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A New Auto Detection Of Cement Bounding Quality In Concrete By Image Processing Techniques

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***Abstract*—Bounding time is considered as an identification boundary of fresh and hardened of concrete. Initial set refers to a change from a fluid to a rigid state, accompanied by a rapid temperature rise in the body of concrete structures. The final set, express the start of strength development. Many techniques were presented to cement bounding time such as Vcat needle (in lab) or resistivity logs in oil well. But both of them have some weaknesses. One of the best techniques to detect of bounding quality is concrete petrography. In this technique all of minerals of cement are visible in microscope. In this paper, a new method was presented to improve this technique by image processing. The results showed, the efficiency of this method was good and all segments of cement minerals were detected in polish section. So cement bounding quality detection has a good decision and efficiency.**

Keywords—component; Concrete Petrography, Image Processing, Cement Bounding quality, Polish Section

I. INTRODUCTION

Todays, the use of high - strength concrete in the world has increased significantly. So, in order to improve strength of concrete, it is important to know the initial and final bounding of the concrete. In fact, bounding time of the concrete can be defined as the moment of turning the fresh concrete into a solid body fresh concrete into a solid body. The initial set is the last possible time to carry the concrete and the final set represents the starting point of the mechanical resistance in it [1]. Type of mineral additives are used to increase the mechanical properties of concrete [2]. Antifreeze is currently known as a concrete additive in the concrete and it causes to reduces the permeability and thus increasing the durability of the concrete [3]. One of the best techniques to detect of bounding quality is concrete petrography. It is used to find concrete fracture, cement bounding quality and so on [4].

Many researchers have proposed several techniques based on an image processing, which enable faster and more efficient in measuring the cracks in concrete surfaces [5, 6, 7, 8, 9, 10, 11].
Bang et al described a new image processing technique that detects cracks and calculates the crack characteristics using images taken with a digital camera [12]. The process of the proposed technique is similar to that developed in previous studies [4, 6, 8, 9, 13, 11] in terms of crack detection and analysis; however, this study focuses on improving the crack detection performance.
In this study, it is tried to design a new simple and user friendly algorithm to detection of cement bounding time and its effect on concrete quality.

II. METHODOLOGY

Image processing is a technique to perform some operations on an image. Nowadays, image processing is among rapidly growing technologies. It has formed core research area within engineering and computer science disciplines too [14]. Image processing basically includes the following three steps that showed in Fig.1.

Figure 1: the steps of image processing.

Image processing used routinely by microscopists will be presented. Because image processing allows the investigator to convert the microscope system into a quantitative device, a number of considerations must be taken into account to ensure that information can be extracted in a meaningful way. This chapter will focus on three basic problems: (1) reducing “noise,” (2) enhancing contrast, and (3) quantifying the intensity of an image [15].

Digital image processing techniques were developed after the advancement of computers. The three general phases that all types of data have to undergo

while using digital technique are pre-processing, enhancement, and display, information extraction [16].

III. Results and Discussion

In order to study about cement bounding in concrete, these steps should be followed:

- Preparing of 6 cubic concrete samples with different properties
- Detection of cement bounding time by cement Vicat apparatus
- Test of concrete compressive strength
- Preparing of polish section
- Concrete petrography
- Auto study of detection of cement bounding quality

In first step, six cubic samples were prepared in size 15*15*15 (Table1). Base on Table 1 A1 and A2 have more weight than other samples. C1, C2 have antifreeze as additive (additives with properties in in Table 2). The cement grade and volume of water in all samples is equal. After preparing the sample, the volume of water reduction in each sample is different so that in sample A, B, c is equal to 450cc, 250cc and 450 cc respectively. Water cement ratio is calculated according to the following equation.

$$\frac{w}{c} = \frac{w_{total} - w_{decreased}}{Kg_{Cement}} \quad (1)$$

Table 1: direct shear tests (kazemi, H., 1392)

sample	A_1	B_1	C_1	A_2	B_2	C_2
Vol (cm^3)	3375	3375	3375	3375	3375	3375
Weight Kg	7674	7610	7665	7800	7670	7690
Special Weight Kg/(cm^3)	2.27	2.25	2.27	2.3	2.27	2.28
Cement Grade	350	350	350	350	350	350
Weight of Gravel	7.8	6	6	7.8	6	6
Weight of Sand Kg	10.2	12	12	10.2	12	12
Water cc	2000	2000	2000	2000	2000	2000
additive type	NO	NO	Antifreeze	NO	NO	Antifreeze
amount additive cc	-	-	105	-	-	105
water cement ratio	0.44	0.5	0.44	0.44	0.5	0.44
Time (Day)	7	7	28	7	7	28

At the second step, bounding cement time is tested by Vcat needle test. The results of this test is shown in Fig.2 and Table 3.

