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EFFECT OF AGGREGATE SIZE AND WATER TO CEMENT RATIO (W/C) ON THE POSSIBILITY OF SEGREGATION OF CONVENTIONAL CONCRETE

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ABSTRACT:
Many studies have been done on the causes and remedies of Segregation in Concrete. Water to cement ratio is the major reason behind the causes of segregation. Cement content, size and surface texture of aggregates, percentage of admixtures, transportation and compaction are other factors for causes of segregation. In this research, how water to cement ratio (W/C) and size of coarse aggregate affect the chances of segregation in concrete have been done. Water to cement ratio varies from 0.4 to 0.6 in this study. Also, size of coarse aggregate varied with different proportions. From test result received and analyzed from segregation test setup it was found the possibility of segregation increased if the water to cement ratio is more than 0.50. Also, the results were compared with slump test as per Indian codal provisions.

Keywords: Concrete, Segregation, Segregation test setup, cement, water-cement ratio

1. INTRODUCTION:

Cement paste and dust are kept apart during the handling and placement of concrete. Internal factors, such as improperly proportioned and improperly mixed concrete, or a mix that is too workable, can cause segregation. Additionally, it might be brought on by outside factors like excessive vibration, poor placement or transportation, or unfavorable weather. Since the circumstances of the concrete ingredients, such as aggregate quality or other additional cementitious components, are constantly changing, It is difficult to select the proper concrete mix proportion required to achieve a suitable consistency. The goal of a concrete mix design is to produce concrete that has the desired properties in both its fresh and hardened states, including uniform appearance, durability, strength, and workability, while also providing a reasonable economic benefit. Due to the broad range of particle sizes and weights in concrete, maintaining uniformity is essential to ensuring good fresh state performance. As a result, in addition to fluidity and mobility, the concept of "workability" should incorporate homogeneity and resistance to segregation. A well-designed mixture should have a unit water content and sand-to-aggregate ratio (S/a) that are representative of the main factors in the uniformity (or segregation) of the concrete mixture in order to prevent segregation throughout the delivery and placement operations. The unit water content of concrete is the amount of water needed to produce one cubic metre of concrete. In mixture proportioning, the target slump establishes the unit water content [1,15]. Because of this, it is possible to think of the unit water content as a deciding element in the concrete mixture's workability. Conversely, if the water to cement ratio stays constant, the unit water content is a portion of the cement paste because concrete mixtures are suspensions of

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aggregates within cement paste [16,22]. As a result, depending on whether the unit water content rises or falls, a different amount of cement paste will be needed to support the aggregates. According to [3,13,18], S/a is the ratio of fine aggregate (sand) to total aggregate in the unit volume of a concrete mixture (one cubic metre).
The characteristics of conventional concrete, particularly its susceptibility to segregation, are significantly influenced by the aggregate size and water-to-cement (w/c) ratio. Coarse aggregates, being larger in size, possess a greater tendency to settle toward the bottom of the mix under the influence of gravity, especially during transportation and placement.

If the concrete mix isn't appropriately proportioned or handled, this settling can lead to segregation, where the larger particles separate from the mortar, compromising the uniformity and integrity of the structure. Conversely, finer aggregates can help fill the voids between coarse particles, aiding in mitigating segregation. However, an excessive content of fines can increase the water demand, potentially exacerbating the risk of segregation if not adequately managed.

Moreover, the water-to-cement ratio is a critical factor governing the workability and strength of concrete. A higher w/c ratio typically results in a more workable mix but can also heighten the likelihood of segregation. Excessive water content can lead to bleeding, where water migrates to the surface of the mix, carrying fine particles with it and causing mortar to segregate from coarse aggregates. Conversely, a lower w/c ratio enhances concrete strength and durability but may reduce workability, making proper consolidation and compaction more challenging.

