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Experimental Study on the Effect of Partial Substitution of Cement Portland on Red Cement against Concrete Compressive Strength

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Abstract
Increasing building will impact indirectly to the increased needs of the concrete. Concrete is a material that has long been recognized in general and has several advantages, namely: is planned and set up, high temperature resistant, can be made by the manufacturer, as well as raw materials easily obtainable. The aim of this study was to determine the effect of red cement substitution by comparing the compressive strength of concrete using the K225 with a mixture of red cement. The method used in this study is an experiment with a sample consisting of 45 concrete cylinders size ϕ 150 mm x height 300 mm, which is divided into 5 treatment (composition at 0%, 10%, 20%, 30% and 40%) and were tested in groups age of concrete after printing (7, 21 and 28 days). The results showed that the red cement can reduce the characteristic concrete compressive strength and the higher the percentage increase compressive strength tends to decline, and the addition of up to 20% did not show any significant decrease.
Key words : Concrete, Pozzolan, Substitution, Concrete Depress Strength

1. Introduction

Technological developments in the field of building construction in Indonesia today there are many elements that use concrete as a construction material. Increased demand for the use of concrete increased along with the increase in the rate of physical development (I Wayan, 2011; Armeyn, 2014). Concrete has several advantages, namely: an easy plan, easy to set up, relatively resistant to aggressive environments and high temperatures, can be produced by the plant and the local cast, easily available raw materials, and so on.

Concrete composition generally consists of coarse aggregate (crushed stone and gravel), fine aggregate (sand), a binder (cement) mixer and medium (water). During this time always wear portland cement concrete which has a relatively high price compared to other materials and limited in number. In this regard, the use of cement portland should be made as efficient as possible with the concrete compressive strength requirement is met or use alternative substitution of other materials as a binder.

One alternative raw materials are often used in the manufacture of concrete for building materials is a pozzolan. The use of pozzolan has been developed for the needs of the construction of concrete structures (Valipour *et al*., 2013). Pozzolan plays an important role in the cement and concrete industry. The use of pozzolan can also improve the mechanical strength of cement matrix and can be used to reduce the amount of cement in the concrete mixture, thereby reducing the economic costs and can reduce environmental pollution (Mendoza & Tobón, 2013; Abbasi & Zargar, 2013).

Red cement is pozolan class and includes artificial materials consisting mostly of elements or silicate and aluminate rektif. Smooth red cement in the state has a strong adhesion when mixed with lime (CaO) and added water. Lime is also the main elements forming the portland cement (more than 60%). Red cement has relatively low cost and easy to make from ingredients former outbuildings.

This research was conducted with partial replacement test function of portland cement binder with red cement. Replacement is intended to reduce the amount of Portland cement in concrete and concrete-making while lowering costs. Terms of the replacement is the minimum compressive strength of concrete are met.

2. Literature Review

2.1. Cement

Cement is an important component for making concrete, its primary function as an adhesive between the fine aggregate (sand), coarse aggregate (crushed stone) and water into a single unit. Cement is a binder that has adhesive and cohesive properties. According to the Indonesian Industrial Standard SII 00-1981 kinds of cement can be distinguished among others:

1. Hydraulic Cement, is the glue that hardens when cement reacts with water, but will remain waterproof (water resistance) and stable in the water.
2. 2. Non-Hydraulic Cement, the cement is hardened and can not be stable in the water. (Amri, 2005)

Table 1. Main Composition of Portland Cement (Hydraulic)

Type Portland Cement (PC)	Normal (%)	Rapid hardening (%)	Low heat (%)	Sulfate resistant (%)
Lime stone (CaO)	63,1	64,5	60,0	64,0
Silicate (SiO_2)	20,6	20,7	22,5	24,4
Alumina (Al_2O_3)	6,3	5,2	5,2	3,7
Iron oxide (Fe_2O_3)	3,6	2,9	4,6	3,0

Resource : Mulyono (2005)

2.2. Concrete

Concrete is a mixture of several materials consisting of coarse aggregate (crushed stone), fine aggregate (sand), adhesive (cement) and water. Coarse and fine aggregate volume can reach 60% - 70% of the total volume of concrete. The most important properties of the aggregate is crushed strength and resistance to impact, which may affect the bond with cement paste. Similarly, the porosity of factors can affect the strength of the aggregate.

