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Limestone Dust and Wood Saw As a Brick Material

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ABSTRACT

The majority of abandoned limestone powder wastes (LPW) and wood sawdust wastes (WSW) is accumulated from the countries all over the world and causes certain serious environmental problems and health hazards. This project a parametric experimental study which investigates the potential use of WSW–LPW combination for producing a low-cost and lightweight composite as a building material. Some of the physical and mechanical properties of concrete mixes having high level of WSW and LPW. The obtained compressive strength and water absorption values the relevant international standards. The results show that the effect of high-level replacement of WSW with LPW does not exhibit a sudden brittle fracture even beyond the failure loads, indicates high energy absorption capacity, reduces the unit weight dramatically and introduces smother surface compared to the current concrete bricks in the market. It shows a potential to be used for walls, wooden board substitute, economically alternative to the concrete blocks, ceiling panels, sound barrier panels, etc.

Keywords:- LPW, WSW

I. INTRODUCTION

Since the large demand has been placed on building material industry especially in the last decade owing to the increasing population which causes a chronic shortage of building materials, the civil engineers have been challenged to convert the industrial wastes to useful building and construction materials. Accumulating of unmanaged wastes especially in developing countries has resulted in an increasing environmental concern. Recycling of such wastes as building materials appears to be viable solution not only to such pollution problem but also to the problem of economic design of buildings. The increase in the popularity of using environmentally friendly, low-cost and lightweight construction materials in building industry has brought about the need to investigate how this can be achieved by benefiting to the environment as well as maintaining the material requirements affirmed in the standards.

Many previous researches undertaken obtained valuable results to use the industrial wastes in various forms of concrete production. For instance, the use of waste rubber, glass powder and paper waste sludge in concrete mix has received conscribe attention over the past years. Some researches carried out in the past used wood ash wastes as a replacement for cement in concrete mixes. Although these researches are providing encouraging results, the concrete mixes having both wood sawdust wastes (WSW) and limestone powder wastes (LPW) combination hitherto has not been investigated. These wastes utilized in this research are widely available in large amount from the forest and limestone industries. This paper presents some physical and mechanical properties of the concrete mixes having high level of WSW and LPW as a replacement for aggregate.

Most of the wastes used in this research are currently disposed in sanitary landfills or open-dumped into uncontrolled waste pits and open areas. A perennial dilemma for the industries has been disposal of WSW and LPW generated. This predicament is not unique to Turkey or the United States. This is a world-wide energy loss and environmental disposal problem. Disposal of this product waste is a major problem for the many small businesses. Therefore, the acceptable solution of this problem with a commercial value is crucial.

The physical and chemical properties of wood dust vary significantly depending on many factors such as geographical location and industrial processes. Hardwoods usually produce more dust than softwoods, and the bark and leaves generally produce more wood dust than the inner wood parts of the tree. On average, the wood sawing results in 5–10% dust. Currently, the blocks of limestone are extracted via chain saw, diamond wire and diamond saws from quarries and then the blocks are cut into smaller suitable sizes to be used as building material. The processing limestone which includes crashed limestone production, results in approximately 20% LPW. The estimated LPW of 21.2 million tones in the UK, 18 million tones in Greece and 30 million tones in Turkey is reported. Disposal of LPW causes dust, environmental problem and pollution because of its fine nature. It contaminates the air with the storms in the summer and spring seasons and therefore causes serious health hazards including specifically asthma. The industry suffers to store LPW due to the costs of storage.

There are limited numbers of studies about the possible utilization strategies of LPW in civil engineering industry. The samples with the diameters of 50 and 80 mm height are produced and their compressive strength, modulus of elasticity and density are determined by Galetakis and Raka. The tests are undertaken on the limited number of cylindrical samples that are not on the standard brick sample forms. The flexural strength and water absorption values are not determined in this research. The other engineering properties required by the international standards such as ASTM C 67-03 need to be investigated.

Using WSW–LPW combination as a fine aggregate in its natural form has allowed economical, lighter and environmental-friendly new composite material. This paper presents the research work undertaken to study the properties of this new composite material which contains the various levels of WSW, LPW, small amount of cement as binder and water. The replacement of these wastes as aggregate in the tested samples dramatically reduces the unit weight. A better and smother surface is obtained. This combination provides a unique kind of building material which exhibits concrete-like appearance but it behaves similar to widely used autoclaved aerated concrete (AAC). Its physical and mechanical properties presented in this paper show that it has a great potential as a low-cost lightweight building material which may offer significant savings not only in labour and transportation, but also in the amounts of binder and steel reinforcement consumed in the construction.

