Research article

Using of Para-rubber to Develop Properties of Concrete Block Mixed with Ethylene Vinyl Acetate Plastic in Masonry

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Abstract The aim of this research is to use Para-rubber (vulcanized latex) as an admixture for improving the properties of EVA plastic waste concrete block. In mix design, cement per EVA plastic waste per quarry dust per water ratio is 1:0.5:4:1.6 by weight, vulcanized latex per cement ratios are 0.00, 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, and 0.45 respectively (by weight of cement), no charge surfactant is 4% (by weight of vulcanized latex). The suitable ratio of vulcanized latex per cement in this testing is 0.15 (by weight of cement). The properties are obtained as follows. 1) The average density in 14 days is 1,169.59 kg/m^3. 2) The average water absorption in 14 days is 9.33%. 3) The average compressive strength in 28 days is 25.74 ksc. 4) The coefficient of thermal conductivity is 0.1527 W/m.K. 5). The sound absorption coefficient at 2,000 hertz is 0.38. 6) The noise reduction coefficient is 0.3. It can be seen that many properties are better than normal EVA plastic waste concrete blocks.

Keywords vulcanized latex, EVA plastic waste, concrete block, thermal conductivity

INTRODUCTION

Ethylene Vinyl Acetate (EVA) is the one of light weight garbage, ex. slippers, sport shoe sole, plastic cones etc. Even though the EVA can be reused by melting, the recycle product's quality is dropped more than the previous product. Then the additives need to be used in products so that the products quality will be better. That affects to the costs in the industry, for example shoe products that produced in Thailand as the fifth largest exporter in the world. Because of low density, sound absorption and thermal insulation properties of the EVA, the researcher did an experiment by mixing the small crushed the EVA in concrete block. Then the result showed that the EVA with proper size and strength had good adhesion with cement. The concrete could hold together tightly as single mass. Therefore this concrete had higher properties than the general concrete; their weight is only 3 kg per piece and the density is 640 kg/m^3, while the general concrete has weight about 8 kg per piece and the density is 1,700 kg/m^3. That is similar as light weight concrete and this concrete could be used together with plaster as same as general concrete block. However the concrete block with the EVA will be complete and could be worked properly, if their properties about low water imperviousness and tension and bending were developed by mixing with the Para-rubber (vulcanized latex) (Khamput, 2007a). Then the using Para-rubber to develop the properties of concrete block mixed with plastic EVA scraps is the wall construction innovation which has many outstanding properties as the user requires. Moreover, this innovation is friendly with environment, suitable price and could be produced to concrete block.

OBJECTIVE

The objective of this research is to study about the physical properties, mechanical properties, and thermal insulation properties of the EVA, plastic waste concrete block mixed with the Para-rubber.

METHODOLOGY

Materials and Equipments

The materials and equipments are used as follows. (1) Vulcanized latex tense 60% preserved with high ammonia (HA). (2) Ethylene Vinyl Acetate scraps from shoe factories, crushed by plastic grinder with sieve size no.4 (4.75 mm) as Fig. 1. (3) Sieved quarry dust from sieve no.4 (4) Normal Portland cement (type 1) (5) Tap water (6) Nonionic Surfactants or Alkyl phenol polyethylene glycol ether. (7) Weighing apparatus (8) Solid concrete block mold size 1.5x30x30 cm^3. (9) Solid concrete block mold size 7.5x20x60 cm^3. (10) Hollow concrete block mold size 7x19x39 cu.cm. (11) Automatic concrete mixer (12) Plastic grinder with sieve no.4 (13) Hydraulic Compactor (as same as producing the general concrete block) (14) Temperature testing room (size 1x2x2.5 m^3). 2 rooms, walls lined with thermal insulation 5 sides in front of the wall using Acrylic and inside set up heat sources (1,000 watt spotlight) temperature, humidity measuring tool, and stopwatch.

Fig. 1 Crushed EVA plastic scrap

Fig.2 EVA concrete block

Mixture Ratio Specification

Specify the ratio of EVA concrete block mixed with vulcanized latex by considering the proper vulcanized volume per concrete block as Table 1.

Table 1 Ratios of EVA concrete block mixed with vulcanized latex for testing (by weight)

Ratio	Cement	EVA	Quarry dust	Water	Pre-vulcanized latex (dried latex weight)	Nonionic surfactants substances
NOR	1	-	10	0.9	-	-
P0.00	1	0.5	4	1.6	-	-
P0.05	1	0.5	4	1.6	0.050	0.002
P0.10	1	0.5	4	1.6	0.100	0.004
P0.15	1	0.5	4	1.6	0.150	0.006
P0.20	1	0.5	4	1.6	0.200	0.008
P0.25	1	0.5	4	1.6	0.250	0.010
P0.30	1	0.5	4	1.6	0.300	0.012
P0.35	1	0.5	4	1.6	0.350	0.014
P0.40	1	0.5	4	1.6	0.400	0.016
P0.45	1	0.5	4	1.6	0.450	0.018

Note: The ratio of civil engineering principles by considering to civil engineer who utilize from this research by comparing from cement weight 1 part and dried latex weight tested from percent test of total solid content (TSC).

