DESIGN AND USAGE OF INORGANIC WASTE IN CONCRETE INTERLOCKING BRICKS

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Abstract : With advancement in material science and introduction of more sophisticated machinery in the production industries, we are now able to experiment and explore the possibility of using various materials together and do numerous tests to better a material's mechanical property. The materials that we have used are freely available and incorporates the values of green construction. The inorganic materials used are construction wastes and further strengthens our believe in green construction techniques. The materials used in this project are all freely available and does not require procurement. The reason for selecting saw dust and quarry dust is for partial replacement of sand. In most quarries, the dust from the machineries is often wasted and furthermore affects the environment. The similar case happens in terms of saw dust from saw mills and other wood-based industries. Using these two materials firstly decreases the environmental impact and secondly, helps in reducing the amount of sand used in the production of sand too. Apart from these two benefits, testes conducted on the prototype brick made from the combined materials of saw dust, risk husk, quarry dust and glass powder (silica powder), has shown improvement in both the physical and mechanical properties of the brick and it is also in accordance with international quality measures of cement mortar bricks.

***Index Terms* – Concrete, Waste material, Bricks, Partial replacement.**

I. INTRODUCTION

The increase in construction work require more of building materials in which brick is one of the most common and important masonry unit form past thousand years. Brick can be defined as modular unit which is connected using mortar that leads to the formation of a building unit or product. Bricks are one of the oldest types of building block that are perfect building material because they are relatively cheap to make, durable in nature, requires little maintenance and can be recycled.

Brick in past uses raw clay as their primary ingredient and it is referred as clay brick however concrete brick has become more favored material in present phase and time. Commonly the clay brick and concrete brick are widely used in construction as both materials have their own advantages over each other. The production of clay brick is simple and continuous process since the raw material is easily available from the environment. Concrete brick is also simple to produce if the ingredient is available at hand and can be manufactured on the site of construction. Portland cement being the main ingredient for concrete brick it is environmentally friendly.

The properties and performance can be further improvised by adding waste material to the brick. Waste material such as waste container glass, fly ash, rice husk, sugarcane and lime stone powder. The addition of such waste material to the brick improves the strength, durability, appearance, benefits environment by reducing the solid waste from landfills and economic benefits due to reduction in the volume of waste material per unit produced.

II. METHODOLOGY OF FORMWORK OF MOULD

It's the process of creating temporary mould where the mixture of materials is poured into the mould to form a brick. Mould is made in required shape of the brick with the help of wood and ply with removal screw and nails.A dry pine wood of 5cm thickness is cut into two rectangular shape of length 29cm and height of 9cm each. Another two square shape of size 9cm each is made. For a base a length of 29cm and width of 19cm is prepared. Rectangular pieces are faced each other and square pieces are faced each other and finally the base is attached and fixed together with removal screws and nails as shown below in Fig. 1.

The brick size is 190*90*90 mm and the mould's interior are kept as same size of that brick. Before a mould is are fixed, for easy removal of brick a kitchen oil is applied.

Figure 1.1: Foam work of mould

III. RESEARCH METHODOLOGY

3.1 Material Used

With advancement in material science and introduction of more sophisticated machinery in the production industries, we are now able to experiment and explore the possibility of using various materials together and do numerous tests to better a material's mechanical property. The materials that we have used are freely available and incorporates the values of green construction. The inorganic materials used are construction wastes and further strengthens our believe in green construction techniques.

The material of a concrete bricks consists of Portland cement (PC), Rice husk ash (as partial replacement of cement) which has high amount of amorphous silica and it leads to strength development, initial permeability of the mixed concrete, initial surface absorption and resistance of the concrete bricks.

1. Organic waste material:

• Saw dust (partial replacement of sand): Saw dust has a significant influence on the thermophysical and mechanical behavior of the bricks.it lighten the bricks and provide sound insulation.

• Rice husk ash (RHA) (partial replacement of sand): RHA are usually agricultural waste and an environmental hazard which are the residue product from rice husk. When the rice husk is burnt in presence of oxygen it produces the ash which can be used as fillers for plastics materials.

