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# Effect of Lime and Clay in Steel Slag Brick

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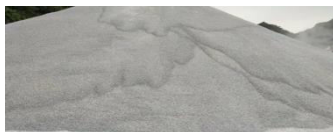
**ABSTRACT:** Steel slag is a byproduct of steel making process of steel industry. It's also one of the biggest industrial wastes which is being produced worldwide in a large quantity. The use of modular bricks has popularity in many foreign countries as an alternative to conventional bricks for sustainable housing. It is being always a challenge for researchers to make modular brick light weight, low cost and improve the performance against aggressive environment. An experimental effort made in this concern. This study gives the result of an experimental investigation in which the compressive strength, water absorption and physical test were investigated by using varying percentage of steel slag, lime and clay with different mix proportion. The experimental result compared with that ordinary burnt clay brick found durable in aggressive environments and have sufficient strength for their use in sustainable building construction. The feasibility of steel slag recycling in clay bricks was assessed through both laboratory tests and industrial trials on three different typologies of wastes and clay bodies.

**KEYWORDS:** Steel Slag, Compressive Strength, Water Absorption.

## I. INTRODUCTION

### Steel Slag

Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel making furnaces. To deal with the problem of increasing serious environmental pollution caused by industrial solid waste such as steel slag, microbial carbonate steel slag bricks are studied in order to promote their utilization. The disposal and the exploitation of residues from steel production are steel unresolved problems, not only due to the large quantities involved but also because of the variety of waste materials produced. Steel slag is a kind of industrial solid waste produced in the process of iron and steel smelting. There are several different types of steel slag produced during the steel making process. These different types are referred to as furnace or tap slag, raker slag, synthetic or ladle slag, and pit or cleanout slag. There are many grades of steel that can be produced, and the properties of steel slag can change significantly with each grade.



Steel Slag

### Characteristics of Steel Slag

**Stability:** Steel slag aggregate mixes combine very high stabilities (1.5 to 3 times higher than conventional mixes) with good flow properties.

**Stripping Resistance:** Steel slag mixes typically exhibit excellent resistance to stripping of asphalt cement from the steel slag aggregate particles. Resistance to stripping is most probable enhanced because of the presence of free lime in the slag.

**Rutting Resistance:** The high stability (1.5 to 3 times higher than conventional mixes) with good flow properties results in a mix that resists rutting after cooling, but is still compactable. Rutting resistance is advantageous for highways, industrial roads, and parking areas subjected to heavy axle loads.

### Objectives

1. To determine effect of lime and clay in steel slag
2. To determine chemical and physical properties of material
3. To determine compressive strength of bricks.
4. To compare strength between the Modular brick and Steel slag brick.

## II. LITERATURE REVIEW

### Qing Su (2022)

This study the performance of concrete containing steel slag in the wall brick structure. Coarse aggregate was replaced by steel slag, and the performance of SSC with different replacement rate was compared. It was found that the increases of steel stone could reduce the slump of concrete. When the replacement rate exceeded 30%, the stability of the specimen was damaged in the later stage of the experiment, with the increase of the replacement rate of steel slag stone, the carbonization resistance decreased. In conclusion, when the replacement rate of steel slag stone was 25%, SSC presented the best performance. The experimental results show that the steel effectively improves the performance of concrete, which provides some reliable support for its further application in the wall brick structure.

### Di Gao & Fu-Ping Wang (2020)

They concluded that steel slag is mainly used in construction, agriculture, and other fields. Compared with other developed countries, the application of industrial recycling has yet to be further explored. In conclusion, steel slag as a catalyst has the characteristics of high efficiency, economy, and reusability and will not be affected by the bad factors. In some catalytic aspects used for pyrolysis and tar cracking, steel slag can synergistically interact with some substances to form a virtuous cycle, and its catalytic performance is greatly improved. In addition to construction, the agricultural industry, and other fields, application of steel slag in catalysis has great potential, which provides more development space for the green sustainable utilization of steel slag in China.

