COMPARATIVE STUDY ON THE COMPRESSIVE STRENGTH AND PRODUCTION COST OF HOLLOW CONCRETE BLOCK (HCB) WITH AND WITHOUT RED ASH IN TEPI TOWN, ETHIOPIA

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ABSTRACT

Construction materials in construction and technology focuses improving the quality, cost, ease of using materials in different form, increasing performance and so on. But if improving cost is considered, quality should not be compromised. The culture of using alternative ingredients to produce materials is weak in Ethiopia. The main objective of this study was to compare the compressive strength and production cost of hollow concrete blocks with and without red ash in Tepi Town. Specifically, it focused in determining the compressive strength of both blocks, to compare the cost of production and to determine the optimum replacement of red ash for crushed aggregate. According to this study, the HCB without red ash achieved 3.72Mpa mean compressive strength and the HCB with 30% red ash achieved 3.60Mpa mean compressive strength. The optimum replacement was obtained at 30% red ash. The production cost of all HCBs with red ash was found lower than the HCB without red ash. According to the weight comparison made, the HCBs with red ash were found lighter than HCB without red ash. The hollow concrete blockwith red ash in this study has achieved a better cost reduction in production cost, higher reduction in weight and a smaller reduction in compressive strength than hollow concrete blocks without red ash. The study further recommended to the micro and small HCB producers to increase the production of HCB with red ash, for the contractors and clients of Tepi Town to use this product instead of importing HCB.

Keywords- *Compressive strength, crushed aggregate, hollow concrete blocks, production cost and red ash.*

I. INTRODUCTION

Recently in Ethiopia, the introduction of different concrete blocks was carried out in the low- cost housing projects. This includes new hollow block size, u shaped blocks, reinforcement for columns inside of the hollow blocks, combined strip- and slab foundation and others (GTZ, 2005). The key natural lightweight aggregates are diatomite, pumice, scoria, volcanic cinder, and tuff. Except for diatomite, all are volcanic in origin. Pumice and scoria are more widely used for hollow and solid concrete block production in Ethiopia (Abebe Dinku, 2005). The use of scoria (red ash) as a construction material will help conserve energy (as heat insulating material) and will provide low cost cement and lightweight concrete (Khandaker M. Anwar Hossain, 2006). And also the journal claims that the pozzolanic activity tests indicate that finely ground scoria is pozzolanically active and has cementitious characteristics to be used as cement additive. This experimental study was conducted by preparing two types of HCB test samples. The first test sample of HCB was produced by using mix proportion 1:3:2:1 of cement, sand, gravel 00 and crushed aggregate respectively as a control group. The second sample HCBs were produced with red ash by using cement, crushed aggregate and red ash (scoria). The ratio of cement to aggregate used was 1:6. Out of the six parts of aggregate, the aggregate was replaced with 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% amounts of red ash by volume.

II. MATERIALS AND METHODS OF RESEARCH

2.1. Study setting or area

This study was conducted in Tepi Town which is located at 609 km from Addis Ababa and found in southern part of Ethiopia in Sheka Zone, coordinates:7° 12'N 35°27'E /7.2000N 35.4500E, found at an altitude of 1,097m above sea level and a population of 19231

2.2. Sample size and sampling procedure

The sampling procedure needs to be conducted in order to select samples that are representatives for the

study. The sampling procedure used in this research was purposive sampling. For compressive strength test, a total of 6 HCB was prepared. For HCB without red ash, a total of 18 samples were prepared which were tested at 7, 14 and 28 days of curing. For HCBs with red ash 10 different sample were prepared with different percentage of red ash.

2.3 Material preparation

Generally red ash, ordinary Portland cement, crushed aggregates, gravel 00 and sand were materials used in this study. But they were also divided in to two. These were materials for HCB with red ash and materials for HCB without red ash.

Table 2.2: Different samples with different percentage of red ash

Sample ID	1	2	3	4	5	6	7	8	9	10
Redash(%)	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

2.4 Materials for hollow concrete blocks without red ash

DANGOTE Ordinary Portland cement(OPC), Crushed aggregate, Sand and Gravel 00.

2.5 Materials for hollow concrete blocks with redash

DANGOTE Ordinary Portland cement(OPC), Crushed aggregate and, Red ash (scoria). The red ash was extracted from Meti quarry site which is located at 17 km from Tepi town.