2. Inorganic waste material:

• Quarry dust (partial replacement of sand): Quarry dust may be a workaround or alternative to natural send in the construction industry as the demand of these materials are high.

• Glass powder: Glass is an excellent recycling material. Glass powder is a pozzolanic substance. When used in the proper proportions, glass powder improves the strength and toughness of bricks. Glass is a chemically inert element that can be recycled and reused several without losing its properties and the properties of the glass powder should match those of the cement. Glass is crushed into specified sizes for use as aggregate in various applications such as water filtration, grit plastering, and sand replacement in concrete.

Ratio of Material

• OPC Cement -50%, 53%,56%
• Rice husk ash-10%,8%,6%
• Quarry dust-15%,13%,11%
• Saw dust-10%,8%,6%
• Glass powder-5%,4%,3%
• Sand-10%,14%,18%

3.2 Testing

3.2.1 Primary Testing

1. Slump test

The most common way to determine concrete consistency is the slump test, which can be performed in a laboratory or on the construction site. It's not a smart option to use it on very wet or very dry concrete. It does not account for all factors that influence workability, nor is it always indicative of the concrete's placibility.

Based on the slump test performed on all the three sets of brick with water ratio 0.45, 0.5 and 0.6, they all fall between the range of 25-50 mm which is best suited for our work.

Taking the water cement ratio to be 0.5, the slump value of the mixture use are as follows:

• Brick from first set = 32mm
• Brick from second set = 34mm
• Brick from third set = 30 mm

The slump of concrete indicates Low Degree of workability and the pattern of slump is shown True Slump.

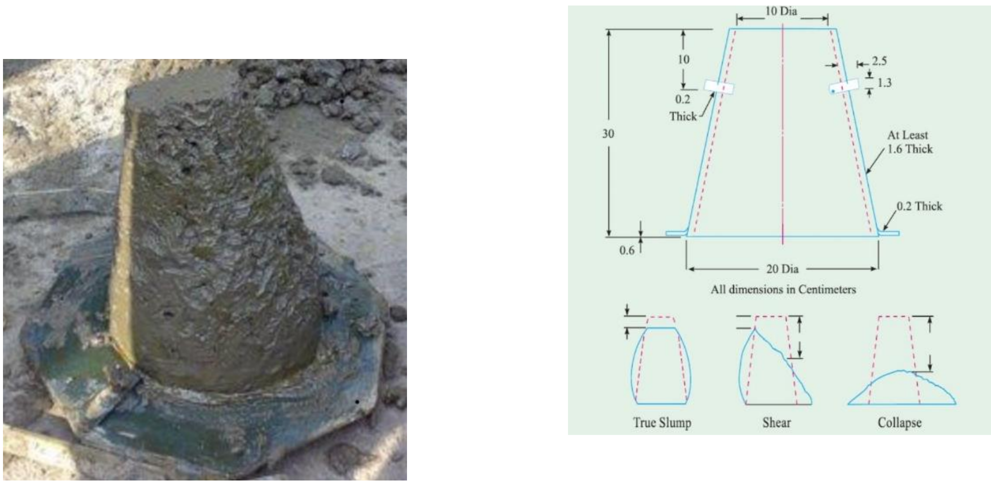


Figure 3.1: Slump test

2. Compaction Factor test

Although developed for use in the laboratory, the compacting factor test can also be used in the field. It is more accurate and sensitive than the slump test, and it is particularly useful for very low workability concrete mixes, which are often used when concrete is compacted by vibration. The process is applicable to plain and air-entrained concrete manufactured of lightweight, medium weight, or hard aggregates with a nominal maximum size of 40 mm or less, although it is not applicable to aerated or no-fines concrete.

