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Investigation of coarse aggregate size effect on compressive strength of C-25 concrete

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ABSTRACT

Ethiopia one of the fastest-growing country in the world so from many sectors of the construction industry is one of them and in the construction industry there are many challenges that are generated during construction activities not identify the aggregate size for concrete have a negative impact on the compressive strength of concrete. So this research has identified the effect of aggregate size on compressive strength of C-25 concrete. This study aims at assessing the effect of aggregate size on compressive strength of C-25 concrete, comparing the result with the standard and to provide solution along with determining the workability of concrete made from different sized coarse aggregates.

This study has given a vast understanding on the effect of aggregate size on compressive strength of C-25 concrete. Significant to major stakeholders like consultant, contractor, in order to minimize construction defects, cost, and poor quality of materials during construction which may cause defects and also be a guide for other researches. In order to satisfy the above objectives laboratory tests should have to be conducted. These tests are Sieve analysis, Slump test, Silt content of sand, Specific gravity and absorption of fine aggregate, Specific gravity and absorption of course aggregate, Moisture content of aggregate and Compressive strength of cubic concrete test. After collecting and analyzing all laboratory results researcher have seen that compressive strength and workability have increased with increasing aggregate size.

The researcher has concluded that Coarse aggregate size is directly proportional to the slump (workability) of fresh concrete with constant water-cement ratio and Compressive strength of a concrete increases with increase in coarse aggregate size until it reaches 37.5mm and declines above the 37.5mm. And as per the ES and BS size, 37.5mm has a mean of 27.15mpa within 28 days of curing this makes it relatively stronger. The researcher recommends that aggregate size 37.5mm can be used for mass concrete structures and size 19.3mm and 63mm with compressive strength of 23.58mpa and 23.65mpa have average strength and can be used to light buildings and to increase the workability of concrete one should increase maximum aggregate size.

Keywords— *Concrete, Aggregate, Compressive strength, Construction defect, Workability*

1. INTRODUCTION

Aggregates constitute about 50 to 60% of the concrete mix depending on the mix proportion used. The larger the aggregate percentage in the concrete mix makes it contribute a lot to its strength. Aggregates are the most mined material in the world. They are a component of composite materials such as concrete and asphalt concrete. The aggregates are responsible for the unit weight, elastic modulus and dimensional stability of concrete because these properties depend on the physical characteristics (strength and bulk density) of the aggregate [1-5].

Concrete is a composite material made of aggregate bonded together by liquid cement which hardens over time. The major components of concrete are cement, water, and aggregates (fines and coarse aggregate) with aggregates taking about 50 to 60% of the total volume, depending on the mix proportion. The amount of concrete used worldwide is twice that of steel, wood, plastics, and aluminum combined. Moreover, according to concrete's use in the modern world is exceeded only by that of naturally occurring water [6-8]. Concrete can be used either singular or reinforced with steel in order to achieve the required strength. Concrete builds durable, long-lasting structures that will not rust, rot, or burn. It is widely used for making architectural structures, foundations, brick walls, bridges and many other civil engineering works. Concrete is used in large quantities almost everywhere mankind has a need for infrastructure because of its high compressive strength and durability. [9]

Cement is generally an agent that is used to bond materials together, which happens as a result of a chemical reaction known as hydration. The concrete needs to be cured by immersing concrete cubes in water (i.e. ponding) for this process. Curing is designed primarily to keep the concrete moist by preventing loss of moisture from it during the period in which it is gaining strength. Curing can be achieved by keeping the concrete element completely saturated or as much saturated as possible until the water-filled spaces are substantially reduced by hydration products [10-12]. Aggregate occupies roughly three-fourths of the volume of concrete. Therefore its properties have considerable importance to the quality of the concrete. Aggregates can be obtained from various sources; natural or manufactured. Natural aggregates are taken from natural deposits without a change in their nature during production, with the exception of crushing, siting grading, or during production [13-16]. A number of concrete structures around the globe cracks and lose stiffness when subjected to the external load. Having premature deterioration of concrete is an international problem, the building industry needs to increase the load-carrying capacity of structures by using concrete of high strength. In concrete structures, the mix proportion of the different components together with the aggregate type and size determine the compressive strength of hard concrete. [17-19]