Figure 2.4. shows the red ash quarry site in Meti.

2.6 Proportioning the materials

The two most widely used cement to aggregate ratios are 1:6 and 1:8 for hollow concrete blocks production (SRCCD, 2008). The study was conducted by using 1:6 mix proportions for both type of HCB. The proportion 1:6 indicates 1bag of cement to 6 boxes of aggregate. The proportioning box used was the box which is commonly used for HCB proportioning, that is 20cmx40cmx50cm (height, width and length). There was a need to prepare another box to measure the 10% incremental of red ash which is 10% of the volume of the six boxes. The calculation conducted to prepare the box was: The volume of one box which is 20cmx40cmx50cm= **0.04 m^3**. Then the volume for 6 boxes is 0.04x6=**0.24 m^3**. Therefor, 10% of 0.24= **0.024 m^3**, **0.024 m^3 =20cmx30cmx40cm.** Therefor a box with 20cm height, 30 cm width and 40 cm length was prepared to measure the 10% red ash for the hollow blocks with red ash. The study also separately conducted the proportioning for the two types of hollow concrete blocks as follows;

a) Proportioning for HCB without red ash

In Tepi town the micro and small HCB enterprises use 1:3:2:1 ratio of cement, sand, gravel 00 and crushed aggregate respectively for producing HCB without red ash. The study was also conducted by using this proportion to produce the blocks.

b) Proportioning for HCB with red ash

The proportion used by micro and small enterprise in Tepi to produce HCB with red ash is 1:4:2. That is cement, red ash and crushed aggregate proportion. But the study used 1:6 cement aggregate ratios. And out of the six part of aggregate it replaced the amount of crushed aggregate with different percentage of red ash with a constant interval of 10% and increased up to 100%. This was done in order to determine the maximum replacement of red ash for crushed aggregate.

2.7 Mixing process

The mixing process was conducted in two steps. The first step was dry mix of aggregates and cement on the floor by hand and the second step was wet mixing of aggregates and cement inside electrically operated mixer.

The first thing for mixing water determination was selecting water cement ratio. The selected water

cement ratio for the HCB without red ash was 0.5, which is between (0.49-0.55) that was recommended by GTZ Low Cost Housing Manual Volume I.

Then the optimum mixing water was checked by rubbing a shovel against the mix as stated by (CCI, 2006) and a ripple mark was observed at the back of the shovel. The water amount added is 25 Kg. The next step was determining mixing water for the HCB with red ash. The first mix considered was 100% red ash and 25kg of water were added slowly by checking the optimum mixing water at some intervals. But due to absorption of the red ash the mix was very dry and the optimum mixing water checked and no ripple marks were observed. Then by continuously adding water and checking for the ripple marks, the water amount was determined and recorded as 27.5 kg. As going down to 90%-80%, the same amount of water was added by following the same procedure. For 70% -60% the water amount 26.5kg was found enough. But while determining the 50%-30% mixes, the mixes attained their optimum mixing water at 25kg. But the 20% and 10% red ash mixes at 24.5kg.

III. RESULT

3.1 The optimum red ash content for this study is the red ash content that gives the maximum compressive strength up to that content and any further increase in the content results a decrease in compressive strength. The optimum content was determined on the 28th day mean compressive strength and clearly plotted in the table 3.1.

Table 3.1:The 28th, 14th, 7th, day mean compressive strength of HCB with red ash

Red ash content (%)	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
28th MCS(Mpa)	2.01	3.11	3.60	2.95	2.7	2.60	2.19	2.18	1.84	1.48
14th MCS(Mpa)	1.77	2.74	3.26	2.66	2.41	2.32	2.04	1.95	1.72	1.30
7th MCS(Mpa)	1.28	2.05	2.27	1.95	1.78	1.72	1.46	1.37	1.14	0.86

As shown in the Figure 3.1, as the red ash amount in the hollow concrete blocks increases up to 30% the compressive strength also increases from 2.01MPa to 3.6MPa. But after 30% to 100% the compressive strength decreases from 3.6MPa to 1.48MPa. The decrease in compressive strength is due to further replacement of crushed aggregates with relatively weak red ash aggregate.

