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IMPACT OF SIZE OF COARSE AGGREGATE IN RIGID PAVEMENT

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Abstract: *Aggregates play an important role in concrete; they serve as Structural fillers which are used in concrete production. Aggregate sizes, types, and gradation are the most important factors when selecting aggregate. This study examines incorporating different sizes and types of coarse aggregate. The various aggregate sizes used in the Various mixes are 10mm and 20mm with a water-cement ratio of 0.45. Specific gravity, Los Angeles abrasion, Impact value, and Aggregate Crushing value tests were carried out on the various sizes of aggregate to determine the Strength of the coarse aggregate. When it comes to concrete, we took an M40 grade of concrete for the rigid pavement surface layer. We cast cubes with 100% 25mm 100% 20mm and 100% 10mm and compared the strengths with the same aggregates in the sub-base layer*

Index Terms - M40 Grade of concrete, Size of aggregate

I. INTRODUCTION

The choice of aggregate size is a fundamental aspect of concrete mix design that significantlyinfluences the mechanical properties of the resulting concrete. The influence of aggregate size on concrete compressive strength has been a subject of considerable interest and investigation within the field of civil engineering and materials science. This experimental study aims to explore and quantify the relationship between aggregate size and the compressive strength of concrete, shedding light on the factors that contribute to this correlation. Aggregates are granular materials such as crushed stone, gravel, sand, or recycled materials, which constitute a significant portion of concrete's volume. The interaction between cement paste and aggregates plays a crucial role in determining the overall strength, durability, and structural performance of concrete. The size of aggregates affects the packing density, interlocking, and bond between particles, which, in turn, influences the resulting concrete's mechanical properties. The background for this experimental study stems from the need to better understand and optimize the selection of aggregate size in concrete mix design. While it is known that aggregates of different sizes can impact concrete performance, the precise relationship between aggregate size and compressive strength requires detailed investigation. Previous research has indicated that a well-graded mix of various aggregate sizes can lead to better packing and densification of the concrete matrix, potentially enhancing the compressive strength. However, there is still a lack of comprehensive data regarding the influence of specific aggregate size ranges on compressive strength across a range of concrete mixes. This study aims to address this gap by conducting a series of carefully controlled experiments. The research will involve systematically varying the size of aggregates while keeping other mix parameters constant. Concrete specimens will be cast, cured, and subjectedto compressive strength tests at different ages. The results will be analyzed to discern patternsand trends, providing insights into how changes in aggregate size impact the compressive strength of concrete. The findings from this experimental study hold significant practical implications for concrete mix design and construction practices. Understanding the effect of aggregate size on compressive strength can assist engineers and construction professionals in making informed decisions about the selection and grading of aggregates for specific applications. This knowledge can contribute to the development of more economical, durable, and high-performance concrete mixes, ultimately enhancing the quality and sustainability ofconstruction projects.

II. LITERATURE REVIEW

Zheng Y, Zhang Y et al (2023) Established a 2D finite element model with a mesoscale level was. The effects of content, maximum particle size, and shape of aggregate on the strength of concrete were simulated. In addition, five mesoscopic models of aggregate gradation and specimen side length (100–450 mm) were established to investigate the influence law of aggregate grading and model size on the compressive strength of concrete. The simulation results were also compared and verified with four theoretical size-effect models. The results showed that the compressive strength shows a trend of decreasing and then increasing with the increase of aggregate content and falling with the growth of maximum aggregate size d max . The peak stress of convex polygonal aggregates is higher than that of round and elliptical. In addition, when the ratio of model side length to the maximum aggregate particle size is about 3.5, the compressive strength gradually decreases with the increase of specimen size, up to 27.65 % decreased, showing a pronounced size effect. After comparative analysis, the simulated data in this paper fitted well with theBažant's Type-2, Kim's modified, Jin's modified, and Carpinteri's size effect law (SEL). In addition, the data obtained from the simulation of this paper would better reflect the existing test conclusions. The mesoscale model established in this paper can significantly improve the effectiveness and efficiency of full-graded concrete modeling, and better simulate the strength difference between full-graded and wet-screened specimens. The difficulties in the mesoscale numerical simulation are solved to a certain extent.

