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Microstructure of Cement Mortar

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Abstract—The surface a sample is revealed by microscope by magnification above 25x is called microstructure. The physical and chemical properties can be analyzed from microstructure analysis. The crack measurement is also microstructural measurement since cracks formed in cement mortar and concrete are micro & macro cracks. From this research cracks on the surface is analyzed by image processing and alternative new method is find for analyzing morphological structure of sample. The research was carried out by using cement mortar 1:3 which is rich mortar. A study was conducted for investigating the cracks in constructuion elements which is one of the major defects in structure.

Index Terms— cracks, detection, image processing, morphological, mortar, physical & chemical properties

1 Introduction

The paste formation of sand and cement with a correct proportion of water is called cement mortar and it used to cover walls, beams, column, slab etc., in structure. The cement mortar protects the structural and non-structural element from atmospheric dust. The formation of cracks in the mortar (plastering) is lead to seepage of water into structural element and it results in collapse of element or structure. Nowadays non-destructive tests are used analyse the defects in structural element and the tests are little expensive too. In order to avoid that cost, the cracks has been detected by using Image processing and from Morphological structure the physical and chemical properties has been analysed. SEM is the advanced technique in finding morphological of an element and some drawbacks are there in SEM for detecting construction element such drawbacks are sample size should be 1cm^3 and cost from one sample will be around 1000 in Indian currency. To avoid this draw back morphological structure is going to examine by using image processing technique since SEM results are image form.

The morphological images can be captured from SEM analysis and by using morphological study the physical and chemical properties can be determined. The microstructure of a material (such as metals, polymers, ceramics or composites) can strongly influence physical properties such as strength, toughness, ductility, hardness, corrosion resistance, high/low temperature behavior or wear resistance. Basically, two types of measurements of microstructures are made. The first group includes measurements of depths (i.e., depth of decarburization, depth of surface hardening, or coating thicknesses).

The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron sample interactions reveal information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample.

In most applications, data are collected over a selected area of the surface of the sample, and a 2-dimensional image is generated that displays spatial variations in these properties. The paste formation of sand and cement with a correct proportion of water is called cement mortar and it used to cover walls, beams, column, slab etc., in structure. The cement mortar protects the structural and non-structural element from atmospheric dust. The formation of cracks in the mortar (plastering) is lead to seepage of water into structural element and it results in collapse of element or structure. Nowadays non-destructive tests are used analyse the defects in structural element and the tests are little expensive too. In order to avoid that cost, the cracks has been detected by using Image processing and from Morphological structure the physical and chemical properties has been analysed. SEM is the advanced technique in finding morphological of an element and some drawbacks are there in SEM for detecting construction element such drawbacks are sample size should be 1cm^3 and cost from one sample will be around 1000 in Indian currency. To avoid this draw back morphological structure is going to examine by using image processing technique since SEM results are image form.

2 Digital Image Processing

Digital image processing is always an interesting field as it gives improved pictorial information for human interpretation and processing of image data for storage, transmission, and representation for machine perception. Image Processing is a technique to enhance raw images received from cameras/sensors placed on satellites, and aircrafts or pictures taken in normal day-to-day life for various applications. This field of image processing significantly improved in recent times and extended to various fields of Science and Technology. The image processing mainly deals with image acquisition, Image enhancement, image segmentation, feature extraction, image classification etc.

2.1 Edge detection

Edge detection the process for determining the edges in images by using mathematical methods. The colour images are

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converted into black and white format and then the edges in image is analyzed. From the brightness of picture this process is carried out, until the brightness gets lowered there were no defects in the element and if brightness level get decreases the edges will be detected from coding. Even though edge detection basic steps in image processing that too have some drawbacks since it deals with picture it may have focal blur, penumbral blur, shading and to avoid this many researchers preferred Gaussian smoothed step edge for detecting edges of image.

2.2 Image acquisition

Image acquisition in foremost step in image processing and this shows a result as encoded image for example making a data in QR code format because it's easy to get data back whenever it's needed. Digital imaging can be closely related to the social presence theory especially when referring to the social media aspect of images captured by our phones.

