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Effects of Aggregate Size on the Concrete Strength

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Abstract: ***With the advancement in the technology, there is an immense growth in the field of construction as well, of which concrete forms the basic unit. Concrete is the structural material consisting of a hard, chemically inert particulate substance, known as aggregate (usually sand and gravel), that is bonded together by cement and water. Aggregate can be fine or coarse, depending on its size. Fine and coarse aggregates make upto 65-80% of the bulk of concrete volume and reduces the cost of concrete formation (1/4 to 1/8 of the cost of cement). Keeping this thing in view, this study is done to find the size of aggregate having more strength so that a particular size of aggregate can be used to meet our demands. The aggregates used are of the size 10mm, 20mm 40mm and mixture of 10mm, 20mm and 40mm. The concrete cubes (150mm x 150mm x 150mm) prepared are tested after 7 days, 14 days and 28 days of curing. The grade of concrete used in this research is M30.***

Keywords: Concrete, Compressive strength, aggregates, Concrete cubes, cement, water-cement ratio, mix design, M30 grade, Compressive Testing Machine (CTM), curing.

I. INTRODUCTION

Concrete, in construction, is a structural material consisting of a hard, chemically inert particulate substance, known as aggregate (usually sand and gravel), that is bonded together by cement (binding agent) and water.

Fine and coarse aggregates make up the bulk of a concrete mixture. Sand, natural gravel and crushed stone are used mainly for this purpose. Recycled aggregates (from construction, demolition, and excavation waste) are increasingly used as partial replacements for natural aggregates, while a number of manufactured aggregates, including air-cooled blast furnace slag and bottom ash are also permitted. The size distribution of the aggregate determines how much binder is required. Aggregate with a very even size distribution has the biggest gaps whereas adding aggregate with smaller particles tends to fill these gaps. The binder must fill the gaps between the aggregate as well as paste the surfaces of the aggregate together, and is typically the most expensive component. Thus, variation in sizes of the aggregate reduces the cost of concrete. The aggregate is nearly always stronger than the binder, so its use does not negatively affect the strength of the concrete. Redistribution of aggregates after compaction often creates inhomogeneity due to the influence of vibration. This can lead to strength gradients. The strength of concrete is measured in pounds per square inch or kilograms per square centimetre of force needed to crush a sample of a given age or hardness. Concrete's strength is affected by environmental factors, especially temperature and moisture. If it is allowed to dry prematurely, it can experience unequal tensile stresses that in an imperfectly hardened state cannot be resisted. In the process known as curing, the concrete is kept damp for some time after pouring to slow the shrinkage that occurs as it hardens. Low temperatures also adversely affect its strength. To compensate for this, an additive such as calcium chloride is mixed in with the cement. This accelerates the setting process, which in turn generates heat sufficient to counteract moderately low temperatures. Large concrete forms that cannot be adequately covered are not poured in freezing temperatures. The strength of concrete depends on many parameters, so a deep understanding of concrete and skills in this much required by designers, manufacturer's specifications, contractors and suppliers. Their skills will determine the quality of the concrete structure to be built. Compressive strength of concrete is influenced by age, type of material, and the process of curing, water cement ratio, size of aggregate, type of aggregate, and some other parameters. Emphasis is given to the parameters of the coarse aggregate size and its impact on the strength and workability of concrete. No additional materials or additives used to maintain strength of concrete. The compressive strength of the aggregate size of 10mm, 20mm, 40mm and mix (10mm, 20mm and 40mm) is the main parameter to be examined, the test used to evaluate the compressive strength is destructive test on day 7, 14 and 28 will be implemented on the sample of concrete cube. This study aims to investigate strength factors. The objectives set for achieving these goals are to comparing the results of concrete compressive strength with destructive test method and relationship between concrete aggregate size 10mm, 20mm, 40mm and mix (10mm, 20mm and 40mm) for aggregate. The scope of the study is record the results of destructive test. Also to compare the result study with theoretical result or other thesis study which has the relationship of the concrete strength.

