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# Evaluation of Grain Size Distribution by Digital Image Processing

*Garapati* Venkata Sai Prasad[1*], *Hari* Naga Prasad. Chenna[2], *Akella* Naga Sai Baba[3], and *Prashant* Hugar[4], *P* Pavani[5], *Nikolai* Ivanovich Vatin[6],

[1]Department of Civil Engineering, KG Reddy College of Engineering and Technology, Telangana, India-501504
[2]National Institute of Technology, Raipur, Chhattisgarh, India.
[3]Department of Civil Engineering, Malla Reddy Engineering College, Hyderabad, Telangana, India.
[4]Department of Civil Engineering, JBIET, Hyderabad, Telangana, India.
[5]Department of CSE, GRIET, Hyderabad, Telangana, India
[6]Lovely Professional University, Phagwara, Punjab, India.

**Abstract.** Sieve analysis tests are frequently used to determine the grain size distribution of granular materials. This project proposes an ImageJ-based image analysis approach for evaluating aggregate particle size distribution. Grain size in image analysis should be estimated to compare the graduation curves between the two methods.. Black sheets were more effective than white sheets for particle placement, perhaps due to light effects. This technology may be utilized for in-suit testing, as it requires a camera and computer. The study used monochromatic light and a high-definition camera to capture grain photos while controlling for background, light direction, and intensity. A ground truth was established to evaluate errors in determining grain areas. All grain shape parameters are obtained using the ImageJ program. The grain size distribution curve is generated using image analysis.

## 1 Introduction

The distribution of particle sizes in materials is a commonly used test in geotechnical engineering to determine material quality. For decades, the sieve analysis test was the standard method for analyzing the particle size distribution of granular materials, particularly coarse materials. Image analysis techniques are widely applied in the medical and electronics sectors. Recently, image-processing techniques have been used in civil engineering, mainly concrete engineering. Images have primarily explored particle shape features such as elongation and angularity. The majority of image analyses have been undertaken on two-dimensional pictures. A few investigators have also examined the form and properties of aggregates using 3-D pictures. In addition to their shape properties, the size characteristics of aggregates, including particle size distribution using image analysis, were previously explored.

* Corresponding author: gprasad@kgr.ac.in

### 1.1 Image Processing Technique:

Image processing is the process of transforming an image into a digital format and conducting different operations on it in order to create an improved image or extract useful information from it. It's a signal distribution where an image, such as a picture or a video frame, is the input and the image or its associated properties are the output.The sieve analysis test generates a particle size distribution curve based on mass. In image analysis, gradation curves can be generated using volume (i.e., mass-based), area, or particle count. In general, image analysis works with two-dimensional pictures.

## 2 Literature Review

G. H. A. Janaka J. Kumara, Kimitoshi Hayano and Keita Ogiwara "Image Analysis Techniques on Evaluation of Particle Size Distribution of Gravel" [1] The particle size distribution of granular materials is frequently investigated using a sieve analysis test. This work proposes an image analysis technique using ImageJ to examine the particle size distribution of gravel. Under specific settings, variations in gradation curves derived by sieve analysis and image analysis were discovered. Based on the findings, the paper examines a variety of aspects of image analysis. They include properly evaluating particle grain size in image analysis, reducing shadow effects in images, determining the number of particles used for sieving and image analysis, and so on. It was revealed that the grain size in image analysis should be accurately defined in order to compare the gradation curves of the two methodologies.

J.M.R. Fernlund "Image analysis method for determining 3-D shape of coarse aggregate" [2] The approach precisely detects each particle's 3-D size and form in the sample. Each particle's size and shape are assessed before and after the Los Angeles test. Thus, the particle size decrease and shape change are calculated. When applied to the Los Angeles exam, the image analysis approach allows for a more detailed evaluation of the data than typical sieve analysis. A link to the Los Angeles value is proposed. The procedure is quick, simple, and very accurate. It may replace Sieve analysis, Flakiness index testing, and Shape index testing for coarse aggregate material.

H.M. Zelelew , A.T. Papagiannakis "Application of Digital Image Processing Techniques for Asphalt Concrete Mixture Images" [3] This study describes the Volumetrics-based Global Minima (VGM) thresholding technique for processing asphalt concrete (AC) X-ray computed tomography (CT) images. The fundamental criterion for determining the air-mastic and mastic-aggregate grey scale border thresholds is based on known volumetric parameters of AC mixes. Several DIP methods were used to analyze the AC microstructure. It is well proven that VGM-processed pictures outperform raw X-ray CT images. The VGM thresholding algorithm outperformed the mostly manual/subjective procedures utilized previously.