Weight of Cement: 350 gr

Temperature of Water: 20 oc

Table 2. Properties of additive.

Form	Jelly
Color	Gray
Special weight	gr/cm^3 1.4
Chlorine	In the permitted range of regulations
Nitrite	NO
Flash point	NO
Freezing point	Zero Centigrade

Table 3. Cement bounding time (date: 27 May 2018)

Test No	W/C	Cement Bounding time (min)	Penetration of needle (mm)
1	25%	15	40
2		25	40
3		35	32
4		45	23
5		50	5
6		55	0

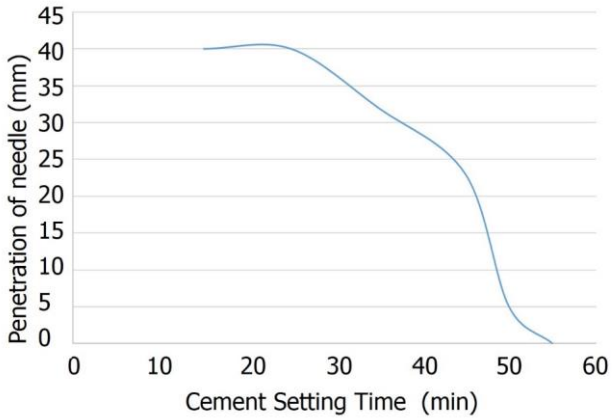

Fig 2. Variety of cement bounding time. The bounding time is completed in 55min.

In third step, the samples were removed from the water after the completion of the required period (7 and 28 days) and dry in the sun. after that, the samples were weighted and then they are placed in uniaxial compressive strength. The result of this test were shown in Table 4.

Table 4. Forces and stresses which are read in testing

Sample No	Force (Kg)	Area (cm^2)	Compressive strength (Kg/ cm^2)
A_1	46300	225	205.8
B_1	35300	225	156.9
C_1	42300	225	183.6
A_2	68100	225	302.7
B_2	53700	225	238.7
C_2	51500	225	228.9

In the fourth step some piece of the breaking down samples were delivered to the laboratory to prepare polish sections. In this study, the criterion for the cement bounding quality are:

- The presence of Alite and Belite as first cement minerals indicates a lack of cement reaction and Subsequently a very bad cement bounding quality.
- The presence of large segmentation of carbonate minerals, which indicates the poor quality of cement shredding, causes the cement bounding quality to be unsuitable.
- There are Ferrite and Aluminate minerals that are secondary cement minerals. In this case, the cement bounding quality is being refined.

In the next step, all of the polish sections were studied by reflection microscopy. The results were described in Fig.3 to Fig. 8. The Alite and Belite are seen in these Figs. So it is very bad cement bounding in concrete. The presence of Ferrite and Aluminate are shown cement maturity.

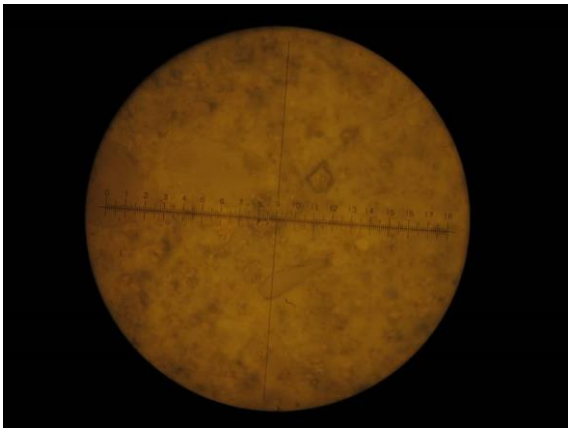

Fig. 3. The rest segmentation (80microns) and Alite and Belite (30microns) in Sample A1

