Visvesvaraya Technological University

Belagavi , Karnataka-590 018

A project Report on

"MANUFACTURE OF INTERLOCKING BLOCK WITH INNOVATIVE DESIGN"

A project report submitted in partial fulfillment of the requirement for the VIII semester degree of

Bachelor of Engineering
In
Civil Engineering

Submitted by

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Department of Civil Engineering 2019-2020

CMR INSTITUTE OF TECHNOLOGY

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Certificate

Certified that the project work entitled **"MANUFACTURE OF INTERLOCKING BLOCK WITH INNOVATIVE DESIGN"** has been successfully presented by **KARTHIK N K(1CR16CV027), MANIKANATA V(1CR16CV032), MANOJ KUMAR S K (1CR16CV034),** at CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirements for the VIII Semester degree of Bachelor of Engineering in Civil Engineering of Visvesvaraya Technological University, Belagavi during the academic year 2019-2020. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the report deposited in the departmental library.

The project report has been approved as it satisfies the academic requirements in respect of project work as prescribed for the said Degree.

Signature of the Guide	*Signature of the HOD*	*Signature of the Principal*
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Mr. SHIVAKUMAR M J Asst.professor Civil Department CMRIT, Bengaluru	Dr. Asha M Nair HOD Department of Civil Engineering CMR Institute of Technology	Dr. Sanjay Jain Principal, CMRIT, Bengaluru

Name of the Examiners	ExternalViva	Signature with date
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DECLARATION

We, KARTHIK N K ,MANIKANATA ,MANOJ KUMAR S K ,AKASH hereby declare that the Project report entitled **"MANUFACTURE OF INTERLOCKING BLOCK WITH INNOVATIVE DESIGN"** has been carried out by me under the guidance of **Mr. SHIVAKUMARA M J**, Asst.professor , Department of Civil Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirements for the VIII Semester degree of **Bachelor of Engineering in Civil Engineering** of Visvesvaraya Technological University, Belagavi during the academic year2019-2020.

Place: Bengaluru

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Abstract

Production of blocks used for wall construction have different techniques adopted which could be in form of hollow or solid blocks produced in varying shapes laid with mortar. An improved form of mortar-less blocks, which is an innovative structural component for masonry building construction, called interlocking block, which can be produced mechanically. This brings about economical production, reduced cost of labour and appreciation of available local materials for construction of structures for both rural and urban development in the world today, thereby eliminating the use of mortar in laying of blocks.

The blocks are neatly fixed through the aid of grooves and protrusion on the blocks to restrain movement when assembling the interlocking block from top and or bottom of one to another forming safe, stable, economical and aesthetic bonding for walls. It can be widely used for both temporary and permanent structures.

The top blocks, middle blocks and toe blocks have different forms of projected and engraved part achieved by the aid of pallet placed at the bottom of mould and replaceable mould lid. The assembling does not require much skill, and more so, faster, neater with improved efficiency. The dismantling in the case of temporary wall is, also, easier, faster and economical which do not involve destroying anypart of thewall.

Acknowledgement

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people, who are responsible for the completion of the Project work and who made it possible, because success is the outcome of hard work and perseverance, but steadfast of all is encouraging guidance. Therefore, with gratitude, I acknowledge all those whose guidance and encouragement served me to motivate towards the success of the project work.

I take great pleasure in expressing my sincere thanks to ***Dr. Sanjay Jain****,* ***Principal, CMR Institute of Technology, Bengaluru*** *for providing an excellent academic environment in the college and for his continuous motivation towards a dynamic career. I would like to profoundly thank* ***Dr. B Narasimha Murthy****, Vice-principal of CMR Institute of Technology and the whole* ***Management*** *for providing such a healthy environment for the successful completion of the Project work.*

I would like to convey my sincere gratitude to ***Dr.Asha M Nair****,* ***civil Engineering Department, CMR Institute of Technology, and Bengaluru*** *for her invaluable guidance and encouragement and for providing good facilities to carry out this project work.*

I would like to express my deep sense of gratitude to ***, Mr.Shivakumara M J Asst. Professor, Department of Civil Engineering, CMR Institute of Technology, Bengaluru*** *for his/her exemplary guidance, valuable suggestions, expert advice and encouragement to pursue this project work.*

I am thankful to all the faculties and laboratory staffs of ***Civil Department of Engineering, CMR Institute of Technology, Bengaluru*** *for helping me in all possible manners during the entire period.*

Finally, I acknowledge the people who mean a lot to me, my parents, for their inspiration, unconditional love, support, and faith for carrying out this work to the finishing line. I want to give special thanks to all my friends who went through hard times together, cheered me on, helped me a lot, and celebrated each accomplishment.

Lastly, to the ***Almighty****, for showering His Blessings and to many more, whom I didn't mention here.*

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INTRODUCTION

OVERVIEW

The interlocking blocks are different from other normal bricks, as it requires less mortar or cement for masonry work. These blocks interlocked with each other by means of positives and negative frogs on the top and bottom of the blocks, which disallow the horizontal compressive stress, and lateral movement of blocks. The projection of one block fits into the depression of the next so that they always align perfectly.

The specifications and the characteristics of this block depend on the machine used to manufacture it. The most common size of block is 300x150x150mm. The basic raw materials are cement, fine aggregate and coarse aggregate. This is usually done with mechanized compaction and vibration. Current process of producing the interlocking block is by using a semi mechanized stationary type machine. The other production systems are - manual mould that requires hand tamping, a mobile semi-mechanized egg-laying machine and fully mechanized system that combines compression and manual concrete filling in mould.

The machine also compacts and consolidates the mix so that the blocks are uniform in size and attain desired physical properties of 14 days, before they're ready to use On an average 600-800 blocks can be made in 8 hours by 1 skilled and 6 to 8 semiskilled labours.These are various types of interlocking blocks .The most commonly used cement interlocking blocks. The most commonly used cement interlocking blocks are regular shaped block, half size block, and U shaped block.

OBJECTIVES

- To enable an efficient and cost effective solution, a new concept of construction was invesgated with these innovative interlocking blocks.
- Main aim of our proposal is to build mortar-free structures with help of this type of interlocks blocks.
- To enhance the performance behavior of interlocking block masonary.
- To make the innovative design to increase the strength of the interlocking blocks.

CHAPTER 2

LITERATURE

- Author:N.A. Herskedal,P.T. Laursen, D.C Jansen, B. Qu
- Title: "*Interlocking Compressed Earth Block Walls: Out-Of-Plane Structural Response*"

Summary: Interlocking compressed earth blocks (ICEBs) are cement-stabilized soil blocks that allow for dry stacked construction. The incomplete understanding of the inelastic performance of ICEB building systems limits wide spread acceptance of this structural form in earthquake prone areas. This paper presents results from an experimental program designed to explore the behaviour of ICEB walls built according to current design practice in Indonesia and Thailand, and subjected to out-of-plane loading. Five reinforced and grouted walls were constructed and tested. Results from experimentation show that the current masonry design code in the U.S. can adequately predict the yield strength of these walls. However, the masonry code grossly over-predicts the actual wall stiffness. Furthermore, a brittle failure was observed in one wall before reaching the predicted flexural strength. The testing results provide useful data for developing analytical models that predicts the seismic behaviour of ICEB walls under out-of-plane loading.

- Author: Dr. M. Mageswari, T. Oviya, S.Ragavi.
- Title:"*An innovative methodology followed using interlocking blocks*".

Summary: Creativity and Innovations are hallmarks of any Industry the world over, to survive, sustain and grow in the present highly competitive market. Lightweight Interlocking Blocks are such an Innovation in the construction Industry, gradually picking up at present, which is likely to increase in the long run. The aim of this Project is to manufacture Interlocking Blocks using new materials like Sawdust and Vermiculite to impart Lightweight property to the Blocks and to test the Blocks for Compression strength and Water absorption to see its suitability for construction of buildings. The study reveals that interlocking bricks are used for construction of buildings as it consumes less time and saves the cost than the conventional bricks.

- Author:Frasson Jr, Artêmio,Casali, Juliana Machado; Oliveira, Alexandre Lima; Prudêncio Jr.,Luiz ,Roberto
- Title: *"A mix design methodology for concrete block units*".

Summary: The use of concrete masonry units for high-rise load bearing construction has created a need for concrete block with high compressive strength. To achieve high strength levels, block producers generally define concrete mixtures by a trial and error process. The most common procedure is to produce some trial mixtures possessing different cement content using the equipment available in the block plant and test the strength of blocks. This approach is costly, time consuming and generally leads to expensive solutions for using large amounts of cement. Besides, it makes difficult to test new combinations of aggregates and admixtures once disturbs very much the plant routine. In this paper is presented a mix design procedure for structural concrete blocks based on laboratory tests. Initially a reference mixture is studied. In this phase, it is possible to vary the type and proportion of aggregates, admixtures and water content in order to achieve a suitable face texture with lower energy of compaction. After that, several mixtures are produced varying the cement content and density. Cylindrical specimens was produced with these mixtures and tested in compressive strength. With the results, it is elaborated a mix design chart where the desired compressive strength can be obtained by varying the aggregate/binder ratio and density. The last phase is testing some selected mixtures in actual block machine, determining both density and compressive strength. With the results, it is possible to make the final adjustments in the mix proportions. The application of this procedure in a block plant of the south of Brazil led to satisfactory results showing that is possible to forecast of the mechanical resistance of the concrete blocks starting from laboratory studies in cylindrical specimens and also demonstrated the importance of the control of several parameters related to the productive process for the compressive strength ofthe units.

- Author: I.P.Malavika, Nipuna.M, Raina T. R, Sreelakshmi A.V, Kripa K.M.
- Title: "*Design of Interlocking Block and Replacement of M sand by Concrete Roof Tile Waste*".

Summary: Interlocking blocks are one of the alternatives for the conventional burnt clay brick. This report deals with the design of interlocking blocks and also replacement of the m-sand by concrete roof tile waste in various percentages and finding the optimum percentage of tile waste by testing the cubes casted for compressive strength of 3 days and finally casting the blocks with that optimum percentage of tile waste. The report finally gives the results of an experimental investigation in which the compressive strength, water absorption and density were investigated by using optimum percentage of tile waste, m- sand, cement and 6mm aggregate with mix proportion of 1:2:4. The experimental results are compared with that ordinary solid block. The results indicate that these blocks are slighter lighter in weight, durable in aggressive environments and have better strength for their use in building construction.