The compacting factor, Fc can be calculated as follows:

$$The\ compacting\ factor\ (Fc) = \frac{Weight\ of\ partially\ compacted\ concrete\ (Wf)}{Weight\ of\ fully\ compacted\ concrete\ (Wp)} \qquad (1)$$

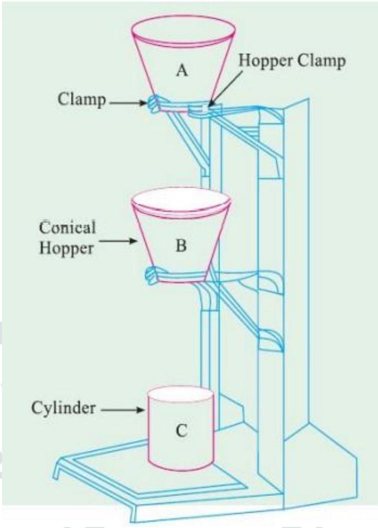


Figure 3.2: Compacting Factor Apparatus

3.2.2 Secondary Testing

1. Water absorption test

The amount of moisture content absorbed by bricks under extreme conditions is determined by an absorption test. Dry brick samples are taken and weighed in this test. Following the measuring, the bricks are immersed in water for a duration of 24 hours. After 24h the wet bricks are weighed and note down its value. The difference between the wet bricks and dry bricks indicates the amount of water absorbed by the bricks.

Bricks are subjected to water absorption tests to assess their durability properties, such as degree of burning, consistency, and weathering behavior. Since pores in bricks absorb water, water absorption tests may be used to assess the degree of compactness.

Calculation of water absorption of bricks

Water absorption (%) = [(W2-W1) / W1] x 100 (2)

Where;

W1 = Dry Brick Weight (oven Dry Condition after 24 hours at temperature 110 to 150 °C)

W2 = Wet Brick Weight (After Immersion for 24 Hour)

A total of three bricks from each set are weighed (wet bricks and dry) and then an average value is taken for water absorption test.

2. Soundness test

The nature of bricks against sudden impact is demonstrated in soundness test. Two bricks are selected at random and struck against each other in this test. The sound made should be a simple bell ringing sound, with the brick not breaking. Then it's considered strong brick.

3. Structure of bricks

A random brick is picked and break it. The inner portion should be compact and free from lumps and holes.

4. Hardness test

A brick is said to be hard enough if there is no impression left on the surface of bricks while scratch by fingernails.

5. Crushing strength or compressive strength test on bricks

For a crushing strength of a bricks a compression testing machine is used. A brick is placed in compression testing machine and loaded are applied until the bricks breaks.

A value of failure load is noted and crushing strength of bricks is calculated.

$$Compressive\ Strength = \frac{Maximum\ Load\ at\ Failure(N/mm2)}{Area\ of\ Specimen\ (mm2)} \qquad (3)$$

Figure 3.3: Universal Testing Machine

6. Thermal Conductivity Test
   Thermal conductivity was measured by the Quick Thermal Conductivity Meter (QTM-500) with sensor probe (PD-11) which uses transient technique (non-steady state) to study the heat conduction of samples.

IV. Data Analysis And Results

4.1 Slump Test Results

Table 4.1: Data on W/C ratio and Slump

Sr. No	Water/Cement Ratio	Slump value(mm)		
		Brick from first set	Brick from second set	Brick from third set
1	0.45	28	30	26
2	0.5	32	34	30
3	0.6	40	42	38

