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Comparative Study of Solid and Hollow Laterite Soil Cement Press Brick for Different Proportion

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Abstract: ***Brick is one of the important construction materials in the building. There are so many different types of bricks present in the market, like burnt brick which is the most common brick used in the construction industry. There are so many disadvantages of burnt brick like air pollution, wastage of material, not proper baking, etc. For this brick, laterite soil cement press brick is the best option and can be used effectively in future. In this project the solid and hollow brick of laterite soil cement press brick were formed by varying proportion of fly ash. The tests like compressive strength, water absorption and density were performed and compared for solid and hollow bricks with different proportion. The compressive strength test was performed on compressive testing machine. From this project, it was observed that by decreasing the fly ash content, compressive strength increases.***

Keywords: laterite soil cement press brick, compressive strength, Fly ash, water absorption.

I. INTRODUCTION

Brick is the basic construction unit for any building. There are different types of bricks available in the market. These bricks are burnt brick, cement brick, fly ash brick, hollow concrete block etc. There is need to choose other alternative for common clay burnt brick as this brick leads to air and soil pollution during manufacturing process. The new technologies are coming in the market for manufacturing of brick and these technologies are needed to be studied so as to implement them effectively in future. The comparative study is also need to be done to analyze the effectiveness of upcoming brick in market over the common clay burnt brick.

A. Material used for laterite soil cement press brick

1) Laterite Soil

- Laterite soil is obtained from the waste from the laterite stone quarries. The powdered form of laterite stone which is considered as wastage in quarries is useful for the manufacturing of brick.
- Laterite soil is red in color due to presence of iron oxide.
- Laterite soil has good porous properties which is the advantage of this soil.
- Laterite is mostly available in the coastal region of Maharashtra.

Fig. 1: Laterite soil

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2) Fly Ash

- Fly is the by product from the coal industries which is collected by the electrostatic precipitator.
- Fly ash is environment friendly, safe and economical building material.
- Use of fly ash in construction industry reduces the environmental impact due to direct disposal.

Fig. 2: Fly ash

3) Cement

- Cement used in brick gives strength after curing.
- The good quality of cement is required to use in manufacturing of brick.
- 53 grade of cement is used in brick.

Fig. 3: Cement

4) Coal

- The residue collected from the burnt coal in the industry known as coal ash is used for the manufacturing of brick.

Fig. 5: Coal

5) Hardener Chemicals

- The chemical used in brick is as accelerator and hardener.
- The accelerator is used to boost the speed of setting time and rate of strength gain.
- Hardeners are used to increase the hardness of the brick.

Fig. 6: Hardener chemical

6) Water

- The clean water is used for the manufacturing of brick.
- The pH of water should be 6 to 7.

B. Advantages of laterite soil cement press brick over burnt clay brick:

1) For the manufacturing of burnt clay brick, burning of brick is required which leads to the air and soil pollution, but in manufacturing of laterite soil cement press brick the bricks are cured using minimum water.

2) The size of each brick of laterite soil cement press brick is same while there is difference between sizes of each burnt clay brick.

3) Because of uniform size of laterite soil cement press brick, the construction of this brick is aesthetically good than burnt clay brick construction.

4) The wastage of burnt clay brick is more than laterite soil cement press brick because of non-uniform size and baking of burnt clay brick.

5) All burnt clay bricks are not uniformly baked hence there is depreciation in the quality of brick. In case of laterite soil cement press brick, baking is not required but uniform curing forms the uniform quality of bricks.

6) For laterite soil cement press brick less surface mortar is required but more surface mortar is required for burnt clay brick.

C. Disadvantages of laterite soil cement press brick over burnt clay brick:

1) The cost per brick of laterite soil cement press brick is more than burnt clay brick.

2) Weight of laterite soil cement press brick is more than burnt clay brick.

3) Skilled labor is required for the manufacturing of laterite soil cement press brick.

4) The material required for burnt clay brick is locally available but in case of laterite soil cement press brick the material is not locally available.

