Concrete Slump Classification using GLCM Feature Extraction

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Abstract. Digital image processing technologies have been widely applied in analyzing concrete structure because the accuracy and real-time result. The aim of this study is to classify concrete slump by using image processing technique. For this purpose, concrete mix design of 30 MPa compression strength designed with slump of 0-10 mm, 10-30 mm, 30-60 mm, and 60-180 mm were analyzed. Image acquired by Nikon Camera D-7000 using high resolution was set up. In the first step RGB converted to grey image than cropped to 1024 x 1024 pixel. With open-source program, cropped images to be analyzed to extract GLCM feature. The result shows for the higher slump contrast getting lower, but higher correlation, energy, and homogeneity.

Introduction

Concrete is a mixture of Portland cement or other hydraulic cement, water, fine aggregate, and coarse aggregate, with or without additional materials (admixture) [SNI 2013]. Air content, workability, and compressive strength are important parameters in making concrete mixture. They should meet sustainability requirements, methods of construction, and the strength of the structure. [Design Control of Concrete Mixture PCA]. Compressive strength is the most important parameters in the resistance of the structure to support the working load (Hemraj R. Kumavat, 2014; F. Falade, 2001).

In order to meet the compressive strength, there are some characteristics in the mix design that must be met, including the workability of fresh concrete. Workability is characteristic of fresh concrete that measure the ease of stirring, transported, poured in the mold, and compacted (KhaledMarar, 2011). Workability measured by Slump testing that shows the size of the concrete viscosity expressed in mm (ACI Committee, 2002). The more viscous the mixture, the smaller the value slump which means the lower the level of workability.

Fresh concrete will lose their slump with the passage of time (delay) (SCG). With the reduced slump value concrete mix can be rejected. It is certainly harm to the readymix. The slump loss value can be fixed by adding water. ASTM recommended water addition as long as it does not cause the water / cement ratio to rise above the maximum allowable value. Additional water is given to the entire batch of concrete mixers, made before the time limit of 1.5 hours since the mixture is stirred. (ASTM C 94, 2003).

Additional of water can improve the workability but decrease the compressive strength (F. Falade, 2001). The addition of water causes the water-cement ratio rose. Water cement ratio is the amount of water compare with the amount of cement used in the concrete mix. It is very influential on concrete MOIME 2016 IOP Publishing
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compressive strength. The higher water cement ratio the lower the compressive strength can be achieved. (OmotolaAlawode, 2011) (H. Ziad, 2014). Improving workability by additional water declined the strength of concrete, it is advisable to avoid this method (J. Sobhani, 2011).

Due to excessive water cement ratio will alleviate the compressive strength of concrete, the slump test alone is not sufficient to control the quality of the concrete mix. The experience to be able to distinguish mixtures with water cement ratio according to plan or mixed with excessive water cement ratio. The experienced supervisors are quite hard to find in the field. Most of the time the project owner doesn’t have that supervisor. It need a tool that could replace the supervisor function in the field.

Use of Information Technology (IT) has penetrated all aspects of research and applications in everyday life. Specifically in the field of civil engineering. Digital Image Processing (DIP) has been widely used to analyse the performance of which is to analyse concrete crack width in concrete structures (Su, 2013) (Ayaho Miyamoto, 2007) (J. Valenca, 2012) (Tung-Ching Su, 2013), analyses the defects in concrete structures (Jian-Hua Tong, 2013) (Bin Sun, 2015) (Xuhao Wang, 2015). On the fresh concrete, the effect of viscosity on the flow identified significant slump (Xuhao Wang, 2015), the monitoring mechanism optimizes concrete mix slump test is used as a parameter in determining the compressive strength of concrete (Hernando Castaneda M), analysis the concrete compression strength (Ju0Sheng Chou, 2012). Image processing is the computer aided reproduction of processes, which humans achieves by mean of their vision system. It’s include many process such as image provision, image digitalization, segmentation, and image enhancement (CelalettinBasyigit, 2012) (Alexander Barley, 2014)

This study will classify the slump by extracting the texture feature, normal concrete with compressive strength design 30 MPa is designed with different slump value wich are 0-10 mm, 10-30mm, 30-60 mm, 60-180 mm. Mix design were made according to DoE method.

