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## Compressive strength of laterite stone mixed concrete

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**Abstract.** Concrete is one of the most durable construction material and cement is one of the most energy intensive structural materials in concrete. This research is conducted to research of the suitability of tap water, river sand and laterite stone which is available abundantly surround the Berau district of Indonesia with Portland composite cement (PCC) and crushed laterite stone to produce concrete. Test result exhibited that fresh concrete had proper workability and all hardened specimens appeared a good compaction result. This paper purposed to utilized tap water, river sand, laterite stone and Portland composite cement to produce the high performance concrete to eliminate the main problems of stone shortage and fine aggregate in the low land areas and the Berau district of Indonesia. Infrastructure development can be sustained through the effective use of available local materials surround the Berau district of Indonesia. The evaluation result on the workability of fresh concrete and strength development of hardened concrete were discussed.

### 1. Introduction

In Concrete material formed by a mixture of cement, fine aggregate, coarse aggregate and water. Components of the aggregate in concrete can be calculated with an approach based on cement consumption. The percentage of the aggregate requirement for a concrete production unit requires a material 3-4 times of the amount of cement. Currently, the development of regional infrastructure is faced with a high unit cost of building costs due to bring in aggregate materials from outside the region. One of them is a lot of laterite stone found in the territory of Indonesia. Laterite stone can be categorized as limestone because composed mostly of the mineral calcite ( $\text{CaCO}_3$ ). Aragonite ( $\text{CaCO}_3$ ), which has the same chemical composition as calcite but a different crystal structure, is economically important only in modern deposits such as oyster shells and oolites [1, 2].

Limestone and dolomite constitute a group of raw materials, commonly referred to as carbonate rocks. They represent the basic materials from which cement, lime, most building stone, and a significant percentage of crushed stone are produced [3, 4]. Carbonate rocks and their derived products are used aggregates. Carbonate rocks form about 15% of the earth's sedimentary crust and are widely available for exploitation. Found extensively on all continents, they are quarried and mined from formations that range in age from Berau district in Indonesia.

In Indonesia, fly ash is the main residue from coal burning, almost of the coal used in Fly ash instead of considering it as a waste material to be disposed of. To contribute a cleaner environment and to



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achieve article saving through the recycling of fly ash, then several cement factories produce the blended cement containing fly ash such as Portland composite cement [5, 6].

This paper reports for a part of an ongoing investigation that focuses on achieving utilization of local materials such as laterite stone as coarse aggregate and Portland composite cement to produce the high performance concrete while as a comparison material used river stone as a coarse aggregate to create of concrete. The testing result on the workability of fresh concrete and strength of hardened concrete were discussed.

## 2. Materials and methods

### 2.1. Aggregates

Crushed stone (Laterite stone (maximum size of 20 mm, fineness modulus of xx, bulk specific gravity of 2.54, oven-dry specific gravity of 2.15 and saturated specific gravity of 2.30) and river stone (maximum size of 20 mm, fineness modulus of 8.10, bulk specific gravity of 2.63, oven-dry specific gravity of 2.82 and saturated specific gravity of 2.70)) and river sand (maximum size of 5 mm, fineness modulus of 2.44, bulk specific gravity of 2.47, oven-dry specific gravity of 2.76 and saturated specific gravity of 2.52) conforming to Indonesia standard were used as coarse aggregate (laterite and river stone) and fine aggregate. Figure 1 shows the deposit of laterite stone in Berau district, Indonesia. Crushed stone (laterite and river stone) were used to produce concrete. Table 1 shows the physical properties of the aggregate.

