IOP Conf. Series: Materials Science and Engineering **371** (2018) 012016 doi:10.1088/1757-899X/371/1/012016

Lock-brick System for Sustainable and Environment Infrastructure Building Materials

Susilawati[1] and Indah Wahyuning Tyas[2]

1 Associated Professor, Lecturer of Flores University, Ende-Flores, Indonesia
2 Lecturer of Flores University, Ende-Flores, Indonesia
E-mail: susipi@uniflor.ac.id

Abstract. The community participation is expected to realize the appropriate housing. But the financial condition does not support, so that appropriate housing to be half constructed, which eventually became jammed unsustainable. Lock-brick system building construction can be implemented for appropriate housing and water infrastructure, such as small ponds and retaining wall construction. Lock-bricks are made from soil as the main ingredients added a little cement, thoroughly mixed in dry conditions, has dampened with water to a level sufficiently moist. Then, pressed with a pressing machine to 60%, forming interlocked bricks when arranged to form the walls of the liveable house. Columns, beams or retaining walls can be constructed with this system. Similarly, other water basin infrastructure such as rainwater catchers-canals can be constructed with this system. Lock-brick systems are used for a wide range of building infrastructure while considering the strength of the structure, so as to meet the standards. Various examples of usability have been done for the simple building liveable housing, student dormitories building, rain water reservoir, runoff catchment canals, soil retaining walls, and pavement floor. The usability, simple, easy to make and cheap, making this lock-brick system can support the development of sustainable infrastructure and built environment.

1. Introduction

Infrastructure development for raw water, such as ponds for conserving rainwater, which has been catch, or canal-traps to collect runoff water, are very important in managing rain water resource to meet the water requirement for live. It is also important to provide the liveable housing, which will support the health of the people. Everything requires a building structure that is quite resistant, strong and sustainable, not easily damaged quickly. This requirement requires an expensive building material, such as reinforced concrete iron, cement, sand and splits. The community encountered many difficulties to fulfil their need independently, even by little funding from the government. Programs have been launched, such as stimulant funding of Rp. 10.000.000.- for unliveable housing. The community participation is expected to realize the liveable housing, but their financial condition does not support, so that appropriate housing only could be half-constructed, which eventually jammed. It is hoped that this initial assistance can support the community to build their homes to be habitable and meet health requirements. But it is also still difficult for people to finish a half-finished house. These problems encourage being developed of an alternative building material that is lock-brick system technology, which can be used for various forms of buildings needed.

2. Lock-brick System Technology

Established in 1988, Habitech Centre has conducted research and developed various building components that are environmentally friendly, energy-efficient and cost-effective. This cost-effective

building system is named Habitech Building System. This system has been tested, demonstrated and disseminated through various housing projects in Thailand and in other countries throughout Asia and Pacific [1].

Literature review of the lock-brick system shows that most of these systems are used for house building construction [2, 3, 4, 5]. The recapitulation of this literature review results is shown as in Table 1

Table 1. Recapitulation of articles literature review

No.	Year	Author	Title	Note
1	2014	Anis Rahmawati	Lock-brick Modular as Innovation Wall Materials Residential Buildings	Research, funding by Ristekdikti
2	2013	M. Khasani, et.al.	Designing Pre-processed Components of Growing House	Vol 1, No 01 (2013) Jurnal Pendidikan Teknik Bangunan
3	2011	Sri Sumarni, dkk	Moulding Machine Development of Sloof and Beam component for Simple Growing House Earthquake Resistant Building	Draft scientific articles
4	2009	Simion Hosea Kintingu	Design of Interlocking Bricks For Enhanced Wall Construction Flexibility, Alignment Accuracy And Load Bearing	Dissertation

Habsya, et al, in his article on the lock-brick system, "Lock-brick Concrete Modular for Alternative Wall Materials that Meets the Quality Standard of SNI at Low Cost", concludes that the cost per m^2 of modular lock-brick wall is 24% cheaper than the cost of the conventional brick wall [6]. From the reviews for various patents associated with the lock-brick system are presented as in Table 2 Patent development is widely available in the United States. That is also registered, the "Modular Lock-brick System for Constructing Buildings". Patent Registration Number, S00201401680, Date: March 21, 2014, Director General of Indonesian Law Ministry [7].