II. OBJECTIVE AND IMPORTANCE OF THE PROJECT

The objective of this research is to compare the compressive strength of concrete with different sizes of aggregates i.e., 10mm, 20mm, 40mm and mixture of 10mm, 20mm and 40mm, used in the preparation of concrete, after 7 days, 14 days and 28 days of curing so that a practical recommendation for the best aggregate size and effective strength of concrete can be provided.The size distribution of the aggregate determines how much binder is required. Aggregate with a very even size distribution has the biggest gaps whereas adding aggregate with smaller particles tends to fill these gaps. The binder must fill the gaps between the aggregate as well as paste the surfaces of the aggregate together, and is typically the most expensive component. Thus, variation in sizes of the aggregate reduces the cost of concrete. The aggregate is nearly always stronger than the binder, so its use does not negatively affect the strength of the concrete.

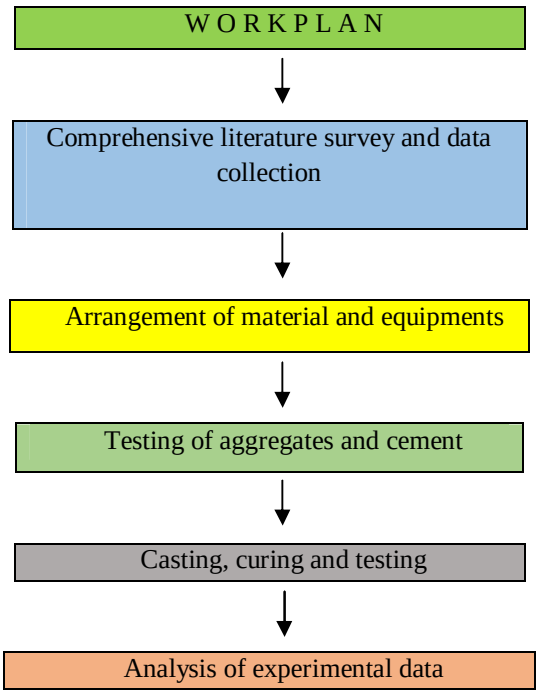
III. LITERATURE REVIEW

1) *Mohad Fedder Musa, A. Aziz bin Saim (2017*): The results shows that the concrete aggregate size of 20 mm has a 45.7% higher compressive strength than the concrete aggregate size of 10 mm. This study is to ascertain the concrete strength, determine the impact and the findings can be applied in the construction industry.
2) *Olumide Moses Ogundipe, Akinkurolere Olufunke Olanike, Emeka Segun Nnochiri, Patrick Olu Ale (2018):* This study investi5gates the effect of aggregate size on the compressive strength of concrete. Two nominal mixes, that is, 1:2:4 and 1:3:6 were used in the study. Concrete cubes were produced with 6, 10, 12.5, 20 and 25 mm aggregates for the two nominal mixes and they were subjected to compressive strength test after curing for 7, 21, 28 and 56 days. It was found in the study that the strength development follows the same trend for both nominal mixes. Also, the results show that the compressive strength increases with increasing aggregate size up to 12.5 mm, while the concrete produced using 20 mm had greater compressive strength than those produced using 25 mm aggregate. This established the importance of ensuring that the right aggregate size is used in the production of concrete. Therefore, it is recommended that careful attention must be paid to the sizes of aggregates used in the production of concrete for structural purposes
3) *Haque M.B., Tuhin I.A. and M.S.S. Farid (2012):* Result states that compressive strength of concrete are strongly influenced by aggregate size distribution as well as fineness modulus. Due to the increase of the fineness modulus of aggregate, compressive strength increases considerably. Maximum compressive strength was achieved 3.87 ksi for the concrete with fineness modulus of fine and coarse aggregate 3.0 and 7.5 respectively. Minimum strength was found 2.7 ksi for the concrete with fineness modulus of fine and coarse aggregate 2.0 and 6.0 respectively. Compressive strength also increases with the increases of maximum aggregate size up to 1.5 inch. Finally is observed that though concrete compressive strength is influenced by aggregate FM but it is independent to combined fineness modulus of aggregate.
4) *Giaccio et al (1993):* They made a comparative study about fracture energies of multiple strengths with compressive strengths. The level of these were from 20 Mpa to 90 Mpa. Aggregate materials were lime stone basalt and gravel. Its sizes were 0.3 inch, 0.6 inch, and 1.3 inch. In addition, the rough surface of aggregate was included as variables. The study revealed that the strength and force of the aggregate was depending upon the material size and compressive strength of concrete.
5) *Zhou et al (1995):* The results shows that when the mixture criteria of different materials is of the some standard quality measures, then the size of the concrete will be same strong and powerful.
6) *Xie et al (1995):* The study shows that though the mixing formula for the materials would be the same but still there were difference in the strength due to its aggregate size 0.4 inch and 0.8 inch that would be more strengthen and powerful as compared to the concrete of more than 1.2 inch of size. This study further explains that the shape of the concrete can bring changes in the strength and force of concrete size. It stated that the split type of cylinder concrete is durable and strengthens the force of concrete.
7) *Perdikaris and Romeo (1995):* They found in their work that the size is the main element of the concrete strength, as in their study they concluded that a moderate size is different to be broken than large size.
8) *Mather and Darwin (1976, 1977):* They identified that the medium size is the more strengthen and durable concrete type.
9) *Burnet and wolsier (1989):* They indicated that building made of concrete materials always be considered as strong and valid as the materials used in it, would be assumed and reassured as of high quality and high standard. In this line, the size of the aggregate will be of great importance and worth because the size is considered a major element in the strength measuring. Though there are no exiting parameters in the size selection and size measurement but aggregate size may not be strength as compared to major size aggregate. Quality concrete is supposed to be more reliable and good than that of low standard concrete. It is fact that a 100Mpa should have high force and strength than that of 20Mpa solid costs. All the aggregate size in a locally

