to study the physical and chemical properties of constituent materials of concrete. To study the fresh and hardened state properties of conventional concrete and self compacting concrete of all dissimilarities.

The scope of this study is to gain advanced good quality and durable concrete. To hike and enhance the alternatives in concrete constituents intern eradicate dangerous and waste material dumping like fly ash and glass fibers.

2.2 Material Characterization

2.2.1 Cement

The cement used in the present work was 53 grade Ordinary Portland cement. The physical properties of cement which were experimentally determined in the current study are shown in Table 1.

Table -1: Physical Properties of Cement used

Physical Properties	Value Achieved	Demand as per IS: 12269-1987
Specific gravity	3.15	-
Standard consistency	30%	-
Fineness of cement	3%	< 10%
Initial setting time	49 minutes	> 30 minutes
Final setting time	197 minutes	< 600 minutes

2.2.2 Manufactured Sand as Fine Aggregate

Manufactured sand is smashed aggregate which is available in the ready mix concrete plant. The properties of fine aggregate used in the current study are shown in Table 2.

Table -2: Physical Properties of Fine Aggregate

Physical Properties	Value Achieved
Specific gravity	2.61
Loose sand bulk density	1435 Kg/m^3
Compacted sand bulk density	1610 Kg/m^3
Packing factor	1.06
Water absorption	3%
Modulus of fineness	3.41
Grade	Fit to grading zone II of IS: 383-1970

2.2.3 Coarse Aggregate

Coarse aggregate were collected from near quarry plant was Bagewadi, Belgaum (District), Karnataka. The properties of coarse aggregate used in the current study are shown in Table 3.

Table -3: Physical Properties of Coarse Aggregate

Physical Properties	Value Achieved
Loose aggregate bulk density	1391 Kg/m^3
Compacted aggregate bulk density	1575 Kg/m^3
Shape	Angular
Specific gravity	2.65
Modulus of fineness	6.7
Packing factor	1.09
Water absorption	1%
Grade	Fit to grading zone II of IS: 383-1970

2.2.4 Fly Ash

Fly ash used in the current study was collected from Raichur Thermal Power Station (RTPS), Karnataka. The physical properties of fly ash are shown in Table 4. The chemical compositions of fly ash are shown in Table 5.

Table -4: Physical Properties of Fly Ash

Physical Properties	Value Achieved
Specific gravity	2.1
Modulus of fineness	2.5%
Normal consistency	31%

Table -5: Chemical Composition of Fly Ash

Characteristics	Raichur Thermal Power Station Fly Ash Composition (%)
SiO_2	54
Absolute sulfur as SO_3	0.40
MgO	1.20
Ignition loss	4
SiO_2 + FeO_3 + Al_2O_3	87
Feasible alkali as sodium oxide (Na_2O)	2.16

2.2.5 Chemical Admixture

In the current study, super plasticizer MYK Remicrete PC 5 is used for conventional concrete and for self compacting concrete MYK Remicrete PC 20 was used. MYK Remicrete PC 20 is not only a super plasticizer but also in conjunction with viscosity modifying admixture. The properties of super plasticizers are shown in Table 6.

Table -6: Properties of Super Plasticizer

Physical Properties	MYK Remicrete PC 5	MYK Remicrete PC 20
Specific gravity	1.05 ± 0.05 at 27^0 C	1.10 ± 0.05 at 27^0 C
Appearance	Clear to light brown	Clear to brown
Chloride content	Minimum 6.0 at 27^0 C	
P_H	Nil to BS: 5075	

2.2.6 Glass Fibers and Water

Cem-Fil Anti-Crack HP glass fibers are used in the current study. Potable water was used for mixing and curing the concrete in fresh and hardened state. Properties of glass fibers are shown in Table 7.

Table -7: Properties of Glass Fibers

Properties	Value
Filament diameter	17 µ
Length	12 mm
Aspect ratio	705.9
Elasticity modulus	72 Gpa
Electrical conductivity	Very low
Chemical resistance	Very high
Ignition loss	1%
Percent elongation	2.3
moisture	0.30% maximum
Tensile strength	1700 Mpa
Material	Alkali resistance
Specific gravity	2.68 g/cm^3