**Material and Method**

**1.1. Materials**

Material used in concrete mix were tested with American Standard Testing Material (ASTM) the world wide international standar for material testing. Aggregate taken from Purwakarta, sand from Cimalaka, Sumedang, and cement type 1 from Indocement.Only properties needed at mix design will be test listed at table 1.

| Characteristic            | Significance                        | ASTM References                  | Requirement or item reported                                  |
|--------------------------|-------------------------------------|----------------------------------|---------------------------------------------------------------|
| Grading                  | Workability of fresh concrete       | ASTM C 117, ASTM C 136           | Minimum and maximum percentage passing standard sieves       |
| Bulk density;            | Mix design calculations             | ASTM C 29                        | Loose weight and compact weight                               |
| Specific gravity         | Mix design calculations             | ASTM C 127, ASTM C 128, ASTM C 66| —                                                             |
| Absorption and surface moisture | Concrete control quality (water-cement ratio) | ASTM C 70, ASTM C 127, ASTM C 128, ASTM C 566 | —                                                             |
1.2. Preparation of sample

Mix Design referred to DOE method, and material proportional justified by the result of slump test. When the slump is lower than design value, limited amount of water is added. Additional water is counted in order to not exceed the water cement ratio maximum (0.6). When slump is higher than design value concrete will be stirred with 90 minutes maximum time limit. If it’s steel high, the concrete should be throw away.

| Slump (mm) | 0-10 | 10-30 | 30-60 | 60-180 |
|-----------|------|-------|-------|--------|
| Stone 20 mm | 11.9 | 11.7 | 10.9 | 10.0 |
| Sand | 17.6 | 17.3 | 16.1 | 14.8 |
| Cement | 4.6 | 4.7 | 4.9 | 5.8 |
| Water | 1.75 | 1.91 | 2.55 | 3.24 |
| Water/Cement ratio | 0.38 | 0.40 | 0.52 | 0.56 |

1.3. Slump Testing

Slump test done with ASTM C143.

Fig. 1. Slump testing

1.4. Preparation of images acquisition

Images of fresh concrete specimen were taken in the field using Nikon D-7000 digital camera. Concrete is poured into the container and levelled. Set up of image acquisition is shown as figure 2. And raw image at figure 3.
1.5. Images Processing

The procedures of image processing include converting RGB image to gray. Than cropped by size 1024 x 1024 pixel. Converting and cropping done by mathlab. Cropped images shown at figure 4.

1.6. Result and analysis

Texture can be defined as spatial relationship of pixel value in an image. It can be thought of as a local characteristic pattern of image intensity that identifies the relationship between the pixels. In this study, GLCM method characterized the image on 4 features: contrast, correlation, energy, and homogeneity. The result of GLCM method given in table 3.
Table 3. GLCM feature

| Slump (mm) | Contrast   | Correlation | Energy    | Homogeneity |
|------------|------------|-------------|-----------|-------------|
| 0 - 10     | 102,017400 | 0.97606     | 0.00035597| 0.259580    |
| 10 - 30    | 76,812300  | 0.97792     | 0.000410  | 0.271020    |
| 30-60      | 47,509100  | 0.97968     | 0.00070749| 0.320610    |
| 60-180     | 37,398700  | 0.97977     | 0.0010239 | 0.354000    |

1. **Contrast**
The function of contrast enhances the contrast of an image. Measure the contrast of intensity between a pixel and its neighbor in the whole image.

\[ \sum_{i,j} |i - j|^2 p(i,j) \]

Contrast range are \([0 \ (\text{size} \ (\text{GLCM},1)-1)^2]\), 0 for a constant image. The result shows that concrete with lower slump has a higher contrast. It mean the lower slump the rough the surface of fresh concrete show by the higher contrast.

2. **Correlation**
Correlation measures of how correlated a pixel is to its neighbor pixel in the whole image.

\[ \sum_{i,j} \frac{(i - \mu_j)(j - \mu_j) p(i,j)}{\sigma_i \sigma_j} \]

Correlation is 1 or -1 for perfectly positively or negatively correlation image. In this study, higher slump is showed by higher correlation. It mean that the texture is smoother for higher slump.

3. **Energy**
Is defined as the sum of squared elements in the GLCM and also knows as uniformity or the angular. Ranges of energy are 0-1 and 1 for constant image.

\[ \sum_{i,j} p(i,j)^2 \]

The result shown that the higher slump the higher energy. Its mean that image with the higher slump has the constant pixel.

4. **Homogeneity**
Homogeneity returns a value that measures the proximity of the distribution of elements in the GLCM to the GLCM diagonal

\[ \sum_{i,j} \frac{p(i,j)}{1 + |i - j|} \]

The ranges are 0-1. As the smooth of texture, homogeneity will be higher. Its shown as the result that concrete with higher slump has an higher homogeneity.

**1.7. Conclusion and suggestion**
The method used in this study GLCM succeeded in extracting concrete image feature that could explain the classification of slump of fresh concrete for 30 MPa concrete compression strength design. The higher the value of the slump (0-10, 10-30, 30-60, 60-180) which is indicated by a low contrast value (102.0174, 76.8123, 47.5091, 37.3987), but the higher correlation (0.97606, 0.97792, 0.97968, 0.97977), energy (0.00035597, 0.00041, 0.00070749, 0.0010239), homogeneity (0.25958, 0.27102, 0.32061, 0.354).
For further research should be investigated the range of contras, correlation, energy and homogeneity which shows the value of a certain slump so that it can be applied as a tool for supervision slump in the field replacing the supervisor function.

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