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UTILISATION OF CERAMIC TILE WASTE AND STEEL SLAG IN BRICK

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Abstract - *The sustainability of raw materials used in construction consume large quantities of materials of great importance. The major raw material in brick industry is clay. Ceramic tile waste and steel slag waste can be used as clay replacement at dosages of 5%, 10%,15%,20% and25% by weight of clay brick. These brick specimens with ceramic tile waste and steel slag waste were compared with that of the conventional bricks. This project report presents a comparative analysis of in corporating ceramic tile waste and steel slag waste as partial replacements for conventional clay in brick manufacturing. The study evaluates the mechanical, Physical, and environmental properties of the resulting bricks compared to traditional clay bricks. The project aims to assess the feasibility and sustainability of utilizing these industrial wastes in brick production, considering factors such as cost-effectiveness, strength, durability, and environmental impact. The experimental investigation involves varying proportions of ceramic tile waste and steel slag waste mixed with clay, followed by comprehensive testing including compressive strength, water absorption, density, and impact. Results indicate the potential of these waste materials to enhance certain properties of clay bricks while reducing environmental burden and promoting resource efficiency.*

The findings contribute to advancing sustainable practices in construction materials and provide insights for the adoption of alternative materials in the brick manufacturing industry. Bricks with ceramic tile waste are lighter with better insulation characteristics and increased porosity and using steel slag waste as a replacement in brick production can offer several benefits. Steel slag is a byproduct of steel production and is often used in construction due to its properties. Additionally, incorporating steel slag waste into bricks can contribute to sustainable construction practices by reducing the need for virgin materials and diverting waste from landfills. However, the exact properties of the bricks will depend on factors such as the percentage of steel slag used the manufacturing process, and any additives or treatments applied. Research and testing are typically conducted to ensure that the resulting bricks meet quality standards and performance requirements.)

Key Words: Steel slag, Ceramic tile, Traditional clay brick

1.INTRODUCTION

Clay consumption had been increasing by manufacturing of bricks. For conserving the resources and to reduce the waste dumping the manufacturing of brick can be utilised by the waste material. Ceramic tile waste and Steel slag is utilized in brick manufacturing which can save the resources such as clay. Ceramic tiles are made using clay. The ceramic tile waste is durable, hard and highly resistant to biological, chemical and physical degradation forces. The properties of these materials make them a good and suitable choice to be used in brick. Waste ceramic (WC) is produced majorly by ceramic industry. WC has different types like ceramic tile, waste ceramic powder (WCP), sanitary ware, and ceramic electrical insulator waste. Ceramic tiles are manufactured by firing natural materials such as clay, quartz, feldspar, sand, etc. Ceramics can be crushed and recycled into a range of useful products, and can be used in manufacturing of brick. The advantages of using waste ceramic dust as a clay replacement include reducing environmental impact and conserving natural resources.

Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. Virtually all steel is now made in integrated steel plants using a version of the basic oxygen process or in specialty steel plants (mini-mills) using an electric arc furnace process. The open hearth furnace process is no longer used. In the basic oxygen process, hot liquid blast furnace metal, scrap, and fluxes, which consist of lime (CaO) and dolomitic lime ($CaO.MgO$ or "dolime"), are charged to a converter (furnace). A lance is lowered into the converter and high-pressure oxygen is injected. The oxygen combines with and removes the impurities in the charge. These impurities consist of carbon as gaseous carbon monoxide, and silicon, manganese, phosphorus and some iron as liquid oxides, which combine with lime and dolime to form the steel slag.

1.1 THE METHODOLOGY FOLLOWED IN THIS PROJECT

- Collection of raw materials such as ceramic tile waste, clay, steel slag
- Preliminary testing of material

- Manufacturing process of brick
- Test on physical properties, mechanical properties, durability properties
- Plotting graphs
- Comparing the results

2. PRELIMINARY TESTING OF MATERIAL

Physical and chemical characteristics clay soil and tea waste such as chemical composition of clay soil, plastic limit, shrinkage limit, dry sieve analysis, hydrometer analysis and specific gravity were studied.

2.1 PLASTIC LIMIT OF CLAY

Plastic limit is the moisture content that defines where the soil changes from a semi solid to a plastic state. It may also defined as that water content at which soil starts crumpling when rolled in to threads of 3mm diameter.