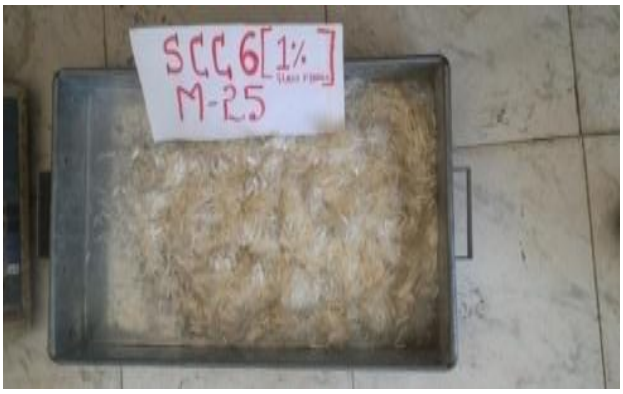

Fig -1: AR (Alkali Resistant) Glass Fibers

2.3 Mix Proportions used

The mix proportions for conventional concrete were attained at by carrying out mix design by using IS: 456-2000. For self compacting concrete mix design was performed by using modified Nan-Su method and suitably using EFNARC guidelines. The cement was replaced by 20% constant fly ash in all the mixes of self compacting concrete. The percentages of glass fibers vary from 0 to 1.5 percent by volume of concrete. The details of the different mixes used in the current work are shown in Table 8.

2.4 Fresh Concrete Tests

Workability test for conventional concrete was carried out as per IS: 456-2000 as shown in Table 9. Workability tests for self compacting concrete of all mixes was carried out as per EFNARC are shown in Table 10.

Contrasting of Table 10 with EFNARC guidelines shows that all the mixes fulfill the workability requirements of self compacting concrete.

2.5 Compressive Strength Tests

The concrete in fresh state was filled in the cube moulds as per IS: 10086-1982 of size (150 × 150 × 150) mm was used. For conventional concrete cube moulds were filled into 4 layers of concrete, each layer was rodded by 25 times with the help of tamping rod and the top surface was finished by the help of trowel. For self compacting concrete cube moulds were filled without compaction and finally the top surface was finished with the trowel. The CC and SCC specimens were left for hardening upto 24 hours. By using compression testing machine applying load at 200 tons, practicing as per IS: 516-1959 at 3, 7 and 28 days tests was carried out. The results are shown in Table 11 and plotted in chart 1. The number within parentheses in Table 11 designates the percentage of hike in strength relative to reference mix.

Table -8: Mix Proportions Used

Mix Code	Mix Proportion (Kg/m³)				W/C Ratio	SP (%)	Glass Fibers (%)
	C	F	FA	CA			
CC1	366.51	-	699.17	1208.72	0.43	1	-
SCC2	360.71	72.28	938.63	772.54	0.43	0.8	0
SCC3	360.71	72.28	938.63	772.54	0.43	0.8	0.25
SCC4	360.71	72.28	938.63	772.54	0.43	0.8	0.50
SCC5	360.71	72.28	938.63	772.54	0.43	0.8	0.75
SCC6	360.71	72.28	938.63	772.54	0.43	0.8	1
SCC7	360.71	72.28	938.63	772.54	0.43	0.8	1.25
SCC8	360.71	72.28	938.63	772.54	0.43	0.8	1.50

Table -9: Fresh Concrete Test Results of Conventional Concrete

Mix Code	Slump Flow	Super Plasticizer (%)
CC1	90 mm	1

Table -10: Fresh Concrete Test Results of SCC without and with Glass Fibers

Mix Code	Glass Fibers (%)	Slump Flow (mm)	T_{50cm} Slump Flow (mm)	J-ring (mm)	L-box (h_2/h_1)	U-box (mm)	V-funnel (sec)	V-funnel T5 minutes (sec)
SCC2	0	700	3	3	0.83	3	7	9
SCC3	0.25	695	3	4	0.84	5	8	10
SCC4	0.50	689	3	5	0.85	7	9	11
SCC5	0.75	685	4	7	0.86	8	10	12
SCC6	1	680	4	7	0.88	10	11	13
SCC7	1.25	677	5	8	0.89	12	12	14
SCC8	1.50	673	5	9	0.90	15	12	15

Fig -2: Compressive Strength Test Set up

Table -11: Compression Test Results of CC, SCC without and with Glass Fibers

Mix Code	Compressive Strength (N/mm²)		
	3 days	7 days	28 days
CC1 (Ref. Mix)	12.73	23.74	34.27
SCC2	14.10 (10.76%)	26.12 (10.03%)	37.05 (8.11%)
SCC3	14.67 (15.24%)	26.82 (12.97%)	38.02 (10.94%)
SCC4	15.29 (20.11%)	27.47 (15.71%)	38.91 (13.54%)
SCC5	15.88 (24.74%)	28.23 (18.91%)	39.76 (16.02%)
SCC6	16.50 (29.62%)	28.92 (21.82%)	40.70 (18.76%)
SCC7	16.10 (26.47%)	28.32 (19.29%)	40.10 (17.01%)
SCC8	15.80 (24.17%)	27.76 (16.93%)	39.50 (15.26%)

