International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.3, Issue No.8, pp : 501-506 01 Aug 2014

Waste Marble Utilization from Residue Marble Industry as a Substitution of Cement and Sand within Concrete Rooftile Production

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Abstract

Research on alternative materials primarily from waste have been additional material at area manufacture of building materials , especially concreteroof tile [1] - [17] . This research will expand utilization of marble waste vBulletin East Java region of Indonesia in the manufacture of concrete roof tiles by combining the use of sand and waste marble powder as a substitute for riversand and portland cement .. This research creates material innovation product of environmentally friendly with relatively low prices without compromising quality. The purpose of research is to find the composition of the mixed-use waste marble tile that produces the most optimal strength . Experimental method used in this study to test the basic material and test physical and mechanical properties of concrete roof tiles (bending loads , water absorption and resistance to water seepage) in accordance with ISO 0096 : 2007 with eight variations in material composition . Concrete tile with marble waste produces a lighter weight 3.6 % - 12.3 % . Replacement PC with marble powder by 20 % qualify flexural strength , water absorption (no more than 10 %) and there is no seepage within 20 hours ± 5 minutes . Composition tile marble concrete using waste as a substitute for river sand PC and a decent and qualified SNI 0096:2007 is a composition of 0.8 PC : 0.2 SL : 1 Ps : 2 PSL and composition 0.8 PC : 0.2 SL : 3 PSL . While most optimum is 0.8 composition PC : 0.2 SL : 1 Ps : 2 PSL . which produces Flexture1141 N.

Keywords : marble waste , bending loads , water absorption , concrete rooftile

I. INTRODUCTION

Technology expasion at area of construction has rapidly depeloped. Some studies construction technology continues to be developed with the aim to generate appropriate construction technology , easy to work , as well as efficient in financing . Research of alternative materials is something that is often used as the object of study, because the material was found appropriate alternative, it will be an effect on cost efficiency .

Alternative materials, especially industrial waste materials are still many who have not utilized optimally . The waste material would be a waste if a certain amount is not handled properly can even cause environmental disturbance .

Some of these alternative materials research has been carried out , among others, is the replacement of river sand with sand marble / onyx on concrete tile [1] on the composition 1 PC : 1 Ps : 2 PSO concrete tile bending loads increased by 327.86 N (29.26 %) of normal concrete tile . Replacement of sand with sand on the paving block onyx [2] at 1 PC composition : 6 PSO paving block compressive strength increased by 147.72 kg/cm2 (64.05 %) , compared with the compressive strength of paving block composition 1 PC : 6 Ps (0 % sand onyx) .

Apart from a few studies that have been conducted primarily on the use of marble and onyx sand substitute for river sand as an ingredient in the manufacture of building materials , there are also studies that utilize waste white marble floured redness results from marble stones are processed into a variety of crafts . This powder when mixed with water will harden and serve as a binder (Sri Utami , 2010) . The results of marble waste as a substitute for portland cement paving stone on the results of 20 % replacement of portland cement with marble waste powder with composition 0.8 PC : 0.2 Lm : 5Ps yield strength Kg/cm2 159.43 paving stone composition compared with 1 PC : 0 Lm : 5ps 156.23 kg/cm2 which generate power .

From the results of these studies apparently marble waste material potential to be developed as an alternative material for the manufacture of building materials can be used in addition to proven as a substitute material such as sand and cement , are also able to improve the quality of building materials . The other reason is the problem of the availability of materials . Availability is pretty much a waste marble because marble quarry resources found on several areas in Indonesia and has many uses and has been used by the people of Indonesia as a raw material in industry or handicraft marble stone marble . That occurred during this marble waste generated from the treatment process is not used and thrown away by local marble manufacturers , causing waste less useful . One of the marble waste control efforts is by making use of waste (residue) as building materials such as concrete tile , and brick paving .

This study is a follow-up that aims to optimize the utilization of waste marble as a material substitute roles river sand with sand marble or reduce the use of Portland cement with marble powder . It also is an effort to make the production of building materials innovation by utilizing the existing waste and make environmentally friendly building materials with relatively low prices without compromising quality.