Table 1; Plastic limit of clay

Container No	1
Weight of container, W_0 (g)	26
Weight of container + Wet soil, W_1 (g)	36
Weight of container + Oven dried soil W_2 (g)	34
Weight of water (W_1-W_2)	2
Weight of oven dried sample (W_2-W_0) g	8
Water Content (W_1-W_2)/(W_2-W_0) x 100	25

2.2LIQUID LIMIT OF CLAY

The liquid limit is the water content, expressed as percentage of the weight of oven dried soil at which the soil has a small shear strength. Liquid limit is determined using Casagrande's liquid limit device and grooving tool.

Table 2 Liquid limit values

Trail No.	1	2	3	4
No of blows	39	35	22	21
Weight of container (W_0)	30	30	30	30
Weight of wet soil (W_1)	40	44	45	48
Weight of dry soil (W_2)	38	40	40	42
Water content (%)	25	40	50	60

3. CASTING OF CUBES FOR TESTS.

Wooden brick mould size 200mm x 100mm x100mm was used for casting bricks. In this step, clay is cleaned of impurities such as stones, pebbles, plant roots etc. after removing impurities it is exposed to weather for few days. This is called weathering. After the completion of weathering process the lumps of clay are converted using a mechanical soil crusher or sieved. Similarly, the ceramic tile waste is cleaned of impurities and crushed in to powder and sieved .steel slag which is collected from Steel Industrials Limited Kerala had crushed to powder and sieved . dried raw materials are used for manufacturing of brick. After drying the raw materials, clay is mixed with tile waste for a set of brick and mixing clay with steel slag for another set. Small quantity of M sand slurry is also added to void cracking while burning. It is added at a percentage of 25. Required amount of water is added to the mixture. The mixture is then pressed or mixed so that the mixture obtain the plastic nature and now it is suitable for moulding.

Mixing ratio of raw materials is obtained by referring many papers given by various researcher Studies showed that clay can be replaced with waste materials by 5%, 10%, 15%, 20% and 25% by weight of clay. Therefore, the clay is replaced with 0%, 5%, 10%, 15%, 20% and 25% of tile waste and steel slag.

Moulding is the process where the prepared mixture is placed in a standard mould which forms it into the shape of a brick. In moulding process, prepared mixture is moulds into brick shape. Rectangular is preferred. Wooden mould of standard size 20 x 10 x 10cm are used. Required amount of clay, tea waste and M sand slurry are taken. Mould is placed on the ground and filled with brick mixture and compressed it by pressing to fill the corners of the mould. Extra clay mixture is taken off by levelling the surface of the mould. The mould is then lifted up and raw brick is kept on the ground. During moulding , inside surface of the mould is oiled. Two sets of bricks are cast done with tile waste and another with steel slag.

After moulding process the brick contains moisture in it. So, drying is to be done otherwise they may be cracked while burning. The drying of done is done by natural process called sun dry. The bricks are laid in stacks. Bricks are dried for a period of 7 days. The sun dried bricks are burned at 200 degree Celsius for more than 2 days. Next is cooling. Cooling is an important stage in brick manufacturing because the rate of cooling has direct effect on colour. Fired bricks are cooled to room temperature for less than 10 hrs.

3.1 WATER ABSORPTION TEST

Water absorption test n bricks is conducted to determine the durability property of bricks such as degree of burning quality and behaviour of bricks in weathering.

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Table 3 Water absorption of of sundry tile waste brick

SI No.	Specimen	Weight before Absorption f water (W_1) g	Weight after Absorption of water (W_2) g	% of Absorption Of water
1	Conventional clay brick	3000	3900	18.18
2	Bricks with 5% of tile waste	2665	3259	22.29
3	Bricks with 10% of tile waste	2694	3271	21.42
4	Bricks with 15% of tile waste	2706	3251	20.14
5	Bricks with 20% of tile waste	2722	3254	19.54
6	Bricks with 25% of tile waste	2733	3296	20.60

