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Evaluating the settlement of lightweight coarse aggregate in self-compacting lightweight concrete

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Abstract. The purpose of this paper is to evaluate the settlement of lightweight coarse aggregate of self-compacting lightweight concrete (SCLC) after placement of concrete on its final position. To investigate this issue, sixteen samples of concrete mixes were made. The water to cementitious materials ratios of the mixes were 0.35 and 0.4. In addition to the workability tests of self-compacting concrete (SCC) such as slump flow, V-funnel and L-box tests, a laboratory experiment was made to examine the segregation of lightweight coarse aggregate in concrete. Because of the difficulties of this test, the image processing technique of MATLAB software was used to check the segregation above too. Moreover, the fuzzy logic technique of MATLAB software was utilized to improve the clarity of the borders between the coarse aggregate and the paste of the mixtures. At the end, the results of segregation tests and software analyses are given and the accuracy of the software analyses is evaluated. It is worth noting that the minimum and maximum differences between the results of laboratory tests and software analyses were 1.2% and 9.19% respectively. It means, the results of image processing technique looks exact enough for estimating the segregation of lightweight coarse aggregate in SCLC.

Keywords: self-compacting; concrete; settlement; segregation; image processing; fuzzy logic

1. Introduction

Self-compacting concrete (SCC) was first recommended in Japan (Okamura 1997). SCC has many advantages over conventional concrete such as reducing the construction time and labor cost, omitting the need for vibration, reducing the permeability and the developing the durability of concrete, strengthening the interfacial transitional zone between cement paste and reinforcement or coarse aggregate, decreasing the noise pollution, and assisting constructability and ensuring good structural performance (Shi and Yang 2005).

Self-compacting lightweight aggregate concrete (SCLC) is a type of concrete developed from self-compacting concrete (SCC). SCLC combines the favorable properties of lightweight aggregate concrete (LWAC) and SCC. In fact, SCLC requests no external vibration, and it can stretch into place, fill the formwork and encapsulate reinforcement with no segregation or bleeding (Wu *et al*. 2009). The other benefit of SCLC is that it reduces the self-weight of structures efficiently.

Different test methods used for SCLC are like those utilized for SCC. Extensive investigations on the workability of SCC have been made in North America and Europe (Khayat *et al*. 2004, Assaad *et al*. 2004, Ding *et al*. 2008). Khayat *et al*. (2004) presented that the J-ring, U-box and L-box tests can be used to assess the passing capability of SCC, the deformability and resistance to segregation. The combination of the slump flow and L-box test is very appropriate for the quality control of SCC on-site. Also penetration and wet sieve segregation tests are generally used to approximate the resistance of SCC to segregation (Bartos 2005).

Various researches have been done on SCC and LWAC; however, there are few studies on SCLC. Choi *et al*. (2006) presented the mix proportion of SCLC by modifying a method suggested by Su and Miao (2003). Afterward, the U-box, slump flow and V-funnel tests were used to estimate the workability of SCLC. Shi and Wu (2005) used the L-box, slump flow and V-funnel tests to investigate the properties of SCLC. Müller and Haist (2002) suggested three mix designs for SCLC and utilized the L-box, slump flow, V-funnel and J-ring tests. Some other important laboratory researches have been carried out in this field during the last few years (Yanai *et al*. 2000, Lo *et al*. 2007, Hossain and Lachemi 2007, Turkmen and Kantarci 2007). Moreover, some case studies on SCC and SCLC have been expressed relating to the strengthening and repairing of structural elements and bridge decks (Sugiyama 2003, Domone 2006). It is worth noting that Karamloo *et al*. (2016) have presented two advanced papers about the fracture behaviors of SCLC.