Concrete Block Forming

For forming of EVA concrete block mixed with vulcanized latex is focused on the forming process as same as production process of general concrete block at most following. (1) Measure the mixture of concrete block by a predetermined ratio. (2) Divide water for mixing to 3 parts and specify 2 parts from 3 parts mixed with vulcanized latex and nonionic surfactants substances. (3) Prepare the concrete mixer which could preserve the fresh concrete in the damp condition. (4) Divide the cement (binder) to 3 parts and bring the binder part 1 and water (without mixed with vulcanized latex and nonionic surfactants substances) in the mixing drum respectively. (5) Add the quarry dust and EVA scrap about half of the total and mixed well. (6) After that add the rest of quarry dust and EVA scrap with cement part 2 and spray the liquid (mixed with vulcanized latex and nonionic surfactants substances) about a half of total liquid. (7) While mixing all materials add gradually the rest of cement and spray the last liquid too. (8) Mix mixture well not more than 10 minutes (9) Do forming the concrete block by hydraulic compaction machine. (10) Remove the concrete block from mold and incubate the forming concrete in the air and indoor.

Property Test

The physical and mechanical properties of EVA concrete block mixed with vulcanized latex is tested according the TIS standard 58-2533 (TIS, 1990) and ASTM (ASTM, 2010) (10 samples per test) following. (1) Enlarge image by Scanning Electron Microscope (SEM) at period age 28 days. (2) Density test at period age 14 days (3) Compression test at period age 7, 14, 21 and 28 days, test 30 examples per a ratio. (4) Water absorption test at period age 14 days (5) Drying shrinkage or length changing test at period age 14 days (6) Thermal coefficient test by forming the concrete block with size 15x30x30 cu.cm at period age 14 days according to ASTM C177-10 (ASTM, 2010) (7) Thermal insulation test with room size 1x2x2.5 cu.m. 2 rooms the walls are made of plywood and zinc lined with thermal insulation 5 sides in front of the wall using Acrylic and inside set up heat sources (1,000 watt spotlight), temperature-humidity measuring tool, and stopwatch. (8) Burning rate test at period age 14 days according to ASTM D635-10 (ASTM, 2010) (9) Sound absorption test at period age 14 days according to ASTM C423-10 (ASTM, 2010).

RESULTS AND DISCUSSION

Enlarging Image

Enlarging image by Scanning Electron Microscope (SEM) magnificent x 2,000, as in Fig. 3 that aggregates and chemical bonding of concrete block as mortar, EVA plastic scraps, quarry dust were coated and inserted in the cavity or gap by Para-rubber film (Ohama, 1987). As a result of the film plate and rubber were inserted in the concrete block which affected to the reducing gap of EVA concrete block.

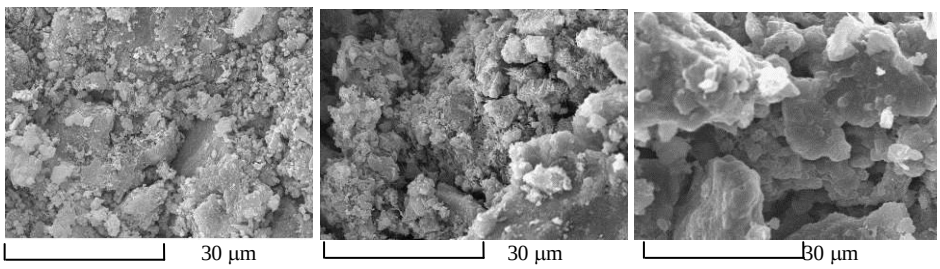

Fig. 3 Enlarging image of EVA concrete block mixed vulcanized latex

Density Test

From the Fig. 4, the vulcanized latex which was mixed in the EVA concrete block effected to the reduced density. The EVA concrete block mixed much vulcanized latex had the low density. The EVA concrete block mixed with less vulcanized latex or without vulcanized latex had the high density. The density of EVA concrete block mixed with vulcanized latex in the highest volume had the low density about 1,150 kg/m^3 while the EVA concrete block without mixing of vulcanized latex had the high density about 1,250 kg/m^3. Because the Para-rubber or film plate from vulcanized latex had the density much lower than the concrete (Ohama, 1987), the Para-rubber was binding as a big lump. When the mixing volume of vulcanized latex in concrete was high, there was much gap in the tract of concrete block.

