International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 02, 2021

Interlocking Stabilized Soil blocks using red earth in Construction

Dr.A.Paulmakesh[1], Gizachew Markos Makebo[2]

[1]*Associate professor, department of civil Engineering, Wolaita Sodo University, Ethiopia*
[2]*Head,department of civil Engineering, paulmakesh1986@gmail.com, Ethiopia*

Email: [2]gizemark2009@gmail.com, [1]paulmakesh1986@gmail.com

Abstract: Interlocking Stabilized Soil blocks are the enhanced form of conventional clay bricks. Each blocks is constructively designed to lock itself to the other block around without the use of mortar.The self-locking is achieved using shear-key and lock mechanism. The main raw materials are red earth (80%), Cement (10%) and 6mm coarse Aggregate (10%) or quarry dust and water. After mixing above ingredients it is compressed and molded hydraulically. This technology that brings no cement mortar required for the masonry works. Its needs small amount of water cement is required to joint interlocking blocks. This is the main advantages of Interlocking Stabilized Soil cement Block (ISSCB). Interlocking blocks are Eco friendly building materials. The net compressive stress required for critical section on the wall for a single story building is found as 0.65 Mpa. (13T/mt.length). Hence ISSCB could be used at load bearing structures. The basic raw material is red soil, which as available at Ethiopia with minimum cost. Hence the production cost is 50% less than cement concrete hollow block. This ISSB is cost effective for the construction user. It brings overall cost deduction and afford for the society. This paper presents that to promote the use of the technology by sharing some case studies of successful ISSB adoption and adaptation to local contexts. It also highlights some of the challenges faced in developing and promoting the technology with some key lessons learned from the growing amount of practical experience.

Keywords: Red soil, self locking, Eco friendly materials, Low cost, Stabilized Soil, mortarless, time efficient.

1. INTRODUCTION

Interlocking blocks are the enhanced form of conventional clay bricks. Each block is constructively designed to lock itself to the other block around without the use of mortar. The self-locking is achieved using shear-key and lock mechanism. Based on the design, the shape of shear-key will vary and a complimentary lock is provided on the opposite side of block. Load transfer is achieved by shear transfer and gravity. Interlocking bricks are a compressed and stabilized earth brick which contributes to strength of the structure. [1],[2] Soil stabilization refers to the application of additional supplements or forces to the soil in order to make it more water- proof and stronger.

The interlocks increase the structural stability of the wall and reduce the amount of cement needed as mortar. The different types of interlocks have different structural purposes and architectural uses. Through interlocking system loads is transferred at horizontal and vertical direction. Horizontal direction through interlocking system.[3] That is load transferred to shear resistance. The vertical direction means through gravity loads, where as solid block

loads is transferred only vertical direction. This is main advantage of interlocking system.

Figure1.Interlocking stabilized soil blocks

Interlocking blocks are like 2 adjoining pieces of a jigsaw puzzle. Each block has a projection at one end and a depression at the other. The projection of one block fits in to the depression of the next so that they always align perfectly. Interlocking technology replaces the conventional brick and mortar in brick masonry. [4] However, basics of the conventional building system remain largely unchanged. Interlocking Building system involves using two technologies: Interlocking Block making using hydraulic block making machines. The machines are versatile for site and factory production. [5] Blocks can be made with different shapes and sizes to suit construction requirements. Variety of raw materials like Fly ash, sub soil, other type of waste materials blended with sand & cement. Interlocking masonry for constructing walls that are largely dry stacked or using minimal mortar or slurry. Interlocking profile in blocks is due to tongue and groove that creates a mechanical bond and enhances structural stability due to shear key. The Blocks have an extremely appealing face-brick finish and provide a pre-pointed straight masonry. The walls may be left exposed, plastered or finished with cement paint.