According to the suggestion of European Project Group (2002) and the researches on LWAC (Wu *et al*. 2009) the study on the resistance of SCLC to segregation is inadequate. The aim of this paper is to present the desire rheology and mix design of SCLC, investigating its homogeneity, and finally evaluating its segregation. But since it is almost impossible to work with hardened

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Table 1 Chemical analysis of cement

Name	Content (%)
CaO	63.95
SiO2	21.46
Al2O3	5.55
Fe2O3	3.46
MgO	1.86
SO3	1.42
K2O3	0.54
Na2O	0.26

Table 2 Fine specifications used in making concrete

Sieve Size		Passing Percentage (%)
No.	mm	
4	4.75	90
8	2.36	61
16	1.18	34
30	0.600	21
50	0.300	12
100	0.150	2

Table 3 The grading of LECA aggregate

Sieve (mm)	Passing Percentage (%)
9.5	100
4.75	70
2.36	0

concrete, the decision was made to investigate the coarse aggregate distribution in concrete using the image processing and fuzzy logic techniques available in toolboxes of MATLAB software. Afterward, the results were compared with laboratory column segregation test results on fresh concrete for evaluating the accuracy of MATLAB software. For reducing the discrepancy between laboratory results and image processing, the number of cuttings in each specimen can be improved. The average results of image processing technique should be closer to the laboratory results.

2. Materials

The cement used in this study was Portland cement type I produced in Tehran Cement Company with the specific gravity of 3.15 gr/cm^3. The chemical analysis of the cement is given in Table 1. The sand utilized in this study was natural sand with the specific gravity of 2.53 gr/cm^3, and its water absorption was 2.5%. The grading of the sand can be seen in Table 2. A polycarboxylate-based superplasticizer is used in this study. Its density was 1.26-1.28 gr/cm^3. The rock flour of this work which was used as neutral filler in the mixtures was passed through sieve No. 100. Using rock flour provides more consistency for the mixes, so it can be used and replaced as a viscosity modifier material.

Table 4 Compositions of silica fume

Composition	Percentage (%)
SiO2	91.7
Al2O3	1.00
Fe2O3	0.9
CaO	1.68
MgO	1.80
SO3	0.87
Cl$^-$	0.08
Loss on ignition	2.00

Table 5 Mix designs of the investigated SCLC mixtures

Mix Designs	W/C	water (Kg/m3)	Cementitious materials (Kg/m3)	Silica Fume (%)	Superplasticizer (%)	Stone Powder (Kg/m3)	LECA (Kg/m3)	sand (Kg/m3)
SCLC 1	0.35	207	591	0	2	250	294	743
SCLC 2	0.35	207	591	10	2	250	294	743
SCLC 3	0.35	207	591	0	2.2	250	294	743
SCLC 4	0.35	207	591	10	2.2	250	294	743
SCLC 5	0.35	207	591	0	2.4	250	294	743
SCLC 6	0.35	207	591	10	2.4	250	294	743
SCLC 7	0.35	207	591	0	2.6	250	294	743
SCLC 8	0.35	207	591	10	2.6	250	294	743
SCLC 9	0.4	236	591	0	0.8	250	280	704
SCLC 10	0.4	236	591	10	0.8	250	280	704
SCLC 11	0.4	236	591	0	1	250	280	704
SCLC 12	0.4	236	591	10	1	250	280	704
SCLC 13	0.4	236	591	0	1.2	250	280	704
SCLC14	0.4	236	591	10	1.2	250	280	704
SCLC 15	0.4	236	591	0	1.4	250	280	704
SCLC 16	0.4	236	591	10	1.4	250	280	704

LECA is an abbreviation for lightweight expanded clay aggregate. The seeds are resulted from the thermal expansion of clay in rotary furnace at about 1000 to 1200^{o}C and are regarded as the strongest kind of artificial lightweight aggregate utilized in concrete. The most significant physical properties of LECA are low thermal conductivity, low density, fire resistance, and lower water absorption than other types of lightweight seeds (Demirboğa *et al.* 2001). Most of references establish water absorption for mix designs as water absorption in one hour. Another suggestion is to consider the double amount of water absorbed in 30 minutes for LECA in mix designs (European Union-BriteEuram III 1998). Also some researchers highlight the use of lightweight aggregate in the form of saturated with dry surface (Yi *et al.* 2003). It means, the grains should be submerged in water first, and then the seeds surface should be dried and used in concrete. In this study, in order to make lightweight concrete, the structural lightweight expanded clay aggregate, which is produced in Tehran LECA Company was used. The water absorption of the utilized LECA was 12% and it was submerged in water one hour before mixing the concrete

