Substitution Local

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Research paper

Substitution Local Resources Basalt Stone Scoria Lampung, Indonesia, as a Third Raw Material Aggregate to Increase The Quality of Portland Composite Cement (PCC)

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Abstract

Domestic cement demand is increasing in line with the increase of development of property sector and construction sector. Cement is one of the important components in making a permanent building. The function of cement in a construction is as an adhesive material that affects the strength of a building. The process of making cement is divided into two groups, namely hydraulic cement and non-hydraulic cement. Hydraulic cement consists of Portland type cement and PCC type cement, PPC cement and slag cement. The type of PCC cement (Portland Composite Cement) is produced from grinding clinker with gypsum with the addition of third raw material. The purpose of this research is to know the effect of cement quality improvement with substitution of basalt scoria stone raw material as much as 0-10% as the third raw material. The source of basalt scoria stone originated from Lampung Timur, Indonesia. The fineness test showed cement fineness was 2983-3665 cm^2/gr with minimum SNI standard 2800 cm^2/gr. Residue test meets the requirements of SNI standard that is equal to 16,07% -18,55%. The compressive strength test was performed at ages 3, 7 and 28 days and obtained the result that the optimum compressive strength produced was 235, 314, 394 kg/cm^2. Basalt rock usage as substitution material in cement production can decrease environmental pollution caused by clinker production. Based on the cost estimation analysis, the use of basalt stone can decrease the production cost which impact on the increase of profit

Keywords: *Basalt Stone, Cement, Construction, Property, and Portland Composite Cement.*

1. Introduction

Infrastructure development can not be separated from cement raw materials as an adhesive material in the manufacture of concrete so that the required cement in large quantities. Cement is one of the important components in making a permanent building. Cement is a non-organic adhesive used in conjunction with sand, aggregate, or fiber materials to make concrete. Cement is also used to make materials that will be used as components in construction work such as brick holes, print ornaments and others. Portland Cement is the industrial product of limestone raw materials (limestone) as the main ingredient and clay (clay) or other substitute materials with the final result in the form of powder-shaped solids. Raw materials are burned until melted to form clinker then crushed and added with gypsum in appropriate amounts. Semen can be divided into two groups, namely non-hydraulic cement and hydraulic cement. Hydraulic cement hardened after reaction with water while non-hydraulic cement is cement that cannot harden in case of reaction with water. The type of PCC cement (Portland Composite Cement) is produced from grinding clinker with gypsum with the addition of third raw material. The third raw material commonly used is pozzolan, trass, limestone and slag blast furnace but the third material has been reduced so that another alternative is needed as a substitute of the third material in the manufacture of type I PCC type cement. One alternative third raw material is basalt rock scoria. The amount of material reserves of basalt scoria stone in Lampung Province is 318,480,000 tons and has not been optimally explored. Based on the analysis of chemical composition of basalt scoria stone material from Labuhan Maringgai Lampung Timur, Indonesia, that is $SiO_2 + Al_2O_3 + Fe_2O_3$ is 78,66%. Material of basalt scoria rock Labuhan Maringgai Lampung Timur, Indonesia, meet ASTM C618 requirement that chemical component of material is pozzolan that $SiO_2 + Al_2O_3 + Fe_2O_3$ at least 70%. Other chemical components present in the material are tri calcium silicate (C3S), dicalcium silicate (C2S), tri calcium aluminate (C3A) and ferrite calcium alumina tetra (C4AF) [1]-[3]

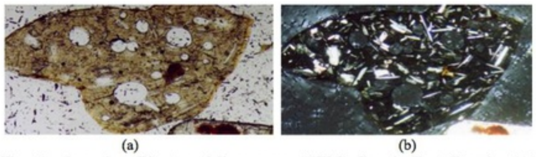

Fig. 1: Scanning Electron Microscopy (SEM) Basalt Test Results (A) Before Warming (b) After Warming

The results of the characteristics of the Scanning Electron Microscopy (SEM) test in Figure 1 (a) above show that the microstructure of the basalt scoria stone minerals appears to be round-shaped, indicating that many of the morphological cavities that develop will be enlarged and enlarged. Figure 1 (b) shows that the new basalt scoria when subjected to a heating will change the micro structure into small needles indicating that the silica elements melt and narrow the pores smaller. The element of sulfur and other gases of oxygen undergo evaporation thereby enriching the silica and alumina minerals. The element of silica and alumina is very good for use as cement raw material because fine silica very influence to compressive strength. Research was conducted to find out the quality of mortar cement by using cement products made from raw stone Basalt Scoria. In addition, there is a need to use the basalt scoria as an alternative to clinker raw materials in the raw material of pure cement making and to utilize the mineral in the form of basalt scoria stone as a mixture of cement production [4]-[5]

2. Page layout

The source of raw material of basalt scoria stone originated from Lampung Timur, Indonesia, taken randomly. Test objects in the design of 21 different compositions and made a cube-shaped 5x5x5 cm. The tests were performed at ages 3, 7 and 28 days which included smoothness test, residue, and compressive strength, binding strength, expansion, SEM test and XRD test. The statistical test of compressive strength was performed to determine the effect of percentage change of basalt stone on the quality of cement mortar [6]-[14]

3. Page style

Based on the results of fineness test can be seen that the optimum refinement level is basalt rock substitution as much as 3% with a fineness value of 3.801. The percentage relationship of basalt addition to the level of fineness can be seen in the figure below:

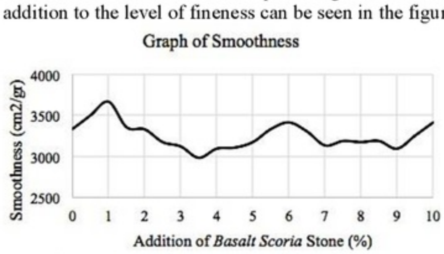

Fig. 2: Graph of percentage addition of basalt to smoothness

The softness of this type of basalt-based PCC cement is still above the standard quality of Portland composite cement SNI-15-7064-2004 which is cement fineness with a blaine tool of minimum 2800 cm2 / gr. Bigger or higher refinement of basalt PCC type cement occurs due to basalt having a chemical composition dominated by silica and alumina minerals and when silica and alumina particles are mixed with clinker dominated by tri-calcium cyclic particles and calcium silicates derived from Lime stone or limestone and will react while the calcium reaction is an exothermic reaction or reaction to release or release heat as it is said that physically the nature of cement one of them is the cement will release heat when mixed with water. The measurement of fineness of cement by the method of sieving by using a sieve of 90 μm and 45 μm is intended to determine the amount of residue left on a sieve 90 μm and 45 μm. The more residuals left in the 90 μm and 45 μm sieve the smaller the cement fineness level or the cement is still coarse grained in other words the more residue left behind then the surface area of coarse cement particles.

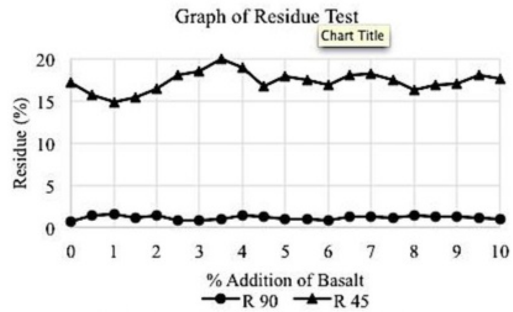

Fig. 3: Grain Residue Test 45 and Residue 90

A 45 μm sieve is smoother compared to a 90 μm sieve size so that when the residue test is done on both sieves the number of residual grains left on the 45 μm sieve is less than the residual grains left on a 90 μm sieve. This is due to the number of holes in the sieve 45 μm less when compared with the number of holes on the sieve 90 μm. Sieved cement on a sieve of 45 μm more passes and fewer left behind while sieving on a 90 μm larger screen is left behind compared to those left in a 45 μm sieve. Based on SNI NO.15-3500-2004 concerning Portland Cement Standards, it is assumed that the physics test requirement for the level of fineness measured using the remaining grain quantity method is stipulated that the number of grains left in the 45 μm sieve is maximum of 24% while for the 90 μm size is not There are standards. Based on the results of the fineness test that the cement type PCC with the addition of basalt as a substitute of limestone and pozzolan meet the requirements of SNI standard that is equal to 16.07% -18.55%. Based on the data of the compressive strength test at age 3, 7 and 28 days can be seen on the graph of the compressive strength relationship to the percentage change in basalt rock content below:

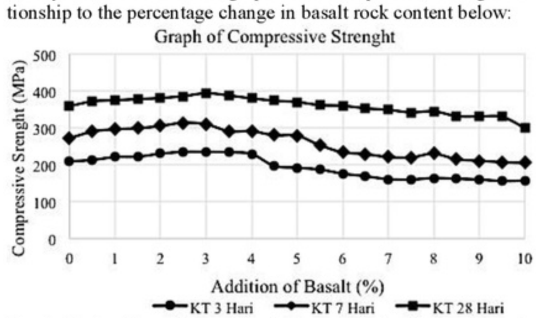

Fig. 4: Graph of the addition of basalt percent relationship to compressive strength

Based on the compressive strength test at age 3, 7 and 28 days it can be seen that the maximum compressive strength of each test age is at 3% basalt percentage and the highest compressive strength value at 28 days. The longer the immersion time, the compressive strength of the mortar produced is also higher until on the 28th day observed in this study, all due to the more perfect cement hydration reaction. Factors affecting compressive strength include cement fineness, cement mortar life and cement composition. Fineness of cement or particles increases the compressive strength of mortar. Substance affects the surface area that will react with water and accelerate contact with aggregates. The compressive strength increases because the fine grain size improves the hydration reaction, thus preventing the occurrence of hardly grain present in the hydration reaction in general cement. The reaction of cement hydration is the reaction that occurs between the cement compound and the water that will produce the hydrate compound, the cement hydration reaction will produce heat which ultimately affects the compressive strength, the hydration compounds include: Calcium Silicate Hydrate + Ca (OH) 2, Calcium Aluminate Hydrate (3CaO.Al2O3.3H2O) and Calcium Sulfuric Aluminate Hydrate (3CaO.Al2O3.3CaSO4.3H2O) 4. C3S compounds contribute to reducing the occurrence of porosity in the concrete so that it will increase the compact density due to the use of soft basalt (Fadillah, Sustiawan, & Lee, 2014). The tensile strength test of mortar is carried out on all specimens separated by the percentage of basalt stone composition. This test is to see the effectiveness of the time that cement needs to bond. The relationship between the percentage of addition of the basalt stone composition and the time required for the bonding of the cement can be seen in the graph

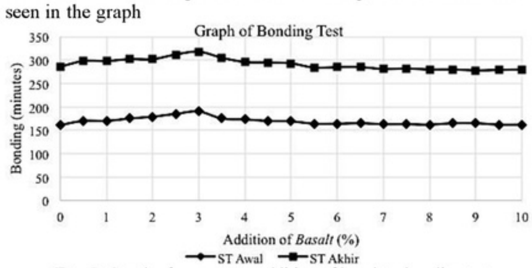

Fig. 5: Graph of percentage addition of basalt to bonding test

Figure 5 shows the strong time fluctuation of the bonding of the specimen on each specimen. The larger the C3A content will tend to result in shorter bonding time. The statement does not apply to basalt-added PCC type cement. Based on preliminary tie test data fluctuated along with the amount of C3A in cement. As shown in the table of chemical test results that the higher the C3A content then the initial binding time is longer and is valid at the time of the final bundle. Thus, the formation of C3A compounds in composite cement does not affect the initial binding time. The expansion test of the autoclave aims to determine the level of cement paste development or to determine the cement to meet the fast rigid specification limits (Indah Pratama, Rauf, & Juarlin, 2015). Prior to the conservation test the form is performed, especially determining the amount of water and the initial binding to be used in the manufacture of cement. Testing of conservation of the form of approval to know the work event when the form cracks, breaks or undergoes other form changes. The relationship of basalt addition to the expansion as shown below:

