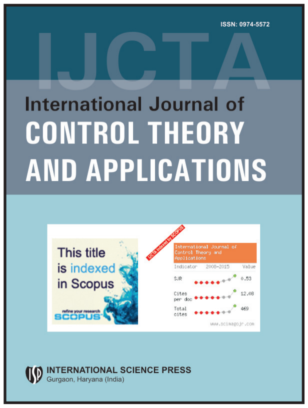

International Journal of Control Theory and Applications

ISSN : 0974-5572

Volume 9 • Number 43 • 2016

Lightweight Concrete Blocks by Using Waste Plastic

Werasak Raongjant[a], Meng Jing[b] and Prachoom Khamput[c]

[a-c]Faculty of Engineering, Rajamangala University of Technology Thanyaburi, Thailand, 39 Moo 1, Rangsit-Nakhonnayok Road, Klong 6, Thanyaburi, Pathumthani, 12110, Thailand. Email: [a]Werasak.r@en.rmutt.ac.th; [b]Meng.j@en.rmutt.ac.th; [c]Prachoom.k@en.rmutt.ac.th

Abstract: The purposes of this research is to study the mechanical properties of moderate lightweight concrete blocks, in which part of fine aggregate was replaced waste plastic. Six large-sized wall samples were designed and fabricated by using the new type concrete blocks, and the shear strengths of walls were investigated by monotonic and cyclic lateral force bearing test. The failure pattern, shear strength, energy dissipation and ductility capacity of the walls were analyzed. The test results showed that the shear strength of concrete block walls decreased with the increase of plastic proportion, while the ductility increased. It is concluded that the moderate lightweight concrete blocks behaved good mechanical properties which appropriate for construction usage.

Keyword: Concrete blocks, Waste plastic, Compressive strength, Lateral cyclic loading, Shear strength, Block walls.

1. INTRODUCTION

The disposal of waste plastic is becoming a major waste management problem. As plastic is extremely durable and not naturally biodegradable, they will remain in landfill with very little degradation over time, presenting a continuing environmental hazard. This promotes recycling ahead of disposal and energy recovery. One of the largest potential recycling routes is in construction of civil engineering.

In recent years, more and more attention has been given to the potential use of waste plastic as concrete aggregate. S.Vanitha et. al., in India [1] used 0%, 2%, 4%, 6%, 8% and 10% waste plastics to replace the same amount of aggregate for M20 concrete. Paver blocks and solid blocks were casted and tested for 7, 14 and 28 days strength. T. Subramani and V.K. Pugal has concluded from their experimental study that [2], 20% of plastic aggregate can be incorporated as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties. Eric Ababio Ohemeng et. al., proposed that although the strengths of plastic content pavement blocks decreased as the plastic content increased, if 10%-50% plastic contents are used, the compressive strengths of blocks are still satisfactory for pedestrians walk ways or light traffic situations. K. Ramadevi, R. Manju [4] carried out the experimental investigation on the properties of concrete with plastic PET (bottle) fibers as fine aggregates. It is found that the replacement of the fine aggregate with 2% of PET bottle fibres will be reasonable than other replacement percentages like 4% and 6% as the compression and split tensile strength reduces gradually. Fahad K. Alqahtani et. al., [5] observed that, 100% replacement of conventional lightweight aggregate with recycled plastic aggregate showed about 13% reduction in chloride penetration. Compressive strength was reduced to 12 to 15 MPa which can be useful for non-structural elements.

The present report focused on the objective of promoting concrete blocks by mixed with waste plastic EVA (Ethylene Vinyl Acetate), which comes from plastic products such as sandals, sports shoes and rubber band. The test program for mechanical properties of this new kind of moderate concrete blocks was explained.

2. CONCRETE BLOCKS MIXED WITH WASTE PLASTIC

The concrete used in this test was got from modifying the gross weight of concrete by replacing 100 g, 150 g or 200 g fine aggregate with the plastic EVA. The plastic grinder crushed by machine was 4 mm large. Plastic EVA is an extremely elastic material with excellent toughness. This material has good stress-crack resistance, flexible and hot-melt adhesive waterproof properties. Table 1 provides the mechanical properties of the materials used for casting concrete blocks. Table 2 shows the mixed modes of three type concrete blocks. Ordinary Portland cement was used.