2.3 Watershed segmentation

Image segmentation is performed using the Watershed Transform. This technique considers the image as a topographic surface. When floods from different sources meet, they are prevented from merging and these locations are marked as boundaries. The transform returns a uniquely labelled set of regions fully enclosed by these boundaries. If performed correctly on our dataset, each region in the segmented data will represent a single microstructural feature. We use a marker based Watershed Transform, which floods the image exclusively from pre-defined locations known as markers. This has been shown to improve segmentation accuracy, particularly in reducing oversegmentation, making it ideally suited to segmenting microstructural images. The marker based Watershed Transform requires two inputs, the topographic surface, estimating grain boundaries, and the markers, estimating grain locations. The transform uses these estimates to find a complete image segmentation by placing boundaries on ridgelines of the topographic surface that are between adjacent markers. These ridgelines should correspond to the edges of segmented objects. Using a suitable topographic surface and set of markers are critical to the accuracy of segmentation. Computing appropriate markers is a difficult task and often requires bespoke techniques to be designed that are dependent on the feature being marked. The image captured for microstructural analysis are segmented using watershed segmentation

3 Scanning Electron Microscope

The scanning Electron Microscope is advanced method to determine the microstructure of element and in this electrons are made to pass through element to get a clear image of morphological structure. From this analysis the crystalline structure, external morphology, chemical composition and its orientation. The maximum and minimum size of sample required for SEM analysis is 1cm and 5 microns in between whatever may be size the analyse will be carried out. The analysis can be carried for whole sample or for certain specified point in element. From 20X to 30000X magnification can be covered with spatial resolution of 50 to 100nm. The samples are kept in vacuum chamber from where electrons will be passes through. 2D and 3D values can be determined from SEM analysis based on the need. The electrons are made to pass from gun from Electron source and it will passes through the sample.

4 Preparation of Mortar Cubes

The cement mortar is mixture of cement and sand with water based of proportion and cubes sizes are 7cmX7cmX7cm. The cement mortar 1:3 is prepared which is rich mortar used for plastering. Here we did a research on the mortar used for plasrering as to detect the defects in mortar to repair it easily and the growth of the crack can be controlled. The bacteria by name bacillus magaterium is added with water as self curing element so that the crack width can be calculated after curing. The cubes are prepared only for analysing crack and morphological structure. M sand is used as fine aggregate which don't want to sieve before using as it prepared for this process. Four cubes are prepared and different tyes of cracks are created in sample by applying load.

The mortar are also having some strength based on proporation is mixed and strength is not ultimate answer, the main aim of this research is to find crack and morphological structure of sample. The water-cement ratio of the mortar is a major factor governing the quality. A good quality mix has a water to cement ration of 0.5 by weight of cement. If water-cement ratio increases more, the quality of outcome product will be worst. The cement and sand should be mixed well and there shouldnot be lumps in mixing. The fresh wet mix is followed up according to IS3466 (B) 1988 and as per IS 296 53 grade cement was used. The mortar was well mixed before casting and compaction was carried out to voids in mortar cube after 24 hours of casting the cubes were kept for curing in water tank.

5 Formation of Cracks

The resaons for crack formation is vast and some cracks can't be avoided in concstruction. The cracks are the maor reason for detoriartion of the structure and the leads to high maintenance cost of structure. Some cracks will occur in the junction of beam and coloum where as others are because of loads, not proper finishing etc,. The cracks are formed in cubes by compressive load upto yield point cube and thickness of crack is maximum 1mm. The bacteria has capacity of precipitating calciumcarbonate in presence of atmospheric so the cubes have to keep in atmospheric air or in water. After 10-15 the cracks will get healed because the calciumcarbonate precipitation.

The picture were captured using Oneplus5T mobile which has camera of 21MP. The picure of both cracked cube and crack healed cubes are captured at a distance 15-25cm from the sample so that crack can be noted keenly. First of all to confirm the thickness of cracks, the cracks are measured using Microscope manually and from the results

have got as mentioned before as maximum of 1mm.

Fig 1 creation of crack by applying load using compressive machine

Fig 2 cracks in mortar cube by compressive machine

6 Analysis of Crack and Morphological Structure by Image Processing

The image captured from device are in coloured format and from the coloured image the defects detection is impossible so the image have to change to black and white coloured image. Image processing implemented with filtering include image smoothing, image sharepening, and egde detecton which helps to determine the cracks in the image. The pixel size of the image can be changed according to our need. The image may contain some other defects such as pot-hole, improper finishing etc, for analyzing the crack alone these defects has to be avoided. Inordered to avoid other defects like holes Morphological segmentation is carried in image processing.

Morphological segmentation is non-linear method to analyse the shape and morpholohy of element from binary images. In this process the image are converted into graysclae picture where pixel is considered in minor values. The structural element are positioned at different positon based on image and points are noted with name or number. The positioned area are taken as binary images with small matrix of pixel and each with value of zero or one.

