International Journal of Advanced Engineering and Technology
ISSN: 2456-7655; Impact Factor: RJIF 5.54
Received: 29-11-2018; Accepted: 03-01-2019
www.newengineeringjournal.com
Volume 3; Issue 1; January 2019; Page No. 31-35

Shape parameters of recycled aggregate and determination its area of mortar and aggregate using imaging techniques

Chiranjib Roy[1], Md. Shariful Islam[2], Firoz Ahamed[3]
[1, 3] University of Asia Pacific, Dhaka, Bangladesh
[2] Rajshahi University of Engineering & Technology, Bangladesh

Abstract
In this study, relationships between aggregate shape parameters and volume of recycle mortar and aggregate were investigated using digital image processing and analysis methods. The study was conducted based on two parameters, aggregate type and maximum aggregate size, at two levels. A total of 3 cylinder recycled concrete specimens were prepared at a constant water-cement ratio. After the tests were performed, each specimen was cut into 4 equal pieces in order to obtain the digital images of cross sections using a digital image analysis. A number of aggregate shape parameters were then determined from the digital image of the cross sections to investigate their relationships with the recycled mortar and aggregate. The results indicated that even though the aggregate type was found to give strong correlation with the compressive strength. The study suggested that the analyses of relationships should be further investigated by including the effects of aggregate distribution within the specimen cross sections.

Keywords: digital image, concrete, aggregate, shape parameter

1. Introduction
Aggregate particles occupy approximately 70 to 80% volume of concrete and hence their characteristics significantly affect the performance of both fresh and hardened concrete. Aggregates have also an impact on the cost effectiveness of concrete, as they are one of the inexpensive components of a typical Portland cement concrete. Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them.
It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too.
Image processing basically includes the following three steps.
1. Importing the image with optical scanner or by digital photography.
2. Analyzing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs.
3. Output is the last stage in which result can be altered image or report that is based on image analysis.

1.1 Purpose of Image processing
The purpose of image processing is divided into 5 groups. They are:
1. Visualization - Observe the objects that are not visible.
2. Image sharpening and restoration - To create a better image.
3. Image retrieval - Seek for the image of interest.
4. Measurement of pattern – Measures various objects in an image.
5. Image Recognition – Distinguish the objects in an image.

1.2 Types image processing
The two types of methods used for Image Processing are Analog and Digital Image Processing.
Analog or visual techniques of image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. The image processing is not just confined to area that has to be studied but on knowledge of analyst. Association is another important tool in image processing through visual techniques. So analysts apply a combination of personal knowledge and collateral data to image processing.
Digital Processing techniques help in manipulation of the digital images by using computers. As raw data from imaging sensors from satellite platform contains deficiencies. To get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are Pre-processing, enhancement and display, information extraction.

1.3 Image Analysis Methods
The extreme progress in image capturing and exceptional increase of the computational power within the last few years have revolutionized microscopic methods and made image analysis methods very popular for the characterization of particles. Especially as in addition to size also relevant shape information becomes available by the method. Currently, mainly instruments creating a 2D-image of the 3D-particles are used. Two methods have to be distinguished.
Static image analysis is characterized by non-moving

particles, e. g. on a microscope slide. The depth of sharpness is well defined resulting in a high resolution for small particles. The method is well established and standardized [ISO 13322-1:2004 Particle size analysis - Image analysis methods - Part 1: *Static image analysis methods*], but can only handle small amounts of data. The particles are oriented by the base, overlapping particles have to be separated by time-consuming software algorithms, and the tiny sample size creates a massive sampling problem resulting in very low statistical relevance of the data. Commercial systems reduce these effects by using large or even stepping microscopic slides and the deposition of the particles via a dispersing chamber. As all microscopic techniques can be used, the size range is only defined by the microscope used.

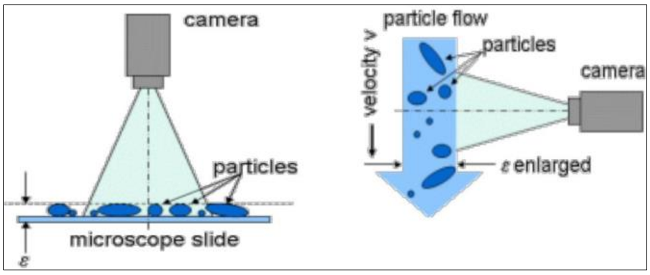


Fig 1: Set-up of static (left) and dynamic (right) image analysis for particle characterization**.**

