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Properties of Self-Compacting Concrete with and without Fly Ash

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Research Article

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ABSTRACT

This paper deals with the properties of self-compacting concrete with and without fly ash. The samples of concrete were made by four groups with a self-compacting concrete with 100% OPC, 5% fly ash replacement, 10% fly ash replacement and 15% fly ash replacement. Strength properties tests were carried at the ages of 7th, 14th and 28th days for the various mixes.

Results indicates that an increase in percentage of fly ash replacement was good in its fresh property and all fly ash replaced self-compacting concrete was have better flowability, fillingability and segregation resistant than a self-compacting concrete with 100% OPC. The compressive strength results of the sample indicates that, a Self-compacting concrete with 10% fly ash have 50.2 MPa at 28th day and has better result than all other specimens

INTRODUCTION

The durability of concrete in Ethiopia is jeopardized due to carelessness of the supervisor to supervision of vibration and lack of knowledge of the laborers how to operate the compaction equipment. The problem of the durability of concrete structures was a major topic of interest in Japan. Progress in concrete technology has led to the advancement of a new type of concrete, which is known as self-consolidating concrete or self-compacting concrete. Generally, SCC components are typically identical to Normal Concrete (NC) with high filler content added, i.e. fly ash, limestone powder and others. The replacement material like fly ash facilitates better flow characteristics of SCC in the fresh state. High durable conventional concrete has to be well vibrated to achieve good compaction. And the creation of durable concrete structures requires adequate compaction by skilled worker. SCC has been developed to ensure adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas. SCC was developed first in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions. Nowadays SCC is becoming more popular and demandable worldwide due to its workability and efficiency. Generally, SCC components are typically identical to normal concrete with high filler content added, i.e. fly ash, limestone powder and others. Due to high workability, it reduces the labor and machine component thereby increasing productivity; it also reduces the need of vibrator for compaction thus reducing the cost component for compaction and also noise pollution caused by it. The replacement material like fly ash facilitates better flow characteristics of SCC in the fresh state. The higher in materials cost of self-compacting concrete will be covered by the benefits that it will provide for the users. The benefits such as, eliminating compaction equipment, accelerating the construction work, minimizing the number of laborers in crew and avoiding the noise of compaction equipment.

MATERIALS AND METHOD

In order to prepare the samples, cement OPC 42.5 N, river sand, coarse aggregate and water was used from local market. Class F Fly ash was collected from Ayika Addis Textile manufacture from Addis Ababa. The chemical admixtures, polycarboxylate based superplasticizer and viscosity modifying agent also used for the study (Tables 1 and 2).

Table 1. Tables for sample Size.

List of Group	Types of Mix	7^{th} day	14^{th} day	28^{th} day
Normal Vibrated Concrete	NVC	3	3	3
Group 1	Control Group	3	3	3
Group 2	SCC (with 5% fly ash)	3	3	3
Group 3	SCC (with 10% fly ash)	3	3	3
Group 4	SCC (with 15% fly ash)	3	3	3

Table 2. Sample of Test methods and their standards.

No.	Standards	Test types
1	ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
2	ASTM C127	Standard Test Method for Specific Gravity and Absorption of Coarse Aggregate
3	ASTM C29	Unit weight and voids in aggregates
4	ASTM C127	Specific gravity and Absorption of coarse aggregate
5	ASTM C128	Specific gravity and Absorption of fine aggregate
6	ASTM C566	Test Method for total moisture content of aggregates
7	ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete
8	ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

In order to accomplish the objective of the study, purposive sampling technique has implemented. The sample size of the concrete was determined by dividing the concretes in to five main groups. The groups are named as, control group without incorporating of fly ash, a SCC with 5% fly ash, a SCC with 10% fly ash and a SCC with 15% of fly ash. Total of 45 cube samples at 7th, 14th and 28th day of curing period was casted and tested as accordingly. Normal vibrated concrete was tested only for checking and comparison purpose.

Methods and standard testing procedure

Those methods were conducted to study on the properties of the fine and coarse aggregate and for the fresh and hardened property of concrete and also for the property of powders (especially fly ash). It was to study the properties according to the standards since they are supportive for the final research work.

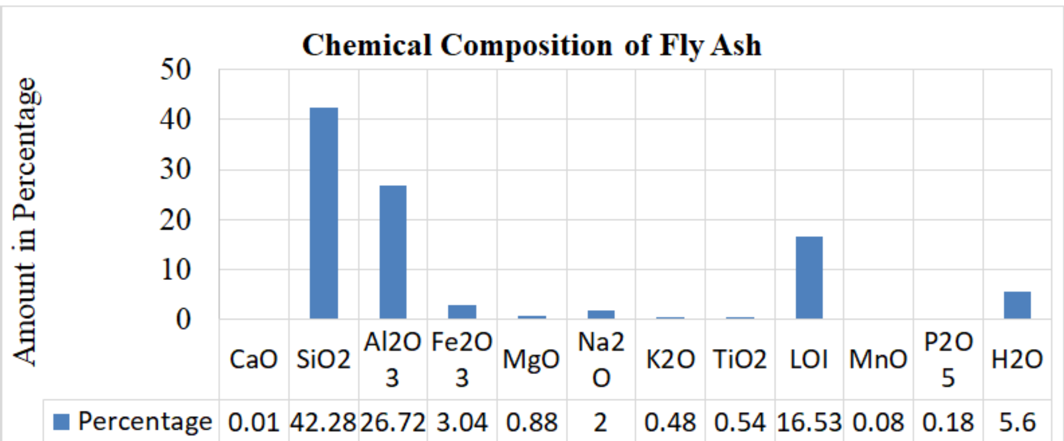
RESULT AND DISCUSSION

Physical properties of the ingredients

In order to control the quality of the materials, laboratory tests were carried out based on the standard specification. The physical properties for fine aggregate, coarse aggregate and fly ash were determined. Unit weight, moisture content, specific gravity, fineness modulus are conducted for the aggregates and only specific gravity chemical composition was conducted for class F fly ash samples.