The interaction between aggregate size and w/c ratio is crucial; larger aggregate sizes may necessitate a lower w/c ratio to achieve adequate workability without segregation, whereas smaller aggregate sizes might allow for a slightly higher w/c ratio while maintaining workability and minimizing segregation risks. Consequently, achieving a balanced mix design tailored to specific project requirements, coupled with proper handling and construction practices, is paramount in producing durable and homogeneous concrete structures resistant to segregation.

If segregation has not taken place, the S/a should be as high as possible to determine the appropriate S/a. Because the sand particles (fine aggregate) in the concrete mixture are relatively small, the S/a is specifically related to the segregation of the concrete, i.e., it is related through the cohesion of the concrete mixture [21].

Most construction sites use ready-mixed concrete made in facilities with a license. Although there is a chance that the concrete mixture will segregate due to factors other than the concrete mix proportion and materials, such as a lengthy transfer time, the supplied concrete should still be examined at the project site. However, generally speaking, the conditions of the concrete mixture after the slump test are observed in order to inspect the segregation of the mixture, and this assessment can be contested because it is a qualitative method [2,4,20]. Till date, many researchers have done studies regarding filling and passing ability segregation resistance of concrete but almost related to Self-Compacting Concrete.

In almost all construction sites of India are having major issues of segregation in concrete during the placing of concrete due to many reasons but a higher water-cement ratio. And unfortunately, there is no on-site equipment available for checking the chances of segregation during the mixing of concrete

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ingredients. In this study Prepared segregation test equipment on trial basis which can measure the possibility of segregation for normal Concrete.

2. EXPERIMENTAL STUDY:

2.1 Ingredients: Following are the basic ingredients used for the present investigation:

- **Cement**: Ordinary Portland Cement, grade 53, was the type of cement utilized for the entire trial. The cement had a specific gravity of 3.15.
- **Aggregates:** Fine aggregate (FA): F.A. with a specific gravity of 2.51 and a fineness modulus of 2.70 that conforms to Zone III of IS: 383-1970 is considered a fine aggregate (FA). Coarse aggregate (CA) : Crushed granite metal with a specific gravity of 2.70 and conforming to
  IS: 383-1970
- **Water** : Clean Potable water available from local sources was used for mixing

2.2 Mix Design: The details of the mix design and its proportions (kg/m3) for the normal concrete grades M 25 and M 40 are shown in the table 1 & 2.

Table 1: Concrete Mix Proportions of M25 Grade

W/C	OPC	FA	CA
0.40	492.50	572.29	1142.24
0.45	437.78	587.66	1172.93
0.50	394.00	599.96	1197.48
0.55	358.18	610.02	1217.56
0.60	328.33	618.41	1234.30

Table 2: Concrete Mix Proportions of M40 Grade

W/C	OPC	FA	CA
0.40	480	580.95	1158.75
0.45	426	596	1188.78
0.50	384	608.40	1213.51
0.55	349.09	617	1231.49
0.60	320	625.18	1247.81

2.3 Specification of Equipment:

A segregation test setup is made up of steel and includes four different compartments. This includes a hopper on top, as shown below in Fig. 1, which has a conical shape. The upper diameter of the hopper is 260mm, the lower diameter of the hopper is 130mm, and the height of the hopper is 280mm. Hopper is able to store up to 0.0084 m^3 of concrete. It has a gate at the lower end that can empty the concrete stored in the hopper. The second part of the model is the reinforcement compartment, which has a size of 300 x 300 x 300 mm^3. In this part, 10 mm and 12 mm-diameter bars are provided as shown above. It also has a shutter at the bottom to pass out the concrete. The third component measures 300 x 300 x 300 mm3. It has a sieve at the bottom of it. These sieves are reusable and are 1.18 mm, 2.36 mm, 4.75 mm, and 6 mm. All the sieves are a wired mess. The last and fourth parts are

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to collect the concrete.