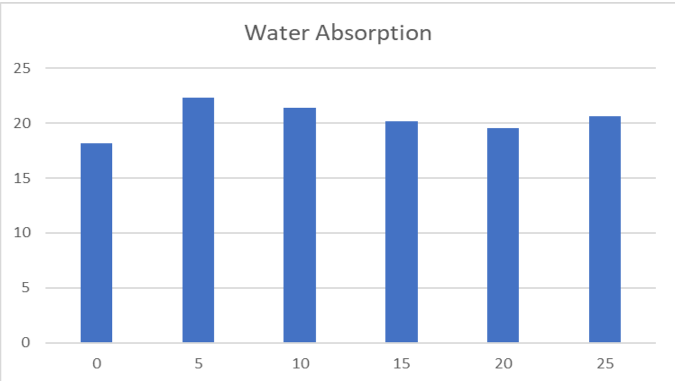

Fig 1 Water absorption graph sun dried tile waste bricks

Table 4 Water absorption of of oven dry tile waste brick

SI No.	Specimen	Weight before Absorption f water (W_1) g	Weight after Absorption of water (W_2) g	% of Absorption Of water
1	Conventional clay brick	3100	3700	19.35
2	Bricks with 5% of tile waste	2349	2820	20.02
3	Bricks with 10% of tile waste	2402	2870	19.48
4	Bricks with 15% of tile waste	2444	2906	18.90
5	Bricks with 20% of tile waste	2514	2970	18.13
6	Bricks with 25% of tile waste	2630	3156	20

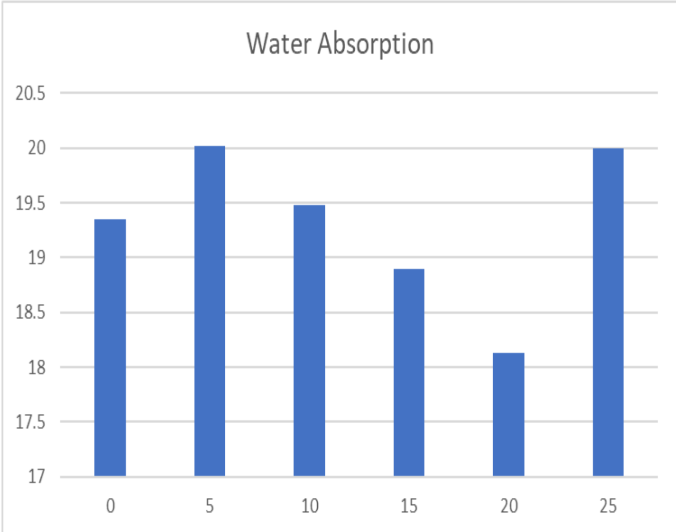

Fig 2 Water absorption graph oven dried tile waste bricks

The above graph shows that water absorption is high for sun dried brick than oven dried brick. Incase of oven dried brick water absorption is high at 5% and 25% .

Table 5 Water absorption of of sun dry steel slag brick

SI No.	Specimen	Weight before Absorption f water (W_1) g	Weight after Absorption of water (W_2) g	% of Absorption Of water
1	Conventional clay brick	3000	3600	20.00
2	Bricks with 5% of steel slag	2720	3299	21.29
3	Bricks with 10% of steel slag	2.755	3320	20.51
4	Bricks with 15% of steel slag	2.779	3340	20.18
5	Bricks with 20% of steel slag	2.783	3330	19.66
6	Bricks with 25% of steel slag	2.795	3312	18.50

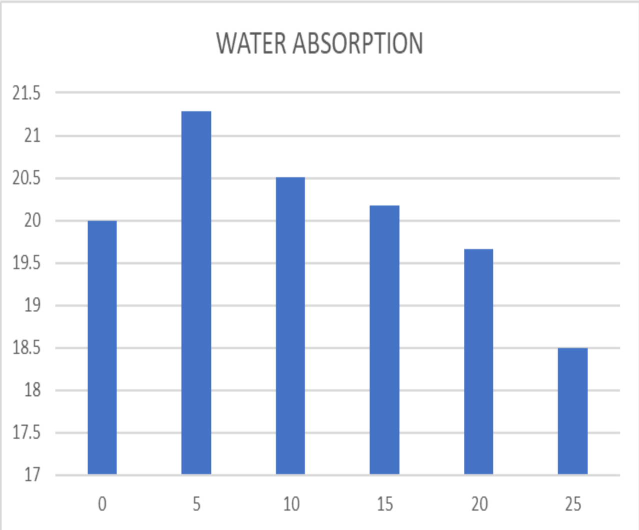

Fig 3 Water absorption graph sun dried steel slag brick

Table 6 Water absorption of ovendry steel slag brick

SI No.	Specimen	Weight before Absorption f water (W_1) g	Weight after Absorption of water (W_2) g	% of Absorption Of water
1	Conventional clay brick	2850	3412	19.72
2	Bricks with 5% of steel slag	2450	29992	22.12
3	Bricks with 10% of steel slag	2472	3012	21.84
4	Bricks with 15% of steel slag	2495	2990	19.84
5	Bricks with 20% of steel slag	2512	2998	19.35
6	Bricks with 25% of steel slag	2570	3053	18.79