The purpose of this study was to determine the effect of replacement of marble sand with river sand replacement PC with marble powder on the physical properties of concrete tile covering seepage water absorption and water resistance , as well as the mechanical properties of the concrete tile bending loads . Another aim was to determine the composition of a mixture of concrete tile with marble wastes as substitutes for PC and river sands that produce the most optimal strength .

ISSN:2319-6890)(online),2347-5013(print)
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II . LITERATURE REVIEW

A. Concrete Rooftile

Some lightweight concrete products (Concrete Masonry) is a concrete tile , paving stone , brick , and kanstin . Definition of concrete tile are building components that are made from a mixture of hydraulic cement material , fine aggregate , water and or without lime , trass and other supplementary materials are made in such a way that it can be used for roofing .

Materials manufacturing concrete roof tile is the normal Portland cement (PC) , sand and water . The composition of a mixture of cement , sand and other materials carried by weight or volume ratio commonly used ranges between 1 cement : 2 sand and 1 cement : 3 sand . Water content in the mixture until mixture is quite well defined and easily printed .

Concrete tile quality requirements according to SNI 03-0096-1999 and then revised by SNI 0096 : 2007 are as follows :

The length, width and thickness of concrete roof tiles for one type of use to be the same and uniform . Ti5le thickness should not be less than 8 mm , except for the laying (interlocking) thickness not less than 6 mm . Tile must have regard (lugs) to be related to the lath width not less than 20 mm and a height of not less than 12 mm which is located on the bottom surface of the tile . If deemed necessary can be equipped with holes for nailing it to the rafters - rafters . Laying on the edge of the tile must have a width not less than 25 mm and is equipped with at least a flow of water that it is not less than 5 mm .

Flexural strength of the tile must be able to withstand bending loads at minimum as follows :

Table 1 . Minimum Bending Load Concrete tile

Elevated profile (mm)	**InterBlock Rooftiles**					
	Profile				Flat	
	t>20		20≥t≥		T<5	
Cover Wide (mm)	≥300	≤200	≥300	≤200	≥300	≤200
Flexture	2000	1400	1400	1000	1200	800

Source: SNI 0096: 2007

Normal size concrete tile are : length 38 cm , width 22 cm , thickness 1.5 to 1.8 cm , length 33 cm useful , useful width of 19.5 cm . Relation length of 3 cm , 2 cm thick and 1 cm height .

1. Permeation of concrete rooftiles

Tile is a building material that is installed roof at any time be exposed to rain . Therefore tile should be safe against water seepage . Likewise, concrete tile , seepage must meet the required standards . Resistance to permeation of water (water tight) at the time of tile tested in a standard way , should not happen droplets of water from the bottom within 20 hours 5 minutes .

2. Absorption of concrete rooftiles

Concrete roof tile has water absorption should average no more than 10 % .

3. Flexture concrete rooftiles

On the flexural strength test specimens used are concrete tile available, measured length and width useful useful from the tile. Then the specimen is placed on the pedestal where the two second gap maximum pedestal. Furthermore amid landscape buffer given load, then run engine until specimen fracture , where the speed should be set between 20-30 kg / sec . Read the maximum load / broken in newtons, then calculate the bending test specimen.

B. Marble Waste

In geological marble is a metamorphic rock types derived from the exposed limestone and Metamorphose Metamorphose regional contact. In community / entrepreneur building materials / trade term is shiny marble , limestone rock can form , granite, marble and other types of basalt .

Marble stone obtained from a mountain located in the region Campurdarat Tulungagung. The marble stones processed into a variety of crafts, including sculpture, table, Fandel and so on. During the milling process to craft marble waste is obtained. Floured marble waste reddish white, marble waste when mixed with water it will harden , because floured then can serve as a binder [15] .

The results Sucofindo PT Jakarta said that the composition of the waste contained in marble is a compound with a CaO content of 52.69 % , 41.92 % CaCO3 , MgO 0.84 % , MgCO3 1.76 % , 1.62 % SiO2 , Al2O3 + Fe2O3 0:37 % of the visible results of the main composition of marble waste is calcium [15] . Most of the compounds present in the cement case, even the compound CaO content in the waste marble similar to cement, which is 52.29 % in the 60-67 % waste in the marble and cement.