Habitech centre develops lock-brick base on soil material. The lock-bricks are made from the main ingredients soil, which be added a little cement, with the comparison of 1-part cement and 8-part soils. These materials thoroughly mixed in dry conditions, and be dampened with water to a level sufficiently moist. Then, poured to the pressing machine until 60% pressed, forming interlocked bricks. The lock-bricks arranged to form the walls of the liveable house. Columns and beams, could be constructed by this system also, with the special moulding, which form the place to lay the irons.

Lock-brick construction system could be an alternative solution for many problems, especially concerning of finance, environment and people participation. It also could be implemented for water infrastructure such as small ponds, channels and other infrastructure water buildings. Lock-brick systems are used for a wide range of building infrastructure but still considering the strength of the structure, according to standards [8].

Table 2 Recapitulation of lock-brick patents review

No.	Year	Inventor	Title	Note
1	2013	M.A. Kashinath	Interlocking Brick	No.: 3434/MUM/2013
2	2012	Janssens et al	Building Blocks with Mating Coupling Means For Constructing Wall And Associated Method	US 2012/0102868
3	2012	Nagy, John R and Krell, Clinton C.	Modular Concrete Building	Paten US8,132,388B2.

4	2009	Steve Eugene Everett	Structural Building Block System and Method Comprising Same	Patent No.: US 7472520
5	2000	Simmons, Scott.	Modular Building Materials	US Paten Number US006,088,987
6	1999	John H	Uniform Building Construction Using Interlocking Connectors	Patent Number: 5901521
7	1997	Williams et al	Flue Walls Using Interlocking	Patent Number: 5676540
8	1981	Khoo Tian	Bricks	No. 4,299,071
9	1970	Zagray	Interlocking building block construction	Patent US 3534518
10	1939	A. J. Cilento	Interlocking Brick	Serial No. 251260
11	1934	P. Brown	Interlocking Building Brick	US 1984393
12	1908	J. Soss	Interlocking Brick	US 903906
13	1895	George J. Herth	Lock-Brick	US Patent No. 535497
14	1892	Louis A. Steiger	Interlocking Brick	Patent No. 468840

2.1. Lock-brick System for livable, healthy and low-cost housing

This lock-brick system could support the development of sustainable infrastructure and built environment because of simple, easy to make, cheap and multifunction of the usability. A design of appropriate technology by using the soil material for lock-brick becomes the building material of the residence. The Lock-brick system support people to build their own low cost healthy and livable house [9]. Some parts of the house construction are illustrated in Figure 1

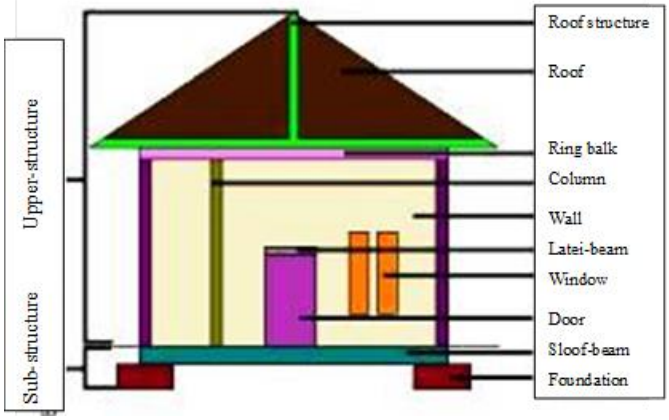

Figure 1 Parts of the simple house.

Detailed stages description of the procedure:

1. The foundation is made of stone, or could be used of this lock-brick, which is arranged, and the hole's brick is filled by mortar.
2. Sloof beams are made of lock-bricks type of U-brick, where on top of brick form U to place in an iron bar, then casted as a concrete sloof (Figure 2).

Figure 2 Foundation and installing iron on the sloof beam.

3. Practical columns structures are made by inserting an iron bar into the vertical hole of the lock-brick, then casted as concrete columns (Figure 3).

Figure 3 Arrange the walls of the building and prepare the iron for the column

4. Walls are constructed using lock-bricks, which are arranged in accordance to the shape of the building, without adding mortar, but only arranged interconnected each other (Figure 4).