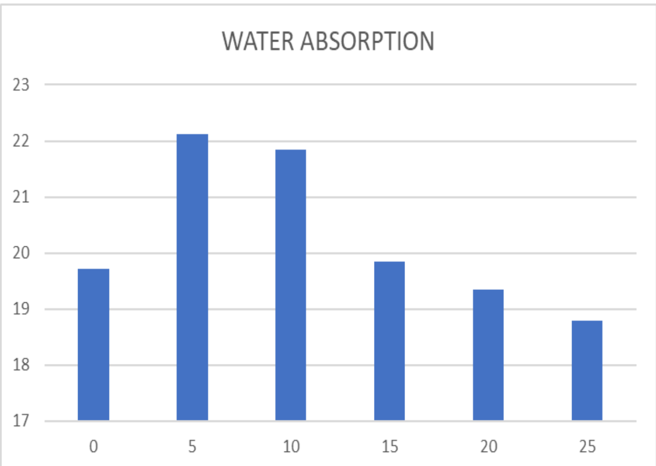

Fig 4 Water absorption graph oven dried steel slag bricks

2.3 BULK DENSITY TEST

Table 7 Bulk density

Test/brick	Conven tional Clay brick	5% brick	10% Brick	15 % brick	20% brick	25% brick
Bulk volume of brick, m^3	0.0015 39	0.001 539	0.001 539	0.001 539	0.000 539	0.001 539
Mass of dry brick, kg	2.550	2.450	2.472	2.495	2.512	2.570
Bulk density Kg/m^3	1851.8 5	1591. 94	1606. 24	1621. 18	1632. 23	1669. 92

Density indicates the weight of brick work. Density of brick depends on clay composition. Density of a conventional clay brick is around 2000 kg/m^3. The test shows that density of brick increases with additional 5%

In conclusion As one of the main functions of the soil is reflected in its bulk density, the soil must also support plants structurally, transfer water and other solutes, and provide aeration.

3.1 COMPRESSION TEST RESULTS

Table 8 compressive strength of sun dried brick sample with tile waste

Si No	Specimen	Cross sectional Area, mm^2	Load, KN	Compressive Strength, N/mm^2
1	Conventional clay brick	190 x 90	65.00	3.801
2	Brick with 5% tile waste	190 x 90	58.50	3.421
3	Brick with 10% tile waste	190 x 90	50.90	2.977
4	Brick with 15% tile waste	190 x 90	70.00	4.090
5	Brick with 20% tile waste	190 x 90	60.00	3.508
6	Brick with 25% tile waste	190 x 90	66.00	3.860

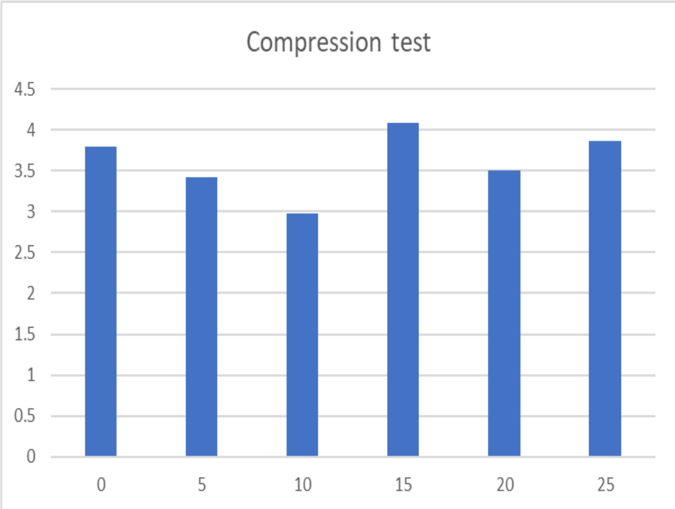

Fig 5 Compressive strength graph sun dried tile waste bricks

Table 9 compressive strength of oven dried brick sample with tile waste

Si No	Specimen	Cross sectional Area, mm^2	Load, KN	Compressive Strength, N/mm^2
1	Conventional clay brick	190 x 90	61.00	3.567
2	Brick with 5% tile waste	190 x 90	68.00	3.977
3	Brick with 10% tile waste	190 x 90	72.00	4.212
4	Brick with 15% tile waste	190 x 90	98.00	5.731
5	Brick with 20% tile waste	190 x 90	50.90	2.977
6	Brick with 25% tile waste	190 x 90	55.30	3.234