- Author: Chukwudi Onyeakpa, Lateef Onundi.
- Title: *"Improvement on the Design and Construction of Interlocking Blocks and its Moulding Machine*".

Summary: Production of blocks used for wall construction have different techniques adopted which could be in form of hollow or solid blocks produced in varying shapes laid with mortar. An improved form of mortar-less blocks, which is an innovative structural component for masonry building construction called interlocking block, which can be produced mechanically, or manually using interlocking block production machine, particularly an improved interlocking block machine with dual mould. This brings about economical production, reduced cost of labour and appreciation of available local materials for construction of structures for both rural and urban development in the world today, thereby eliminating the use of mortar in laying of blocks. The blocks are neatly fixed through the aid of grooves and protrusion on the blocks to restrain movement when assembling the interlocking block from top and or bottom of one to another forming safe, stable, economical and aesthetic bonding for walls. It can be widely used for both temporary and permanent structures. The top blocks, middle blocks and toe blocks have different forms of projected and engraved part achieved by the aid of pallet placed at the bottom of mould and replaceable mould lid. The assembling does not require much skill, and more so, faster, neater with improved efficiency. The dismantling in the case of temporary wall is, also, easier, faster and economical which do not involve destroying any part of the wall.

- Author: Amin Al-Fakih, Bashar S Mohammed1, Fadhil Nuruddin, and Ehsan Nikbakht
- Title: *"Development of Interlocking Masonry Bricks and its Structural Behaviour*".

Summary: Conventional bricks are the most elementary building materials for houses construction. However, the rapid growth in today's construction industry has obliged the civil engineers in searching for a new building technique that may result in even greater economy, more efficient and durable as an alternative for the conventional brick. Moreover, the high demands for having a speedy and less labour and cost building systems is one of the factor that cause the changes of the masonry conventional systems. These changes have led to improved constructability, performance, and cost as well. Several interlocking bricks has been developed and implemented in building constructions and a number of researches had studied the manufacturing of interlocking brick and its structural behaviour as load bearing and non-load bearing element. This technical paper aims to review the development of interlocking brick and itts structural behaviour. In conclusion, the concept of interlocking system has been widely used as a replacement of the conventional system where it has been utilized either as load bearing or as non-load bearing masonry system.

- Author: Sampson Assiamah , Herbert Abeka , Stephen Agyeman
- Title: *"Comparative study of interlocking and sandcrete blocks for building walling systems".*

Summary: The high cost of building materials, especially sandcrete blocks in Ghana, has made building construction products expensive and created a housing deficit of about 1.6 million. Meanwhile, the interlocking blocks, which are made up of laterite and cement abound could be exploited to help reduce the cost of housing construction. Especially, wall construction which is one of the major components of the entire building process. This paper sought to explore the possibility of adopting the interlocking block wall system as a means of making wall construction of buildings affordable in Ghana. A comparative study using interlocking blocks system and sandcrete blocks was made. An observation of the processes were made to identify the extent to which each system falls in line. A sample size of 45 respondents comprising 20 workers of P-A Capital Estate Housing, 5 personnel from consultancy firms and 20 private individuals were selected for further confirmatory study with the use of convenience and purposive sampling technique. To determine whether there were any statistically significant differences between the mean values, paired-sample t-test at the 0.05 level of significance was done. Results showed that, the use of interlocking blocks do not only lead to elimination of a number of non-value adding activities associated with the use of the sandcrete blocks, but also make the wall construction process cheaper and faster. It was also discovered that the absence of mortar jointing in the interlocking system reduced the quantity of materials, like cement and sand, required in the sandcrete wall construction process. Furthermore, there was no statistically difference between the compressive strength of interlocking blocks and conventional sandcrete blocks. However, there were statistically significant differences between construction cost and speed of construction using the two systems of construction.

- Author: RuteEires, Thomas Sturm, Aires Camões, Luís F. Ramos
- Title:"*Study of a new interlocking stabilised compressed earth masonry block".*

Summary:Earth has been a traditional construction material to build houses in Africa. One of the most common earthen masonry techniques is the use of sun dried or kiln fired adobe bricks with mud mortar. Although this technique is cheap and allows the self-construction, the bricks vary largely in shape, strength and durability. This has lead historically to weak houses, which suffer considerable damage during floods and seismic events. Furthermore, the use of firewood kilns to burn bricks has caused extensive deforestation in several countries of Africa. A solution, which has been proposed in the second half of the last century, is the use of stabilized compressed earth blocks (CEBs). These blocks are manufactured by compacting stabilized earth in a manual or hydraulic press. The resulting blocks present higher values of strength and durability, as well as uniform shapes. Since earth is available almost in every location of the world, the CEBs can be produced in-situ. The fact that this blocks are unburned and that the transport can be omitted makes them a cheap material with very low embodied energy. Their use is a cost effective opportunity for locals to have better houses while reducing deforestation.

In this context, one developed an ongoing study for the manufacture of CEBs according to different materials available in Malawi. It is envisaged that the constructive solution with the proposed CEBs will enable improvements in durability, in thermal and acoustic comfort and in seismic behaviour of buildings in Malawi, where earth is an abundant material and labour is unskilled.

This paper presents some results of the experimental campaign which has been carried out. For this purpose, soils from Malawi were characterized and tested without stabilization, as well as with cement and/or lime addition.

- Author: ChukwudiOnyeakpa , Lateef Onundi

- Title: "*Improvement on the Design and Construction of Interlocking Blocks and its MouldingMachine".*

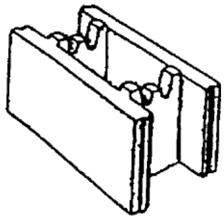
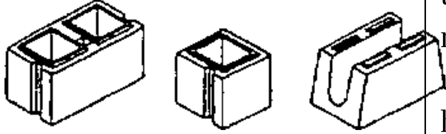
Summary: Production of blocks used for wall construction have different techniques adopted which could be in form of hollow or solid blocks produced in varying shapes laid with mortar. An improved form of mortar-less blocks, which is an innovative structural component for masonry building construction, called interlocking block, which can be produced mechanically, or manually using interlocking block production machine, particularly an improved interlocking block machine with dual mould. This brings about economical production, reduced cost of labour and appreciation of available local materials for construction of structures for both rural and urban development in the world today, thereby eliminating the use of mortar in laying of blocks. The blocks are neatly fixed through the aid of grooves and protrusion on the blocks to restrain movement when assembling the interlocking block from top and or bottom of one to another forming safe, stable, economical and aesthetic bonding for walls. It can be widely used for both temporary and permanent structures. The top blocks, middle blocks and toe blocks have different forms of projected and engraved part achieved by the aid of pallet placed at the bottom of mould and replaceable mould lid. The assembling does not require much skill, and more so, faster, neater with improved efficiency. The dismantling in the case of temporary wall is, also, easier, faster and economical which do not involve destroying any part of the wall.

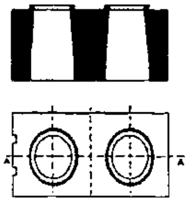
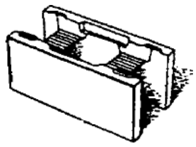
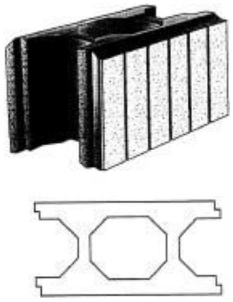
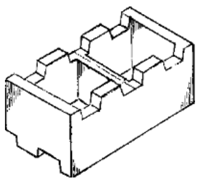
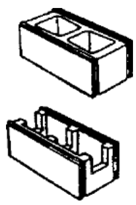
- Author: T. Praveen Kumar, R.Vigneshvar
- Title: "*Development of an Innovative Interlock Blocks".*

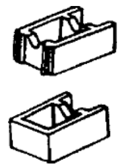
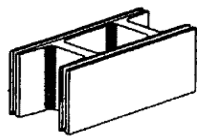
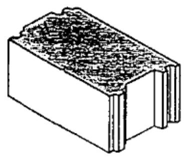
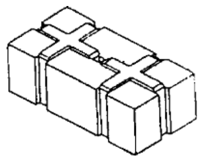
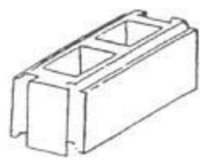
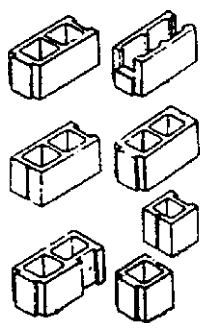
Summary: Cost effective earth quake resistant housing is desirable in seismically active rural areas of developing countries. These regions often suffer a significant loss of life during strong ground motion because of lack of seismic resistant housing. Recently, in the most developed countries, it has been verified that the traditional and conventional technologies used for construction and maintenance of buildings are inefficient and resource wasteful due to enormous amount of resources consumed. This situation leads to an increasing demand for further development of their technologies (Ghosh, 2002). To enable an efficient and cost-effective solution, a new concept of construction was investigated with these innovative interlocking blocks. Each blocks have two interlocks (i) a projection 'tongue' part and a depression 'groove 'part , this helps to resist the lateral movements and horizontal compressive stresses caused due to earthquakes. (ii) a 'T' projection in the end of block's side face and a depression in other end .The projection of one block fits in to the depression of the next so that they always align perfectly. And a partial replacement of flyash to cement is done . Fly ash decreases mechanical properties while increasing durability of blocks. One of the main aims of our approach, is to build mortar-free structures with the help of this type of interlocks. It is anticipated that the mortar-free construction can reduce the impact of earthquake to a greater extent due to the relative movement of the interlocking blocks. In this study a general study about the existing interlock patterns, sizes , types and characteristics of our innovative interlocking blocks.