C.F. Mora, A.K.H. Kwan "Sphericity, shape factor, and convexity measurement of coarse aggregate for concrete using digital image processing" [4] A method for determining the sphericity, form factor, and convexity of coarse aggregate for concrete has been developed using digital image processing (DIP). This technique, unlike earlier DIP approaches, can estimate particle thickness and volume, allowing it to measure shape parameters based on thickness and assess weighted mean values of form features of individual particles in an aggregate sample. The method was applied to 46 rock aggregate samples from five different sources derived from three different types of rock, and the shape parameters obtained were correlated to the traditional measure of angularity in with the objective of identifying shape parameters that could be used as direct measures of angularity.

# 3 Methodology

## 3.1 Sieving the Aggregates

A particle size of more than 4.75mm is termed a coarse aggregate and is taken as a sample for our approach. The aggregate should be chosen to have a uniform and consistent colour.

## 3.2 Image Capturing

Particles were carefully organized so that they stood in a stable posture. Particles were arranged without touching or overlapping each other to avoid using superfluous image processing techniques. During the initial analysis, particles were put on a clear sheet. Transparent sheets were employed because lights were applied from both the bottom and top of the sheet, eliminating shadow effects. The known measurement was drawn on the page using a scale. Since photographs provide dimensions in pixels, the mark was put at the bottom of the page to acquire dimensions in millimetres. This scale was utilized during the picture analysis process. Images were obtained using a camera, and the camera was positioned perpendicular to the sheet.

## 3.3 Image Capturing

The picture analysis was carried out in ImageJ. ImageJ supports several image formats, including TIFF, GIF, JPEG, BMP, DICOM, and FITS. ImageJ can calculate the area and pixel value statistics of user-defined selections. It's also capable of measuring distance and angle.

## 3.4 Image Capturing

The initial upload captured the image into the ImageJ software; Figure 1 describes the recorded picture uploaded to ImageJ. Later, the uploaded data needs to be duplicated. Figure 2 illustrates how the uploaded data is duplicated.

**Fig 1.** Uploading Captured image

**Fig 2.** Duplicated Image

**Fig 3.** Highlighted area in a image

Now, select the rectangle option in the toolbar and select the required area highlighted in green. Next, a new dialogue box will open. Click OK. Figure 3 shows the required area is highlighted after choosing the area,

- Go to the image option available in the status bar, as shown in figure 4 Select the option type and Select 8-bit, where the image will be converted to an 8-bit image as shown in figure 4 After converting the image to 8-bit, go to the next option in the image, select adjust, and select threshold as shown figure 5 After the threshold, go to the process option and select binary convert data into binary as shown in figure 6

**Fig 4.**Converting Image to 8-bit

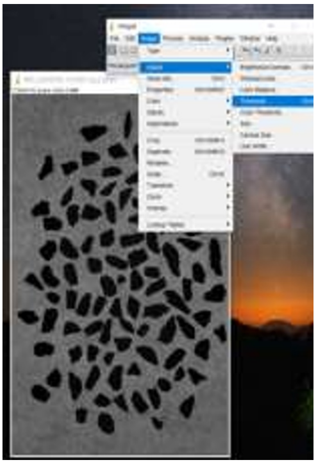

**Fig 5.**Applying threshold to image

**Fig 6.** Converting Image to binary data

After the data is converted to binary, we need to clear dust using the erode option as in figure 7, where dust will be removed from the data. After clearing the dust in the data, we need to fill holes in the following material, as shown in figure 8, so select the fill hole option. After the holes are filled, analyze the data. For that, analyze and choose the scale option where scale is allotted manually in centimeters by providing the following data shown in the figure 9,Data is analyzed and required data is given as output.

**Fig 7.**Clearing dust in Image

**Fig 8.**Filling the holes in material

**Fig 9.**Analyzing the data

## 4 Results & Discussion

In image analysis, 2-D pictures may be utilized to calculate the area or number of particles directly. The program measures the area of these aggregates. In the current study, a total of 100 aggregates are taken randomly. Each aggregate has a different size. Following the above procedure, each sample area is to be calculated. In the current study, 2-19 mm sieves are used. The aggregates are sieved by using a sieve saker. Each sieve measures the weight of the material retained in the sieve. After calculating the weight, the next step is to calculate the cumulative percentage retained in each sieve. In this step, observe how much amount of material is passing through each sieve. Based on the last step, to calculate the percentage of fines.. The percentage retained on each sieve is measured by using a weighing balance. Table 1 display where image analysis directly estimated the area and Percentage finer is calculated as shown below.