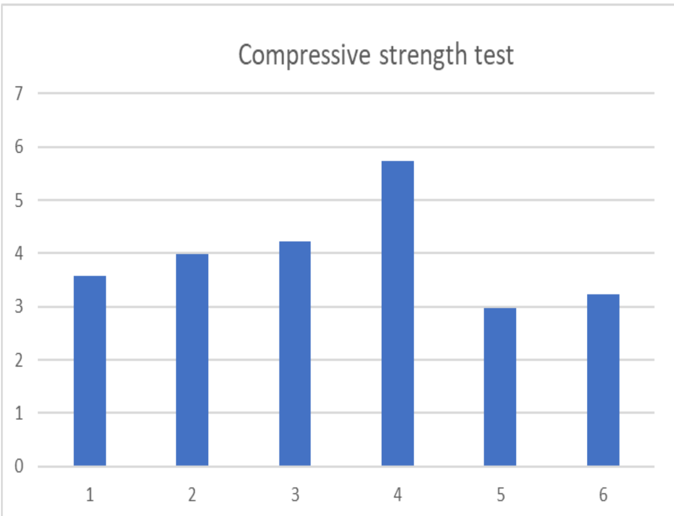

Fig 6 Compressive strength graph oven dried tile waste bricks

Table 10compressive strength of sun dried brick sample with steel slag

Si No	Specimen	Cross sectional Area, mm^2	Load, KN	Compressive Strength, N/mm^2
1	Conventional clay brick	190 x 90	70	4.094
2	Brick with 5% steel slag	190 x 90	65	3.801
3	Brick with 10% steel slag	190 x 90	101	5.906
4	Brick with 15% steel slag	190 x 90	69	4.035
5	Brick with 20% steel slag	190 x 90	60	3.508
6	Brick with 25% steel slag	190 x 90	51	2.982

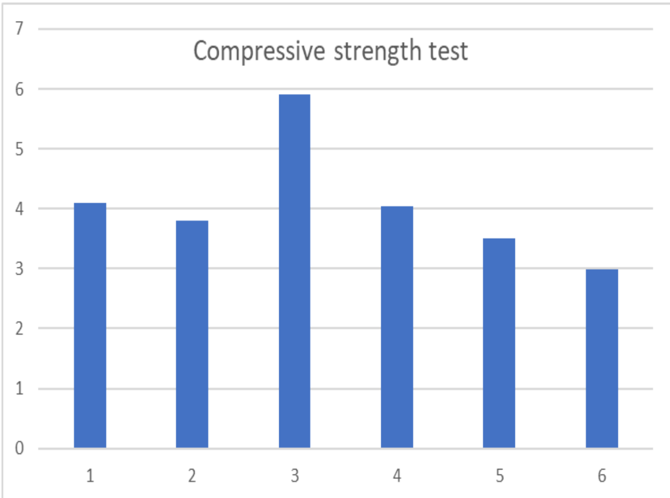

Fig 7 Compressive strength graph sun dried steel slag bricks

The compressive test results for brick samples with steel slag and oven dried brick samples are tabulated and the graph is plotted

Table 11 compressive strength of oven dried brick sample with steel slag

Si No	Specimen	Cross sectional Area, mm^2	Load, KN	Compressive Strength, N/mm^2
1	Conventional clay brick	190 x 90	75.00	4.356
2	Brick with 5% steel slag	190 x 90	69.00	4.035
3	Brick with 10% steel slag	190 x 90	115.00	6.725
4	Brick with 15% steel slag	190 x 90	72.00	4.210