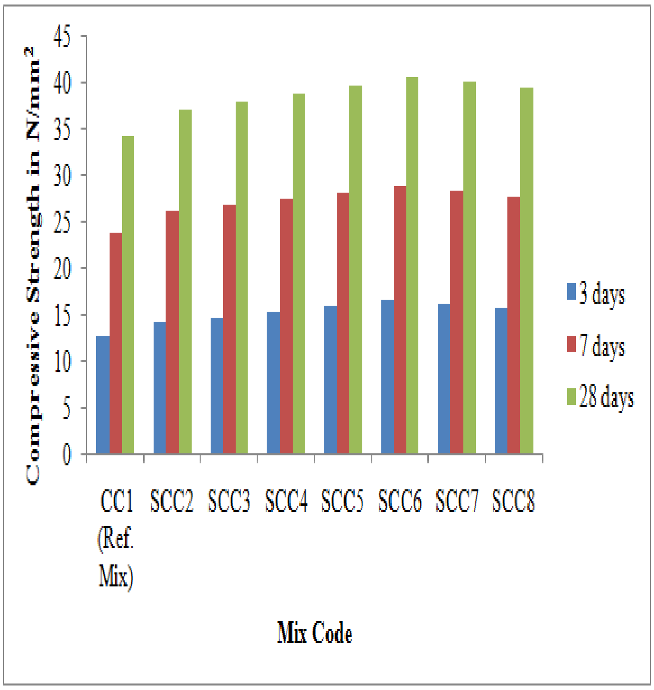

Chart -1: 3, 7 and 28 days Compressive Strength of CC, SCC without and with Glass Fibers

From Table 11 and chart 1, the following observations are made:

- Addition of glass fibers to SCC hikes the 3 days compressive strength by 11% to 30%. Addition of glass fibers to SCC hikes the 7 days compressive strength by 10% to 22%. Addition of glass fibers to SCC hikes the 28 days compressive strength by 8% to 19%. The compressive strength of 3, 7 and 28 days of SCC with glass fibers are optimum at a fiber percentage = 1%.

- The compressive strength of SCC2 is less than SCC of all percentage variation of glass fibers. Thus, compressive strength of CC1 is less than all the mixes of SCC.

2.6 Split Tensile Strength Tests

The concrete in fresh state of conventional concrete was filled into cylinders by 4 layers; each layer was rodded by 25 times with the help of tamping rod. But, in self compacting concrete without any compaction of concrete. For CC and SCC top surface was finished with the trowel. The cylindrical moulds of size 150 mm diameter × 300 mm height were casted. The CC and SCC specimens were left for hardening upto 24 hours. By using compression testing machine applying load at 200 tons, practicing as per IS: 516-1959 at 3, 7 and 28 days tests was carried out.

Fig -2: Split Tensile Strength Test Set up

The results are shown in Table 12 and plotted in chart 2.

Table -12: Split Tensile Strength Test Results of CC, SCC without and with Glass Fibers

Mix Code	Split Tensile Strength (N/mm²)		
	3 days	7 days	28 days
CC1 (Ref. Mix)	1.43	2.65	3.89
SCC2	1.56 (9.09%)	2.91 (9.81%)	4.41 (13.37%)
SCC3	1.70 (18.88%)	3.10 (16.98%)	4.57 (17.48%)
SCC4	1.75 (22.38%)	3.25 (22.64%)	4.69 (20.57%)
SCC5	1.83 (27.97%)	3.32 (25.28%)	4.76 (22.37%)
SCC6	1.90 (32.87%)	3.44 (29.81%)	4.88 (25.45%)
SCC7	2.02 (41.26%)	3.50 (32.08%)	5.04 (29.56%)
SCC8	1.96 (37.06%)	3.35 (26.42%)	4.91 (26.22%)

The number within parentheses in Table 12 designates the percentage of hike in strength relative to reference mix.

