DEVELOPMENT OF ECO-FRIENDLY MASONRY BLOCKS MADE FROM INDUSTRIAL RESIDUES

Kavitha E [1,2], Vidhya K.[1,3], Revathi S[1,2] and Shivasakthivadivelan R A [1,2]

[1]*Department of Civil Engineering, Mahendra Engineering college, Namakkal-* 637503,
Tamil Nadu, India
[2] *Research scholar,* [3]*Professor*

---***---

Abstract - Bricks and building blocks have played a key role in the construction of buildings and other structures for centuries. Despite their reliability and affordability, it is commonly accepted that the production of burnt clay bricks has historically been an energy-intensive and resource-intensive operation. Numerous researchers have carried out extensive research on sustainable and creative bricks, with the goal of mitigating the brick industry's high carbon footprint. An attempt was made to develop sustainable, eco-friendly building blocks using industrial by-products such as fly ash, lime, gypsum, marble powder, and crusher dust. The properties of the materials have been studied. The size of the solid block used in this study was 230 mm x 230 mm x 75 mm. Cast solid blocks were tested for compressive strength, water absorption, and so on. The test results were compared with those of conventional cement solid blocks.

Key words: Fly ash, Marble powder, Crusher dust, Solid blocks, compressive strength

1. INTRODUCTION

Earthen construction techniques have been used for centuries. While it is unknown when or in what century the first earthen houses were constructed, the oldest adobe bricks used in the construction of dwellings were unearthed in the Tigris River Basin and dated to roughly 7500 B.C.

Since ancient times, earth has been the primary building material utilised by numerous countries, and it is currently making a comeback as a material for producing construction elements due to its availability and cheap energy demands. Therefore, earthen materials are sustainable raw resources with a reduced carbon footprint.

The conventional construction materials, such as concrete block, hollow blocks, solid blocks, pavement blocks, and floor tiles, are produced from naturally occurring resources that are already there.

This causes the ecosystem to become fragmented as a result of extensive investigation, which causes the natural resources to run out. Researchers have faced a tremendous task in recent years trying to recycle waste materials into useful contemporary construction materials because of the rising demand for high strength lightweight building materials. This study focuses on the utilization of industrial waste products like fly ash, marble powder, lime, and crusher dust. Fly ash is a residue of the coal combustion process and is utilised in a variety of applications, including cement manufacture, brick and block production, and partial replacement of cement in concrete mix. Marble powder is a by-product of the seizing process for polishing marble stone.

Gypsum and lime are employed as binding materials. Bilgin et al. (2012) performed tests and studies on the use of waste marble powder in the manufacturing of bricks. They observed that adding marble dust to industrial bricks enhances the chemical, physical, and mechanical qualities of the bricks. Replacements for marble dust ranging from 0% to 80% by weight were evaluated. The results show that 10% by weight of marble powder can be added to a material without compromising its engineering properties. Using more than 10% marble powder, on the other hand, improves porosity, water absorption, and mechanical properties. Dhoka (2013) examined the use of industrial wastes such as paper-pulp, marble powder, quarry dust, and wood ash to reduce natural resource and energy consumption, as well as atmospheric pollution. 14 to 20% of cement is saved by the use of such residual material.

Significant improvements have been made to the concrete's resistance to sulphate attack and alkali-aggregate reaction. Ilangovan et al. (2008) examined the feasibility of utilising quarry rock dust as a replacement for natural sand in concrete. In order to measure the durability and strength of concrete, cubes and beams were tested with quarry dust. The compressive, durability, and flexural strengths of concrete made with quarry rock dust were found to be around 10 percent greater than those of normal concrete. Faith and Umit (2001) conducted extensive study on the use of fly-ash as a clay substitute in constructing bricks, which were traditionally created by moulding, curing, and kiln burning a combination of clay and sand. The loss of flexibility of brick clay containing a high proportion of fly-ash can be related to the rise in compressive strength of fly-ash bricks with rising temperature and decreasing amount of fly-ash used as an ingredient. Naganathan et al (2015) A combination of fly-ash, bottom ash, and cement was utilised to cast bricks without the requirement for burning or pressing.

As the percentage of fly ash increased, compressive strength increased. Kavitha and Vidhya (2022) investigated solid blocks including fly ash coal ash, quarry sand, and olivine sand. The results of the tests indicated that the mechanical and durability qualities of the solid blocks are superior to those of typical fly ash blocks. Revathi and Vidhya (2021) examined the incorporation of municipally burned ash into geo polymer-based bricks. The bricks have more durability than typical clay-burned bricks.

2. MATERIALS USED FOR CASTING OF SOLID BLOCKS

The fly ash was collected from the Mettur thermal power plant in Tamil Nadu, India. Marble powder was obtained from a local marble processing plant in Erode, Tamil Nadu, and India. The gypsum and lime powder were acquired from SSS enterprises in Tirunelveli, India. Crusher dust was taken from a quarry unit in Erode, India.

2.1 Properties of materials

The physical properties of materials are given in Table 1. Table 2 lists the proportions of various materials for 8 mix trails.