II. EXPERIMENTAL DETAILS

A. Proportions of material:

1) Proportion as Per Existing Plant: The first proportion was considered as per the existing brick manufacturing plant i.e. 1:1.25:1.25:3 (cement: fly ash: coal: laterite soil). The material quantity for one brick is as follows:

Table No: 1
NORMAL PROPORTION

Sr. No.	Material	Weight (kg)
1.	Cement	0.16
2.	Fly ash	0.2
3.	Coal	0.2
4.	Laterite soil	0.72

2) Proportion as per Increased Fly Ash: The second proportion was considered by increasing fly ash content by 20%. Thus the proportion of material modifies as 1:1.50:1.25:4.25. The material quantity for one brick is as follows:

Table No: 2
PROPORTION BY INCREASING FLY AS

Sr. No.	Material	Weight (kg)
1.	Cement	0.16
2.	Fly ash	0.24
3.	Coal	0.2
4.	Laterite soil	0.68

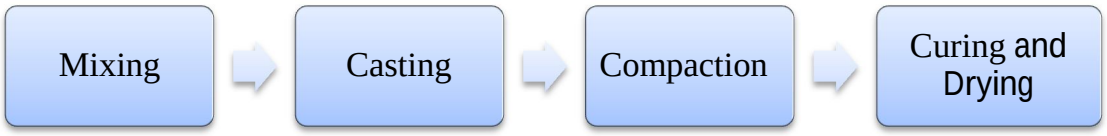
3) *Proportion as per Decreased Fly ash:* The third proportion was considered by decreasing fly ash content by 20%. Thus the proportion of material modifies as 1:1:1.25:4.75. The material quantity for one brick is as follows:

Table No: 3
PROPORTION BY DECREASING FLY ASH

Sr. No.	Material	Weight (kg)
1.	Cement	0.16
2.	Fly ash	0.16
3.	Coal	0.2
4.	Laterite soil	0.76

B. Preparation of brick:

The flow chart for the preparation of brick is as follows:



1) Mixing of Material

Hand mixing: The process is done on the rectangular pan until a homogenous mix is obtained. All constituent material must be uniformly mixed with a trowel so that no lumps should exist.

Fig. 7: Mixing

The dry ingredients laterite soil, fly ash, coal and cement are thoroughly mixed. After proper mixing of dry ingredients, the wet ingredients like water and chemical are added and the mixture was again mixed with trowel.

2) *Casting of Brick:* The solid and hollow bricks were casted using the mold prepared with the desired dimensions of 3-inch X 4-inch X 9-inch.

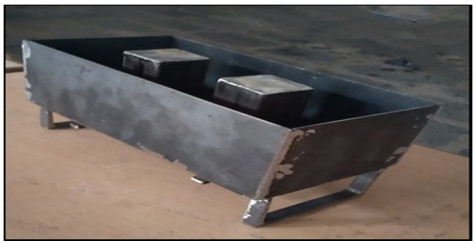


Fig. 8: Mold size

The oil was applied from inner sides of mold so that brick will be removed easily from the mold. The bricks were casted in three layers and compaction was done at each layer to minimize the voids in the brick. For each layer 25 blows were given for the compaction. Total 18 solid bricks and 18 hollow bricks, 3 bricks for each test and proportion were prepared.

Fig. 9: Hollow bricks

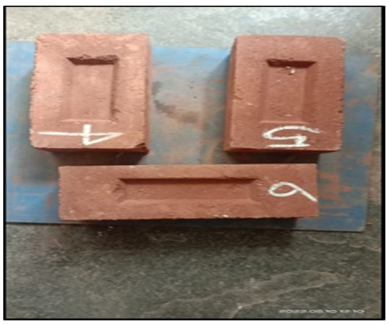


Fig. 10: Solid bricks

3) *Compaction:* Compaction was done through tamping bar; minimum 25 strokes was done in all parts of a cube for proper compaction. This tamping bar has the dimension of diameter 16mm and length of 0.6m. The proper compaction gives strength to the brick.
4) *Curing and Drying:* Curing is one of the important steps in manufacturing of laterite soil cement press brick to gain the desired strength. The brick specimens were immersed in water for 8 days for curing. After removing bricks from water, drying was done for 2 days.

