EXPERIMENTAL ANALYSIS ON PROPERTIES OF M15 AND M20 CONCRETE BRICK SAMPLE WITH PARTIAL REPLACEMENT OF SAND BY CRUMB RUBBER AND COARSE AGGREGATE BY EXPANDED POLYSTYRENE

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Abstract

The suitability of crumb rubber and EPS (expanded polystyrene) as an alternative to sand and coarse aggregate in concrete production was researched here. Sand and coarse aggregate were partially replaced by crumb rubber and EPS in different percentages like 0%, 10%, 20% and 30% for Grade M20 and M15 concrete samples. The sample of size (240 × 115× 57) mm for M15 and M20 grade of concrete were prepared for the test. Various properties like Compressive strength, Bulk density and water absorption of the concrete brick prepared were determined. The normal consistency, initial and final setting time and compressive strength of cement used for the experiment were determined as 27%, 120 minutes, 290 minutes and 40.34 N/mm2 respectively before carrying out the experiment. The nominal maximum size of sand, coarse aggregate, crumb rubber and EPS used for the preparation of concrete brick sample were found as 2.36 mm, 12.5mm, 2.36 mm and 4.75 mm respectively from the sieve analysis. Impact value of coarse aggregate obtained was 17.06 %.

The experimental results showed that water absorption of prepared M15 and M20 concrete brick samples increased whereas compressive strength and bulk density decreased with increase in percentage replacement of sand by crumb rubber and coarse aggregate by EPS. The results obtained from the experiment showed that concrete brick made with partial replacement of sand and coarse aggregate y crumb rubber and EPS respectively had sufficient compressive strength compared to common brick.

Keywords: *Brick, Bulk Density, Compressive Strength, Crumb rubber; EPS, Water Absorption*

1. Introduction

In current time, bricks are the most widely used building materials. Bricks are prepared by molding clay into rectangular blocks of the same size followed by drying and burning. The main types of bricks commonly used in masonry are Common Burnt Clay Bricks, Sand Lime Bricks (Calcium Silicate Bricks), Engineering Bricks, Concrete Bricks and Fly ash Clay Bricks.

Concrete is a composite and versatile material. Being one of the most popular building materials in the world, there is a high demand for the constituent materials of concrete. Cement, sand and aggregate are the main constituent materials of concrete. River sand in Nepal has been used as one of the major components of concrete as it is easily accessible in nature. River sand is widely used in various kinds of civil engineering constructions. With the increase in construction of structures, the use of river sand has increased excessively. The excessive excavation of river sand is becoming a serious environmental concern. In addition, most of the aggregates are obtained from the environment and numerous environmental problems and natural disasters are occurred due to high extraction of aggregate and sand. It is therefore necessary to explore another possible solution to reduce the use of these basic constituent materials. Therefore, replacement of materials for natural river sand and aggregate in concrete is the requirement of time.

One of the potential marginal materials suitable for replacing sand in concrete is crumb rubber which is a recycled rubber produced from automotive and truck scrap tires. The number of discarded waste tires has become a serious ecological and environmental problem. Decomposition of waste tire rubber can take longer than 50 years, and every year the number of discarded tires is rapidly going. Hence there is a need for recycling more and more waste material. The most widely used fine aggregate for making concrete is the natural sand mined from the riverbeds. However, the availability of river sand for the preparation of concrete is becoming demand due to the excessive nonscientific method of mining from the riverbeds, lowering of water table, sinking of the bridge piers, etc. Thus, there is high demand for the identification of substitute materials for the river sand for making concrete. The choice of materials to replace sand in concrete depends on a few factors such as their availability, physical properties, and chemical ingredients.

The present demands identification of substitute materials for the river sand for making concrete. A recent successful study on the use of crumb rubber as a new brick material supplement appears to be viable solution not only to the environmental problem but also to the problem of to economic design of building. Large quantity of wastes used in this research is currently disposed in sanitary landfills or open dumped into uncontrolled waste pits and open areas.

Similarly, Expanded polystyrene (EPS) can be used as a replacement for coarse aggregate. EPS refers to a strong, durable and lightweight thermoplastic product. EPS is usually white and is made of expanded polystyrene beads. EPS is suitable for the packaging and construction industries due to its light weight, high strength and excellent thermal insulation properties. EPS is highly resistant to biological corrosion. It also reduces the effects of moisture and water vapor, so it is used as a insulation product. EPS is posing a threat to waste disposal as well as for waste management. This material is a cause of concern to environmentalists.

