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Compressive Strength Of Metakaolin Based Self-Compacting Concrete

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Abstract: Self-compacting concrete (SCC) refers to high strength concrete which will compact under its own weight and does not require external vibration. SCC composition consists of maximum volume of fine aggregate and powder content, whereas coarse aggregate occupies lesser quantity. The concrete prepared for SCC was highly fluid and it was achieved by Super plasticizers and Stabilizers of optimum dosages. In present work, an experimental study was made to study the strength of SCC using metakaolin (MK). Here cement was replaced by MK with 15%. For an experimental investigation, conventional vibrated concrete CVC and SCC cube and cylinder specimens were cast and tested at the age of 28 days after curing. The concrete mix design was developed using ACI code provisions for conventional and SCC type concrete. With the obtained results, it was found that compressive and split tensile strength of SCC specimens found to be higher compared to CVC. Finally, the increase of powder content by mineral admixtures improves the flow property and strength parameters of SCC.
Keywords: Metakaolin, Self Compacting Concrete, powder, conventional vibrated concrete.

Introduction

Self-compacting concrete differed from conventional concrete in terms of mix composition, fresh state and hardened state behaviour. In total quantity, the coarse aggregate occupies lesser percentage compared to fine aggregate and powder content. The powder content namely fines less than 0.125 mm influences more effect on the strength characteristics of SCC. The cement was used as binder material. In present study, the powder content namely metakaolin was used for developing SCC by cement replacement up to 15%. The water to powder ratio was 0.4 and the dosages of super plasticizers and stabilizers were added up to 1.4% and 0.1% of weight of cement in litres respectively.

The study on the durability properties of self-compacting concrete (SCC) containing rice husk ash (RHA), metakaolin (MK) and their combination of MK and RHA (1:1 ratio) were obtained[1]. The study on performance and durability by flash-calcined metakaolin (MKF) was made by Portland cement replacement[2]. A new methodology was adopted in mix design of high strength self compacting concrete using metakaolin and they obtained the strength up to 120 MPa[3]. Author investigated the effect of metakaolin while replacing cement or lime stone in order to study the rheology and the mechanical properties of SCC[4]. The study on fresh and hardened properties of SCC was made with metakaolin and cement kiln dust. The cement was replaced by metakaolin and cement kiln dust up to 10%[5]. The study on effect of SCC using mineral and chemical admixtures was made and cost effective SCC design was developed[6]. The study made on influence of the new generation super plasticizers (SP) cause the rise of excessive air content in self compacting concrete (SCC)[7]. The use of admixtures in SCC and their proportions, ratio of powdery materials and plasticizers was studied. It was observed that 10% to 15% of powdery content improved the strength of SCC at the age of 28 days[8]. The rheology of SCC was investigated by powder content and poly carboxylated ethers subjected to low and high temperatures[9]. The study on ductile self compacting concrete (DSCC)was made by cement replacement up to 20% Microwave Incinerated Rice Husk Ash (MIRHA), silica fume (SF) and fly ash (FA) in certain ratios. For DSCC, fresh property tests were conducted and in the hardened state DSCC with replacement of 10% FA and 10% MIRHA achieved the highest compressive strength[10]. For SCC mix design, fresh properties test methodology as per EFNARC[11, 12].

Experimental Programme

Material properties

Cement, Ordinary Portland Cement of 53 grade and specific gravity =3.15
Metakaolin, mineral admixture was added with 15 %, as cement replacement in SCC.
Fine aggregate, river sand was used. Specific gravity of fine aggregate (F.A)=2.6
Maximum size of Coarse aggregate used was 12.5 mm and Specific gravity of Coarse aggregate (C.A) = 2.64
TEC MIX 550 and 640 were used as super plasticizer and stabilizer in optimum dosages.
Dry Rodded Bulk Density of fine aggregate = 1726 kg/m^3
Dry Rodded Bulk Density of coarse aggregate = 1638 kg/m^3

Mix Proportioning

It was developed as per ACI code. For conventional concrete-1:1.35:2.19 and for SCC-1:1.954:1.598 was proportioned.

Test on Cubes and cylinders

For cube compression test, 100 mm x 100 mm x 100 mm was adopted, prepared by a wooden mould of inner dimensions mentioned above. The specimen was cast and curing done for 28 days. The test has been conducted under automatic compression testing machine after making surfaces dry on the specimen after 28 days curing.

Figure 1-Cube compression test

For cylinder specimens, the split tensile and axial compression test was conducted. The ratio of 1:2 was followed with 100 mm diameter and 200 mm height. Finally the prepared specimen was made curing for 28 days. After curing, the test has been conducted on specimens using automatic compression testing machine.

Figure 2- Split tensile test on cylinder

Figure 3- Axial compression test on cylinder

Results

For SCC with 15% of metakaolin by cement replacement, the test on basic material, the test on hardened state were discussed as below:

Table 1- Cube compression test results

Sl.no.	Compressive strength(MPa)	
	CVC	SCC
1	54	56
2	51.5	58.5
3	49	61
Average	51.5	58.5

Table 2-Cylinder compression test results

Sl.no.	**Compressive strength(MPa)**	
	CVC	**SCC**
1	52.5	57
2	53.5	59
3	55	62
Average	53.7	59.33

Table 3-Cylinder split tensile test results

Sl.no.	**CVC – Cylinder split tensile strength(N/ mm^2)**	**SCC – Cylinder split tensile strength(N/ mm^2)**
1	2.037	2.419
2	1.909	2.292
3	1.655	2.546
Average	1.867	2.419

Discussion

In comparing the values of cube compressive strength, it was found that average compressive strength of SCC cubes obtained was 58.5 MPa, which had an higher value compared to CVC cube average strength of 51.5 MPa. Since same w/c ratio was used both for CVC and SCC, lesser value obtained for CVC. The average compressive strength of SCC cylinders were 59.33 MPa, had an higher value compared to CVC cylinders of 53.70 MPa. The average split tensile strength of SCC cylinders were 2.419 MPa, also found to be greater compared to CVC cylinders of 1.867 MPa.

Conclusion

In present work, the self compacting concrete was developed with cement replacement by 15% of metakaolin and following conclusions were drawn:

- The strength of SCC specimens was found to be 12% higher than CVC specimens in compression and 30% higher than CVC in split tensile test. Hence replacement of cement with metakaolin was found to be feasible in terms of strength.
- It was also found that additions of chemical admixtures resulted segregation of concrete and bleeding.
- The other mineral admixtures in the form of powder content could also be used for developing SCC to attain improved strength values.

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