Table 1
Properties of Materials used in the Test

Categories	*Fine Aggregate*	*Categories*	*Plastic EVA*
Average Specific Gravity	2.7	Specific Gravity	1.14
		Density	0.956 g/cc
Average Absorption	1.0%	Melting Point	96 °C
		Elongation at Break	>750%
Free Moisture	2.0%	Soften Point	110°C

Table 2
Proportion of Materials in Concrete Block Samples

Sample	*Cement (g)*	*Fine Aggregate (g)*	*Plastic EVA (g)*	*Water (g)*
EVA 100	600	2500	100	450
EVA 150	600	2350	150	450
EVA 200	600	2300	200	450

Concrete block samples in the size of 19cm × 39cm × 7 cm (length × width × thickness), with 5-cell hollow 4 cm diameter, which are similar to the block commonly used in Thailand were produced (see in Fig.1) and the mechanical and physical properties of them, such as compressive strength, density, absorption, voids and permeability, were tested. Moisture content of three type concrete blocks, EVA100, EVA 150 and EVA200, were 3.105%, 3.151% and 3.241%, respectively. Due to the addition of plastic materials, the weight of the block is significantly reduced. The weights of the concrete blocks in the age of 28 days correspond to EVA100, EVA 150 and EVA200 were 6.526 kg, 5.756 kg and 5.124 kg, and the density were 1258 kg/m^3, 1109 kg/m^3 and 987.8 kg/m^3, respectively.

Figure 2 gives the comparison between compressive strengths of three type concrete blocks. It can be seen that, the compressive strength of the block decreased with the increased proportion of plastic. When the plastic EVA increased by 50%, the compressive strength in 28 days decreased by 12.38%. When the plastic EVA increased by 100%, the compressive strength decreased by 27.6%. For the concrete block with plastic, the early compressive strength develops slowly due to the decrease of cement consumption. From the 7 days to 14 days, the compressive strength of EVA100 increased by 30%, while the compressive strength of EVA150 and EVA200 increased by 18.75% and 13.91%, respectively. From 21 days to 28 days, the compressive strength of

EVA100 only increased by 7.69%, while the compressive strength of EVA150 and EVA200 increased by 21% and 16%, respectively.