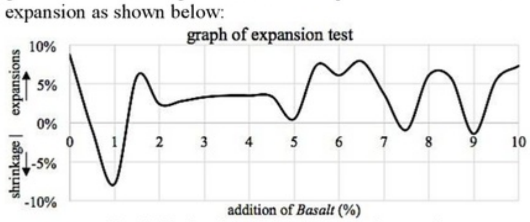

Fig. 6: The basalt additions to expansion graph

Figure 6 shows the basalt addition relationship to the expansion in the autoclave. From the addition of basalt as a substitute of limestone and Pozzolan cement type PCC above can be seen that the test results showed are on the threshold in accordance with the SNI. 15-7064-2004 on the physical terms of the PCC type cement that the maximum expansion of 0.08%. Cement with the addition of basalt instead of limestone and pozzolan undergoes expansion below 0.08%, thus basalt has an effect on decreasing expansion in the PCC cement type so that cement is not easily broken, it is not easy to crack and not easily change shape. The PCC type cement added basalt instead of limestone and Pozzoland is resistant to expansion in the autoclave. The silica and alumina compounds in the basalt undergo a reaction to the hydrolysis of calcium hydrolysis when heated under pressure. The addition of gypsum material will form a chemical reaction and form a compound of CSH (calcium silicate hydrate). Other compounds produced include C3S, C2S, C3A, and C4AF. The compounds will have a good initial and final strength effect, thus helping to harden the cement. The resultant CSH compound between basalt and clinker will fill the cavities and will form contact points so that it will produce stiffness. The next stage will lead to the binding of CSH compounds that will hinder the mobility of cement particles. So when the cement is heated with a high enough pressure then the cement will withstand the expansion and even the cement is resistant to crack and not easily broken. Test Scanning Electron Microscopy (SEM) SEM Characteristics to see the morphology of PCC type cement formed by the addition of basalt instead of stone Lime and Pozzolan by mixing certain compositions. In this characterization the test sample is prepared in the form of fine powder at least passing the mesh size 100, the powder sample is then done preparation into the SEM tool as shown in Figure 18. The output from the SEM characterization results in the form of microstructural images seen from the observation using SEM . The SEM test is performed at all levels of the percentage sample of basalt stone content, assuming that the physical cross-sectional characteristics of the specimen will be denser and the particle size smaller as the percentage increase of the basalt level. The test results indicate that there is an increase in pore and enlargement of particle size along with the increase of basalt stone percentage until testing is done up to basalt level of 5% assuming that the pore area is directly proportional to the basalt content used. The results of the test can be seen in the following figure:

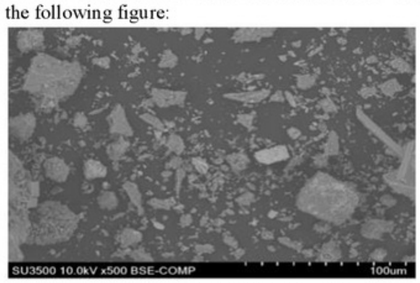

Fig. 7: SEM Result of Basalt Stone Material (Pure)

The result of SEM can be seen in Figure 7 that the basalt raw material when done characteristic has a structure that is still sparse and hollow, so there are still many empty pores to be filled by other materials. The structure is diverse and irregular form of meta, tetra and needle. EDS shows that the dominant element of the basalt raw material with the highest peak is Ca = 23.37%, Fe = 4.07%, Si = 4.86%, and Al = 3.21 but all these elements can form into oxides due Element O is very high = 42.90% with carbon content is also quite high C = 20.54%.

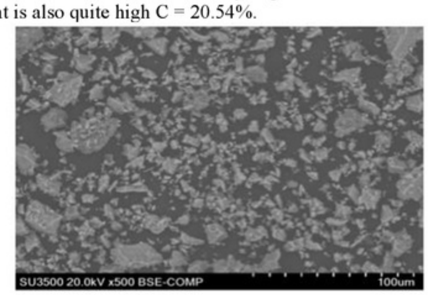

Fig. 8: SEM Composite Cement with Addition of 0% Basalt Stone.

Figure 8 shows that the results of SEM cement analysis of PCC type without any addition of basalt visible cement structure is quite uniform there is no needle but all are dominated forms Meta and tetra and pretty full there are not many cavities pores but the form still small, this is due to the rich content of silica and calcium derived from the raw material clinker with the addition of gypsum, limestone and pozzolan as it is known that the pozzolan many siliceous and aluminum and calcium so that when reacted with clinker will be formed CSH will fill the pores of cement resulting reaction Pozzolanik Ca (OH) 2 with SiO2.Pada EDS shows that the dominant element of cement types PCC without The addition of basalt is the highest peak is Ca = 40.67 %%, Fe = 0.7%, Si = 12.73%, and Al = 1.36% but all these elements can form into oxide due to the very high O = 35.58% with carbon content which is also quite high C = 6.74%. As it is known that cement is a very hydroscopic material which is very easy to absorb water derived from the dominant CaO content in the cement of CaO composition on cement between 60-65% as well as very dominant silica cemented between 20-22%.