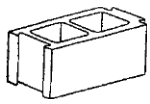
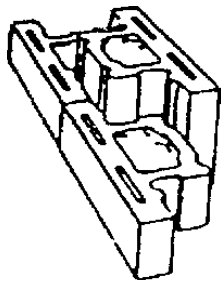
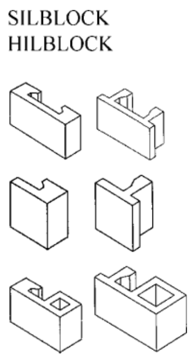
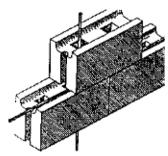
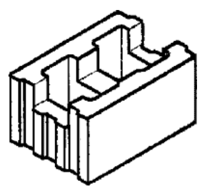
CHAPTER 3

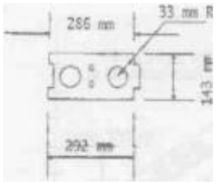
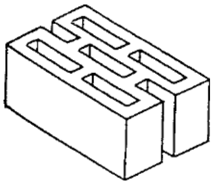
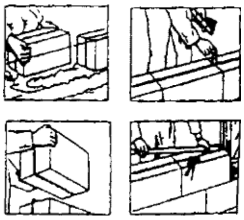
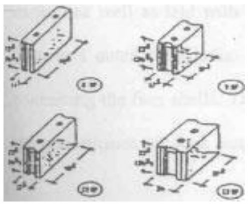
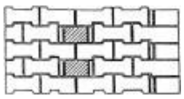
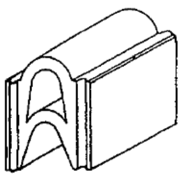
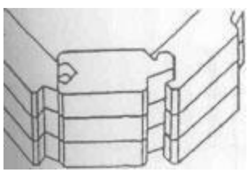
CLASSIFICATION OF INTERLOCK BLOCKS

Name of system, country, reference, geometry.	Typical unit	Block details
Haener system, USA and Canada Hollow block, concrete		Four nibs projecting above two webs to provide interlocking and control of positioning. Block placed above has four depressions on the under side of the same web locations to receive the protrudingnibs Modified block has a tongue and groove fitted head joint with alternating male– female matching on opposite face shells.
Etherington system, Manila and Bangkok Hollow block, concrete		Basic block is a closed-ended two-cell unit with a raised rim around each cell on the upper surface providing horizontal interlock. Lower surfaces have matching recesses or depressions to receive the projecting rims of the blocks below. Vertical interlocking by cement grouting of the small cells provided in the web.
Jordanian block, Jordan Hollow block, concrete		Three cell units with a raised lip around the cells which provides horizontal interlock; open ends with tongue and groove fit on the head joints. Units are arranged in stack bond pattern

TSZ block, Czechoslovakia Hollow block: light weight no-fines concrete		Laid without any mortar. The interlocking elements are the rings on the top surface of blocks around the hollow core
Sinusat system, Berlin and London Hollow block, concrete		Open ended dry stack system with a central cell. Basics blocks are widths of 125,175,200 mm. Interlocking mechanism consists of lugs placed on the face shells
Azar block, Canada[18] Hollow block: concrete		Interlocking is provided by three mechanisms Key on top of the web fits into a recess on the web of the block above Two levels of bearing surface along each face shell at the bed joint Interlocking of adjacent blocks along the head joint by shiplap geometry.
Link block system, South Africa Hollow block: concrete		Projections and recesses in the bedding surfaces resultin self–alignment, thus achieving horizontal interlocking .Blocks are stacked in stretcher bond
McIBS Inc. mortarless system Hollow block, lightweight concrete		Two-cell closed-end unit with a tongue and groove joint on the bed and head joint Closed cells result in vertical threading over the reinforcement bars during construction

Stepoc building system, UK Hollow block, concrete		Single-cell unit with one open end laid dry in 1/3 running bond with standard width of 140, 190, 256 mm. Can be reinforced in vertical and horizontal directions
Modified H block, USA[21] Hollow block, concrete		Has grooved face shells on both the head and bed joints with completely self- aligning cores. Open ends of the unit facilitate construction around the vertical reinforcement.
German KLB system, Germany, Solid block, lightweight, concrete		Partial interlocking with a tongue-and-groove arrangement on head joint
Soil-cement block, Thailand Hollowblock, Soil–cement		Modification of soil cement block which rely on interlock laying and cement grouting at the central hollow space instead of mortar bed
Whelan block[24] Hollow block, concrete		Blockwithadovetailedendjointandprojectionsandrecesses onthebedjoints. Suitable for vertically reinforced construction, but closed cells result in vertical threading over the reinforcement bars during constructions
Barlock system, Texas[12] Hollow block, concrete		Has dovetail lug with sharp corners on head joint for a snug fit. The units are 150 and 200 mm wide Can be reinforced in the vertical and horizontal directions with a bond beam

WHD system, USA Hollow block, concrete		Has more rounded dovetail lug on head joint Consists of stretcher, corner and half block units
Sparlock system, Canada[26,27,28] Hollow block, concrete		Mostintricateshapedinterlockingblocksthroughgeometryandstackingpattern with interlock both in vertical and horizontals directions. Consists of full and half course blocks for stretcher unit and end blocks Masonry construction may by dry stacking, surface bonded or grouted Suitable for vertically reinforced construction only, but closed cells result in vertical threading over the reinforcement bars during construction
Silblock/hilblock, India Solid /hollow block, concrete		Simple shaped interlocking blocks through geometry and stacking pattern without tongue-and-groove and without undercuts. Interlocking in both vertical and horizontals directions Discontinuity of bed joint and cross joint from inner to outer face System is comprised of three basic shapes stretcher, jambs, and corner blocks with full and half-height units
Mecanosystem,Peru Hollow block		Blocks are dry-stacked then reinforced and grouted. Basic units are 150 mm high, 300 mm long and 120–150 mm wide Can be reinforced in the vertical and horizontal directions
Faswall system, South Carolina Hollow block, composite of cement and mineralized wood		Can be reinforced and grouted to form a solid structural wall

Dry stacked clay masonry wall system, USA		partially reinforced single-wythe wall
Spar fill system, Canada Hollow block, lightweight polyester-gene aggregate concrete		Dry-stacked and surface-bonded with a matrix of glass fiber in Portland cement
Tasta system, Netherland Block with horizontal grooves, light- weight cellular concrete		Synthetic coupling strips shoved into the vertical grooves and H shaped strips, which are placed into the horizontal grooves in the blocks connected to the coupling strips. Surface of the masonry is provided with glass fibre skin covered with plaster
German KS-R system, Germany Solid block, lightweight concrete		Interlocking at head joint and laid with mortar on the bed joints
I-shaped blocks Hollow block, concrete		Mortar-laid masonry with blocks of special shape which may interlock together Can be reinforced in vertical direction and grouted
Domed block, Canada Hollow space for double-domed unit, concrete		Blocks can be dry-stacked as well as laid with mortar
Baker system, Australia Solid block		Interlocking head joints by means of dovetail lugs without bed joint interlocking Allows courses to be curved

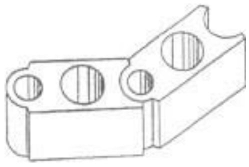
Structural block system, Hollow block		Units have circular cores may be rotated at the interlock connection between adjacent blocks to form curved walls

Table 3.1

BLOCKS

Two types of blocks done in our project are:

Mud blocks

Earth block is a construction material made primarily from soil. Types of earth block include compressed earth block (CEB), compressed stabilized earth block (CSEB), and stabilized earth block (SEB).

Stabilized mud block (SMB) or pressed earth block is a building material made primarily from damp soil compressed at high pressure to form blocks. If the blocks are stabilized with a chemical binder such as Portland cement they are called compressed stabilized earth block (CSEB) or stabilized earth block (SEB). Creating SMBs differs from rammed earth in that the latter uses a larger formwork into which earth is poured and manually tamped down, creating larger forms such as a whole wall or more at one time rather than building blocks and adobe which is not compressed. Stabilized mud block uses a mechanical press to form block out of an appropriate mix of fairly dry inorganic subsoil, non-expansive clay, aggregate, and sometimes a small amount of cement.

Fig 3.2.1.1 example for mud blocks

Concert blocks

Cement concrete dense/ hollow bricks and blocks are very popular and are extensively used in building construction throughout the country because of the many advantages such as durability, strength and structural stability, fire resistance, insulation and sound absorption it possess. The cement concrete blocks have an attractive appearance and are readily adaptable to any style of architecture. It lends itself to a wide variety of surface finishes for both exterior and interior walls. The blocks are used for both load bearing and non-load bearing walls. The hilly states of India have high humidity, dampness and rainfall, so the blocks are much useful for the N.E. Region, Himachal Pradesh, J&K, U.P. etc.

The blocks are made out of these blocks in masonry there is stone chips. With the use of these blocks in masonary there is saving in cement, stell, time and labor as compared with burnt bricks masonry. This saving, therefore, brings down the cost of construction considerably. The cement concrete blocks have an attractive appearance and are readily adaptable to any style of architecture. It lends itself to a wide variety Of surface finishes for both exterior and interior walls.

Fig 3.2.2.1 example for concrete block

CHAPTER 4

MATERIALS

Mud blocks

Soil

- Soil characteristics and climatic conditions of an area must be evaluated before manufacturing soil building blocks.
- A dry climate, for example, needs different soil blocks from those used in temperate, rainy or tropical areas, all soils are not suitable for every building need.
- The basic material, however, required to manufacture compressed stabilized earth building blocks is a soil containing a minimum quantity of silt and clay so as to facilitate cohesion.
- Soils are variable and complex materials, whose properties can be modified to improve performance in building construction by the addition of various stabilizers.
- All soils consist of disintegrated rock, decomposed organic matter and soluble mineral salts. Soil types are graded according to particle size using a system of classification widely used in civil engineering. This classification system based on soil fractions shows that there are 4 principal soil fractions - gravel, sand, silt and clay. For soil stabilization, the clay fraction is most important because of its ability to provide cohesion within a soil.
- The manufacture of good quality, durable compressed stabilized earth blocks requires the use of soil containing fine gravel and sand for the body of the block, together with silt and clay to bind the sand particles together.
- An appropriate type of stabilizer must be added to decrease the linear expansion that takes place when water is added to the soil sample. The stabilizer has further benefits that are described in a later section.

Soil Identification

A very few laboratories can identify soils for building purposes, but soil identification can be performed by anybody with sensitive analyses. The main points to examine are:

- Grain size distribution, to know quantity of each grain size
- Plasticity characteristics, to know the quality and properties of the binders (clays and silts)
- Compressibility, to know the optimum moisture content, which will require the minimum of compaction energy for the maximum density.
- Cohesion, to know how the binders bind the inert grains.
- Humus content, to know if they are organic materials which might disturb the mix.