From the mathematical methods the morphological structure of element is analysed from binary images. This is process is somewhat related with analysis of crack in element, from the same picture the cracks can be detected. The image filteratin, image smoothing, image sharpening, edge detection were used to find the cracks in element and atlast the parameters

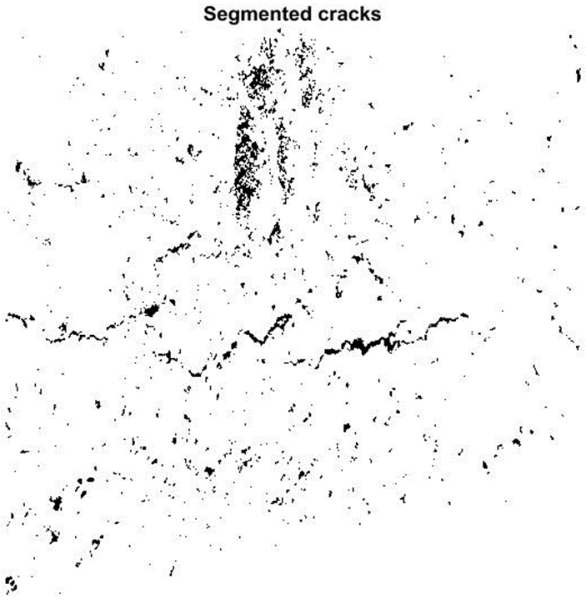

Fig 3 segemented crakcs by image processing

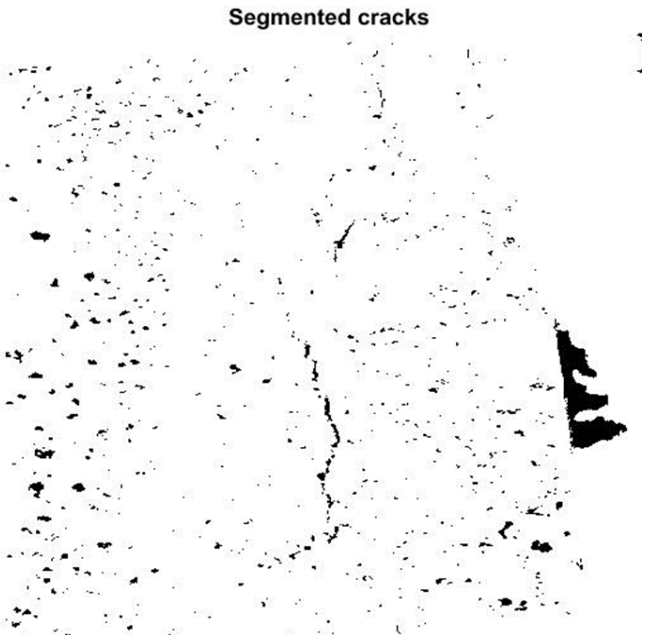

Fig 4 segmented cracks by image processing

7 MORPHOLOGICAL ANALYSIS BY SEM

The morphological structure of mortar cubes are analysed by SEM. The process involved in SEM analysis are passing of electrons, vacuum chamber, and computer. The electrons are made to pass vacuum chamber where sample kept and by using scrolling mouse the position and the maginifaction of structure. The chemical composition present in the sample can also be analysed by SEM with EDAX. As mentioned in morphological segmentation by image processing, the image were pointed to indicate the elements found in morphological structure. In this research the mortar sample of $1cm^3$ were given for analysis and the morphological structure were analysed for different magnification so as to analyse the element clearly.

The morphological structure won't change based on magnification but the picture clearance will change according to the magnification. The magnification kept for this samples are 2000X, 5000X, 1000X and 30000X and spatial resolution are 10nm, 5nm, 1nm, and 0.5nm respectively. From the grains showed from image, the strength of the mortar can be analysed and all other physical and chemical properties can aslo be analysed. The SEM is one of the advanced technology to found the microstructure of an element with maximum magnification and addition to the SEM edax is also carried out to determine the presence of chemical substance in sample. As bacteria was added in the sample, the chemical composition of normal mortar will change and that too has analysed.