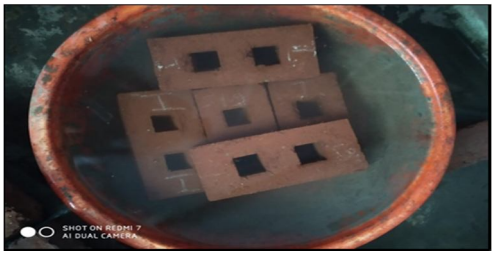


Fig. 11: Curing


Fig. 12: Drying

C. Compressive strength of Brick

Compressive strength is one of the important parameters to check the quality of brick. Compressive strength is calculated from the force and area in contact. There are mainly three types of brick on the basis of compressive strength:

1) First class brick: 10.5 N/mm^2
2) Second class brick: 7 N/mm^2
3) Common building brick: 3.5 N/mm^2

Compressive strength is measured in compression testing machine (CTM).

Fig. 13: Compression testing machine

The procedure adopted for determination of compressive strength for this project is as follows:

a) Place the prepared mix in the mold for casting.
b) Once it sets, after 24 hours remove the brick from the mold.
c) Then specimen was kept in water for 8 days.
d) Ensured that brick specimen was well dried before placing it on the CTM.
e) Weight of samples was noted in order to proceed with testing.

Fig. 14: Brick weighing

a) Testing specimen was placed in the space between bearing surfaces.
b) Care must be taken to prevent the existence of any loose material or gritted on the metal plates of machine or specimen blocked
c) The brick specimen was placed on bearing plate and aligned properly with the center of thrust in the testing machine plates.
d) The loading must be applied axially on specimen without any shock and increased at the rate of 140kg/sq.cm/min till the specimen collapsed.
e) Due to the constant application of load, the specimen started cracking at a point & final breakdown of the specimen was noted

Fig. 15: Failure of brick

f) The readings of failure loads were recorded in the CTM.
g) From the failure load and surface area, the calculations were done for calculating compressive strength.

Compressive strength= Load / surface area

D. Water Absorption Test

Water absorption capacity of brick gives idea about the strength of brick masonry. If the dry brick absorbs more water than the recommended limits then the mortar becomes dry and weak which leads to reduce the strength of masonry. If the brick is porous more water gets absorbed and there is rise in dampness of wall. Hence before using in construction, brick is needed to be tested for the water absorption.

The types of brick and water absorption limits are as follows:

Table No. 4
TYPES OF BRICK ACCORDING TO WATER ABSORPTION

Sr. No.	Type of brick	Water absorption
1.	First class	20%
2.	Second class	22%
3.	Third class	25%
4.	Heavy-duty machine-made bricks	5%

The procedure adopted for determining water absorption of brick is as follows:

1) Three specimens of each proportion of solid and hollow bricks were selected for the testing.
2) The bricks were dried after curing until they achieve the constant mass.
3) All the brick samples were weighed and recorded the weights of bricks (W_1).
4) Then the bricks were immersed in water at room temperature of about 27 ±2°C for 24 hrs.

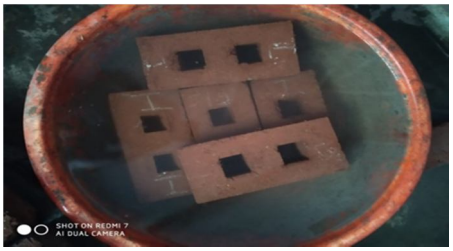


Fig. 16: Failure load reading

5) The bricks were removed from water after 24 hrs and the water was wiped out using a damp cloth.
6) The weights of bricks were again recorded (W2).
7) The water absorption of each brick was calculated using formula:

Compressive strength= Load / surface area

III. CALCULATIONS AND RESULTS

A. *Calculations for Compressive Strength of hollow Brick*

Some important conversion: 1 kg = 9.81 N

Surface area of brick = Total surface area – Area of holes = (230 X 101) – (2 X 37 X 37) = 20492 mm^2

1) Compressive strength of brick with normal proportion

a) Compressive strength of brick for specimen1

= Load carried by brick / surface area= (16000 X 9.81) / 20492= 7.66 N/mm^2

b) Compressive strength of brick for specimen2

= Load carried by brick / surface area= (10750 X 9.81) / 20492= 5.15 N/mm^2

c) Compressive strength of brick for specimen3

= Load carried by brick / surface area= (12750 X 9.81) / 20492= 6.10 N/mm^2

Average compressive strength of brick = (7.66 + 5.15 + 6.10) / 3 = 6.30 N/mm^2

Table No. 5
COMPRESSIVE STRENGTH OF HOLLOW BRICK FOR NORMAL PROPORTION

Sr. No.	Brick specimen	Load carried by brick (kg)	Compressive strength of brick (N/mm^2)	Average Compressive strength (N/mm^2)
1.	Specimen 1	16000	7.66	6.30
2.	Specimen 2	10750	5.15	
3.	Specimen 3	12750	6.10	