5	Brick with 20% tile waste	190 x 90	66.00	3.860
6	Brick with 25% tile waste	190 x 90	59.00	3.450

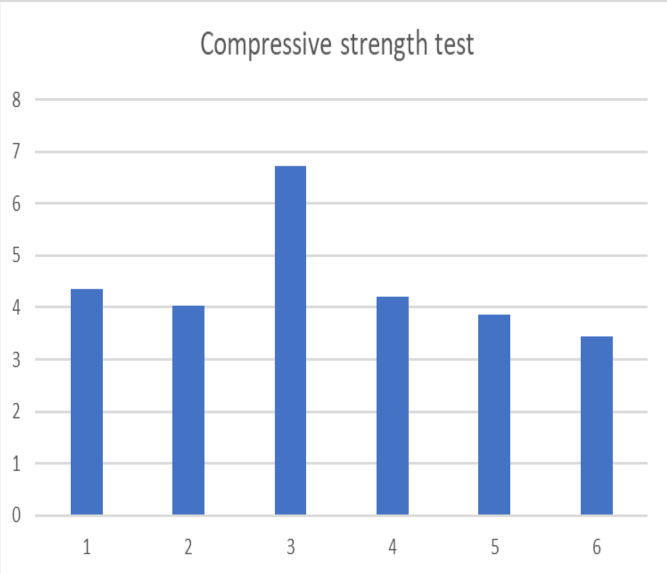

Fig 8 Compressive strength graph oven dried steel slag bricks

Based on the observations, the standard value of oven dried bricks and sun-dried bricks were compared to the values obtained in case of bricks with 5%, 10% ,15%,20%and25% ceramic tile waste and steel slag waste . The values are compared in the table given.

3. CONCLUSIONS

Clay bricks, as one of the most frequently used building materials, are a very interesting research material because of their durability, fire resistance, strength, aesthetic characteristics, insulating and many other properties. Visual inspection shows that the brick has constant shape and size. The hardness of the bricks was normal. There is no efflorescence in bricks with 0%, 5% ,10% and 15% in ceramic tile waste and 0%,5%,and10% in steel slag waste . Slight efflorescence was observed in brick with 20%and 25%ceramic tile waste and 15% ,20%,and 25% steel slag waste.

The impact test showed that the brick is sufficiently hard in both waste materials. The soundness of the bricks was also good. It produced a clear ringing sound. The compressive strength of bricks with 15% ceramic tile waste was higher than that of conventional clay brick both in sun-dried and oven dried condition and in 10% steel slag waste was higher than that of convectional clay brick both in sundried and oven dried. The water absorption of the brick increase with increase in tea waste addition up to 15%.

Based on the observations, the standard value of oven dried bricks and sun-dried bricks were compared to the values obtained in case of bricks with 5%, 10% ,15%,20%and25% ceramic tile waste and steel slag waste . The values are compared in the table given below:

Utilization of Ceramic Tile Waste in Brick:

Therefore, the optimum value was found to be 15%. The result shows that compressive strength and efflorescence of the brick can be improved by adding tea waste as additives. Thus, due to these beneficial properties, an economic and environmental friendly bricks were prepared.

Utilization of steel Slag waste in Brick:

Therefore, the optimum value was found to be 10%. The result shows that compressive strength and efflorescence of the brick can be improved by adding tea waste as additives. Thus, due to these beneficial properties, an economic and environmental friendly bricks were prepared.

Based on the observations, the standard value of oven dried bricks and sun dried bricks were compared to the values obtained in case of bricks with 5%, 10%, 15%, 20%, 25% tile waste and steel slag.

The values are compared in the table given below.

Brick with ceramic tile waste are given below

SI No.	Specimen	Bulk Density	Water Absorption	Compressive strength (sun-dried)	Compressive strength (Oven-dried)
1	Conventional clay brick	1851.85	18.18	3.801	3.567
2	Brick with 5% tile waste	1526.97	22.29	3.421	3.977
3	Brick with 10% tile waste	1559.45	21.42	2.977	4.212
4	Brick with 15% tile waste	1585.45	20.14	4.090	5.731
5	Brick with 20% tile waste	1630.93	19.54	3.508	2.977
6	Brick with 25% tile waste	1708.90	20.60	3.860	3.234

Brick with steel slag is given below

SI No.	Specimen	Bulk Density	Water Absorption	Compressive strength (sun-dried)	Compressive strength (Oven-dried)
1	Conventional clay brick	1851.85	19.72	4.094	4.356
2	Brick with 5% steel slag	1591.94	22.12	3.801	4.035

3	Brick with 10% steel slag	1606.24	21.84	5.906	6.725
4	Brick with 15% steel slag	1621.18	19.84	4.035	4.210
5	Brick with 20% steel slag	1632.23	19.35	3.508	3.860
6	Brick with 25% steel slag	1669.92	18.79	2.982	3.450

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