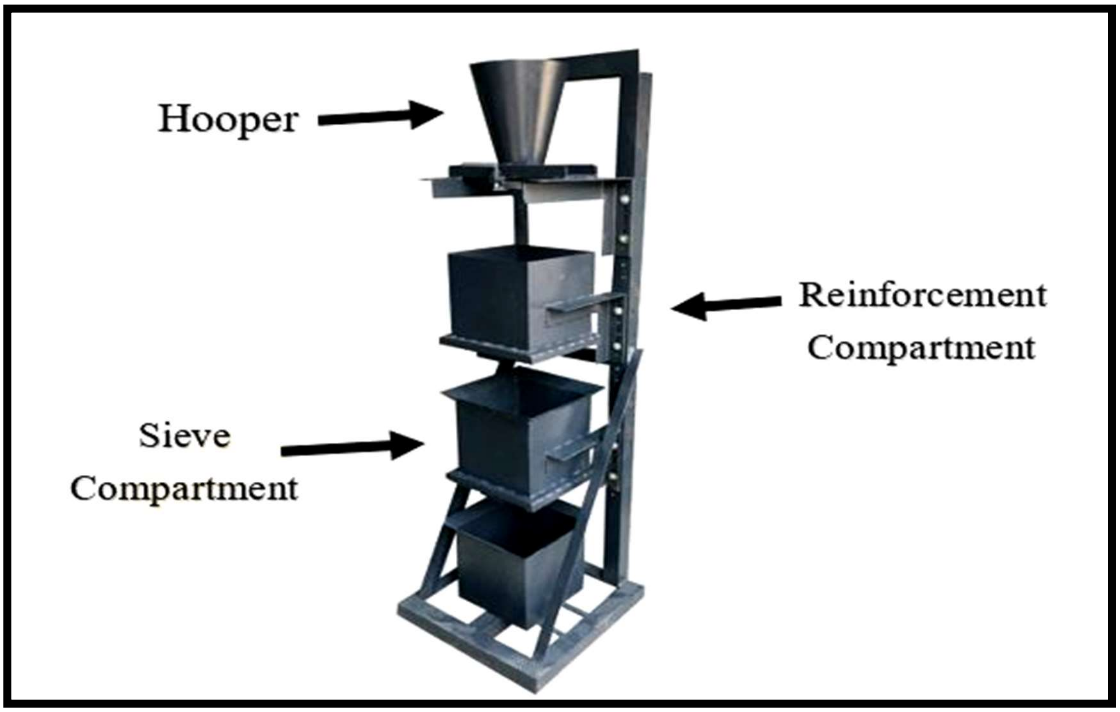

Fig 1: Segregation Test equipment

2.4 Test procedure of newly designed segregation test setup:

In this newly designed segregation test, we are going to find the possibility of segregation in concrete. We consider the left slurry at the end of the test. And compare it with existing methods. And make a Graph of segregation possibilities.

- As needed, place a sieve on the lower box and reinforcement bars on the upper box.
- Using the hand scoop, carefully fill the upper hopper with the concrete sample until it is level.
- Open the hopper's bottom trapdoor to let concrete drop into the lower box. With the road, gently push the concrete that is sticking out on its sides.
- Allow the concrete to fall into the lower box, which has a sieve at its lower part, by opening the Shutter at the bottom of the upper box.
- Finally, let the concrete fall into the collection box by opening the Shutter of the lower box as well.
- Measure the quantity of left-over slurry in the box.

3 TEST RESULTS:

- The Segregation Test results for this study are shown in table 3 and 4.and Also show the Cumulative graph of Relationship between Water/Cement (W/C) Ratio and bleeding of fresh concrete For M25 and M40.

