ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

INVESTIGATION OF THE EFFECT OF ELONGATION AND FLAKINESS INDEX AND IMPURITY TO CONCRETE PROPERTIES

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ABSTRACT

By the method of laboratory experiments, this study evaluates the effect of elongation and flakiness index of coarse aggregate and impurity of fine aggregate to concrete properties through slump index and compressive strength of concrete mixture. From the type of selected materials, component of the concrete mixture was designed by the theoretical and empirical methods. Elongation and flakiness index of coarse aggregate (with 0%, 5%, 10%, 15%, 20% and 25%) and impurity of fine aggregate (with 0%, 2%, 4%, 6%, 8% and 10%) were adjusted while the amount of stone, sand, cement and water weer kept unchange. Subsequently slump index and compressive strength of concrete were determined. The result shows that, the effect to concrete property is clearly noticeable. The elongation and flakiness index were maintained below 4% of impurity. If these limits are exceeded, the specification of concrete would not be satisfied.

KEYWORDS: Concrete; Slump, Compressive strength, Elongation and flakiness index, Impurity content.

INTRODUCTION

The determination of particle size distribution and technical characteristics are crucial for the design of concrete components since these factors greatly affect the specification of thedesigned concrete. Thusfar, reseach on concrete often concentrates on some factor such as crushing value and strength of coarse aggregate (Ai-Qin Shen, 2004; Zhong-Wei Wu, 1999; Zhao-Yuan Chen, 1997; Tian-Yu Liang, 2004; Kai-Wei Song, 2005; A.M Na Wei er, 1983; Francois de Larrard and Albert Belloc, 1992); Largest normial diameter (Li-Bin Yu, 2002; Fu Zhi, 2002; A.M Na Wei er, 1993; Kai-Wei Song, 2005); elongation and flakiness index (Tian-Yu Liang, 2004; Li-Bin Yu et al, 2002; Kai-Wei Song, 2005); content of coarse aggregate (Baalbaki and partner, 1991; Wang. Zemin et al, 1995; Turan et al, 1997; Alain Derris, 2002).... The conclusion from this study are taken from the experiment results with scientific basis; however, the number of trial is limited and beside there isn't systematic and comprehensive. Furthermore, the results are not entirely the same with giving factors and sometimes it is contradictory. Therefore, we must continue to researching these problems. This research is going to study on concrete for road class, elongation and flakiness index of coarse aggregate, content impurity, and temperature condition. By method in laboratory, this study evaluates the effect of elongation and flakiness index of coarse aggregate and impurity of fine aggregate to concrete properties through slum index and compressive strength of concrete.

MATERIALS AND METHODS

Materials

Binder: Using Portland cement with technical properties shown in Table 1.

Table 1: Typical properties of cement

N°	Test	Request
	Compressive strength	
1	- 3 days (± 45 minutes)	≥ 16 N/mm^2
	- 28 days (± 8 hours)	≥ 30 N/mm^2
	Setting time	
2	- Initial	≥ 45m
	- Final	≤ 375m
	Fineness:	
3	- The amount of 0,09mm sieve	≤ 15 %
	- Blain rate	≥ 2800 cm^2/g

Aggregate: Using fine aggregate which is according to ASTM C331.
Composition of concrete: Composition of concrete is designed by experiment and theoretic method. The result is showed in Table 2.

Table 2: Selecting composition of concrete

Stone (kg/m^3)	Sand (kg/m^3)	Cement (kg/m^3)	Water (litre)
1140	765	390	195

2. Test program

2.1. Methodology

Base on result of concrete component designing, we will adjust elongation and flakiness index of coarse aggregate, and impurity particle of fine aggregate to make experiment sample. The sample is tested compressive strength and slump of concrete. From result of experiment, we will evaluate these factors.