1.4 Application

1. **Intelligent Transportation Systems:** This technique can be used in Automatic number plate recognition and Traffic sign recognition.
2. **Remote Sensing:** For this application, sensors capture the pictures of the earth's surface in remote sensing satellites or multi – spectral scanner which is mounted on an aircraft. These pictures are processed by transmitting it to the Earth station. Techniques used to interpret the objects and regions are used in flood control, city planning, resource mobilization, agricultural production monitoring, etc.
3. **Biomedical Imaging techniques:** For medical diagnosis, different types of imaging tools such as X- ray, Ultrasound, computer aided tomography (CT) etc are used. The diagrams of X-ray, MRI, and computer aided tomography (CT) are given below.

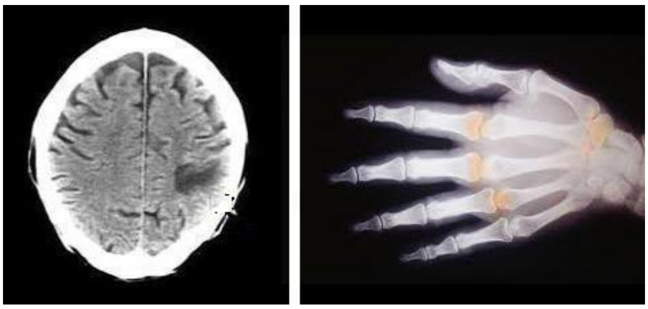


Fig 2: Applications of Image analysis in Biomedical.

2. Research Objectives and Scope

In this study, it is hypothesized that the volume of recycle aggregate is affected by the volume of recycled mortar and aggregates. To prove the proposed hypothesis, an experimental program was performed, based on image analysis 3 cubical concrete specimens. The specimens were prepared in 3 replicates for two maximum aggregate size levels two gradation types (well gradation and gap gradation), and two aggregate types (crushed and natural) obtained from the same source. Thus, a total of 3 specimens were prepared. After the tests, each specimen was cut into 4 pieces of equal thickness parallel to the applied load direction. This process resulted in 6 cross sectional surfaces for each specimen. The gray color digital pictures of these surfaces were obtained by utilizing a digital flatbed scanner at 150 dpi resolution level. Subsequently, only 3 images within the non-overlapping cut planes were selected to determine various aggregate shape parameters of each specimen.

Finally, statistical analysis of variance was conducted to determine the effects of design variables of the concrete specimens. Statistical analyses of relationships between the shape parameters of aggregates was also investigated. The layout of the study presented in this thesis is given as follows: In Chapter 2, the scope of digital image processing is presented. In Chapter 3, a summary of literature survey on the computer based aggregate shape characterization methods is given a discussion of aggregate shape parameters. Chapter 4 presents the experimental program and the procedures used for testing laboratory specimens. Chapter 5 summarizes the procedures used for determining aggregate shape parameters to investigate possible relationship between concrete (stone and brick aggregate) and the measured shape parameters.