Table 1 Physical properties of materials

Properties	FA	L	G	MP	CD
Specific gravity	2.35	2.21	2.19	2.68	2.64
Surface area(m^2/kg)	330	294	300	746	985
Bulk Density (kg/m^3)	1150	1295	884	1320	1926

Table 2 Mix proportions of materials

Mix ID	FA	L	G	MP	CS
Ingredients in (%)					
M1	50	10	5	35	0
M2	50	10	5	30	5
M3	50	10	5	25	10
M4	50	10	5	20	15
M5	50	10	5	15	20
M6	50	10	5	10	25
M7	50	10	5	5	30
M8	50	10	5	0	35
FA- Fly ash, L-Lime, G-Gypsum, MP-Marble dust, CS-Crusher dust					

2.2 Casting of blocks

The eight mix trials were utilised to cast solid blocks. In all mix combinations, 50%, 10%, and 5% of fly ash, lime, and gypsum are used, respectively. The size of block was 230mmx230mmx75mm. Marble powder and crusher sand were combined for 35 percent. The proportion of marble powder to crusher sand in mix M1 was maintained at 35%. Marble powder was gradually reduced by 5%, while crusher sand was gradually added by the same amount. All ingredients are added to the drum mixer. All ingredients should be fully combined in a dry condition. Then, water is added until a uniform mixture is achieved. The wet mixture is subsequently conveyed by conveyor belt. Each mould was subjected to a hydraulic pressure.

After pressing, each cast green block is moved to a wooden rack for 48 hours of air drying. The solid blocks are then water-cured for a further several days. After curing in water, solid blocks are sun-dried for up to 28 days. Figure 1 depicts the brick casting process after removal from the mould.

Figure 1 Casting of solid blocks

2.3 Testing of blocks

After curing, the blocks were evaluated for compressive strength, water absorption, density, hardness, and efflorescence. All tests were conducted according to IS 2185- part1: 2005. Compressive strength test of blocks were done by using 200 ton compressive testing machine after 28 days after curing. For the compressive strength test, three solid block samples were obtained from each combination. Water absorption test was conducted after 28 days of curing. The water absorption value was determined in accordance with the IS: 2185 (Part 1):2005. The sample of dry block was maintained in an oven at 105°C to 115°C until it was completely dry. The mass of each solid block was recorded (W1) after being removed from the oven and allowed to cool at room temperature. 24 hours were spent immersing the dry blocks in potable water at a room temperature of

27 + 2°C. After 24 hours, blocks were removed from water and scrubbed clean to remove all residual water.

The mass of soaked block was recorded (W2). The ratio of the change in mass to the initial mass in percentage is the water absorption value of a block. The weight density of the block is the ratio of its weight to its volume. Using an efflorescence test, the presence of alkaline substance in the blocks were determined. The solid block was submerged in water to a depth of 25 mm, and the set is stored in a room with adequate ventilation.

The solid block specimens absorbed nearly all of the water in the tray, which was replenished to a depth of 25 mm, and the procedure was repeated. The summary of test results are given in Table 3

Table 3 Summary of Test results on Mechanical strength properties

Mix ID	Average Compressive strength @ 28 days (Mpa)	Water absorption (%)	Weight density (kg/m³)
M1	9.98	8.22	18.22
M2	10.85	8.40	18.30
M3	12.12	8.91	18.37
M4	13.25	9.27	18.54
M5	14.09	9.50	18.71
M6	13.76	9.64	18.85
M7	13.14	9.80	18.92
M8	12.95	9.92	19.01
CCB	10.35	12.06	20.08

2.4 Discussion on test results

The mechanical characteristics of solid blocks formed using marble dust and crusher dust are summarised in Table 3. The compressive strength of the mixtures ranged from 9.98 MPa to 14.09 MPa. The mix ID M5 achieved the greatest strength compared to all other mixes. When the amount of crusher sand was increased, the strength decreased. Water absorption values ranged between 8.2% to 9.92%. Water absorption values are increased when the increasing the amount of crusher sand. Blocks' weight density ranged from 18.22 kg/m³ to 19.01 kg/m³.

Density of typical cement block was 20.08 kg/m³. Weight density increased as the proportion of crusher sand increased. No white patches appeared on the surface of the blocks following the efflorescence test.

3. CONCLUSIONS

- The maximum compressive strength was achieved with the mix ID M5 (15%MP&20%CS)
- When the percentage of crusher sand exceeded 20%, the compressive strength decreased.
- The mix ID M1 has a lower water absorption value than other mixes.
- The CCB has a denser weight of 20.08 kg/m³, which is 10.22% greater than mix M1.
- The test results indicate that industrial waste materials such as marble dust, fly ash, and crusher dust can be utilised efficiently in the production of building blocks without compromising their strength.

4. REFERENCES

1. Bilgin, N., Yeprem, H. A., Arslan, S., Bilgin, A., Günay. E., and Marsoglu, M. (2012) Use of waste marble powder in brick industry Construction and Building Materials, Vol. 29, pp. 449–457.
2. Ilangovana. R., Mahendrana. N. and Nagamani. K., (2008) Strength and Durability Properties of Concrete Containing Quarry Rock Dust as Fine Aggregate||, ARPN journal of Engineering and Applied Sciences, Vol. (5), pp. 20 – 26
3. Fatih, T., and Umit, A. (2001) Utilization of fly ash in the manufacturing of building bricks, International Ash Utilization Symposium, Paper 13, University of Kentucky, USA
4. Monica C. Dhoka , (2013) Green Concrete: Using Industrial Waste of Marble Powder, Quarry Dust and Paper Pulp, International Journal of Engineering Science Invention Volume 2 Issue 10, pp. 67-70
5. Naganathan, Sivakumar and Tan Linda ohamed, (2013) Effect of Fly Ash Fineness on the Performance of Cement Mortar Jordan Journal of Civil Engineering, Volume 7, No. 3, pp. 326-331.