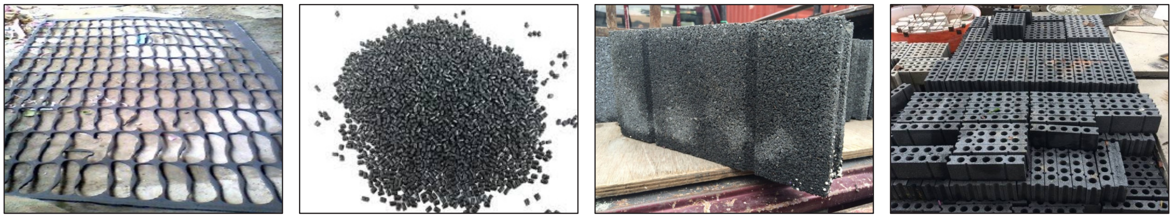

Figure 1: Waste plastics EVA and concrete blocks

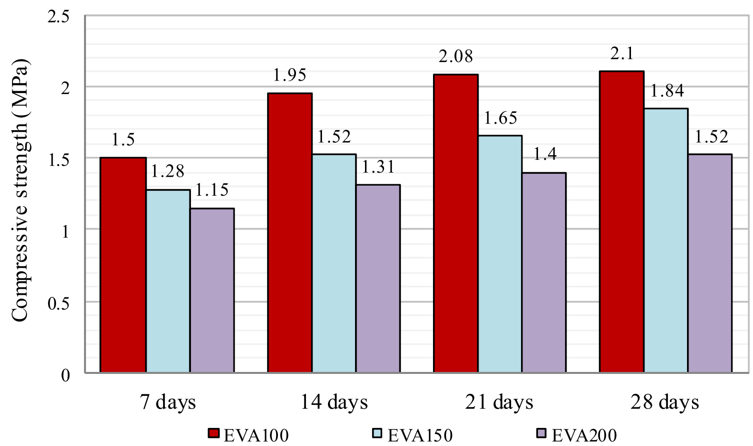

Figure 2: Development of compressive strengths for three type concrete blocks

3. SHEAR STRENGTH OF CONCRETE BLOCK WALLS

In order to further test the practicability of this new kind of concrete block, shear resistance of block walls were tested. Six blocks walls were constructed in dimension of 120cm × 160cm × 7cm (height × length × thickness). Each course of the 1.6 m long wall was constructed using four masonry units. Two jacks are fixed in the vertical direction, each applying a 100kg vertical load on the wall through a steel distributed beam. The loads of the two hydraulic jacks kept constantly during the tests. Linear displacement transducers are placed at the bottom and top of the wall, respectively, to measure the lateral displacement of the wall. One hydraulic jacks were fixed on the steel frame to apply the lateral load (see in Figure 3).

Figure 3: Test set-up for concrete block walls

A. Monotonic Lateral Force Bearing Test

Three block walls were tested under monotonic lateral load. The lateral force applied on the top of the wall through hydraulic jack increased until the specimen damaged. Figure 4 shows the development curves of lateral load vs. displacement for three type concrete block walls. It can be seen that the relationship between load and displacement for all three type concrete block walls behaved almost linear development, which indicates the brittle property of concrete block wall. With the increased proportion of plastic EVA used, the shear resistance of block wall was reduced, while the ductility increased correspondingly.

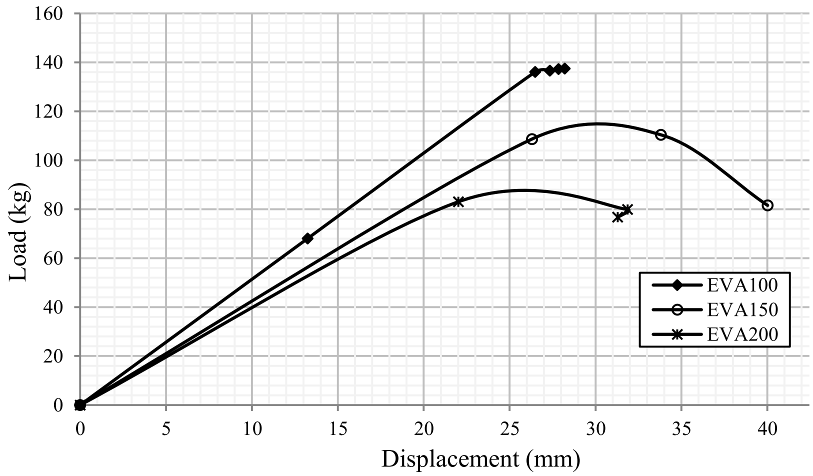

Figure 4: Monotonic lateral Load vs. displacement curve of concrete block walls

B. Cyclic Lateral Force Bearing Test

In this study, three type concrete block walls were subjected to one-way half-cycle cyclic lateral loading. The lateral load was increased from zero to 20 kg and then unloaded until the specimen displacement recovered, after which an increment of 20 kg was upgraded from zero to the maximum and then unloaded, until the destruction of the specimen so far. During the test, at each loading level the wall was cycled only once, because the main purpose of this study was to obtain the envelope bone curve of the concrete block shear wall. The cyclic test was terminated until the shear capacity of the shear wall decreased abruptly or the load–displacement curve reached the 85% of the peak load in the descending branch. The failure state indicates that the specimen has large cracks, most occurred at the bottom of the first piece of brick joints.

Figure 5 gives the hysteresis curves of three type concrete block walls. All walls behaved in an almost linearly elastic manner at each cycle. This resulted in thin hysteresis loops which are characterized by low energy dissipation. Comparing the hysteresis curves of the three type block walls, it can be seen that the ultimate bearing capacity decreased with the increase of plastic EVA proportion, while the maximum displacement corresponding to the peak value of lateral force increased. Moreover, for EVA 150 and EVA 200 block walls, the residual displacement after each load cycle increased and the area within the hysteresis loops increased, indicating that with the increased proportion of plastic material, the energy consumption capacity of block wall has been improved, as a result of increased inelastic deformation and the level of damage.