1.1 NEED FOR REPLACEMENT OF CEMENT IN BRICKS :

- The effects of partial substitution of Portland cement clinker with limestone addition on the physical and chemical properties of cement paste and hardened mortar in two ranges of blain fineness values. Laboratory tests were conducted on limestone and clinker samples before used for the intended purpose and then checked for conformity with the Ethiopian and European standards.
- The study investigated the physical properties and chemical composition of saw dust ash (SDA) as well as the workability, and compressive strength properties of the concrete produced by replacing some percentages we are used by weight of ordinary Portland cement with SDA.
- In some countries, the usage of sawdust for the construction has been easily. The physical and chemical properties of the sawdust will not be same and it will be varies from one tree to another tree. in process for several years ago. This is the light weight material which can be carried

1.2 ADVANTAGES OF LIME STONE DUST AND SAWDUST AS CEMENT REPLACEMENT :

- ➢ Limestone is a valuable natural resource, used to make things such as glass and cement. Limestone quarrying provides employment opportunities that support the local economy in towns around the quarry. Chemicals used in making dyes, paints and medicines also come from limestone. Limestone is widely available and is cheaper than granite or marble. It's also a fairly easy rock to cut. Limestone looks attractive and fire resistant.
- ➢ Sawdust is the main component of particle board. Wood dust is a form of particulate matter, or particulates. Research on wood dust health hazards comes within the field of occupational health science, and study of wood dust control comes within the field of indoor air quality engineering.
- ➢ A major use of sawdust is for particleboard; coarse sawdust may be used for wood pulp.

1.3 OBJECTIVE OF THE STUDY :

The objective of our project to find a substitute for cement which is more economical and durable without reducing the strength of the cement bricks. Such a substitute should comply with the existing standards stipulated for cement. It also should be available at cheaper rates in abundant quantities.

The principal objective of this study is to prepare cement bricks by adding lime stone dust and wood saw dust in different volume proportions of (0%,5%,10% and 20%) of cement.

To investigate the fresh properties of cement bricks like workability by replacement of cement with lime stone dust and wood saw dust in different.

To investigate the mechanical properties such as compressive strength of cement bricks by replacement of cement with lime stone dust and wood saw dust in different.

To investigate the durability properties such as compressive acid and alkali attack cement bricks by replacement of cement with lime stone dust and wood saw dust.

II. LITERATURE REVIEW

2.1 REVIEW OF EARLIER INVESTIGATIONS

Some of the investigations on the use of lime stone and saw dust as cement replacement are

A STUDY OF BRICK MORTAR USING SAWDUST AS PARTIAL REPLACEMENT FOR SAND

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The paper reports results of study on standard masonry mortar containing sand and sawdust as aggregates in a mix proportion of 1:3 and water-cement ratio of 0.55. A modified mortar of same design mix proportion (1:3) but varying water/cement ratio and constant slump of 74.3 mm to achieve higher workability was also evaluated. Six different percentages (5, 10, 15, 20, 30 and 50%) of sand replacement were investigated. The flexural tensile strength, compressive strength, dry density, masonry wallet compressive strength, water absorption and slump were evaluated. The British code recommended masonry wallet compressive strength of 5.3 N/mm2 was achieved with 8 and 13% sawdust contents in the standard and modified mortars, respectively. Such mortars can be used as jointing and rendering materials on interior walls of buildings where water absorption by the mortar would be reduced.