2.2. Experiment to determine effect of elongation and flakiness index

Determining effect of elongation flakiness index (symbol: Y) of coarse aggregate to slump and compressive strength of concrete. We use 6 samples with coarse aggregate having respectively elongation and flakiness index 0%; 5%; 10%; 15%; 20%; 25% to make concrete. The aggregate composition that is stone (D), sand (S), cement (C) and water (W) are determined according to specification. The data is showed in table 3.

Table 3: The amount composition in 6 samples

No	**Y** (%)	**D** (kg/m^3)	**S** (kg/m^3)	**C** (kg/m^3)	**W** (l/m^3)
1	0	1140	765	390	195
2	5	1140	765	390	195
3	10	1140	765	390	195
4	15	1140	765	390	195
5	20	1140	765	390	195
6	25	1140	765	390	195

2.3. Experiment to determine effect of impurity content

To assess effect of impurity composition (symbol: B) of fine aggregate to slump and compressive strength of concrete. We use 6 samples with fine aggregate having the number of impurity composition 0%; 2%; 4%; 6%; 8% and 10% to make concrete. The aggregate composition that is stone (D), sand (S), cement (C) and water (W) are determined according to specification. The data is showed in table 4.

Table 4: The amount composition in 6 samples

No	B (%)	D (kg/m^3)	S/B (kg/m^3)	C (kg/m^3)	W (l/m^3)
1	0	1140	765/0	390	195
2	2	1140	750/15	390	195
3	4	1140	734/31	390	195
4	6	1140	719/46	390	195
5	8	1140	704/61	390	195
6	10	1140	689/77	390	195

Workability and compressive strength of concrete are determined according to ASTM C143 and ASTM C1314.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

RESULTS AND DISCUSSION

1. The effect of elongation and flakiness index to slump

The slump of samples that is determined after 01 minute (S_1- the first slump) and 30 minutes (S_{30}) are showed in table 5

Table 5: The effect of elongation and flakiness index to slump

N0	Y (%)	Slump (mm)							
		First		Second		Third		Average	
		S_1	S_{30}	S_1	S_{30}	S_1	S_{30}	S_1	S_{30}
1	0	65	46	68	45	70	48	68	46
2	5	62	44	64	43	62	45	63	44
3	10	58	42	56	40	58	40	57	41
4	15	50	32	46	34	46	33	47	33
5	20	40	25	42	23	40	22	41	23
6	25	28	15	30	16	31	16	30	16

From the result, we illustrate relationship between elongation and flakiness index to slump by figure 1.

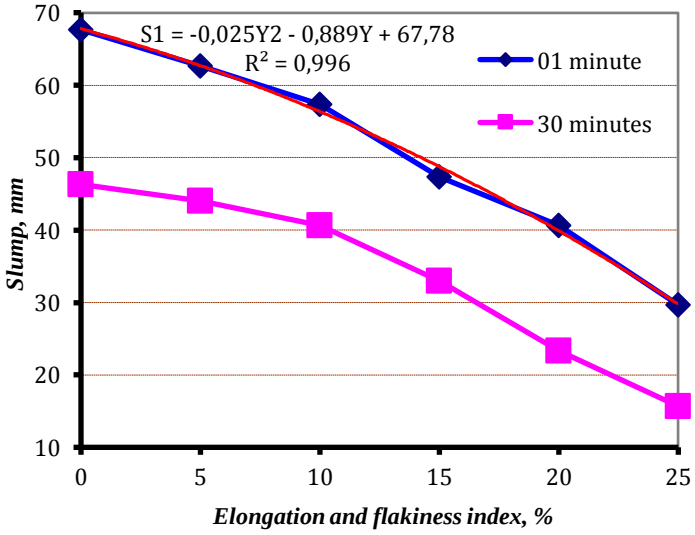

Figure 1: Elongation and flakiness index to slump

As can be seen in table 5 and figure 1 we have: Slump of concrete decreases when elongation and flakiness index increase. Because long and sharp stone change the uniform in composition of concrete and create separate and segregated phenomenon. Elongate stone has large surface area so the total contact area between aggregate and cement increase. Leading to request for mixing water rising. If we do not rise up water, the slump of concrete will not go down.