Graph 4.1: Slump Vs W/C Ratio

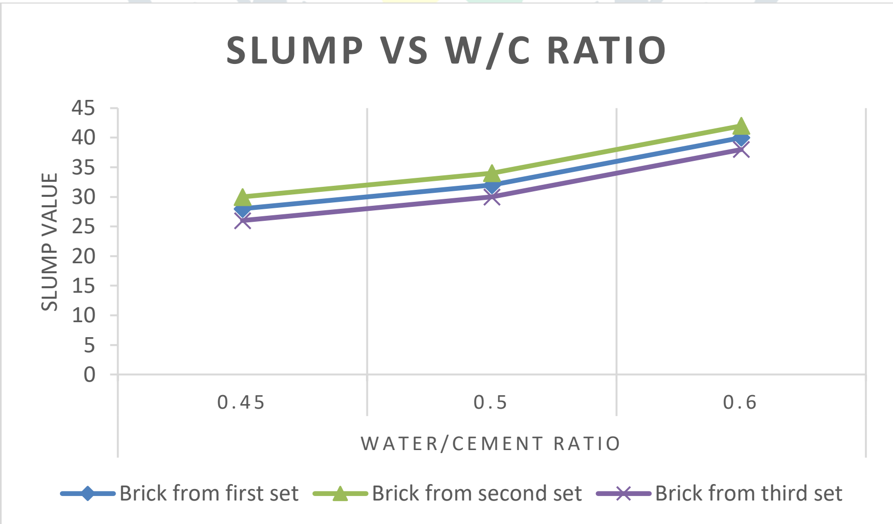
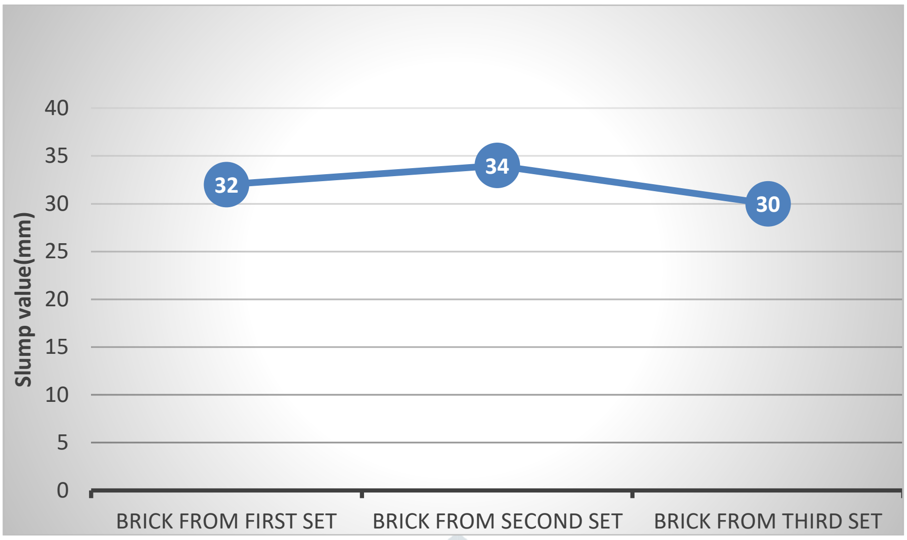


Table 4.2: Data on Data on workability and pattern based on slump value

Sr. No	Sample	Water/Cement Ratio	Slump value(mm)	Degree of Workability	Pattern of Slump
1	Brick from first set	0.5	32	Low	True
2	Brick from second set	0.5	34	Low	True
3	Brick from third set	0.5	30	Low	True

Graph 4.2: Slump value for Bricks with w/c as 0.5

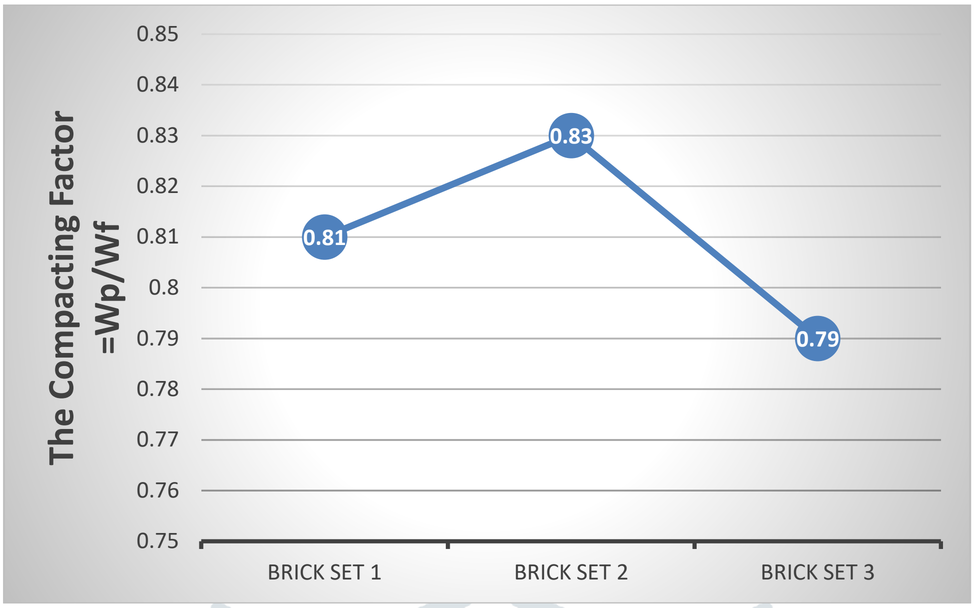


4.2 Compacting Factor Test Result

Table 4.3: Calculated data for the compaction factor(Fc)