2. LITERATURE SURVEY

Swapnil H.Patil (2016) is presentedthat a literature studies of research & development on Interlocking Stabilized Soil Bricks. The different developed conceptional design for interlocking systems of blocks which is used for construction of brick walls described and various working principles related to the Interlocking Stabilized Soil Bricks systems concepts are outlined. This is followed by & overviewed of research work that has been related to I.S.S.B. by several research articles. The research work under taken which is received categorized according to proposed I.S.S.B. systems concepts (types of materials, of moulds, various compacting equipments, economical consideration & others as per section 3 to 5 based on basis of this literature study, recommendation for future work.

Abhijitsinh Parmar (2017) are studied that interlocking bricks masonry has gained rapid popularity in many foreign countries as an alternative to conventional bricks for sustainable

housing. It is being always challenge for researchers to make interlocking brick with light weight material at low cost and improve the performance against aggressive environment. An experimental effort made in this concern. The results of an experimental investigation in which the compressive strength, water absorption and density were investigated by using varying percentage of fly ash, stone dust, and sand with different mix proportion. Mainly the weakest part of a masonry wall is the mortar joint, as the substitution of lime for aggregate reduces the overall strength of the joint. A manmade fibre ,fly ash, glass fibre reinforce polymer (GFRP), scoria aggregates, EPS beads utilize as reinforcing material to produce the interlocking blocks which gives appreciable results discuss in detail. The experimental results compared with that ordinary brunt clay brick and interlocking brick found durable in aggressive environments and have sufficient strength for their use in sustainable building construction.

Emmanuel Nana Jackson (2018) are executed that the extensive use of Sandcrete blocks (SBs) for residential buildings as compared to interlocking bricks (IBs) has significantly increased its cost and has therefore affected the cost of housing delivery in Ghana. The research aimed at comparing the cost of SBs and IBs for residential buildings in Ghana. The study adopted qualitative and physical measurement methods of data collection on a two bedroom self–contain floor plan building. The findings revealed that lesser construction time was required for IBs. It was also established from the study that a total cost of GH¢14,268.54 and GH¢ 18,869.64 were observed for IBs and SBs respectively. The difference in cost of SBs were found to be GH¢4,601.10, representing 24.38%. The consequence is reduction in laborer force, limited finishing time and minimum running cost, without compromising the aesthetic and strength value. The study therefore recommends the use of IBs for prospective building developers, entrepreneurs and individuals due to its cost saving, time and running cost.

Mageswari (2019) are performed that creativity and innovations are hallmarks of any Industry the world over, to survive, sustain and grow in the present highly competitive market. Light weight 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 study reveals that interlocking bricks are used for construction of buildings as it consumes less time and saves the cost than the conventional bricks

3. METHODS AND MATERIALS:

Interlocking stabilized soil blocks cost:

The basic raw materials are red soil, which as available at Ethiopia with minimum cost. Hence the production cost is 50% less than cement concrete hollow block. This ISSB is cost effective for the construction user.

Structural Stability of Interlocking stabilized soil blocks:

The average ultimate compressive stresses of ISSB is 5.4Mpa, allowing factor of safety is 3 then safe compressive stress are 5.4/3 = 1.8 Mpa.The net compressive stress required for critical section on the wall for a single story building is found as 0.65 Mpa. The critical load occurred on Ground floor is 78KN for wall section (200mm x 600mm). i.e wall load 130KN/m or 13T/m. For two floor comp. stress req. = 0.65 *2 = 1.3Mpa. Required strength is more than available strength of Interlocking stabilized soil blocks. HenceInterlocking stabilized soil blocks could be used at load bearing structures for G+1.

Significance features of ISSCB:

Cost Effectiveness, Structurally Stable in construction for G+1, Main raw materials (Red earth) are available locally, Less cement consumption, Easy afford table by the people due to less cost.