The following Conclusions are observed

Mortar prepared with sawdust as partial fine aggregates was investigated. Standard mortar of mix ratio of 1:3 andin inadequate workability. In view of that a modified mortar of better workability with constant slump of 74.3 mm was also prepared. The compressive strength and flexural tensile strength of the mortar and masonry compressive strength of wallets were assessed from test specimens. The results showed that the sawdust possessed the characteristics of a well-graded aggregate. The dry density, compressive strength and flexural tensile strength were observed to decrease with increasing sawdust content. A more porous mortar was produced with increased sawdust content. However the modified mortar was slightly impervious compared with the standard mortar. Therefore in terms of durability the modified mortar could be presumed to be more durable. At higher percentages of sawdust the crushing of the cubes was not sudden compared to the control for both mortar types. Failure of masonry wallets for the modified mortar was characterized by cracking along the masonry

units whilst that of the standard mortar was observed to fail along the brick-mortar joint. This can be observed. The better bonding in the case of the modified mortar could be attributed to the improved workability which led to better adhesion between the bricks and the mortar. On a micro-scale the better adhesion could be also be due to sawdust fibres penetrating into the block surfaces.

The densities of both mortars decreased considerably with each percentage replacement. Low density mortar could be achieved by the partial replacement of the fines with sawdust. A thorough examination of the above results and discussions showsthat there is a possibility of replacing fine aggregates with sawdust in masonry mortar preparation. With 8 and 13% percentages of replacement, the standard and modified mortars respectively produced mortars with properties which compare adequately well with theoretical values of BS 5628:1992 Code.

UTILIZATION OF LIMESTONE DUST IN BRICK MAKING

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In Egypt, Large amounts of limestone dust are accumulated annually during running limestone quarries. Disposal of these wastes is a rapidly growing problem, and causes certain serious environmental problems and health hazards. Therefore, research for utilizing these disposals is urgently needed. The main aim of this study is to investigate both physical and mechanical properties of brick specimens containing combinations of limestone dust and small amount of Portland cement as a binder for producing building brick material. Limestone dust and cement were mixed, humidified and molded by two methods, hand-making method and mechanical molding method applying small compaction action. After demolding, the produced specimens were left to dry in air at room temperature for 28 days. The obtained values of water absorption, bulk density, slake durability index, and compressive strength satisfy the Egyptian standard of fired clay building units for non- load bearing walls. The test results indicate that brick specimens contain 13% cement satisfy the requirements of building of non-load bearing walls in Egypt. The process undertaken can easily be applied in the working Egyptian brick plants using semi mechanization system. The positive use of these wastes converts them into useful products that can alleviate the disposal and environmental problems.

The obtained results in this study lead to the following conclusions:

* The results show that combination of limestone dust and cement can be used in the production of masonry building bricks with acceptable mechanical properties which match the Egyptian Standard specifications of non- load bearing walls.

* The added cement in the mixture affects positively the studied properties of the produced bricks.

* Reasonable quality brick can be produced with addition of about 13 % cement, in the mix, which attained strength of 33 kg f /cm2 and 45 kg f /cm2 respectively in the two-tested series. These values satisfy the requirements for buildings of non – load bearing walls (25 to 45 kg f /cm2).

* The produced bricks have the following properties: 20-21 %water absorption, bulk density of 1.65-1.68 g/cm3 slake durability of over 95 % and compressive strength of 33-45 kgf / cm2

* The process of mechanical moulding method can easily be applied in the existing Egyptian brick plants using semi mechanization system.

* The positive uses of these wastes produces useful profitable products and decreases environmental problems for the neighbouring society.

III. LIMESTONE DUST AND WOOD SAWDUST AS BRICK MATERIAL

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The majority of abandoned limestone powder wastes (LPW) and wood sawdust wastes (WSW) is accumulated from the countries all over the world and causes certain serious environmental problems and health hazards. This paper presents a parametric experimental study which investigates the potential use of WSW–LPW combination for producing a low-cost and lightweight composite as a building material. Some of the physical and mechanical properties of concrete mixes having high level of WSW and LPW are investigated. The obtained compressive strength, flexural strength, unit weight, ultrasonic pulse velocity (UPV) and water absorption values satisfy the relevant international standards. The results show that the effect of high-level replacement of WSW with LPW does not exhibit a sudden brittle fracture even beyond the failure loads, indicates high energy absorption capacity, reduces the unit weight dramatically and introduces smother surface compared to the current concrete bricks in the market. It shows a potential to be used for walls, wooden board substitute, economically alternative to the concrete blocks, ceiling panels, sound barrier panels, etc.

