Influence of size of aggregates on the Compressive strength of concrete

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Abstract: Aggregate grading is an important element in concrete mixing and the resultant compression strength. An experiment was conducted to determine the effect of aggregate size on the compressive strength of concrete. The experiment had three treatments, which were the aggregate sizes (10 mm, 12 mm and 15mm) and the control. A constant mix of 1:2:4 with a water/cement ratio of 0.5 was used throughout the experiment. Tests that were conducted included the slump and compressive strength tests. Fresh concrete batches were formulated from each of the coarse aggregate sizes and the slump test was conducted to test for workability. Three cubes (150 mm × 150 mm) were cast from each batch and the compressive strength was determined using a concrete load testing machine after 7 days curing. The results reflected that workability (slump) increased with increasing aggregate size. The concrete made from the 10 mm, 12mm and 15 mm aggregate sizes had workability (slumps) of 10 mm, 15 mm and 20 mm, respectively. The mean compressive strength for the 10 mm, 12 mm, and 15 mm were 13 N/mm2, 15 N/mm2 and 20 N/mm2, respectively. The 10 mm and 12 mm aggregates had compressive strengths that were significantly different, while the 10 mm and 15 mm aggregate sizes had compressive strengths that were not significantly different. It was concluded that concrete workability (slump) was directly proportional to aggregate size. The mean concrete compressive strength increased with increasing aggregates size.

Keyword: - Aggregate Size, Concrete, Compressive Strength, Models.

1 INTRODUCTION

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.

Water:

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.

Cement:

Commercially available Ordinary Portland Cement was used for this purpose. This cement has a specific gravity.

Aggregate:

Three types of coarse aggregates; 10mm, 12mm and 15mm are used. The fine aggregate is normal sand obtained from a borrow pit. Mixing investigation was conducted to ascertain the suitability of using the aggregates for construction work. Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and port land cement, are an essential ingredient in concrete.

Sand:

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles.

The compressive strength of concrete is one of its major properties that structural engineers take into consideration

67 Bruce Roy Thulane Vilane and Ndlangamandla Sabelo: The size of Aggregate Size on the Compressive Strength of Concrete before erecting any structure (Hollaway, 2010). 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 (Loannides and Mills, 2006).

Aggregates constitute about 50 to 60% of the concrete mix depending on the mix proportion used. The larger the aggregate percentage in concrete mix makes it to contribute a lot to its strength (Waziri et. al., 2011). 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 (Anonymous, 2012).

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. According to Hassan and Mohammed (2014) curing concrete

increase strength by up to 50% and also improve durability, making it more water tight and improve its appearance. If the concrete is not cured and is allowed to dry in air, it will gain only 50% of the strength of continuously cured concrete (Raheem, 2013).
A number of concrete structures around the globe cracks and lose stiffness when subjected to 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. According to Adiseshu and Ganapati (2011), larger aggregates demand lower water on its mix thus reducing the workability and increasing the compressive strength of concrete, hence this study.

1.1 OBJECTIVE
To investigate the effects of aggregate size on the compressive strength of concrete, with particular reference
1) To determine the workability of concrete made from different sized coarse aggregates.
2) To assess the compressive strength of different coarse aggregate sizes on concrete.

1.1.1 SAMPLING
(i) Clean the mounds and apply oil
(ii) Fill the concrete in the molds in layers approximately 5cm thick
(iii) Compact each layer with not less than 35strokes per layer using a tamping rod
(iv)Level the top surface and smoothen it with a trowel

2. METHODOLOGY
The research was an experiment with three treatments including the control and three replications per treatment. Concrete mixtures of different aggregate sizes were used as treatments. The first, second and third treatments utilized the coarse aggregate sizes of 10 mm, 12 mm and 15 mm (control), respectively. The constituents that were used to formulate the concrete mixes were, Portland cement, river sand as fines and crush stone as coarse aggregates. A constant mix proportion of 1:2:4 and a constant water to cement (w/c) ratio of 0.5 were used throughout the experiment.