Table 6 Compressive strength of the investigated SCLC mixtures

Mix Names	28 Day Compressive Strength (Mpa)	Density (kg/m^3)
SCLC 1	41.3	1922
SCLC 2	45.7	1891
SCLC 3	38.5	1913
SCLC 4	43.6	1884
SCLC 5	36.4	1906
SCLC 6	41.5	1879
SCLC 7	34.3	1897
SCLC 8	39.6	1875
SCLC 9	33.7	1825
SCLC 10	37.8	1797
SCLC 11	32.9	1819
SCLC 12	35.9	1786
SCLC 13	30.5	1792
SCLC14	33.4	1767
SCLC 15	29.8	1779
SCLC 16	31.8	1747

components, and the saturated with dry surface technique was used here. The grading of LECA aggregate is given in Table 3.

Because of the lightness of LECA, they have a propensity to split from other components of the mixture. To fix this trouble, silica fume and superplastisizer can be used to improve the consistency of concrete. Silica fume used in this study was obtained from Iranian Ferro Silicon Company. The chemical compositions of the utilized silica fume are given in Table 4.

3. Mix proportions

In this study, sixteen different mixes were investigated. The mixes were built with the water to cementitious materials ratios of 0.35 and 0.4, and the silica fume replacement level was 10%. The information about mix designs can be seen in Table 5. Also the 28-day compressive strength and density of the mixes are presented in Table 6. It is worth noting that Tapali *et al*. (2013) have new suggestions in concrete mix designs for target strengths.

4. Workability tests

Regular tests of self-compacting concrete are concerned with the properties of SCLC during the process of mixing, transportation and casting. They are slump flow, V-funnel and L-box tests as follow. The details of these tests are presented by the previous publications of the first author (Mazloom *et al*. 2015, Mazloom and Yoosefi 2011, 2013).

4.1 Slump flow test

Table 7 Slump flow test results

Mix names	W/C	T50 (s)	Slump flow diameter
SCLC 1	0.35	4.1	680
SCLC 2	0.35	6.4	625
SCLC 3	0.35	2.4	700
SCLC 4	0.35	4.5	650
SCLC 5	0.35	1.95	735
SCLC 6	0.35	3.1	685
SCLC 7	0.35	1.8	770
SCLC 8	0.35	2.5	750
SCLC 9	0.4	2.1	720
SCLC 10	0.4	3.4	670
SCLC 11	0.4	1.95	755
SCLC 12	0.4	3.05	705
SCLC 13	0.4	1.85	780
SCLC14	0.4	2.65	735
SCLC 15	0.4	1.7	805
SCLC 16	0.4	2.4	750

Table 8 V-funnel test results

Mix names	W/C	Exit time of concrete (s)
SCLC 1	0.35	15.2
SCLC 2	0.35	17.8
SCLC 3	0.35	14.4
SCLC 4	0.35	16.5
SCLC 5	0.35	13.2
SCLC 6	0.35	15.3
SCLC 7	0.35	12.9
SCLC 8	0.35	11.2
SCLC 9	0.4	14.7
SCLC 10	0.4	15.9
SCLC 11	0.4	11.6
SCLC 12	0.4	12.8
SCLC 13	0.4	10.9
SCLC14	0.4	11.4
SCLC 15	0.4	10.7
SCLC 16	0.4	9.7

This test is defined to determine the ability of concrete to deform under its own weight without any barrier except the friction of slump plate (EFNARC 2002, 2005). The slump flow test is used to evaluate the rheology and performance of concrete (Kim *et al*. 2012). The final diameter of flowing concrete is the criterion for decision making. In addition, the time for reaching the diameter of 50 cm and of course the way of carrying coarse aggregate is observed and recorded.