Many previous researches undertaken obtained valuable results to use the industrial wastes in various forms of concrete production. For instance, the use of waste rubber, glass powder and paper waste sludge in concrete mix has received conscribe attention over the past years. Some researches carried out in the past used wood ash wastes as a replacement for cement in concrete mixes. Although these researches are providing encouraging results, the concrete mixes having both wood sawdust wastes (WSW) and limestone powder wastes (LPW) combination hitherto has not been investigated. These wastes utilized in this research are widely available in large amount from the forest and limestone industries. This paper presents some physical and mechanical properties of the concrete mixes having high level of WSW and LPW as a replacement for aggregate.

The following Conclusions are observed from their study,

- The physical and mechanical properties of brick samples with WSW and LPW are investigated. The test results show that the WSW–LPW combination provides results which are of potential to be used in the production of lighter and economical new brick material.
- The observations during the tests show that the effect of 10–30% WSW replacements in WSW–LPW matrix does not exhibit a sudden brittle fracture even beyond the failure loads and indicates high energy absorption capacity by allowing lower labour cost.
- This composition produces a comparatively lighter composite which is about 65% lighter than the conventional concrete bricks.
- Concrete with 30% replacement level of WSW which attained 7.2 MPa compressive and 3.08 MPa

flexural strength values, satisfies the requirements in BS6073 for a building material to be used in the structural applications.

- However, the complete investigation of brick samples with LPW and LPW–WSW combi-nation should include further durability tests.

COTTON AND LIMESTONE POWDER WASTES AS BRICK MATERIAL

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Large amounts of cotton and limestone wastes are accumulated from the countries all over the world. The majority of cotton wastes (CW) and limestone powder wastes (LPW) is abandoned, and causes certain serious environmental problems and health hazards. This paper presents a parametric experimental study, which investigates the potential use of CW–LPW combination for producing new low cost and lightweight composite as a building material. The physical and mechanical properties of concrete mixes having high level of CW and LPW are investigated. The obtained compressive strength, flexural strength, ultrasonic pulse velocity (UPV), unit weight and water absorption values satisfy the relevant international standards. The results show that the effect of high level replacement of CW with LPW does not exhibit a sudden brittle fracture even beyond the failure loads, indicates high energy absorption capacity, reduces the unit weight dramatically and introduces smother surface compared to the current concrete bricks in the market. The process undertaken can easily be applied in the current brick plants. It results a sturdy lighter weight composite having potential to be used for walls, wooden board substitute, economically alternative to the concrete blocks, ceiling panels, sound barrier panels, etc. Paper presents the results and draws conclusions.

The physical and mechanical properties of brick samples with CW, LPW, and glass powder wastes are investigated. The test results show that the CW–LPW combination pro-vides results, which are of potential for this combination to be used in the production of lighter and economical new brick material. The observations during the tests show that the effect of 10–40% CW replacements in CW–LPW matrix does not exhibit a sudden brittle fracture even beyond the failure loads and indicates high energy absorption capacity by allowing lower labour cost. This CW–LPW composition produces a sturdy lighter composite, which is about 60% lighter than the conventional concrete bricks. Concrete with 30% replacement level of CW which is attained 7 MPa compressive and 2.19 MPa flexural strength values satisfies the requirements in BS6073 for a building material to be used in the structural applications.

The performed tests presented in this paper constitute only a first step research on CW–LPW combination to be used as brick materials and the further tests are possibly needed prior to use the new bricks as construction materials. The possible behaviour of the bricks assembled in masonry also needs to be investigated to asses the physical and mechanical behavior of the brick/ mortar system. The further tests may be required such as the water absorption co efficient, the pore size distribution and the bond wrench tests as well as the mechanical tests on brick/mortar combination. The variation in the mechanical strength of these bricks containing the high percentage replacement of cotton when they are saturated with water is another research area need to be investigated. This further information on the new bricks would allow proposing this composite as new building material.

3 EXPERIMENTAL PROGRAMME

3.1 GENERAL

In this chapter, the experimental investigations on the various physical and other properties of all the materials used in this study. And type of tests conducted on different materials and test procedures also discussed.

3.2 MATERIALS USED :

The different materials used in this investigation are:

- Cement
- Fine aggregates- Sand
- Gypsum
- Fly ash
- Dust
- Lime stone dust
- Wood saw dust
- Water

3.2.1 CEMENT :

Portland cement is the product obtained by pulverization of clinker, which essentially consists of hydraulic calcium silicates, with a certain proportion of natural calcium sulfate that contains additions of substances to modify its properties or facilitate its use. In the production of samples, the Portland cement was used because it is pozzolanic, common, and easily acquired due to its popularity.