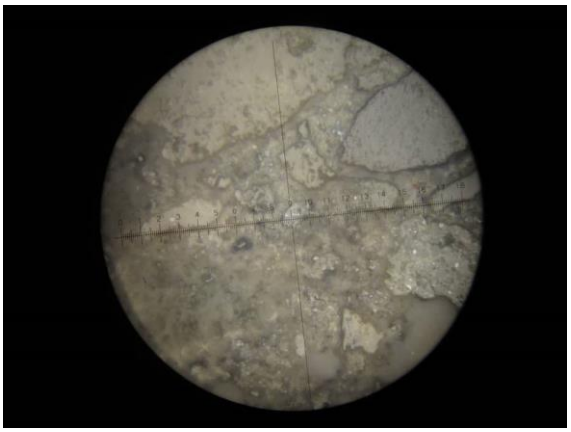

Fig. 4. The single and independent form of silicate phases of cement in dimensions smaller than 50 microns remain unchanged in B1

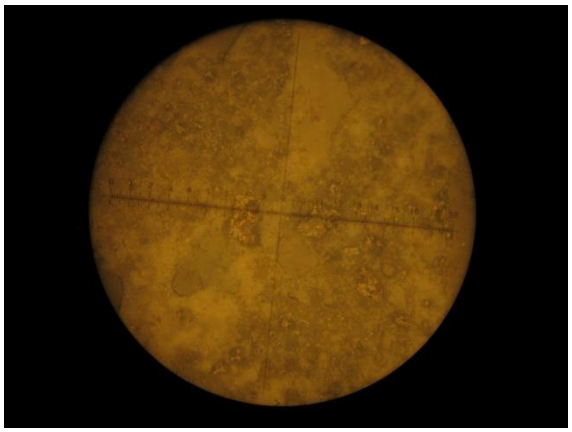

Fig. 5. Two pieces of Alite that one of them is 60*80 and the other is 60*100 in C1

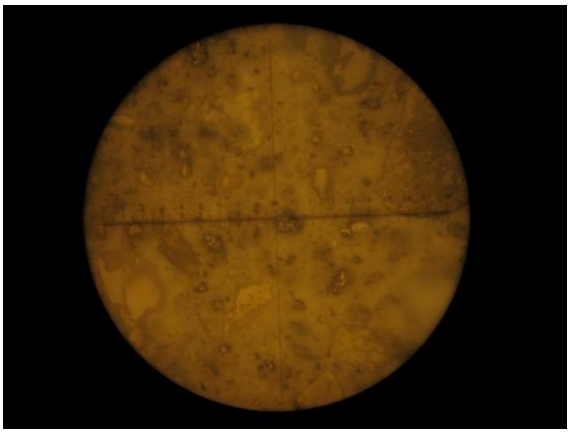

Fig. 6. The remaining set pieces of cement minerals in A2. The size of these pieces is 30 - 40 microns. There are at least 10 pieces in this square. Note the scale of the ruler, each piece is equivalent to 4 microns.

