Experimental and Feasibility Studies of Recycled Bricks using C & D Waste

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ABSTRACT

Traditional fired clay bricks are widely used as a fundamental building material in most countries. The use of burnt bricks has negative effects such as cutting of trees for burning fuel and degradation of soil near rivers where clay is available for manufacturing of bricks. The other problem is that of improper disposing of C & D waste which results in environmental degradation. With growing awareness of sustainable development it is important to incorporate this waste in the production of building materials and reduce burden on the virgin materials. In this view an experimental investigation is carried to utilize these C & D waste as raw materials for brick making. The materials includes: brick powder, recycled fine aggregate, natural fine aggregate along with cement as a stabilizer. The principles of stabilized earth blocks are employed to attain proper binding rather than burning the bricks. Three different mix compositions are used in this study with Brick powder is a predominant constituent which is about 70%. To assess the properties of the bricks a representative cube samples of size 70.6mm X 70.6mm X 70.6mm are first prepared, and then bricks of size 222mm X 106mm X 73mm is casted for three different mixes. The bricks were cured and tested for compressive strength and water absorption. Based on the results, it has been concluded that C& D waste be can used as a substitute materials for brick making.

Keywords: Construction and demolition Waste (C & D Waste), Re-use & Recycling of C & D

INTRODUCTION:

The construction industry has the largest impact on nature and environment. Previously, the concern on environment formed a small part of construction development. However, with the growing awareness on environmental protection due to the depletion of non-renewable resources, global warming and extremity of destruction to ecology and biodiversity impact, this issue is gaining wider attention by the construction practitioners.

Sustainable construction is a widely used concept now. It was introduced due to the growing concern about future of the planet, and it applies specifically for construction industry as, this being a huge consumer of natural resource. Sustainable construction is thus an aspect of sustainable development, defined as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Thus sustainable construction should make efficient use of resources while minimizing any adverse impacts on the environment.

The estimated waste generation during construction is 40 kg per m^2 to 60 kg per m^2. The highest contribution to waste generation comes from the demolition of buildings which on average generates between 300 kg per m^2 to 500 kg per m^2 of waste. In India, around 12 million to 14.7 million tonnes of construction and demolition waste are produced every year, seven to eight million tonnes are concrete and brick waste.

The disposal of these huge amounts of waste material places strain on landfill sites. On the other hand, the construction industry uses vast amounts of natural resources all around the world. Both these practices are damaging the environment and are no longer considered sustainable. *An obvious solution lies in the Re-use & Recycling of C & D waste*.

Concrete recycling has been identified throughout the world as part of the strategy on responsible management

of C & D materials. Utilization of concrete that uses RCA as a construction material is expected to contribute to solving the issue of lack of raw materials, and thus would allow the construction of infrastructures using a circulatory system for resources (Tokushige, 2007). In a similar line, a masonry waste like brick bats can also used as raw materials for the production of recycled brick, thus achieving sustainability in construction industry.

AIM AND OBJECTIVE:

Motivations for use of Brick powder as substitute materials in the brick manufacturing include: preservation of natural resources, effective utilization of the growing waste stream and energy savings. Currently an R&D effort in utilization of demolished masonry waste in brick making is not addressed in the Indian context. Hence an experimental study is carried out to assess the suitability of demolished waste in brick manufacturing.
The objectives of the present experimental study are as follows:

1. To study basic properties of demolished waste materials such as brick powder and recycled fine aggregate which is considered as potential materials for recycling.
2. To ascertain the proper mix proportion required for the manufacturing of Recycled bricks.
3. To study the properties of the recycled bricks made with different mix proportions.
4. To study the influence of curing methods on the strength of recycled bricks.

SCOPE OF THE STUDY:

The Experimental work deals with recycling of Masonry waste which is obtained from demolition of the building. The demolished waste is characterized based on physical properties. The demolished Masonry materials are collected from outer ring. In the present experimental study only three different mix proportions are considered with brick powder as a main constituent in the mix.

MATERIALS USED IN EXPERIMENT:

Brick Powder:

This material is obtained by crushing of demolished brick bats that is collected from the outer ring road of Mysore city. The collected waste is the solid form and is processed through Los Angeles Abrasion testing Machine with 8 spheres for 30 revolutions. The processed materials is in the form of powder and it is separated through IS 4.75mm sieve. For the experimental work, a material passing through IS 2.36 mm is used.