The physical properties of the cement are listed in Table – 3.1

S.No	Properties	Results	IS : 12269-1987
1.	Specific gravity	3.15	-
2.	Normal consistency	32%	-
3.	Initial setting time	60 Min	Minimum of 30min
4.	Final setting time	350 Min	Maximum of 600min
5.	Compressive strength A. 3 days strength B. 7 days strength C. 28days strength		Minimum of 27 Mpa Minimum of 40Mpa Minimum of 53Mpa

Table 3.1 Properties of Ordinary Portland cement

3.2.2 FINE AGGREGATE :

The standard sand used in this investigation was obtained from penna River in Nellore. The standard sand shall be of quartz, light grey or whitish variety and shall be free from silt. The sand grains shall be angular; the shape of the grains approximating to the spherical form elongated and flattened grains being present only in very small or negligible quantities. The standard sand shall (100 percent) pass through 2-mm IS sieve and shall be (100 percent) retained on 90-micron IS Sieve and the sieves shall conform to IS 460 (Part: 1): 1985.

The physical properties of sand are listed in Table – 3.2

Colour	Light yellow
Specific gravity	2.65
Shape of grains	Rounded

Table 3.2 Properties of Fine aggregate

3.2.3 LIMESTONE DUST :

Crushed Limestone Dust. We supply Crushed Limestone Dust, available from our Ardsley and Bufford quarries. These materials are suitable for cable ducting, reconstituted stone manufacture, agricultural lime for soil improvement. The main application is for agricultural purposes, for neutralizing acidic soils.

3.2.4 WOOD SAW DUST :

Sawdust or wood dust is a by-product or waste product of woodworking operations such as sawing, milling, planning, routing, drilling and sanding. It is composed of fine particles of wood. These operations can be performed by woodworking machinery, portable power tools or by use of hand tools. Wood dust is also the byproduct of certain animals, birds and insects which live in wood, such as the woodpecker and carpenter ant. In some manufacturing industries it can be a significant fire hazard and source of occupational dust exposure.

Sawdust is the main component of particleboard. Wood dust is a form of particulate matter, or particulates. Research on wood dust health hazards comes within the field of occupational health science, and study of wood dust control comes within the field of indoor air quality engineering

The properties of the LPW & WSW Table – 3.3

Properties	LPW	WSW
SiO2 (%)	0.26	1.17
CaO (%)	56.19	0
MgO (%)	0	0
Al2O3 (%)	0.25	2.38
Fe2O3 (%)	0.30	0.23
SO3 (%)	0	0
Na2 O (%)	0	0
K2O (%)	0	0
CL (%)	0	0
Loss on ignition (%)	42.65	96.22
Ph	—	9.9
Density	2.67	
Specific surface area (m2/kg)	145	—
Compressive strength for 28 days (MPa)	—	—

Table 3.3 Properties of LPW & WSW

3.2.5 GYPSUM :

Gypsum is a soft sulfate mineral composed of calcium sulfate dihydrate, with the chemical formula $CaSO_4 \cdot 2H_2O$. It is widely mined and Is used as a fertilizer, and as the main constituent in many forms of plaster, blackboard chalk and wallboard. Gypsum uses include: manufacture of wallboard, cement, plaster of Paris, soil conditioning, a hardening retarder in Portland cement. Varieties of gypsum known as "satin spar" and "alabaster" are used for a variety of ornamental purposes; however, their low hardness limits their durability. Flue Gas Desulfurization (FGD) gypsum is also known as scrubber gypsum. FGD gypsum is the by-product of an air pollution control system that removes Sulphur from the flue gas in calcium-based scrubbing systems. It is produced by employing forced oxidation in the scrubber and is composed mostly of calcium sulphate. FGD gypsum is most commonly used for agricultural purposes and for wallboard production.

