Proceedings of IOE Graduate Conference, 2016
pp. 361–364

Light Weight Concrete Brick using Expanded Polystyrene EPS: Preparation and Cost Estimation

Pratichhya Pradhan [1], Sanjeev Maharjan [2]

[1, 2] *Department of Mechanical Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal*
Corresponding Email: textsuperscript1 pradhanpratichhya@gmail.com

Abstract
Concrete bricks made up of cement, sand, coarse aggregate(CA) and Reused EPS were prepared with Cement : Sand : (EPS and CA) ratio of 1:1.5:3. To determine the effect of EPS/CA ratio on cost perbrick, 100/0, 90/10, 80/20, 70/30 and 0/100 mix proportion by volume were used. The bricks were prepared by hand mixing and hand compaction. Cost per brick for each composition was calculated including material, labour and wastage cost.

Keywords
Reuse EPS – Portland Pozzolana Cement PPC – Light Weight Concrete

1. Introduction

Nepal has suffered huge human and infrastructure losses due to April 2015 earthquake. Lower density walls contribute to smaller cross sections of frames structures. Therefore, in case of earthquake or any natural disaster, human losses can be minimized if light weight construction can be achieved.

On the other hand, consumption of aggregates of all types has been increasing in recent years in most countries at a rate far exceeding that suggested by the growth rate of their economy or of their construction industries. The continued and expanding extraction of natural aggregate is accompanied by serious environmental problems often leading to irremediable deterioration of the country side. In addition, the demand for light weight concrete in many applications in modern construction is increasing, owing to the lower density results in a significant benefit in terms of load bearing elements of smaller cross sections and corresponding reductions in the size of foundation [1].

1.1 Objective

The main objective of this research work is to prepare EPS lightweight concrete bricks consisting of cement, sand, coarse aggregate and EPS (as a reuse) and estimate its cost per brick for each composition.

1.2 Assumptions

- Temperature and humidity are assumed to be consistent in preparing three samples of each type.
- Homogeneity in EPS distribution over cross section of brick is assumed to be achieved using hand mixing and hand compaction.
- No admixtures have been used in making the bricks.
- Volume batching is used and the sand is susceptible to bulking so amount of water used is dependent on the desired workability.
- EPS is taken as waste material for reuse, therefore, its cost is not considered for cost estimation for EPS concrete bricks.

2. Literature Review

2.1 Common Brick

According to IS - 1077 (1992), minimum compressive strength that a common brick should have is 3.5 MPa. The density of common brick varies from 1600 to 1920 kg/m^3 according to IS-875. Thermal conductivity of common brick (50mm brick) for 10 W power supply = 0.6847 W/m.K, for 20W power supply = 0.8271 W/m.K [2].

2.2 Lightweight Aggregate

Lightweight aggregates are broadly classified in to two types- natural (pumice, diatomite and volcanic cinders) and artificial (perlite, expanded shale, clay, slate and sintered pulverized fly ash (PFA)). EPS beads are a type of artificial ultra-lightweight (Density of less than 30 kg/m^3), non absorbent aggregate. It can be used to produce low density concretes required for building applications like cladding panels, curtain walls, composite flooring systems, and load-bearing concrete blocks. [3]

Lightweight aggregate concrete can be produced by replacing the normal aggregate with the lightweight aggregate, either partially or fully, depending upon the requirements of density and strength [4]. It is also claimed that lightweight concrete is more durable than traditional concrete [5].

3. Research Methodology

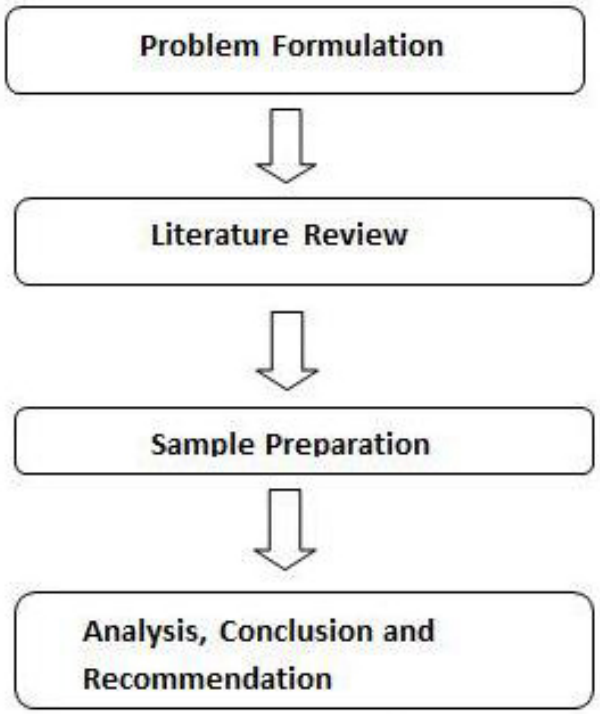

Figure 1: Flowchart showing the research methodology

Figure 1 shows that the research started with identification of problem regarding need of light weight bricks, literature review is done to strengthen knowledge about the topic.