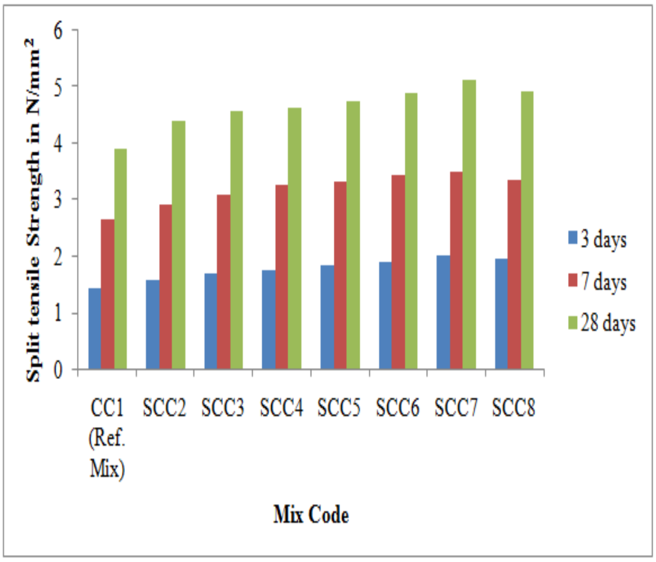

Chart -2: 3, 7 and 28 days Split Tensile Strength of CC, SCC without and with Glass Fibers

From Table 12 and chart 2, the following observations are made:

- Addition of glass fibers to SCC hikes the 3 days split tensile strength by 9% to 41%.
- Addition of glass fibers to SCC hikes the 7 days split tensile strength by 10% to 32%.
- Addition of glass fibers to SCC hikes the 28 days split tensile strength by 13% to 30%.
- The split tensile strength of 3, 7 and 28 days of SCC with glass fibers are optimum at a fiber percentage = 1.25%.
- The split tensile strength of SCC2 is less than SCC of all percentage variation of glass fibers. Thus, split tensile strength of CC1 is less than all the mixes of SCC.

2.7 Water Absorption Tests

The CC and SCC specimens having size (150 × 150 × 150) mm cubes were casted. The 28 days cured specimens was oven dried at temperature of 105^0 C till the constant weight was achieved. After cooling cube specimens to room temperature its weight was noticed. Next, specimens were immersed in water. These specimens were taken from water and weighed at routine period. The mechanism was continued till the weight of specimen found to be constant (fully saturated). The weight change between water saturated sample and oven dried weight is the Saturated Water Absorption (SWA). The results are shown in Table 13 and plotted in chart 3.

Table -13: Percentage of Water Absorbed Results for Various Mixes

Mix Code	Percentage of Water Absorbed in 28 days
CC1	1.54
SCC2	1.40
SCC3	1.34
SCC4	1.29
SCC5	1.20
SCC6	1.16
SCC7	1.09
SCC8	1.02

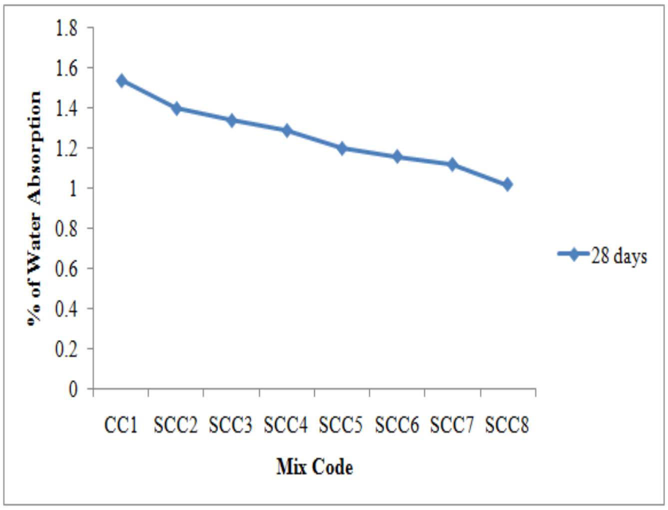

Chart -3: Percentage of Water Absorption to Various Mixes

From Table 13 and chart 3, the following observations are made:

- The percentage of water absorbed in 28 days goes on decreases as the percentage of glass fiber increases. This is due to the presence of Zirconia (ZrO_2) in glass fiber is responsible for low absorption of water.
- The percentage of water absorbed in 28 days by conventional concrete is slightly more than all the mixes of SCC.

2.8 Density Tests

The CC and SCC specimens having size (150 × 150 × 150) mm cubes were casted and tested at 28 days. Density of CC and SCC was determined by mass per unit volume of concrete. The density of concrete is directly proportional to the strength of concrete. The results are shown in Table 14 and plotted in chart 4.

