JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

"Effects of Aggregate Size on Concrete Strength"

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Abstract: *This study investigates the effects of aggregate type, size, and content on the mechanical behavior of normal- and high-strength concrete. Concrete mixes were prepared with basalt or limestone aggregates of 12 mm and 19 mm sizes, with varying aggregate volume factors and water-cement ratios. Results show that compressive strength is only slightly influenced by aggregate type and size, but higher coarse aggregate content improves strength in most cases. Flexural strength is mainly governed by aggregate type and matrix-aggregate interaction, with basalt generally providing higher values than limestone. Fracture energy is strongly affected by aggregate type, with basalt mixes performing better than limestone mixes, while its relation to compressive or flexural strength is unclear. Overall, basalt aggregates enhance flexural strength and fracture energy, whereas aggregate size has limited influence.*

Index Terms – Effects of Aggregate, Concrete Strength, Workability.

Introduction:

It is well recognized that coarse aggregate plays an important role in concrete. Coarse aggregate typically occupies over one-third of the volume of concrete, and research indicates that changes in coarse aggregate can change the strength and fracture properties of concrete. To predict the behavior of concrete under general loading requires an understanding of the effects of aggregate type, aggregate size, and aggregate content. This understanding can only be gained through extensive testing and observation. There is strong evidence that aggregate type is a factor in the strength of concrete. Ezeldin and Aitcin (1991) compared concretes with the same mix proportions containing four different coarse aggregate types. They concluded that, in high strength concretes, higher strength coarse aggregates typically yield higher compressive strengths, while in normal-strength concretes, coarse aggregate strength has little effect on compressive strength. Other research has compared the effects of limestone and basalt on the compressive strength of high-strength concrete (Giaccio, Rocco, Violini, Zappitelli, and Zerbino 1992). In concretes containing basalt, load-induced cracks developed primarily at the matrix aggregate interface, while in concretes containing limestone, nearly all of the coarse aggregate particles were fractured. Darwin, Tholen, Idun, and Zuo (1995, 1996) observed that concretes containing basalt coarse aggregate exhibited higher bond strengths with reinforcing steel than concretes containing limestone. There is much controversy concerning the effects of coarse aggregate size on concrete, principally about the effects on fracture energy. Some research (Strange and Bryant 1979, Nallathambi, Karihaloo, and Heaton 1984) has shown that there is an increase in fracture toughness with an increase in aggregate size. However, Gettu and Shah (1994) have stated that, in some high-strength concretes where the coarse aggregates rupture during fracture, size is not expected to influence the fracture. parameters. Tests by Zhou, Barr, and Lydon (1995) show that compressive strength increases with an increase in coarse aggregate size. However, most other studies disagree. Walker and Bloem (1960) and Bloem and Gaynor (1963) concluded that an increase in aggregate size results in a decrease in the compressive strength of concrete.Cook (1989) showed that, for compressive strengths in excess of 69 MPa (10,000 psi), smaller sized coarse aggregate produces higher strengths for a given water-to-cement ratio. In fact, it is generally agreed that, although larger coarse aggregates can be used to make high-strength concrete, it is easier to do so with coarse aggregates below 12.5 mm (Y, in.) (ACI 363-95). There has not been much research on the effects of coarse aggregate content on the fracture energy of concrete. One study, conducted by Moavenzadeh and Kuguel (1969), found that fracture energy increases with the increase in coarse aggregate content. Since cracks must travel around the coarse aggregate particles, the area of the crack surface increases, thus increasing the energy demand for crack propagation. There is controversy, however, on the effects of coarse aggregate content on the compressive strength of concrete. Ruiz (1966) found that the compressive strength of concrete increases with an increase in coarse aggregate content until a critical volume is reached, while Bayasi and Zhou (1993) found little correlation between compressive strength and coarse aggregate content.

In light of the controversy, this report describes work that is aimed at improving the understanding of the role that coarse aggregate plays in the compressive, tensile, and fracture behaviors of concrete.

I. REVIEW OF LITERATURE:

1. A.Ndon and A. Ikpe (2021) analysed the compressive strength of concrete made with various crushed stone sizes

A.Ndon and A. Ikpe (2021) analysed the compressive strength of concrete made with various crushed stone sizes (e.g., 3.35mm–10mm, 13.2mm–19mm, and 20mm–28mm) in order to identify the variations in strength between the various sizes of crushed stones that were tested after 7days, 14days, and 28days of crushing.According to the findings, compressive strength increased with increasing coarse aggregate size. It also demonstrated that the strength of concrete increased with the number of curing days and, finally, that concrete cubes created with larger coarse aggregate sizes were found to weigh more than those generated with smaller coarse aggregate sizes. Larger aggregate should be utilised for foundation construction because it has a higher compressive strength.