Water Absorption Test

The results of water absorption of EVA concrete block mixed with the vulcanized latex in the various volumes could be summarized as Fig. 5. The adding of vulcanized latex volume in EVA concrete block affected to the reduced water absorption. The EVA concrete block without mixing of vulcanized latex showed the value of water absorption about 13%. When the vulcanized latex was added about 0.20 of the weight of the cement, the water absorption would be reduced about 9%. Because the film plate from the reaction of cement and vulcanized latex was inserted in the texture of EVA concrete block, this film plate was the water denser material (Ohama, 1987). However, from the testing of the water absorption all types of EVA concrete block had the water absorption lower than TIS standard 58-2533. This limitation was not more than 25% in all conditions.

Drying Shrinkage Test

From the Fig. 6, the vulcanized latex could help to reduce the drying shrinkage value which was occurred due to humidity loss through a capillary pore (Aly and Sanjayan, 2010). That affected to changes of the length and volume of concrete block. Normally the EVA scrap was the water absorbing material. Then the EVA concrete block had the drying shrinkage lower than normal concrete block. When the vulcanized latex, whose characters were as film plate inserted in the concrete block, was used for mixing in the concrete block, the water in concrete block was difficult to lose. Therefore the drying shrinkage from water loss (Khamput, 2007b) was quite nearly happened less than the concrete block without mixing the vulcanized latex. The particle of rubber film inserted as film plate in various gaps could help for the difficult shrinkage and expansion.

Compression Test

From the results of the compression or compressive strength test of EVA concrete block mixed with vulcanized latex that could be summarized by division of mixtures ratio as Fig. 7. The proper mixing of vulcanized latex in EVA concrete block could develop the various properties. The compression property was reached to TIS standard 58-2533. That was defined not more 25 ksc. The highest limit of mixing the vulcanized latex was not more than 0.15 of cement weight and their compression was still higher than 25 ksc because the mixing of vulcanized latex could make the compression reduced (Khamput, 2007b). Because the Para-rubber film were the polymer material which were cohesive, high flexible, not sturdy like aggregates, so the space for compressive strength was reduced due to mixing of vulcanized latex in high volume.

Thermal Conductivity Test

The result of thermal conductivity, coefficient of EVA concrete block mixed with vulcanized latex according to ASTM C177-10 (ASTM, 2010) operated the testing by Department of Science

Service, Ministry of Science and Technology Thailand presented as Fig. 8. The vulcanized latex could help to reduce the thermal conductivity coefficient of EVA concrete block by adding the highest vulcanized latex volume. That was the best way for reducing the thermal conductivity coefficient; from the mixing of vulcanized latex about 0.20 of cement weight. Their thermal conductivity coefficient was lower than the adding of vulcanized latex volume at 0.05 of cement weight and without mixing of vulcanized latex. Because the rubber film was the good material for the thermal insulation (McCrum et al., 1997), and while mixing the vulcanized latex in concrete block produced the air bubble in the flesh of concrete block (Khamput, 2007b), that made the density and the thermal conductivity, coefficient reduced.

Thermal Insulation Test

From the result of thermal insulation test in Fig. 9, the EVA concrete block mixed with vulcanized latex could reduce the temperature in the testing room lower than the EVA concrete block without mixing the vulcanized latex about 1 degree Celsius. That was lower than general concrete about 2 degrees Celsius which were related with the result of the thermal conductivity coefficient test.