Preliminary tests

Laboratory analysis of the raw material is always necessary for large-scale production of compressed stabilized earth blocks. For small-scale production, however, it is not essential to employ sophisticated tests to establish the suitability of a soil. Simple field tests can be performed to get an indication of the composition of the soil sample. Such tests are

a) Smell test

Smell the soil immediately after it has been sampled. If it smells musty it contains organic matter. This smell will become stronger if the soil is heated or wetted. Soil containing organic matter is not suitable for production of compressed stabilized earth blocks.

b) Nibble test

Care should be taken to ensure that it is safe to place any samples in the mouth. Nibble a pinch of soil, crushing it lightly between the teeth. If it grinds between the teeth with a disagreeable sensation, the soil is sandy. If it can be ground between the teeth, without a disagreeable sensation the soil is salty. If it has a smooth or floury texture and if when a small piece is applied to the tongue it sticks, the soil is clayey.

c) Touch test

Remove the largest grains and crumble the soil by rubbing the sample between the fingers and the palm of the hand. If it feels rough and has no cohesion when moist the soil is sandy. If it feels slightly rough and is moderately cohesive when moistened the soil is silty. If, when dry, it contains lumps or concretions which resist crushing, and if it becomes plastic and sticky when moistened the soil is clayey.

d) Sedimentation test:

- The tests mentioned previously make it possible to form a general idea of the texture of the soil and the relative particle sizes of the different fractions.
- To obtain a more precise idea of the nature of each soil fraction, a simplified sedimentation test can be carried out in the field.
- The apparatus required is straight forward: a transparent cylindrical glass bottle with a flat bottom and a capacity of at least one litre, with a neck wide enough to get a hand in and a lid to allow for shaking.
- Fill the bottle to one-third with clean water. Add approximately the same volume of dry soil passed through a 6mm sieve and add a teaspoonful of common salt.
- Firmly close the lid of the bottle and shake until the soil and water are well mixed. Allow the bottle to stand on a flat surface for about half an hour.
- Shake the bottle again for two minutes and stand on level surface for a further 45 minutes until the water starts to clear.
- The finer particles fall more slowly and as result will be deposited on top of the larger size particles. Two or three layers will emerge, with the lowest layer containing fine gravel, the central layer containing the sand fraction and the top layer containing silt and clay.

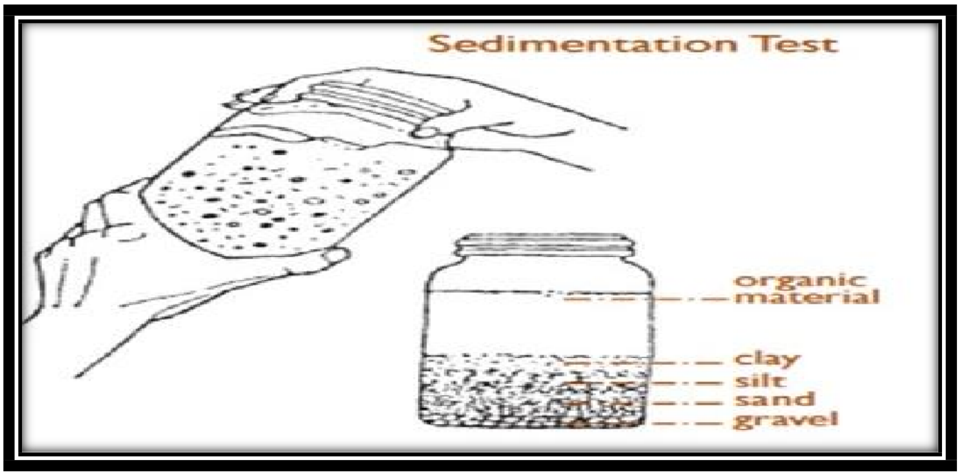


Fig 4.1.3.1 Sedimentation test

- The relative proportions, and hence percentages, of each fraction can be determined by measuring the depth of each layer.

e) **Adhesion test:**

Compact a ball of moist soil so that it does not stick to the fingers and insert a spatula or knife. If the spatula penetrates it with difficulty, and soil sticks to it upon withdrawal, the soil is extremely clayey. If the spatula can be pushed into, it without great difficulty but a bit of soil remains on the knife upon withdrawal the soil is moderately clayey. If the spatula can be pushed into the mass without encountering any resistance at all, even if the spatula is dirty upon withdrawal the soil contains only a little clay

f) **Washing test:**

Rub the hands with some slightly moistened soil. If the hands are easy to rinse clean this implies that the soil is sandy. If the soil appears to be powdery and the hands can be rinsed clean fairly easily the soil is silty . If the soil has a soapy feel and the hands cannot be rinsed easily the soil is clayey.

g) **Water Retention Test:**

- Form a ball of fine soil, 2 or 3cm in diameter.
- Moisten the ball so that it sticks together but does not stick to the fingers.
- Slightly flatten the ball and hold it in the palm of the extended hand.
- Vigorously tap the ball with the other hand so that the water is brought to the surface. The ball will appear smooth, shiny or greas.

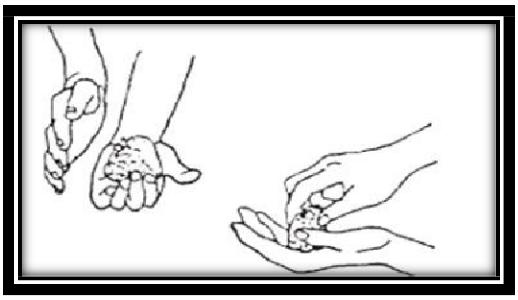


Fig4.1.3.2 Water retention test

- Press the ball flat between thumb and index finger.
- Observe the number of taps required for a reaction as well as the consistency of the soil.

Soil Suitability and Stabilization

Not every soil is suitable for earth construction and CSEB (Compressed Stabilized Earth Blocks) in particular. But with some knowledge and experience many soils can be used for producing CSEB. Topsoil and organic soils must not be used. Identifying the properties of a soil is essential to perform, at the end, good quality products. Some simple sensitive analysis can be performed after a short training. A soil is an earth concrete and a good soil for CSEB is more sandy than clayey. It has these proportions:

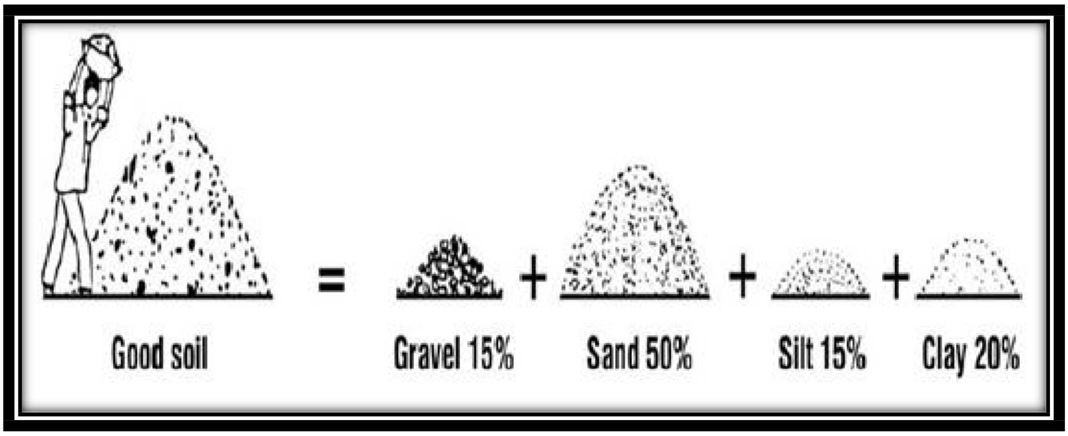


Fig 4.1.3.3.Propotions of good soil

According to the percentage of these 4 components, a soil with more gravel will be called gravely, another one with more, sand, sandy, others silty or clayey, etc. The aim of the field tests is to identify in which of these four categories the soil.

Cement:

For mud blocks with cement as stabilizing agent showed more compressive strength than the mud blocks with lime as the stabilizing agent. For lime when percentage of stabilizer is increased, the change/increase in compressive strength was very slight.

Water content:

- The water content should not exceed the 20% by weight.
- In this project 15% of water is added.

Cement concrete blocks

Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. The word “cement” traces to the Roman’s, who used the term opus caementicium to describe masonry resemblingmodernconcretethatwasmadefromcrushedrockwithburstlimeasabinder.Thevolcanic ash and pulverized brick supplements that were added to the burnt lime, to obtain hydraulic binder, were later refer redtoascementum, cementum, cament and cement. Although the percentage of cement in concrete is around 15%, the role of the cement is very important in the strength and durability of concrete.

Tests on Cement

a).Normal Consistency Test: Standard consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 10mm dia and 50mm length to penetrate to a depth of 33-35mm from top of the mould.

NAME	CAPACITY/ RANGE /SIZE	ACCURACY/LEAST COUNT
Vicat Apparatus	Should be made as per Is: 5513	—
Balance	1000 g	1g
Measuring Cylinder	100 ml	1ml

Table (a)

Fig 4.2.2.1(a)Vicat apparatus

Procedure

1. Take 400g of cement and place it in the enameled tray.
2. Mix about 25% water by weight of dry cement thoroughly to get a cement paste. Total time taken to obtain thoroughly mixed water cement paste i.e. “Gauging time” should not be more than 3 to 5 minutes.
3. Fill the vicat mould, resting upon a glass plate, with this cement paste.
4. After filling the mould completely, smoothens the surface of the paste, making it level with top of the mould.
5. Place the whole assembly (i.e. mould + cement paste + glass plate) under the rod bearing plunger.
6. Lower the plunger gently so as to touch the surface of the test block and quickly release the plunger allowing it to sink into the paste.
7. Measure the depth of penetration and record it.
8. Prepare trial pastes with varying percentages of water content and follow the steps (2 to 7) as described above, until the depth of penetration becomes 33 to 35mm.

