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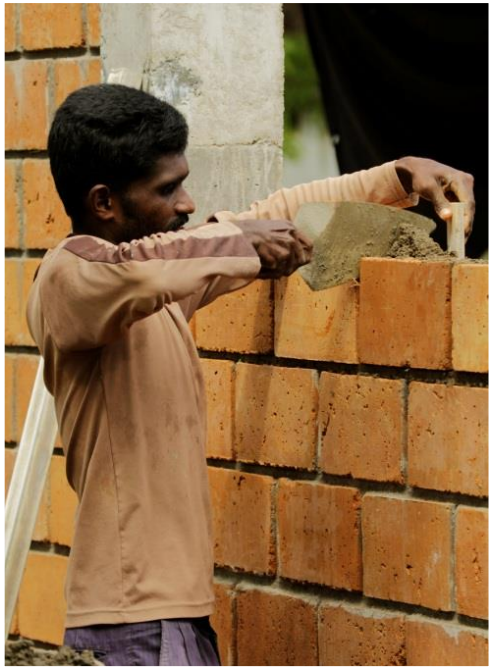

COMMUNITY EMPOWERMENT THROUGH MUD-CONCRETE TECHNOLOGY

Sustainable building techniques to revitalise the war victim communities in Batticaloa, Sri Lanka

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Introduction

1 **Community**	"Communities" are groups of people that may or may not be spatially connected, nevertheless who share common wellbeing, or identities	**(“WHO | Track 1,” 2009)**
2 **Community Empowerment**	'Empowerment' denotes to the process by which people gain control over the factors and decisions that shape their lives. People cannot "be empowered" by others; they can only empower themselves by obtaining more of power's in different forms. Empowerment is a powerful approach for solving many community problems.	**(Laverack and Keshavarz Mohammadi, 2011)** **(Kasmel and Andersen, 2011)**
3 **Appropriate Technology**	Appropriate Technology is a concept which represents providing for human needs with the least effect on the Earth’s limited resources and it will fill in the gap to make over community development into community empowerment.	**(Wicklein, 2004)**

Design criteria to judge the Appropriateness of Technology *(Wicklein, 2004)*

Design criteria	Description
Systems-independence	This criteria refers the capability of technological devise to perform the job with **minimum supporting facilities**
Image of modernity	**People must believe the technology** should raise their social status as well as meet the basic human needs.
Individual technology vs. Collective technology	**Technology must tally with the cultural norms of its community/society**. Then that will be the most appropriate technology which will provide the best service to that society.
Cost of Technology	The reduction of costs is an urge, when designing technological devices for developing countries. The cost of the device must be reduced significantly for the **people to afford the expense.** Thus it could help to meet the basic needs of life.
Risk Factor	The risk to the success of appropriate technology must be considered in detail but not necessarily be totally removed.
Evolutionary Capacity of Technology	Appropriate technology should allow for (i.e., have design characteristics) a continuation of development. **This technology should capable to expand and be reconfigured to undertake a higher volume of work or mass production.**

Framework of Empowerment *(Sianipar et al., 2013)*

	Triple bottom line in sustainable development		Trio perspectives of appropriate technology	Three parties in community empowerment
	Social	People	Social	Community members
	Environment	Planet	Technical	ACADEMIA
	Economic	Profit	Economic	Government
Development	**Sustainable Development**			**Empowerment**

‘Soil’ as a sustainable

Mud based Construction in Global Context

Adobe

Cordwood

Straw bale

Wattle & Daub

Cob

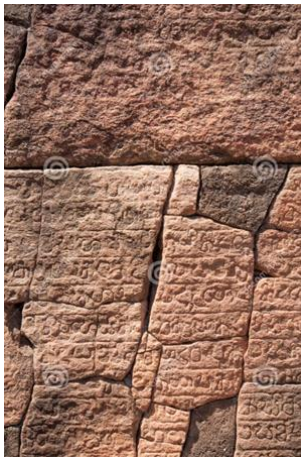
Rammed Earth

Earth bags

Mud based Construction in Local Context

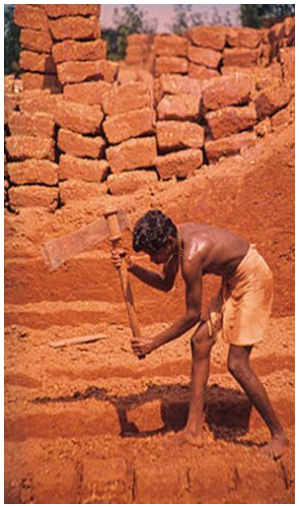
Wattle and daub (වරිච්චි බැම්ම)