Chen J, Du W et al (2022) Studied porosity and compressive strength are important indicators for evaluating the properties of planting concrete. By preparing planting concrete with different aggregate gradations (10–30 mm, 20–40 mm) and water–cement ratios (0.25, 0.27, 0.29, 0.31, 0.33), the effect of aggregate gradation and water–cement ratio on the porosity and compressive strength of the planting concrete was analyzed, the intrinsic relationship between aggregate gradation and plane pore parameters was studied, the strengthgrowth pattern and microscopic strengthening mechanism were studied, the relationship between porosity and compressive strength of the planting concrete were explored, and a tall fescue planting experiment was carried out to evaluate the plantation planting concrete. The results show that under the same conditions of water–cement ratio, thesmaller the particle size of the aggregate, the smaller the porosity of the plane, and the denser the structure. The average diameter of the planting concrete shows an exponential relationship with the porosity of plane. The early growth of the compressive strength of the planting concrete is rapid; the compressive strength has a linear relationship at the ages of 7 days and 28 days. Compared to polynomial and logarithmic functions, the exponential function gives a better insight into the relationship between the porosity and compressive strength of the planting concrete. Tall fescue seeds germinate and grow well; height, cover, and leaf rootstock and element content of plants can be used as indicators to assess the performance of vegetated concrete planting.

Wei H, Liu Y et al (2022) Investigated the effects of aggregate size on the mechanical properties of lightweight concrete (LC). Four gradings of lightweight aggregate (LWA) were designed and used to prepare the specimens for compressive strength, splitting tensile strength, and flexural strength tests. An estimating method for compressive strength of LC was then established. The compressive strength of tested LC was up to 95 MPa at 90-day curing time. The test results suggested that the absence of medium-size particles decreasedthe compaction of LC, therefore the density and compressive strength were negatively affected. Specimens having single size of aggregate showed lower splitting tensile and flexural strengths than that having three sizes of LWA. The parameters of the estimating model were determined according to the test results, and the compressive strength predictionsof estimation model were compared with the results from other literature.

Jin L, Yu W (2021) Established the meso-mechanical modelling method has been based on the continuous grading aggregate model to simulate the uniaxial compressive failure behavior under quasi-static load of concrete square samples having different side lengths, maximum aggregate sizes (MAS) and concrete strength grades. The numerical results demonstrated that the MAS affected the crack propagation form in the internal components ofconcrete and the nominal compressive strength decreased with the increasing MAS; the increasing MAS could enhance the sensitivity of strength-to-structural size and make the size effect more obvious. In addition to the numerical analysis, a modified Type-2 size effect law considering the MAS for the nominal compressive strength has been proposed from theoretical perspective, which makes it possible to quantitatively predict the size effectbehavior of compressive strength. Mesoscopic simulation results and some experimental results have validated the modified Type-2 size effect law.

Huang J, Luo Z (2020) prepared 56 groups of pervious concrete samples with different aggregate types and sizes and mineral admixtures. Test results show that higher compressive strength and permeability are obtained in pervious concrete with dolerite aggregate comparedto previous concrete with granite aggregate. The optimum porosity and w/c for pervious concrete with both dolerite and granite are 18% and 0.25, respectively, in the studied ranges. For granite aggregate, the permeability decreases as the particle size increases in the case of single size and the lowest permeability is observed for the combined gradation of granite aggregate. The compressive strength of pervious concrete increases with the increase of replacement level of silica fume while it decreases with the increase of replacement level of fly ash. The maximum permeability for single used of silica fume and fly ash is found at the replacement level of

6% and 10%, respectively. The maximum permeability for the combinedused of silica fume and fly ash was observed in the case of 0% fly ash and 6% silica fume.

