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MUD-CONCRETE BLOCK CONSTRUCTION
Community centres for war victim communities in Batticaloa, Sri Lanka

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Abstract

Rejuvenating social interaction within community is an essential factor to survive together for a long time success. Designing buildings for war victim communities is challenging, thus it should be planned with great care, involving the people in the community to the design process, addressing their issues in poverty and fundamental needs through utilizing readily available materials and using locally available cost effective resources. As a new sustainable material, Mud-Concrete block (MCB) technology was introduced to build community centres for selected war victim communities in Batticaloa through 'UN Re-settling programme'. Thus, different walling materials were introduced to build the community centers in identified areas in Batticaloa. Among those constructions, Mud concrete block (MCB) technology was identified as a highly viable solution which could use locally available soil in construction sites. This paper explores the up-to-date research process of introducing a new sustainable material to restore a war victim community within their context through community architecture.

Key words – *War victim community, Community Architecture, Sustainable material, Mud-concrete blocks (MCB)*

1. Rejuvenating social interaction through Community Architecture

Sri Lanka as a developing country which has been suffering for 26 years civil war, many communities were displaced and scattered in North and North eastern provinces. The war situation in Sri Lanka more or less destroyed thousands of lives and infrastructure of the North and East. As reported by Jayaraj (1999), Batticaloa District is in the Eastern Province (population 330,000) where 30,000 government armed personnel controlled most thoroughfares and towns while an estimated 1,500 militants operated in 'uncontrolled areas' and villages. Local population consists of Tamil (60%--largely Hindu, with minority Christian sub-populations) and Tamil–speaking ethnic Muslim (40%). As stated by Chase and Bush (2000), Batticaloa district remained in a militarized stalemate between government army and police forces, with checkpoints, security operations and underlying communal ethnic tensions, armed gangs, and severe economic contraction for a long period as well as known for high suicide rates and child recruitment to militant groups.

All these factors had shown deterioration in relation within communities and isolation of individuals. In such situation, thus the challenge is to maintain a responsive relationship with the local communities promoting dialogue about ongoing local communal tensions and offering an approach to compromise to resettle their destroyed livelihood and scattered communities. There are diverse approaches to studying resettling and empower the war victim communities of Sri Lanka relating to resources, interventions, and practice. Many studies provide appropriate intervention designs and methodology but few actually apply these interventions and evaluations in post conflict nations.

In order to empower the victim communities, rejuvenating social interaction within community is an essential factor to survive together for a long time success. Social interactions or the response of individuals to each other is a basic sociological concept, because such interaction is the elementary component of all relationships and groups that make up human community. In any community the physical environment around it, affects the human psychology for their social interaction with others. That physical environment can either enhance the interaction or discourage them. According to Rapoport(1969), "The interplay of social forces, relevance with cultural, economic, political and physical forces involving climate, location and technology will give rise to an inherent quality of the community and to the nature of the settlement."

Ray Oldenburg an American Sociologist (1989) calls these social interaction spaces as the "third places". The first being the home and the second being the work places. These third places are crucial to a community. By community living and interacting with each other allows people to discover and to gain experience by learning from others while enhancing the supporting and sharing nature of people. According to Chansomsak and Vale (n.d.) collaborative work involving all community elements and continual development are obviously keys to creating a sustainable community. The more people work together for sustainability, the more they can develop their activities and processes. Involvement in community activities also encouraged a sense of belonging and sharing and acknowledges the concept and the way to achieve sustainability under the particular conditions of the community. Also this leads individuals and institutions to strengthen belief in their ability to develop their community and be willing to take care of it. Thus the Architecture as a social art and a problem solving method, (Ching, 1979) rejuvenation of social interaction could be achieved through 'community Architecture'.

According to Wates (2000), 'Community Architecture' can be simply defined as, "architecture carried out with the active participation of the end-users". This alternative approach to the conventional architectural practice of non-participation of users can be copied back to the 1950s self-help community initiatives in the developing countries. In these self-help projects, the professionals joined hands with the people to improve their environment. As reported by Wates and Knevitt (2013), Community Architecture since then has developed in different forms around the world with a common vision, that is, public participation in decisions affecting their environments and hence their lives.