The compressive strength of concrete is one of its major properties that structural engineers take into consideration before erecting any structure. This property can be affected by many factors including water to cement ratio, degree of compaction, aggregate size and shape to name a few. Aggregate gradation plays an important role in concrete mixing. Unsatisfactory gradation of aggregates leads to segregation of mortar from the coarse aggregates, internal bleeding, need for chemical admixtures to restore workability, excessive water use and increased cement use. [20-22]

1.1 OBJECTIVE OF STUDY

The objective of this research is to investigate the effect of aggregate size on compressive strength of C-25 concrete and to compare the compressive strength of the concrete with the standard.

2. MATERIALS AND METHODOLOGY

2.1 POPULATION OF STUDY

The main population of this study is different aggregate sizes, to investigate its effect on compressive strength and workability of C-25 concrete.

2.2 SAMPLING TECHNIQUES

Sampling is the act, process, or technique of selecting a suitable sample, or a representative part of a population for the purpose of determining parameters or characteristics of the whole population. For this research have used random sampling technique.

2.3 RESEARCH VARIABLE

The two types of research variables are dependent and independent variables.

(a) Dependent variables: The effect of aggregate size on compressive strength of C-25 concrete.
(b) Independent variables: The effect of aggregate size on compressive strength and workability of C-25 concrete have investigated by Laboratory tests.

3. RESULT AND DISCUSSION

In this part, the results obtained from the experimental programs of testing the compressive strength of C-25 concrete by using different aggregate sizes have been discussed. Things kept constant while the experiment progress is Shape and texture of coarse aggregate, Water cement ratio and Quantity of Gamebella sand and PPC is as per the mix design.

3.1 SLUMP TEST RESULT

In table and figure, one bellow indicates that the workability of concrete has increased with the increase of maximum aggregate size, this is due to as aggregate surface area increases, and more cement paste is needed to cover the entire surface of aggregates. So mixes with smaller aggregates are less workable compared to larger size aggregates. And all aggregate sizes are true failure which rages up to 100mm depending on ASTM standard.

Table 1: Slump Test Result

Max. Aggregate size (mm)	Slump Value (mm)	Type of slump Failure(ASTM)
9.3	15	True
13.2	25	True
19	30	True
37.5	48	True
63	67	True
75	80	True

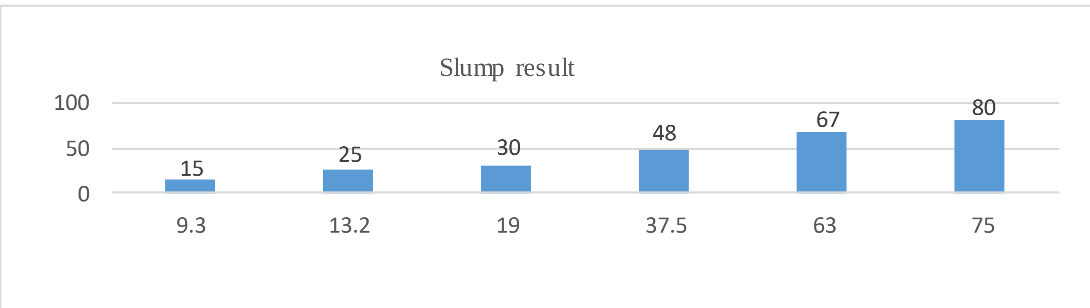

Fig. 1: Slump Test Result

4.2 COMPRESSIVE STRENGTH TEST RESULT

Based on the results from this laboratory investigation on pervious concrete mixtures, the following results are made.