Kim K, M Lee et al (2019) studied that dynamic increase factor (DIF) is a measure of therate effect in the analysis and design of structures subjected to impact or impulsive loads. A variety of DIFs have been suggested based on the results of split Hopkinson pressure bar (SHPB) tests, which is the test technique most used to obtain dynamic material properties. However, due to the lack of a standard test method and some limitations in the SHPB equipment, most SHPB tests have been conducted for mortar or concrete specimens containing small size coarse aggregate that is very different from the actual concrete used in construction. The DIFs that are provided in most structural design codes are based on these test results. Therefore, it is necessary to investigate the effect of coarse aggregate size on the dynamic concrete compressive strength. In this study, a series of SHPB tests were conducted for mortar and concrete specimens with various maximum aggregate sizes. The test results indicated that the larger maximum coarse aggregate sizes induce larger heterogeneity of specimens. On the other hand, the pure rate DIFs did not exhibit a dependency on the maximum coarse aggregate size. Based on these results, guidance as to the maximum coarse aggregate size of concrete specimens for SHPB tests is provide

III. METHODOLOGY

1. Test on Aggregate

Specific Gravity Test

Aggregate Crushing Value Test

Los Angeles Abrasion Test

Impact Value Test

2. Mix Design

a) STIPULATIONS FOR PROPORTIONING

a) Grade designation: M40

b) Type of cement: OPC 53 Grade conforming IS 12269

c) Maximum nominal size of aggregate: 25mm

d) Maximum water-cement ratio: 0.45 (Table 5 of IS 456:2000)

e) Workability: 100-120mm slump

f) Exposure condition: Moderate (For Reinforced Concrete)

g) Method of concrete placing: Pumping

j) Degree of supervision: Good

k) Type of aggregate: Crushed Angular Aggregates

m) Maximum cement content: 360 kg/m^3

b) TEST DATA FOR MATERIALS

a) Cement used: OPC 53 Grade conforming IS 12269

b) Specific gravity of cement: 3.15

c) Specific gravity of Aggregates:

1) Coarse aggregate 10mm, 20mm, 25mm: 2.68, 2.67, 2.7

2) Fine aggregate: 2.65

d) Water absorption:

1) Coarse aggregate: 0.5 %

2) Fine aggregate (Msand) : 2.5 %

e) Free (surface) moisture:

1) Coarse aggregate: Nil (Absorbed Moisture also Nil)

2) Fine aggregate: Nil

f) Sieve analysis:

1) Coarse aggregate: Conforming to all in aggregates of Table 2 of IS 383

2) Fine aggregate: Conforming to Grading Zone II of Table 4 of IS 383

c) TARGET STRENGTH FOR MIX PROPORTIONING

f’ck =fck + 1.65 s

Where,

f’ck = target average compressive strength at 28 days,

fck = characteristics compressive strength at 28 days, and

s = standard deviation.

From Table I of IS 10262:2009, Standard Deviation, s = 5.6 N/mm^2.

Therefore, target strength = 40 + 1.65 x 5.6 = 49.24 N/mm^2.

d) SELECTION OF WATER•CEMENT RATIO

Adopted maximum water-cement ratio = 0.38. From the Table 5 of IS 456 for Very severe Exposure maximum Water Cement Ratio is 0.45 0.38 < 0.45 Hence ok.

e) SELECTION OF WATER CONTENT

From Table 2 of IS 10262:2009, maximum water content for 20 mm aggregate = 180 litre (for 25 to 50 mm slump range) Estimated water content for 100 mm slump = 180+ (6/180) = 180 litre.

f) CALCULATION OF CEMENT CONTENT

Adopted w/c Ratio = 0.38

Cement Content = 180/0.38 = 473 kg/m^3

g) PROPORTIO0N OF VOLUME OF COARSE AGGREGATE AND FINEAGGREGATE CONTENT

From Table 3 of (IS 10262:2009) Volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.38

Then coarse aggregate weight = 0.65 * 1600 = 1039 kg per cum

Fresh concrete density for 25mm size aggregate = 2375kg/m^3

Approx. Air content =1.5% Therefore, fine aggregate weight= 0.985(2375) – (180+473+1039) = 646kg per cu.m of concrete

Cement = 473 kg/m^3 Water = 180 l/m^3

Fine aggregate= 645 kg/m^3 Coarse aggregate = 1039 kg/m^3

Mix Proportion By weight = 1:1.3:2.1

w/c	Cement content	Fine aggregate content	Coarse aggregate content
180	**474 kg/m^3**	**645 kg/m^3**	**1040 kg/m^3**
0.38	**1**	**1.36**	**2.1**