For EPS concrete bricks preparation, samples are prepared by varying the EPS to Aggregate ratios. The composition used is given in 1. For each sample type, three samples of brick are made. The procedure of preparation is explained in section 4.

The preparation is followed by cost estimation. According to the quantities of cement, sand and coarse aggregates used, material cost is calculated. Labour cost and wastage cost is added to it for final cost. The details about the estimation are discussed in section 5.

Table 1: Composition for the lightweight concrete samples prepared

Cement : Sand : Aggregate	Aggregate (Reuse EPS : CA)	Sample No.	Sample Type
1:1.5:3	100:0	1,2,3	A
	90:10	4,5,6	B
	80:20	7,8,9	C
	70:30	10,11,12	D
	0:100	13,14,15	E

4. Experimental Procedure

Referring to the composition conceptualized in Table 1, the detailed calculation for amount of each ingredient was done for volume batching as given in Table 2. Additional 50% amount are included in volume calculation considering shrinkage.

Table 2: Calculation for volume of each ingredient of the varied compositions of brick

C:S:CA	01:05.5			
L	24	cm		
B	11.5	cm		
H	5.7	cm		
Volume of mould	1573.2	cc		
Total volume to use	2359.8	cc (50% higher than volume of mould)		
Cement	429.05	cc		
Sand	643.58	cc		
Coarse Aggregate	1287.16	cc		
Density of EPS	11.36	kg/m3 =	0.011	g/cc
1 cup =	180	cc		

EPS : CA	Sample No.	EPS		Aggregate
		cc	gm	cc
100:0	1,2,3	1287.16	14.62	0.00
90:10	4,5,6	1158.45	13.16	128.72
80:20	7,8,9	1029.73	11.7	257.43
70:30	10,11,12	901.01	10.24	386.15
0:100	13,14,15	0.00	0.00	1287.16

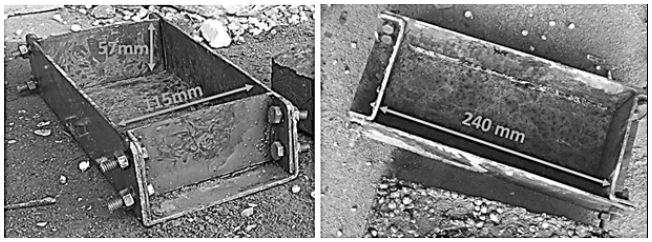

Figure 2: Preparation of Steel Moulds (240mm x 115mm x 57mm)

First step of the experiment was the preparation of detachable steel moulds. The moulds were of regular brick size (240mm x 115mm x 57mm) as shown in Figure 2. The EPS was extracted from the EPS boards used for making physical models. The 6-9mm diameter beads were obtained after segregating each bead by hand from the boards. The beads are shown in Figures 3 and 4. Nirman PPC cement, river sand and coarse aggregates of size 10-12.5 mm were used. Figure 5 shows the sieves that were used to obtain coarse aggregates of given sizes. Dry ingredients i.e. cement, sand and coarse aggregates were mixed first. Water and pre-wetted EPS beads were added to the dry mix. Water in the mix was added to obtain consistent workability for three samples of each type. Mixing procedure is shown in Figure 6. The wet mix obtained was placed into the mould. To ensure proper finishing and easy demoulding, the mould surface was oiled and a thin plastic was placed before pouring in the mix as shown in Figure 7. Hand compaction was achieved using a tamping rod. After 24 hrs of setting, the demoulded bricks were taken for curing as shown in Figure 8.