It brings green buildings effect to the user. It brings good environmental, no air pollution and peace to user. It's good for seismic resistance .Cement consumption for 10m^2 wall construction

A) Solid type blocks

For masonry works cement required	= 2 bags
For plastering works cement required	= 2.5 bags
Total bags req.	= 4.5 bags .

b) Interlocking blocks

For masonry works cement required	= 1/2 bags
For plastering works cement required	= Not required
Total bags req.	= 0.5 bags.
Net saving 10m^2 wall construction	= 4 bags

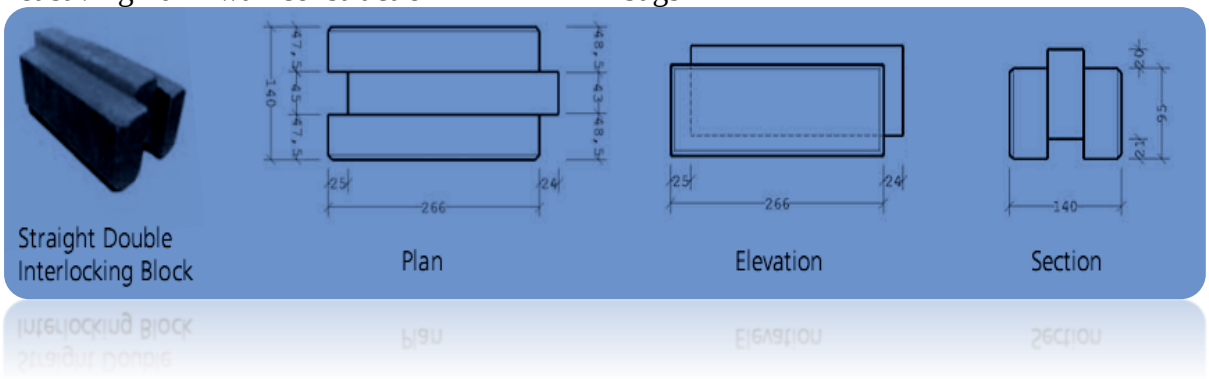

Figure2.Cross section of Interlocking stabilized soil blocks

Technical Features of Interlocking stabilized soil blocks:

Dimension	300 x 200 x 200 mm
Weight (kg)	8-10 kg
Texture	Smooth and flat
Ultimate Compressive Strength	5.40 Mpa
Safe Compressive Strength 5.40 / 3	= 1.8Mpa
Thermal Insulation (W/m C)	0.8 - 1.4
Density (kg/m3)	1700 - 2200

The quality of ISSCB depends on good and locally available soil section, a stabilizer to compliment type, and good practices during production and implementation.

Minimum compressive strength required, if we used Interlocking stabilized soil blocks load bearing structures for G+1 building

For each floor comp. stress req. = 0.65Mpa

For two floor comp. stress req. = 0.65 *2 = 1.3Mpa

Safe comp. stress for ISSB (after allowing F.S 3) = 1.8 Mpa

Hence, the ISSB used as a load bearing structures are safe upto G+1

Mortar less wall building

Mortarless brick construction, usually employing interlocking bricks, is growing in popularity round the world, indicative of acceptability. Mortarless techniques demonstrate the following advantages: increase of construction productivity reduction in construction duration and labor and reduced construction cost. Because of its technological simplicity and local resource dependence, mortarless-brick construction is more appropriate to many local communities than conventional mortared-brick techniques. Designers have developed machines of different types (manually operated, hydraulic, electrically operated, automatic or semi-

automatic) for producing different shapes and sizes of stabilized-soil bricks/blocks for Mortarless wall. For this technology to be successful the bricks require very high dimensional accuracy. The cost of construction of a wall using ISSB is estimated to be 40% lower than that using more conventional materials.

Statement of the problem

Typically, the construction process and masonry can be tedious, time consuming, and expensive. To overcome the hardships and issues encountered during construction, varied methods of construction is being considered and developed. .[1],[4]Simultaneously, materials and equipment used for construction are also being fabricated to enhance the quality of construction and furthermore minimize the time and cost. Interlocking bricks is one such advancement in the construction industry

Interlocking blocks are a compressed and stabilized earth brick which contributes to strength of the structure. They are usually not subjected to baking. Interlocking blocks come in various sizes and locking systems depending on the supplier. A typical block size is 300x200x200mm. Interlocking stabilized soil blocks are high quality and environmental friendly which is already used in East Africa. These blocks are low cost and sustainable building materials.[3] The main raw materials are red earth and small quality of cement. Compared with alternatives such as cement concrete, hollow block, it has offer lower construction cost at comparable quality are suitable for a wide range of environments and dramatically reduces the impact on the environment.