**Table 1.** Physical properties of aggregate.

No.	Physical properties	Standard	Laterite stone	River stone	River sand
1	Maximum size (mm)	-	20	20	5
2	Fineness modulus	SNI 03-1968-1990	7.44	8.10	2.44
	Specific gravity				
	a. Bulk		2.54	2.63	2.47
	b. Oven dry		2.15	2.82	2.76
3	c. Saturated surface dry	SNI 03-1970-2008*	2.30	2.70	2.52
	d. Water absorption (%)	SNI 03-1969-2008**	7.26		1.75
	Weight volume				
4	a. Loose condition	SNI 03-1973-1990	1.26	1.80	1.43
	b. Solid condition		1.40	1.90	1.74
5	Water content (%)	SNI 03-1971-1990	1.97	1.69	2.35
6	Sludge content (%)	SNI 03-4142-1996	1.96	0.50	1.50
7	Organic content (%)	SNI 03-2816-1992*	-	-	No.1 (Lowly)
8	Abrasion (%)	SNI 2417-2008**	46.25	24.36	-

\*River sand

\*\*Laterite stone and river stone



**Figure 1.** Deposit of laterite stone in Berau district, Indonesia.

## 2. Portland composite cement

The experimental program was planned to investigate the effect of laterite stone for coarse aggregate. This study includes the determination of compressive strength (up to 28 days) of concrete made and cured by using tap water. A laboratory study was undertaken to investigate the effect of laterite stone as a coarse aggregate on the hydration characteristic of cement and the properties of corresponding cement mortar and concrete. The experiments were carried out using Portland composite cement containing fly ash and produced by Indonesia manufacture. Some component oxides (MgO of 0.97%, SO<sub>3</sub> of 1.16%, and loss of ignition of 1.98%) and physical properties of cement used in this research are shown in table 2 and table 3, respectively. The component oxides and physical properties of Portland composite cement meet the requirement of SNI 15-7064-2004 (Indonesia Standard for Portland Composite Cement) from a single lot were used for the entire investigation.

**Table 2.** Component oxides of PCC.

No.	Oxide	SNI 15-7064-2004	Portland Composite Cement (PCC)
1	MgO (%)	6.0 max	0.97
2	SO <sub>3</sub> (%)	4.0 max	2.16
3	Loss of Ignition (%)	5.0 max	1.98

**Table 3.** Physical properties of PCC.

No.	Physical properties	SNI 15-7064-2004	Cement used (PCC)
1	Air content of mortar (%)	12 max	11.5
2	Finess/Blaine meter (m <sup>2</sup> /kg)	280 min	382
3	Expansion, % (max)	0,8 max	-
4	Compressive strength		
	e. 3 days (kg/cm <sup>2</sup> )	125 min	185
	f. 7 days (kg/cm <sup>2</sup> )	200 min	263
g. 3 days (kg/cm <sup>2</sup> )	250 min	410	
Time of setting (Vicat test)			
5	c. Initial set, minutes	45 min	132.5
	d. Final set, minutes	375 max	198
6	False setting time (minutes)	50 min	-
7	The heat of hydration 7 days, cal/g		65
8	Normal consistency (%)		24,15
9	Specific gravity		3.13

## 2.3. Concrete mixture and curing method

Table 4 shows the mix proportion of concrete. Two concrete mixes were prepared in the laboratory. The first and second concrete mix were used laterite stone and river stone as coarse aggregate, respectively. Fresh concrete was pouring into the cylindrical mold with a diameter and height of 15 cm and 30 cm. All bond specimens were demolded after 24 h of casting. After demolding, the specimens were divided

into one set based on the curing condition. One curing condition of tap water immersion curing were designed.

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**Table 4.** Mix proportion of concrete.

W/C	Water (kg/m <sup>3</sup> )	Cement (kg/m <sup>3</sup> )	River sand (kg/m <sup>3</sup> )	Crushed stone (kg/m <sup>3</sup> )	
				Laterite	River
0.45	165.84	433.33	605.41	1195.42	1195.42

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#### 2.4. Testing method of slump and compressive strength

The design slump was  $10 \pm 2.5$  cm. Slump test was done according to SNI 1972. The compressive strength were tested according to SNI 1974-2011 (Indonesia Standard Method of test for compressive strength of concrete) The diameter and height of cylinder specimen were 15 cm and 30 cm, respectively.