The difference between the coarse and fine aggregates lies in the size of the aggregate. For fine aggregate grains must be escaped with a hole diameter of 4.75 mm sieve. Usually this aggregate can be natural sand, sand processed or a combination of both. The most important ingredient should not contain organic materials and granulated diverse. For coarse grained aggregates did not pass with a bore diameter of 4.75 mm sieve and escaped with a maximum diameter of 25 mm sieve holes. Usually this can be a gravel aggregate, broken gravel, crushed stone, blast furnace slag or broken hydraulic cement concrete. The properties of a good coarse aggregate for concrete is hard grained, non-porous, rough surface, and is eternal (Hindarko, 1999)

2.3. Pozzolan

Pozzolan is a very attractive material for building materials or as a way to increase the durability of mortar and concrete. Various types of natural and artificial pozzolans showed pozzolanic activity is different depending on the characteristics of the material (Pontes *et al*., 2013). Natural pozzolan is a material of geological deposits with different chemical composition when combined with the appropriate alkali activator can be converted to a geopolymer cement for concrete production (Bondar *et al*., 2011).

Talah *et al*. (2012) stated that natural pozzolan suitable for the formulation of high performance concrete and its significantly better than the artificial concrete. Bondar et al. (2012) stated that the concrete alkali-activated natural pozzolan have lower oxygen permeability when compared to ordinary portland cement concrete. Ribeiro *et al*. (2011) stated that mortars containing 30 wt. (%) Of cement replaced with red mud showed a higher power. Vejmelková *et al*., (2012) stated that the lime-pozzolan mortar only has better mechanical properties significantly and frost resistance than the reference mortar of lime, while the Thamrin and Asran (2011) states that pozoland portland cement has a value of temperature rise greater than the portland cement and lime pozoland no effect even lowering its reactivity. Yenny and Anto (2011) stated that overall, the use of land pozolan Tulakan and lime instead of cement can effectively maintain and even increase the value of the compressive strength of concrete

Frias *et al*. (2012) stated that all coal mine waste that has been activated showed high pozzolanic activity. Najimi *et a*l. (2012) stated that the application of natural zeolite as a cement material has enhanced strength and durability properties of concrete and reinforced by statements Valipour *et al*. (2013) which states that the zeolites are not as active as silica fume or metakaolin, has the characteristics of better durability and economical and environmentally friendly as well. Pacheco-Torgal & Jalali (2011) states that the concrete with partial replacement of cement with ceramic powder despite having minor strength loss, but had an increase in the compressive strength of concrete.

I Wayan (2011) and Armeyn (2014) states that the use of fly ash as an ingredient added to the concrete mix to increase the compressive strength of normal concrete, while Ni Nyoman and I Nyoman (2012) states that the concrete from rice husk ash pozolan produce compressive strength almost the same natural pozolan.

2.4. Red Cement

Red cement according pubi -1982 is a natural material or artificial ingredients are mostly composed of the elements and the silicate or aluminate reactive. This material does not actually have the properties of the cement, but in a delicate state when mixed with lime and water outages over time can harden at room temperature. Formed a solid mass and sparingly soluble in water. (Syaefuddin, 1999)

Belonging to the red cement materials (pozolan) is:

- Natural Tras
- Red brick or ceramic powder

- The mill slag height kitchen
- Fly Ash

Table 2. Conditions of Tras and Red Cement

Parameter	Level I	Level II	Level III
Free water content in 110° ± 5° (% weight)	< 6	6 - 8	8 - 10
Subtlety - held by sieve 0,21mm (% weight)	< 10	10 - 30	30 - 50
The maximum binding time (increment 24 hours)	1	2	3
Compressive strength in 14 days (kgf/cm²)	100	100 - 75	75 - 50
Tensile strength in 14 days (kgf/cm²)	16	14	12

Resource : Persyaratan Umum Bahan Bangunan di Indonesia (1982)

3. Methodology

3.1. Sampling

Samples taken consisted of three concrete cylinders K225 size ϕ 150 mm x height 300 mm for each treatment composition of concrete and concrete testing phase age when printed. Treatment in the form of a substitution or replacement of portland cement with red cement on the composition of 0%, 10%, 20%, 30% and 40%. While testing performed on concrete samples aged 7, 21 and 28 days. So the total sample specimen required is 45 pieces.

3.2. Design

This study used an experimental method is done by comparing the characteristics of the concrete compressive strength between concrete K225 K225 concrete cement which uses a mixture of red, as shown in Table 3 as follows.

Table 3. Design Concrete Cylinder Test Objects

Addition Red Cement (%)	Number of Objects Test (Cylindrical Concrete)	Examination of Concrete Compressive Strength Age (days)
0	9	7, 21, 28
10	9	7, 21, 28
20	9	7, 21, 28
30	9	7, 21, 28
40	9	7, 21, 28

3.3. Calculation

In the discussion of the experimental substi-as- Portand cement with red cement in the concrete mix first calculated the quantities that will be used in the analysis, which includes:

1. Compressive strength of concrete (σ'_b) :

$$\sigma'_b = \frac{Q}{A} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

2. Concrete compressive strength on average (σ'_{bm}) :

$$\sigma'_{bm} = \frac{\sum_{1}^{N} \sigma'_b}{N} \quad \ldots\ldots\ldots\ldots \quad (2)$$

3. Standard deviation (S) :

$$S = \sqrt{\frac{\sum_{1}^{N} (\sigma'_b - \sigma'_{bm})^2}{N-1}} \quad \ldots\ldots (3)$$

4. Characteristic compressive strength of concrete (σ'_{bk}):

$$\sigma'_{bk} = \sigma'_{bm} - 1{,}64.S \quad \ldots\ldots (4)$$

Remarks:
Q = Axial Load (kg)
A = cross-sectional area (cm2)
N = number of test specimens of each sample

Then the characteristic concrete compressive strength compared to standard concrete compressive strength desired (in this case the compressive strength of concrete characteristics K225)

4. Result and Discussion

The data on the compressive strength test results of concrete samples that have been made can be presented as in Table 4.

Table 4. Compressive Strength Test Results of Concrete

Percentage Cement Red (%)	Repeat	Compressive strength of concrete (kg/cm^2) at age		
		7 days	21 days	28 days
0	I	167,02	232,99	249,11
	II	164,19	230,99	247,98
	III	186,83	230,43	240,62
10	I	150,03	215,14	237,79
	II	155,69	220,80	247,98
	III	169,85	223,63	226,46
20	I	152,86	214,01	233,82
	II	153,43	212,31	230,43
	III	158,52	209,48	226,46
30	I	147,20	192,49	217,97
	II	148,33	198,15	209,48
	III	154,56	199,29	215,14
40	I	140,41	189,66	208,35
	II	141,54	191,36	198,15
	III	139,27	198,15	204,95

Summary of calculation of the test results as shown in Table 5 below:

Table 5. Results of Concrete Compressive Strength Calculation

Percentage Cement Red (%)	Repeat	Compressive strength of concrete (kg/cm^2) at age		
		7 days	21 days	28 days
0	σ'_{bm}	172,68	231,18	241,56
	S	12,34	1,35	4,61
	σ'_{bk}	152,45	228,97	234,00
10	σ'_{bm}	158,52	219,86	237,41
	S	10,21	4,32	10,77
	σ'_{bk}	141,78	212,77	219,76
20	σ'_{bm}	154,94	211,93	230,24
	S	3,12	2,29	3,68
	σ'_{bk}	149,83	208,18	224,20
30	σ'_{bm}	150,03	196,64	214,20
	S	3,96	3,64	4,32
	σ'_{bk}	143,53	190,67	207,11
40	σ'_{bm}	140,41	193,06	203,82
	S	1,14	4,49	5,19
	σ'_{bk}	138,55	185,69	195,30

Graph the results of the calculation of the characteristic concrete compressive strength (σ'_{bk}) can be shown in Figure 1.

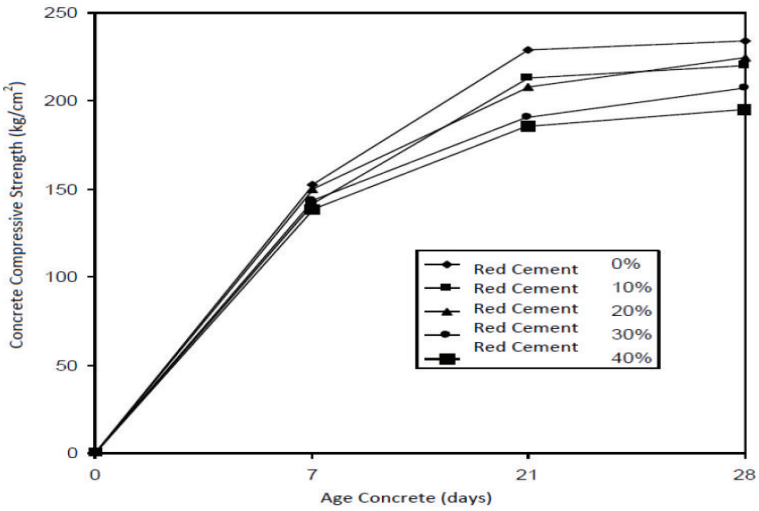

Figure 1. Graph Characteristics of Concrete Compressive Strength

Figure 1 shows that the addition of red cement can reduce the compressive strength of concrete characteristics. The higher the percentage the addition of red cement compressive strength characteristic values generated tend to be dwindling.

K225 concrete construction requirements is to have a compressive strength characteristics(σ'_{bk}) at 22.5 MPa or 225 kg/cm^2 with a tolerance limit of 5%. Therefore, when a concrete having compressive strength karak-teristik minimum is 213.75 kg/cm^2, the concrete can be described as a concrete construction K225.

The experimental results obtained have been done magnitude characteristic concrete compressive strength at 28 days as follows:

- Percentage 0%: 234.00 kg/cm^2.
- Percentage 10%: 219.76 kg/cm^2.
- Percentage 20%: 224.20 kg/cm^2.
- Percentage 30%: 207.11 kg/cm^2.
- Percentage 40%: 195.30 kg/cm^2.

From the results seen in the percentage at 0%, 10% and 20% of the characteristic concrete compressive strength is greater than the minimum requirement of concrete K225 (> 213.75 kg/cm^2), while the percentage of 30% and 40% of concrete compressive strength characteristics of the lower minimum requirement figure of concrete K225 (<213.75 kg/cm^2). This means a decrease in the strength of concrete due to the addition of cement characteristic red to a limit of 20% is not significant / not real, so concrete produced from such compositions are still said to be worth as concrete K225.

5. Conclusion

Conclusions from the experiment partly replacement of portland cement with red cement in the concrete composition can be concluded that the higher the percentage of the addition of red cement compressive strength characteristic values generated tend to be getting lower and the addition of red cement up to a limit at 20% on the concrete composition did not show any impairment concrete compressive strength of significant characteristics, so the concrete resulting from the composition is said to be worth as concrete K225.

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