The properties of gypsum are listed in Table – 3.4

Properties	Gypsum
Chemical classification	Sulphate
Colour	Clear, Colourless, White, Grey, Yellow, Red, Brown
Streak	White
Luster	Vitreous, Silky, Sugary
Diaphaneity	Transparent to translucent
Cleavage	Perfect
Mohs hardness	2
Specific gravity	2.3
Diagnostic properties	Cleavage, Specific gravity, Low hardness
Chemical composition	Hydrous calcium sulphate
Crystal system	Monoclinic

Portland cement

Table 3.4 properties of gypsum

3.2.6 FLYASH:

It is collected from different rows of electrostatic precipitators in dry form. The fly ash is produced from the burning of pulverized coal in a coal-fired boiler. It is a fine grained, powdery particulate material in nature. It is carried through the flue gas and collected from the flue gas by means of electrostatic precipitators, bag-houses, or mechanical collection devices such as cyclones. Fly ash is the finest of coal ash particles. It is transported from the combustion chamber by exhaust gases. Fly ash is the fine powder produced from the mineral matter present in coal, plus a small amount of carbon that remains due to incomplete combustion. Fly ash is generally light tan in colour and consists mostly of clay-sized and silt-sized glassy spheres. This gives fly ash to a consistency somewhat like talcum powder. Properties of fly ash vary with coal composition and plant operating conditions.

Fly ash can be referred as either pozzolanic or cementitious. A cementitious material is one that hardens when mixed with water. A pozzolanic material also hardens when mixed with water but only after activation with an alkaline substance such as lime. Due to cementitious and pozzolanic properties of fly ashes they are used for replacement of cement in concrete and many other building applications.

The properties of fly ash are listed in Table – 3.5

Physical properties	Fly ash
pH	6.0 – 10.0
Specific gravity	1.45 – 2.25
Bulk density(g/cc)	0.85 - 1.2
Grain size distribution	Silt to silty loam
Porosity (%)	45 – 55
Water holding capacity (%)	25 – 40
Electrical conductivity (ds/m)	0.15 – 1.10

Table 3.5 properties of fly ash

3.2.7 DUST:

Dust for this study was purchased from Pal Stone Industry, Halduchaud, Uttarakhand, India. Index properties of the stone dust were determined as per IS codes and are presented in Table-3.6.The stone dust is classified as SP. Stone dust was randomly mixed with soil samples in 10%, 20%, 30%, 40% and 50% of the dry weight of soil.

3.2.8 WATER :

Portable water was used in the experimental work for both preparing and curing. The pH value of water taken is not less than 6.

The allowable limits of physical and chemical impurities and the test methods of their evolution are compiled. The limits of impurities as per Indian, Australian, American and British standards are presented. From the literature it is seen that, the reaction between water and cement affect the setting time, compressive strength and also lead to softening of concrete. All the impurities may not have adverse effect on the properties of concrete. The use of impure water for concrete mixing is seen to favorable for strength development at early ages and reduction in long term strength.

IS 3025 recommended that, testing of water play an important role in controlling the quality of cement concrete work. Systematic testing of the water helps to achieve higher efficiency of cement concrete and greater assurance of the performance in regard to both strength and durability.

3.3 MIXING DESIGN :

CALCULATION PER ONE BRICK :

An example of calculating the required quantities of different materials for a considered proportion is given below:

- Dimension of the cube= 23*15*14cm
- Volume of the cube= 4830 cm3 =4830*(10-2)3
- Let, density of Brick=22 KN/m3= 22×1000⁄9.81= 2242.61kg/m3

We know that, mass=density × volume

=2242.61×4830×10-3

=10831.80Kg

∴ The total weight of the sample=10831.80Kg

Let us consider,

Ratio of binder to aggregate as 1:4

The water cement ratio as 0.62

∴The weight of binder= 10831.80/3=3610.6Kg

Weight of aggregate (Quarry dust) = 3610.6×4=14442.4.8kg

Weight of water= 0.62×3610.6= 2238.57Kg

Therefore, to prepare a brick of 23*15*14 cm dimension the amount of binder, quarry dust and fluid to be taken are 3610.6kg,14442.4 kg and 2238.57kg respectively.

After all the ingredients were ready, the mixing was done. In this project, mixing was done manually. The mixing process of cement blocks are different. The exact mix proportion was not known. So, trial proportions were used in this project.