Fig: Demolished Masonry waste and Brick Powder after processing through abrasion testing machine

Recycled Fine Aggregate (RFA):

Is a material recovered by crushing of concrete waste in the laboratory. The Material is separated through IS 4.75 mm sieve. In the present experimental study a sample passing through IS 2.36 mm and retained 1.18 mm is used.

Fig: Recycled Fine aggregate recovered in the demolition of concrete waste

Natural Fine Aggregate (NFA):
Locally available river sand with maximum size of 4.75 mm are used as fine aggregate in the experimental study. In the present experimental study a sample passing through IS 2.36 mm and retained 1.18 mm is used.

Cement:
Ordinary Portland Cement (OPC) of 43 grade Zuari cement conforming was used. The physical properties of cement used in the experiment are tested according to Indian standards.

Water:
Potable water which is suitable for drinking is used for mixing.

TESTS ON MATERIALS:

Following are the tests conducted to ascertain the properties of the materials which are used in the manufacturing of the recycled bricks:

1. Sieve Analysis.
2. Specific Gravity.
3. Standard Proctor's Compaction Tests.

Table 1 : Properties of the materials used in the Experimental study

Material	Source of Material	Specific Gravity (SPG)	Fineness Modulus (FM)	Standard Proctor's Compaction (SPCT)
Recycled Fine Aggregate (RFA)	Is a material recovered by crushing of concrete waste in the laboratory	**2.27**	**3.14**	**11%**
Natural Fine Aggregate (NFA)	Locally available river sand.	**2.36**	**2.48**	**10%**
Brick Powder (BP)	Is a material obtained by crushing of demolished brick bats through abrasion testing Machine	**2.40**	**2.11**	**20%**

MIX PROPORTIONS AND SPECIMEN PREPARATION:

In the present experimental study, the waste materials such as brick powder and recycled fine aggregate along with the virgin sand is used to manufacture a brick. Three different mix compositions have been tried with 15% cement along 17% of water. The Mixes are designated as M1, M2 & M3. In these mixes Brick Powder constitute a major proportion of about 70% and other two materials in individual or combination constitute only 30%. The details of the mix in the study are given below:

- MIX-1 (M1) = 70 % BRICK POWDER + 30 % NFA
- MIX-2 (M2) = 70 % BRICK POWDER + 30 % RFA

- MIX-3 (M3) = 70 % BRICK POWDER + 15 % NFA + 15% RFA

The cement and the water content remains constant for all the mixes. The water content is decided based upon optimum moisture content of materials used in the study. The OMC of the brick powder, recycled aggregate and natural sand are 20%, 11% and 10% respectively. The OMC of the three mixes is hypothetically calculated from the individual material test results.
For Example, the OMC of the Mix-1 is calculated as follows:
70% of brick powder: water content
= 0.7 X 20 % (OMC of BP) = **14%**
30% of Natural fine aggregate: water content
= 0.3 X 10 % (OMC of BP) **= 3%**
Hence the OMC of the Mix-1=14% +3% **=17%**
A similar calculation is done with Mix-2 and Mix-3 and approximately same (17%) value is obtained for both the mixes. Hence a constant water content of 17% is maintained for all the three mixes. The cement content of 15% is used as a stabilizer for all the three mixes. The higher cement content is used in the study since the predominant material; brick powder has lower calcium and alumina content.

SPECIMENS FOR EXPERIMENTAL STUDY:

Initially a representative cube sample of size 70.6 X 70.6 X 70.6 mm is prepared and then compressive strength of the specimen is assessed at the end of 7 and 28 days in both wet and dry condition.