### Hanifi Canakcia, Fatih Celika (2016)

Based on the experimental results, it can be concluded that. Adding aluminum beverage cans to the expansive soil increase MDD; therefore, less effort could be considered during compaction and stabilizing expansive soil. Adding aluminum beverage cans to the expansive soil decreases OMC; therefore, for specific project with low water content the stabilized expansive soil with aluminum could be recommended. Stabilizing expansive soil with aluminium beverage cans could be considered environment friendly way because no manufacturing is used with this technic Adding aluminium with 6% of dry mass considered the effective percentage of aluminium could be used to get best CBR improvement.

### Wojciech Sas, Andrzej Gluchowski, (2015)

Aggregates of steel slag have chemical and mechanical properties comparable to similar natural aggregates. An important fact is that varying results are common to virgin soils, so there is no uncertainty regarding performance under working stress. However, due to their heterogeneity, it is important to verify them before using. Their parameters fill requests for road construction independently from their origin. The designated high content of chromium and zinc are strongly associated with the internal crystal structure of steel slag. Consequently, they can be safely applied in roads'



structure. The aforementioned results suggest a possibility to recycle steel slag as a material for subbases. Test results concerning lack of fines and soaked conditions were mixed. Those circumstances are negative and mostly affect the performance of subgrade constructed from steel slag. CBR tests show a drop of bearing capacity of this material when the aforementioned phenomena occur. Therefore, the constructed subbase is cut off from any water inflows or outflows. This treatment makes obtaining steady conditions possible. Well-graded steel slag reached the CBR value exceeding 60% in each of the 25 repetitions. On the other hand, poorly graded soaked samples mostly did not cross 40% of CBR value. Upon comparing the impact of the previously mentioned properties on bearing capacity gradation and saturation conditions, steel slag is more sensitive to poor gradations or simply to a lack of fine graded grains.

**Huang Yi, Guoping Xu, Huigao cheng (2012)**

Compared to the developed countries, the utilization rete of steel is still very low in china. Therefore, large-scale utilization is a substantial resolution to the environmental resolution to the environmental problems arisen but steel slage dump. when the technologies of CO2 capture and flue gas desulfurization become reliable in the future, the tow technologies will be selective before utilization in other ways. In addition, the database establishment of steel characteristics and applications is a substantial task for steel utilization.

**III. METHODOLOGY**

**Raw Materials**

**Steel slag:**

The main advantage of steel slag is its cost effectiveness. Because it’s produced as a by-product of metal melting, it’s generally much cheaper than traditional aggregates or materials like asphalt or concrete. Additionally, steel slag has great compressive strength and can be used as an alternative to gravel or other materials in roadbeds and foundations. Furthermore, its heat resistance makes it useful for applications where temperatures may get hot enough to damage more traditional materials like asphalt. Steel slag also has several environmental advantages over traditional materials. For example, it reduces air pollution because its production doesn’t require burning fossil fuels like oil or natural gas that produce harmful emissions when burned. Steel slag offers many advantages over traditional construction materials, including cost-effectiveness, environmental friendliness, and increased durability however there are some drawbacks that should be considered before deciding if this material is appropriate for your project. Ultimately, only you can decide whether the benefits outweigh the risks associated with using steel slag but understanding both sides will help make an educated decision about what material is best suited for your project needs.

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 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, scarp 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 combines charge. The impurities consist of carbon as gaseous carbon monoxide, and silicon, manganese, phosphorus and some iron as liquid oxide, which combine with lime and dolime to form the steel slag.

Steel slag aggregates are highly angular in shape and have rough surface texture. They have high bulk specific gravity and moderate water absorption (less than 3 percent). The chemical composition of steel slag is usually expressed in terms of simple oxides calculated from elemental analysis determined by x-ray fluorescence. Virtually all steel slag falls within these chemical ranges but not all steel slags are suitable. They of more importance is the mineralogical form of slag, which is highly dependent on the rate of slag cooling in the steel-making process.