Sr. No	Description	Brick Set 1	Brick Set 2	Brick Set 3
1	Weight of Empty Cylinder (W1)	7.245	7.245	7.245
2	Weight of Cylinder + Partially Compacted Concrete (W2)(Kg)	17.330	16.505	15.5
3	Weight of Cylinder + Fully Compacted Concrete (W3) (Kg)	19.730	18.405	17.625
4	Weight of Partially Compacted Concrete (Wp=W2-W1) (Kg)	10.09	9.26	8.225
5	Weight of Fully Compacted Concrete (Wf=W2-W1) (Kg)	12.485	11.16	10.38
6	The Compacting Factor =Wp/Wf	0.81	0.83	0.79

Graph 4.3: Compacting Factor based of sets of bricks

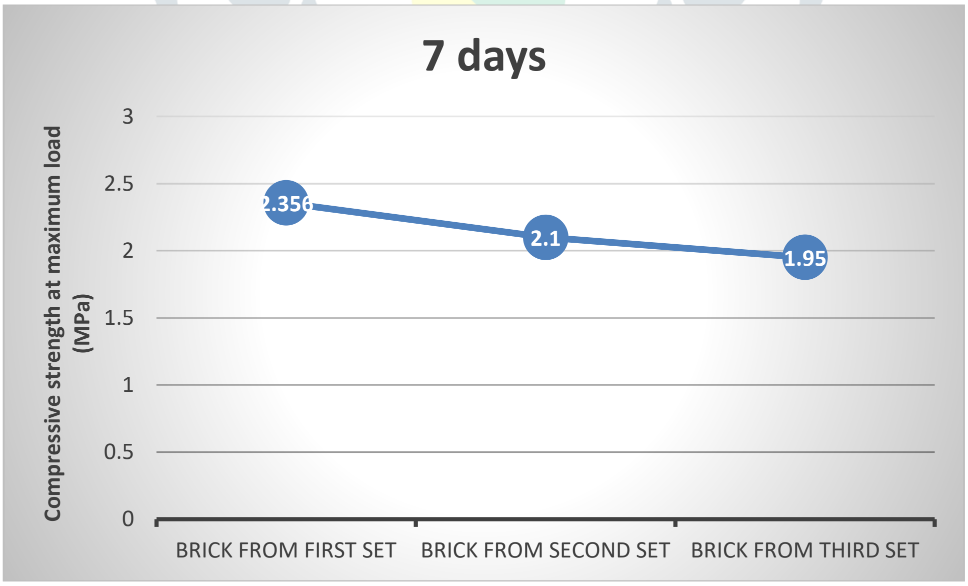


4.3 Compressive strength

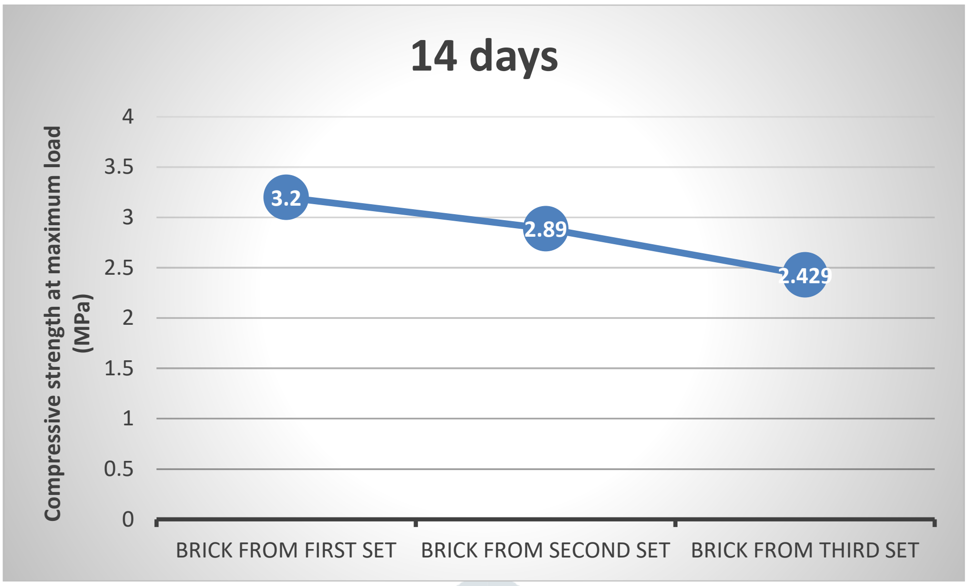
Table 4.4: Calculated data for the compaction factor(Fc)