Eco-friendly building material

Construction technologies can be made more afford able to the urban poor people. These techniques also help in mitigating climate change by avoiding carbon emissions during the production of building materials and construction as well as by saving thousands of trees. This type of construction will bring less usage of cement. It doesn't require wall plaster. Hence usages of sand are minimized and natural resources are not disturbed. The main raw materials are red earth, small quantity of cement and small quantity of 6mm coarse Aggregate, water Cement Concrete blocks produce 143 Kg of Co_2 making 1 ton of blocks Common fired clay bricks produce 200 Kg of Co_2 making 1 ton of blocks ISSCB produce 22Kg of Co_2 for making 1 ton of ISSB Hence its Eco Friendly Material.

Building materials play a significant role in sustainable architecture. The choice of materials is crucial from the perspective of both the thermal performance and the environmental impact of the building. In all tropical countries, traditional construction materials and methods are still used in buildings. Some of the advantages of traditional materials are their plentiful supply, low environmental impact, low cost, and good reaction to climate; moreover they can be handled by local skilled labour, who are familiar with both the production and repair of traditional constructions. The use of modern building materials, which are generally imported, is now developing in towns. These are the materials used in developed countries and are characterized by a high environmental impact, especially as far as the embodied energy is concerned. It is thus desirable to focus on alternative materials that combine tradition and innovation, in order to reduce costs and energy consumption. Eco-friendly materials are characterized by low embodied energy and low related emissions; they are durable and convenient for recycling and reuse. Traditional building materials are mostly made from naturally available materials such as clay, stone, sand and biomass. The selection of appropriate materials should be driven by local/ regional and environmental considerations. Appropriate technologies refer to materials, methods and/or practices which help protect the natural environment, take inspiration from the cultural values and practices in the area, make use of local resources, and contribute to local economic development.

Interlocking Stabilized Soil Blocks (ISSB) are made of a compacted mixture of soil and a stabilizing agent such as lime or cement. They are formed in moulds that form grooves within the blocks such that they interlock horizontally and or vertically. This technical note focuses on the use of Interlocking Stabilized Soil Blocks as an alternative building material.

Advantages of Interlocking Stabilized Soil Block

Structural

ISSB technology allows the production of uniform blocks with greater strength than fired blocks, concrete blocks etc. These blocks have a high density which gives it more load bearing capacity and improved water resistance. Due to the high density and thermal properties of soil, these blocks provide better thermal insulation by the ability to absorb heat during daytime keeping buildings cool inside, and to release that heat inside buildings at night, keeping them warm

Environmental

ISSBs are cured in the sun hence there is no need for fuel such as wood thus saving the environment from degradation. Financial due to the interlocking nature of ISSBs, far less mortar is required thus saving on construction costs. Since the blocks can be made on site, costs associated with their transportation are eliminated. • Due to their appearance, plastering of the walls can be avoided further reducing construction costs. • Using the blocks results to fast construction since they are largely stacked and have no curing time.

Aesthetics

The blocks have an appealing appearance with an elegant profile, uniform size and face-brick look that takes the natural colours of the soils used that does not require plastering.

Does not require plaster work

Plastering can be time consuming and costly in case of conventional wall construction. Plastering of walls can be completely eliminated by using fair faced bricks of your choice available in the market. If required the walls can be given a smooth finish by applying a thin layer of paint. Since these bricks are self-designed that gives a neat finish, the maintenance cost is minimized.

Provides cooler interior

High compacted bricks generally result in higher density, which in turn converts itself into high thermal mass. Interlocking bricks are less heat intensive. This enables lesser/no use of air conditioners resulting in minimized energy consumption and more cost saving. This mud block will reduce rooms temperature in summer time and increase in winter. The reason behind is red soil retards heat energy. It willn't transmit.