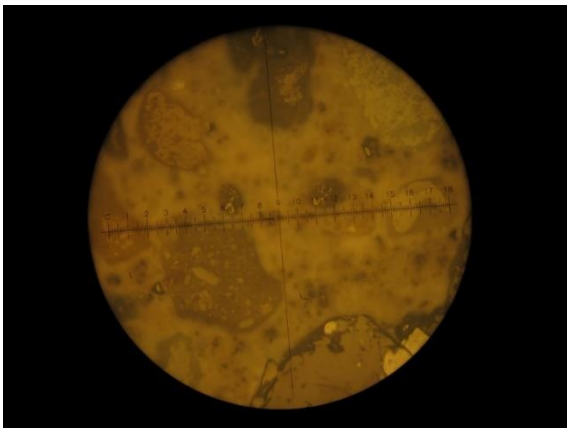

Fig. 7. The remaining set pieces of cement minerals in scale of the ruler in B2

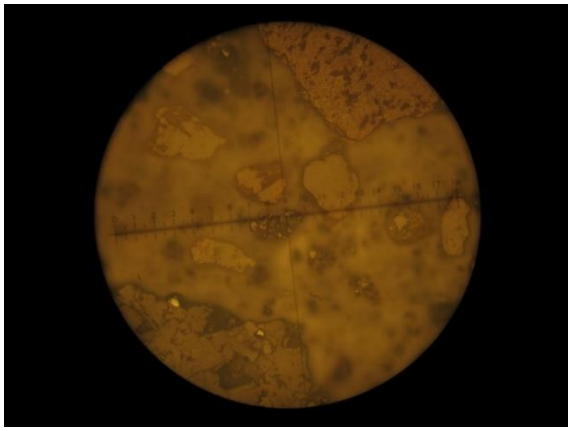

Fig. 8. A large segment of Alite (100 microns) in C2

At the last step, the processing difficulty of the cement bounding quality detection completely depends on the size of the image. Some digital cameras have the image resolution beyond 10 megapixels. This increase in resolution enables the acquisition of detailed images of concrete surfaces. By using the trendy cameras of commercial purpose, a wide range of a concrete surface can be acquired in a single shot. For inexpensive applications, a wide range image can be used for the cement bounding quality detection.

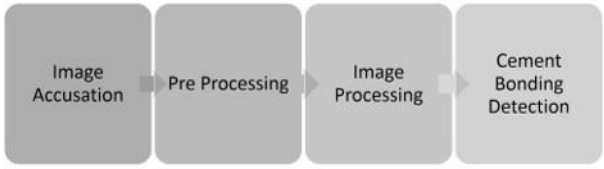

Fig. 9. The architecture of image processing based cement bounding time detection

Fig. 9 shows general architecture for cement bounding time detection based on the image processing. The steps in the image processing technique are as follows:

- Initially collect the image of the polish sections which will be subjected to the cement bounding quality detection process using the camera or any sources.
- After the image acquisition, the collected images are pre-processed within which the methodologies like convert color system and segmentation are done there by making it an efficient one for the image processing procedure.
- In the image processing, some of the techniques are employed to process the deducted image sample.
- The cement bounding quality detection will be noticed here using the result of the processed image.

The results of these steps were shown in Fig. 10 to Fig. 15. All of these Figs verified good precision. The cement minerals are shown in blue circles in these Figs. It is illustrated good identification of cement minerals in each section. All of these polish sections are studied by image processing technique. For example, in Fig14 the Alites and Belite are recognizable in the C2 sample. Of course, in this section, there are other shapes that are similar to the Alites segments. These segments are changing to Ferrite and Aluminate (lower samples).

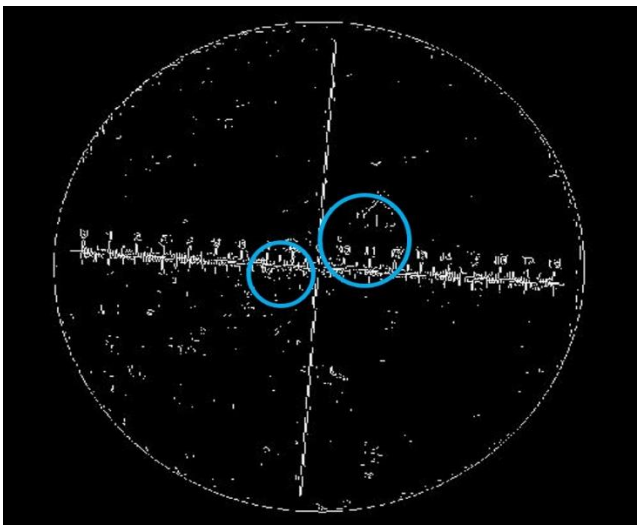

Fig. 10. Separation of different segments in the polished section of sample A1. The two striking features of the Alite and Belite illustrate good performance of this method.

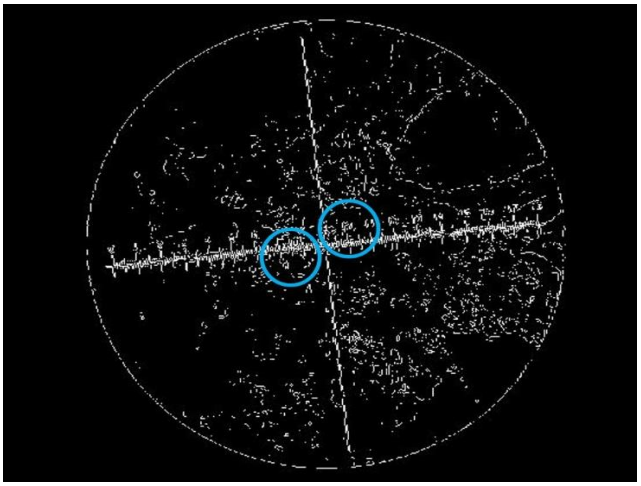

Fig. 11. Separation of parts containing information in the polished section of sample B1. As it is seen, some samples

containing the Alite are visible on the microscopic scale line and also below the line on the left.