2) Compressive strength of brick by increasing fly ash content by 20%:

a) Compressive strength of brick for specimen1

= Load carried by brick / surface area= (11750 X 9.81) / 20492= 5.63 N/mm^2

b) Compressive strength of brick for specimen2

= Load carried by brick / surface area= (15250 X 9.81) / 20492= 7.30 N/mm^2

c) Compressive strength of brick for specimen3

= Load carried by brick / surface area= (11500 X 9.81) / 20492= 5.50 N/mm^2

Average compressive strength of brick = (5.63 + 7.30 + 5.50) / 3 = 6.14 N/mm^2

Table No. 6
COMPRESSIVE STRENGTH OF HOLLOW BRICK BY INCREASING FLY ASH BY 20%

Sr. No.	Brick specimen	Load carried by brick (kg)	Compressive strength of brick (N/mm^2)	Average Compressive Strength (N/mm^2)
1.	Specimen 1	11750	5.63	6.14
2.	Specimen 2	15250	7.30	
3.	Specimen 3	11500	5.50	

3) Compressive strength of brick by decreasing fly ash content by 20%:

a) Compressive strength of brick for specimen1
= Load carried by brick / surface area= (19250 X 9.81) / 20492= 9.21 N/mm^2

b) Compressive strength of brick for specimen2
= Load carried by brick / surface area= (20000 X 9.81) / 20492= 9.57 N/mm^2

c) Compressive strength of brick for specimen3
= Load carried by brick / surface area= (24000 X 9.81) / 20492= 11.49 N/mm^2

Average compressive strength of brick = (9.21 + 9.57 + 11.49) / 3 = 10.09 N/mm^2

Table No. 7
COMPRESSIVE STRENGTH OF HOLLOW BRICK BY DECREASING FLY ASH CONTENT BY 20%

Sr. No.	Brick specimen	Load carried by brick (kg)	Compressive strength of brick (N/mm^2)	Average compressive strength (N/mm^2)
1.	Specimen 1	19250	9.21	10.09
2.	Specimen 2	20000	9.57	
3.	Specimen 3	24000	11.49	

B. Calculations for Compressive Strength of Solid Brick

Some important conversion: 1 kg = 9.81 N

Surface area of brick = Total surface area = 230 X 101 = 23230 mm^2

1) Compressive strength of brick with normal proportion:

a) Compressive strength of brick for specimen1
= Load carried by brick / surface area= (11750 X 9.81) / 23230= 4.96 N/mm^2

b) Compressive strength of brick for specimen2
= Load carried by brick / surface area= (15500 X 9.81) / 23230= 6.55 N/mm^2

c) Compressive strength of brick for specimen3
= Load carried by brick / surface area= (14500 X 9.81) / 23230= 6.12 N/mm^2

Average compressive strength of brick = (4.96 + 6.55 + 6.12) / 3= 5.88 N/mm2

Table No. 8
COMPRESSIVE STRENGTH OF SOLID BRICK FOR NORMAL PROPORTION

Sr. No.	Brick specimen	Load carried by brick (kg)	Compressive strength of brick (N/mm^2)	Average compressive strength (N/mm^2)
1.	Specimen 1	11750	4.96	5.88
2.	Specimen 2	15500	6.55	
3.	Specimen 3	14500	6.12	

2) Compressive strength of brick by increasing fly ash content by 20%:

a) Compressive strength of brick for specimen1

= Load carried by brick / surface area= (11550 X 9.81) / 23230= 4.88 N/mm^2

b) Compressive strength of brick for specimen2

= Load carried by brick / surface area= (14000 X 9.81) / 23230= 5.91 N/mm^2

c) Compressive strength of brick for specimen3

= Load carried by brick / surface area= (14500 X 9.81) / 23230= 6.12 N/mm^2

Average compressive strength of brick = (4.88 + 5.91 + 6.12) / 3 = 5.64 N/mm^2

Table No. 9

COMPRESSIVE STRENGTH OF SOLID BRICK BY INCREASING FLY ASH BY 20%

Sr. No.	Brick specimen	Load carried by brick (kg)	Compressive strength of brick (N/mm^2)	Average compressive strength (N/mm^2)
1.	Specimen 1	11500	4.88	5.64
2.	Specimen 2	14000	5.91	
3.	Specimen 3	14500	6.12	