Cement concrete hollow block will increase rooms temperature in summer time and no change in winter. The reason behind is cement block accelerating heat energy. It will transmit.

Unskilled / Fewer Labours

In case of Conventional brick laying, skilled labour is required for checking water level, spirit level and various other operations. Therefore a layman or an unskilled labour may find it difficult to learn the conventional methods of construction. Whereas interlocking bricks construction enables an unskilled labour to easily follow up on the construction procedure. It also provides various opportunities for an entrepreneur.

Minimizes cost

Since there is no use of mortar in the construction process, the cost of buying cement, sand, mortar and stone dust can be neglected. Also the cost for transportation can also be immensely reduced along with the cost on skilled labour. It does not require plasterwork,

minor bar bending work, lesser cement and fewer labourers hence contributing to the overall cost reduction of the construction project.

Interlocking block technique

The block's sizes are rectangular (200 mm high, 200 mm wide and 300 mm long) in shape. Its dimensions permit multi-dimensional walls making configuration such as buttresses, lintels or columns possible. Corner or junction block is required to maintain right angled corner or a proper T junction. The interlocking blocks are different from conventional bricks since they do not require mortar to be laid during bricklaying work. Because of this characteristic, the process of building walls is faster and requires less skilled labour as the blocks are laid dry and lock into place. Concrete blocks may be produced with hollow centres to reduce weight, avoid seepages or improve insulation. The holes inside the concrete block allow rebar and concreting (creating reinforced concrete) to run vertically through the block to compensate for the lack of tensile strength. Rebar used can be of mild steel instead of the usual higher grade steel. Once a section of wall is built, grout holes are filled with a lean cement mixture to seal the wall and making a permanent solid wall. The amount of grout used was calculated to be less than 7.5% of the mortar used in conventional masonry. I.S.S.B. is not only helps in raising the speed of construction but also it reduces the time required for completion of particular work or project. I.S.S.B. having the simple technology & it mainly depends on the raw material which is available in surrounding area of construction this is the benefit which will help to complete the project/construction in short period.

Performance of Interlocking stabilized soil block

Interlocking Stabilized Soil Blocks, also called Interlocking Compressed Earth Blocks (ICEBs), are bricks that are made from compressed mixed soil using an ISSB machine. The blocks are then assembled similar to other types of masonry. Planning the production of ISSBs starts with the site and properties of the soil there. A sedimentation test can be performed to determine the percentages of clay, silt, sand, and gravel in the soil. Other tests include shrinkage tests, sending the soil to the laboratory, or using a portable soil-testing kit. Stabilizers include cement lime or bitumen, fibrous natural materials, chemicals and resins, or sands and gravels. It is important to refer to more detailed material to determine what stabilizer is most appropriate for the type of earth mix that is being used. The process of producing the blocks includes steps of training the labour force (quality assurance is extremely important for ISSB production), excavation, sieving, mix preparation, mixing, measuring the mix, compressing the mix, removing the block, dry and stack, and quality check.

