

PRODUCTION OF PLASTIC INCORPORATED CONCRETE AND STABILIZED MUD BLOCK

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Received: February 15, 2023; Revised: August 16, 2023; Accepted: September 21, 2023

Abstract

Rapidly escalating plastic consumption has led to a significant surge in plastic waste, causing notable repercussions for environmental well-being due to the non-biodegradable nature of plastics. In order to mitigate the environmental impact of plastic, it is imperative to explore alternative approaches to recycling plastic. In the present day, several industries repurpose plastic waste to create a wide array of products, including domestic items, clothing, household materials, textiles, construction elements, and even convert waste plastic into fuel. Among these options, the utilization of plastic waste in the creation of building materials has garnered significant focus. This practice not only reduces the amount of plastic waste discarded as litter or sent to landfills but also diminishes the necessity for mining raw materials used in construction. This, in turn, contributes to mitigating the adverse environmental impacts associated with the construction industry. Within this endeavor, the initiative involves partially substituting plastic waste for the fine aggregate in both concrete blocks and stabilized mud blocks. A comparative analysis is conducted between the compressive strength of these integrated plastic blocks and conventional standard blocks. The outcomes unequivocally demonstrate the viability of recycling plastic waste in a constructive manner, achieved through the incorporation of waste plastics in the production of building blocks. Notably, incorporating plastic waste by approximately 3%-6% to replace fine aggregates in Fly-Ash blocks results in enhanced strength compared to regular Fly-Ash blocks

Keywords: Recycled Plastic, Concrete Block, SMB, GGBS block, Fly-Ash block, Fine Aggregate

Introduction

Plastics, encompassing a diverse range of semi-synthetic or synthetic materials, predominantly consist of polymers. Smaller plastic aggregate size replacing normal aggregates by 10% volume will allow the plastic to mix better with the cement as well as increases the workability by Merna Amir

Ramina *et al.* (2021). Polymers are composed of lengthy, pliable chains of monomers, which can be fashioned into solid objects. Plastics find their application in an array of items such as containers, packaging, zip-lock bags, totes, switches, utensils, electrical cables, and flame-resistant textiles.

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DOI: <https://doi.org/10.55766/sujst-2023-05-e0434>

Suranaree J. Sci. Technol. 30(5):010257(1-9)

According to Pooja Limba *et al.* (2021) Lightweight concrete containing 10% of HIPS and LDPE plastic wastes attained 30 N/mm² compressive strength after 28 days of curing. Workability mainly depends on the shape, size and roughness of the plastic aggregate and despite the manifold forms polymers can take, plastics are recognized for their lightweight nature and enduring durability. Plastics exhibit a virtually boundless capacity for transformation, encompassing techniques like folding, twisting, and various shaping methods. They can even be drawn out to create textile-like fibers. Furthermore, plastic constitutes a significant constituent in the realm of adhesives, sealants, and coatings.

In another study by (Ibrahim Almeshal *et al.* 2020; Dharwesh 2021) examined that the workability of concrete decreased due to non-uniformity of particle size. Plastics cannot be broken down into simple components since they are non-biodegradable, and if it tossed plastic in the ground, it will take many years for it to degrade. Plastic trash output has steadily grown since the 1950s, rising from 1.8 million tonnes in 2010 to 8.3 billion tonnes in 2021. Plastic trash has risen sharply because of economic expansion and rising plastic usage. Siti and Nur *et al.* (2018) examined that plastic pollution, often known as plastic waste, denotes the buildup of plastic items in the environment, causing detriment to both human beings and wildlife. This encompasses the considerable volume of plastic that remains unrecycled and finds its way to insecure dumps or landfills. Plastic has become deeply intertwined with every facet of our daily existence. Its attributes like low density, strength, versatile designs, efficient production, extended lifespan, lightweight nature, and cost-effectiveness have collectively propelled its swift proliferation. Consequently, the escalation in its utilization is a recurring trend each year. It is especially evident because plastic rubbish makes up such a sizable portion of total solid waste. Plastic waste has been regarded as a severe solid waste problem due to its high use.

According to (Raghatate *et al.*, 2012; Vikram Kathe *et al.*, 2015), the improvement of tensile strength of concrete up to 0.8% of plastic improvement of strength of concrete decreases with addition of plastic, thus it is conclude that the use of plastic can be possible to increase the tensile strength of concrete. In another study using waste plastic in making bricks and blocks is advantageous due to its extreme versatility and ability to be tailored to meet specific technical needs and its light weight compared to other competing material which reduces fuel consumption during transportation. The thermal conductivity depended upon the plastic

content of the moulded materials. Decreases in the thermal conductivity were observed with increases in the plastic content of both the bricks and concrete blocks (Ghaly *et al.*, 2020; Jahidul and Shahjalal, 2021).