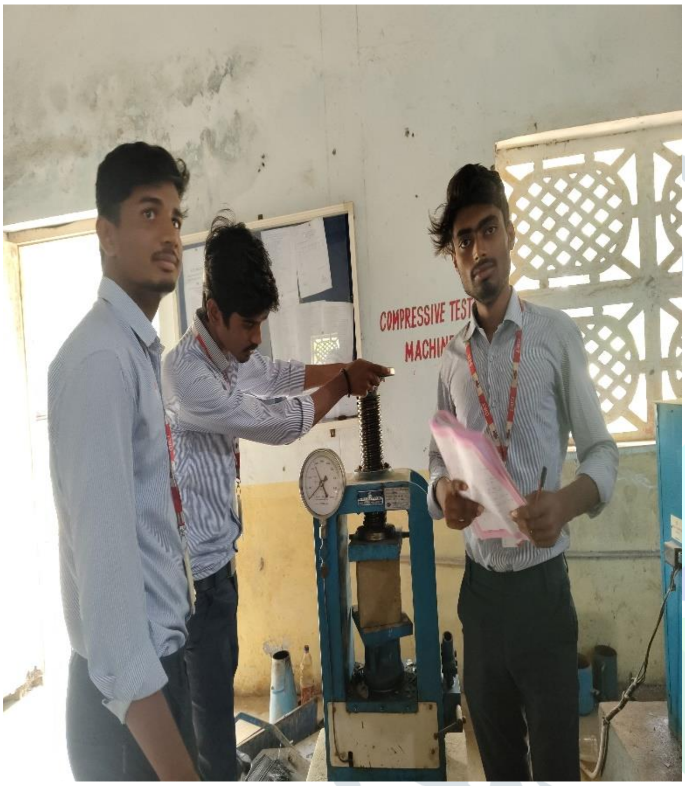
IV. RESULTS AND DISCUSSION

4.1 Test results for Aggregates

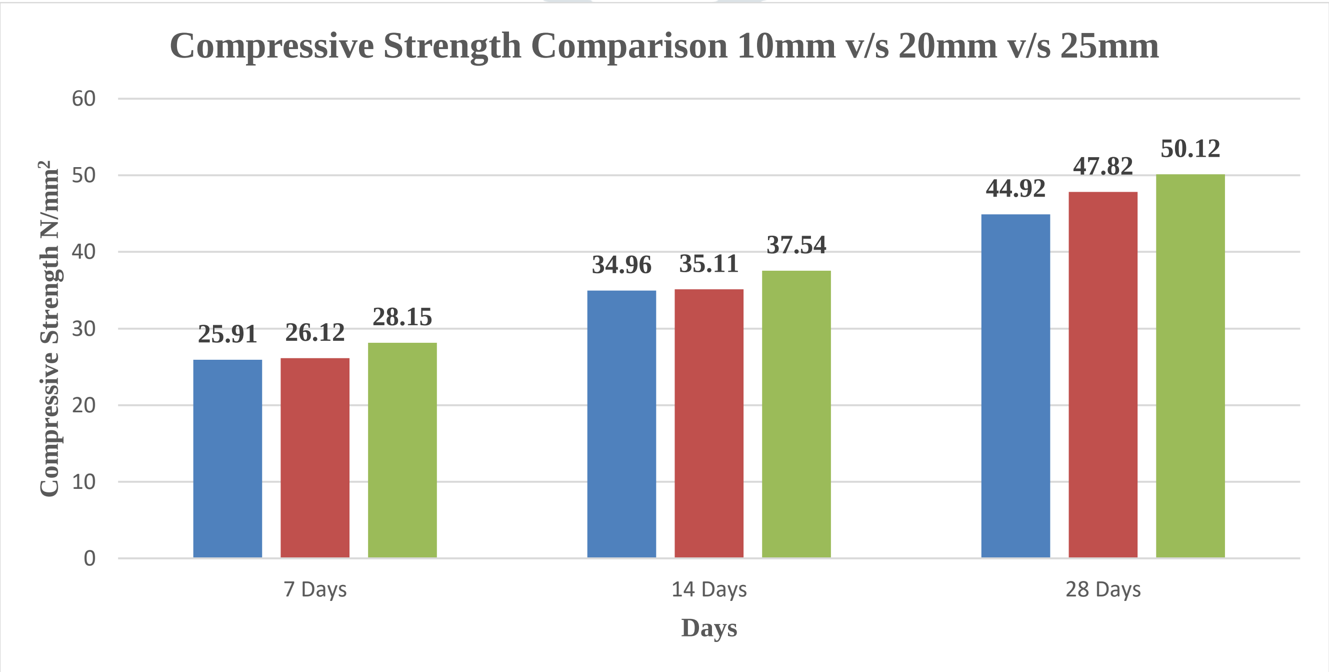
Test	Size of aggregate 10mm	Size of aggregate 20mm	Size of aggregate 25mm
Specific Gravity Test	2.6	2.68	2.78
Aggregate Crushing Value Test	20%	18%	-
Los Angeles Abrasion Test	15%	18%	15%
Impact Value Test	15%	16%	--