4. METHODOLOGY

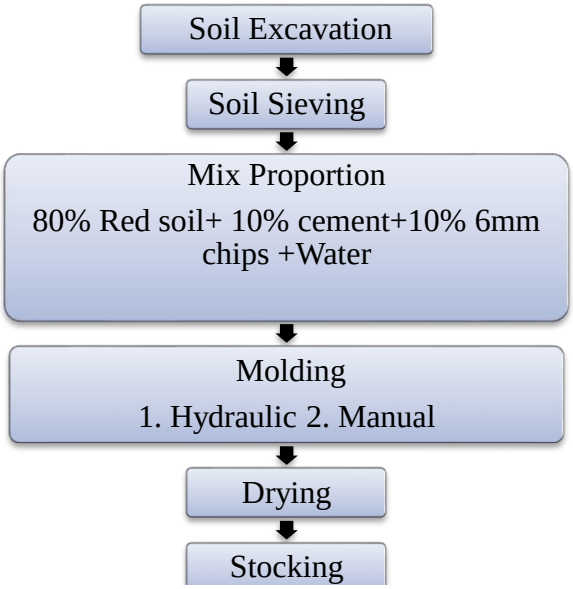

Figure3.Flow chart of Interlocking stabilized soil blocks

The major factors governing the selection of materials included the cost-effectiveness of these materials, strength expected from their use, local availability and their environmental impacts. This technology will be promoting to wolaita sodo people. Further, these technologies haveextended to the other places. Interlocking blocks can be useful to their society.

Interlocking stabilized soil blocks Production Process

In order to achieve quality blocks, proper selection of the raw materials must be made. These materials that include soils, sand, water and stabilizers (cement) must be carefully selected.

Soil selection:

Carrying out a site evaluation ensures that suitable soil is available for the preparation of the blocks. It is recommended to use sub-soil of a fine quality. The soil must be free of organic material and should not contain harmful quantities of salts. Soils with a high clay content result to cracked blocks and should be not used. However, if they must be used, then they must be mixed with a blending agent (such as sand or quarry dust) and a higher cement content to prevent the blocks from cracking.

Stabilizer

The most commonly used stabilizers are cement and lime. Cement is best used with soils that have low clay content to achieve greater strength quickly. Lime is recommended for high-clay content soils but takes longer to harden and to produce strong blocks. Sand and gravel may be added into high clay content soil to increase its density. Fibrous material such as dried grass, or synthetic fibres can be introduced into the soil mixture as reinforcers.

Mix preparation

The soil must be sieved to remove foreign elements and organic matter. Mix the sieved soil with stabilizers at predetermined ratios until the mixture has a uniform color. Mixing can be done either by hand or using a mixer. Water should be added gradually to the mixture until it is moist but not too wet (no water should run between the fingers when the mixture is squeezed). This water must be clean and should not contain any harmful quantities of salts, acids, alkalis or any other organic chemicals.

Compaction

The soil mixture is then loaded into the machine's mould and compacted to ensure strength and quality. The resulting block should be removed carefully from the mould and checked for texture and quality.

Curing

Curing is the process of hardening the soil blocks so that they can gain maximum strength. The blocks should be placed on a flat surface with adequate spacing between the stacked rows. The blocks can be stacked in layers of five and covered either with grass or polythene paper to protect from direct sunlight and to reduce the rate of evaporation in order to maintain proper humidity. Curing starts from the second day after the blocks have been prepared. They should be watered every morning and evening for a minimum of 7 days.

Types of Interlocking stabilized soil blocks machines

The manual / hand pressed and hydraulic block making machine When choosing the most appropriate machine, the following factors need to be considered: The type and scale of the building / structure to be constructed; Ease of maintenance of the machine,Availability, reliability and cost of electricity, The cost of the end product. Of the two options, the manual /hand pressed machine is the most preferred option especially in a rural setting since it is manually operated and easy to use.

5. RESULTS AND DISCUSSION

Interlocking bricks are the enhanced form of conventional clay bricks. Each brick is constructively designed to lock itself to the other bricks around without the use of mortar. The average ultimate compressive stresses of ISSB is 5.4Mpa, allowing factor of safety is 3 then safe compressive stress are 5.4/3 = 1.8 Mpa. The net compressive stress required for critical section on the wall for a single story building is found as 0.65 Mpa.The critical load occurred on Ground floor is 78KN for wall section (200mm x 600mm). I.e wall load 130KN/m or 13T/m. For two floor comp. stress req. = 0.65 *2 = 1.3Mpa. Required strength is more than available strength of Interlocking stabilized soil blocks. Hence Interlocking stabilized soil blocks could be used at load bearing structures for G+1.