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### 3. Results and discussion

The result of the slump test of laterite stone and river stone as coarse aggregate to produce concrete can be seen in figure 2. Fresh concrete had a slump value of 10 cm and 9 cm of laterite stone and river stone as coarse aggregate, respectively, with met the slump design of  $10 \pm 2.5$  cm. Visual observation showed that fresh paste made with tap water and PCC could maintain the workability and homogeneity of the mixture without segregation and bleeding occurred.



(a) Laterite stone

(b) River stone

**Figure 2.** Slump test.

#### 3.1. Compressive strength

The visual observation on the cylindrical specimens showed that the surface of hardened concrete was smooth without any honeycomb and large air voids. This result showed that fresh concrete consisted of crushed stone (laterite stone and river stone), tap water, PCC and river sand can be poured with maintaining mixture homogeneity led to a good achievement of compaction. Figure 3 shows the compressive strength equipment in laboratory. The compressive strength of concrete consisted of laterite stone and river stone are shown in table 5.



**Figure 3.** Compressive strength test.

**Table 5.** Compressive strength result of laterite stone and river stone concrete.

No.	Age (day)	Weight (kg)		Compressive strength (kg/cm <sup>2</sup> )	
		Laterite stone	River stone	Laterite stone	River stone
1	28	11.580	12.600	292.27	303.51
2		11.593	12.620	317.56	261.36
3		11.510	12.460	295.08	278.22
Average		11.561	12.560	301.63	281.03

Based on table 5 <sup>16</sup> it can be seen that there is a difference in compressive strength between concrete made of laterite stone and river stone as coarse aggregate. The compressive strength of concrete made from laterite stone as a coarse aggregate was 301.63 kg/cm<sup>2</sup> while the compressive strength produced on concrete made of river stone as a coarse aggregate was 281.03 kg/cm<sup>2</sup>. This suggests that concrete using laterite stone as coarse aggregate has higher compressive strength which was greater than 7.33% of concrete using river stone as a coarse aggregate. Besides, using laterite stone as a coarse aggregate can reduce the weight of concrete by 8.64% compared to concrete using river stone as a coarse aggregate. The average of weight of concrete using laterite stone and river stone as a coarse aggregate were 11.561 kg and 12.560 kg, respectively.

The difference between compressive strength of concrete using laterite stone as a coarse aggregate compared with concrete using river stone as a coarse aggregate can be caused by several factors such as the result of abrasion testing using a smaller xx percent Los Angeles machine shown in Table 1 so as to have the strength big due to the collision. Besides, concrete using laterite stone as a coarse aggregate has good adhesion, cohesion bonds, and interlocks which can integrate and bond well with Portland composite cement (PCC) as shown in Figure 4. Good binding ability between laterite stone and cement Portland composites can also due to lime content found in the laterite stone to provide abundant calcium ions (Ca<sup>2+</sup> and Mg<sup>2+</sup> ions). These ions tend to displace the cations in general and produce a flocculation process in which small particles will congregate and clump together to form larger particles which can increase the strength in the form of compressive strength. Pozzolanic reactions also contribute to forming a variation of cementation-forming materials in which this reaction depends on time and temperature [7]. Therefore, an increase in compressive strength value using laterite stone as a coarse aggregate can support mineralogical alteration and utilization of local materials.



**Figure 4.** Section of concrete after compressive strength test.

#### 4. Conclusions

- a. Based on the results, the potential utilization of laterite stone as a local material is prospective enough to be used as a coarse aggregate in the manufacture of concrete.
- b. The slump test result showed that fresh concrete had proper workability while the hardened specimen exhibited that the mixture can maintain its homogeneity during pouring into the mold and the compaction process led to achieving a good compaction result without honeycombs and large void appeared on the surface of specimens.
- c. Compressive strength test showed that the specimens that cured in the tap water and laterite stone as aggregate had a higher 28 days compressive strength as compared with the specimens cured with tap water and river stone as aggregate.

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#### 5. Acknowledgments

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