**Table 3.1 Chemical and Physical Properties of Steel Slag**

Chemical properties	Values
Silicon dioxide	37.89
Aluminium oxide	10.23
Ferric oxide	2.95
Calcium oxide	35.86



Magnesium oxide	7.38
Potassium oxidopotassium	1.15
Physical Properties	Values
Specific Gravity	2.63
Bulk density	1430
Water absorption (%)	2.56



Steel Slag sample 1



Steel Slag sample 2

**Lime**

Lime scientifically known as calcium hydroxide, is an inorganic compound with the chemical formula  $Ca(OH)_2$ . It is a colourless crystal or white powder and is produced when quicklime is mixed, or slaked with water. Lime based mortar is more flexible and less brittle. If there is building movement, lime mortar will eventually re-seal the cracks in the mortar. Having a softer means soft bricks won't be forced to break. The mortar is the "sacrificial component" of any masonry wall. With Portland, the mortar is so hard that it chisels off the face of the bricks with even the slightest building movement and buildings move. This means that moisture that gets in the wall (from damp conditions inside or outside) will escape rapidly. Portland cement seals moisture into a wall, causing mould problems inside, deterioration of wood, and deterioration of the bricks themselves. Lime based mortar still sheds water from rain just as well as Portland cement. Lime will last longer than Portland cement. Lime mortar that from 98% pure calcium will last 100 years minimum. Portland cement mortar lasts about 50 years, and sometimes cracking and deterioration is visible within 10 years. Portland cement degrades from the inside out because of impurities like aluminium silicates. These impurities cause it to get hard fast, but also cause it to deteriorate fast. Because lime base mortar is softer, it can be removed easily, without damaging the bricks or stones. Portland mortar is so hard that it is very difficult to replace without breaking the bricks or stones, even if it is badly deteriorated.

Lime (calcium oxide) is a white solid with strongly basic properties. Lime reacts readily with water to produce slaked lime, which is the chemical compound calcium hydroxide. A considerable amount of heat energy is released during this reaction. Calcium hydroxide is sparingly soluble in water producing an alkaline solution known as limewater. When carbon dioxide gas is passed through or over limewater, it turns milky due to the formation of calcium carbonate.

If a marble-sized piece of lime is heated to a high temperature, it emits a very bright white light. In the 1820s, British army officer Thomas Drummond used in lighthouses and on the battlefield called Drummond light, they eventually replaced the gas lights used in music halls and theatres. Performers and actors were now 'in the limelight' when on stage.

**Chemical and Physical Properties of Lime**

Chemical Properties	Values
Calcium oxide	>83.3
Magnesium oxide	<0.5
Ferric oxide	<2
Aluminium oxide	<1.5
Silicon oxide	<2.5
Sulphur trioxide	<0.5
Sodium oxide	0.4-0.5
Carbon dioxide	<5
Physical Properties	Values
Specific Gravity	2.2
Bulk density	0.60
Soundness	20



Lime sample

**Test on Clay**

**Liquid Limit Test**

**Apparatus: -**

1. Spatula
2. Pan with soil sample sieve 0.425mm
3. Casagrande apparatus with grooving tools
4. Moisture Can & oven
5. Glass plate
6. Weighing machine
7. Water sprinkler

**Procedure: -**

1. About 120 gm of air-dried soil from thoroughly mixed portion of material passing 425 micron I.S sieve is to be obtained.
2. Distilled water is mixed to the soil thus obtained in a mixing disc to form uniform paste. The paste shall have a consistency that would require 30 to 35 drops of cup to cause closer of standard groove for 12 mm length.
3. For clayey soil leave it for 24 hours prior to test to ensure distribution of Moisture throughout the soil mass.
4. The soil should then be remixed thoroughly before the test. A portion of the paste is placed in the cup of Mechanical Liquid Limit device and spread into portion with few strokes of spatula as possible.
5. At the same time, trim it to a depth of 1 cm at the point of maximum thickness and return excess of soil to the dish.
6. The soil in the cup shall be decided by the firm strokes of the grooving tool (Indian Standard/ Casagrande's Grooving Tool for Clayey soils and ASTM Grooving Tool for sandy soils) along the diameter through the centre line of the follower so that clean sharp groove of proper dimension is formed.
7. Lift and drop the cup by turning crank at the rate of two revolutions per second until the two halves of soil cake come in contact with each other for a length of about 12 mm by flow only.
8. The number of blows required to cause the groove close for about 12 mm shall be recorded.
9. A representative portion of soil is taken from the cup for water content determination.
10. Repeat the test with different moisture contents at least three more times for blows between 15 and 35.