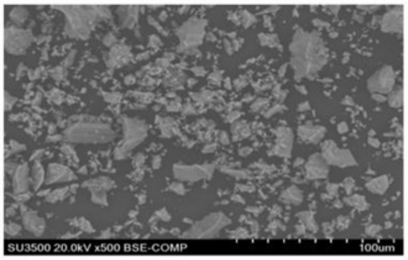

Fig. 9: SEM Semen Composite Test with 3% Basalt Addition

Figure 9 shows the results of SEM cement analysis of PCC type with 3% basalt addition, uniform cement structure and no needle shape but all dominated by meta and tetra forms. There are not many pore cavities and larger particle forms compared to PCC type cement without the addition of basalt. Changes in structure morphology will be more developed towards the big. This is due to the large amount of silica and calcium content derived from clinker raw materials and the role of basalt stones. While pozzolan and gypsum still exist. When basalt is included as a substitute for limestone, some calcium from limestone will be replaced by silica and alumina, so it will form a new compound of C3A that will cover calcium and silica. CENTA compounds will have an impact on the compressive strength of a certain age to be stronger.EDS shows that the dominant element of PCC type cement with 3% basalt addition at the highest peak changes from Ca to Si ie Ca = 6.17% Fe = 0.89%, Si = 18.49%, and Al = 9.05% but all these elements can be formed into oxide due to very high O = = 51.49% with carbon content which is also quite high C = 10 , 37%. When basalt is added then basalt will replace the role of limestone. Basalt is dominated by silica and alumina to silica and alumina that is replacing the existing calcium in the clinker and is visible on

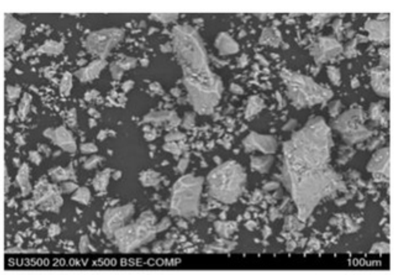

Fig. 10: SEM Test Basalt Cement Composites with Addition of 5%

From Figure 10 shows that the results of SEM analysis appears to cement types of PCC with the addition of basalt as much as 5% after the characteristic shows the cement structure is quite uniform no needle shaped but all dominated by meta and tetra and quite full but there was enough there are cavities pores and shape of the particles appear larger than the cement types PCC with the addition of basalt as much as 3% with so visible changes in the morphological structure will be further developed towards larger, this is due to the rich content of silica and calcium derived from the raw material clinker and the role of the limestone was replaced by basalt, while pozzolan and gypsum Still there will be but the result dar I blanketing will be bound to each other hence will be enlargement of cavity and looks visible enlarge structure when compared with cement type of PCC with addition of basalt as much as 3% but there is cavity enlargement. When the basalt is entered as a substitute for limestone then some calcium derived from limestone will be replaced silica and alumina derived from basalt so that it will form a new compound in the form of C3A that will envelop calcium and silica, and the compound C4AF also formed in the cement while the compound C4AF not Providing impact resistance on high compressive strength only gives impact to the color change of cement to be more black. With a considerable increase of 5%, the role of calcium in the cement is replaced too much and will give the compressive strength at a certain age to be weaker than when the addition of basalt is only 3%. Silica element is a compound that acts as a binder for cement quality improvement. According to SNI S-04-1989-F (DPU: 1989), pozolan is a material containing silica. The addition of mineral in the form of silica to the concrete mixture is one way to improve the quality of cement, which also means to improve the quality of the concrete produced. From the EDS it is seen that the dominant element of PCC cement material with 5% basalt addition is the highest peak that occurred when the addition of basalt as much as 3% cement Si but when added basalt as much as 5% changed to dominated Ca that is Ca = 55,24%, Fe = 15,30%, Si = 2,92%, and Al = 2,75% but all of these elements can be formed into oxide Because the element O is very high = 11.34% with carbon content which is also quite high C = 10,47%. In this case the addition of basalt which amounted to 5% will not have a high impact of compressive strength even down to only affect the color change in cement only more black due to the formation of C4AF which is dominated by Fe.Uji XRD (X-Ray Diffractometer)

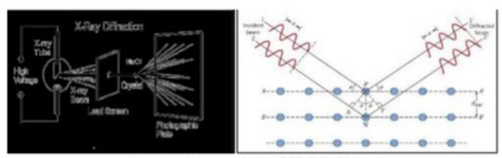

Fig.11: Illustration of X-RD X-ray

Diffraction Characterization using X-RD tools as shown in Figure 11 is required in the data analysis in order to see the structures formed in the PCC cement by using basalt addition raw materials and compared with the SEM results. In the execution of characterization using the X-RD tool the test samples are prepared in the form of fine powder minimum of 100 mesh passes equal to the time of execution of the SEM test. The technical characteristics to be seen on the PCC type cement by using X-RD and SEM relating to the main component testing are done in Materials Laboratory of Research Center for Physics - LIPI Serpong. X-RD test results can be seen in the following results:

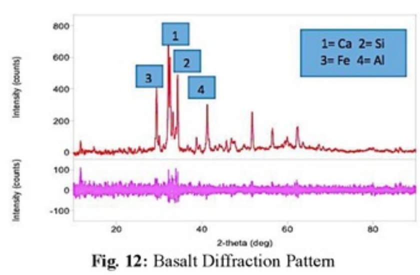

Fig. 12: Basalt Diffraction Pattern

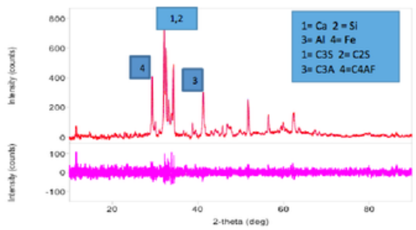

Fig. 13: PCC Cement Diffraction Pattern Without Basalt Addition

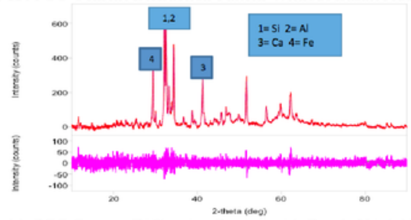

Fig. 14: PCC Cement Diffraction Pattern with Basalt 3% Addition

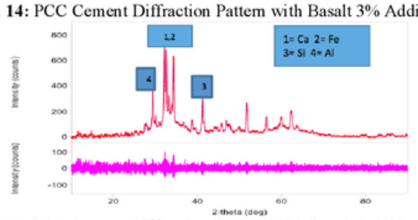

Fig. 15: PCC Cement Diffraction Pattern With Basalt Addition 5%

The result of PCC Cement diffraction with 5% basalt addition shows that the pattern formed shows the main component of PCC cement with 5% basalt addition on spectrum line and certain diffraction angle. Pattern of diffraction in figure 4.27 showed the element dominated by Ca, Fe, Si and Al this is the same as the result of the characterization of the SEM tool that the effect of addition of basalt is too much 5% it will produce calcium compounds but the iron compound (C4AF) also dominate so will affect the compressive strength To be low and only give effect on the change of color become more black. Test statistic of data of compressive force using statistic application with free variable input is the addition of basalt stone and the dependent variable is the result of compressive strength at age 3 days, 7 days and 28 days. Based on the test results above the correlation value is 0.892. This value can be interpreted that the dependent variable relationship to the independent variable of research is in very strong category. From the analysis results obtained the value of R Square or coefficient of determination (KD) which shows how well the regression model formed by the interaction of independent variables and dependent variables. The value of KD obtained is 79.5% which can be interpreted that the combination of mixed effect of 79.5% to the compressive strength of Mortar and 20.5% influenced by other factors. Durbin-Watson autocorrelation test is used to determine whether or not the deviation of the classical autocorrelation assumption is the correlation between residuals on one observation with other observations on the regression model. From the statistic calculation obtained K = 0.308 and from the Durbin-Watson table for K = 3 and n = 20 are: dL = 0.9976dU = 1.6763 Based on the above test results it is known that the result of Durbin Watson 0.308 which means below the dL table value or limit Bottom threshold. So it can be concluded that there is a correlation (r not equal to 0), which means that the results can be accepted. Elastic Modulus (Ec) Based on the test results obtained graph of test results as shown below: Figure 16. Graph Test Elasticity Mortas Age 7 Days 16 above is the result of mortality elasticity test at age 7, 14 and 28 days. The result of the general test of 7 days shows that the mortar compressive strength is 7.569 kg with the size of 5 x 5 cm test specimen. From the test results can be calculated the strength of K mortar press is equal to 7.569 kg / 25 cm2 = 302,76 kg / cm2. By using the equation Ec = 4700 x √fc 'obtained the value of Elasticity of 23,560.6 kg / cm2. In the mortar test age of 14 days obtained the test results such as picture 4.16 above. The value of compressive strength of mortar age of 14 days amounted to 8.320 kg with a cross section of 5x5 cm test object so that the compressive strength of K for 332.8 kg / cm2. Using the equation Ec = 4700 x √fc 'we get the Elasticity value of 24,701,8 kg / cm2. From the results of 28 day test, it is known that the value of compressive strength of mortar is 9.697 kg. So that obtained by compressive strength K equal to 387,88 Kg / cm2. By using the equation Ec = 4700 x √fc 'obtained the value of Elasticity of 26,667.7 kg / cm2. Over time, the concrete will experience a decrease in the quality of either the compressive strength or elasticity. To determine the quality degradation is done by using the equation of SNI Concrete in 2013 following: _fc__t = _fc__28. (T / (4 + 0.85t)); fct = Strength of concrete press at age t (MPa) f C28 = Compressive strength of concrete at age 28 days (MPa) t = Time (Day) The equation above to calculate the compressive strength prediction at maximum age up to 360 days. So to make the prediction analysis decrease of compressive strength at age more than 360 day hence correction factor coefficient needed time. Based on AASHTO LRFD specifications (Eq. [16]) the time correction factor can be calculated by the following equation: k_td = (t-ti) 0.6 / (10+ (t-ti) 0.6); ktd = time correction factor, t = Time (days), ti = 1. Using both equations above can predict the decrease of concrete quality based on the following equation: _fc__t = _fc__28. (T / (4 + 0,85t) _kt__28 / ktd Input: fct = Compressive strength of concrete at age t (MPa), fc28 = Compressive strength of concrete at age 28 days (MPa), t = Time (Days), kt28 = Factor of correction time at age 28 days, ktd = correction factor Time at age t. based on the above equation, the prediction of the compressive strength of the concrete against time above, can be made graph of the compressive relationship t on t with time (t). Graph of the relationship as shown below: Figure 17. Strong Decrease Chart Press against Time Based on the above graph it can be seen that the compressive strength of concrete decreases siring with time. Maximum compressive strength occurs at 28 - 100 days of mortar age. Decrease the quality of the graph above by ignoring the factors of loading and force affecting the mortar. At the age of 20 years, the concrete is still feasible with compressive strength above K-250. From all the above test that the compressive strength with 0% basalt content of 358 kg / cm2 shows significant difference by using 3% basalt equal to 394 kg / cm2. So it can be concluded that the use of basalt as a third material in the production of type PCC cement I with basalt content of 3% is feasible to use. The proportion of basalt 3% has an optimum compressive strength compared with smaller or larger proportions. Analysis of Production Cost of Mining Location of basalt scoria stone material source in East Lampung District is spread over 6 districts. From the total source of the basalt rocks, the basalt mineral resources can be calculated as follows: L = (Basalt Material Volume) / (Basalt Average thickness) L = (7.985.803m ^ 3) / 4mL = 199.6 m ^ 2 ≈199,6 Ha Dump Truck = 12 m3 x 2 = 24 m3 / Unit Capacity / Hour = 15 units x 24 m3 / 8 Hours = 45 m3 / Jam According (Lilies Widojoko and Rajiman, 2011) that the availability of basalt scoria stone in Lampung district East is 7,985,803,00m3. So it can be calculated the basalt rock exploration duration as follows: (7.985.803 m ^ 3) / (45m ^ 3 x 8Jam x 360 Days) = 61.6 years