3) Compressive strength of brick by decreasing fly ash content by 20%:

a) Compressive strength of brick for specimen1

= Load carried by brick / surface area= (16750 X 9.81) / 23230= 7.07 N/mm^2

b) Compressive strength of brick for specimen2

= Load carried by brick / surface area= (17750 X 9.81) / 23230= 7.50 N/mm^2

c) Compressive strength of brick for specimen3

= Load carried by brick / surface area= (19500 X 9.81) / 23230= 8.23 N/mm^2

Average compressive strength of brick = (7.07 + 7.50 + 8.23) / 3= 7.6 N/mm^2

Table No. 10

COMPRESSIVE STRENGTH OF SOLID BRICK BY DECREASING FLY ASH CONTENT BY 20%

Sr. No	Brick specimen	Load carried by brick (kg)	Compressive strength of brick (N/mm^2)	Average compressive strength (N/mm^2)
1.	Specimen 1	16750	7.07	7.6
2.	Specimen 2	17750	7.50	
3.	Specimen 3	19500	8.23	

C. Calculations for Water Content of Hollow Brick

1) Water Absorption test of brick with normal proportion

a) Water Absorption of brick for specimen1

= [(W_2 - W_1) *100] / W_1= [(3.285 - 3.115) * 100] / 3.115=5.45 %

b) Water Absorption of brick for specimen1

= [(W_2 - W_1) *100] / W_1= [(3.250 - 3.060)* 100] / 3.060=6.20 %

c) Water Absorption of brick for specimen1

= [(W_2 - W_1) *100] / W_1= [(3.315 - 3.110) * 100] / 3.110=6.59 %

Average compressive strength of brick = (5.45% + 6.20% + 6.59%) / 3 = 6.08 %

2) Water Absorption test of brick by increasing fly ash content by 20%

a) Water Absorption of brick for specimen1

= [(W_2 - W_1) *100] / W_1= [(3.160 – 2.985) * 100] / 2.985=5.8 %

b) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(2.830 – 2.615)* 100] / 2.615 = 8.22\ \%$

c) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.050 – 2.920) * 100] / 2.920 = 4.45\ \%$

Average compressive strength of brick = (5.8% + 8.22% + 4.45%) / 3 = 6.1 %

3) Water Absorption test of brick by decreasing fly ash content by 20%

a) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.130 – 2.900) * 100] / 2.900 = 7.93\ \%$

b) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.030 – 2.860)* 100] / 2.860 = 5.94\ \%$

c) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.285 – 3.115) * 100] / 3.115 = 5.45\ \%$

Average compressive strength of brick = (7.93% + 5.94% + 5.45%) / 3 = 6.44 %

Table no: 11
WATER ABSORPTION OF HOLLOW BRICK

Sr. No.	Water Absorption of Hollow Brick (%)		
	Normal proportion	Increased fly ash	Decreased fly ash
1.	5.45	5.80	7.93
2.	6.20	8.22	5.94
3.	6.59	8.45	5.45
Avg.	6.80	6.10	6.44

D. Calculations for water Content of Solid Brick

1) Water Absorption test of brick with normal proportion

a) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.310 - 3.080) * 100] / 3.080 = 7.46\ \%$

b) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.295 - 3.155)* 100] / 3.155 = 4.43\ \%$

c) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.010 – 2.740) * 100] / 2.740 = 5.42\%$

Average compressive strength of brick = (7.46% + 4.43% + 5.42%) / 3 = 5.77%

2) Water Absorption test of brick by increasing fly ash content by 20%

a) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.030 – 2.900) * 100] / 2.900 = 4.48\ \%$

b) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.100 – 2.945)* 100] / 2.945 = 5.26\ \%$

c) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.050 – 2.955) * 100] / 2.955 = 7.81\ \%$