Tabulations

% of water	Amount of water added (ml)	Depth of penetration (mm)
24	26	39
26	104	32
28	112	28
30	120	21
32	128	11
34	136	7
36	144	4

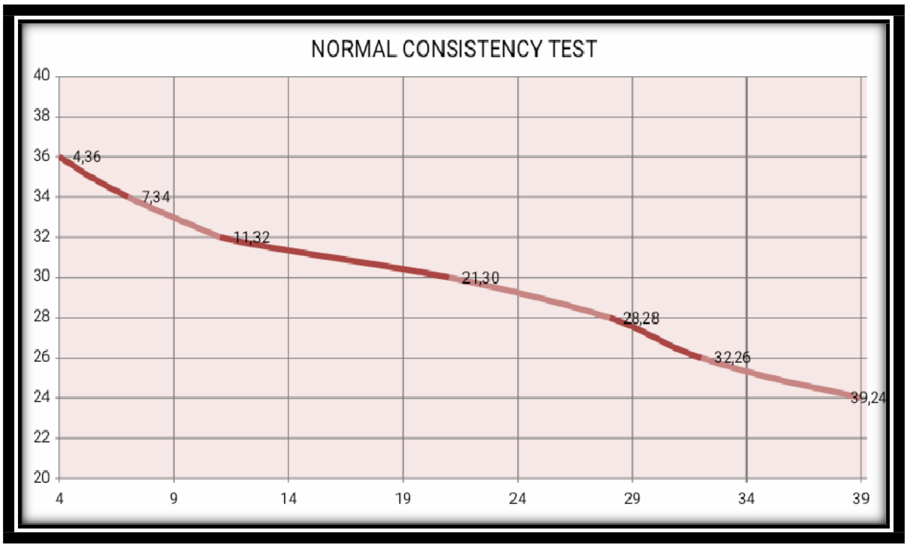


Fig 4.2.2.2(a) graph

Result: The Normal consistency of the given sample is **35%**

b). Specific Gravity: Specific gravity of cement is the ratio of weight of volume of material to the same weight of volume of water.

Fig 4.2.2.3 (b) Le- Chatelier's apparatus

Procedure

1. The bottle should be free from the liquid that means it should be fully dry. Weigh the empty bottle.
2. Next, fill the cement into the bottle up to top of the bottle around 50g and weigh with its stopper.
3. Add kerosene to the cement up to a top of the bottle. Mix well to remove the air bubbles in it. Weigh the bottle with cement and kerosene.
4. Empty the flask. Fill the bottle with kerosene up to the top and weigh the bottle.

Tabulations

1. Weight of empty bottle, w1	322.6g
2. Initial level of kerosene in the flask, h1	0.8
3.Weight of empty bottle + kerosene + weight of cement poured in the flask	386.2 g
4.Final level of kerosene e after pouring cement, h2	20.9
5.Mass of cement taken (w2 – w1)	63.6g
6.Volume of kerosene displaced (h2 – h1)	20.1
7.Density of cement = mass of cement / volume displaced	3.164 g/cc
8.Specific gravity of cement = density of cement / density of water	3.164

Table 4.2.2(b)

Result: Specific gravity of cement = **3.164**

Fine aggregates

Fine aggregates are obtained from a variety of sources. The sources of aggregate are in variably close to their demand locality; it is difficult to transport the large quantity of aggregate (in tonnes) and there will be high cost of transportation. They can be sourced from pits, river banks and beds, the seabed, gravelly or sandy terraces, beaches and dunes. The other deposits that provide granular materials can be processed with minimal extra effort or cost. Sand and gravel, which are unconsolidated sedimentary materials, are important sources of natural aggregate. The occurrence of high quality naturals and sand gravels with in economic distance of major urban areas may be critical for viable concrete construction in those areas.

Fine aggregate (Sand) is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to at external class of soil or soil type;i.e.a soil containing more than 85% sand-size particle by (mass).

In concrete 30- 40% of the volume is occupied by fine aggregate. Aggregate passes through

9.5mm sieve and almost passes through the 4.75mm sieve and predominantly retains on the 75-micron sieve. Most of the fine aggregate passes 4.75mm IS sieve and contains a huge amount of coarser materials.

Tests on Fine Aggregate

a). Specific Gravity of Sand: Specific gravity is the ratio of the weight in the air of a given volume of a material to the weight in air of an equal volume of distilled water.Specific gravityofriversandis around 2.5 and manufactured sand is around2.7

Fig 4.2.4.1 (a) pycnometer

Procedure:

1. Take a clean, dry pycnometer, and find its weight with its cap and washer(W1).
2. Put about 500g of sand in pycnometer and find its weight(W2).
3. Fill the pycnometer and filled in sand as step2, with distilled water and measure its weight (W3).
4. Empty the pycnometer value, clean it thoroughly, and fill it with clean water only to the hole of the conical cap, and find its weights(W4).
5. Repeat the same procedure at least for three differentsamples.

Tabulations

	Trail 1	**Trail 2**
1.weight of pycnometer , w1g	657	657
2.weight of aggregate + pycnometer, w2g	957	957
3.weight of aggregate + pycnometer +water, w3g	1720.2	1719
4.weight of water + pycnometer, w4g	1532.2	1535
5.Specific gravity of sand = (w2 - w1)/(w2 - w1) - (w3 - w4)	2.68	2.59

Table 4.2.4(a)

Result: Specific gravity of sand **= 2.63**

b). Sieve Analysis: Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) –1963. In this we use differentsievesasstandardizedbytheIScodeandthenpassaggregatesthroughthemandthuscollect different sized particles left over different sieves.

Fig 4.2.4.2. (b) Sieve analysis apparatus

Procedure:

1. Using the sieve sizes required by the specification, arrange sieves in descending order with the largest size ontop.

2. If using a mechanical sieve shaker, place the set of sieves on top and pour the prepared aggregate on to the top sieve, cover the stack of sieves and pan, turn on the machine, and set it to shake for at least 5minutes.

3. If hand sieving, start with the largest size, and progress toward the smaller sieve sizes; move the sievesinlateralandverticalmotionsaccompaniedbyajarringactiontokeepthematerialmoving continuously over the surface of the sieves. Hand manipulation without forcing particles through the sieve is permitted.

4. For either mechanical or hand sieving, sieve the material until not more than 1% by mass of the residue on any individual sieve will pass that sieve during 1 minute of continuous handsieving.

5. Using a scale with a capacity large enough to obtain the mass of the total sample, determine the mass of the fine aggregate to the nearest 0.1 g and coarse aggregate to the nearest1g.

6. First, determine the mass of the aggregate retained on the largest sieve size and record thevalue.

7. Add the contents of the next largest sieve size on the scale, obtain the cumulative mass of the two sizes and record thismass.

8. Finally, add the contents of the next size, and repeat this operation until the contents of thesmallest sieve size used is empty, and cumulative mass has been obtained andrecorded.

9. When the specifications require percent passing, record the weights retained on each sieve individually.

Tabulations

Sl. No	IS sieve size	Empty wt. of sieve, kg	Wt. Of sieve + sand, kg	Mass of sand retained, kg	% retained on each sieve	Cumulative %retained	% passing
1	4.75	0.373	0.373	0	0	0	100
2	2.36	0.288	0.288	0	0	0	100
3	1.18	0.36	0.545	0.185	37	37	63
4	0.6	0.361	0.464	0.103	20.6	57.6	42.4
5	0.3	0.317	0.379	0.062	12.4	70	30
6	0.15	0.3	0.37	0.07	14	84	16
7	pan	0.288	0.368	0.08	16	100	0

Table 4.2.4(b)

The results should be calculated and reported as : The cumulative percentage by weight of the total sample. The percentage by weight of the total sample passing through one sieve and retained on the next smaller sieve, to the nearest 0.1percent. The results of the sieve analysis may be recorded graphically on a semi-log graph with particle size as abscissa (log scale) and the percentage smaller than the specified diameter asordinate.Fine aggregate is generally considered to have a lower size limit of 0.07mm or 0.06mm. Originally, all natural aggregate particles are a part of larger mass.

Coarse aggregate

The material which is retaining on BIS test sieve No.480 is termed as coarse aggregate. The broken stone is generally used as coarse aggregates. The nature of work decides the maximum size of the aggregate. For the thin slabs and walls, the maximum size of coarse aggregate should be limited to one–thirdthethicknessofconcretesection.Theaggregatetobeusedforcementconcreteworkshould be hard, durable and clean. The aggregate should be completely free from lumps of clay, organic and vegetable matters, fine dust, etc. Crushed coarse aggregate are collected from local source. The size varying from 20 to 4.75mm. Aggregates were in saturated surface dry (SSD) condition and these are prepared to meet the requirements of IS code.

Tests on soil

Aim: To determine the optimum moisture content of the soil as per IS:2720 (Part VII) .

Apparatus: Standard mold, Rammer, Soil taken for testing may retain on 4.75mm sieve, Weighing balance.

Procedure:

1. Collect the soil sample weighing 3kg. The sample must be 3kg after air drying it. Usually, this soil will be pulverized soil that passes through 4.75mm sieve. If the soil is coarse-grained type, the water is added such that its water content comes to 4%.
2. If the soil is fine-grained, water is added to make its water content to 8%. The water content of the sample after addition must be less than the optimum water content.
3. Next, the apparatus is prepared by cleaning the mold thoroughly. The mold has to be dried and greased lightly. The mass of the mold with base plate and without collar is weighed. Let it me (Wm).
4. The mold placed over solid base plate is then filled with prepared matured soil to one-third of the height. This layer will take 25 blows with the rammer. The rammer has a free fall height of 310 mm.
5. The compaction must be done in such a way that the blows are evenly distributed over the surface of each layer.
6. Next, the second layer is added. Before adding the second layer the top of the first layer has to be scratched. Now the soil is filled to two-thirds of the height of the mold. This too is compacted with 25 blows.
7. Later the third layer is added. It is compacted similarly. The final layer must project outside the mold and into the collar. This amount must not be greater than 6mm.
8. The bond between the soil in the mold and the collar is broken by rotating the collar. Next the collar is removed and the top layer of soil is trimmed and levelled to the top layer of mold.
9. Next, the mass of the mold with compacted soil and base plate is determined (W_{ms}). Hence the mass of the compacted soil (W_s) is determined as: $\mathbf{W_s = Wm - W_{ms}}$. The mass of compacted soil and the volume of the mold gives bulk density of the soil. From the bulk density the dry density can be determined for the water content used (w).
10. The same procedure from (1-8) is repeated by increasing the water content in the soil by 2 to 3%. Each test will provide a different set of values of water content and dry density of soil. From the values obtained **compaction curve** is graphed between the dry density and water content.