3.4 MANUFACTURING PROCESS :

The process of manufacture of cement concrete hollow blocks involves the following 6 stages;

(1) Proportioning

(2) Mixing

(3) Moulding

(4) Curing

(5) Drying

3.4.1 Proportioning :

- The determination of suitable amounts of raw materials needed to produce mortar of desired quality under given conditions of mixing, placing and curing is known as proportioning.
- As per Indian Standard specifications,
- Mix ratio of mortar 1:4.
- Water cement ratio of 0.62 by weight basis can be used for cement bricks.
- Moulds size 23*15*14 cm

3.4.2 Mixing :

- Mixing is simply defined as the "complete blending of the materials which are required for the production of a homogeneously".
- Once the appropriate mixing has been chosen, it is necessary to determine the mixing time.

3.4.3Moulding :

- The purpose of moulding is to fill all air pockets with mortar as a whole without movement of free water through the mortar. Excessive moulding would result in formation of water pockets or layers with higher water content and poor quality of the product.

3.4.4 Curing :

- Bricks removed from the mould are protected until they are sufficiently hardened to permit handling without damage.
- This may take about 24 hours in a shelter away from sun and winds.
- The bricks thus hardened are cured in a curing yard to permit complete moisturization for atleast 21 days. When the bricks are cured by immersing them in a water tank.
- The greatest strength benefits occur during the first three days and valuable effects are secured up to 10 or 14 days. The longer the curing time permitted the better the product.

3.4.5 Drying :

- Bricks shrinks slightly with loss of moisture. It is therefore essential that after curing is over, the bricks should be allowed to dry out gradually in shade so that the initial drying shrinkage of the bricks is completed before they are used in the construction work.
- Generally a period of 7 to 15 days of drying will bring the bricks to the desired degree of dryness to complete their initial shrinkage. After this the bricks are ready for use in construction work
-

IV. TESTS ON BRICKS & RESULTS

Following tests are conducted on bricks to determine its suitability for construction work.

- Water absorption test
- Crushing strength test
- Hardness test
- Shape and size
- Color test
- Soundness test
- Structure of brick

4.1Absorption Test on Bricks :

Absorption test is conducted on brick to find out the amount of moisture content absorbed by brick under extreme conditions. In this test, sample dry bricks are taken and weighed. After weighing these bricks are placed in water with full immersing for a period of 24 hours. Then weigh the wet brick and note down its value. The difference between dry and wet brick weights will give the amount of water absorption. For a good quality brick the amount of water absorption should not exceed 20% of weight of dry brick.

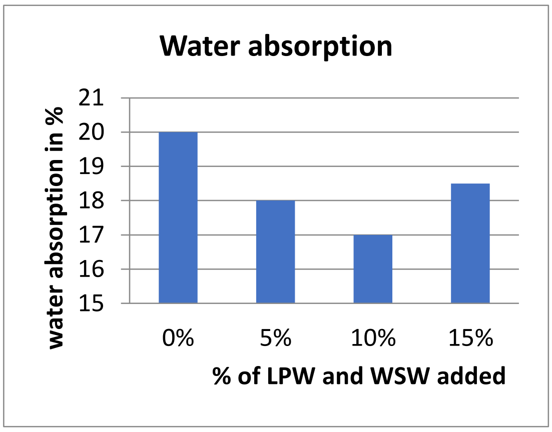
The water absorption of bricks after immersing 24 hours in water is given by

$$W = \frac{M_2 - M_1}{M_1} X\ 100$$

Where M_1= weight of brick before immersing
M_2= weight of brick after immersing

Sl. No.	% of LPW and WSW added	Oven Dry wt. of specimen (M_1)	Wet wt. of specimen (M_2)	Water Absorption (%)
1.	0%	2.90	3.393	20
2.	5%	2.85	3.363	18
3.	10%	2.82	3.384	17
4.	15%	2.87	3.055	18.5

Table 4.1 Water Absorption Test Results



Graph 4.1(a) Water absorption test results on different % of LPW and WSW added to bricks after 24 hours immersing in water

