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A Technical Review on Aggregate Characteristics

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Abstract— *concrete is a worldwide used material. Among that 60 to 80 % volume is occupy by aggregates. Characteristics of aggregate includes shape, size, surface texture etc. Aggregate characteristics like shape, size, texture and gradation affect the workability, flow ability, finishing, bleeding, and segregation of fresh concrete and also affect the strength and durability of hardened concrete. From this paper a critical mark are pointed that the aggregate characteristics play important role and different methods are described to find aggregate characteristics.*

Keywords- *aggregate, shape, size, aggregate characteristics, analysis*

I. INTRODUCTION

Concrete is a widely used material in the world. Concrete is a mixture of cement, fine aggregate, course aggregate and water. Among all this aggregate characteristics is more important because aggregate occupy approximately 60 to 80 percentage of the total concrete mix volume. Aggregate characteristics affect the requirements of water. Angular, Rough, and elongated particles require more water to produce workable concrete than smooth, rounded and compact particles. So the shape and texture of aggregate have a significant effect on the water requirement. Near-spherical aggregates require less water for mixing. Flat, needle-shaped and elongated particles should be avoided due to high requirement of water and are prone to segregation. Generally, flat and elongated particles should be limited to about 15 percent by weight of the total aggregate.

Particles shape affect workability of fresh concrete. The specific surface area is related with the requirement of cement paste in the concrete mix. For lower amount of specific area, the requirement of cement paste is less. To achieve same amount of workability with higher surface area, requirement of cement paste is high due to flat and elongated particles. Water requirement is also affected by the aggregates shape and texture. If requirement of water is high to get given workability then it reduces strength of concrete and increases concrete bleeding.

II. LITERATURE REVIEW

Persson, A.-L. (1998) [1] present a method to characterize fine aggregate by digital image analysis. Author used 26 different location samples for the study. Among that 26 samples; 11 are crushed rocks and remaining are natural sand and gravel materials. Sieve analysis process is carried out according European code. They used different methods like scanning electron microscope method (back scatter mode), thin section method, polarization microscopy with UV light method for different range of materials. They used high resolution camera to capture images. The relationship between shape, mineral content and grain-size distribution of fine aggregates is obtained from these methods. There is a major and noticeable difference between the shape of natural aggregates and crushed aggregates.

Kwan et al (1999) [2] describes the shape characteristics of course aggregates. Two different methods used in this paper namely traditional method and digital image processing method. Different type and different type of twenty five samples of rock have been analyzed in this paper. Traditional method carried out by mechanical sieving and also manual sieving used as detailed in the British Standard code. Graphically results of this method shown in the form of grading charts. Author noted some important point from this method. An elongated particle can pass along the sieve without any difficulties even its length more than the sieve size. Flaky particles can pass along the sieve even particles with greater breadth and smaller length than diagonal length of the sieve. Flakiness and elongation indexes prepared for different friction size of aggregates. This traditional method is time consuming, tedious and laborious. In second method digital image processing can be performed with a photographic stand, light sources, CCD camera, computer and software for image analysis. DIP can be performed better with high quality picture of aggregate particles. As per requirement the focus of lens is adjusted. From that a clear and sharp image of the aggregate sample can be obtained. The projected area of the particle is known as area of a particle. The analyzed projected image is bonded in rectangular box. The length and breadth of that box is defined as the length and breadth of particle. There is minor change for different stable position of particle. Digital image processing is very fast and time saving method with respect to traditional method. Once all the equipments has been setup and adjusted then it required around 10 minutes. In this method volume of particles or the mass of particles is not measured. Results of DIP method converted to correlate with traditional method. Results of DIP area frictions converted in to mass friction and breadth to relevant sieve size. For that they took some assumptions and

trial and error process taken to determine it. Results of both method compared and correlation between the shape characteristics defined. Author concluded that results of DIP had strong correlation with traditional method.

