STUDY ON CHEMICAL COMPONENT AND COMPRESSIVE STRENGTH OF PORTLAND COMPOSITE CEMENT USING LIMESTONE ADDITIVE

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Abstract. The study aims to determine the characteristics and compressive strength of Portland Composite Cement with limestone as an additive. The method of analysis chemically used was X-Ray Fluorescence (XRF) and mechanically through the physical test compressive strength. The results of the research indicated that the Portland Composite Cement containing components CaO and SO$_3$ is high (70.96% and 4.81%). Besides, Al$_2$O$_3$ were not found in the cement. Whereas the results of the compressive strength test descending for 3 days (33.86%), 7 days (45.60%), 28 days (21.10%) from SNI minimum standard.

Keywords: Portland Composite Cement, limestone additive

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INTRODUCTION

Cement is a mixture of material between limestone and clay contain silica, alumina, iron, and other oxides, burned into clinker, added gypsum and ground into a powder that when added water will bind other materials become a strong mass material and solid (Neville et al., 2010). Joseph Aspdin 1824 (England) submitted the patent for the manufacture of Portland cement from mixture clay and limestone which are burnt and the strength of the natural cement is same with island Portland (Nugroho et al., 2007). The major compound in cement is CaO, SiO$_2$, Al$_2$O$_3$, and Fe$_2$O$_3$. Besides, minor compound in cement, such as MgO, Na$_2$O, K$_2$O, TiO$_2$, P$_2$O$_5$, and gypsum (Neville et al., 2010). The formula concentration of the main compounds Type I Portland cement according to ASTM C 150-2004 is CaO (63.23%); SiO$_2$ (20.17%); Al$_2$O$_3$ (5.07%); Fe$_2$O$_3$ (2.66%); and SO$_3$ (3.26%) (Tennis et al., 2006).

To reduce the impact of global warming through an emissions reduction in CO$_2$, the cement industry as one of the emitters of CO$_2$ (as much as 830 kg/ton of cement) have switched production of Portland composite cement by reducing the use clinker are replaced with alternative materials in final milling process (Partana, et al., 2010; Priyo et al., 2012).

Portland composite cement is the result of mixing between Portland Cements with one or more inorganic materials such as powder blast furnace, pozzolan, silicate compounds, limestone (CaCO$_3$), with total concentration of 6-35% from the total mass of the Portland composite cement. Standard Physics rule for the Portland composite cements is the compressive strength of mortar of 3 days (125 kg.cm$^{-2}$), 7 days (200 kg.cm$^{-2}$) and 28 days (250 kg.cm$^{-2}$) (Anonymous, 2004b). Limestone need as an additive in SNI (Anonymous 2004b), is also the main raw material of cement production so that it is ready available around in the manufacture when compared with other additives.

The research results the physical and chemical experiments through, Dhir et al. (2007), Tosun et al. (2009), and Marzuki (2009) that each increase of limestone at least 2% as an additive in cement can reduce its quality. Therefore, needed the experiments to show the test chemical analysis and physical of Portland composite cement that using limestone additive.

MATERIALS AND METHODS

Location and Time Research

This research conducted at the Research and Development Laboratory, Faculty of Mathematics and Natural Sciences, Hasanuddin University, Makassar and Laboratory of Concrete Materials and Civil Engineering of State-Owned Polytechnic Ujung Pandang, from May to July 2013.

Materials and Devices Research

Materials that used consisting of Portland composite cement that use limestone additive from PT. Semen Kupang, smooth aggregate (sand), and water. The tools used in this study consists of a measuring glass (500 ml), digital pair of scales (2000 grams), X-RF (Thermo Scientivic), standard mixing machine, mold cube-shaped specimen with a side length of 5 cm, stopwatch, compactor, grader spoons, steel bar with a length of 20 cm, and press machine (ELE International).

Research Methods

The method of analysis chemically use was XRF to determine the concentration of the chemical compounds in the cement (Lakowicz, 1999; Della, 2002; Salas, et al., 2009; and Ummah, et al., 2010) and mechanically through the physical test compressive strength by Anonymous, 2004a.
RESULTS AND DISCUSSION

Comparison of main compounds concentration of the Type I Portland Cement and Portland Composite Cements

The results of concentration CaO, Fe₂O₃ and SO₃ are higher when compared to the concentration in Type I Portland cement, whereas low concentrations of SiO₂ and Al₂O₃ are not found in Portland composite cement. This is due to the addition of limestone (CaCO₃) as an additive in cement so that trigger increases concentration of CaO in the cement. When the reaction between CaO and SiO₂ with water, will produce more Ca(OH)₂ to form a very large cavity, can lead to high water absorption, and its strength is low.

Al₂O₃ concentration is not found in Portland Composite Cement caused by X-rays emitted by the intersection between the system conversion experiences from state single to state triplet with a longer wavelength (lower energy) caused by the lack of Al atoms in the sample and is unable to emit fluorescence, but instead emit phosphorescence. Al₂O₃ resulted in the loss of binding time delay long enough due to high gypsum, strength is low and is not resistant to other chemical reactions, so that the building is cracked and shattered.

Table 1. Comparison of concentration chemical compounds of cement

<table>
<thead>
<tr>
<th>Comparison</th>
<th>CaO (%)</th>
<th>SiO₂ (%)</th>
<th>Al₂O₃ (%)</th>
<th>Fe₂O₃ (%)</th>
<th>SO₃ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I*</td>
<td>63.23</td>
<td>20.17</td>
<td>5.07</td>
<td>2.66</td>
<td>3.26</td>
</tr>
<tr>
<td>Result Test **</td>
<td>70.96</td>
<td>19.10</td>
<td>-</td>
<td>3.98</td>
<td>4.81</td>
</tr>
</tbody>
</table>

* Type I Portland Cement according to ASTM C 150-2004 (Tennis et al., 2006)
** Portland Composite Cement with Limestone additives

The compressive strength test specimens 3 days, 7 days, and 28 days in a row decreased 33.86%, 45.60%, and 21.10% when compared to the value of the minimum compressive strength of Portland Composite Cement based on SNI (Anonymous, 2004b). Thus can said that the use of limestone as an additive in Portland Composite Cement can reduce the strength of the cement.

Table 2. Comparison of compressive strength cement

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Compressive Strength (kg.cm⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 days</td>
</tr>
<tr>
<td>SNI*</td>
<td>125</td>
</tr>
<tr>
<td>Result Test **</td>
<td>82.67</td>
</tr>
</tbody>
</table>

** Portland Composite Cement using limestone additives

CONCLUSIONS AND RECOMMENDATIONS

Based on the research data it can be concluded that: the use of limestone as an additive in Portland cement can increase the concentration of CaO becomes more dominant and the compressive strength is lower. Need accuracy to calculate of the concentration ratio of the chemical components of raw material for clinker by considering the
addition of limestone additive in final milling process.

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REFERENCES
1. Anonymous, 2004a, Semen Portland, SNI 15-2094, Dep. PU Jakarta
3. Della, V.P., Kühn, I., and Hotza, D., 2002, Rice husk ash as an alternate source for active silica production, Mater. Lett. 57, 81-82.