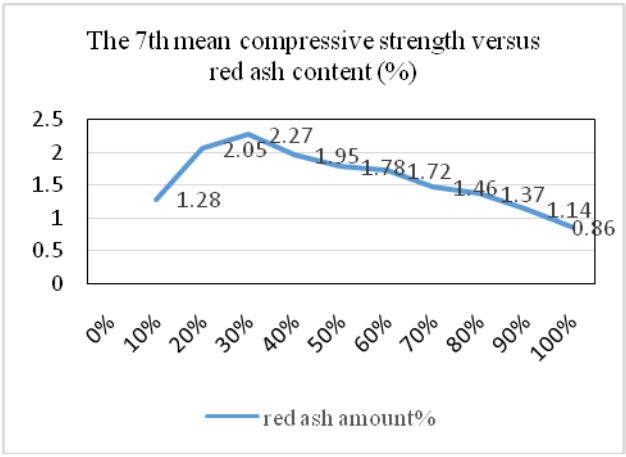

Figure 3.1 (a). The 7th mean compressive strength versus red ash content (%)

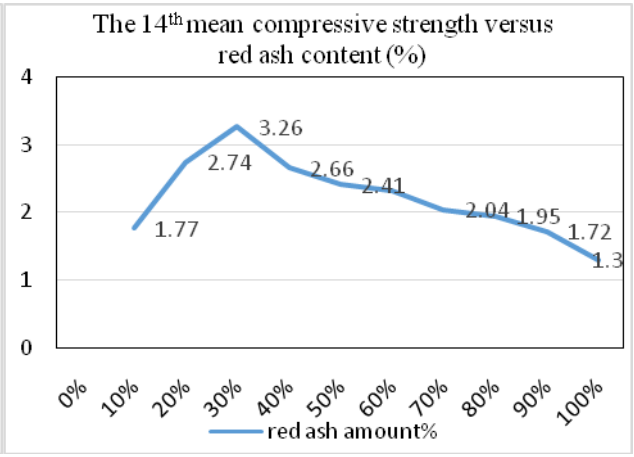

Figure 3.1 (b). The 14th mean compressive strength versus red ash content (%)

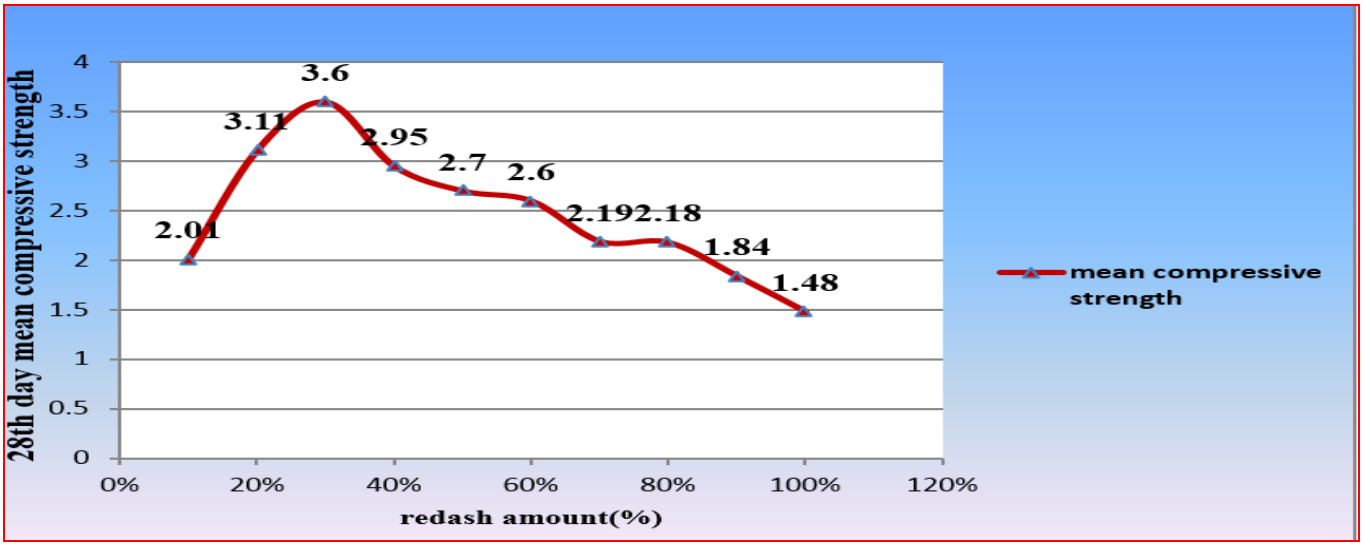

Figure 3.1 (c).The 28th mean compressive strength versus redash content (%)