Drawbacks from the disposal of waste plastic.

According to Noorwirdawati Ali *et al.*, (2018), Advancing further in the disposal process entails managing potentially hazardous components within plastics, like stabilizers or colorants. The environmental and health effects of many such substances remain largely uncharted territory, as comprehensive environmental risk assessments haven't been conducted for all of them. A prime example is phthalates, commonly employed in PVC production. The act of discarding plastics carries a significant ecological footprint. The majority of plastics do not naturally degrade, resulting in protracted breakdown periods once discarded. A mounting quantity of plastic items, particularly packaging, are swiftly discarded post-purchase, intensifying concerns about the growing expanse of landfill sites attributed to plastic waste. Plastic, while undeniably valuable for its affordability and wide availability, presents a slew of challenges and concerns. Noteworthy among these are:

There was a decrease in density, compressive strength, and flexural strength with increase in the proportion of waste LDPE plastic in mortar. Also, water absorption of mortar increased as the content of waste plastic increased by (Eric and Stephen 2019; Shabimam *et al* 2019). Prolonged Degradation: Certain types of plastic are non-biodegradable, requiring nearly a millennium to decompose naturally.

A study by (Ramadevi *et al.*, 2010; Abbas *et al.*, 2020) that environmental contamination: Plastic pollutants infiltrate lakes, seas, and oceans, with one in three marine species deemed marine debris. Ingestion of plastic proves fatal for numerous animals, while plastic fragments are pervasive within seabirds' digestive systems. Plastic packaging, commonly used, has been linked to health issues, including cancer from food consumption. Both plastic manufacturing and recycling release harmful gases and residues, polluting the air, water, and land. Additives like phthalates, meant to preserve plastic integrity, can lead to severe hormonal imbalances in both genders. Plastic poses fire hazards and is challenging and costly to recycle. Many countries have prohibited the use of plastic bags due to their well-documented drawbacks.

Sai Gopi *et al.* (2020) examined that despite being a widely employed material due to its cost-effectiveness, versatility, and strength, plastic's

endurance factor remains a concern. While the awareness of prolonged decomposition timelines exists, the consumption and production of plastic continue to surge.

C K Subramania Prasad *et al.* (2012) says that the proper disposal of plastic trash is a big issue since it pollutes the environment and harms wildlife. As a result, the old methods of burning and dumping plastic garbage, which contributes to global warming and soil degradation, must be abandoned. Because there is such a high need for building supplies worldwide, it is unusually possible to use plastic waste in construction materials, which is a better way to manage plastic trash. By adding plastic waste powder to concrete blocks and stabilised mud blocks,

Objectives of this project:

- Reduces pollution across ecosystems.
- Helps in conserve natural resources.
- Saves fast depleting landfill space.
- Protect the environment.

Materials and Methods

Materials

Cement, coarse aggregate, sand, GGBS, lime, Fly-Ash, and chopped plastic are materials needed to accomplish the goals.

Cement

In construction, cement is a binder that binds materials together by setting, hardening, and sticking to them. Sand and gravel (aggregate) are typically joined using cement. Concrete is produced by mixing cement with sand and gravel, whereas mortar for masonry is produced by mixing cement with fine aggregate. Concrete, the most often used substance in the world after water, is the resource that is used the most. The majority of cement used in construction is inorganic, often composed of lime or calcium silicate, and can either be categorised as hydraulic cement or non-hydraulic cement depending on whether it can set in the presence of water. In this project, regular Portland Cement was employed.

Coarse Aggregate

The broad category of coarse- to medium-grained particle material known as construction aggregate includes materials like sand, gravel, crushed stone, slag, recycled concrete, and geosynthetic aggregates. Aggregates are the most frequently mined materials in the world. Aggregate serves as reinforcement in composite materials like concrete and asphalt to raise the overall strength of

the composite. Due to their relative high hydraulic conductivity value when compared to most soils, aggregates are widely used in drainage applications such foundation and French drains, septic drain fields, retaining wall drains, and roadside edge drain. Aggregates are also used as the foundational material for roads, railroads, and buildings. To put it another way, aggregates provide a stable foundation for railroads and highways.