By reducing the water to cementitious material ratio, the rheology and workability of concrete decreased, and this is not recommended. Table 7 shows the slump flow test

Table 9 L-box test results

Mix names	W/C	H2/H1
SCLC 1	0.35	0.84
SCLC 2	0.35	0.81
SCLC 3	0.35	0.87
SCLC 4	0.35	0.84
SCLC 5	0.35	0.91
SCLC 6	0.35	0.89
SCLC 7	0.35	0.92
SCLC 8	0.35	0.9
SCLC 9	0.4	0.85
SCLC 10	0.4	0.75
SCLC 11	0.4	0.88
SCLC 12	0.4	0.8
SCLC 13	0.4	0.89
SCLC14	0.4	0.86
SCLC 15	0.4	0.92
SCLC 16	0.4	0.9

results. It is clear that with the same water to cementitious materials ratio, by increasing the amount of superplasticizer, the diameter increased and the time for reaching the diameter of 50 cm reduced. It should be noted that in the absence of silica fume, the diameter of flow greatly increased and the mixtures were more on the verge of segregation. By increasing the water to cementitious materials ratio, the diameter increased.

4.2 V-funnel test

In this test, the total time for concrete to flow through the V-funnel apparatus is measured and used as a criterion to determine the filling and plastic viscosity of concrete (EFNARC 2002, 2005).

The influences of superplasticizer and silica fume on concrete in V-funnel test are summarized in Table 8. SCLC mixes containing silica fume got better rheology and it was much easier to work with this kind of SCLC compared to the ones without it. It is clear in Table 7 that by increasing the water to cementitious materials ratio the exit time of concrete reduced and the filling ability of concrete increases.

4.3 L-box test

This test explains the flowability of concrete and also describes obstruction due to reinforcement spacing in concrete. As shown in Table 9, by increasing the water to cementitious materials ratio, h_2/h_1 ratio or the ability to cross the reinforcement increased. It should be noted that in the absence of silica fume the mixtures were more on the verge of segregation in this test.

5. Laboratory test for segregation

Table 10 Results of laboratory test of coarse aggregate distribution

Mix Name	W/C	Superplasticizer (%)	Silica Fume (%)	LECA percentage in different parts (%)
SCLC 2	0.35	2	10	30.88
				31.83
				28.43
				36.45
SCLC 4	0.35	2.2	10	30
				32.13
				32.92
				33.41
SCLC 5	0.35	2.4	-	26.02
				28.91
				29.87
				31.21
SCLC 7	0.35	2.6	-	28.38
				28.69
				29.41
				30.14
SCLC 9	0.4	0.8	-	28.8
				29.3
				29.74
				35.59
SCLC 11	0.4	1.0	-	25.52
				26.73
				27.74
				29.63
SCLC 14	0.4	1.2	10	26.58
				28.53
				29.54
				29.96
SCLC 16	0.4	1.4	10	29.55
				30.14
				31.19
				34.49

One of the issues which jeopardized the stability of SCLC was the drop height of SCLC mixtures. In fact, dropping SCLC from more than 1m height improved the risk of segregation in concrete significantly. The other subject that could weaken almost all properties of SCLC was delay in placing the concrete. Because of the high absorption of LECA in this study, which was about 12%, the concrete was really sensitive to the pouring time, and any delay in placing the concrete increased the possibility of segregation. Therefore, even by designing great mixes, it is not possible to assure SCLC will have all required features if the two items above are not considered. Moreover, compared with normal aggregate, lightweight aggregate in SCLC were easier to flout up, causing segregation. A satisfactory SCLC should not only have good deformability, filling ability and fluidity, but also have homogeneous aggregate distribution and high resistance