11. Tabular column

Water content (%)	Mass of the soil (g)	EWC (g)	EWC+WS (g)	EWC+DS (g)	volume of mould (cc)	Density of soil (g/cc)
12	1567	14	26	25	1005.31	1.558723

14	1639	13	27	24	1005.31	1.630343
16	1678	11	22	20	1005.31	1.669137
18	1749	22	33	31	1005.31	1.739762
20	1757	17	31	29	1005.31	1.747720
22	1819	10	22	20	1005.31	1.809392
24	1875	14	28	25	1005.31	1.865096
26	1859	12	27	24	1005.31	1.849181
28	1827	14	29	22	1005.31	1.817350

Table 4.2.6(a)

EWC = Empty weight of the cup

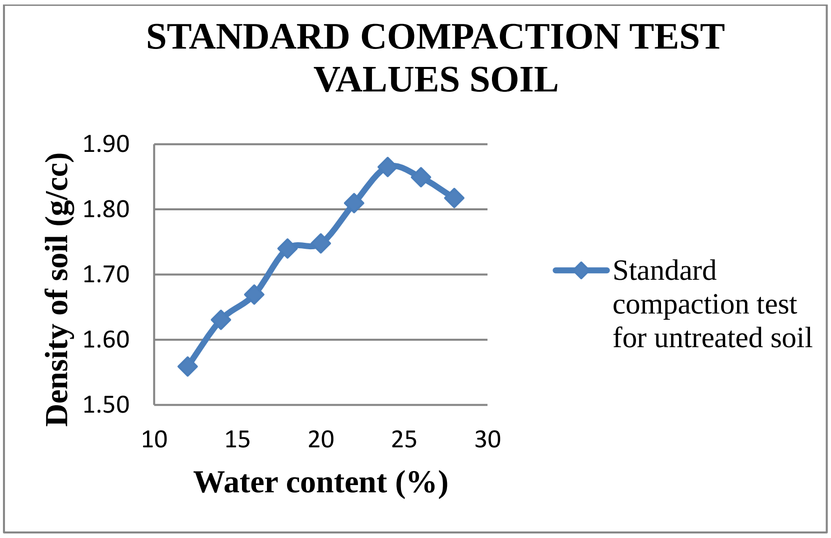
EWC+WS = Empty weight of the cup+ wet soil

EWC+DS = Empty weight of the cup+ dry soil

Diameter of mould = 10cm

Height of the mould = 12.8cm

Volume = (Π/4)*102*12.8 = 1005.31 cc



Result

Optimum moisture content of soil <u>**24%**</u>

Maximum dry density of soil **1.865096g**

Tests on Coarse Aggregate

Specific Gravity of Coarse Aggregate: Specific gravity is defined as the ratio of weight of aggregate to the weight of equal volume of water. The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Aggregates having low specific gravity are generally weaker than those with high specific gravity. Specific gravity of coarse aggregate is found using the wire basketmethod.

Fig 4.2.6.2(b) Specific gravity apparatus

Procedure:

1. Take about 2kg of the coarse aggregate sample and the place in a wire basket. Now immerse the basket into a tank of distilled water.
2. The entrapped air is removed from the sample by lifting the basket 25mm above the base of tank and allowing to drop 25 times at the rate of about one drop per second.
3. The basket and aggregate is then left immersed completely in water for next 24 hours. Then weighed while suspended in water(w1).
4. The aggregate in the basket is then removed from water and allowed to drain for few minutes and then transferred to an absorbent cloth.
5. The empty basket is then jolted in water again for 25 times and weighed(w2).
6. The surfaced dried aggregate is then weighed(w3).While some amount of aggregate are let to oven dry at 110˚C.
7. After 24 hours the oven dried aggregates are weighed as (w4).

Tabulations

1. Weight of saturated aggregate and basket in water, w1 g	1940
2. Weight of basket in water, w2 g	694
3. Weight of saturated aggregates in air, w3 g	2000
4. Weight of oven dried aggregates in air, w4 g	1990
5. Specific Gravity = w4/(w4-(w1-w2))	2.67

Table 4.2.6(b)

Result: Specific gravity of coarse aggregate is **2.67**

CHAPTER 5

METHODOLOGY

Collection of materials

- Soil.
- Cement.
- Fine aggregates(M sand)
- Coarse aggregates.

Fig 5.1.1 soil

Fig 5.1.2 cement

Fig 5.1.3 fine aggregates

Fig 5.1.4 Coarse aggregates

Design of Mould

For the sake of better interlocking purpose the innovative design is done by our team, which is having grove section width 50mm, and projection width having 48mm, two millimeters gap because to have better interlocking between two blocks and also as per our design we made block size of 300X150X150mm. The clear details are given in figures.