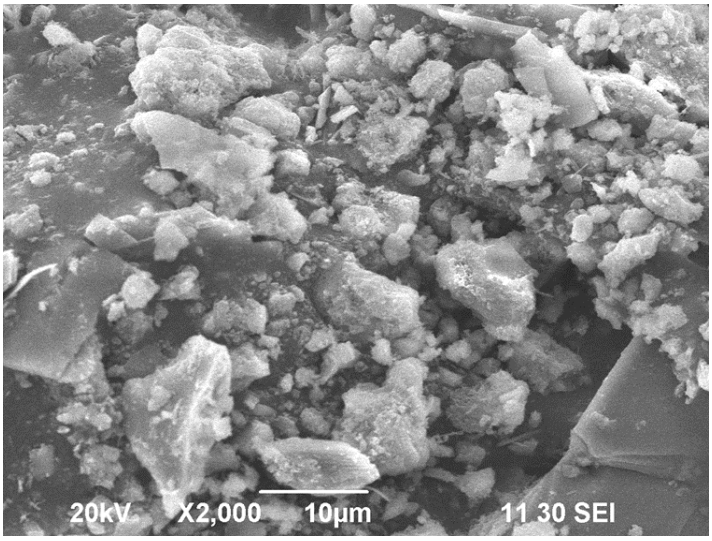

Fig 5 microstructure of mortar in 2000X

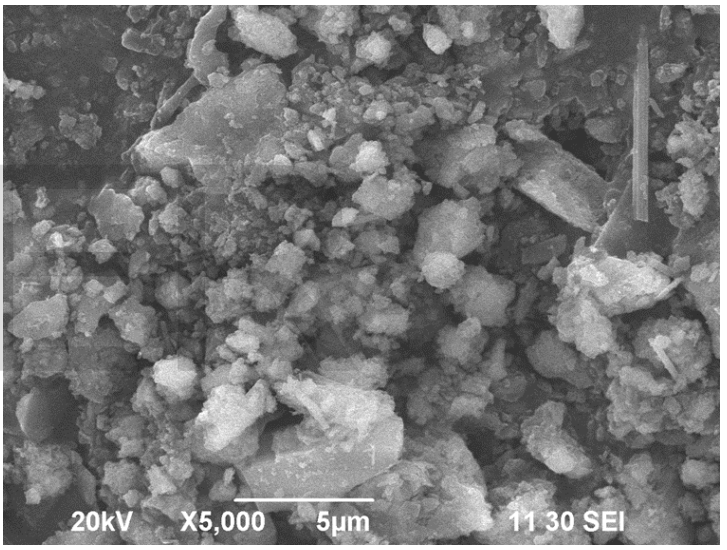

Fig 6 microstructure of mortar in 5000X

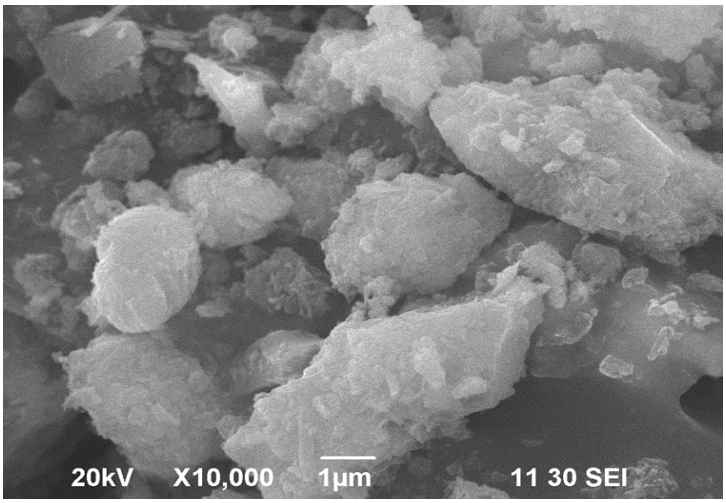

Fig 7 microstructure of mortar in 10000X

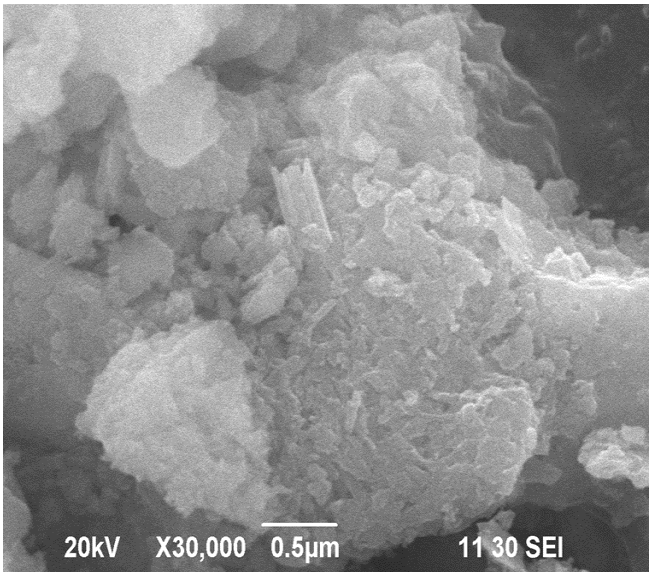

Fig 8 microstructure of mortar in 30000X

8 Conclusion

The cracks were analysed using image processing and by using algorithm the cracked images were derived in grayscale format. For morphological structure the image segmentation was carried out and image was segmented using watershed transform. This research is a starting stage of the main project which will be conducted using concrete element in future research. The exact thickness and morphological structure by using image processing are upcoming research and the morphological structure by SEM was collected with different maginafication. By analysis the crack using image processing, we can reduce the renovation time and cost of building since the results will give apt method for curing the cracks.

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