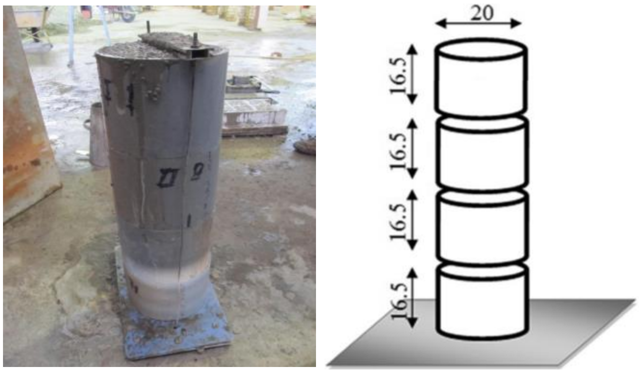

Fig. 1 Column segregation test apparatus

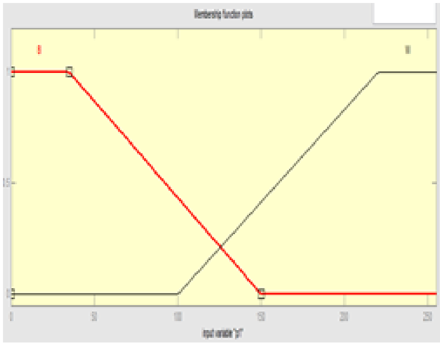

Fig. 2 Input membership function

to segregation. In this paper, the column segregation test was performed to investigate the consistency of distribution of lightweight aggregate. As shown in Fig. 1, the circular column consists of four short columns with height of 165 mm (16.5 cm) and the diameter of 200 mm (20 cm). The fresh concrete mixes were poured in the column. After 30 minutes, the four short columns were separated. The SCLC in each short column was poured onto a No. 4 sieve and then washed by water. The weight of coarse aggregate in each short column was lastly measured. The ratios of the weight of coarse aggregate to the total weight of concrete in each short column were used to evaluate the consistency of distribution of coarse aggregate. Table 10 shows the result of this test. It is worth noting that SCLC mixes which contained silica fume had better adhesion and resistance to segregation.

This is in agreement with the finding of other researchers (Bauchkar and Chore 2014). In fact, the distribution of LECA in different parts of the investigated concrete mixtures containing silica fume was more homogeneous than the ones without it. Therefore, silica fume improved the consistency and uniformity of SCLC. It is worth noting that two comprehensive studies on the properties of concrete containing silica fume is executed recently (Yong 2014, Mahdikhani and Ramezanianpour 2014). It is worth noting that the results of Tables 7 to 10 did not show advanced correlation among the workability and aggregate settlement data.

6. Segregation test using image processing technique

Table 11 Eight fuzzy rules for decision

Rules	If	Then
1	(p1 is B) and (p2 is B) and (p3 is B) and (p4 is B) and (p8 is B)	(p9 is B*)
2	(p1 is W) and (p2 is W) and (p3 is W) and (p4 is W) and (p8 is W)	(p9 is W*)
3	(p2 is B) and (p3 is B) and (p4 is B) and (p5 is B) and (p6 is B)	(p9 is B)
4	(p2 is W) and (p3 is W) and (p4 is W) and (p5 is W) and (p6 is W)	(p9 is W)
5	(p4 is B) and (p5 is B) and (p6 is B) and (p7 is B) and (p8 is B)	(p9 is B)
6	(p4 is W) and (p5 is W) and (p6 is W) and (p7 is W) and (p8 is W)	(p9 is W)
7	(p6 is B) and (p7 is B) and (p8 is B) and (p1 is B) and (p2 is B)	(p9 is B)
8	(p6 is W) and (p7 is W) and (p8 is W) and (p1 is W) and (p2 is W)	(p9 is W)

*B=Black; W=White

To recognize the segregation of concrete, the actual results could be achieved after final setting time of concrete. As explained earlier, column segregation tests were carried out only 30 minutes after filling the molds. Also performing column segregation test in sites is not an easy task. Therefore, it is decided to use image processing technique to check the uniformity of distribution of lightweight aggregate in SCLC. For this purpose, after curing of concrete columns for three days, they were cut to four cylinders and each cylinder was cut along the diameter of its cross section. At the end, the uniformity of distribution of lightweight aggregate in each column was checked by these sections using image processing technique. In fact, dividing the total area of the coarse aggregate in each section to the total surface area of the section gives the LECA percentage in each part of the column.

The colorful JPG format images were the input values for image processing technique. After preparing images, it was possible to apply RGB (Red, Green, and Blue) processing on the colorful images. Because of the nearness of the color of some of the aggregate to the paste in some areas, the recognition of the borders only by image processing technique was not possible in some circumstances. In order to eliminate this problem, fuzzy logic technique was utilized for achieving better binary images. For this purpose, a 3×3 matrix was used as a mask so that according to the color of neighboring pixels the color of central pixel was rewritten. After applying the fuzzy rules, the output images were converted to binary ones. In binary pictures only two colors of black and white are available; therefore, all the borders can be found easily. Silva and Štemberk (2013) have used Genetic-fuzzy approach to model concrete shrinkage too.