Figure 1 . Waste Marble

C. Research On Concrete Rooftile And Marble Waste

Research on Utilization of Marble Waste as Fillers (FILLER) on Mixed Asphalt Concrete Road Surface Layer [10] focused on the durability performance of asphalt concrete mixtures with gradation type of mixture is used which is used to follow the mixture gradation No.IV SNI 1990. The use of waste marble dust as filler in combination against stone , with marble waste content variation levels of 0% , 50 % and 100 % . From the analysis of the durability performance values obtained mixture IKS mixture of marble waste levels of 100 % and 50 % were below the IKS mixture without waste marble , but still above the minimum requirement of Highways (IKS = 75 %) for

longer durability (4, 7 and 14 days) value of IDPs and IDK mixture showed the same trend .

Marble fragments as Partial Replacement Coarse Aggregate Self Compacting Concrete (SCC) [11] concluded that the SSC can divert the flow kelecekan desaign and meet existing cavities in the mold , and there are no concrete is porous . SCC using marble as coarse aggregate fractions whole or partial is including normal concrete . Compressive strength of SCC containing fractions lower than SCC marble containing crushed stone aggregate .

Alternative coarse aggregate (crushed stone) in concrete using waste marble reviewed against compressive strength of concrete , with a mixture of coarse aggregate fractions using limestone 0 % , 50 % , 75 % and 100 % . The test results showed that the use of marble fragments produced in the manufacture of concrete compressive strength on average decreased to 40.70 % compared with concrete using stone as coarse aggregate [17]

Influence the use of waste as a substitute for sand onyx sand and gravel to the compressive strength and tensile strength of concrete . The results of stress testing concrete compressive strength characteristics and voltage characteristics of the maximum tensile strength of concrete occurred in the composition of the mixture 1 PC : 2 PSO : 3 Kro with each value of 94.666 and 13.04 kg/cm2 kg/cm2 . [12]

Replacement of sand with sand on the marble tile. The result is a descriptive make a difference to bending loads concrete tile . Replacement of sand with sand on composition onyx 1 PC : 2 Ps : 1 PSO cause an increase in the flexural load of concrete tile 175.80 N (15.69 %) of normal concrete tile (0 % sand onyx) . The composition 1 PC : 1 Ps : 2 PSO concrete tile bending loads increased by 327.86 N (29.26 %) and composition 1 PC : 3 PSO concrete tile bending loads increased by 165.73 N (14.79 %) of the normal concrete tile [1] .

Marble waste research as a substitute for portland cement paving stone on the results of 20 % replacement of portland cement with marble waste powder with composition 0.8 PC : 0.2 Lm : 5ps yield strength Kg/cm2 159.43 paving stone composition compared with 1 PC : 0 Lm : 5ps 156.23 kg/cm2 which generate power . [15] .

Research on the replacement of river sand with onyx sand on the paving block descriptively make a difference to the compressive strength of paving blocks . The composition 1 PC : 6 Ps (0 % onyx sand) obtained compressive strength of paving block 230.64 kg/cm2 . The composition 1 PC : 4 Ps : 2 PSO cause an increase in the compressive strength of paving block by 1.54 kg/cm2 (0.67 %) , 1 PC composition : 3 Ps : 3 PSO compressive strength of paving blocks decreased by 3.75 kg / cm2 (1.63 %) , 1 PC composition : 2 Ps : 4 PSO paving block compressive strength increased by 105.95 kg/cm2 (45.94 %) , 1 PC composition : 6 PSO paving block compressive strength increased by 147 , 72 kg/cm2 (64.05 %) , compared with the compressive strength of paving block composition 1 PC : 6 Ps (0 % sand onyx) [2] .

III. RESEARCH METHODOLOGY

1 . Samples and Populations

Test specimens for flexural strength , water absorption and resistance to seepage using concrete tile with a length of 38.8 cm , width 29 cm , thickness 1.5 to 1.8 cm , length 34 cm useful , useful width of 25.8 cm . Relation length of 3 cm , 1.2 cm thick and 1 cm height . This specimen had a single test alone . Styles that work is a static style .