As Towers (1995) reported, 'Community Architecture' has provided alternative design and development approaches in the form of the following three priorities.

1. Save what already exists within a neighbourhood, based on the community's wishes. There should be a minimum destruction of community networks.
2. Community members be included in the design process
3. The end-users are most familiar with their needs and requirements, which is also directly related to the success of a project.

Based on these observations, Community Architecture lastly admits the participation of the community members in the decision-making and supervision of the community-based projects.

In order to rejuvenate social interaction within the immediate community, UN habitat has proposed to build prototype model of community centres in identified areas. The goal of a new community centres set in create a unique place that will unite people in a neighbourhood by providing a setting that will bring the community together, once again. The principle element that these war victim communities lack is a cultural or social bond. By providing a place where members of the community can gather together, celebrate and share their different cultures will ultimately create a new cultural and social bond within the neighbourhood and the greater community. Also by providing a place for everyday activities to take place within the community, rather than remote from its core, will allow for more social interaction. Several key objectives were considered at the beginning of design process of self-help community centre projects as follows;

- Identifying the exact Social & functional needs within the community.
- Necessity of introducing sustainable materials to reconstruct the built environment.
- Introduce strategies to use locally available materials.
- Introducing easy production process of materials.
- Challenge of building skilled labour force to possess the relevant skills in order to take advantage of the opportunities arising from improved infrastructure and other capital investment.
- Developing ‘soft skills’ and management and technical capabilities.
- Introducing low cost construction with highly viable solutions while keeping unique appearance.
- Possible techniques to consume less energy while maintain less impact to the environment.
- Making built environment more responsive to user community as well as nature.
- To achieve above objectives in building design process Mud-Concrete technology was introduced as a sustainable material to constructions.

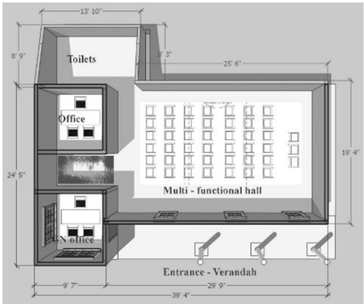


Figure 2: Plan of Community center at Batticaloa

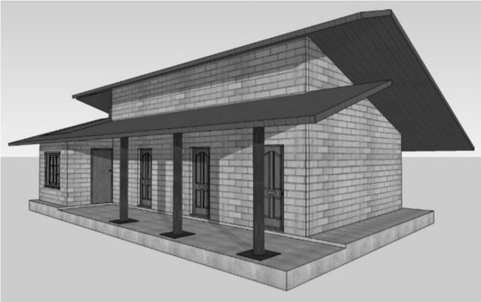


Figure 1: 3-Dimesional view of Community center at Batticaloa

2. Research through Material innovation: Mud-Concrete as a sustainable material

Selection of construction materials that have minimum environmental burdens and adoptability to local context is useful in the means of sustainable development when rebuilding the local communities through community Architecture. So, the research methodology was generated through the research process and this approach is to link the research process of inventing Mud-Concrete technology to building process and practiced through community architecture to rejuvenate the social interaction to empower the war-victim community within their context.

Mud-based construction has been very popular in ancient times, though it is not so in the present context of the industry. According to Cofireman et al. (1990) earth has been used in the construction of shelters for thousands of years and approximately 30% of the world's present population still lives in earthen structures. As Ren & Kagi (1995) presented earth is a cheap, environmentally friendly and abundantly available building material. It has been used extensively for wall construction around the world, particularly in developing countries. Several construction techniques have been practiced: dugout, earth-sheltered space, fill-in, cut-blocks, compressed earth, direct shaping, stacked earth, moulded earth, extruded earth, poured earth, straw clay, and daubed earth. These construction techniques have likely evolved through time and are still in use around the world. These earth based techniques are becoming unpopular day by day due to social believes on their strength and durability parameters , though these products got eco manufacturing process. But 'Concrete' is one of the most popular construction materials used currently, particularly due to the strength and durability factor.