**Observation: -**

1. Weight of cup = 0.082 kg - 82 gm
2. 120 gm sample passing through 425-micron sieve.
3. No. of blows = 25
4. Weight of Container = 15gm – 0.015kg
5. Weight of Container + wet soil = 21gm – 0.021kg
6. 24 hours oven

**Observation Table (Liquid Limit Test): -**

Sample no.	01	02	03
Container no.	B1 3	B2 11	B3 13
No. of Blows	21	27	33
Mass of empty container (M1) gm	15	17	19
Mass of empty container + Wet soil (M2) gm	21	23	25
Mass of empty container + Dry soil (M3) gm	17	20	24
Water content $W = \frac{(m2-m3)}{M3 - M1} \times 100\%$	200	25	20



Liquid Limit Test sample 1



Liquid Limit Test sample 2

#### IV. EXPERIMENTAL RESULTS

##### Compressive strength Test

Mix Proportion	Load (KN)	Compressive Strength(N/mm <sup>2</sup> )
M1	30	1.75
M2	38	2.22
M3	45	2.63
M4	58	3.39
M5	65	3.80

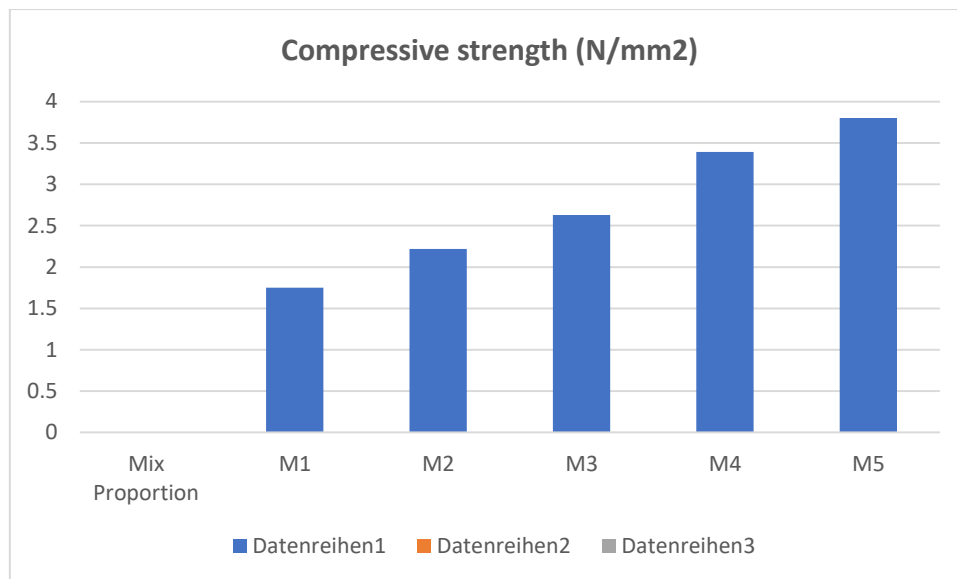


Fig. 4.4 Compressive Strength of Brick

##### Discussion

1. It functions of steel slag is protects the weld from oxidation and from the atmosphere.
2. The increase in steel slag aggregate content decreases the plasticity and increases the maximum dry density of the clay soils.
3. Steel slag reduces the early – age strength but improves the later- age strength.
4. Steel slag affects the workability and volume stability of concrete but improves compressive strength, frost resistance and wear resistance, whereas it is controversial in flexural strength and permeability
5. Iron and steel slags are valuable raw materials that are obtained during the pig iron and crude steel production processes.

## V. CONCLUSION

1. Strength of steel slag bricks with increasing steel slag increases with age.
2. All mix proportions give satisfactory higher values of compressive strength.
3. Steel slag brick with economically available steel slag in large proportion have sufficient strength for their use in low-cost housing, non-load bearing construction and in regions where good quality burnt clay bricks are not available.
4. The density of steel slag bricks was found to be less high than that ordinary burnt clay bricks.
5. Steel slag brick with industrial waste material it low-cost as compare to the modular clay bricks.

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