made concrete sizes may be observed in all the available materials but in that study it was concluded that locally made concrete size will have lesser impact on strength of concrete of different size aggregate.

10) *Plorato (2003), Neville and Adam (1997) and Tasdemir (2003):* They found in their studies that the size of the concrete if made by the same mixture of materials in the same time period would depend upon its size. If the size of the aggregate is small then it will be more powerful and strong than the concrete having large size of the aggregates. It shows that if the material is homogenous but size of aggregate is different then one of the aggregate will be more durable and strong. It also concluded that the mixture elements should be of equal and must have all the same type materials which include aggregates, ratio of cement and water, sand, weight of the materials and days of its completion.

IV. WORK PLAN



Phases of the Project Work

A. *Arrangement Of Material*

Since the preparation of concrete requires three basic materials i.e., aggregates (coarse and fine), cement and water and their availability was the first step in the progress of the research. Coarse aggregate was collected from the Baramulla district of J&K. Fine aggregate used was zone 2 sand from the Ganderbal district. Cement used was Ultra Tech OPC, 43 grade.

B. *Testing Of Aggregates And Cement*

1) *Flakiness Index:* The flakiness index of aggregate is the % by weight of the particles (aggregates) whose thickness is less than $3/5^{th}$ (0.6 times) of their mean dimension. Its value comes out to be 7%.
2) *Elongation Index:* The elongation index of aggregate is the % by weight of the particles (aggregates) whose length is greater than $9/5^{th}$ (1.8 times) of their mean dimension. Its value comes out to be 12%.
3) *Aggregate Impact Value:* Aggregate Impact Value is an ability or toughness of aggregates which resist sudden impact or shock load on it. Its value comes out to be 11.11% which means the aggregates are strong.
4) *Abrasion Test:* Abrasion Test is the measure of aggregate toughness and abrasion resistance such as crushing, degradation and disintegration. Its value comes out to be 14%.
5) *Standard Consistency Test:* At about 25% of water quantity of cement are sufficient to form cement paste which allow the Vicat Plunger will penetrate in Vicat mould specimen of cement to 5-7mm point to the bottom or 33-35mm from top of Vicat mould. So consistency of cement is 25%.

6) *Fineness of Cement:* The weight cement particle whose size greater than 90 microns is determined and the percentage of retained cement particle are calculated. This is known as Fineness of cement and its value for TCI (OPC-43Grade) comes out to be 9%, which is less than 10 % (maximum limit).

Figure 1: Casting of concrete cubes

C. Testing of Hardened Concrete

The concrete specimens were tested for compressive strength after 7, 14 and 28 days of water curing. This test is conducted on cubes (150mm x 150mm x 150mm) which are loaded on their opposite faces in a Compression Testing Machine (CTM). Samples were cast in each casting after 7 days, after 14 days and after 28 days. The load at which first crack appears is considered as failure load and the compressive strength is calculated corresponding to this particular value of load.