When elongation and flakiness index exceeds 15%, the slump of concrete decreases sharply (28.78% to 66.19%). In addition, after 1 hour the slump also reduce (29.07% to 47.19%). when the elongation and flakiness index increase, the link between aggregate become strongly, not flexible, and the mobility of mixture decrease (the decreasing slump). Moreover, with the time hydration and hardening processing, and strength formation occur, so that the mixture doesn't mobility.

The relationship between the elongation and flakiness index and the first slump of concrete mixture is described in equation (1):

$$S_1 = - 0{,}025Y^2 – 0{,}889Y + 67{,}78 \quad (1)$$

Here:

S_1 – The first slump of concrete, mm;

Y – The elongation and flakiness index of course aggregate, %.

2. The effect of elongation and flakiness index to strength

The result of compressive strength of concrete sample at 7 days (R_{b7}) and 28 days (R_{b28}) is showed in table 6.

Table 6: The effect of elongation and flakiness index to compressive strength

No	Y (%)	Compressive strength at R_7 và R_{28} (MPa)							
		First		Second		Third		Average	
		R_{b7}	R_{b28}	R_{b7}	R_{b28}	R_{b7}	R_{b28}	R_{b7}	R_{b28}
1	0	17.3	22.2	16.8	21.5	16.8	21.6	17.0	21.8
2	5	16.8	21.5	16.6	21.3	16.4	21.0	16.6	21.3
3	10	16.3	20.9	16.1	20.6	15.9	20.4	16.1	20.6
4	15	15.1	19.4	15.4	19.7	15.3	19.6	15.3	19.6
5	20	13.9	17.8	14.3	18.3	13.7	17.6	14.0	17.9
6	25	12.7	16.3	12.8	16.4	13.0	16.7	12.8	16.5

From the result, we build the relationship between elongation and flakiness index and compressive strength of concrete mixture. They are showed in figure 2.

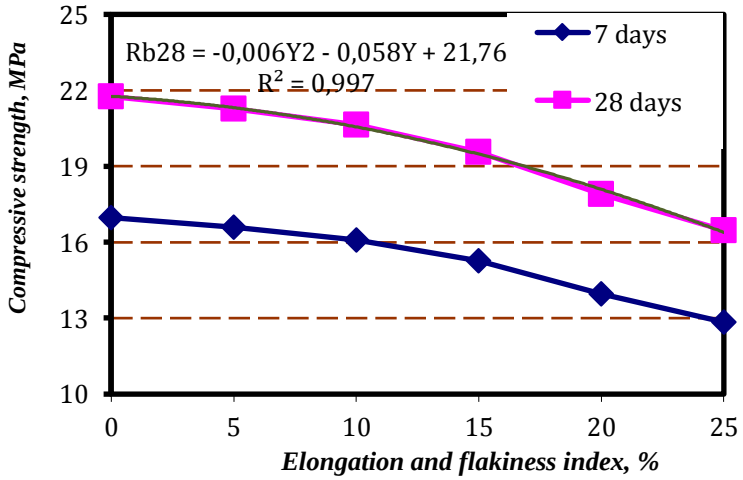

Figure 2: Relationship between elongation and flakiness index and strength

As can be seen in table 6 and figure 2 we have: The strength of concrete fall down sharply when the elongation and flakiness index grow up. When the elongation and flakiness index doesn't exceed 15%, the compressive strength of sample fall down slowly and satisfy request (20Mpa). When they exceed 15%, the one decrease more sharply (17.76% to 24.35%) and doesn't satisfy request.

Causing of decline in strength is ununiformed in composition and separate and segregated phenomenon by long and sharp stone. Furthermore, the compressive strength of stone is affected by shape and fractured in small dimension. The elongation and flakiness index rise when the request of mixing water also increase. Therefore, the slump and strength is declined.