Sand

Sand is a granular material comprised of microscopic bits of rock and minerals. Sand contains a variety of materials, but what sets it apart is the size of the grains. Silt is finer than sand, and gravel has smaller particles. Sand is a soil type or textural class defined as having more than 85% of its mass in sand-sized particles. In inland continental settings and non-tropical coastal settings, silica (silicon dioxide, or SiO_2), often in the form of quartz-like particles, is the most common component of sand. Sand composition, however, varies depending on the local rock sources and conditions. Sand is a limited resource that has been used sparingly throughout human history, and it is especially important for making concrete. Deserts are inappropriate for concrete despite their abundance. The structure utilises 50 billion tonnes of beach sand and fossil sand annually.

GGBS (Ground-Granulated Blast Furnace Slag)

Molten blast furnace iron slag must first be quenched in water or steam to transform it into glassy, granular blast furnace slag that can be dried and crushed into a fine powder. Calcium silicate hydrates (CSH), a substance that is prevalent in ground-granulated blast furnace slag and is highly cementitious, enhance the strength, longevity, and aesthetics of the concrete. The chemical composition of the raw materials used to create iron affects the slag's composition substantially. To lessen the viscosity of the slag, silicate and aluminate impurities from the ore and coke are combined with a flux in the blast furnace. Limestone and forsterite are frequently combined to create the flux required in the production of pig iron, while dolomite is also occasionally utilised. Instead, the liquid slag is temporarily cooled with water before being pushed into the air by a rotating drum during the palletization process.

To achieve the desired reactivity, the resultant fragments are ground to a fineness comparable to Portland cement. The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). In general, the basicity and compressive strength of the slag increase as the CaO content grows.

Lime

Lime is an inorganic calcium-containing material that mostly consists of oxides and hydroxides, frequently calcium oxide and/or calcium hydroxide. This word also refers to calcium oxide, a result of coal seam fires and a component of altered limestone xenoliths in volcanic ejecta. The International Mineralogical Association defines lime as a mineral with the chemical formula CaO . The definition of "lime" comes from its historical use as mortar in building. These materials, including items made of limestone, cement, concrete, and mortar, are still extensively used in building and engineering.

Fly-Ash

The particulates (fine particles of burned fuel) and flue gases that are driven out of coal-fired boilers make up a coal combustion product known as flyash, flue ash, coal ash, or pulverised fuel. The ash that accumulates at the bottom of the boiler's combustion chamber, also called the fire box, is referred to as bottom ash. In modern coal-fired power plants, fly ash is frequently collected by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the boiler, it is referred to as coal ash.

Fly ash is composed of a variety of substances depending on the type and content of the coal being burned, but all fly ash contains large amounts of the main mineral substances that are present in coal-bearing rock strata: amorphous and crystalline silicon dioxide (SiO_2), aluminium oxide (Al_2O_3), and calcium oxide (CaO). Flyash can be used as a lightweight aggregate (LWA) to recycle one of the largest waste sources in the US. Fly ash may also offer a number of benefits from an economic and environmental standpoint when used as a Lightweight Aggregate.

Chopped plastic

Collected LDPE plastics initially and sent them to a shredding facility for destruction. The shredded plastic was then collected; however, it was not the proper size (40mm), chopping plastic to the required size (2-4mm) is done manually.

Methodology

- Collection of plastic wastes
- Preparation of plastic powder
- Partial replacement of fine aggregate with plastic powder in concrete blocks and SMB.
- Casting cube
- Check for its compressive strength
- Comparison of compressive strength with commercial block.

Procedure

Tests conducted on soil

Liquid limit using Casagrande's apparatus:

1. To make sure the liquid limit device is in good working order, it needs to be cleaned and tested. Also clean the grooving equipment.
2. To precisely 10 mm for each handle turn, adjust the descent of the cup using a gauge, the grooving tool handle, or the adjustment plate of the liquid limit device (Casagrande). Adjustments made, tighten the screw to secure the plate.
3. After passing the soil sample through a 425-micron IS sieve, transfer it to a flat glass plate or an evaporating dish, and weigh it at roughly 120 grammes.
4. Mix the dirt and distilled water to get a uniform paste.
5. Apply pressure, spread some paste into the liquid limit device's cup above the region where the cup rests on the base, and level to a depth of 10 mm at the point of maximum thickness.
6. To divide the dirt in the cup, firmly run the grooving tool in opposite directions to make a clean groove.
7. Once the two soil sections have made contact with the groove's bottom over a distance of roughly 12 mm, count the requisite number of drops by rotating the crank at a pace of two revolutions per second.
8. Keep going back and forth between Steps 6 and 7 until two runs result in the same number of drops for the groove's closure. A little of the soil from the evaporating dish is added, and it is thoroughly mixed.
9. To evaluate the moisture content of the soil, cut a representative slice from the sample at an angle to the groove that includes the region where the soil flowed together and is roughly the width of the spatula.
10. Transfer the remaining soil to the evaporation dish and add more soil or water as necessary to change the paste's consistency.
11. Recurring Steps 5 through 9.
12. Repeat the test four or five times, noting how many drips, between 15 and 35, are required each time to seal the groove.