Thus, the initial concept of developing Mud-Concrete is to incorporate the both strength and durability of concrete to mud-based constructions and make such constructions popular locally while ensuring indoor comfort, low cost load bearing walling system with easy construction technique which has least impact on the environment. Hence the novel concept in Mud-Concrete is that it employs a 'Concrete' made using earth/ soil. Concrete is a composite construction material made out of cement, sand, metal and water. Here, metal (coarse aggregate) governs the strength, cement acts as the binder and sand (fine aggregate) reduces the porosity and water acts as the reactor to cement. In Mud-Concrete, the intended functions of sand and metal of concrete are replaced by fraction of soil. The precise gravel percentage governs the strength of Mud-Concrete. The cement in this concrete is also used as a stabilizer in very low quantities. In this research fraction of soil has been classified as follows;

Gravel	-	sieve size 4.25mm ≤ gravel≤ 20mm
Sand	-	sieve size 0.425mm ≤ sand ≤4.25 mm

Fine (silt and clay) - ≤ sieve size 4.25 mm

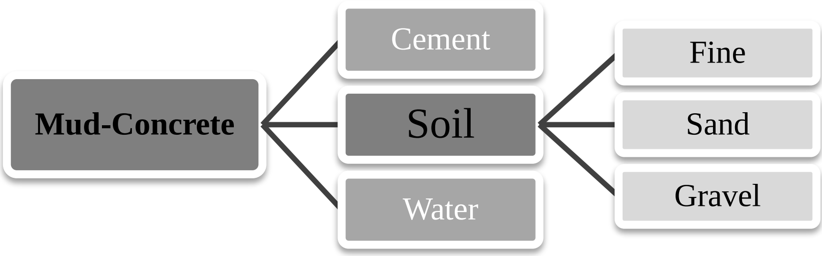


Figure 3: Composition of Mud-Concrete

The impact to the strength of mud-concrete with varied compositions of each of the above components has been studied as follows:

a. Change the fine percentage while keeping the sand and gravel constant
b. Once the optimum/ most practical fine content is known, the sand/gravel percentage was changed to find the optimum sand and gravel contents
c. Then the proposed mix was tested with different cement percentages, to optimize the required wet and dry strength of the block

According to gradual experiment process, the best mix proportions of unique Mud concrete block is achieved with minimum cement percentage and optimum water requirement which allows its self-compacting nature. Unlike conventional approaches to mud based construction, the MCB as a sensitive technology explained below significant innovative ideas which could utilize people ambitions in real world construction.

d. Soil will be slightly modified to form a concrete, which can withstand high strength and is durable.
e. The gravel acts as the strengthening agent, while clay and cement will act as the binder.
f. High water / cement ratio used will reduce strength; however, it would be regained by the proposed mix proportions.
g. The proposed water content will allow the mix to flow freely, which would create a mix that can compact itself.

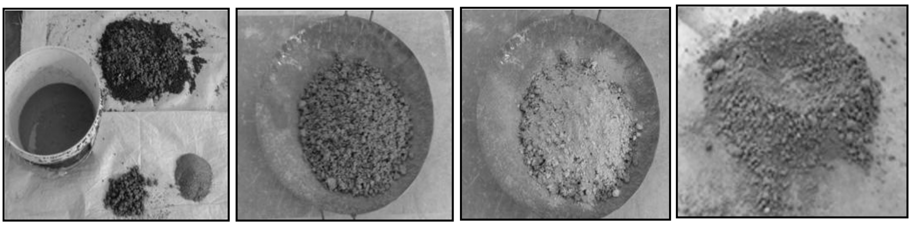
h. Excess water in the mix will create a porous structure that will later act in cooling the building through convection. This will increase the thermal comfort of the interior than other earth based constructions.
i. The porous structure and the absence of compaction will ensure aeration which would cut down heat gain due to low conductivity.
j. The extra water within the block will ensure that the block achieves its strength with time without any curing process. This will allow the block to be used as soon as it achieves the required minimum strength.
k. Since there is no burning involved, the block can be casted to any dimension, which matches the structural and architectural equipment.
l. Due to high water content and presence of clay, the block will end up with a clear and smooth surface which allows it to be used without plaster.
m. The proposed manufacturing techniques as well as the proposed proportions finally make a block that is low cost, has low embodied energy and requires lesser technical input / knowhow at the construction stage.