Average compressive strength of brick = (4.48% + 5.26% + 7.81%) / 3 = 5.85 %

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3) Water Absorption test of brick by decreasing fly ash content by 20%

a) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.160 – 2.932) * 100] / 2.932 = 7.77\ \%$

b) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.030 – 2.900)* 100] / 2.900 = 4.48\ \%$

c) Water Absorption of brick for specimen1

$= [(W_2 - W_1) *100] / W_1 = [(3.315– 3.110) * 100] / 3.110 = 6.59\%$

Average compressive strength of brick = (7.77% + 4.48% + 6.59%) / 3 = 6.28 %

Table no: 21

WATER ABSORPTION OF SOLID BRICK

Sr. No.	Water Absorption of Solid Brick (%)		
	Normal proportion	Increased fly ash	Decreased fly ash
1.	4.46	4.48	7.77
2.	4.43	5.26	4.48
3.	5.42	7.81	6.59
Avg.	5.77	5.85	6.28

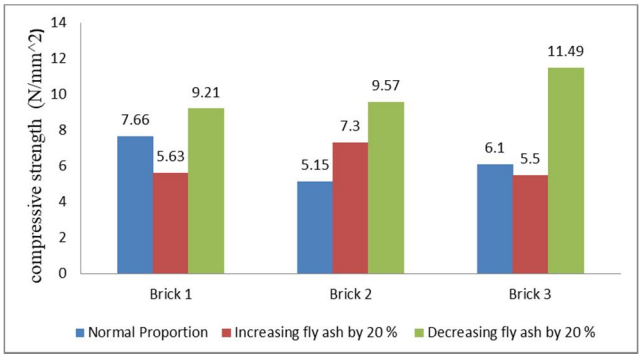

Fig. 17: Compressive strength of Hollow brick

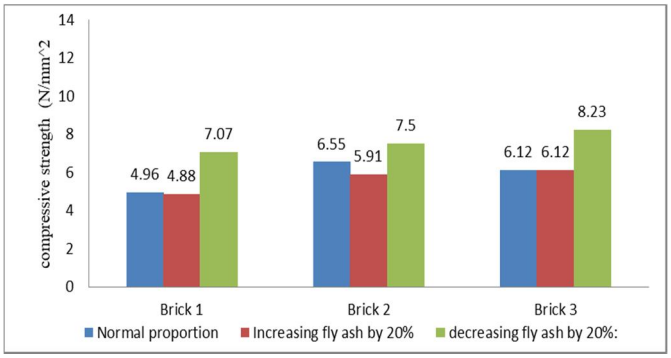

Fig.18: Compressive strength of Solid brick

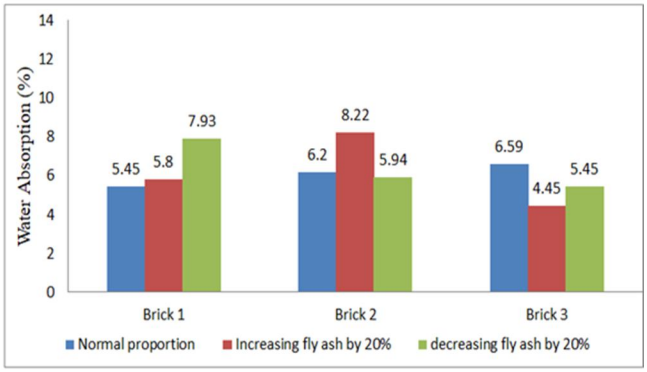

Fig. 19: Water Absorption content of Hollow Brick

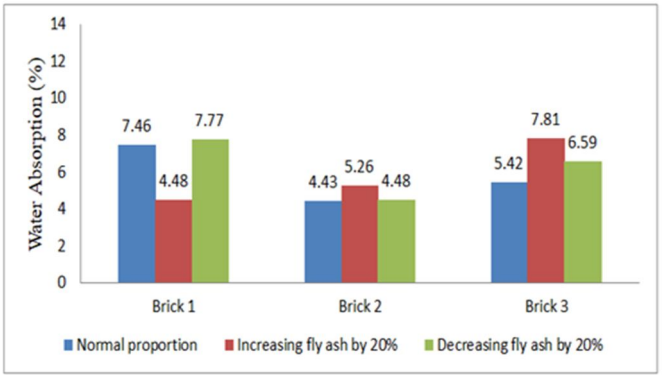

Fig. 20: Water Absorption content of Solid brick

IV. CONCLUSION

From above calculation and result, following conclusion are drawn:

1) As fly ash content increases, compressive strength decreases. By decreasing the fly content the compressive strength of brick increases and the brick can be classified as second class brick as per standard values; otherwise the brick is common building brick.