Fig 5.1.5

Fig 5.1.6

BLOCK SIZE 300*150*150mm

Fig 5.1.7

Fig 5.1.8

T-Section

I-Section

DESIGN OF BLOCK

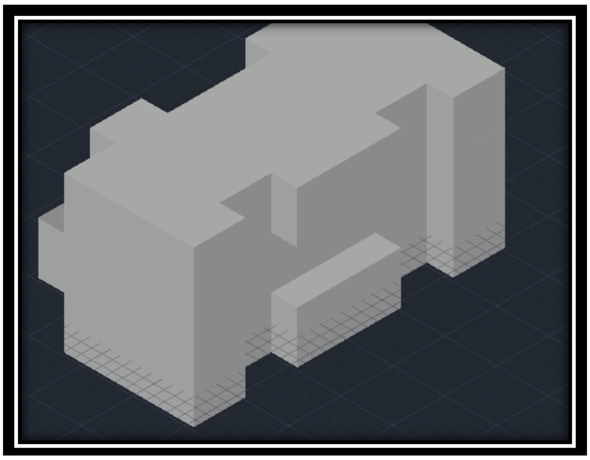


Fig 5.1.9 Groove-Section

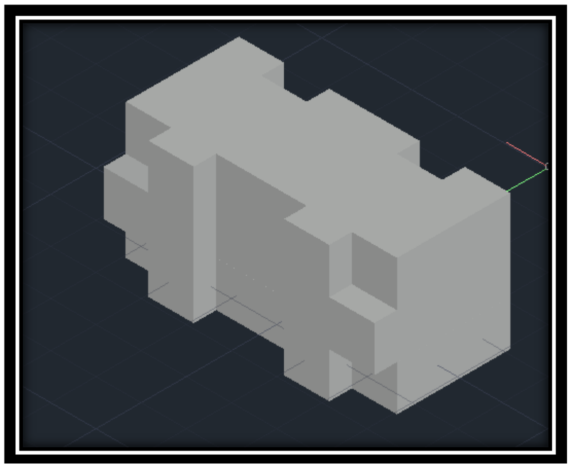


Fig 5.2 Projection-Section

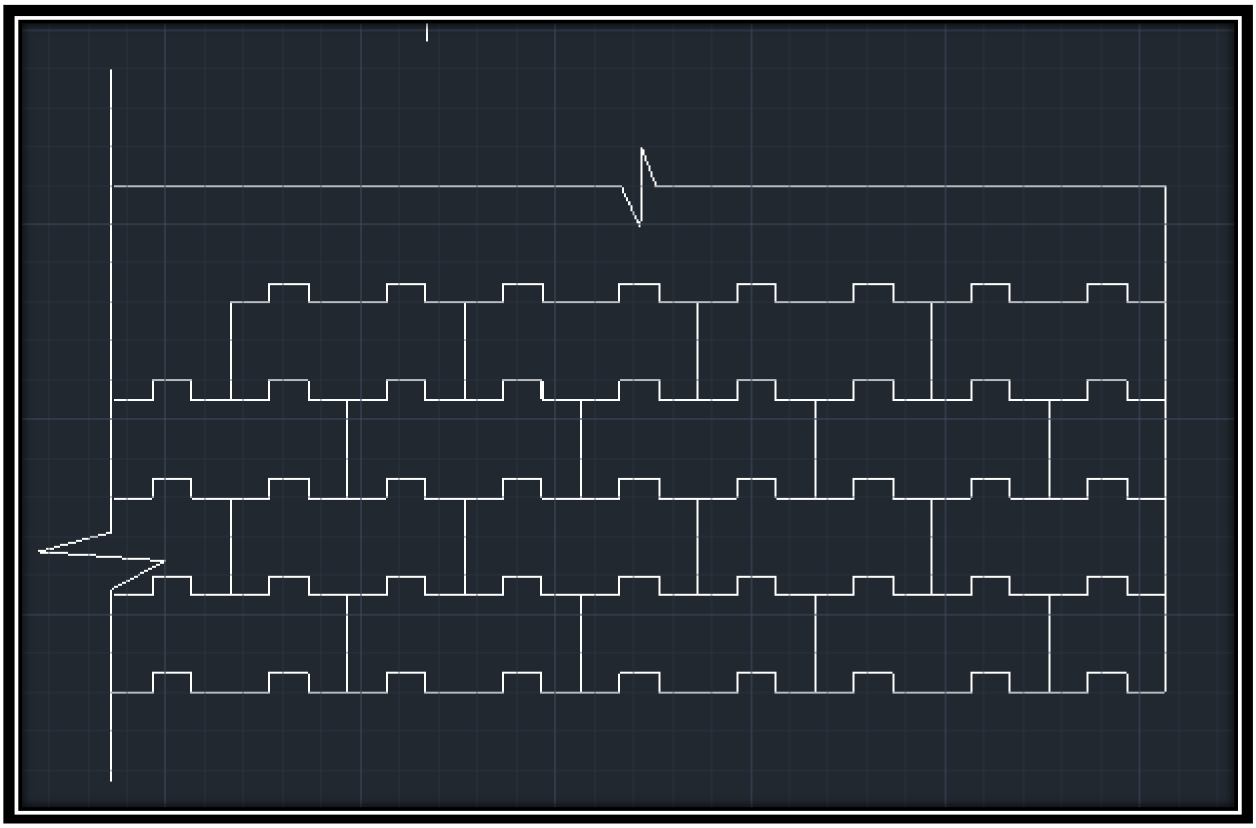


Fig 5.2.1 CONSTRUCTION OF WALL

Projection section

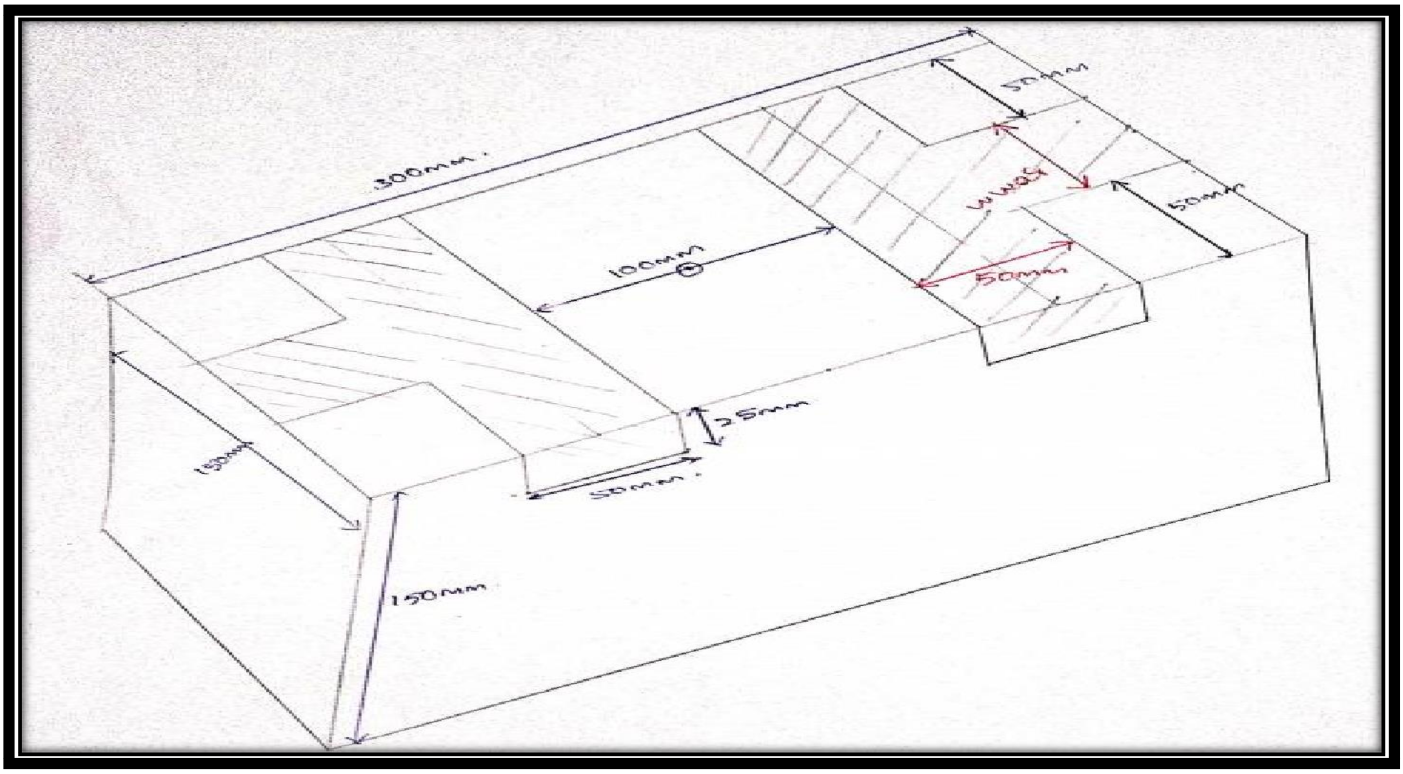


Fig 5.2.2 Projection section

Groove section

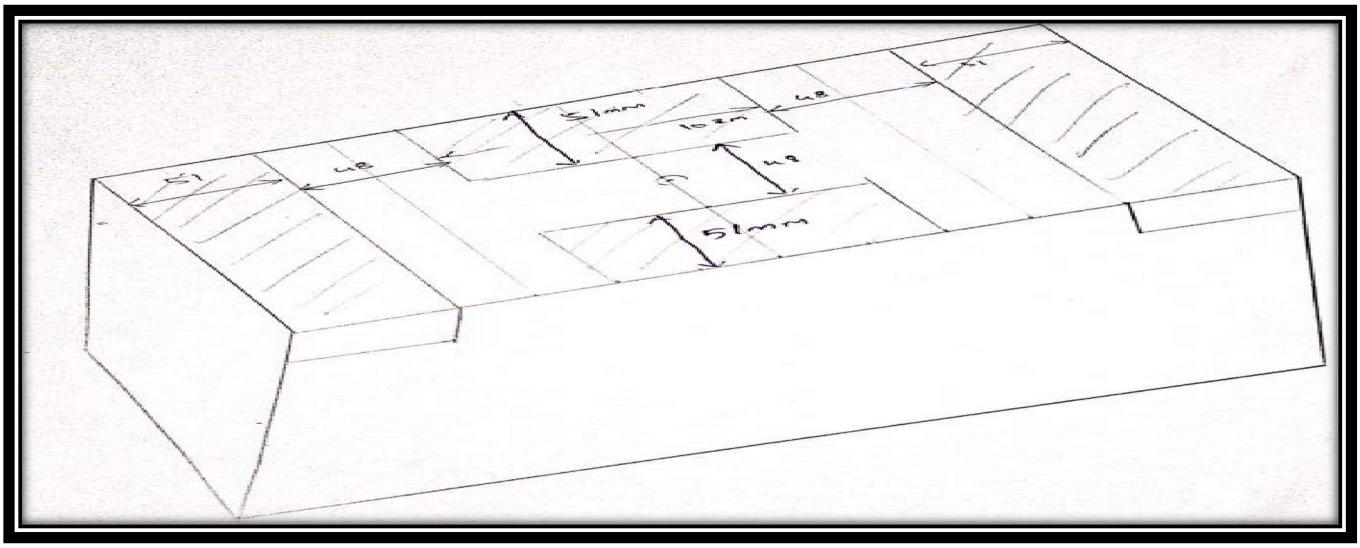


Fig 5.2.3 Groove section

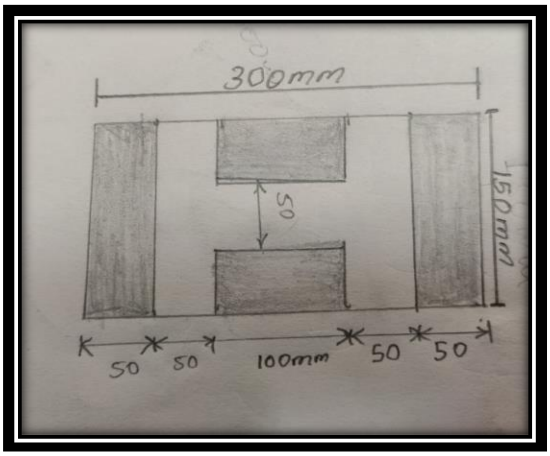


Fig 5.2.4.Plan section for groove

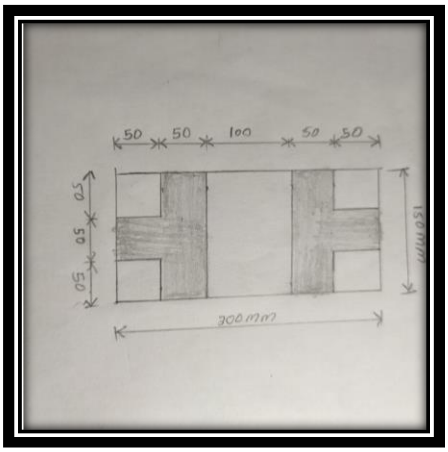


Fig 5.2.5.Plan section for projection

Mix proportion used for the blocks:

Mud blocks

- The soil must be free from organic material, must not contain harmful quantitiesof salts, and should contain sufficient clay to bind the blocks, so that they may behandled immediately after manufacture, without disintegrating. Generally, the soil should comply with the grading and plasticity requirements set out below.
- Soils with a higher plasticity (greater than 15) are acceptable, if the material istreated with lime; laboratory testing will confirm the dose needed and additional curing time required.
- Water must be clean and should not contain any harmful quantities of acid,alkalis, salts, sugars, or any other organic or chemical material. Drinking wateris normally satisfactory.
- The cement content required will typically be in the range 4-7%, by volume of dry soil, for 4MPa blocks and 7-10%, by volume of dry soil, for 7MPa blocks.

From this we estimate quantity, Example:

- Its production will need about 7.5 to 8.5kg of materials depending on the compaction pressure.
- The exact amount of stabilizer necessary must be established for any particular project.
- The fraction of lime or cement usually varies between 5% to 8% by weight. Similarly, the optimum

water content (OMC) for any particular soil must be determined experimentally. The moisture level varies widely with the nature of the soil. An approximate estimate of about 15% by weight is often assumed.

Cement concrete blocks

- Concrete blocks are often made of 1:3:6 concrete with a maximum size aggregate of 10mm or a cement-sand mixture with a ratio of 1:7, 1:8 or 1:9.
- Cement conforming to IS 269 orIS8112 or IS 12269 is used .
- The aggregates used in the manufacture of blocks at the mixer or the mixing platform shall be clean and free from deleterious matter and shall conform to the requirements of IS 383.
- The grading of the combined aggregates shall conform as near as possible to the requirements indicated in IS 383.
- The water used in the manufacture of concrete masonry units shall be free from matter harmful to concrete or reinforcement, or matter likely to cause efflorescence in the units and shall conform to the requirements of IS 456.
- The standard mix for Concrete Blocks is 1:3:5, 1 part cement to 3 parts sand & 5 parts stone aggregate, by volume. 1 part cement to 8 parts mixed aggregate is used as per weight it differs..

From this, we can estimate quantity, Example:

- Cement=10kg
- Sand= 30-40kg
- Coarse aggregate (<10mm) = 40-50kg
- Water = 5000ml

Casting and curing

- Casting is done as per the IS:2185 (Part 1): 2005,as per design of mould the blocks are casted.
- Curing the blocks hardened in accordance with After ejection demoulding, the blocks shall be handled carefully to avoid damage.
- The blocks shall be protected until they are sufficiently hardened before starting curing shall then be cured as per 13.5 of IS 456.

Tests for blocks as per code book IS: IS 2185 (Part 1): 2005

Method for the determination of compressive strength.

Compressivestrengththisthecapacityofmaterialorstructuretoresistorwithstandundercompression.

AThe Compressive strength of a material is determined by the ability of the material to resist failure in the form of cracks and fissure.

Aim: To determine the compressive strength of mud block and cement concreteblo

Fig 5.6.1.1 compressive strength test machine

Apparatus: Testing machine, Steel bearing blocks and plates, Test specimen.

Procedure:

Preparation of block.

Place the prepared cement concrete mix in the mould forcasting. Once it sets, after 24 hours remove the cement concrete block from themould. Keep the test specimens submerged under water for stipulatedtime. As mentioned the specimen must be kept in water for 7, 14, or 28days and for every 7 days the water ischanged. Ensure that concrete specimen must be well dried before placing it on theUTM.Weight of samples is noted in order to proceed with testing and it must not be less than8.1Kg.

Positioning of Specimens.