Fig: Cube Moulds (70.6 X 70.6 X 70.6 mm) used to prepare samples

Fig: Mould of size 222 X 106 X 73mm is used to make Recycled Bricks

RESULTS AND DISCUSSIONS:

The compressive strength of compressed recycled bricks (that is, the amount of pressure can resist without collapsing) depends upon the Material composition, type and amount of stabilizer and the compaction pressure used to the brick. Maximum strengths (described in MN/m^2) are obtained by proper mixing of suitable materials and attaining proper compacting and curing. In practice, typical wet compressive strengths for compressed stabilized earth building blocks may be less than 4 MN/m^2. Compressive strengths of bricks for the maturity age of 7 days and 28 days for different mix are presented in the following table:

Table 2 : Cubes Compressive Strength at 7 and 28 days of curing for Wet and Dry Condition (Spray curing)

Mix Designation	Wet Condition (MPa)		Dry Condition (MPa)	
	7 days	28 days	7 days	28 days
M1	3.52	3.78	4.17	6.86
M2	3.88	7.63	4.06	8.95
M3	3.8	5.3	3.34	5.28

From the test results, the cube compressive strength is much higher when it is tested under Dry condition. This result holds good for both 7 and 28 days of testing of cube specimen irrespective to that of the mix.
The cube compressive strength of Mix-2, which is made up of 30% Recycled fine aggregate is more than that of Mix-1which is made of 30% of virgin sand, this is may be due to the presence of unhydrated cement particles in the mix. However the Mix-3 which is made up of 15% recycled fine aggregate and 15% of virgin sand signifies a lesser strength than that of Mix-1 and Mix-2.
By considering the above test results of cube samples, bricks of similar mix proportions are casted and the compressive strength of the bricks are assessed at the end of 28 days. The average test results of three specimens of designated mix such as Mix-1, Mix-2 and Mix-3 are given in Table 4.

Tables 3: Bricks Compressive Strength at 28 days of curing for Dry Condition (Spray curing).

Mix Designations	Compressive Strength at 28 days (MPa)
M1	6.63
M2	7.17
M3	7.75

From the test results, the higher compressive strength of 7.75Mpa is noticed for the Mix-3 which constitutes of 15% of recycled fine aggregate and 15%of virgin sand. This results is quite opposite than that of representative cube sample which yields lower strength. The compressive strength of Mix-2 is about 7.17Mpa which is lower than cube strength of the same mix at 28 days of curing. The lowest compressive strength for Mix-1 which is 6.61 MPa correlates with the representative cube sample. Similar failure mode is observed for brick specimen of different mix proportion
Further, the test is conducted to assess the influence of the curing methods on the strength of the bricks. The results are tabulated below:

Table 4: Cubes Compressive strength at 28 days for different curing Methods

Mix Designations	Specimens in Dry Condition	
	Spray Curing	Water Immersion Curing
M1	6.86	5.72
M2	8.95	7.18
M3	5.28	5.7

The compressive strength of Mix-1 and Mix-2 at 28 days spray curing is much higher than that of the specimen which is immersed in water. However an insignificant result is observed with Mix-3 specimens, where the strength is slightly increased for the specimen that is immersed in water. From the available literature it is evident that the spray curing is a prominent method of curing for both blocks and bricks which holds good in the present experimental program.

Table 5 : Results of Water absorption Test

Mix Designation	Initial Weight of the Brick (kg)	Final Weight of the Brick (kg)	Water Absorption (%)
M1	3.09	3.425	10.84
M2	3.135	3.433	9.5
M3	3.14	3.46	10.19

From the water absorption test results indicates higher water absorption capacity for the Mix-1 which has 30% of virgin fine aggregate. The lower value is noticed for the Mix-2 bricks which signify denseness of the materials. However the test results for all the three mixes of bricks are within the permissible limit (should not exceed 15%) specified in IS 3495 (Part 2): 1992

CONCLUSION:

Based on the results obtained from the experiment the following conclusions are drawn:

- The brick powder and recycled fine aggregates which are derived from demolished waste can be used as a source material in the manufacturing of Recycled bricks.
- The chemical analysis of brick powder indicates the maximum silica content which is about 92%.This is one of the reasons for the usage of high percentage of stabilizer in the project.
- The various mix proportions which is considered in the study exhibits the compressive strength around 7Mpa with water absorption of 10 %(Average Value).
- The Recycled brick with 100% waste (Mix-2) containing 70% of brick powder and 30% of recycled fine aggregates shows impressive results in the study.
- The specimens which are tested in Dry condition have higher compressive strength than that of the specimen tested in wet condition.
- Spray curing is considered as the best method of curing for bricks which is outlined in the study.

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