Figure 4 Installation of lock-brick wall, door and window holes

5. Concrete beam wall hole, is a concrete latei-beam to hold the wall brick above the wall hole. The construct concrete reinforcement for latei-beam is shown on Figure 5.

Figure 5 Construct concrete reinforcement for latei-beam

6. Ring balk made as well as making sloof beam, as wall coverings and pedestal of the roof construction.
7. Roof structure is constructed from wood, and for the finishing by lock-brick also. The implementation of roof installation work is shown in Figure 6.

Figure 6 Implementation of roof installation work

8. Building a simple house that has been completed. Figure 7 show the completed simple house lock-brick system in Tli'u and Nursing dormitory.

Figure 7 The completed simple house lock-brick

2.2. Lock-brick System for Various Building Infrastructure

Lock-brick system is also suitable for various building structures, such as water structure, such as pond conservation, rain catcher channel, etc.

2.2.1. Lock-brick System for Water Ponds

To create a rain-water pond is required stages of work as follows:

1. Soil excavation
2. Lock-brick arrangement for the base of water pond
3. Lock-brick arrangement for the wall
4. Concrete slab for the top of water pond

The work stages are described as follow:

1. Soil excavation for the water pond. Excavation is done for the construction of existing tubs in the soil. For the construction of the container tub that does not require excavation, then directly arranged the retaining wall structure as a pond wall.
2. Lock-brick arrangement for the base of water pond. This arrangement is intended to stabilize the base of the pond, which can be directly casted, thereby reducing the volume of casting concrete that requires high cost. Figure 8 show the installation of sloof beam reinforcement floors and wall of the pond.

Figure 8 Installation of sloof beam reinforcement floors and wall of pond.

3. Lock-brick arrangement for the wall. This lock-brick system intended to reduce the required concrete wall volume. The arrangement of this wall each brick hole given a rod iron as reinforcement of concrete. Figure 9 show the installation of up-ground pond wall.

Figure 9 Installation of up-ground pond wall

4. Concrete slab for the top of water pond. The concrete slab structure is constructed for cover the water pond, and conventionally such as concrete slab construction (Figure 10).

Figure 10 Concrete slab for the top of the pond

2.2.2. Lock-brick System for Other Building Infrastructure

Lock-brick system could be used for runoff water-trap channels (Figure 11).

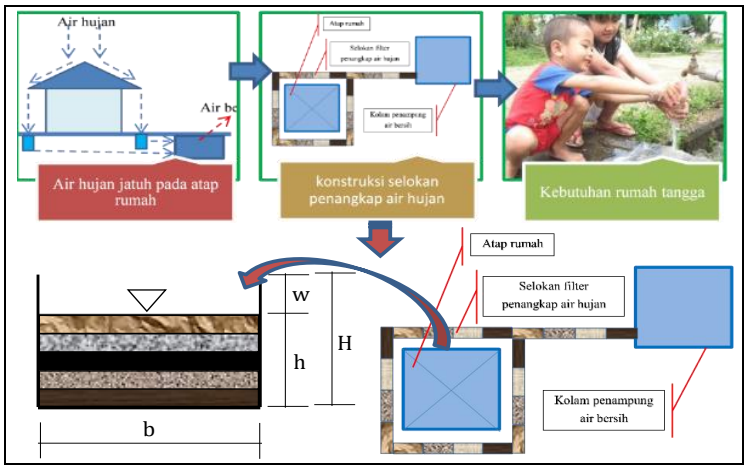

Figure 11 Runoff water-trap channels concept

The rainwater runoff catcher channel is created to capture runoff flowing rainwater, and then flowed into a rainwater catchment pond, through this channel. Water runoff flowing through this channel is expected to experience of mineralization process, so that the quality of rainwater harvested is quite feasible for raw water. Figure 12 show the structure of rainwater runoff catcher and the connection to the pond.