Figure 6 further draw the envelope bone curves of three type concrete block walls, which connected all the peak points at each loading cycle in the hysteresis curves. It can be seen that the block wall under cyclic lateral loading behaved similarly to the brittle behavior of wall under monotonic lateral loading. The shear strength under cyclic lateral loading was about 90% of that under monotonic lateral loading. With the increased plastic EVA proportion, the ductility of the wall increased.

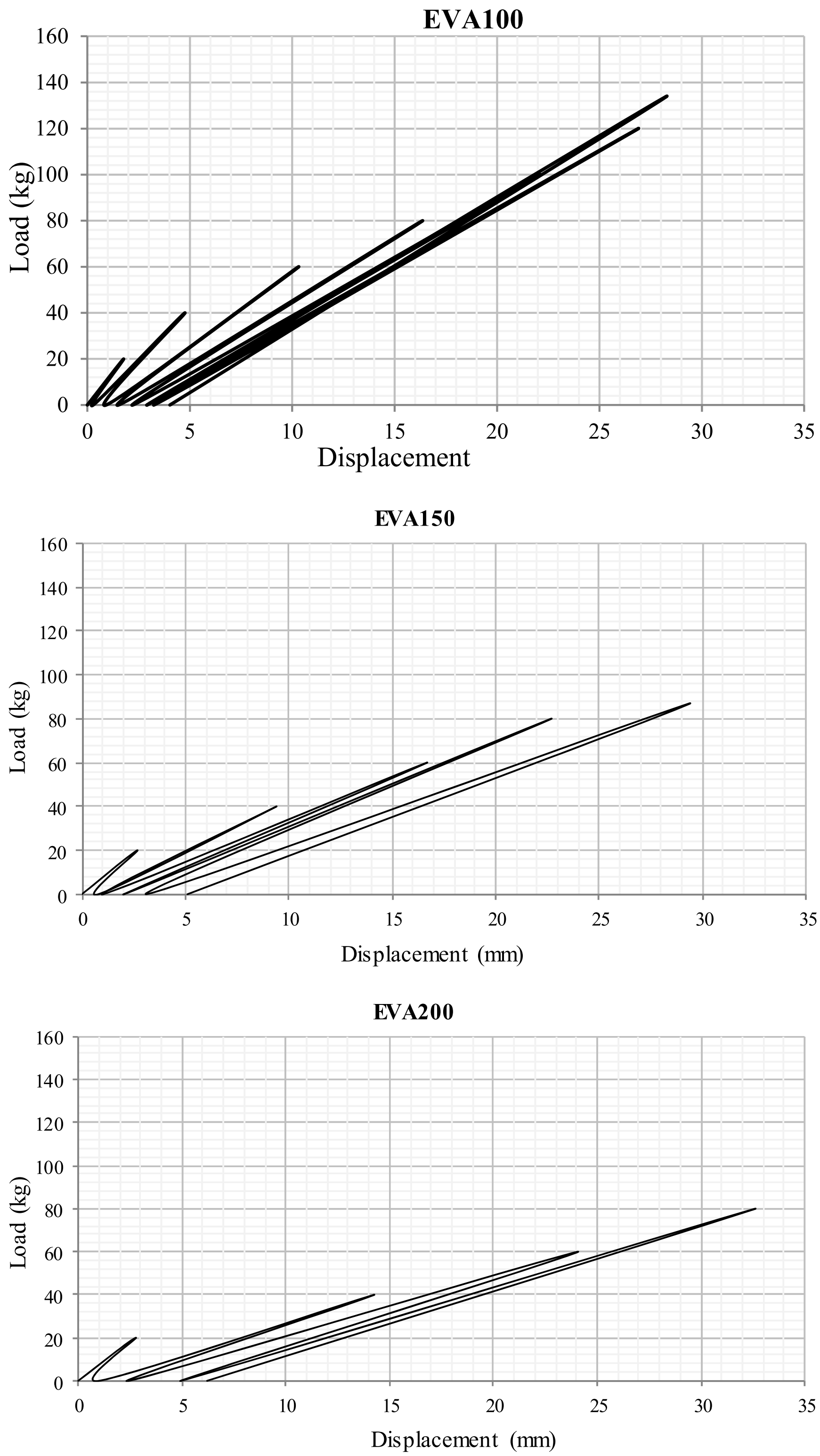

Figure 5: Hysteresis curves of concrete block walls under cyclic lateral loading

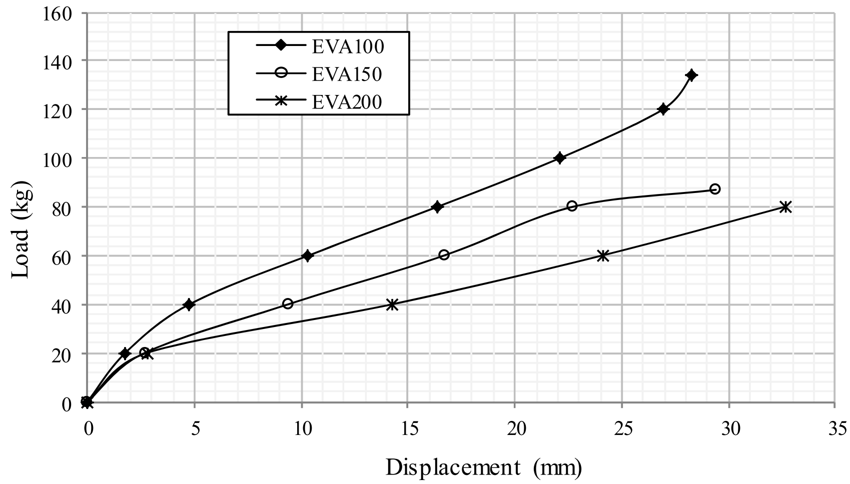

Figure 6: Envelope bone curve of the concrete block walls

4. CONCLUSIONS

In this study, the mechanical properties of three kinds of new concrete blocks with different proportions of plastic EVA were tested. And the shear strengths of three kinds of concrete block walls were investigated. The following conclusions can be drawn:

1. The compressive strength of concrete blocks tended to decrease with increases in the plastic EVA proportion in concrete.
2. The shear strength of concrete block walls decreased with increasing amounts of plastic EVA mixed in the concrete. In the contrary, the ductility of concrete block walls increased by the increasing amounts of plastic EVA.
3. With the increased proportion of plastic material, the energy consumption capacity of concrete block wall has been improved.