2.1 Flow diagram of image analysis process

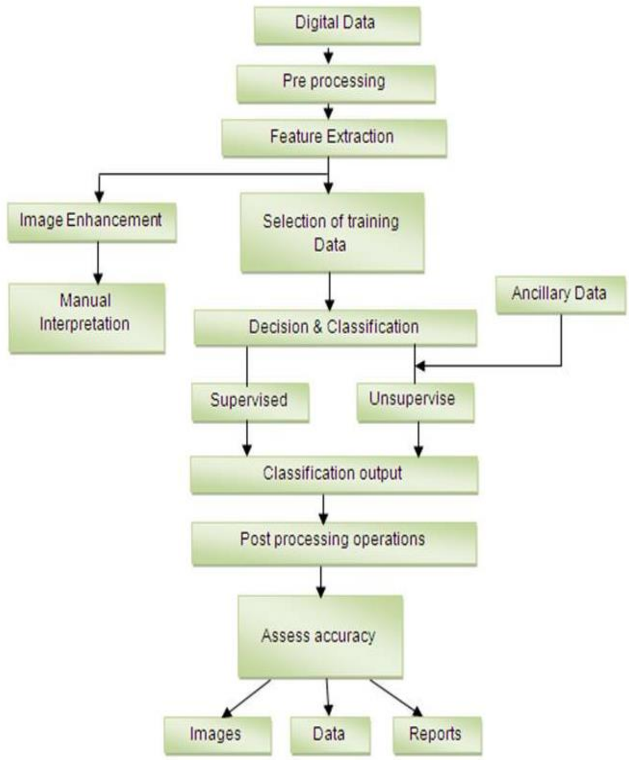


Fig 3

3.1 Experimental Program

The objective of this study is to investigate the relationships between aggregate shape parameters and concrete strength using digital imaging techniques. In this respect, two aggregate types of the same source, namely, natural and crushed aggregates were used in preparing concrete specimens. Using these aggregates, well and gap graded mixtures were prepared at two different maximum aggregate sizes. A total of 8 different concrete mix proportions with 5 replicates were prepared. The experimental program resulted in a total of 40 cubic specimens prepared at a selected water-cement (w/c) ratio. After the compressive strength tests, each specimen was cut into 4 pieces of equal thickness along the direction parallel to the applied load. This process resulted in 6 cross sectional surfaces which were numbered from left to right and then converted into a digital form using a digital flatbed scanner. Subsequently, for each specimen three images from the six cross sectional surfaces were used to determine the various aggregate shape parameters. Finally, the relationships between the concrete strength and the aggregate shape parameters for retained No.8 were investigated using various statistical methods.

3.2 Cement

The cement used in the mixtures was a typical Portland cement CEM I 42.5R which complies with the ASTM Type 1 cement specifications. The physical properties and the chemical composition of the selected cement used in this study are presented in the below tables.

Table 1(a): Physical properties of Portland cement (b) chemical composition of Portland cement

Chemical Composition	%
CaO	67.01
SiO_2	18.90
Al_2O_3	4.74
Fe_2O_3	3.03
MgO	1.76
SO_3	2.88
K_2O	0.70
Na_2O	0.51

Table B

Property	Value
Specific Gravity	3.18
Blaine Fineness (g/cm^2)	2982
Normal Consistency (%)	27.0
Initial Setting Time (min.)	158
Final Setting Time (min.)	225
Soundness (mm)	0.7

3.3 Aggregates

Table 2: Size fractions of natural aggregates

Passing From	Retained on	Type
1 in.	¾ in.	Coarse
¾ in.	½ in.	Coarse
½ in.	⅜ in.	Coarse
⅜ in.	No.4	Coarse
No.4	No.8	Fine

Aggregates used in this investigation were obtained from Erişsan Ready Mix Concrete Company. Blended aggregates obtained had a maximum size of 1-2 inches, and were used in their present condition after sieving. These aggregates were termed as *natural* throughout this investigation. The other aggregate set was cobbles from the same source having around 3-4 in. size

3.4 Preparation of Specimens for Image Processing

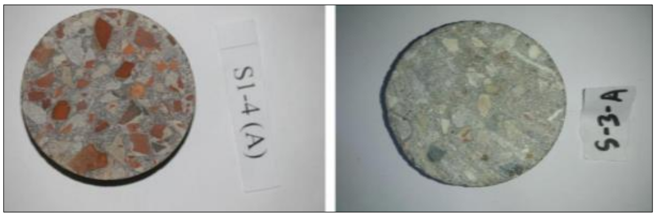
After the compressive strength tests, each specimen was cut into 4 equal pieces parallel to the applied load direction using a circular diamond saw as shown in given figure.

(A) **(B)**

Fig 5: (a) Selection of Aggregate (b) Aggregate Collection

Fig 6: Casting of Sample and cutting of sample

An HP flatbed scanner was used to acquire digital image of each cross sectional surface. The resolution of the scanner was set to 150 dpi in order to keep the file size moderate for further processing and analysis. The digital images were stored in gray scale colors in which every pixel has a color depth ranging from 0 to 255.



(a) (b)

Fig 7: (a) Sample of Brick Chips (b) Sample of Stone Chip

In the analyses of relationships between the compressive strength and the aggregate shape properties, only those images corresponding to the 2nd, 3rd and 5th cross sectional surfaces were considered hence eliminating the duplication of analyses for the overlapped cross sections.

In the following chapter, the procedures used to determine the aggregate shape parameters and the methods of analysis for the aforementioned relationships are discussed.

3.5 Elimination Aggregate and Recycled Mortar Particles

As stated previously, the analyses of relationships between the strength and the shape parameters were performed only for those aggregates which are recycled. This required the elimination of aggregate portions that are finer than No.8 before conducting the statistical analyses.