Smearing Test

According to IS 2720-17(1986) An accurate amount of water should be added to a known quantity of soil to create a sticky paste. Mix the soil with hand, once the soil has been thoroughly moistened with addition of water. Make a ball out of this soil. Roll the wet ball about in hands long enough for it to start to dry off a bit. Pinch out

a small amount of soil with thumb and index finger, then spread it on thumb all at once. The type of smear the soil makes can also tell us about condition of soil.

Concrete block using GGBS mix:

Mixing

Mix Ratio = 1:2:4 (GGBS Mix, Fine Aggregate and coarse aggregate)

W/C Ratio = 0.5

The required amount of sand and GGBS+lime is transferred to the mixing panel with the help of a trowel mixing it in the dry state till a mixture of uniform colour is obtained then coarse aggregate is added and mix the mixture in the dry state thoroughly. Water is added to the mix based on the W/C ratio calculation and the mixture is mixed thoroughly till a uniform colour and consistency are obtained (Figure 1).



Figure 1. GGBS Concrete Mix

Moulding

A metallic mould of size 19x9x9 cm to cast concrete block, as per IS:1725-1982. Before adding concrete to the mould oiling is done to the inside area of the mould. then concrete is filled in the mould layer by layer, the mould is filled in 5 layers and after each layer 25 tamping is given using tamping rods to achieve density finally the top surface is finished using a trowel to get a smooth surface.

Curing

The concrete block is detached from mould one day after moulding then it is cured using gunny bags. The gunny bag is soaked in water daily and placed over the concrete blocks. Blocks are cured for desired days using the same procedure.

Plastic incorporated concrete blocks are produced using the same procedure by replacing 3% and 6% of fine aggregate.

Concrete block using fly-ash+lime mix: - Mixing

Mix Ratio = 1:2:4 (80% Fly-Ash+20% Lime Mix, Fine Aggregate and Coarse aggregate)

W/C Ratio = 0.5.

The required amount of sand and Fly-Ash+lime mix is transferred to the mixing panel with the help of a trowel mixing it in a dry state till a mixture of uniform colour is obtained then coarse aggregate is added and mix the mixture in a dry state thoroughly. Water is added to the mix based on the W/C ratio calculation and the mixture is mixed thoroughly till a uniform colour and consistency are obtained.

Moulding and Curing

Moulding and curing are done in the same as the GGBS block. (Figure 2).



Figure 2. Plastic Incorporated SMB

Stabilized mud block (SMB):

Mixing

Mix Ratio = 15% Clay, 10% Cement, 75% Sand

Water added= 15% of total volume

The required amount of soil and cement is transferred to the mixing panel with the help of a trowel mixing it in a dry state, and sand is added to the mixture and mixed in a dry state thoroughly. Water is added to the mix based on the Liquid limit and the mixture is mixed thoroughly till a uniform colour and consistency is obtained.

Moulding

A metallic mould of dimension 19x9x9 cm. Oiling is to be done to the inside area of the mould before adding the mixture to the mould. The mixer is filled in the mould, in 5 layers, and after each layer 25 tamping is given using tamping rods to achieve a density of 1.98g/cc,

finally the top surface is finished using a trowel to get a smooth surface.

Curing

The Stabilized Mud Block is detached from mould immediately after moulding and after a day it is placed for curing using gunny bags. The gunny bag is soaked in water daily and placed over the blocks. Blocks are cured for desired days using the same procedure.

Plastic incorporated SMB is produced using the same procedure by replacing 5% and 10% of fine aggregate.