Table 3.2. Mean compressive strength of HCB without red ash

Testing day	Mean compressive strength(average of 6 HCB) in MPa
7th day	2.19
14th day	3.10
28th day	3.72

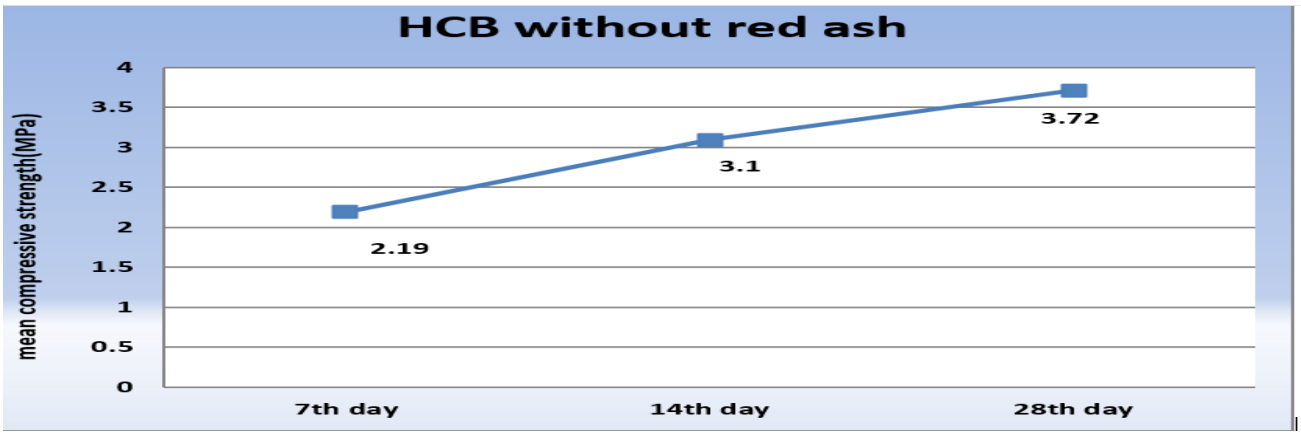

Figure3.2. Compressive strength graph for HCB without red ash

Table 3.3: Direct unit cost of HCB without and 30% red ash HCB

Type of HCB	Direct unit cost (birr)
HCB without red ash	19.34
30% red ash HCB	13.001

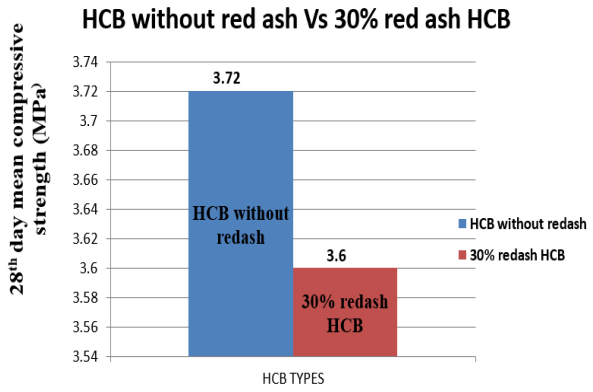

Figure 3.4. Compressive strength of HCB without

Type of HCB produced	28th day's mean compressive strength(Mpa)
HCB without red ash	3.72 Mpa