6.1 Preparing images and initial processing

To obtain optimum quality, a five megapixel camera is used. The initial photos were saved in jpg format. Afterwards a 3×3 mask was slid across the whole images and the data were sent to the fuzzy logic toolbox of MATLAB software as inputs. Li and An (2014) have used image processing for estimating the workability of self-compacting concrete too.

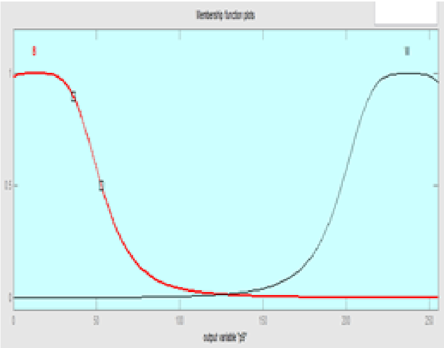

Fig. 3 Output membership function

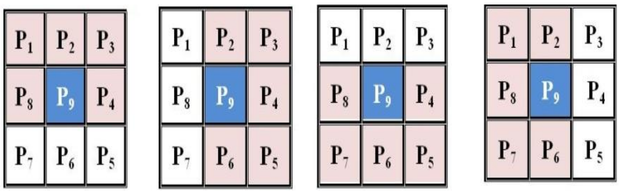

Fig. 4 3×3 Matrix for sliding across image

Fig. 5 Input image

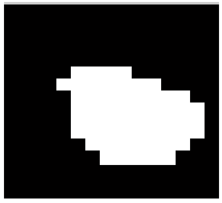

Fig. 6 Out image after processing

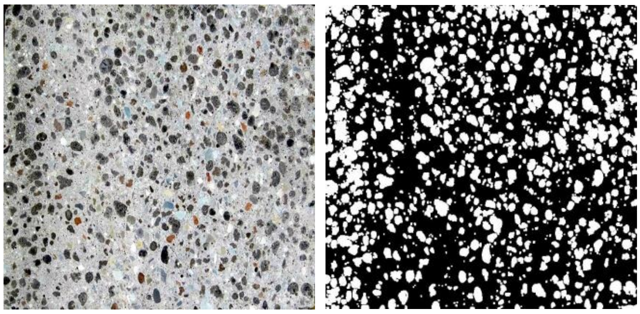

Fig. 7 The input and output images of MATLAB software

6.2 Fuzzification of images using membership functions

Using fuzzy logic capabilities to analyze ambiguous problems, they must be defined qualitatively first. To describe the light intensity values of image pixels in MATLAB software some convertors should be used called fuzzy membership functions. In this paper to detect the boundary between the coarse aggregate and paste, some functions were used in order to detect the small differences and zoom in for more details in these areas for next processing stages and ultimately making decisions.

6.3 Sliding 3×3 matrix across the image and fuzzy rules

Regarding the rules of scattering intensity of the image pixels, a trapezoidal membership function (trapmf) is used for input data, and a bell membership function (gbellmf) is applied for output values as shown in Figs. 2 and 3 respectively (Kaur *et al*. 2010). After applying the input data, eight fuzzy rules should be executed for deciding the color of each pixel according to the four U-shaped models presented in Fig. 4. All these fuzzy rules are presented in Table 11. According to the eight answers about the color of each pixel, they are rated by fuzzy logic method and ultimately the final decision is made for the color of central pixel.

6.4 Fuzzy decision and coarse aggregate segregation

After fuzzy reasoning, quantitative values of images are converted to numerical values by fuzzy membership functions. The color of each pixel is written according to its neighbors' colors. After this step, the output image is converted to a binary image. In this research, the white and black colors are referred to the pixels that show the coarse aggregate (LECA) and the paste respectively. The area of coarse aggregate can be determined by using functions available in the MATLAB software. The percentage of LECA can be calculated in four parts of each sample by dividing this value to the total surface area of each section (Ammouche *et al*. 2000).