Compressive strength test on blocks

A compressive strength test was conducted as per IS 516: 1959 on blocks after curing periods of 7, 14 and 28 days using Compression Testing Machine (Figure 3)



Figure 3. Tested Flyash Block

Results and Discussion

Test conducted on blocks

Fly ash concrete blocks : (Table 1)

Notations used:

1. FL-Fly Ash
2. S-Sand
3. CA-Coarse aggregate
4. S₃-3% of sand replaced by Plastic
5. S₄-6% of sand replaced by Plastic

When the compressive strength of sand replaced by plastic chops in Fly-Ash blocks was compared (Figure 4) with normal Fly-Ash blocks

for different curing periods considering the 28 days' compressive strength as final strength, it is observed that after 14 days, 3% sand replaced by plastic, block achieved 69% of the final strength and it gave same strength as normal block, after 28 days, 3% sand replaced block achieved 2% more strength than the final strength when the block is cast with 6% sand replaced by plastic, the block achieved 43% of the final strength and it was 38% less than normal block after 14 days, 6% sand replaced block achieved 63% of the final strength and strength was 37% lesser than the normal block.

Table 1. Compressive strength of fly ash concrete blocks

TYPE OF MIX (1:2:4)	Curing Period(days)		
	7 days (N/mm ²)	14 days (N/mm ²)	28 days (N/mm ²)
FL:S:CA	1.580	2.456	3.560
FL: S ₃ :CA	1.871	2.456	3.620
FL: S ₄ :CA	1.345	1.520	2.250

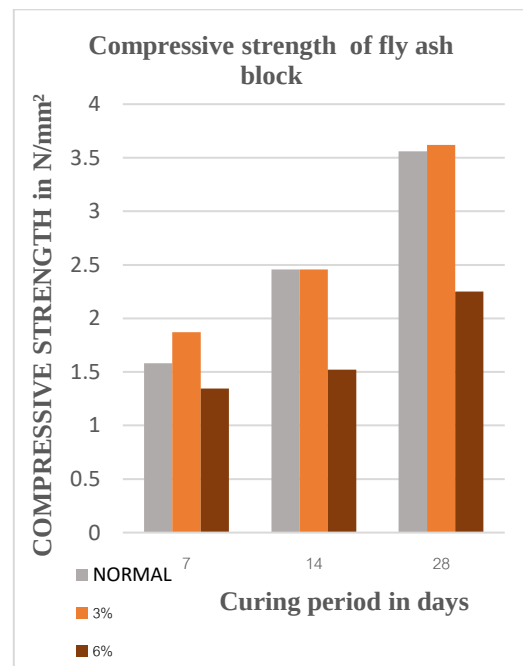


Figure 4. Column Graph Showing Compressive Strength of the Fly-ash Block

Table 2. Compressive strength of fly ash concrete blocks

TYPE OF MIX (1:2:4)	Curing Period(days)		
	7 days (N/mm ²)	14 days (N/mm ²)	28 days (N/mm ²)
GL:S:CA	8.011	12.163	15.632
GL:S ₃ :CA	7.894	7.836	8.360
GL:S ₄ :CA	6.198	7.543	9.432

GGBS concrete blocks : (Table 2)

When the compressive strength of sand replaced by plastic chops in GGBS blocks was compared (Figure 5) with normal GGBS blocks for different curing periods considering the 28 days' compressive strength as final strength, it is observed that after 14 days, 3% sand replaced by plastic, block achieved 50% of the final strength and it was 36% less than normal block, after 28 days, 3% sand replaced block achieved 53% of the final strength and strength was 47% lesser than normal block when the block is cast with 6% sand replaced by plastic, the block achieved 48% of the final strength and it was 38% less than normal block, after 28 days, 6% sand replaced block achieved 60% of the final strength and strength was 40% lesser than the normal block.

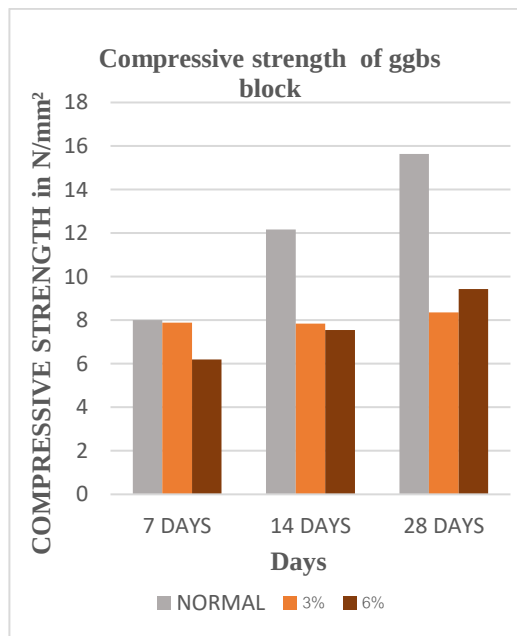


Figure 5. Column Graph Showing Compressive Strength of the GGBS Block

Table 3. Compressive strength of SMB

TYPE OF MIX (10:15:75)	Curing Period(days)		
	7 days (N/mm ²)	14 days (N/mm ²)	28 days (N/mm ²)
C:CS:S	2.982	3.508	4.093
C:CS:S ₁	2.982	2.807	2.690
C:CS:S ₂	2.614	2.512	2.579