Compressive strength at maximum load (MPa)			
Sample	7days	14days	28days
Brick from first set	2.356	3.20	4.910
Brick from second set	2.100	2.890	4.350
Brick from third set	1.950	2.429	3.590

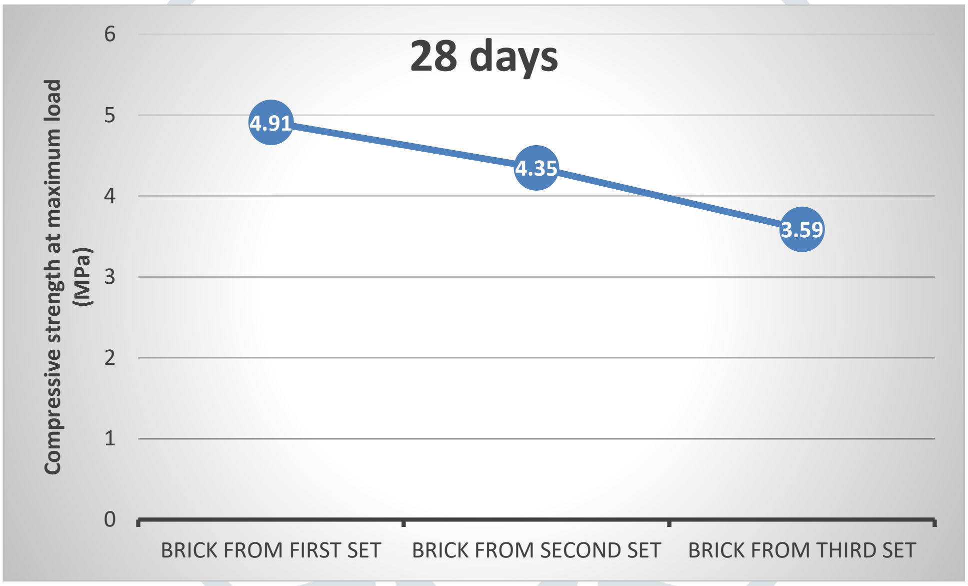
Graph 4.4: Compressive strength of bricks at 7 days



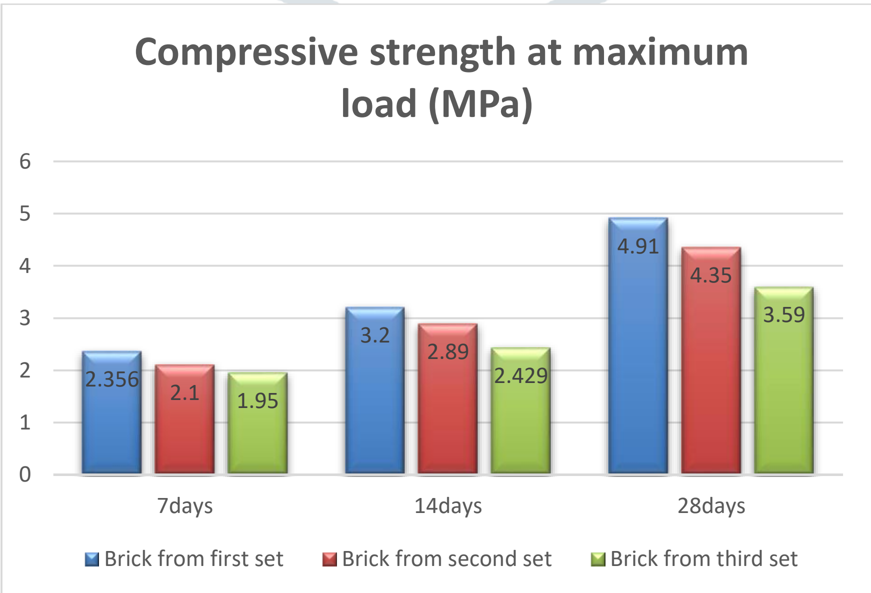
Graph 4.5: Compressive strength of bricks at 14 days