Day by day society's misconception on Soil based constructions is growing, because it is considered that these technologies only employ for poor who runs with low cost budget. Thus, the innovation of MCB drives people to rethink on soil based construction once again in making their built environment more responsive, while fading their doubts on strength and durability measures of soil. UN Habitat and the beneficiary community in the area was identified "Mud Concrete Block" as a cost effective technology for construction through the presentation and workshops conducted by the inventors from University of Moratuwa. Therefore, three community centres out of six were decided to construct using Mud-Concrete Blocks.

3. Research through building process: Introducing Mud-Concrete Block technology in construction of community centres

Step 01: Conducting soil test

Visited the selected site for constructions and soil samples were borrowed from each selected sites. Laboratory tests were conducted and all soil samples borrowed from the proposed sites were analysed at laboratory. Identify the existing proportions of available soil of selected sites. Proposed possible techniques were introduced to bring the soil up to best practical mix. According to the test results Soil: Cement mix proportion decided. (4%-8%). Then the composition of Mud concrete could be concluded as Fine (≤ sieve size 0.425mm), Sand (sieve size 0.425mm ≤ sand ≤4.25 mm), Gravel (sieve size 4.25 mm ≤ gravel≤ 20 mm), Cement (minimum of 4%) and Water (pouring stage).



Fraction of Soil: Gravel, Sand, Mud | Prepared soil samples after | Added cement | Mixture ready to add water

Figure 4: Composition of Mud-Concrete

Step 02: Development of form work

Form work was developed and introduced most optimum way of casting the blocks with the available resources to maintain easy manufacturing through less involvement of technology. As an initial approach form work made by 0-1" thick laminated plywood sheets. (Figure: 5) Due to the easy removal, maintain the quality of block finishes and maintain the durability of moulds 'form work' was developed from plywood to steel. (Figure: 6)

Step 03: Taking part in the discussion of technology, people and interaction

Community meetings were conducted to introduce the technology to people and maintain a responsive relationship with the local community and different Training programs/workshops were conducted to technical officers from UN habitat. Ongoing collaboration with families from the different ethnic groups and dialogue with village leaders was encouraged

Community provided labour used to manufacture Mud blocks, hence community was empowered and educated for manufacturing their own material. Within this programme skilled and unskilled labour force was identified and technology was develop to make easier and user friendly to people.

Step 04: Mud-Concrete block casting and curing at site (Figure: 7)

Casted block sizes were 225mm x 200mm x 150mm and required half sized blocks also casted prior to the work. According to the calculations, 2500

Mud-Concrete blocks (with added 5% wastage) were required per Community centre.

Step 05: Preparation of Mortar

During the masonry construction cement, soil and sand mortar was used. Mortar proportion was considered as cement 1: soil 3: sand 4 and it should prepared with adequate workability for facilitating the mason to fill the joints easily. The water content of the mortar is decided by achieving a good workable mix. Sieving the soil and sand from a mesh size of 6mm is essential in case of removing the coarser particles and to achieve good homogeneity of the mortar in the joints between the blocks.