4. Conclusion

Basalt scoria stone can replace the third raw material of limestone and pozzolan in cement production process type I PCC type. Substitution of basalt scoria stones as much as 1-10% as a substitute of third raw material in cement production produces compressive strength that is still within the limit of SNI requirement. No. 7064-2014. The maximum compressive strength test resulted from the combination of composition on the addition of 3% basalt stone is 394 kg / cm2. The production process of type I PCC type cement with substitution of basalt scoria stone reduces the use of pure cement (clinker) so as to reduce the level of environmental pollution. The use of basalt scoria stone as the third raw material aggregate in the production of type I PCC type cement can reduce production costs so as to increase profit for producers.

References

[1] D. A. Fadillah, F. Sustiawan, and H. A. Lee, 2014, *J. Karya T. Sipil, 3, 4*

[2] Pratama, N. Rauf and E. Juarlin, 2015, *J. Fisika FMIPA Unhas*

[3] W. Suarnita, J. 2011, *SMARTek, 9, 1*

[4] N. A. Syafpoetri, O. Monita and D. Lita, 2013, *J. T. Sipil Universitas Riau*

[5] L. Widojoko, and Rajiman, 2011, *J. T. Sipil UBL, 2, 1*

[6] J. Suyono, A. Sukoco, M. I. Setiawan, Suhermin, and R. Rahim, "Impact of GDP Information Technology in Developing of Regional Central Business (Case 50 Airports IT City Development in Indonesia)," *IOP Conf. Ser. J. Phys. Conf. Ser.*, vol. 930, p. 11002, 2017.

[7] N. Kurniasih, C. Hasyim, A. Wulandari, M. I. Setiawan, and A. S. Ahmar, "Comparative Case Studies on Indonesian Higher Education Rankings," *J. Phys. Conf. Ser.*, vol. 954, no. 1, p. 12021, 2018.

[8] Y. Hanun, M. I. Setiawan, N. Kurniasih, C. Hasyim, and A. S. Ahmar, "Airport Performance and Construction Enlargement Activities," *J. Phys. Conf. Ser.*, vol. 954, no. 1, p. 12016, 2018.

[9] Sabib, M. I. Setiawan, N. Kurniasih, A. S. Ahmar, and C. Hasyim, "Pavement Technology and Airport Infrastructure Expansion Impact," *J. Phys. Conf. Ser.*, vol. 954, no. 1, p. 12017, 2018.

[10] Ratnadewi, R. P. Adhie, Y. Hutama, A. S. Ahmar, and M. I. Setiawan, "Implementation Cryptography Data Encryption Standard (DES) and Triple Data Encryption Standard (3DES) Method in Communication System Based Near Field Communication (NFC)," *J. Phys. Conf. Ser.*, vol. 954, no. 1, p. 12009, 2018.

[11] M. I. Setiawan, S. Surjokusumo, D. M. Ma'soem, J. Johan, C. Hasyim, N. Kurniasih, A. Sukoco, I. Dhaniarti, J. Suyono, I. N. Sudapet, R. D. Nasihien, S. W. Mudjanarko, A. Wulandari, A. S. Ahmar, and M. B. N. Wajdi, "Business Centre Development Model of Airport Area in Supporting Airport Sustainability in Indonesia," *J. Phys. Conf. Ser.*, vol. 954, no. 1, p. 12024, 2018.

[12] D. Napitupulu, R. Rahim, D. Abdullah, M. I. Setiawan, L. A. Abdillah, A. S. Ahmar, J. Simarmata, R. Hidayat, H. Nurdiyanto, and A. Pranolo, "Analysis of Student Satisfaction Toward Quality of Service Facility," *J. Phys. Conf. Ser.*, vol. 954, no. 1, p. 12019, 2018.

[13] T. D. Laksono, N. Kurniasih, C. Hasyim, M. I. Setiawan, and A. S. Ahmar, "The Impact of Airport Performance towards Construction and Infrastructure Expansion in Indonesia," *J. Phys. Conf. Ser.*, vol. 954, no. 1, p. 12015, 2018.