2. 1 MATERIALS AND METHODS
The equipment and materials that were used in the study were; metal cube mould (150 mm × 150 mm × 150 mm), spade, compacting rod, slump test cone, concrete load testing machine, crush stone, river sand, Portland cement, trowel and a scale rule. The crush stone was sourced from a quarry site , already graded and in the desired sizes.
Mixture Proportions
A nominal mix ratio of 1:2:4 (Cement: Fine sand: aggregates) was adopted for the purpose of this work and a water-cement ratio of 0.6 was used.
(I) Remove the specimen from water after specified curing time and wipe out excess water from the surface.
(II) Take the dimension of the specimen to the nearest 0.2m
(III) Clean the bearing surface of the testing machine
(IV) Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
(V) Align the specimen centrally on the base plate of the machine.
(VI) Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
(VII) Record the maximum load and note any unusual features in the type of failure.

2.1.1. CONCRETE MOULDING
The concrete was mixed manually on a clean concrete covered surface to avoid incorporation of debris and absorption of moisture by the surface. Since coarse aggregates were sourced already graded from the quarry site, only the fine aggregates were sieved using a 5 mm test sieve to remove debris and attain homogeneity of the particles. The sand and cement were mixed on a non-absorbent surface using a spade and the mixing was done until the mixture was thoroughly blended and was of uniform colour. Then the coarse aggregates were added and mixed with the cement and sand made earlier until they were thoroughly distributed on the batch. A mound was opened from the top of the prepared mixture (cement, sand and coarse aggregates) and water was added using a water to cement ratio of 0.5. A spade was used to thoroughly mix the concrete constituents by working from the sides towards the centre until the desired mix was achieved.

Curing
Concrete curing was done by covering the specimen with a plastic sheet under shade, while in the concrete moulds for the first 24 hours after moulding. The cube moulds were then carefully removed and the cubes were then immersed in clean water for a period of 6 days. This added up to 7 days of concrete curing.

2.1.2. COMPRESSIVE STRENGTH
The concrete cubes were weighed using a beam balance prior to testing and the mass were recorded against the cube reference code. All the concrete cubes were tested on the same day using a cube concrete load testing machine.

3. COMPRESSIVE STRENGTH RESULT
The mean compressive strength results for hardened concrete after seven days of curing reflected an increase of compressive strength with increasing aggregate size. This trend ranged from 13N/mm2 for the 10 mm aggregate size to 20 N/mm2 for the 15 mm aggregate size.
The mean compressive strengths for the 10 mm, 12 mm and 15mm aggregate size varied and were found to be 13 N/mm2, 15 N/mm2 and 20N/mm2, respectively. Given the fact that aggregates were extracted from the same site, therefore have the same mineralogy; the reason behind the variation of compressive strengths could be attributed to the differences in wetted surface areas in the respective concrete batches. Concrete batches of smaller aggregates have a larger wetted area than larger aggregates. When wetted area dries up during the curing process, it leaves pores where micro cracks start. This is the reason attributed to the low compressive strength associated with smaller sized aggregates compared to large sized aggregates.
The results in Table indicated that the 10 mm 12mm and 15 mm aggregate size. The mean compressive strength for the 15mm was higher (20 mm) than the 10mm (13 mm) coarse aggregates.

Compressive strength = Compressive Load / Cross Sectional Area of the Specimen

Grade of Concrete	Different -different sizes of aggregates (10mm,12mm,15mm)	Minimum compressive strength N/mm2 at 7 days	compressive strength (N/mm2) at 14 days	Specified characteristic compressive strength (N/mm2) at 28 days
M20		13	15	20
		65 % for 7 days strength	90 % for 14 days strength	99 % for 28 days strength

The results indicated that larger sized coarse aggregates yielded higher compressive strength than smaller sized aggregates.

4. CONCLUSION
Given a constant water to cement ratio (0.5) and mix (1:2:4), a change in coarse aggregate size affected the workability (slump) of concrete. The workability (slump) was directly proportional to the aggregate size. It increased from 13N/mm2, 15N/mm 2 to 20N/ mm 2 for the 10 mm, 12 mm and 15 mm, respectively. As the slump increased, the concrete became more workable.
The mean compressive strength of the concrete aggregates was assessed and found to increase with increasing aggregates size. The aggregate sizes 10mm, 12 mm and 15 mm had mean compressive strengths of 13 N/mm2, 15N/mm2 and 20 N/mm2, respectively. The 10mm and 12mm course aggregate sizes were significantly different, while the 10mm and 15mm aggregate sizes had compressive strength that was not significantly different.

5. REFRENCES
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