Research survey concludes that if we made production of ISSB blocks on site then it reduces the transportation which will save cost of transportation, fuel, time & money. This product is energy efficient & environment friendly because it required 15 – 20 % less energy consumption per m3

Than energy consumed by Fired bricks per m3 . This survey also conclude that the construction of a interlocking blocks are easy & time saving with less investment of money which increase the speed of construction . Also one of the benefits is that it needs not required firewood for production of ISSB which will automatically saves the forests.

6. CONCLUSION

The basic raw material is red soil, which as available at Ethiopia with minimum cost. Hence the production cost is 50% less than cement concrete hollow block. This Interlocking stabilized soil blocks is cost effective for the construction user. It brings overall cost deduction and afford for the society/ The purpose of this journal is to promote the use of the technology by sharing some case studies of successful Interlocking stabilized soil blocks adoption and adaptation to local contexts. Most people are improving in construction facilities. Construction cost will reduce in the society while using Interlocking stabilized soil blocks. It also highlights some of the challenges faced in developing and promoting the technology with some key lessons learned from the growing amount of practical experience.

7. REFERENCES

[1] AbhinandanR.Gupta,Dr S.K.Deshmukh 2013. Interlocking Brick Design-Paradigm for Sustainable. International Journal for Research in Applied Science & Engineering Technology (IJRASET). 3 (1): 103-109.

[2] Abhijitsinh Parmar 2015. A literature review on light weight concrete using waste material. International journal of pure and applied research engineering and technology.4 (2): 97-102.

[3] Ahmad Z, Othman S. Z, Md Yunus B, Mohamed A.2011. Behavior of Masonry Wall Constructed using Interlocking Soil Cement Bricks. InternationalJournal of Civil, Environmental, Structural, Construction and Architectural Engineering 5(3):34-39.

[4] Akeem Ayinde Raheem, 2012.Production and Testing of Lateritic Interlocking Blocks. Journal ofconstruction in developing countries. 4(1): 33–48.

[5] Achal Garg, Harinder Yadav, 2014. Study of Red Mud as an Alternative Building Material for Interlocking Block Manufacturing in Construction Industry. International Journal of Materials Science and Engineering.04(3):2278-8719.

[6] Bansal Deepak2012.Sustainable Dry Interlocking Block Masonry Construction. 15th International Brick and Block Masonry Conference, Florianópolis –Brazil : 125

[7] Carrasco, E. V. M, Mantilla, J. N. R., Espósito, T., Moreira, L. E 2012.Compression Performance of Walls of Interlocking Bricks made of Iron Ore ByProducts and Cement. International Journal of Civil & Environmental Engineering IJCEE-IJENS13(3):143-155

[8] Montgomery D. , Thomas T.2001.Minimizing thecement requirement of stabilized soil block walling:224-235

[9] Browne G 2014 .Reconstruction with compressedinterlocking stabilized earth blocks: 219-234

[10] Eires R, Sturm T.2011. Study of new interlocking stabilized compressed earth masonry block.

[11] Nagesh. Mustapure, H.Eramma. 2014. Experimental investigation on lightweight concrete blocks of density. International Journal of Advanced Technology in Engineering and Science. 2(8):122.126

[12] Mahyuddin Ramli, Eethar Thanoon Dawood.2010. Effects of Palm Fiber on the Mechanical Properties of Lightweight Concrete Crushed Brick. American J. of Engineering and Applied Sciences 3 (2): 489-493

[13] R. K. Watile, S. K. Deshmukh, H.C.Muley. 2014. Interlocking sustainable housing development" International journal of science spirituality business and technology (IJSSBT). 2(2):213-234.

[14] Sajad Ahmad, Sadam Hussain, Mohd Awais, Mohd Asif, Hakim Muzamil5, Rafiq Ahmad6, Shakeel Ahmad, 2014. To study of Interlocking of masonryunits/blocks", IOSR Journal of Engineering IOSRJEN .4(3):39-47.

[15] T. Praveen Kumar, R.Vigneshvar.2011. Development of an Innovative Interlock Blocks Department of civil engineering panimalar engineering college. Chennai, India Journal of Civil Engineering and Environmental Technology. 1(5):23-29