2. Aves and A Jr (2022) examined the compressive strengths of concrete built with fine and coarse particles from five different regions.

Several physical tests, including those for specific gravity and absorption, sieve analysis, abrasion testing, workability testing, and compressive strength testing, were used to assess the application of these aggregates on the compressive strength of concrete.The results showed that the average compressive strength of concrete formed from fine and coarse aggregates from natural river quarry sites was 23.465 MPa, and that provided crushed fine and coarse particles had an average compressive strength of 19.555 MPa. The aggregates from rivers that occasionally experienced saline water intrusion had a lower average compressive strength (18.54 MPa). For 7, 14, and 28 days, compression strength observations were made

3. Bianet.al (2021) identified peak stress and elastic modulus of recycled concrete using the response surface methodology to develop regression equations

Bianet.al (2021) identified peak stress and elastic modulus of recycled concrete using the response surface methodology to develop regression equations. Design considerations include coarse aggregate content, aggregate form, and maximum aggregate size. Experiments, theoretical research, and numerical modelling were used to evaluate how aggregate quality affected the mechanical characteristics of recycled concrete.The peak stress and elastic modulus of recycled concrete were found to be at their best when the coarse aggregate content was 45 percent, the maximum coarse aggregate size was 16 mm, and the regular round coarse aggregates made up 75 percent of the mixture. The maximum aggregatesize and aggregate shape remain constant while the peak stress and elastic modulus of recycled concrete first climb and then fall with an increase in the amount of coarse aggregate. While the maximum aggregate size increases, the peak stress and elastic modulus of recycled concrete fall while the coarse aggregate concentration and aggregate shape remain unchanged. While the fraction of coarse aggregate and maximum aggregate size remain constant, the peak stress and elastic modulus of recycled concrete increase as the amount of regular round aggregates increases.

4. Lee et.al (2021) looked at the compressive strengths of concrete for various ages based on water content and aggregate volume fractions

Lee et.al (2021) looked at the compressive strengths of concrete for various ages based on water content and aggregate volume fractions, such as dune sand (DS), crushed sand (CS), and coarse aggregate (CA). Using experimental data, the effects of changes in aggregate volume fraction on compressive strength were investigated. Compressive strength of concrete increases until the volumetric DS to fine aggregate (FA) ratio (DS/FA ratio) reaches 20%, beyond which it tends to decrease. The relationship between compressive strength variations and aggregate volume fractions was investigated under two different circumstances, taking into account the effects of each aggregate on compressive strength: (2) 0 CA CS DS and (1) 0 DS CS CA When condition (1)'s effect factor of CA = 1, the ranges for DS and CS for all mixtures were, respectively, 0.04-0.83 and 0.72-0.92. The CS and CA values fell between the ranges of 0.68-0.80 and 0.02-0.79, respectively, when the DS effect factor for

condition (2) was 1. The slump/AD ratio increased, whereas the DS/FA ratio increased by up to 40%, according to the results. For concrete workability, for example, a DS/FA ratio of 40% was ideal. Compressive strength of concrete increased till the DS/FA ratio reached 20%. After then, the compressive strength decreased as the DS/FA ratio rose. For the same DS/FA ratio, the compressive strength typically increases dramatically as water content decreases. Changes in the DS/FA ratio had a greater impact on differences in compressive strength than did changes in the unit water content. Therefore, when assessing the strength of concrete built with DS and CS, the DS/FA ratio should take precedence over the unit water content.

5. Pertiwi et.al (2021) the effect of coarse particles on the compressive strength of concrete

Pertiwi et.al (2021) the effect of coarse particles on the compressive strength of concrete was examined. Using natural river sand as the fine aggregate, ordinary Portland cement as the coarse aggregate, and polymer admixture to ensure workability, two concrete samples (CS1 and CS2) were created. 5 mm–10 mm and 10–20 mm coarse aggregate combinations were used. Additionally, specimen controls were made for each circumstance. The water-cement ratio of 1: 2: 4 and 0.55 was kept, and the planned concrete slump flow was 60-5 mm.A 300 x 300 mm concrete cylinder was tested for compressive strength after 28 days ofcuring. CS1 had the highest compressive strength, measuring 33.28 MPa, while CS2 came in second with 36.10 MPa. These different compressive strength traits were obtained when the coarse aggregate was resized, demonstrating the influence of coarse aggregate size on concrete. Additionally, the size of the coarse aggregate has little effect on how well the concrete performs.