Acknowledgment

The financial support of the RMUTT Annual Government Statement of Expenditure in 2016 is greatly appreciated.

REFERENCES

[1] S. Vanitha, V. Natrajan and M. Praba, Utilization of waste plastics as a partial replacement of coarse aggregate in concrete blocks, Indian Journal of Science and Technology, Vol. 8(12), June 2015, pp.1-6.

[2] T.Subramani, V.K.Pugal, Experimental study on plastic waste as a coarse aggregate for structural concrete, International journal of application in engineering and management, Volume 4, Issue 5, may 2015, pp. 144-152.

[3] Eric Ababio Ohemeng, Peter Paa-Kofi Yalley, John Dadzie and Susan Dzifa Djokoto, Utilization of waste low density polyethylene in high strengths concrete pavement blocks production, Civil and environmental research, Vol. 6, No. 5, 2014, pp. 126-135.

[4] K.Ramadevi, R.Manju, Experimental investigation on the properties of concrete with plastic PET (bottle) fibers as fine aggregates, International journal of emerging technology and advanced engineering, Volume 2, Issue 6, June 2012, pp. 42-46.

[5] Fahad K. Alqahtani, Gurmel Ghataora, M.Lqbal khan, Samir Dirar, Azzedine Kioul and Mansour Al-Otaibi, Lightweight concrete containing recycled plastic aggregates, Proceeding in International conference on electromechanical control technology and transportation, 2015, pp. 527-533.