Before eliminating the finer aggregates, an effective particle size parameter that best simulates the passing of a particle through a sieve opening needs to be determined so that it can be used to perform a virtual sieving operation. For this purpose, the actual particle size distribution of the specimens was compared with the particle size distributions obtained using a) *area*, and b) *maximum Feret diameter* parameters. Using the *area* parameter, the total pixel area of each particle was converted into the area in units of square millimeters given the fact that the resolution of the images was known in advance. Then, the area of each particle was compared to the area of sieve openings for a range of standard sieve sizes that were initially used in the laboratory. If the particle area is larger than the area of the sieve opening, the particle is assumed to retain on that sieve, and it is assumed to pass if its area is smaller. Similarly, in the case of using the *maximum Feret diameter*, the maximum Feret diameter of particles in each specimen was converted into the unit of millimeters. Then, the maximum Feret diameter of each particle was compared to the sieve openings of a range of standard sieves sizes. If the particle maximum Feret diameter is larger than the standard sieve opening, the particle is assumed to retain on that sieve, and it is assumed to pass if its maximum Feret diameter is smaller.

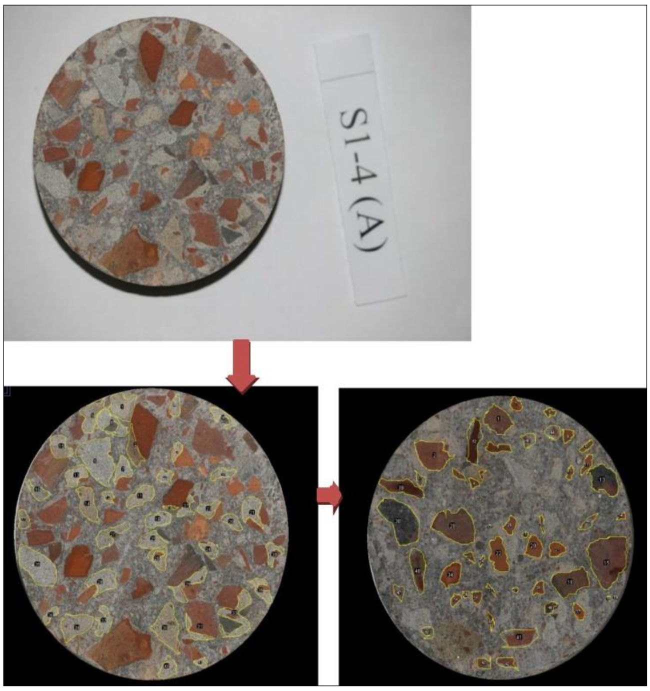


Fig 8:.Elemination of Aggregate **Fig 9:** Elimination of Mortar

4. Results

4.1 Analysis by color threshold and area object

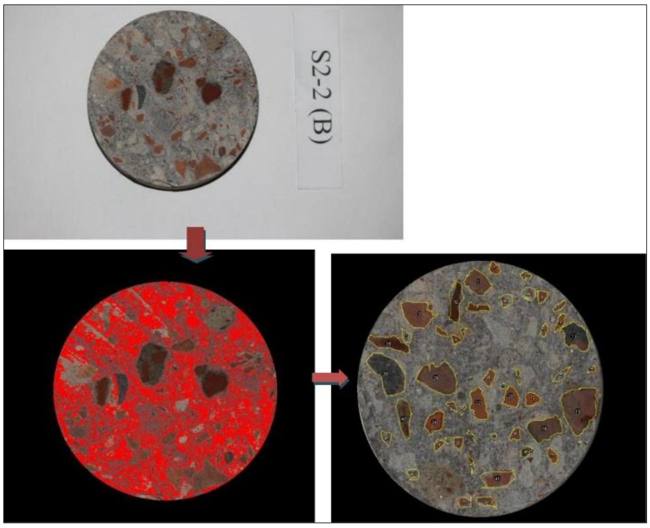


Fig 10

4.2. Graph of mortar & aggregate (Brick Chips)

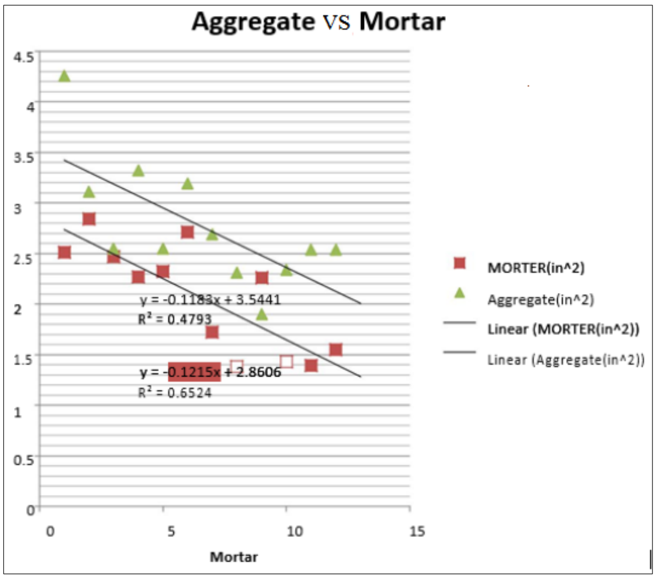


Fig 11

4.2 Graph of Mortar & Aggregate (Stone Chips)

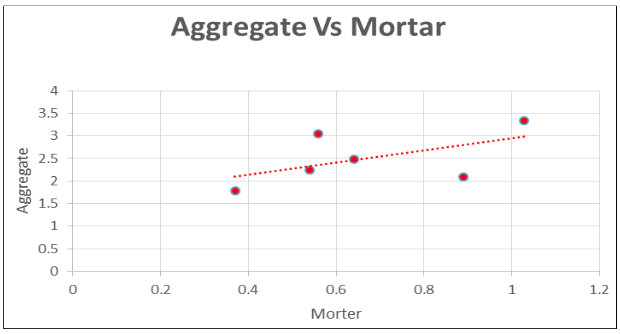


Fig 12

4.3 Comparison between (Aggregate and Mortar) in Samples

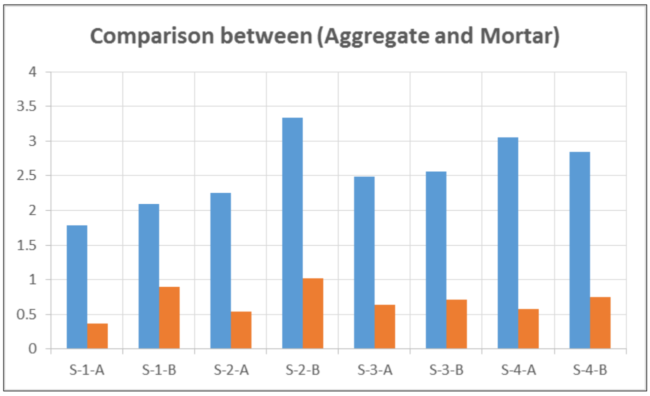


Fig 13

5. Conclusion