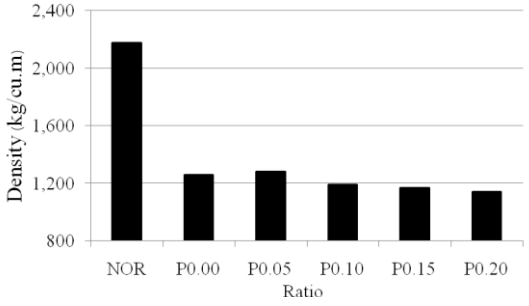

Fig. 4 The results of density

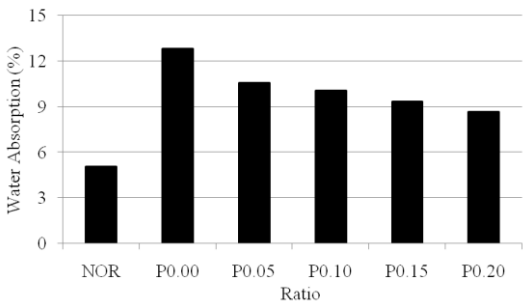

Fig. 5 The results of water absorption

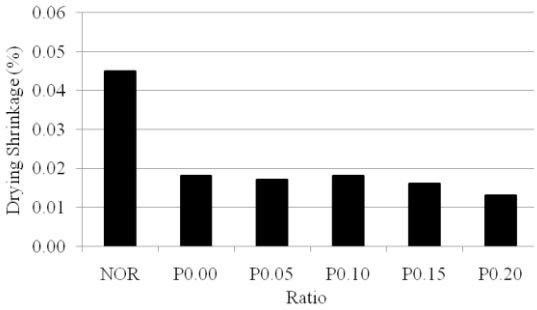

Fig. 6 The results of drying shrinkage

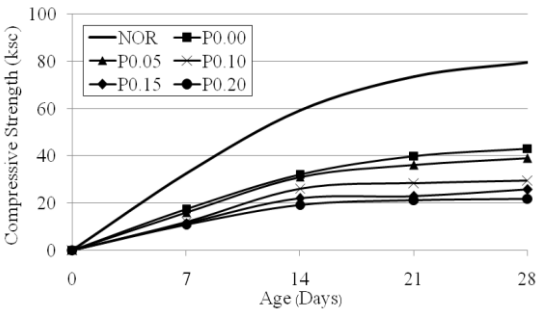

Fig. 7 The resuls of compressive strength

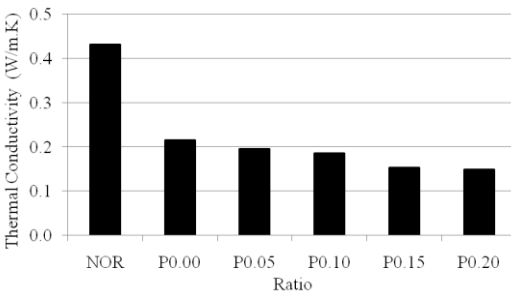

Fig. 8 The results of thermal conductivity

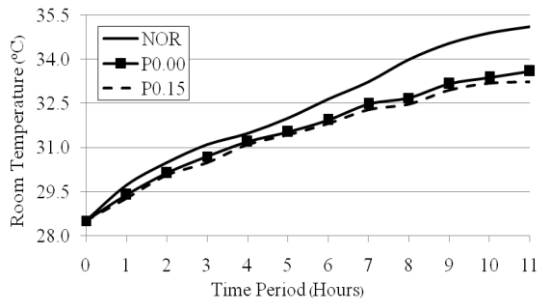

Fig. 9 The results of thermal insulation

Burning Rate Test

From the test of fire according to ASTM D635-10 (ASTM, 2010) to find out the burn rate value, the EVA concrete block mixed with vulcanized latex had no fire property because the most tract of concrete block was not easy flammable. The vulcanized latex and EVA scrap inserted in the flesh of concrete block was not melt continuously, then that was not flammable and could be used usual. The concrete block was practically used by laying brick wall and plastering with thick mortar about 1-2 cm. The flammability was difficult to happened because that depends on 3 factors; heat, fuel and air. The plastering was the thermal and air insulation for the concrete block while burning.

Sound Absorption Test

From NRC of various concrete blocks as Table 2 that showed the efficacy of EVA concrete block to prevent the noise on the medium level. The process to develop the efficacy of sound absorption was the adding of much vulcanized latex volume because of the flexibility of polymer inserted inside in concrete block; EVA scraps, rubber and film plate could help to absorb the sound energy as good as compared them with using the thick carpet as sound absorbed materials.

Table 2 Results of sound absorption coefficient and the noise reduction coefficient

Thickness(cm)	Ratio	Sound absorption coefficient				
		250	500	1,000	2,000	NRC
	NOR	0.044	0.054	0.097	0.082	0.07
7.5	P0.00	0.17	0.19	0.36	0.38	0.28
included	P0.05	0.19	0.25	0.36	0.37	0.29
gaps	P0.10	0.21	0.24	0.36	0.37	0.30
	P0.15	0.22	0.25	0.36	0.38	0.30
	P0.20	0.23	0.26	0.35	0.38	0.31

CONCLUSION

Vulcanized latex could help to develop some property of the EVA concrete block; reducing of density, water absorption, drying shrinkage and thermal conductivity coefficient and adding some property of sound absorption, thermal insulation and non flammability. Nevertheless the mixing of vulcanized latex overmuch could make the compressive strength reduced and the costs of EVA concrete block would be higher. The vulcanized latex volume about 0.05 of cement weight (ratio P0.15) had a good property reached TIS standard 58-2533 (TIS, 1990) and the cost was not so high. After comparing with the wall materials in the construction market; concrete block and light weight, block the EVA concrete block mixed with vulcanized latex had better property than the general concrete block. This EVA concrete block had similar property with light weight block but their costs were less than light weight block. Moreover the vulcanized latex could reduce water absorption problem. That made the EVA concrete block easy to plaster and mortar.

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