Graph 4.6: Compressive strength of bricks at 28 days



Graph 4.7: Compressive strength at maximum load

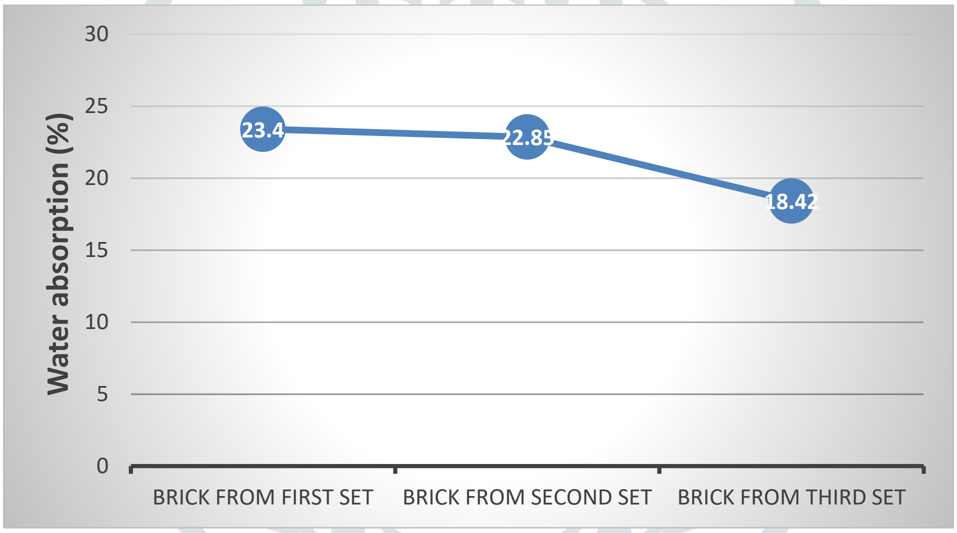


4.3 Water absorption Test

Table 4.5: Data on water absorption in percentage

Sample	Weight of wet brick(kg)	Weight of dry brick(kg)	Water absorption (%)
Brick from first set	4	3.2	23.40
Brick from second set	4.3	3.5	22.85
Brick from third set	4.5	3.8	18.42

Graph 4.8: Water absorption percentage by each brick



V. Conclusion

As we started doing this project we had in mind, certain goals and aims that we wanted to fulfill and certain ideas that we wanted to test and experiment on. Those were:

Aim/ outcome:

- To know the compatibility of using organic and inorganic waste in concrete bricks.
- To implement green construction methods and techniques in construction.
- To achieve improvement in mechanical property of the brick.
- To make a brick that is eco-friendly and economical.

Now as the project came to a conclusion, we can say that although not all ideas and aspirations were fulfilled, most of them were completed. After performing various tests and experiments, we can conclude that it is possible to add and mix certain inorganic and organic material in the production of bricks, but only a small quantity. Additionally, using waste materials such as saw dust, quarry dust and glass powder as the primary materials in the production of the prototype, we also implemented green construction methods and techniques in this project. After various tests, we can also conclude from the results that there was a slight improvement in the compressive strength in the prototype brick. And since the bricks were made of waste materials, it can also be classified as an eco-friendly brick and its production is also economical.

VI. Acknowledgment

We are very thankful to all researcher those who have done a research in the field of concrete technology and use of waste material in concrete brick making. They have done an excellent work to save the environment for the future generation. We are also very thankful to Mr. Humaib Nasir (Assistant Professor, LPU) who have been constant source of inspiration, guidance and encouragement.

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