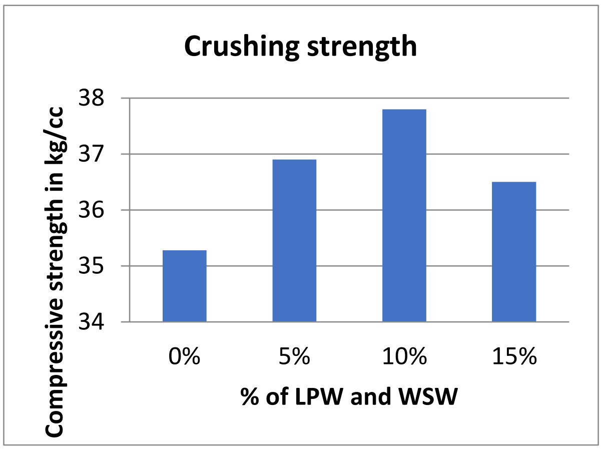
4.2 Crushing Strength or Compressive Strength Test on Bricks :

Crushing strength of bricks is determined by placing brick in compression testing machine. After placing the brick in compression testing machine, apply load on it until brick breaks. Note down the value of failure load and find out the crushing strength value of brick. Minimum crushing strength of brick is 3.50N/mm^2.if it is less than 3.50 N/mm^2, then it is not useful for construction purpose.
The compressive strength of bricks is given by

$$\text{Compressive strength} = \frac{\text{Maximum load at failure (N)}}{\text{Average area of bed face (mm}^2\text{)}}$$

Sl. No.	% of lime added	Avg.area of bed face(Cm^2)	Compressive strength (kg/cm^2)
1.	0%	420	35.28
2.	5%	420	36.9
3.	10%	420	37.8
4.	15%	420	36.5

Table 4.2 Crushing Strength Test Results



Graph 4.2(a) Crushing strength test results on different % of LPW and WSW added to bricks

4.3 HARDNESS TEST :

In this test, a scratch is made on brick surface with the help of a finger nail. If no impression is left on the surface, the brick is sufficiently hard.

From the results of hardness test, as the percentage of lime added to bricks increases, hardness also goes on increases upto 10% after that at 15% hardness is decreased. This is because of percentage increase in lime will makes the brick brittle. This was clearly observed, at 15% of lime content, the scratch is easily made by finger nail.

4.4 SHAPE AND SIZE :

In this test, a brick is closely inspected. It should be of standard size and its shape should be truly rectangular with sharp edges. For this purpose, 20 bricks of standard size (24cm x 15cm x 14cm) are selected at random and they are stacked lengthwise, along the width and along the height.

For good quality bricks, the results should be within the following permissible limits

From the examination of bricks with increasing lime content, all bricks had clear shape and size.

4.5 COLOR TEST :

A good brick should possess bright and uniform color throughout its body.

From the examination of bricks with increasing lime content, all bricks had same colour, With the increasing of lime content the reddish color turns into pale color.

4.6 SOUNDNESS TEST :

In this test, the two bricks are taken and they are struck with each other. The bricks should not break and a clear ringing sound should be produced.

From the examination of bricks for soundness test with increasing lime content, all bricks had better ringing sound.

4.7 STRUCTURE OF BRICK :

A brick is broken and its structure is examined. It should be homogeneous, compact and free from any defects such as holes, lumps, etc.

Randomly four bricks were selected from the group and the structure of each brick was examined.

V. CONCLUSION

Based on the result of both experimental and filed investigation on cement bricks and stabilized LPW and SWS bricks, the following concluding remarks can be drawn :

- The physical and mechanical properties of brick samples with WSW and LPW are investigated. The test results show that the WSW and LPW combination provides results which are of potential to be used in the production of lighter and economical new brick material.
- The observations during the tests show that the effect of 10–30% WSW replacements in WSW and LPW matrix does not exhibit a sudden brittle fracture even beyond the failure loads.
- The compressive strength of bricks increases with lime proportion up to 10% after that if the % of LPW & WSW increases the compressive strength decreases.
- As long as the percentage of LPW & WSD both increases water absorption decreases.
- Major usage in the world for construction is cement bricks; many researchers are presently looking for newer options because they need low cost materials, which are also environmentally friendly. The process of manufacturing cement bricks .
- LPW & WSW added cement blocks include; uniformed building component sizes, use of locally available materials and reduction of transportation. Uniformly, sized building components can result in less waste, faster construction and the possibility of using other pre-made components or modular manufactured building elements.
- The use of natural, locally-available materials makes good housing available to more people, and keeps money in the local economy rather than spending it on imported materials, fuel and replacement parts.
- The reduction of transportation time, cost and attendant pollution can also make LPW & WSW stabilized bricks more environment friendly than other materials.

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