The advantages of replacing sand by crumb rubber for the production of concrete brick are:

1. Lightweight
2. Low thermal conductivity
3. Good sound absorption
4. High flexibility

Similarly, the advantages of replacing coarse aggregate by EPS for the production of concrete brick are:

1. Extremely durable
2. High thermal insulation
3. Resistance to moisture
4. Easily recyclable
5. Versatile in strength
6. Light weight and portable
7. Manufactured into different shapes, sizes and compression materials
8. High shock absorbency characteristics
9. Compression resistance

These replacement exhibits many benefits over the traditional concrete including reduction in weight of the structure by reducing the dead loads transmitted to the foundation. Replacement of coarse aggregate by EPS becomes more economical as compared to using sand and aggregate in concrete brick. So, in this study, it is attempted to partially replace fine aggregate by crumb rubber and coarse aggregate by EPS beads.

2. LITERATURE REVIEW

Oyedepo et al.,(2014) investigated the properties of concrete using sawdust as partial replacement for sand. The concrete mix ratio of 1:2:4 was prepared using water/cement of 0.65 with 0%, 25%, 50%, 75% and 100% sawdust as partial replacement for fine sand. Using sawdust in a proportion greater than 25% replacement of sand is detrimental to strength and density properties of concrete.

Cammille A Issa, et al conducted research on recycled crumb rubber as a substitute for fine aggregate in concrete at 0% to 100% replacement to crushed sand in concrete mix. The result of research showed that 25% Replacement of crushed sand gives good compressive strength and by using crumb rubber up to 25% results in 8% decrease in density of concrete and ductility of concrete increases therefore it is useful in shock resisting element , highway barrier etc. And also damping properties improves.

F.pache co-Torgal et al studied the effect on fresh and hardened concrete properties by using polymeric waste like tyre rubber and PET bottles in concrete mix. The research result showed that with increase in rubber content workability (slump) increases, and the properties like compressive strength, split tensile strength, flexural strength and modulus of elasticity decreases. However, the toughness of concrete mix increases with the higher content of tyre rubber.

In another similar research, Ghaly and Cahill carried out experiments with 5%, 10%, and 15% by volume of rubber aggregates in concrete with water and cement ratios of 0.47, 0.54, and 0.61. Around 180 samples were tested for compressive strength. Test results showed that compressive strength reduces for rubber mix concrete by 10-30%. The author suggests that such rubber mix concrete is not suitable for critical building components. However, this can have application in non-load bearing structures and road paving works.

(Ghimire,2018) experiment on the properties of Concrete brick with partial replacement of Sand by Saw Dust and Partial Replacement of Coarse Aggregate by Expanded Polystyrene. The final result of experiment showed that water absorption of prepared M15 and M20 concrete brick samples increased with increase in percentage replacement of sand by saw dust and EPS by coarse aggregate. Compressive strength and Bulk density of prepared M15 and M20 concrete brick sample decreased with increase in percentage content of saw dust and EPS. The result of the experiment show that partial replacement of sand by saw dust and coarse aggregate by EPS in concrete brick sample had sufficient strength as compared to common bricks.

(Bhatta,2019) experiment on properties of concrete brick with complete replacement of sand by Brick Dust Waste and Partial Replacement of Coarse Aggregate by EPS. The final result show that with increased in percentage of EPS, compressive strength of the Brick sample decreased. The result showed that concrete brick made with replacement of sand by BDW and partial replacement of coarse aggregate by EPS had enough compressive strength as compare to common brick. The result obtained from research show that with whole replacement of sand by brick dust and upto 30% partial replacement of coarse aggregate by expanded polystyrene, the concrete brick so produced can be used for masonry unit in construction of building.

3. RESEARCH METHODOLOGY

A research design is a framework that has been created to find answers to research question. All the research carried out here is centered on laboratory experimentation so the research method adopted can be considered as the experimental study.