Table 2: Compressive Strength Test Result

Sieve Size (mm)	7day mean compressive strength test Result (Mpa)	14day mean compressive strength test Result (Mpa)	28day mean compressive strength test Result (Mpa)
9.5	12.81	16.96	19.84
13.2	14	18.44	21.53
19.3	15.11	20.52	23.58
37.5	18.44	23.33	27.15
63	16.52	21.33	23.65
75	14.74	18.81	21.4

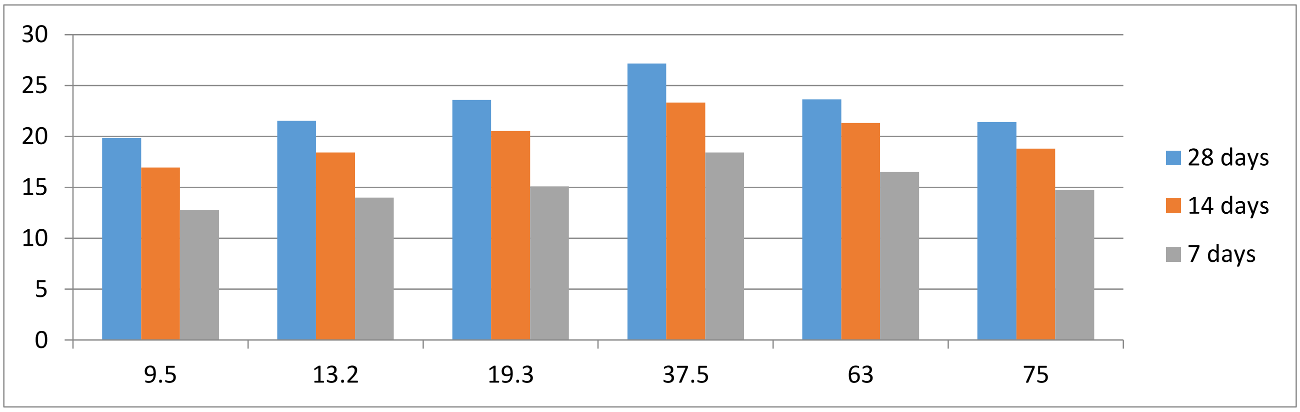

Fig. 2: Compressive Strength Test Result

For seven day ES and BS permit the compressive strength of concrete to be 60-70% or 15-17.5mpa after experiment results the mean compressive strength of size 9.5mm, 13.2mm, and 75mm has become 12.81mpa, 14mpa, and 14.74mpa respectively, so these sizes did not satisfy the Ethiopian standard. But the size 19.3mm, 37.5mm and 63mm result is 15.11mpa, 18.44mpa and 16.52mpa respectively, so these sizes have satisfied the standard.BS and ES states that 14day compressive strength result should be at least 90% or 22.5mpa so size 9.5mm, 13.2mm, and 75mm have a result of 19.84mpa,21.53mpa, and 21.4mpa respectively, therefore, these sizes do not satisfy the standard but size 19.3mm,37.5mm and 63mm have a result of 23.53mpa,27.15mpa and 23.65mpa respectively which satisfies the standard.BS and ES states that at the 28th day a concrete must have 99% of compressive strength, so size 9.5mm,13.2mm, 19.3mm, 63mm and 75mm have result of 19.84mpa, 21.53mpa, 23.58mpa 23.56mpa and 21.4mpa respectively which they don't satisfy the standard but size 37.5mm has a compressive strength of 27.15mpa which satisfy the standard effectively.

From table 2 and Figure 2 results, Compressive strength of concrete has been increased with increase in coarse aggregate size, until it reaches 37.5mm and declines above the size 37.5mm. Size 19.3mm, 37.5mm and 63mm have relatively a good mean 28th-day result with 23.58mpa, 27.15mpa and 23.65mpa respectively.

4. CONCLUSION

The coarse aggregate size is directly proportional to the slump (workability) of fresh concrete with constant water-cement ratio. As aggregate surface area increases, more cement paste is needed to cover the entire surface of aggregates. So mixes with smaller aggregates are less workable compared to larger size aggregates, and all aggregate sizes are true failure which rages up to 100mm depending on ASTM C-143-89a.

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Compressive strength of a concrete increases with increase in coarse aggregate size, until it reaches 37.5mm and declines above the size 37.5mm. Using the largest maximum aggregate size has resulted in a reduction in cement content and water content. Size 19.3mm and 63mm have an average compressive strength result of 23.53mpa and 23.56mpa but Size 37.5mm has 27.15mpa which is stronger compared to other sizes and is advisable to use this size where strength is the most essential goal.

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