**Table 1** Percentage finer is calculated from areas obtained

| S.NO | Area | Mean | Min | Max |
|---|---|---|---|---|
| 1 | 2.142 | 255 | 255 | 255 |
| 2 | 1.367 | 255 | 255 | 255 |
| 3 | 2.79 | 255 | 255 | 255 |
| 4 | 2.402 | 255 | 255 | 255 |
| 5 | 2.103 | 255 | 255 | 255 |
| 6 | 1.873 | 255 | 255 | 255 |
| 7 | 1.767 | 255 | 255 | 255 |
| 8 | 1.725 | 255 | 255 | 255 |
| 9 | 1.921 | 255 | 255 | 255 |
| 10 | 1.847 | 255 | 255 | 255 |
| 11 | 2.141 | 255 | 255 | 255 |
| 12 | 2.157 | 255 | 255 | 255 |
| 13 | 1.488 | 255 | 255 | 255 |
| 14 | 1.532 | 255 | 255 | 255 |
| 15 | 1.966 | 255 | 255 | 255 |

| | | | | |
|---|---|---|---|---|
| 16 | 1.899 | 255 | 255 | 255 |
| 17 | 1.697 | 255 | 255 | 255 |
| 18 | 1.061 | 255 | 255 | 255 |
| 19 | 1.87 | 255 | 255 | 255 |
| 20 | 1.218 | 255 | 255 | 255 |
| 21 | 4.719 | 255 | 255 | 255 |
| 22 | 1.64 | 255 | 255 | 255 |
| 23 | 1.537 | 255 | 255 | 255 |
| 24 | 1.173 | 255 | 255 | 255 |
| 25 | 1.731 | 255 | 255 | 255 |
| 26 | 1.944 | 255 | 255 | 255 |
| 27 | 2.189 | 255 | 255 | 255 |
| 28 | 1.353 | 255 | 255 | 255 |
| 29 | 1.95 | 255 | 255 | 255 |
| 30 | 1.196 | 255 | 255 | 255 |
| 31 | 1.928 | 255 | 255 | 255 |
| 32 | 2.042 | 255 | 255 | 255 |
| 33 | 1.869 | 255 | 255 | 255 |
| 34 | 2.143 | 255 | 255 | 255 |
| 35 | 1.882 | 255 | 255 | 255 |
| 36 | 2.359 | 255 | 255 | 255 |
| 37 | 1.367 | 255 | 255 | 255 |
| 38 | 2.548 | 255 | 255 | 255 |
| 39 | 1.777 | 255 | 255 | 255 |

| | | | | |
|---|---|---|---|---|
| 40 | 3.238 | 255 | 255 | 255 |
| 41 | 2.257 | 255 | 255 | 255 |
| 42 | 3.517 | 255 | 255 | 255 |
| 43 | 2.541 | 255 | 255 | 255 |
| 44 | 1.999 | 255 | 255 | 255 |
| 45 | 1.784 | 255 | 255 | 255 |
| 46 | 1.943 | 255 | 255 | 255 |
| 47 | 2.196 | 255 | 255 | 255 |
| 48 | 5.61 | 255 | 255 | 255 |
| 49 | 2.346 | 255 | 255 | 255 |
| 50 | 1.394 | 255 | 255 | 255 |
| 51 | 1.976 | 255 | 255 | 255 |
| 52 | 1.414 | 255 | 255 | 255 |
| 53 | 0.482 | 255 | 255 | 255 |
| 54 | 2.429 | 255 | 255 | 255 |
| 55 | 1.916 | 255 | 255 | 255 |
| 56 | 1.72 | 255 | 255 | 255 |
| 57 | 2.649 | 255 | 255 | 255 |
| 58 | 1.727 | 255 | 255 | 255 |
| 59 | 2.774 | 255 | 255 | 255 |
| 60 | 1.038 | 255 | 255 | 255 |
| 61 | 2.192 | 255 | 255 | 255 |
| 62 | 1.554 | 255 | 255 | 255 |
| 63 | 1.952 | 255 | 255 | 255 |