[14] A. S. Ahmar, N. Kurniasih, D. E. Irawan, D. U. Sutiksno, D. Napitupulu, H. Hafid, M. I. Setiawan, J. Simarmata, A. Wibowo, A. Sururi, A. Iskandar, A. P. Saleky, C. Kurniawan, D. Sagala, D. Novitasari, D. E. Indriani, E. R. Kismawadi, Ende, F. Souisa, F. Liantoni, F. Soehardi, Hardi, H. Pribady, H. Baharun, H. V. Saiya, I. Mulyaningsih, I. D. Faryuni, I. Sugiarto, J. Sampurno, L. D. Putri, M. B. N. Wajdi, M. S. Kahar, M. Anggraini, N. N. Rosyida, O. Fajarianto, Ratnadewi, R. A. Madi, R. Sumiati, S. Bahri, T. Listiawan, U. D. Al Muddatstsir, V. Aulia, W. Widyantoro, W. Anita, W. A. Teniwut, A. A. G. S. Utama, A. Aswari, A. Ghofur, A. Atsar, A. H. Nasution, A. R. Suleman, A. Hasibuan, A. D. GS, A. Yusuf, A. Santoso, A. N. C. Saputro, A. Darmuki, A. Suradi, A. Al Yakin, A. Rifqi, A. Raditya, A. P. Narendra, Amaliatulwalidain, A. Upe, A. Riyanto, A. Wijayanto, A. Yanto, A. M. Ruswana, A. D. Moelyaningrum, A. Yuliana, A. Ariyanto, Ardiansah, A. Purwadi, A. Hendrawan, A. Wahyuni, Arjulayana, A. Dewi, As'adi, A. Najmurrokhman, A. Niati, Asrianti, M. B. Laode, B. E. H. Cahyono, B. A. Prakosa, B. U. Nindya, B. Hamuddin, C. F. B. Hartanto, C. A. Sugianto, Chairuddin, C. Sriyanti, D. Purnomo, D. S. Marbun, D. Andayani, D. Susilo, Darmawan, D. U. Anggraini, D. I. S. Saputra, D. F. Sari, D. Rianita, D. Arief, D. Susanto, D. H. Saputra, D. Darmawan, D. Afriansyah, D. Maknun, D. R. Pattilouw, D. Cahyono, D. Ermayanti, E. Wityasminingsih, E. Hartati, E. M. S. S. Ciptaningsih, E. Santoso, E. Sumartono, E. Ratnawati, E. Gultom, E. Khuzaemah, E. D. Pelipa, E. Masrunik, E. Fourianalistyawati, E. Defitriani, E. Yudianto, E. K. Aribowo, Erpidawati, E. Satria, E. Youhanita, E. Erlin, E. Gravitiani, E. Sukmayeti, Fadlina, Fathimah, Fatimah, F. N. Arifah, F. Farchan, Febrianty, F. Augustinah, F. Huda, Fidrayani, Firman, F. E. Laumal, G. Gumelar, G. Ali, H. Arnowo, H. Dafitri, H. Hendri, H. Tuasikal, H. Djanggih, H. Dhika, H. Prabowo, H. Ahmad, H. Ulya, I. N. Sari, I. K. Siregar, I. G. Pratama, Indriyani, I. S. Damanik, I. Setyawati, I. Bempah, I. Setyowidodo, I. Coryanata, I. B. Rangka, J. R. Saragih, J. C. Kumaat, J. Sihite, J. Sipahelut, Kadeni, Kamid, K. Sukiyono, K. Imtihan, K. Husna, K. N. Sari, Kurniawan, L. Ili, L. O. Asmin, L. O. Husen, L. N. Zamnah, L. Fitriani, L. I. Achmad, L. D. Setia, M. C. B. Umanailo, M. A. Ghufron, M. P. Nduru, Marsahip, M. Napratilora, M. Y. Aditya, M. Andriani, M. Madjid, M. A. Rachmawati, M. Rosaliza, M. Affaf, M. R. F. Pratama, M. Khairani, M. J. Purba, M. A. Kurniawan, M. Shofi, M. Ratodi, M. Y. Noch, M. A. Ramadhana, M. Alif, M. Fajri, M. Fuad, M. I. Nasution, M. K. Harahap, M. L. H, M. Sholahuddin, Murjainah, Mursyid, Mustafa, M. Akbar, M. A. Hamid, Muthmainnah, N. Nopeline, N. Hartati, N. Setyowati, Nastia, Nataliningsih, N. W. Nursini, N. A. Nuari, N. B. S. Wangi, N. Yessirita, Nopriadi, N. C. Mamuaya, N. Susanti, N. Kusumawati, N. F. Siregar, N. Siregar, Nurhidayah, Nurmawati, Nurussama, O. Yendri, O. Purwaningsih, Patmawati, P. T. Ningrum, R. E. P. Rr, P. Subekti, P. S. Kurniawan, Qashlim, R. O. S., R. Hidayat, R. Hidayat, R. Fauzia, R. Lubis, R. Kertamukti, R. Oktavian, R. D. Suryaratri, R. Farwati, R. Said, R. W. Simbolon, R. Yunus, R. S. Dewi, R. Rachmadtullah, R. A. Azdy, R. Fatmasari, R. Marginingsih, R. F. Nanuru, R. N. Yanti, R. Septiani, R. Wikansari, R. Wardiani, R. Sari, R. Arridha, R. P. Pratama, R. Rahim, Rochmady, R. T. Utami, R. T. Manurung, R. A. Arum, Rustam, S. Bahri, Salniwati, S. Soebandhi, S. Widodo, Sayyida, S. Handayani, S. W. Handani, S. Juariah, S. N. Hakim, S. F. Saleh, S. Wahyuni, S. Winarni, S. H. Utari, Suhono, Sukardin, S. Sallu, Suliawati, Sumitro, Supriyadi, Supriyanto, Suriani, S. Susiana, Suwarsih, S. Hidayat, S. Saputra, T. Nuryanto, Taufiqurrahman, T. Trianton, T. Zubaidah, T. Magfirah, T. Limbong, T. Listyorini, T. Pahlawan, T. Suryaningsih, U. Rahmi, U. A. Husaeni, V. Hary, V. N. S. Lestari, V. V. Sununianti, V. N. Sitijak, W. Arumwanti, Widodo, Y. Sonatha, Yansyah, Y. K. Panjaitan, Yetti, Y. Dakhi, Y. D. Putra, Yulia, Y. B. Setiawan, Z. Muktamar, Zulfikar, A. F. Arsal, A. I. S. Idris, A. Muis, A. Hadis, A. Mun'im, Abdurahman, A. K. Samlawi, A. Oktarino, Adiatma, Adnan, A. Faridhi, A. Purnomo, A. Bahtiar, A. F. H. Hasibuan, A. F. Majid, A. Gunawan, A. Hasyim, A. Yani, A. Zaki, A. A. FN, A. Saleh, Alimin, Alimuddin, A. J. Tallo, A. Akifah, A. Aprasing, A. A. Azis, A. D. Angriani, A. N. M. Arifin, A. Reni, A. C. Yusro, A. P. Saleky, A. Nugraha, A. Yulianeu, A. V. Vitianingsih, A. R. S. Tambunan, A. P. Pradana, A. Riswanto, A. R. Putra, A. N. Arifin, A. Ahmad, A. Auliah, A. Michael, A. Ahmad, Aswi, A. Tatipata, Awi, A. W. S. Pradana, B. Parmadi, B. P. Sutjiatmo, Bernard, B. D. Amin, Busro, D. Abdullah, D. S. Bataona, D. Muhtadi, D. J. Panjaitan, D. U. Anggraini, D. A. Sari, D. S. Ahmar, D. Zuhroh, D. Nofriansyah, D. Chamidah, Djadir, D. M. Nuris, D. E. Kurniawan, D. N. Rachmah, E. E. Danius, E. F. Afriza, E. F. Hamsyah, E. S. Handayani, E. Zuliana, E. Susanto, E. J. Mihardja, E. A. Sinambela, E. Rosyidah, E. Kembauw, E. Desembrianita, E. N. Rachmah, E. Rinata, E. Nurvitasari, F. Arwadi, F. K. K. Putra, F. Fatmasari, F. Ahmad, F. Az-zahra, F. Megawati, F. Destiawati, F. N. Ralahallo, F. F. Lokollo, G. C. Manulangga, H. Husain, H. Sakdiah, H. Thalin, Hamda, H. Sirine, Hardin, H. Munandar, H. Mardiana, H. Hermawan, R. H. Fajrin, Hasri, Haviluddin, H. Nurdiyanto, H. Tehubijuluw, H. D. Mulyaningsih, H. D. Hahury, H. M. P. Simarmata, H. M. D. Soewardini, H. D. Putranto, Herman, H. Munawaroh, H. Karim, I. N. Sudiana, H. Ihsan, Ibrahim, I. Minggi, I. S. Wardani, Inderawati, I. S. Idris, Irmawanty, Irwan, I. R. Badji, Ismail, I. Dini, J. C. D. Rijoly, J. Burhanudin, J. P. Purwaningrum, J. Safitri, J. Patty, J. Rimbing, K. Arafah, K. Ahmad, Khadijah, K. Ngibad, K. S. Utami, K. H. Ahmar, Kustanto, L. Nurlina, L. A. Abdillah, L. Istiqomah, L. Agustin, L. Nugroho, L. T. Muharlisiani, M. A. Martawijaya, M. M. A. Pratama, M. T. Qurohman, Maddatuang, M. M. D. Widiastuti, M. Putriana, M. Muhammadiyah, M. Noviyanti, M. S. Wahyuni, M. Gienardy, M. P. Azmi, M. Azmi, M. Hariani, M. A. Tongko, M. Irfan, M. A. Anwar, M. N. Nugroho, M. T. Multazam, M. Yamin, M. Roesli, M. M. Wijaya, M. Praseptiawan, M. Yunus, M. J. Al-Pansori, M. Novie, M. Agus, M. Anwar, M. A. Rusli, M. Asfar, M. Danial, M. Darwis, M. J. Djangi, M. Junda, M. Wiharto, M. Y. Matdoan, M. Yusuf, M. Yusuf, Mujiarto, Mukrimin, M. Hasyim, N. Muna, N. Hendracipta, N. Kurnia, N. N. Kurniyati, N. R. Timisela, N. Erlyani, N. Herawati, N. A. Hernadi, N. I. Sari, Nuraini, Nurhayati, B. Nurhayati, Nurmawati, N. Qamar, O. Trinanda, P.