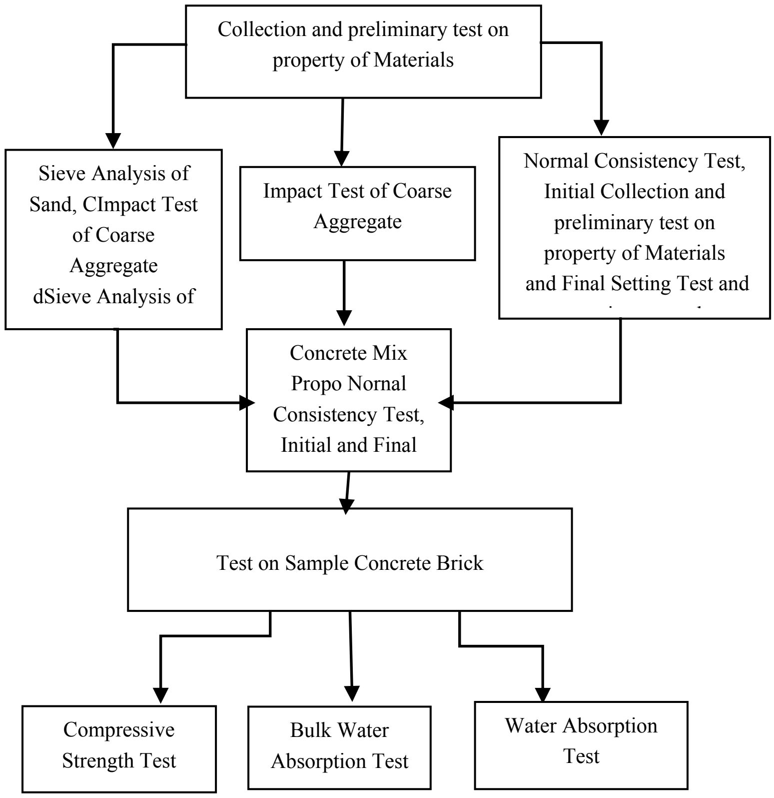

Figure 1: Flow chart of research methodology

4. MATERIALS USED

Following materials were used in this research work:

- OPC cement
- Sand
- Coarse aggregates
- EPS
- Crumb rubber and
- Water

Following equipment/machines available in Central Material Testing Lab in Institute of Engineering, Pulchowk Campus were used for the experimental works:

- Sieve sets as per Indian Standard
- Sieve Shaking Machine
- Volumetric Flask
- Vicat Apparatus

- Buckets
- 240*115*57 mm brick moulds
- Curing tank
- Electronic Balance
- Compressive Strength Testing Machine
- Others

5. SAMPLE PREPARATION

The dimension of common standard brick found in Nepal is 240 mm x 115 mm x 57 mm. So, six moulds of same dimension were prepared for sample production in order to compare their properties with brick practice in Nepal. Various samples of M15 and M20 grade concrete brick were made by partial replacement of sand by crumb rubber and coarse aggregate by EPS. Volume batching was used for the mix.

Three samples for each sample type A, B, C and D were made for M15 grade concrete brick. Thus, in total twelve samples were made for M15 grade concrete brick. Sample type A was considered as control sample of M15 grade whereas sample type B, C, D were made by replacing 10%, 20% and 30% of sand by crumb rubber and coarse aggregate by EPS respectively. Calculation for different mix proportion of M20 grade is given in Table C1 of annex C.

Table 1 shows the various compositions of M15 grade concrete bricks for sample type A, B, C and D.

Table 1: Composition of various M15 grade brick samples

Cement:(Sand and crumb rubber): (Coarse aggregate and EPS)	Sand Replacement by coarse Aggregate (%)	Coarse Aggregate Replacement by EPS (%)	Sample Type	Sample
1:2:4 (By Volume)	0	0	A	A1
				A2
				A3
	10	10	B	B1
				B2
				B3
	20	20	C	C1
				C2
				C3
	30	30	D	D1
				D2
				D3

Three samples for each sample type E, F, G and H were made for M20 grade concrete brick. Thus, in total twelve samples were made for M20 grade concrete brick. Sample type E was considered as control sample of M20 grade whereas sample type B, C, D were made by replacing 10%, 20% and 30% of sand by crumb rubber and coarse aggregate by EPS respectively. Calculation for different mix proportion of M20 grade is given in Table C2 of annex C.

Table 2 shows the various compositions of M20 grade concrete bricks for sample type E,F,G and H.