Fig. 5 shows a small area from input image. The lack of clarity between the boundary of coarse aggregate and paste is quite obvious. This problem is more evident for aggregate with bright colors, which are close to the color of cement paste. Fig. 6 shows the modified picture after utilizing fuzzy logic method, which is quite applicable. This method is applied for finding the boundary of other problems earlier (Cheng *et al*. 2000, Elewa *et al*. 1995, Wettimuny and Penumadu 2004, Smith *et al*. 1997, Peterson *et al*. 2001).

The proposed algorithm is coded in MATLAB software. In fact, the input image should be sent to the program and after applying the algorithm on the image, the output result is obtained as a binary image. In output image, the white and black colors are referred to the pixels that show the coarse aggregate (LECA) and the paste respectively. In Fig. 7 the input image and the output image after applying the algorithm is shown.

7. Comparing laboratory and image processing results

The results of column segregation test and image processing technique in the mixes are shown in Table 12. The generalized results in all the mixes show that the consequences of the two methods were close to each other. The minimum and maximum differences between the results of the two methods were 1.2% and 9.19% respectively. Consequently, the results of image processing technique can be used to estimate the settlement of coarse aggregate (LECA) in SCLC with good approximation. Moreover, in most cases, the percentage of LECA obtained

Table 12 The results of two segregation tests

Mix name	Laboratory test	Form position	Image processing	Mix name	Laboratory test	Form position	Image processing
SCLC2	30.88%	1	32.29%	SCLC9	28.8%	1	30.16%
	31.83%	2	32.54%		29.3%	2	30.04%
	28.43%	3	29.10%		29.74%	3	32.27%
	36.45%	4	36.89%		35.59%	4	38.29%
SCLC4	30%	1	32.66%	SCLC11	25.52%	1	26.43%
	32.13%	2	33.58%		26.73%	2	27.50%
	32.92%	3	34.72%		27.74%	3	28.23%
	33.41%	4	35.33%		29.63%	4	30.61%
SCLC5	26.02%	1	26.65%	SCLC14	26.58%	1	27.16%
	28.91%	2	29.85%		28.53%	2	29.36%
	29.87%	3	32.35%		29.54%	3	32.07%
	31.21%	4	34.08%		29.96%	4	32.77%
SCLC7	28.38%	1	29.05%	SCLC16	29.55%	1	30.83%
	28.69%	2	30.06%		30.14%	2	30.88%
	29.41%	3	30.86%		31.19%	3	33.75%
	30.14%	4	31.21%		34.49%	4	37.12%

from image processing technique was slightly higher than the other. The reason for it may be the shorter time that coarse aggregate have for settlement in laboratory test. It means, in this test the percentage of LECA is measured 30 minutes after pouring concrete in column segregation mold, but in image processing technique it is measured three days after casting the concrete. In fact, the advantage of image processing technique is that it investigates the stability of concrete when it is in its final location and completely rigid, and at this stage no further settlement of aggregate is possible.

The other reason for the small difference between the results of image processing and laboratory test is that the processes of finding the percentage of LECA in these two methods are completely different. It means, in image processing technique and laboratory test the calculations are based on the area and the weight of coarse aggregate respectively.

8. Conclusions

The conclusions of this study are summarized in the following points:

• Self-compacting lightweight concrete (SCLC) mixes containing silica fume got better rheology and ability to fill the form and it was much easier to work with this kind of SCLC compared to the ones without it.

• In addition to previous advantage of silica fume, SCLC mixes which contained silica fume had better adhesion and resistance to segregation. In fact, the distribution of LECA in different parts of the investigated concrete mixtures containing silica fume was more homogeneous than the ones without it. Therefore, silica fume improved the consistency and uniformity of SCLC.

• The minimum and maximum differences between the results of image processing technique and column segregation test were 1.2% and 9.19% respectively. Therefore, image processing technique can give acceptable results to check the uniformity of distribution of lightweight aggregate in SCLC.

• The important advantage of image processing technique over laboratory test for checking the distribution of lightweight aggregate is that it investigates the stability of concrete when it is in its final location and completely rigid. In fact, at this stage no further settlement of aggregate is possible.

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