Variations in the composition of the mixture of concrete roof tile in each treatment was 8 (eight) wide . The selection of compositions 1 PC and 3 sand that serves as the control is based on the composition of the concrete tile manufacturing standards in the market . Number of iteration of each treatment is 10 pieces for the test specimen and the water absorption and flexural strength test specimens for 3 pieces seepage so that the number of specimens to be made is 184 pieces . The breakdown is as follows :

Figure 2. Concrete Rooftile

Table 2. Total object of tests concrete rooftile

No	Compotition	Concrete Rooftile		
		Water Absorption Test	Permeation of water test	Flexture test
1	1 PC : 3 Ps	10	3	10
2	0,8 PC : 0,2 SL: 1 Ps : 2 PsL	10	3	10
3	0,6 PC : 0,4 SL : 1Ps : 2 PsL	10	3	10
4	0,4 PC : 0,6 SL : 1Ps : 2 PsL	10	3	10
5	0,2 PC : 0,8 SL : 1Ps : 2 PsL	10	3	10
6	0,8 PC : 0,2 SL: 3 Ps	10	3	10
7	0,8 PC : 0,2 SL : 2 Ps : 1 PsL	10	3	10
8	0,8 PC : 0,2 SL : 3 PsL	10	3	10
	Amount	**80**	**24**	**80**

Description:
PC = Portland Cement
SL = Powdered Marble Waste
Ps = Sand river
PSL = Sand Marble Waste

ISSN:2319-6890)(online),2347-5013(print)
01 Aug 2014

2. Research Design

To determine the mechanical characteristics of concrete tile with the replacement of river sand with marble sand, then conducted a number of tests in the laboratory. Testing began with a preliminary testing testing marble waste chemicals, waste includes physical density, absorption and smooth modulus. Continued planning and construction of concrete mix, making the specimen, specimen maintenance and strength testing specimens include flexural load test, water absorption and resistance to water seepage. The next stage is to perform calculations, statistical analysis, and discussion and concludes the research.

IV. RESULTS AND DISCUSSION

A. Testing results Marble Powder and Sand

Table 3. Chemical elements Marble Powder

No	Chemicals	contents (%)	Standart of natural cement content (%)
1	Silikon Dioksida (SiO_2)	0.48	22-29
2	Aluminium Dioksida (Al_2O_3)	0.17	5,2-8,8
3	Feri Oksida (Fe_2O_3)	0.12	1,5-3,2
4	Kalsium Oksida (CaO)	55.01	31-57
5	Magnesium Oksida (MgO)	0.40	1,5-2,2
6	Potassa (K_2O)	0.01	-
7	Sulfur Trioksida (SO_3)	0.01	-
8	(Lol)	43,48	-
	Amount	**100**	-

Sources : Lab Testing Sucofindo 2013

To test the results obtained marble powder content of Calcium Oxide (CaO) was 55.01 % for the marble is in conformity with the standards as a natural cement that is 31-57 % . But for the content of other elements such as Silicon Dioxide (SiO2) , Aluminum Dioxide (Al2O3) , Feri Oxide (Fe2O3) , Magnesium Oxide (MgO) do not fit into a standard natural cement . This means that marble powder characterized as natural cement but not fully functioning as a natural cement.

B. Concrete rooftile Weight

Replacement of river sand and a PC with sand and marble dust make a difference in the weight of the test specimen . On concrete tile decline 3.6 % - 12.3 % . Largest decline occurred in the composition of the PC 0.2 : 0.8 SL : 1 Ps : 2 PSL . This means concrete tile with marble waste material has a lighter weight of the marble tile without waste .