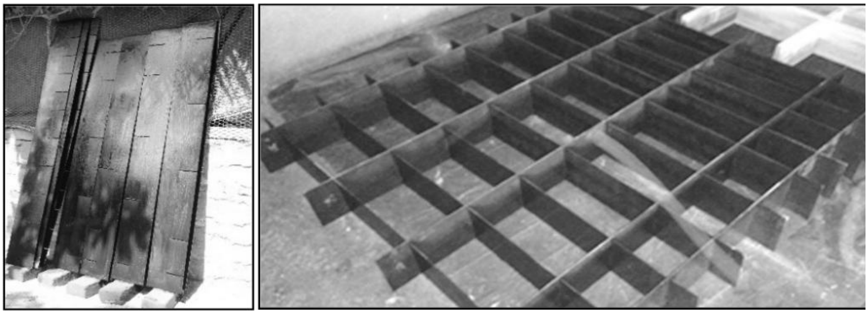


Figure 5: Development of Form work - Form work made by Steel sheets

Figure 6: Form work made by plywood

a. Soil borrow pit identified and sample tested at University of Moratuwa. According to the test results Soil: Cement mix proportion were decided.

b. Soil sieved through 20mm & 6mm net

c. Mix soil with sand and then add cement. Pour water to make the proper mixture

d. Pour mixture into the oiled mould and compact manually, let the mixture dry for approx.3 hours and remove from the mould, Let the blocks self-cure in a shady area for 5 -7 days & start wall construction

Figure 7: Mud- Concrete block Casting and curing procedure at Site

<u>Step 06: Construction of walls (Figure: 8)</u>

To control the quality of work, there was a necessity to pre-plan for controllable failures. Therefore, easy handling simple tools were introduced to levelling and aligning the mortar joints and construction of walls. Continuous monitoring and quality controlling measures were provided by inventors & technical officers during construction.

3.1 Research on cost reduction strategies of a Mud-Concrete Block through the manufacturing process

Several work studies were carried out to find the optimum construction labour/ machinery cost. Several trials were done with 1-3 moulds and found the best as to have 2 laboures at each site while sharing the production cost of 3 moulds among more than 2 sites, to gain the best cost saving for the buildings. With the careful and continuous supervision, the labour cost of a block can be reduced from LKR. 33.92 to LKR.7.21 and this will lead to an extra cost saving of Rs.60, 000.00 by having 3 laboures at the site with 2 moulds and increasing the number of cycle of casting. The calculations are based on reusing of the moulds for at least 10 sites. (Table: 2) Further, study was carried out to minimize the Material cost through optimizing added cement from 8% to 4%. (Table: 1)

Figure 8: Introduction of simple tools to maintain the labour skilfulness

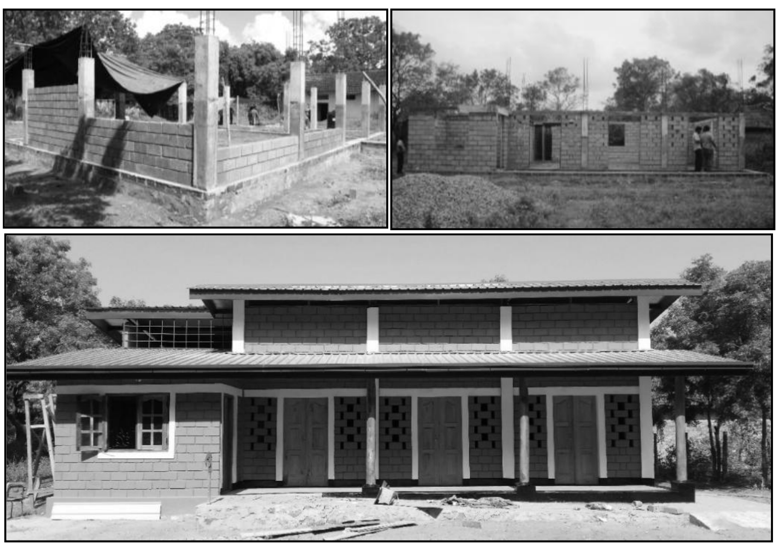


Figure 9: Photographic survey- Different stages of community center construction in Batticaloa

Once the foundation was done the floor concrete was laid to get a uniform surface to do the block casting. This will make sure a continuous water seal membrane at the foundation level and hence, it will minimize/ totally eliminate water movements due to capillary action as well as can reduce the termite attacks. Further, with this a good workable platform will be created and hence, quality of block production will be endorsed. Project cost also can be reduced by avoiding brick work at the foundation level.