Test conducted on SMB : (Table 3)

Notations used:

1. S₁-5% of Sand replaced by plastic
2. S₂-10% of sand replaced by plastic

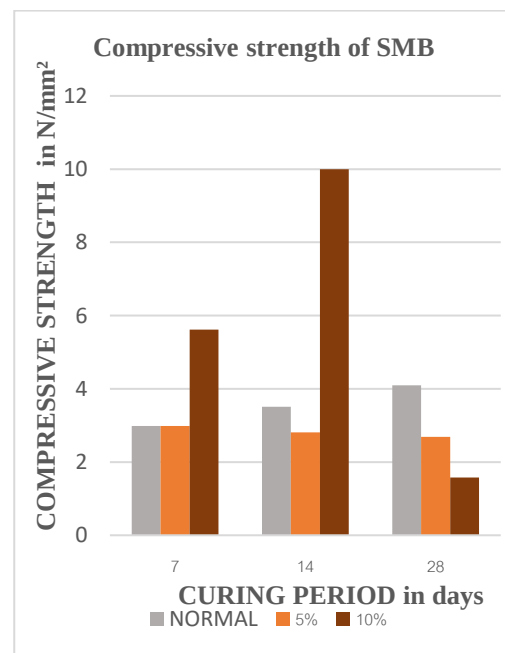


Figure 6. Column Graph Showing Compressive Strength of SMB

When the compressive strength of sand replaced by plastic chops in SMB was compared (Figure 6) with normal SMB for different curing periods considering the 28 days compressive strength as final strength, it is observed that after 14 days, 5% sand replaced block achieved 69% of the final day strength and it was 20% lesser than the normal block, after 28 days, 5% sand replaced block achieved 66% of the final day strength and it is 34% lesser than the normal block when 10% sand

replaced block was tested under CTM, it is observed that, after 14 days, 10% sand replaced block achieved 2.4 times more strength than the normal block on final day strength and it was 2.85 times more than the normal block, after 28 days, 10% sand replaced block achieved 39% of the final day strength and it is 61% lesser than the normal block. This shows that the compressive strength of 5% plastic incorporated blocks decreases as the number of curing days increases. For 10% sand replaced blocks, strength increased very highly for 14 days and decreased about 61% for 28 days. (Figures 7 to 10)



Figure 7. Moulding of Block



Figure 8. Chopped Plastic



Figure 9. Casting of SMB



Figure 10. Performing Liquid Limit Test

Conclusions

The following are the conclusions derived from the findings

- Replacement of 5% sand with plastic in SMB produced strength equal to second-class brick (i.e., 3N/mm^2)
- Strength of 5% plastic incorporated SMB shows less strength when compared to conventional SMB.
- Fly-Ash Block with 3% sand replacement shows more strength than regular Fly-Ash Block.

- Plastic incorporated GGBS Block shows the strength equal to Engineering class brick (i.e., 10N/mm²).
- Density of the block will decrease as the percentage of sand is replaced by plastic.

Acknowledgement

We are grateful to Dr. Ashok Kumar T., Principal, and Dr. Krishnaprasad P.A., the head of the department, for their guidance and ideas during the project. We also thank Management of SDM Institute of Technology, Ujire for providing us with a comfortable laboratory amenities.

We would like to extend our sincere gratitude to the following organisations : Sri Laxmi Cement Pre-Casting Works, Ujire, for giving sand and coarse aggregate; Udupi Power Corporation Limited, Padubidri, for providing fly ash; Mugrody Construction Kavoore, Ujire, for providing GGBS; and Replastico Private Limited, Ujire, for contributing plastic shredding to this project. We are grateful for the assistance and support provided by the Civil Engineering teaching and non-teaching staff.

Finally, we would like to use this occasion to send our regards to everyone who has helped us, directly or indirectly, in the successful completion of this project work.

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