C. Calculation of Flexture concrete rooftiles

The test results of concrete tile bending loads are as follows :

Table 4 . Flexture concrete rooftiles

Compotition		Fc (N)
1	1PC : 3 Ps	1807,55
2	0,8 PC : 0,2 SL : 1 Ps : 2 PsL	1141,33
3	0,6 PC : 0,4 SL : 1 Ps : 2 PsL	729,32
4	0,4 PC : 0,6 SL : 1 Ps : 2 PsL	405,17
5	0,2 PC : 0,8 SL : 1 Ps : 2 PsL	169,05
6	0,8 PC : 0,2 SL : 3 Ps	783,53
7	0,8 PC : 0,2 SL : 2 Ps : 1 PsL	803,5
8	0,8 PC : 0,2 SL : 3 PsL	1082,09

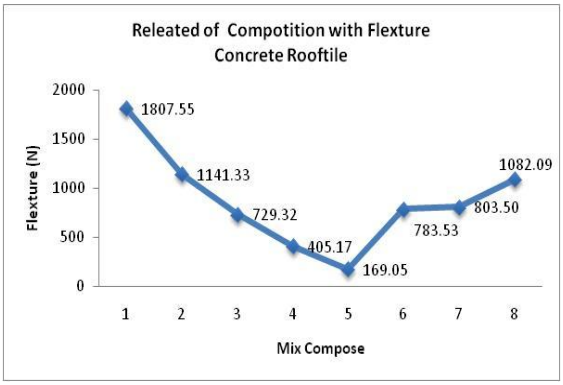

Figure 2. Releated Of Compotition With Flexture Concrete Rooftile

Flexture characteristics calculation results indicate replacement concrete tile with river sand and marble sand replacement PC with marble powder makes a difference to bending loads concrete tile. The composition 1 PC: 3 Ps (0% marble powder and sand) obtained bending loads at 1807.55 N. Accordance with SNI 0096:2007 standards that concrete tile with 15 mm thick and 200 mm useful width - 300 mm Flexturecharacteristics have a minimum of 1000 N, the flexture obtained with the use of concrete tile marble waste composition only 0.8 PC: 0, 2 SL: 1 Ps: 2 PSL and composition 0.8 PC: 0.2 SL: 3 incoming PSL SNI 0096:2007 standard since 1141 produces bending loads N and 1082 N.

D. Calculation of Water Absorption concrete rooftiles

The test results of water absorption of concrete roof tiles are as follows:

Table 5. Absorption concrete rooftile

Compotition		Absorption (%)
1	1PC : 3 Ps	7,26
2	0,8 PC : 0,2 SL : 1 Ps : 2 PsL	9,46
3	0,6 PC : 0,4 SL : 1 Ps : 2 PsL	8,41
4	0,4 PC : 0,6 SL : 1 Ps : 2 PsL	9,74
5	0,2 PC : 0,8 SL : 1 Ps : 2 PsL	9,66

ISSN:2319-6890)(online),2347-5013(print)
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6	0,8 PC : 0,2 SL : 3 Ps	10,32
7	0,8 PC : 0,2 SL : 2 Ps : 1 PsL	8,39
8	0,8 PC : 0,2 SL : 3 PsL	7,49

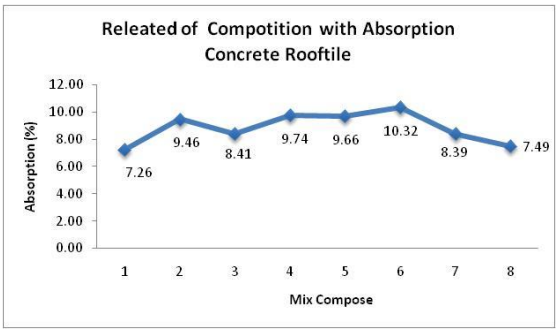

Figure 3 . Releated Of Compotition with Absorption Concrete Rooftiles

Replacement of river sand with sand replacement PC with marble and marble powder on tile make a difference to water absorption of concrete roof tiles . Appropriate SNI standard , the higher the quality of concrete tile , the lower the percentage of water absorption and water absorption not more than 10 % . Water absorption calculation results in this study indicate that the composition of the concrete tile on all incoming standard SNI except composition 0,8 PC : 0.2 SL : 3 Ps do not go in for SNI standard yield 10.32 % water absorption . The increase is due to the absorption of water by the material test results showed heavy marble sand volume , density , and modulus are refined according to ASTM standards , but for the absorption of water is greater than that required by ASTM standards (1 % -2 %) at 5 , 01 % .