Only two tests are conducted for fly ash. Chemical composition test was conducted at geological survey of Ethiopia and specific gravity was tested in the laboratory by using pycnometer apparatus. In order to know different chemicals that are available in the materials and also Loss on Ignition (LOI) was determined by having this test (Figure 1).

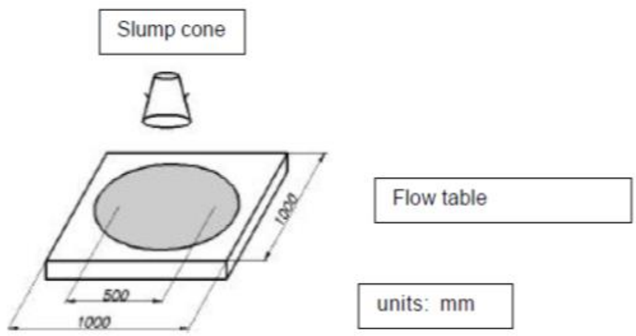
Figure 1. Chemical Composition of fly ash.



Flow table test t500mm test

This test is used to measure the free horizontal flow of SCC on a plain surface without any obstruction. Concrete poured in slump cone without external compaction is made to flow on flow table. Time required the concrete to cover 50 cm diameter spread circle (T500mm time) from the time the slump cone is lifted is noted. Average flow of concrete after concrete stops flowing is measured to ascertain the slump flow value. It is most commonly used test and gives a good assessment of filling ability and indications on stability of the mix (Figure 2).

Figure 2. Slump flow test and T500 mm slump flow test.



The test is used to determine the passing ability of the concrete. The equipment consists of a rectangular section (30 mm × 25 mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar. These sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3 × the maximum aggregate size might be appropriate. The diameter of the ring of vertical bars is 300 mm, and the height 100 mm.

Prepared samples for normal vibrated concrete and self-compacting concrete with and without fly ash was determined for their fresh property and hardened property. Fresh property, slump flow test, flow table test, J-ring test and from hardened property, compressive strength test was determined.

According to EFNARC, standard, a self-compacting concrete with a slump flow diameter of ranging from 650mm to 800mm was considered to be a good self-compactable and good flowable concrete. As per the results show under, slump flow diameter increases with the increased quantity of fly ash in self-compacting Concrete.

A flow time of 3 up to 5 second was very enough to decide whether the concrete is self-compacting concrete or not. According to the result, three types of self-compacting concretes with different quantity of cement replaced by fly ash can fulfill the requirements of the standard specification and guidelines of self-compacting concrete. SCC with 0% fly ash has a flow speed of 6.1 sec and it doesn't satisfy the requirement of the specification.

The result of the passing ability test was measured for every corner of the flow table and it showed that, the height difference for a Self-compacting concrete with 5% fly ash was 18, 15, 4 and 1 and the average of the readings was

9.5. When the result is compared with that of the result which is recommended by EFNARC, it was satisfactorily achieved the specification of Self-compacting concrete. The height difference for SCC with 10% fly ash replacement was 14, 13, 4 and 4 and the average of these readings was 8.75 and the average reading for a SCC with 15% fly ash was 8.5.

Mainly, in column and beam conjunction, the places where heavily congested with reinforcement bar. Due to this reason, compaction may not be properly done. Therefore, a SCC sample conducted in this study confirms EFNARC standard.

As we can see under the chart below, all fly ash replaced self-compacting concrete has attained their better compressive strength result at later age of curing. Especially a SCC concrete with 10% fly ash does have admirable result than of other specimens at the age of 28 days.

Price per strength computation of self-compacting concrete samples

In order to decide the most economical concrete samples, it is necessary to compare their cost in terms of the result that they are achieved. Since the proportions of the ingredients were the same for the whole mixes, except, the quantity of fly ash and cement, the samples were only compared with the cost of fly ash and cement. The necessity of conducting cost for the samples was, to recommend the feasible concrete types and its material proportion for future uses.

CONCLUSION

It was observed that, the samples for self-compacting concrete is good in its filling ability, flowability, segregation resistance and passing ability around congested reinforcement. A sample of self-compacting concrete with 15% fly ash replacement was better in its fresh property than the other specimens. A self-compacting concrete samples showed better compressive strength result than the desired strength at 7th, 14th and 28th days. Fly ash replaced self-compacting concrete samples were having better compressive strength value at later age of curing than a control grouped sample and a SCC with 10% fly ash replacement having the largest compressive strength value, which is 50.2MPa.

Finally, it was concluded that a self-compacting concrete with fly ash is less costly, good in its fresh and hardened property, beneficial and accelerate the duration of the project. Even, if the concrete construction was not heavily congested with reinforcement and even if when the location of the concrete structure is possible to use the vibration equipment.

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