III. EXPERIMENTAL METHODOLOGY:

1. Collection of material and site visits, collection of different type of aggregate
2. Preparation of blocks by using different sizes of aggregate
3. Checking the prepared blocks compressive strength with the help of CTM
4. Comparison with the obtained result
5. Study and compare the cost and strength of material

IV. RESULTS AND DISCUSSION:

The Results of the Compression Tests:

COMPRESSIVE STRENGTH AFTER-7 DAYS

Sr.No	**Size of Aggregate**	**Compressive Strength**
1.	6mm	7 N/mm²
2.	8mm	10 N/mm²
3.	10mm	22 N/mm²
4.	20mm	16 N/mm²
5.	40mm	14 N/mm²

COMPRESSIVE STRENGTH AFTER-14 DAYS

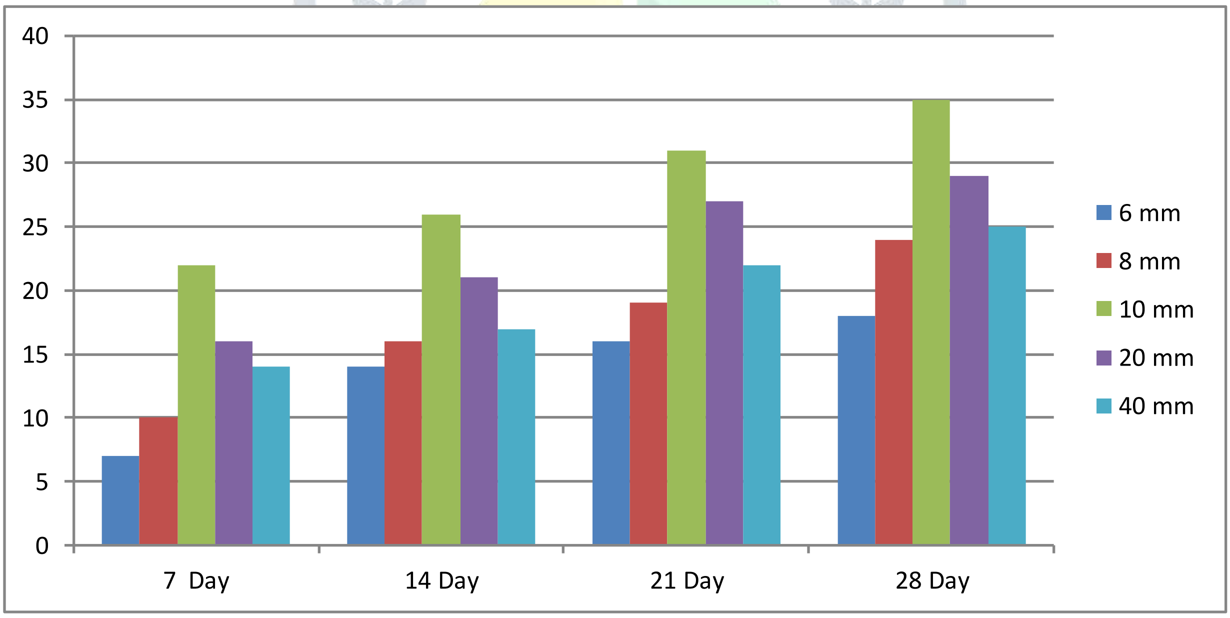
Sr.No	**Size of Aggregate**	**Compressive Strength**
1.	6 mm	14 N/mm²
2.	8 mm	16 N/mm²
3.	10 mm	26 N/mm²
4.	20 mm	21 N/mm²
5.	40 mm	17 N/mm²

COMPRESSIVE STRENGTH AFTE-21 DAYS

Sr. No	Size of Aggregate	Compressive Strength
1.	6 mm	16 N/mm²
2.	8 mm	19 N/mm²
3.	10 mm	31 N/mm²
4.	20 mm	27 N/mm²
5.	40 mm	22 N/mm²

COMPRESSIVE STRENGTH AFTER-28 DAYS

Sr. No	Size of Aggregate	Compressive Strength
1.	6 mm	18 N/mm²
2.	8 mm	24 N/mm²
3.	10 mm	35 N/mm²
4.	20 mm	29 N/mm²
5.	40 mm	25 N/mm²



Compressive Strength of Concrete made with different aggregate size

V. CONCLUSION:

Concrete compressive strength generally increases with smaller aggregate size, with 10 mm aggregates giving optimum strength. Aggregate size strongly influences strength, especially when the cement-to-aggregate ratio is below 6. Economical mixes can be achieved by reducing aggregate size and increasing the cement ratio, and lean mixes become usable structurally with small aggregates. Basalt aggregates enhance fracture energy compared to limestone. In high-strength concrete, fracture energy decreases with aggregate size, while in normal-strength concrete it increases. Aggregate content affects fracture energy differently depending on aggregate type and strength level. The flexural-to-compressive strength ratio is 9–12% for high-strength and 18–20% for normal-strength concrete. While fracture energy has no clear relation with compressive or flexural strength, it correlates closely with peak bending stresses.

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