The relationship between elongation and flakiness index and strength of concrete at 28 days is described in equation 2.

$$\mathbf{R_{b28} = - 0{,}006Y^2 - 0{,}058Y + 21{,}76} \quad (2)$$

Here:

R_{b28} – Compressive strength of concrete at 28 days , MPa;

Y – the elongation and flakiness index, %.

3. The effect of impurity content to slump

The result of slump is showed in table 7.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

Table 7: The effect of impurity content to slump

TT	Y (%)	Slump after 01 minute and 30 minutes (mm)							
		First		Second		Third		General	
		S_1	S_{30}	S_1	S_{30}	S_1	S_{30}	S_1	S_{30}
1	0	65	46	68	45	70	48	68	46
2	2	70	47	68	46	69	50	69	48
3	4	71	48	72	50	72	52	72	50
4	6	70	46	69	48	70	49	70	48
5	8	68	45	67	46	69	47	68	46
6	10	64	43	65	44	65	43	65	43

The relationship between impurity content in sand and slump is showed in figure 3.

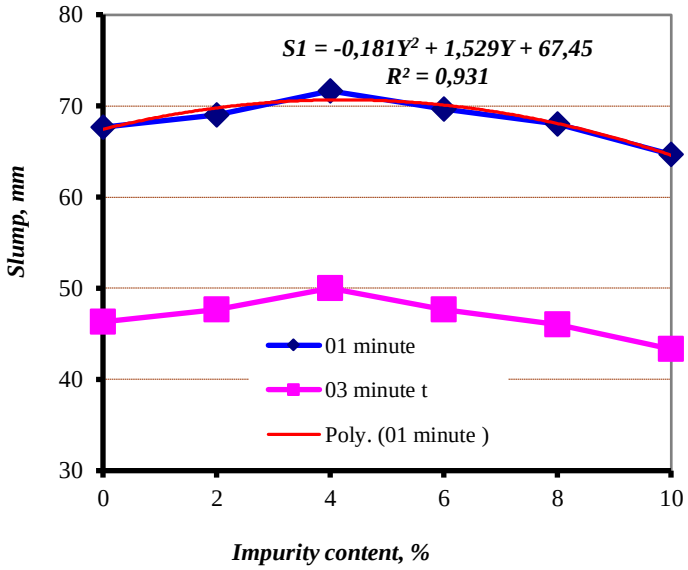

Figure 3: Relationship between Impurity content and slump

We can be seen from table 7 and figure 3. At beginning, trend of slump is rising with impurity not exceeding 6%. Then, the impurity content exceeds 4%, the slump tend to decrease. This can be explained the follow, the impurity is main clay and mud. They are greater mobility than aggregate, so the content of clay particles rising in limit make rise slump of concrete. However, the clay participle has large capable of water absorbing. The mixture will absorb a significant amount of mixing water, therefore, with constant mixing water, if the mixture has large clay particles, it reduce the amount of free water in the mixture. In addition it can also affect the hydration process of cement (not enough requirement water for hydration). Hence, when the clay content of impurity increases over a certain limit, it will make decreasing slump of concrete.

The relationship between impurity of fine aggregate and first slump of concrete could be described in equation 3:

$$S_1 = - 0{,}181Y_2 + 1{,}529B + 67{,}45 \quad (3)$$

Here:

S_1 – first slump of concrete, mm;

B – the impurity content in fine aggregate, %.

4. The effect of impurity content to strength

The compressive strength of sample group having various content of impurity is described in table 8.