E. Masad et al (2000) [3] studied the one of the important property "Angularity" of fine aggregate in this paper. Two computer automated procedures used in this paper. The first method is based on the concepts of the erosion-dilation techniques and the second method is based on the fractal approach. Total 23 sand sample ware used for this study. In first method, pixels to the edges of objects are removed from a binary image in erosion process. This process tends to smooth the object. Erosion done evenly from all sides towards the centre. Vary small objects may be lost completely in this process. In dilation process, pixels to the edges of objects are added from a binary image**.** To separate these two effects and to find angularity only, the image-analysis algorithm starts by determining the number of erosion operations required to smooth the objects and, at the same time, do not cause particles to disappear during the process. In this technique, objects area is measured two times; original image area and area after erosion-dilation process. The difference between those two areas is calculated in percentage which measured the aggregate angularity. That value indicates the surface angularity. In second method, erosion and dilation process is also applied. With the help of logical operator that two images are combined. These operators compared those two images and remove the pixels from both images at the same location. The pixels removed and added in the erosion and dilation operations respectively are retained on the final image. Retained pixel shows width of the image which is proportional to the number of erosion-dilation cycles and surface angularity. The effective width of the boundary increased which is measured by varying the number of erosion-dilation cycles. The effective width versus the number of erosion-dilation cycles is plotted on a log-log scale. The graph show a linear variation for angular boundary and its slope indicates the fractal length of the boundary. Fractal length increases with an increase in the boundary angularity. Author compares the result of aggregate angularity for both indirect method and imaging techniques. Different correlations derived from this and concluded that imaging results had moderate correlation with the uncompacted voids and poor correlation with the angle of internal friction.

Al-Rousan et al(2007) [4] present a significant effect of different characteristics of aggregate. Aggregate characteristics performance measured on hydraulic cement concrete and hot mix asphalt for different layers. For that most widely used method to analysis aggregate characteristics taken in this paper. Aggregate form and texture analyzed by using Fourier series formulas. The ratio of the intermediate dimension to the shortest dimension is taken to measure flatness of particle. The ratio of the longest dimension to the intermediate dimension is taken to measure elongation of particle. Author used the erosion–dilation technique to capture fine aggregate angularity and even surface texture. Author also used outline slop method to determine angularity and wavelet analysis method for texture. Three independent parameter texture, angularity and form used to quantify aggregate characteristics. It has been proven that imaging techniques are strong emerging technology to quantify shape characteristics of aggregate. Author recommended Wavelet analysis of gray images of particle for texture and Gradient method for angularity.

Lee et al (2007) [5] describes a method to acquire and analysis of 3D data from the surfaces of coarse aggregate particles. Aggregate particles passing along a conveyor belt in this method. The data of the upper hemisphere is acquired with the help of Laser Triangulation method. To provide a geometrical interpretation of particle shape, algorithm used with mathematical morphology. The three dimensional surface data of the aggregate particle are recovered with Laser triangulation method. A laser line applied vertically down on a conveyor belt in such a way that the line is perpendicular to the direction of conveyor belt. At the intersection point of laser line camera captured the image. The acquired image of aggregate and the observed position of laser line is correlate with the help of trigonometry. To calculate the corresponding coordinate of a given point Pythagoras' theorem is used. For that points which are not visible from both the camera and the laser; a second camera is added. This is placed in same position but in opposite direction to the first camera and also about the laser plane. The results of each camera captured are combined to provide a complete description. From that the upper hemisphere of particle is calculated. But the bottom side of the particle are invisible from both cameras. The particle size is validated manually by using calliper. The validation of measurement of angularity is more difficult due to manual classification. It is difficult to recover surface texture along with the size, form and angularity of the aggregate particles at the acquisition stage due to laser speckle.

Zhang et al (2012) [6] describe study the different characteristics of course aggregates in this paper. Image analysis approach is used to study three main characteristics length, thickness and width of aggregate. Also its statistical distribution is studied in this paper. Different shape of aggregates likes hexahedron, pentahedron, and tetrahedron; flat and elongated are separated manually. Result of three main characteristics gets with the help of image analysis approach. From that two sizes of each aggregate particle can be obtained easily. To get third size of aggregate, particles set upright and the other picture is captured. For this process, particles are placed in white background and image is captured from top. After that aggregates placed right angle manually and then take a picture from top. To get three size of aggregate those two pictures is analyzed. Author develops indicators which shows characterize the angularity and surface texture of aggregate particles and analyze its statistical distributions. Authors summarized results and get its mean value, standard deviation value, and statistical distributions. AT indices and the composite AT shows different sized limestone and basalt aggregates. Three main characteristics of aggregate of different-size and different type of aggregates used in this study.

For all that aggregate the approximately normal distribution obtained. The all different types of aggregate are distributed according to percentages. The approximately normal distribution and AT value is obtained for all aggregate in this study.

III. CRITICAL REMARKS

Following remarks are carried out from above literature review;

1. The analysis methods are not capable to distinguish between aggregate characteristics.
2. To define aggregate characteristics many mathematical formulas and assumptions are used.
3. In DIP particles are analyzed with white background which consist a shadow effect.
4. Accurate surface area is not defined.
5. Aggregate characteristics are not measured below 2mm.
6. Effect of aggregate characteristics on workability is not measured.

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