Figure 2: Compressive strength test using CTM

Table 1: Result of 7-day Compressive Strength test

Nominal size of aggregate used in concrete cube (mm)	Load at which concrete cube failed (KN)	Compressive Strength (MPa)
10	351	15.6
20	521	23.16
40	456	20.27
Mix (10, 20 & 40)	467	20.76

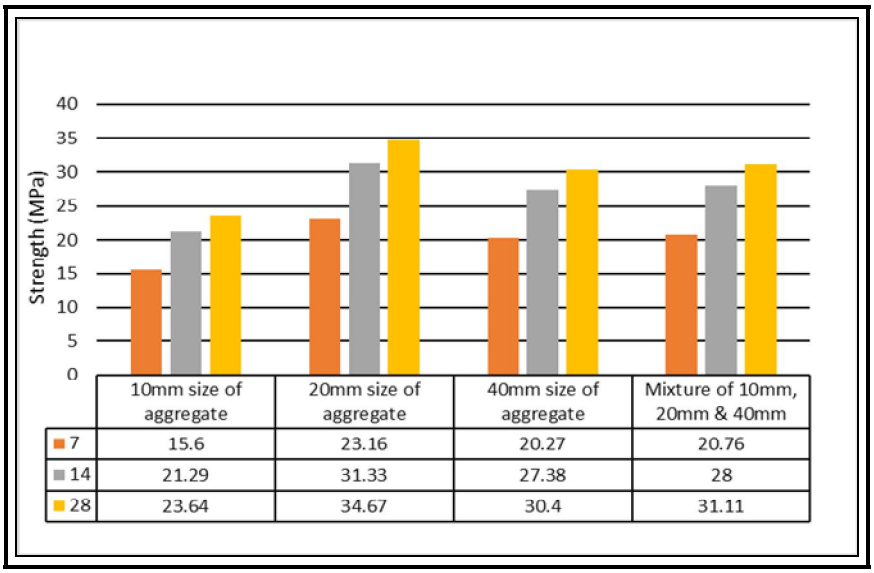
Table 2: Result of 14-day Compressive Strength test:

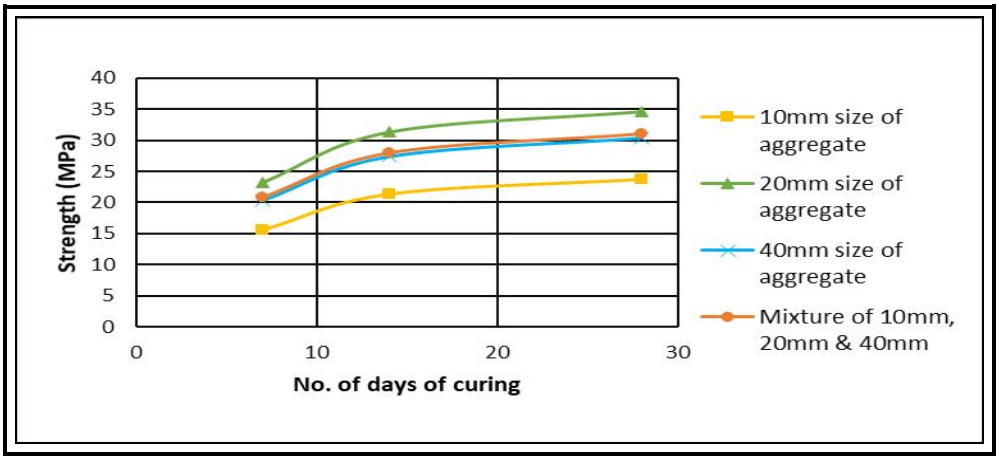
Nominal size of aggregate used in concrete cube (mm)	Load at which concrete cube failed (KN)	Compressive Strength (MPa)
10	479	21.29
20	705	31.33
40	616	27.38
Mix (10, 20 & 40)	630	28.00

Table 3: Result of 28-day Compressive Strength test:

Nominal size of aggregate used in concrete cube (mm)	Load at which concrete cube failed (KN)	Compressive Strength MPa
10	532	23.64
20	780	34.67
40	684	30.40
Mix (10, 20 & 40)	700	31.11

V. ANALYSIS OF EXPERIMENTAL DATA





VI. CONCLUSION

The results conclude that the strength increases from 10mm to 20mm nominal size of aggregates. This means that initially the strength of concrete increases with the increase in the nominal size of the aggregate until it reaches medium size of aggregate i.e., 20mm nominal size where it achieves its maximum value. Then the strength starts decreasing from 20mm to 40mm nominal size of aggregates. This implies that, after medium size of aggregates, the strength of concrete starts decreasing with the increase in the nominal size of aggregates.