Specimens shall be tested with the centroid of their bearing surfaces aligned vertically with the centre of thrust of the spherically seated block of the testingbmachine. Except for special units intended for use with their cores in a horizontal direction, all hollow concrete masonry units shall be tested with their cores in a vertical direction. -Masonry units that are hundred percent solid and special hollow units intended for use with their hollow cores in a horizontal direction may be tested in the same direction as in service.

Speed of Testing.

The load up to one-half of the expected maximum load may be applied at any convenient rate, after which the control of the machine shall be adjusted as required to give a uniform rate of travel of the moving head such that the remaining load is applied in not less than one nor more than two minutes.

Sample.	Failure load in KN (For 7 days)	Compressive strength N/mm² (For7days)	Failure load in KN (For 28days)	Compressive strength N/mm^2 (For28 days)

Table 5.6.1.2

Observation:

1. Compressive strength of Cement concrete block = average load/ area of the specimen

2. Compressive strength of Mud block= average load/area of specimen

Results:

1. .Compressive strength of Cement concrete block =
2. Compressive strength of Mud block =

Method for the determination of water absorption.

Absorption testing is a popular method of determining the water-tightness of concrete. Measures the amount of water that penetrates into concrete samples when submersed.

Aim: To determine the water absorption for samples.

Apparatus: The balance used shall be sensitive to within 0.5 percent of the mass of the smallest specimen tested.

Fig 5.6.2.1 water absorption

Procedure:

Saturation

- The test specimens shall be completely immersed in water at room temperature for 24 h.
- The specimens shall then be weighed, while suspended by a metal wire and completely submerged in water.
- They shall be removed from the water, allowed to drain for one minute by placing them on a 10 mm or coarser wire mesh, visible surface water being removed with a damp cloth, and immediately weighed.

Drying

Subsequent to saturation, all specimens shall be driedin a ventilated oven at 100”C to 115°C for not less than 24 h and until two successive weighing’s at intervals of 2 h show an increment of loss not greater than 0.2 percent of the last previously determined mass of the specimen.

Calculations:

A= wet mass of units, in kg;

B= dry mass of units, in kg;

C= suspended immersed mass of units, in kg.

Block	A	B	C	Water absorption, kg/m³	Water absorption in percentage
Cement concrete block					
Mud block					

Table 5.6.2.2

Results:

1. The water absorption of cement concrete block is kg/m³.
2. The water absorption of mud block is kg/m³.

Method for the determination of block density

Aim: To determine the block density of samples.

Apparatus: Blocks, Measuring scale, weighing instrument, oven.

Procedure:

- The three clocks should select randomly.
- Three blocks shall be dried to constant mass in a suitable oven heated approximately 100 ºC.

- After cooling the blocks to room temperature, the dimensions of each block shall be measured in centimetres to the nearest millimeter and the overall volume computed in cubic centimetres.

- The blocks shall then be weighted in kilograms to the nearest 10 gm.

Calculations:

$$\text{Density} = \frac{\text{Mass of block, in kg}}{\text{Volume of specimen, in cm}^3} \times 10^6 \ \text{kg/m}^3$$

Block	Trail 1	Trail 2	Trail 3	Density of blocks
Mass of mud blocks in kg				
Volume of specimen in cm^3				
Mass of cement concrete blocks blocks in kg				
Volume of specimen in cm^3				

Table 5.6.3.1

Result:

Block density of mud blocks in kg/m^3=

Block density of cement concrete blocks in kg/m^3=

Method for the determination of drying shrinkage

Aim: To determine the drying shrinkage for sample.

Apparatus: Dail guage accurate to 0.0025mm, test specimen, drying oven.

Preparation of specimens:

One sample shall be cut from each of the blocks such that the length of each specimen is not less than 15 cm and the cross-section is as near to 7.5 cm x 7.5 cm as practicable in case of solid blocks and 7.5 cm x thickness of-the wall in the case of other blocks. Two reference points consisting of 5 mm diameter steel balls or other suitable reference points providing a emispherical bearing shall be cemented with neat rapid-hardening Portland cement or other suitable cementing material at the centre of each end of each.

Specimen after drilling or cutting a shallow depression. After fixing, the surface of the steel balls shall be wiped clean of cement, and dried and coated with lubricating grease to prevent corrosion . The specimens shall then -be completely immersed in water for 4 days, the temperature being maintained at 27 + 2°C at least for the last 4 h.

Procedure for testing:

- Immediately after removal of the specimens from the water, the grease shall be wiped from the steel balls and the length of each specimen measured to an accuracy 0.002 5 mm by the apparatus described in . This shall be taken as the original wet measurement.
- The specimen shall then be dried for at least 44 h in an oven of the type described in code book, at the specified temperature and humidity. The specimens shall then be removed from the oven and cooled for at least 4 h in a desiccator containing solid calcium chloride or a saturated solution of calcium chloride. Each specimen -shall then be measured as described in code book, at a temperature of 27 + 2°C.
- The cycle drying cooling and measuring shall be repeated until constant length is attained that iswhen difference between consecutive readings separated by a period of drying of at least 44 h followed by cooling for at least 4 h, is less than 0.005 mm for a 15 cm specimen and pm *rata* for a larger specimen. The final reading shall be taken as the dry measurement.
- During the above drying process further wet -specimen shall not be placed in the same oven and there shall be free access of air to all surfaces of the specimen. After the dry measurement has been taken, the length of the specimen shall be measured, adjacent to the steel balls, to the nearest millimetre and this shall be taken as the dry length.

Calculation of result:

The drying shrinkage shall be calculated as the difference % between the original vet measurement and dry measurement expressed m a percentage of the dry length. Report all results separately for each unit.

Method for the determination of moisture movement

Aim: To determine the moisture movement for sample.

Apparatus: Dail guage accurate to 0.0025mm, test specimen, drying oven.

Procedure:

The specimens which have previously been used for the drying shrinkage test (see Annex F) shall after the completion of that test, be immersed in water for 4 days, the temperature being maintained at 27 + 2°C for at least 4 h prior to the removal of the specimen and the wet length measured. The moisture movement shall be determined as the difference between the dry and wet lengths and expressed as a percentage of the dry length for each specimen.

Should the value obtained with any one of the three specimens tested be greater than the limit specified in 9.7, the test shall be repeated on the further three blocks which were set aside. In repeating the moisture movement test, the shrinkage test shall be repeated, if the previous specimens have failed on that test also; otherwise, the drying shrinkage test may be omitted. The three new specimens, in that event, shall be dried to constant length at 50 + 1‘C measured after cooling and the moisture movement test carried out as described in

Results:

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2: 1960 ‘Rules for rounding off numerical values . The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

CHAPTER 6

RESULTS

Preliminary tests

Sl No	Tests conducted	Result
1	Specific gravity of coarse aggregate	2.68
2	Impact value of coarse aggregate	27.86%
3	Specific gravity of fine aggregate	2.63
4	Specific gravity of cement	3.17
5	Consistency index of a cement	35%

Table 6.1.1

Blocks tests

Compressive strength test:

Results:

i. Compressive strength of Cement concrete block =N/mm²

ii. Compressive strength of Mud block =N/mm²

Water absorption test:

Results:

i. 1. The water absorption of cement concrete block is = kg/m³.
ii. 2. The water absorption of mud block is = kg/m³.

Block density test:

Results:

i. Block density of mud blocks is = kg/m^3

ii. Block density of cement concrete blocks is = kg/m^3

CHAPTER 7

ADVANTAGES OF INTERLOCKING BLOCKS

- Being a less heat-intensive and natural material, laterite retains coolness inside the house.
- Less labor intensive and more time saving as the Interlocking blocks need only be fitted to each other; instead of conventional cement mortar construction.
- The Interlocking bricks can be salvaged without damage when the house is being dismantled in the future
- The materials required for production are widely available so they do not have to be shipped in from long distances. Since the manufacturing process is a simple one, once again reducing the cost of transporting them to the construction site.
- This innovative interlock system is earthquake-resisting .It is also faster in operation with a potential of saving over 65%of time and cost of the masonry work.
- Without the need of high waged skilled masons, by saving cement and with the speed of construction, the building costs are lower than that for standard masonry construction. When compared to convention masonry block construction.

DISADVANTGES OF INTERLOCKING BLOCKS

- It is difficult to ensure availability of the same coloured bricks for the entire construction. If painting is not planned, all the bricks should be having the same color. For this all these bricks have to made from the soil of the same place
- Not suitable for buildings having more than 2 floors, if it is not supported by pillars. Pillars are not needed for double storeyed buildings.

CHAPTER 8

CONCLUSION

The elimination of the various non-value adding steps associated with the conventional sandcrete block wall construction when using the interlocking block system significantly reduce the cycle time of block bonding thus increasing the speed of wall construction for interlocking blocks. Interlocking blocks are affordable in terms of cost and the ability to make the room cooler especially in hot weather conditions compared with sandcrete blocks. There is also a significant reduction in the material requirement for the interlocking block wall construction process due to the absence of mortar jointing. Reduction in the labor and material requirements in the interlocking block wall construction make the cost associated with the process of building walls using the interlocking blocks less expensive.

On the basis of the above, interlocking blocks provide a very good economic alternative to sandcrete blocks. Economically, it provides a cheaper means of construction, low cost resources (materials) and erection process. They therefore have the potential of supporting the affordable housing concept in Ghana. Interlocking blocks are also likely to support sustainable construction concept since they use materials that are locally abundant, less energy for their production and use, and make the interior part of the buildings cooler than sandcrete blocks.

Although the study revealed unparalleled advantages of interlocking-block masonry in terms of shorter period of operation, lesser gang of labour and reduced cost of construction, its usage in construction of houses is very low. This is partly due to low level of awareness on the part of professionals and the public and its non-availability in the market. In view of this, Government agencies and stakeholders in the building industry should accept the use of the material as proposed in this research to give a wide publicity to them and make the proposed building materials available in the market for users. Interlocking-block masonry should be used in public housing projects to demonstrate government's sincerity and to create awareness within the populace. In conclusion, accelerated dry masonry system through interlocking masonry is recommended for housing projects as an alternative method that is cheaper than the conventional wet type. Since this innovative interlock system is earthquake-resisting .It is also faster in operation with a potential of saving over 65% of time and cost of the masonry work. It reduces wastage of materials, and gangs of labour required for operation Interlocking blocks can be produced with the same materials as used in the production of conventional blocks.

CHAPTER 9

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