Analysis of variance results indicated that the aggregate stone chips volume is more than the Brick chips aggregate. The results showed that recycle mortar is less in Stone chips recycle than Brick chips recycle concrete. From the analysis variance table. It was also found that there is a strong interaction effect on the compressive strength between aggregate type and the maximum aggregate size design variables. The weak correlations obtained for most of the shape parameters may be because of the interactions effects that were not accounted for in the analyses or the particle distribution characteristics that need to be considered separately in the analyses of the shape parameters.

6. References

1. Arasan S, Yener E, Hattatoglu F, Hinislioglu S, Akbulut S. The Correlation between Shape of Aggregate and Mechanical Properties of Asphalt Concrete: Digital Image Processing Approach (under review), 2010.
2. Akbulut S. Fractal Dimensioning of sand grains using image analysis system, Pamukkale University, Journal of Engineering Science. 2002; 8(3): 329334.
3. Barksdale RD, Kemp MA, Sheffield WJ, Hubbard JL. Measurement of aggregate shape, surface, area, and roughness, Transportation Research Record. 1991; 1301:107-116.
4. Fernlund JMR. The effect of particle form on sieve analysis: a test by image analysis. Engineering Geology. 1998; 50:111-124.
5. Fernlund JMR. 3D image analysis size and shape method applied to the evaluation of the Los Angles test. Engineering Geology. 2005b; 77:5767.
6. Hryciw RD, Raschke SA. Development of Computer Vision Technique for In Situ Soil Characterization. In Transportation Research Record. 1996; 1526:86-97.
7. Hyslip JP, Vallejo LE. Fractal analysis of roughness and size distribution of granular materials. Engineering Geology. 1997; 48:231244.
8. Masad E, Button J. Unified imaging approach for measuring aggregate angularity and texture. Journal of ComputerAided Civil and Infrastructure Engineering. 2000; 15(4):273280.
9. Stephens JE, Sinha KC. Influence of Aggregate Shape on Bituminous Mix Character. Journal of The Association of Asphalt Paving Technologists. 1978; 47:434-456.