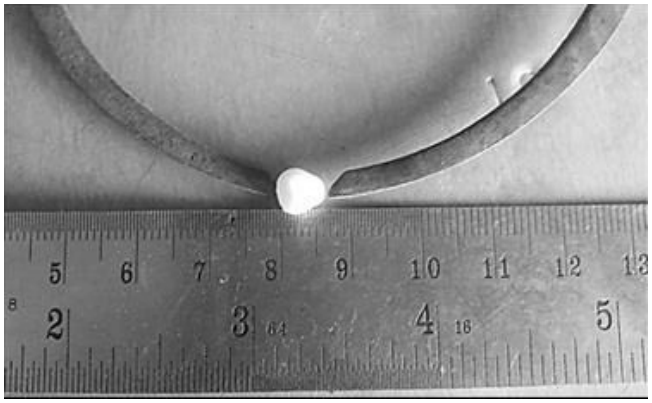

Figure 3: Measuring diameter of EPS using Outside Calipers and scale

Figure 4: Segregation of EPS beads from used EPS boards

Figure 5: Sieves used to obtain aggregates of size range 10mm - 12.5mm

Figure 6: Dry mixing followed by wet mixing of the ingredients

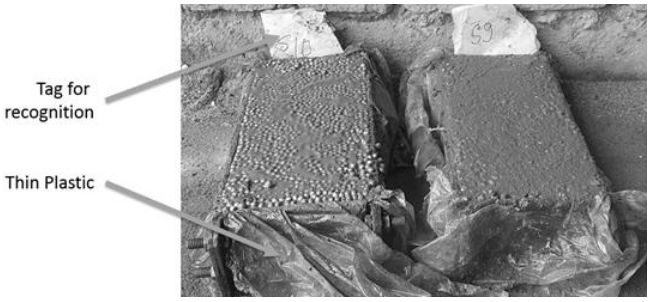

Figure 7: Placing the fresh concrete in the brick moulds

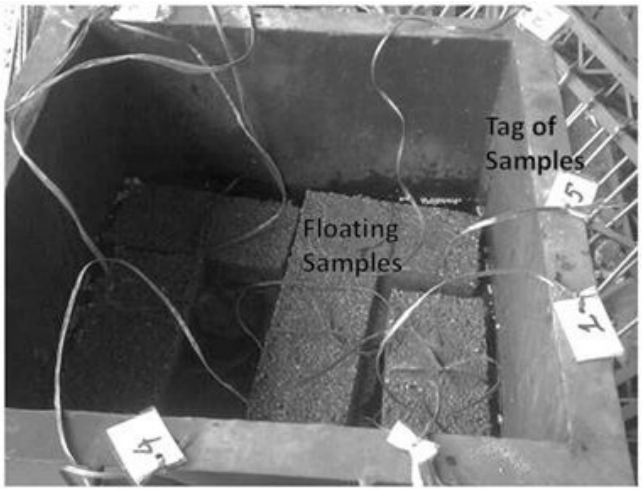

Figure 8: Curing of the samples

5. Result and Discussions

Cost of materials and no. of labours required were as per District Rate for Kathmandu (2072-2073) and Rate Analysis by Department of Urban Development and Building Construction, Nepal respectively. Here, cost for reused EPS was neglected. Table 3 shows the cost calculation details for Type C brick while Table 4 summarizes the cost for each type of brick including the common brick.

The estimated cost per brick of all samples was less than NRs. 19. The cost after commercial manufacturing may differ from these cost estimation due to change in various other parameters (eg. mass production, technology used, additives used etc).

Table 3: Sample calculation of cost per 1 m^3 of bricks for Type C and common brick

SN	Description	Quantity	Rate per unit, NRs	Cost	Total cost
1	Cement	7.91 bag	644 per bag	5093 NRs	
2	Sand	14.44 cu. ft	81 per cu. ft	1169 NRs	Material cost = 6771 NRs
3	Aggregate	5.77 cu. ft	88 per cu. ft	508 NRs	
4	Skilled labour	1 no.	785 per person	785 NRs	Labour cost = 3085 NRs
5	Unskilled labour	4 no.	575 per person	2300 NRs	
					Total cost = 9856 NRs

Table 4: Cost Summary for each type of brick

Description	Lightweight EPS brick (EPS:CA ratio)				
	100:0	90:10	80:20	70:30	0:100
Cost per brick, NRs	14.70	15.10	15.50	15.90	18.70

6. Conclusion

- By performing the experiments for the preparation of bricks we can conclude that hand mixing and hand compaction can also result in satisfactory finishing.
- Furthermore, Table 3 suggests that the cost of EPS concrete bricks are dependent on amount of cement than on other ingredients.
- On the other hand from Table 4, it was ocnfirmed that these light weight bricks can be prepared in reasonable cost (as compared to common bricks).

7. Recommendation

- Tests regarding the compressive strength and thermal insulation can be conducted to understand the behaviour and possible use of these bricks.
- The properties and cost can be studied by varying the cement sand ratios, as strength, bonding and cost change significantly with this variation.

References

[1] Abdulkadir Kan and Ramazan Demirboga. Effect of cement and eps beads ratios on compressive strength and density of lightweight concrete. *Indian Journal of Engineering and Materials Sciences*, 14:158–162, 2007.

[2] Surya Man Koju. Thermal behaviour study of eps based cement panel and its comparison with common brick. 2015.

[3] K. Miled, R. L. Roy, K. Sab, and C. Boulay. Compressive behavior of an idealized eps lightweight concrete: size effects and failure mode. *Mechanics of Materials*, 36:1031–1046, 2004.

[4] K. Ganesh Babu and D Saradhi Babu. Behaviour of lightweight expanded polystyrene concrete containing silica fume. *Cement and Concrete Research*, 33:756–762, 2003.

[5] Ramazan Demirboga and Rustem Gul. Durability of mineral admixtured lightweight aggregate concrete. *Indian Journal of Engineering and Materials Sciences*, 11:201–206, 2004.