Table 3.4. Compressive strength of HCB without red ash versus 30% redash HCB

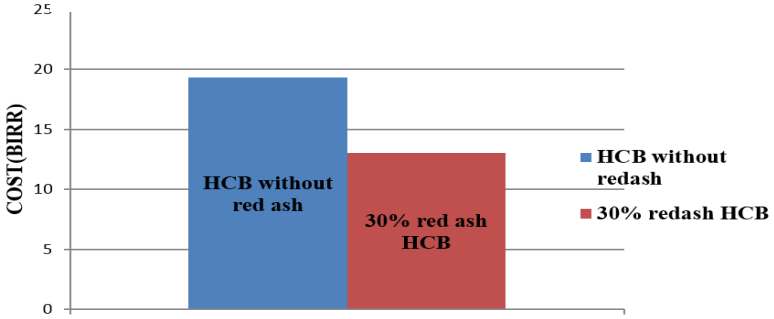

Figure3.5. Cost comparison between HCB without red ash and 30% red ash HCB

Table 3.5 Direct unit cost of HCB without and 30% red ash HCB

Type of HCB	Direct unit cost (birr)
HCB without red ash	19.34
30% red ash HCB	13.001

Table 3.6 Unit weight of 30% red ash HCBs and HCBs without red ash

sample no	28th day unit weight of the HCBs	
	30% red ash HCB(Kg/m3)	HCB without red ash(Kg/m^3)
1	909.375	1053.125
2	912.5	1106.25
3	890.625	1078.125
4	906.25	1050
5	903.125	1078.125
6	887.5	1084.375
Average	**901.5625 Kg/m^3**	**1075 Kg/m^3**

IV. CONCLUSION AND ECOMMENDATION

4.1 CONCLUSIONS

The main objective of this study was to compare the compressive strength and production cost of HCB without and with red ash in Tepi town. During conducting this study, it is concluded that the compressive strength of the HCB without red ash was greater than the HCB with red ash. But cost wise the HCB without red ash incurred very higher direct cost of production than the HCB with red ash. While meeting the specific objectives of the study, the red ash amount which gives a higher strength was achieved at 30% red ash content, which is the optimum replacement of red ash for crushed aggregate that gives a higher compressive strength than the rest red ash replacement contents. During The replacement of different percentage of red ash, the 30% red ash hollow concrete blocks have achieved a 28th day mean compressive strength which is only 3.3% smaller than that of HCB without red ash. On the other aspects of production cost and self-weight, the 30% red ash HCB has achieved 32.77% cost and 19.23% weight reductions. Therefore, the 30% red ash HCB can be used in place of HCB without red ash. According to the 28th day mean compressive strength test results, hollow concrete blocks produced without red ash and with red ash except 90% and 100% red ash HCBs, all were Class C according to Ethiopian standards. The 90% and 100% red ash HCBs were out of Class according to Ethiopian Standard. According to ASTM, the 30% red ash HCBs and HCB without red ash in terms of individual requirements, were non-load bearing hollow concrete blocks. Generally, it is concluded that, by using red ash as an aggregate a higher reduction in cost of production, higher reduction in weight and a small reduction in compressive strength than the HCB without red ash were achieved.

4.2 Recommendations

According to the study conducted on the comparison of compressive strength and production costs of HCB with and without red ash, the following recommendations were made for concerned bodies.

For Tepi Town Administration Office

The construction units of Tepi Town Administration should create awareness to the users of HCB about the use of red ash HCB. The construction unit should also encourage the micro and small HCB production enterprises for their contribution in production of cost effective hollow concrete blocks.

For contractors and micro and small HCB production enterprises

If it is properly produced, with a small difference in compressive strength but with large amount of cost and weight reduction HCB can be produced from red ash. Therefore, it is recommended that the micro and small producers of hollow concrete blocks in Tepi town should increase the production of HCB with red ash and crushed aggregate. Since other lightweight aggregates are not available around Tepi, it is recommended that producers of HCB use red ash as light weight aggregate alone with crushed aggregates in the production of HCB. The contractors shall produce or buy HCB with red ash instead of using HCB without red ash, which has higher cost of production and self-weight than the red ash HCB. They are also recommended to use red ash HCB instead of importing HCB from other town to reduce the cost of construction.

For other Towns in Ethiopia where red ash is abundantly available

For other Towns in Ethiopia where red ash is abundantly available, it is recommended that HCB producers should adopt the use of red ash alone with crushed aggregate in HCB production.

For construction materials research centers

The governmental and non-governmental materials research centers are recommended to conduct further studies on red ash as a hollow concrete block production material, in areas where red ash is abundantly available.

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