4.2 Tests on Concrete

Grade of Concrete	7 Days Compressive Strength (N/mm^2)	14 Days Compressive Strength (N/mm^2)	28 Days Compressive Strength (N/mm^2)
M40 (100% 10mm)	25.91	34.96	44.92
M40 (100% 20mm)	26.12	35.11	47.82
M40 (100% 25mm)	28.15	37.54	50.12



4.3 Comparison of Strength



V. COCNLUSION

In conclusion, we observed that size of aggregate increase means the strength of concrete is increased. For 10mm aggregate the compressive strength of concrete for 28 days is 44.92 N/mm^2, For 20mm aggregate the compressive strength of concrete for 28 days is 47.82 N/mm^2 25mm aggregate the compressive strength of concrete for 28 days is 50.122 N/mm^{2}The selection of coarse aggregate size plays a pivotal role in determining the overall performance and longevity of rigid pavement structures. Larger aggregate sizes, such as 20mm and 25mm, typically offer superior strength, durability, and resistance to cracking, owing to their enhanced interlocking properties within the concrete matrix. However, considerations regarding workability during construction must be weighed against these benefits, as smaller aggregate sizes like 10mm may provide improved ease of placement and finishing. Moreover, the impact of aggregate size extends to surface characteristics, with larger aggregates offering enhanced skid resistance but potentially resulting in a rougher surface texture. Ultimately, the choice of aggregate size should be guided by a comprehensive assessment of project requirements, including structural demands, construction feasibility, and long-term pavement performance goals.

VI. REFERENCE

1. Du, Y., Zhao, Z., Xiao, Q., Shi, F., Yang, J. and Gao, P., 2021. Experimental study onthe mechanical properties and compression size effect of recycled aggregate concrete. Materials, 14(9), p.2323.
2. Jin, L., Yu, W., Li, D. and Du, X., 2021. Numerical and theoretical investigation on the size effect of concrete compressive strength considering the maximum aggregate size. International Journal of Mechanical Sciences, 192, p.106130.
3. Ogundipe, O.M., Olanike, A.O., Nnochiri, E.S. and Ale, P.O., 2018. Effects of coarse aggregate size on the compressive strength of concrete. Civil Engineering Journal, 4(4), pp.836-842.
4. Kim, K.M., Lee, S. and Cho, J.Y., 2019. Effect of maximum coarse aggregate size on dynamic compressive strength of high-strength concrete. International Journal of Impact Engineering, 125, pp.107-116.
5. Zheng, Y., Zhang, Y., Zhuo, J., Zhang, P. and Hu, S., 2023. Mesoscale synergistic effect mechanism of aggregate grading and specimen size on compressive strength of concrete with large aggregate size. Construction and Building Materials, 367,p.130346.
6. Chen, J., Du, W., Zhao, G., Shi, M. and Xue, B., 2022. Effect of aggregate size and water/cement on compressive strength and physiological performance of plantingconcrete. Materials, 15(19), p.6685.
7. Wei, H., Liu, Y., Wu, T. and Liu, X., 2020. Effect of aggregate size on strength characteristics of high strength lightweight concrete. Materials, 13(6), p.1314.
8. Güçlüer, K., 2020. Investigation of the effects of aggregate textural properties on compressive strength (CS) and ultrasonic pulse velocity (UPV) of concrete.
9. Wang, Y., Wu, J., Ma, D., Yang, S., Yin, Q. and Feng, Y., 2022. Effect of aggregate size distribution and confining pressure on mechanical property and microstructure of cemented gangue backfill materials. Advanced Powder Technology, 33(8), p.103686.