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Improving of recycled aggregate quality by thermal-mechanical-chemical process

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Abstract

To save natural resources and promote the sustainable development of construction industry, the use recycled coarse aggregate (RCA) from waste concrete has been encouraged recently. However, it is widely accepted that RCA concrete has lower performance about 15% to 20% than that of natural aggregate concrete. The adhered mortar on RCA surfaces causes lower quality of RCA produced through conventional recycling process. Therefore, it is necessary to provide higher quality of RCA from waste concrete by detaching old mortar as much as possible; so that the quality of RCA concrete can be improved as well. This research proposes a thermal-mechanical-chemical process to produce better properties of RCA from waste concrete. Then, new concrete was produced by utilizing the RCA. Results indicate that the physical properties of RCA are close to natural aggregate and meet the requirement of Indonesian Standard for concrete aggregate. Furthermore, the mechanical performance of RCA concrete produced by the proposed method has better mechanical properties to that of conventional RCA. It is about 3-8% lower than the mechanical properties of natural coarse aggregate concrete.

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1. Introduction

Construction wastes are increasing as the growth of the construction industry; therefore, the issue of waste concrete recycling has become more important in the world nowadays. After the service period is over, the concrete construction might be demolished and disposed. It causes the problem of accumulation of waste concrete in the near future and leads to environmental problem. In addition, significant exploitation of natural resources for concrete production is highly prohibited in some parts in the world. Thus, in favor of the reducing of waste concrete and pointing at sustaining environment, the utilizing of recycled aggregate from waste concrete has been encouraged, recently.

However, the conventional method of recycling does not meet the demand of recycled aggregate to re-utilized for making a new concrete. This recycling process only produces smaller part from concrete lumps [1]. It only can be applied as road bed materials due to low quality of recycled aggregate. The surface of recycled aggregate is still attached by the old cement paste leading to low density and high water absorption of this aggregate [2,3].

To solve this problem, a new recycling technique has been developing in our laboratory using combination of thermal-mechanical-chemical techniques. Heating exposure up to 100 °C – 200 °C weakens bonding between cement past and aggregate [2]. It should be noted that heating up to 500 °C does not affect the structure of the aggregate in concrete. After heating, the hot concrete lumps are then grinded to obtain the size of recycled aggregate. In addition, the recycled aggregate is soaked in acid solution to clean the residue of attached cement paste. Before the recycled aggregate manufactures will be used in, it needs to have the correct physical and mechanical properties. A series of research to examine the recycled aggregate will be discussed in this paper.

2. Related Works

It is widely recognized that compressive strength in recycled aggregate concrete is lower than that of normal concrete with the same water-to-cement ratio. Therefore, the utilization of recycled aggregate in producing new concrete is often associated with physical and mechanical deterioration of concrete as well as its durability. Concrete manufactured from recycled aggregate has compressive strength as much as 26% lower than that of concrete made by natural aggregate [3]. This can be understood because generally the recycled aggregate produced by conventional method, the aggregate is still attached by cement paste; therefore, the adhesion of interface between recycled aggregate and cement paste on new concrete reduce. As a result, the mechanics strength of concrete also decreases.

In attempt of producing higher quality recycled aggregate from waste concrete, a pulsed power (PP) technique was implemented [4]. The high quality recycled coarse aggregate (RCA) produced by PP has been conducted. Density and absorption test results of the aggregate meet the requirement for H (high) class set by Japanese Industrial Standard for recycled aggregate. Other research has concentrated on mechanical properties of concrete made using the pulsed power recycled coarse aggregate (PP-RCA). It is clarified that the concrete made by high grade PP-RCA has sufficient compressive strength and Young's modulus to be utilized as construction material [5] and furthermore, analysing of kind of recycled aggregate concrete under acoustic emission testing show the similar behaviour to that of normal concrete aggregate [6].

3. Experiment

3.1. Material

There were several steps in producing recycled coarse aggregate. First, concrete lumps were heated up to 100 °C for 24 hours. Second is mechanical grinding by 500 cycles using Los Angeles machine. These processes were objected to produce heating-grinding (H-G) recycled coarse aggregate. The addition treatment; which was soaked in acid solution (H₂SO₄) in 24 hours, was objected to produce heating-grinding-acid (H-G-A) recycled coarse aggregate.

Then new concrete was made using two types of recycled coarse aggregate. For analysis consideration, normal fresh coarse aggregate concrete was also produced taken from the same quarry as material for recycling. Water cement ratio was 48%. Specimens were cylinder concrete. Mixture proportion is shown in Table 3.

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