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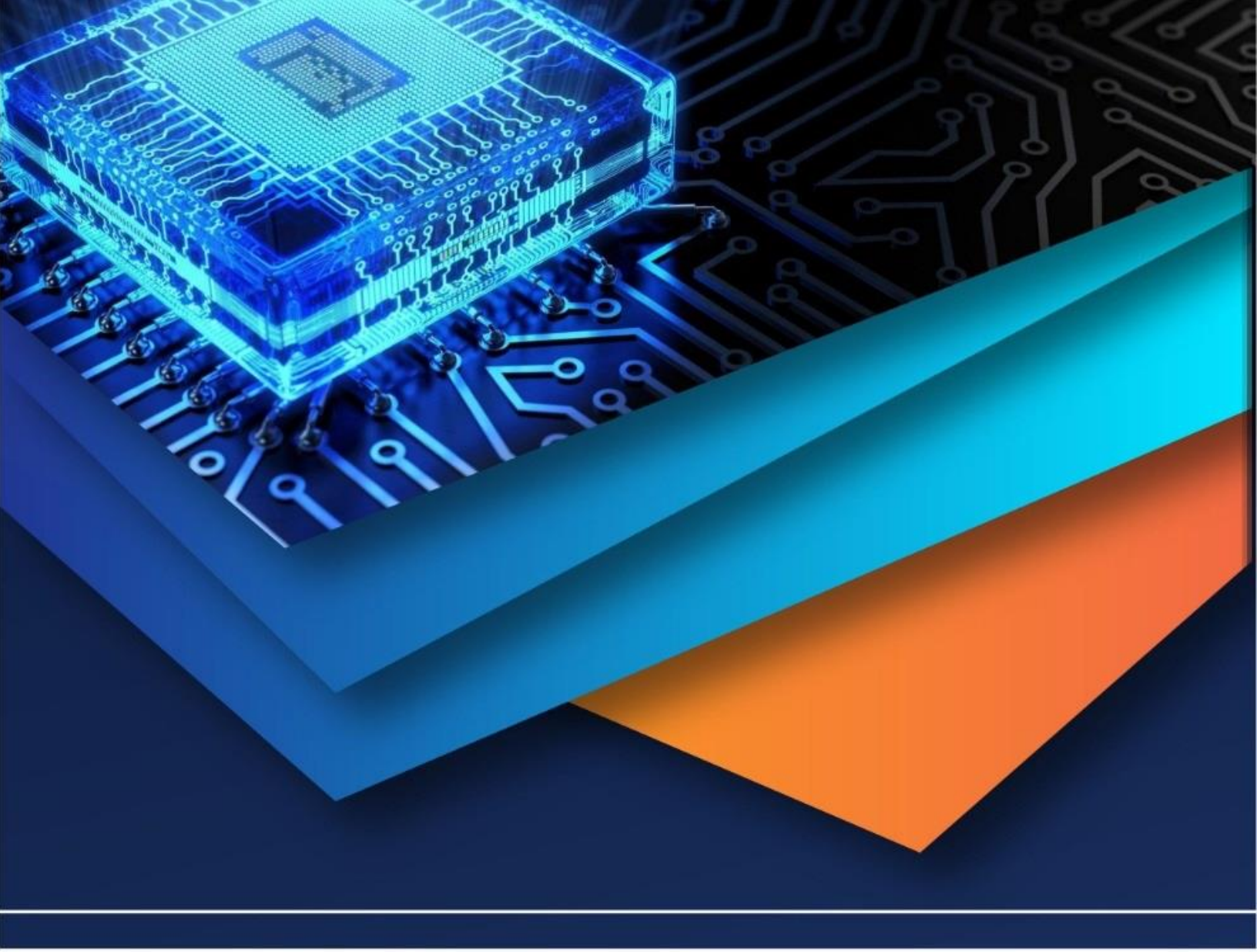

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