E. Resistance toward Water of Permeation

According to the standard SNI that water seepage resistance should not occur droplets of water bottom within 20 hours ± 5 minutes . From the test results shows that the composition 1 PC : 3 Ps ; Composition 0.8 PC : 0.2 SL : 1 Ps : 2 PSL ; Composition 0.6 PC : 0.4 SL : 1 Ps : 2 PSL ; Composition 0 , 8 PC : 0.2 SL : 2 Ps : 1 PSL ; Composition 0.8 PC : 0.2 SL : 3 PSL , there is no seepage of up to 20 hours 5 minutes and thus qualified SNI 0096:2007 . While the composition 0.4 PC : 0.6 SL : 1 Ps : 2PsL and 0.2 PC : 0.8 SL : 1 Ps : 2PsL going to drop at 5 .

F. Statistical Analysis

Flexture on the test tile there are 8 treatment was repeated 10 times . Effect of treatment of the Flextureof the ANOVA results proved that the treatment significantly ($p < 0.05$) to bending loads genting.Perbedaaan flexural strength followed by a different test average using Duncan Multiple Range Test (DMRT) and the Levene test results of the variance in eighth treatment was homogeneous ($p > 0,05$) . ComparSNIn of test results with an average of eight treatments DMRT testified that have significant differences . Greatest flexural strength is in P1 treatment , while the smallest is in P5 treatment .

Comparison of the average test groups using contrast and the results explained that all treatments have different flexural strength with others . Reduction in the proportion of PC will be followed by a decrease in flexural strength precarious . This treatment results per group comparisons lead to the conclusion that the best treatment of the utilization of waste for treatment P2 (0.8 PC : 0.2 SL : 1 Ps : 2 PSL) .

To test the water absorption are 8 treatment was repeated 5 times . Levene test results of the variance in the eighth treatment was homogeneous ($p > 0,05$) . ANOVA results also explain that the treatment significantly ($p < 0.05$) to water absorption of concrete roof tiles . Comparison of test results with an average of eight treatments DMRT testified that have significant differences in water absorption . Reduction in the proportion of PC treatment is not always followed by a decrease in water absorption tiles . The comparison of treatment results per group to the conclusion that the best treatment is no treatment at P8 (0.8 PC : 0.2 SL : 3 PSL) .

V. CONCLUSION

From the analysis and discussion, it can be concluded as follows :

1. The use of waste marble powder as a form of sand and river sand replacement material in concrete tile and PC produces a lighter weight 3.6 % - 12.3 % .
2. The use of waste as a substitute for marble and river sand in concrete tile PC cause Flexturereduction compared to concrete without waste marble tile . But the composition of PC 0.8 : 0.2 SL : 1 Ps : 2 PSL and composition 0.8 PC : 0.2 SL : 3 PSL still eligible in accordance with SNI standards for produce bending loads 1141 N and 1082 N. Thus the replacement of PC with marble powder exceeding 20 % can not be done on a mixture of concrete tile because it will produce a Flextureunder SNI 0096:2007 standards .
3. Replacement PC with marble powder and marble sand river sand with water absorption causing the increase but still meet the SNI 0096:2007 standard is no more than 10 % .
4. The test results in retention of water seepage , concrete tile with marble waste qualifies because there is no seepage within 20 hours ± 5 minutes unless the composition 0.4 PC : 0.6 SL : 1 Ps : 2PsL and 0.2 PC : 0 , 8 SL : 1 Ps : 2PsL .
5. Statistical test results explained that the variation in the treatment of mixed composition tile with marble waste significant effect on the bending loads and water absorption . While the average test results of different groups raises in each treatment .
6. Composition tile marble concrete using waste as a substitute for river sand PC and a decent and qualified SNI 0096:2007 is a composition of 0.8 PC : 0.2 SL : 1 Ps : 2 PSL and composition 0.8 PC : 0.2 SL : 3 PSL. While most optimum in terms of the value of bending loads , water absorption and resistance to water seepage is a composition of 0.8 PC : 0.2 SL : 1 Ps : 2 PSL .

ACKNOWLEDGEMENT

This research funding from the Directorate of Research and Community Services Directorate General of Higher Education, National of Education and Culture Secretary,Indonesia.

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