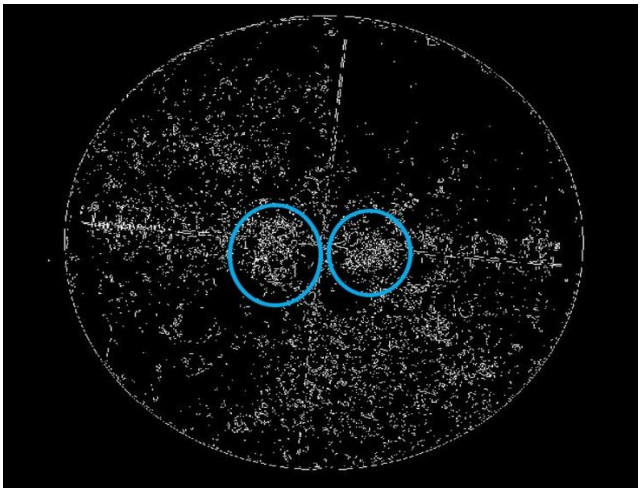

Fig. 12. The Alite parts can be seen well in the center of the image on both sides of the vertical microscope scale line in the C1 sample.

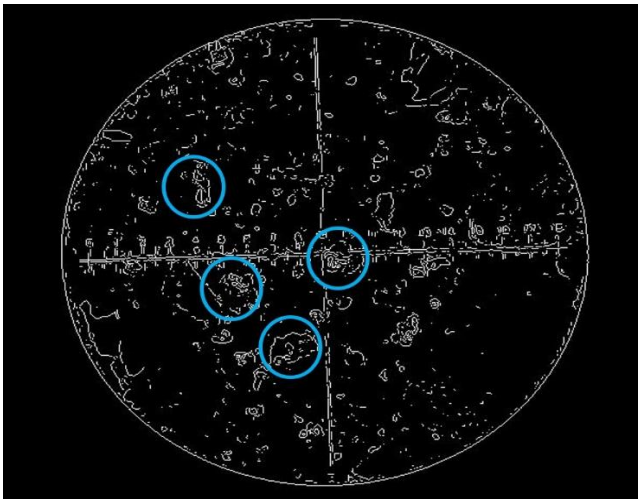

Fig. 13. Many pieces of cement in the blue circle are well illustrated in A2.

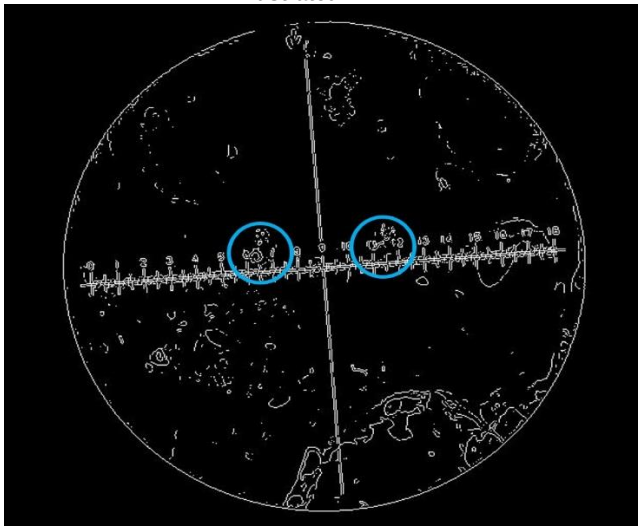

Fig. 14. Alite segments in the center of picture are recognizable on both sides of the microscope's line. This section is related to sample B2.

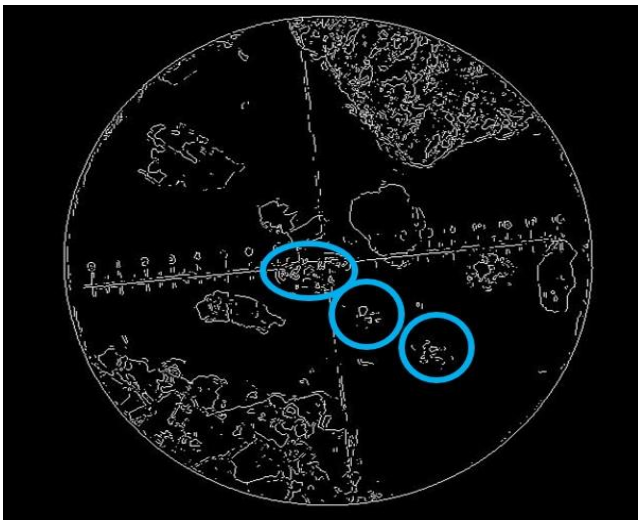

Fig. 15. The Alites and Belite are recognizable in the C2 sample. Of course, in this section, there are other shapes that are similar to the Alites segments. These segments are changing to Ferrite and Aluminate (lower samples).