2) As fly ash increases, water content decreases and vice versa. All the bricks tested have water absorption less than 20% hence all the bricks are first class brick.

3) The compressive strength of solid brick is less than that of hollow brick because surface area of solid brick is more than the hollow brick.

4) Water absorption capacity of solid brick is less than the hollow brick because for water absorption hollow brick has more surface area due to holes to absorb water.

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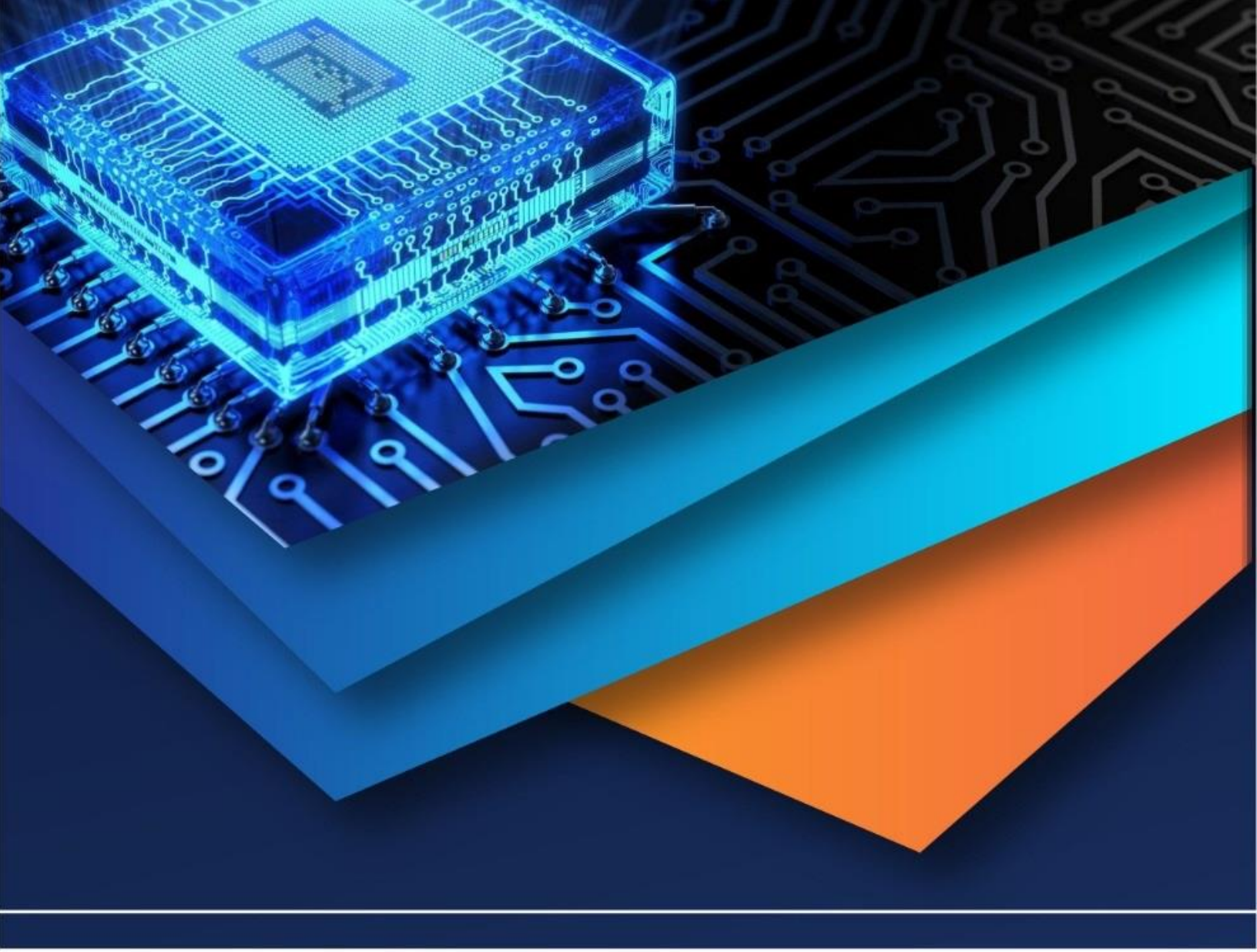

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