Table 2: Composition of various M20 grade brick samples

Cement: (Sand and crumb rubber): (Coarse aggregate and EPS)	Sand Replacement by coarse Aggregate (%)	Coarse Aggregate Replacement by EPS (%)	Sample Type	Sample
1:1.5:3 (By Volume)	0	0	E	E1
				E2
				E3
	10	10	F	F1
				F2
				F3
	20	20	G	G1
				G2
				G3
	30	30	H	H1
				H2
				H3

Thus, all together 24 concrete brick samples were prepared in the laboratory for the research.

6. RESULT AND DISCUSSION

The overall experimental result obtained from the tests carried out in lab is shown in table below:

Table 3 : Overall result of M15 and M20 concrete brick

Sample Type	Compressive Strength (N/mm^2)	Bulk Density (KN/m^3)	Water Absorption (%)
For M15 Grade concrete			
A	19.08	24.36	2.61
B	16.85	22.56	2.97
C	13.24	21.63	3.24
D	9.41	20.3	3.56

For M20 Grade Concrete			
E	26.08	24.23	2.31
F	18.05	23.9	2.47
G	15.45	22.61	2.67
H	13.76	21.21	2.71

The result obtained from the experiment shows that compressive strength and bulk density of the sample decreases with increase in percentage contain of crumb rubber and EPS whereas water absorption of the sample increases with increase in percentage contain of crumb rubber and EPS.

Variation of compressive strength with bulk density

Figure 2 shows the graph between Compressive strength and bulk density of M15 and M20 grade sample. The graph shows that the compressive strength of concrete brick sample increases with increase in bulk density.

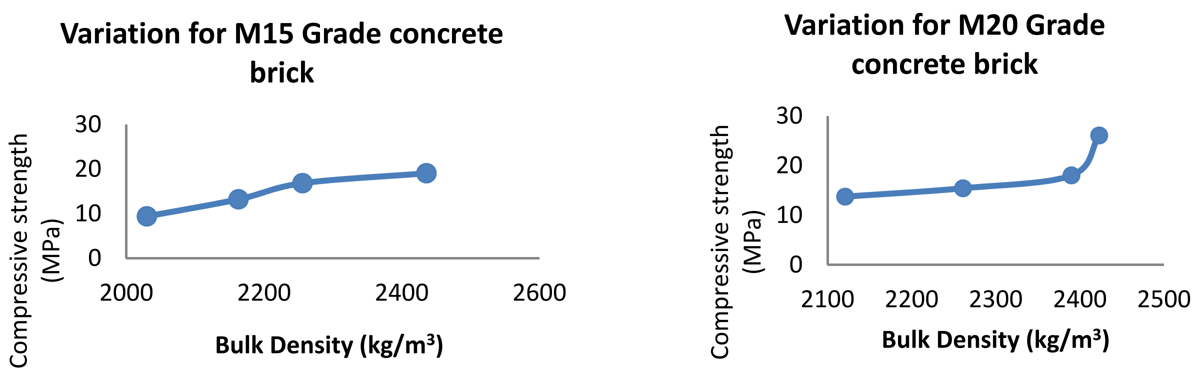

Figure 2: Variation of Compressive strength with bulk density of M15and M20 grade sample

Average value of compressive strength and bulk density of M15 grade concrete brick sample type A, B, C and D were plotted. Thus, the result obtained shows that compressive strength is directly proportional to bulk density.

The graph of M20 shows that compressive strength increases with increases in bulk density.

Variation of compressive strength with water absorption

Figure 3 shows the relation between average value of compressive strength and water absorption for M15 grade concrete brick. The graph was plotted from the experimental results obtained for the sample type A, B, C and D. Thus, the result obtained shows that compressive strength decreased with increased in water absorption value. Similarly, the relation between average value of compressive strength and water absorption for M20 grade concrete brick. The graph was plotted from the experimental results obtained for the sample type E, F, G and H. Thus, the result obtained shows that compressive strength decreased with increased in water absorption value