| | | | | |
|---|---|---|---|---|
| 64 | 2.845 | 255 | 255 | 255 |
| 65 | 2.516 | 255 | 255 | 255 |
| 66 | 2.709 | 255 | 255 | 255 |
| 67 | 1.904 | 255 | 255 | 255 |
| 68 | 1.895 | 255 | 255 | 255 |
| 69 | 2.253 | 255 | 255 | 255 |
| 70 | 2.933 | 255 | 255 | 255 |
| 71 | 1.84 | 255 | 255 | 255 |
| 72 | 1.721 | 255 | 255 | 255 |
| 73 | 1.556 | 255 | 255 | 255 |
| 74 | 1.008 | 255 | 255 | 255 |
| 75 | 1.293 | 255 | 255 | 255 |
| 76 | 1.755 | 255 | 255 | 255 |
| 77 | 2.227 | 255 | 255 | 255 |
| 78 | 2.233 | 255 | 255 | 255 |
| 79 | 1.436 | 255 | 255 | 255 |
| 80 | 1.512 | 255 | 255 | 255 |
| 81 | 2.347 | 255 | 255 | 255 |
| 82 | 2.444 | 255 | 255 | 255 |
| 83 | 0.88 | 255 | 255 | 255 |
| 84 | 1.125 | 255 | 255 | 255 |
| 85 | 2.048 | 255 | 255 | 255 |
| 86 | 2.605 | 255 | 255 | 255 |
| 87 | 0.948 | 255 | 255 | 255 |

| | | | | |
|---|---|---|---|---|
| 88 | 1.475 | 255 | 255 | 255 |
| 89 | 1.904 | 255 | 255 | 255 |
| 90 | 2.466 | 255 | 255 | 255 |
| 91 | 1.282 | 255 | 255 | 255 |
| 92 | 2.151 | 255 | 255 | 255 |
| 93 | 1.706 | 255 | 255 | 255 |
| 94 | 2.176 | 255 | 255 | 255 |
| 95 | 1.317 | 255 | 255 | 255 |
| 96 | 1.483 | 255 | 255 | 255 |
| 97 | 2.019 | 255 | 255 | 255 |
| 98 | 1.308 | 255 | 255 | 255 |
| 99 | 2.586 | 255 | 255 | 255 |
| 100 | 0.832 | 255 | 255 | 255 |

| **Sieve Sizes** | **Total Area Retained On Each Sieve** | **Percentage Retained On Each Sieve** | **Cumulative Percentage Retained On Each Sieve** | **Percentage Finer** |
|---|---|---|---|---|
| 2 | 4 | 4.719 | 2.482561 | 97.51744 |
| 1.6 | 2.36 | 48.351 | 25.43638 | 72.08106 |
| 1.2 | 1.44 | 112.527 | 59.19794 | 12.88312 |
| 1 | 1 | 21.35 | 11.23176 | 1.651358 |
| 0.9 | 0.81 | 2.66 | 1.399367 | 0.251991 |
| 0.475 | 0.225 | 0.482561 | 0.253865 | 0 |

Based on the value of the fines plot the graph and identify the shape of the graph. In the current study, the curve represents the poorly graded gravel (GP). Figure 10 represents the particle size distribution curve for the aggregates.

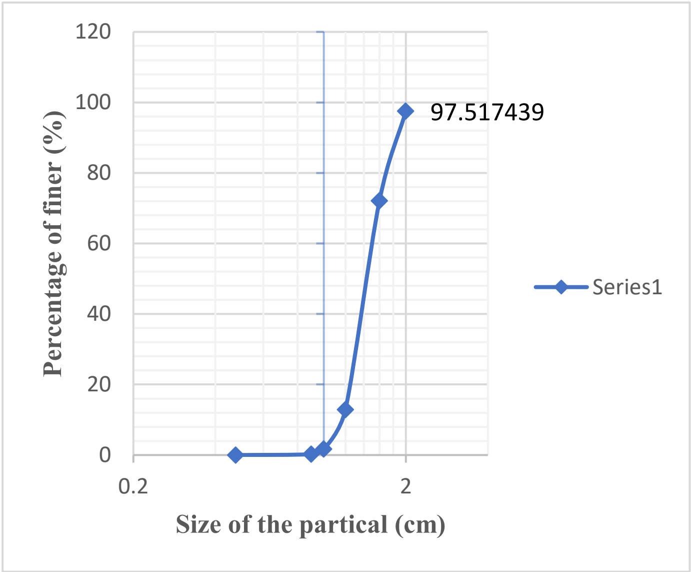


**Fig 10.** Particle Size Distribution Curve

## 5 Conclusions

- The particle size distribution curve of coarse materials (2–19 mm) was analyzed using the image analysis software ImageJ, which employed 2-D pictures of particles.
- Gravel: If more than 50% of the coarse fraction is retained on a 4.75mm screen, the sample is categorized as gravel, and the particle size ranges from 4.75 to 20.
- When some particle sizes are absent from the sample, it is classified as poor-grade gravel (GP).
- It was discovered that the opposite colour paper to that of the aggregate works best for arranging the aggregate sample.
- Capture should be done in sufficient light. Shadows should be ignored.
- Image capture is important and should be done perpendicular to the plane.
- Image processing makes it easier and faster to create a particle size distribution curve than sieve analysis.

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