Figure 12 Rainwater runoff catcher channel and the connection to the pond

3. The Lock-Brick System Can Be Environmentally, Friendly and Sustainable

This lock-brick system is environmentally sound and suitable as a material that supports various building structures is a concern in this research. Several reasons that support this statement include: cement is about 1: 8-10. This indicates that most of the main materials used to form lock-brick are natural materials with no chemical processing or engineering. The lock-brick system used to build various structures is based on community participation system. Meaning that to make the lock-brick can be done by the community itself because it is simple and easy, as well as in arranging it into a building structure. More significant impact is the need for the required cost becomes very low. This provides an opportunity to build more people's needs for development to become more prosperous. Through various experiments performed and mention before, that can be said that this lock-brick system is environmentally sound, friendly and suitable as a material that supports various building structures

4. Lesson Learned

Some examples of usability have been done for the simple building liveable housing (Figure 7), student dormitories building (Figure 11), rain water ponds (Figure 9), runoff water-trap canals (Figure

12) and other construction. This lock-brick system could support the development of sustainable infrastructure and built environment because of simple, easy to make, cheap and multifunction of the usability.

5. Conclusion and Recommendation

From various studies conducted so far, and also the application of research results that have been done for various types of structural buildings using a lock-brick system, it can be concluded that lock-brick system is environmentally friendly and suitable as a material that supports various building structures.
This lock-brick system is recommended to be applied to other building structures such as retaining wall structures, village road structures by adding plastic waste materials to increase its strength as filler fibres in lock-bricks, and other innovations, as it will be done for road construction on the way to Experimental garden in Agriculture Faculty of Flores University.

6. References

[1] Klong Neung, Klong Luang, Habitech Centre, Asian Institute of Technology, Pathumthani 12120 Thailand, 2016. Download at: http://www.habitech.ait.asia/
[2] Anis Rahmawati, Lock-brick Modular as Innovation Wall Materials Residential Buildings (Lockbrick Moduler Sebagai Inovasi Material Dinding Bangunan Rumah Tinggal), Penelitian Unggulan Perguruan Tinggi RISTEKDIKTI, 2014. Download at: http://jarlitbangnov.bappeda.jatengprov.go.id/index.php?ref=publication&mod=doc&id=19606
[3] M. Khasani, dkk., Designing Preprocessed Components of Growing House (Perancangan Komponen Prapabrikasi Rumah Tinggal Tumbuh), Jurnal Pendidikan Teknik Bangunan, Vol 1, No 01, 2013. Download at: https://eprints.uns.ac.id/1895/1/1375-3069-1-SM.pdf
[4] Sri Sumarni, dkk. Moulding Machine Development of Sloof and Beam component for Simple Growing House Earthquake Resistant Building (Pengembangan Mesin Pencetak Segmen Sloof dan Balok Moduler Rumah Sederhana Tumbuh Tahan Gempa (RT2G). Download at: http://lppm.uns.ac.id/kinerja/files/pemakalah/lppm-pemakalah-2011-0308201380248.pdf
[5] Simion Hosea Kintingu, Design of Interlocking Bricks For Enhanced All Construction Flexibility, Alignment Accuracy And Load Bearing, Dissertation, The University of Warwick, School of Engineering, May 2009.
[6] Habsya, et.al., Lock-brick Concrete Modular for Alternative Wall Materials that Meets the Quality Standard of SNI at Low Cost (Lockbrick Modular Beton Untuk Alternatif Bahan Dinding Yang Memenuhi Mutu SNI Dengan Biaya Murah), Sinektika Vol.14 No.2, 2014. Download at: http://journals.ums.ac.id/index.php/sinektika/issue/download/258/9
[7] Habsya C. 2014. Modular Lock-brick System for Constructing Buildings, Paten Register Nomor, S00201401680, Dirjen HKI Kemenkumham RI, Date 21 Mart 2014.
[8] Susilawati, System-Trap-Rainwater Engineering and Lockbrick Technology In Household Scope To Improve Quality Of Life, ARPN Journal of Engineering and Applied Sciences, Vol. **11**, No. 11, June 2016.
[9] Susilawati, Model Desain Prototipe Kombinasi Jebakan Air Berantai dengan Rumput Vetiver untuk Mengatasi Permasalahan Sumber Daya Air Pulau Kecil Daerah Kering Indonesia. Laporan Akhir Penelitian Hibah Bersaing, 2016.