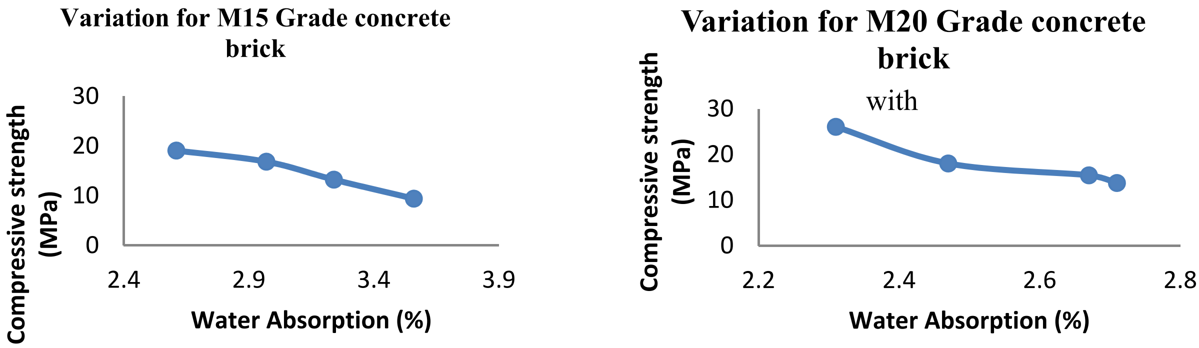

Figure 3 Variation of Compressive strength water absorption of M15 and M20 grade sample

Variation of bulk density with water absorption

Figure 4 shows the relation between average value of bulk density and water absorption for M15 and M20 grade concrete brick. The graph was plotted from the experimental results obtained for the sample type A, B, C and D. Thus, the result obtained shows that bulk density decreased with increased in water absorption percentage.

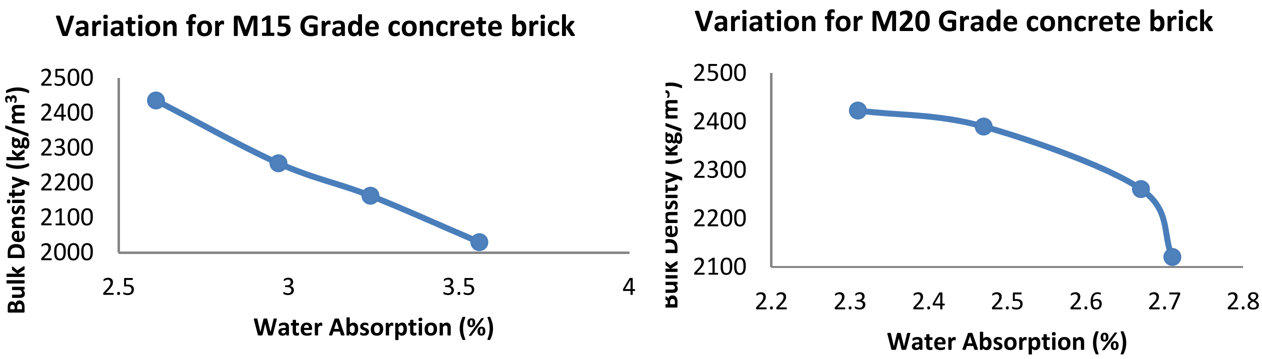

Figure 4 Variation of bulk density with water absorption of M15 grade sample..

5. Suggestion and recommendation

The compressive strength of M15 and M20 concrete brick decreased from 10.08 to 9.41 MPa and 26.08 to 13.76 MPa respectively while increasing the percentage content of crumb rubber and EPS as partial replacement of sand and coarse aggregate respectively from 0 to 30 %. Similarly, the bulk density of M15 and M20 concrete brick reduced from 24.36 to 20.3 KN/m3 and 24.23 to 21.21 KN/m3 respectively while increasing the percentage content of crumb rubber and EPS as partial replacement of sand and coarse aggregate respectively from 0 to 30 %. This indicated that the concrete brick becomes light weight with the increase in amount of crumb rubber and EPS. In the same way, the water absorption of M15 and M20 concrete brick increased from 2.61 to 3.56 % and 2.31 to 2.71% respectively while increasing the percentage content of crumb rubber and EPS as partial replacement of sand and coarse aggregate respectively from 0 to 30 %. The result indicated that water absorption increases with the increase in percentage replacement of sand by crumb rubber and coarse aggregate by EPS.

The results obtained from the experiment showed that concrete brick made with partial replacement of sand and coarse aggregate y crumb rubber and EPS respectively had sufficient compressive strength compared to common brick. The research recommended that upto 30% replacement of sand and coarse aggregate by crumb rubber and EPS respectively, the concrete brick so produced could be used for masonry unit in building construction.

It is recommended for further study on the effect of additives on mechanical properties of crumb rubber and EPS concrete brick samples. Furthermore the study on properties of crumb rubber and EPS concrete hollow block samples can be done.

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