Table 3: Bleeding of fresh concrete (M 25) from different sieves size

W/C ratio	Slump (mm)	Bleeding from different sieve size (ml)			
		1.18mm sieve	2.36mm sieve	4.75mm sieve	6mm sieve
0.4	0	0	0	0	0
0.45	52	0.02	0.02	0.08	0.1
0.5	120	0.035	0.06	0.25	0.5

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0.55	180	0.065	0.14	0.36	1
0.6	205	0.105	0.24	0.7	1.3

Table 4: Bleeding of fresh concrete (M 40) from different sieves size

W/C ratio	Slump (mm)	Bleeding from different sieve size (ml)			
		1.18mm sieve	2.36mm sieve	4.75mm sieve	6mm sieve
0.4	0	0	0	0	0
0.45	60	0.01	0	0.08	0.02
0.5	160	0.02	0.03	0.06	0.7
0.55	180	0.06	0.095	0.18	0.95
0.6	220	0.095	0.13	0.3	1.2

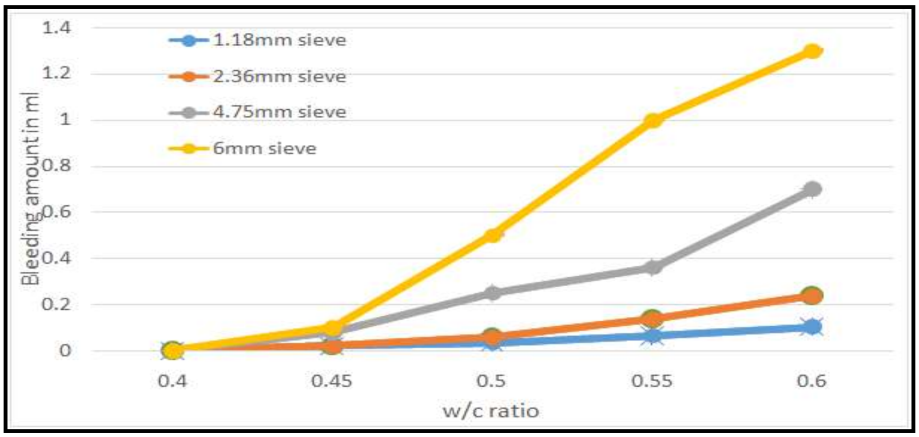

Fig 2: Cumulative graph of Relationship between Water/Cement (W/C) Ratio and Bleeding of fresh concrete (M25)

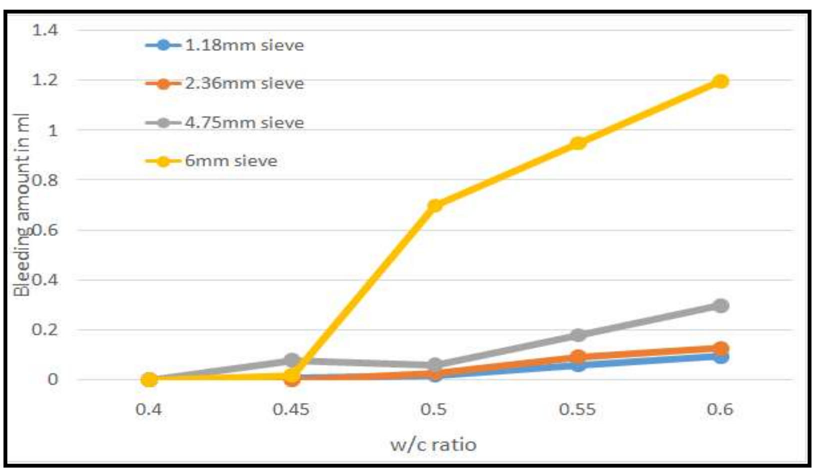

Fig 3: Cumulative graph of Relationship between Water/Cement (W/C) Ratio and Bleeding of fresh concrete (M40)

4. CONCLUSION

In this research, a new test setup for segregation is introduced. On the basis of the study of already available tests of workability and segregation, this new model has been developed. done tests on M25 and M40 grades of normal concrete and found bleeding amounts from different sizes of the sieve of 1.18mm, 2.36mm, 4.75mm, and 6mm. compared all their results with existing methods.

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plotted a graph of the bleeding amount and W/C ratio. From all these results, they prepared a segregation possibility curve of normal concrete. It has been observed from test results the possibility of segregation increased if the water to cement (w/c) ratio is more than 0.50.

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