Table -14: Density of Concrete Results for Various Mixes

Mix Code	Density of Concrete (Kg/m³)
	28 days
CC1	2325.93
SCC2	2353.48
SCC3	2356.74
SCC4	2380.44
SCC5	2405.33
SCC6	2439.70
SCC7	2478.81
SCC8	2499.26

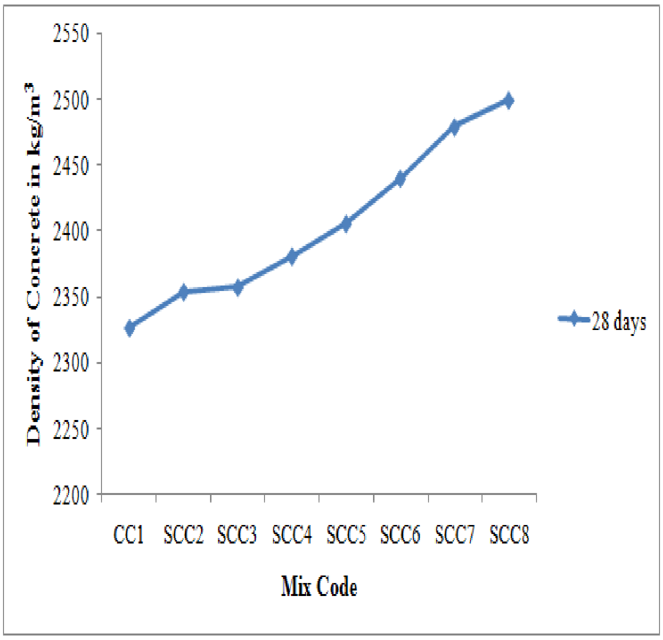

Chart -4: Density of Concrete to Various Mixes

From Table 14 and chart 4, the following observations are made:

- The Density of concrete in 28 days goes on increases as the percentage of glass fiber increases. This is due to the specific gravity of glass fibers obtained in the present work is higher than that of aggregates specific gravity.

- The density of concrete in 28 days by conventional concrete is less than all the mixes of SCC.

3.CONCLUSIONS

Based on the present work the following conclusions are arrived:

- The SCC developed compressive strength ranging from 14.10 to 16.50 Mpa at the end of 3 days, from 26.12 to 28.92 Mpa at the end of 7 days and from 37.05 to 40.70 Mpa at the end of 28 days and CC developed compressive strength of 12.73 Mpa, 23.74 Mpa and 34.27 Mpa at 3, 7 and 28 days respectively.
- The compressive strength of 3, 7 and 28 days of SCC with glass fibers are optimum at a fiber percentage = 1%.
- The SCC developed split tensile strength ranging from 1.56 to 2.02 Mpa at the end of 3 days, from 2.91 to 3.50 Mpa at the end of 7 days and from 4.41 to 5.04 Mpa at the end of 28 days and CC developed compressive strength of 1.43 Mpa, 2.65 Mpa and 3.89 Mpa at 3, 7 and 28 days respectively.
- The split tensile strength of 3, 7 and 28 days of SCC with glass fibers are optimum at a fiber percentage = 1.25%.
- The presence of Zirconia ZrO_2) in glass fiber is responsible for low absorption of water. Thus, the percentage of water absorbed in 28 days goes on decreases, ranging from 1.40 to 1.02% as the percentage of glass fiber increases. But conventional concrete is 1.54% of water absorption which is slightly more than all the mixes of SCC.
- The specific gravity of glass fibers obtained in the present work is higher than that of aggregates specific gravity. The Density of concrete in 28 days goes on increases, ranging from 2353.48 to 2499.26 Kg/m^3 as the percentage of glass fiber increases. However, density of concrete in 28 days by conventional concrete is 2325.93 Kg/m^3 which is less than all the mixes of SCC.
- In all above cases, the strength of SCC is higher than CC because of addition of super plastisizer in SCC to maintain flowability gives proper compaction of concrete which enhance all properties of SCC. Also the addition of fly ash in SCC improves microstructure of concrete that also helpful to enhance all mechanical properties with the durability of concrete. Use of fly ash reduces the consumption of cement due to which CO_2 emulsion in manufacturing process is also reduced. By adding fly ash the disposal problem is neglected which reduces air pollution and land pollution.

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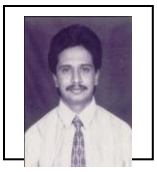

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