Thus cost can be curtailed. Foundation work was kept for 14 days to achieve the strength and until that the labours at the site were used to cast the blocks. 120 blocks were made for a day and the total requirement was 2750 blocks for the whole buildings. As an average amount, 20 days were required to cast the blocks for construct a community building. Hence when the site is ready for waling, the blocks were ready. According to the project records, the typical prototype modelled community centers constructed through Sandcrete blocks was cost 2.995million and Brickwork (rat trap bond) was cost 2.966 million. But the community center constructed through Mud-Concrete block technology was cost only 2.84 million and the technology saved nearly 0.1 million from a building and saved 0.3 million from three projects which constructed at Batticaloa.

Step 01- Table 6: Cost comparison through optimizing added cement percentage

Type	Masonry work	Plastering	Cost per square (single side Plastering)	Cost variation for No. Plastering (%)	Cost variation with plastering (%)
Mud Block (6 ")					
4% cement	8580.11	5279.00	13859.11	0%	Not required
6% cement	9518.41	5279.00	14797.41	11%	
8% cement	10456.72	5279.00	15735.72	22%	
10% cement	11395.02	5279.00	16674.02	33%	
12% cement	12333.33	5279.00	17612.33	44%	
Brick (6")	18753.75	10558.00	29311.75	119%	150%
Hollow block (6")	15213.00	10558.00	25771.00	77%	124%

Step 02- Table 7: Cost Comparison of a MCB block through sharing moulds among different sites per day

Scenario	Practice No.	No. of moulds	No. of Sites	No. of labour	No. of MCB blocks	Cost per MCB block (LKR)
1	i	1	1	2	2500	33.92
	ii	2	1	2	2500	15.78
	iii	2	2	2	2500	12.58
	iv	2	10	2	2500	10.02
2	v	3	1	2	2500	15.85
	vi	3	2	2	2500	11.05
	vii	3	10	2	2500	7.21
3	viii	3	1	3	2500	18.98
	ix	3	2	3	2500	14.18
	x	3	10	3	2500	10.34

4. In conclusions: The Social acceptance towards the Mud-Concrete (MCB) technology

To sum it all, challenge of designing for a war victim community was achieved through a multi-disciplinary practice. In this study, it was integrated with research process to building process and practiced through community architecture to rejuvenate the social interaction to empower the war-victim community within their context. It was a definite factor to identify their extreme social, economic and functional needs prior to the implementation of the project. Further, introducing a new sustainable material to the 'Building Process' to restore a damaged community must incorporate with all these communal needs and ultimately this process should socially acceptable, environmentally compatible and economically viable.

Thus, Mud-Concrete technology was identified as a sensitive technology which utilizes the ambitions of victim community in a third world. Mud concrete technique is sound in strength and durability along with self-compacting nature unlike other mud based conventional approaches. Though there were different walling materials were introduced to build the community centres in identified areas in Batticaloa, Mud-concrete technology was identified as a highly viable solution which could use locally available soil in construction sites. When comparing with the other walling materials MCB took a prime place in load bearing, durability and thermal comfort while maintaining low embodied energy. The natural earth colour, texture and proportions of MCB were added permanent beauty to the building form, creating unity with nature while adapting to the context of space. Easy production process, new appearance, low cost constructions and the less energy consumption of MCB has been attracted people more in to embrace the technology.

Thus, the introduced technology, achieved the challenge of developing the labour skills among the community. Introduced community Architecture helped to intervene community members to the design process and educated them within the building process. Then the end-users understood the actual requirements of a community and how to achieve those requirements through the building process. Moreover, they understood the challenges, failures and how to pre-plan for controllable failures of a construction project. Therefore, construction of community centre projects in Batticaloa resulted in a great success where, Mud concrete block technology was highly appreciated as a sustainable solution by people who are rebuilding their communities.

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