IV. CONCLUSION

In this study six concrete samples were analyzed. The main purpose of this paper was cement bounding quality detection automatically. In general, the following results were obtained from this study:

- The presence of Alite and Belite showed a lack of cement reaction and Subsequently a bad cement bounding quality.
- The presence of large segmentation of carbonate minerals indicated the poor quality of cement shredding.
- The presence of Ferrite and Aluminate minerals in some sample (such as C2) illustrated that the cement bounding quality was being refined.
- By using image processing, the presence of Alite and Belite minerals as primary minerals in Ferrites and Aluminates as secondary minerals (as Criterion of cement bounding quality) was identified more precise than traditional methods.
- By using of image processing and required features extraction for the study of cement bounding quality, the need for studies of electron microscopy and the cost is reduced.

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REFERENCES

[1]. Mehta, P.K. and Monteiro, P.J.M. Concrete – Structures, properties and materials, Englewood cliffs, NJ: Prentice-Hall, 1993, pp. 443-336.
[2]. Aitcin, PC. High Performance Concrete, E & FN Spon. 1998,
[3]. Mazloom, M., Ramezanianpour, A.A. and Brooks, J.J. Effect of silica fume on mechanical properties of high-strength concrete, Cement & Concrete Composites, 2004, Vol. 26, pp. 347-357.
[4]. John St, Poole, D. A., A. B., & Sims, I. Concrete petrography: a handbook of investigative techniques. Arnold; Copublished in North, Central and South America by J. Wiley, 1998.
[5]. Kaseko, M.S. and Ritchie, S.G., A neural network based methodology for pavement crack detection and classification. Transportation Research. Part C, Emerging Technologies, 1 (4), 275–291. 1993.
[6]. Ito, A., Aoki, Y., and Hashimoto, S., Accurate extraction and measurement of fine cracks from concrete block surface image. IEEE Industrial Electronics Society, 3, 2202–2207. 2002.
[7]. Schutter, G.D., Advanced monitoring of cracked structures using video microscope and automated image analysis. NDT & E International, 35 (4), 209–212. 2002.
[8]. Sohn, H.G., et al., Monitoring crack changes in concrete structures. Computer-Aided Civil and Infrastructure Engineering, 20, 52–61. 2005.
[9]. Chen, L.C., et al., Measuring system for cracks in concrete using multitemporal images. Journal of Surveying Engineering, 132 (2), 77–82. 2006.
[10]. Hutchinson, T.C. and Chen, Z., Improved image analysis for evaluating concrete damage. Journal of Computing in Civil Engineering, 20 (3), 210–216. 2006.
[11]. Yamaguchi, T., et al., Image-based crack detection for real concrete surfaces. Transactions on Electrical and Electronic Engineering, 3, 128–135. 2008.
[12]. Bang Yeon Lee, Yun Yong Kim, Seong-Tae Yi and Jin-Keun Kim, Automated image processing technique for detecting and analysing concrete surface cracks, Structure and Infrastructure Engineering Vol. 9, No. 6, 567–577. 2013,
[13]. Sinha, S.K. and Fieguth, P.W., Automated detection of cracks in buried concrete pipe images. Automation in Construction, 15, 58–72. 2006.
[14]. Russ, J.C., 1995, The Image Processing Handbook. Second ed. Boca Raton, Florida: CRC Press.
[15]. Cardullo, Richard A., Fundamentals of Image Processing in Light Microscopy. Methods in Cell Biology. Volume 72, 2003, Pages 217-242
[16]. Gonzalez, R.C. and R.E. Woods, Digital Image Processing. Reading, Massachusetts: Addison-Wesley. 716. 1992,The study of NE part of darrekan river, noandishan design consulting engineers- water and environment (2011).