K. Hadi, P. Palloan, P. H. Rantelinggi, P. L. Isrianto, P. Ariwibowo, P. Z. Diana, R. Mardikaningsih, R. Fitri, R. H. Sitaniapessy, R. Hidayat, R. Simbolon, Ramlawati, R. Umar, R. Maming, R. Rahmawati, R. Nirawati, R. V. Zwagery, R. Yuliana, R. Apriyani, R. Muliyani, R. Bakri, R. Safriyani, Rohana, R. Ngitung, R. Abdullah, R. Syahputra, Rusli, Safrizal, S. Sidjara, R. Jefri, S. F. Assagaf, S. Arifin, Setiabudhi, S. H. Lekipiouw, S. H. Mulyani, S. Saenab, S. Kristianto, Sowanto, S. Elviani, S. Maryanti, S. M. Nur, S. P. Dewi, S. Susilawati, S. W. Mudjanarko, S. H. Syarif, S. J. Gomies, Sudarmin, Sudding, Sugianto, Sugiarti, Suharto, Sukarna, S. Zhiddiq, S. Sangadji, Suprapta, S. Nur, Susilo, Sutamrin, Syamsiah, S. Basri, T. Sulastry, T. Bidullah, T. P. Alamsyah, T. Rokhmawan, T. Agustin, U. Madyananda, Usmaedi, Usman, U. Fatoni, Vebtasvili, V. T. C. Siahaya, V. R. Pattipeilohy, W. Wahyani, W. Albra, W. Rindayati, W. Handayani, Wiyanto, Y. I. Pratiwi, Y. Yumiati, Y. Juniardi, Yuniningsih, Y. Noviyanty, Y. R. Al Hakim, Y. E. Patras, Z. H. Abdurrahman, Z. Amatahir, Z. Rais, R. Hidayat, and J. Abraham, "Lecturers' Understanding on Indexing Databases of SINTA, DOAJ, Google Scholar, SCOPUS, and Web of Science: A Study of Indonesians," *J. Phys. Conf. Ser.*, vol. 954, no. 1, p. 12026, 2018..

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