Table 8: The effect of impurity content to compressive strength

No	Y (%)	Compressive strength R_7 and R_{28} (MPa)							
		First		Second		Third		Average	
		R_{b7}	R_{b28}	R_{b7}	R_{b28}	R_{b7}	R_{b28}	R_{b7}	R_{b28}
1	0	23.6	30.2	23.0	29.5	22.0	28.2	22.9	29.3
2	5	21.9	28.1	22.1	28.3	21.8	28.0	21.9	28.1
3	10	20.7	26.5	20.0	25.6	21.0	26.9	20.5	26.3
4	15	19.8	25.4	19.3	24.7	20.2	25.9	19.8	25.3
5	20	19.3	24.8	18.2	23.3	19.2	24.6	18.9	24.2
6	25	17.4	22.3	17.9	23.0	17.7	22.7	17.7	22.7

From the result, we draw relationship between impurity content of fine aggregate and compressive strength, showing in figure 4.

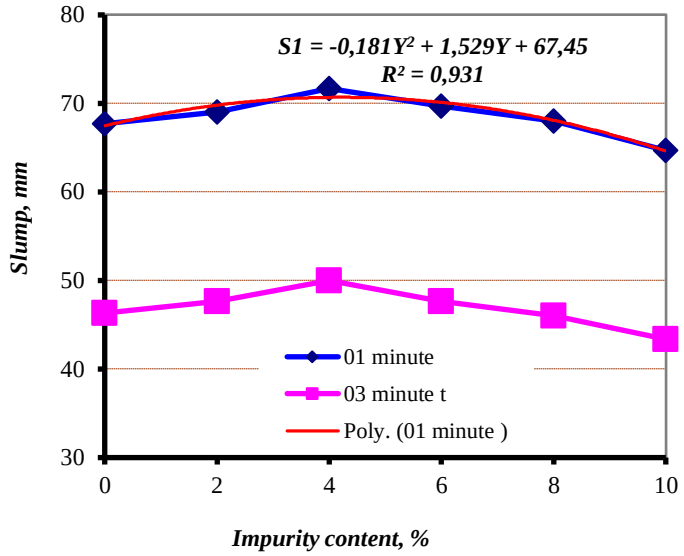

Figure 4: Relationship between impurity content and strength

As can be seen from table 8 and figure 4 we have: The strength of concrete decrease gradually (from 2.6% to 24.5%) when impurity content increase. However the amount of decreasing increase when the impurity content exceed 4% (from 11.03% to 24.5%). This issue can be explained as following, the mud and clay impurity often have small size, they contribute to cause dense of mixture. When the impurity content still is small (under 4%), the majority of impurity add this role, leading to strength of concrete reduce slightly. But the impurity content is high, there is too much mud in mixture, they will prevent from contacting between aggregate and cement, and reduce strength of cement mortar. Therefore, strength of concrete reduces rapidly when the impurity content is high.

The relationship between impurity content of fine aggregate and compressive strength of concrete describe in equation 4:

$$R_{b28} = - 0{,}038Y^2 – 0{,}15B + 21{,}74 \quad (4)$$

Here:

R_{b28} – the strength of concrete at 28 days, MPa;

B – the impurity content of fine aggregate, %.

CONCLUSION

When elongation and flakiness index exceeds 15%, the slump of concrete decreases rapidly (28.78% to 66.19%), and after 1 hour, the slump falls down significantly (29.07% to 47.19%).

When elongation and flakiness index does not exceed 15%, the strength of sample goes down slowly, and it is still satisfied requirement strength. When elongation and flakiness index exceeds 15%, the strength drops sharply and to not satisfy requirement strength.

At beginning, the slump of concrete mix has rising trend when the impurity content goes up. However, the content of one goes pass 4% so the slump decease slightly.

The strength of concrete has a change downward when the impurity content increase. However, the impurity content goes pass 4% so the strength goes down dramatically and to not be satisfied requirement strength.

According to workability and strength of concrete using crushed stone, sand, Porlant cement (not using admixture) we recommend: the elongation and flakiness index of course aggregate is not over 15%, the impurity content of fine aggregate is under 4%.

ACKNOWLEDGEMENTS

The laboratory tests were performed at the laboratory center of Mechanic and Civil Engineering faculty in Vietnam Forestry University.

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