Sun dried block laid in mud mortar (මෝඩ ගඩෝල් බැම්ම)



Rubble laid in mud mortar

Rammed earth (තාප්ප බැම්ම)



Lateritic laid in mud or lime / sand/ mud mortar(කබොක්

Lime stone (හුණු ගල් බැම්ම)

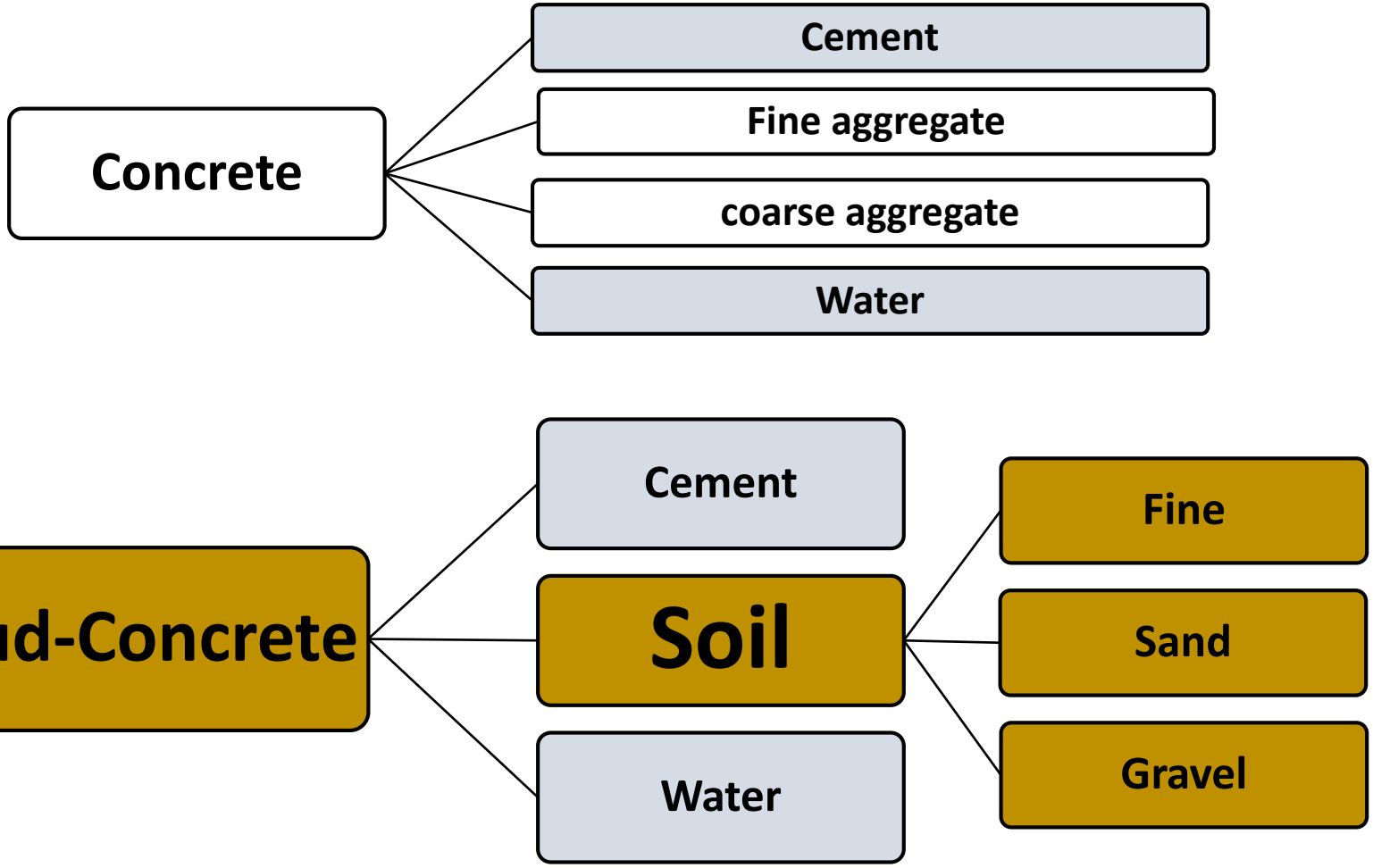
Understanding the research gap

Available Technologies	Block/ wall	Raw materials & Construction Method	Stabilised/ Unstabilised	Formwork	Compaction method	Reinforced/ Non-reinforced	Load-bearing/non-loadbearing	Weaknesses in technology	Ref.
Adobe	Block	Sun-dried brick [soil & water & local fibre materials] bonded with clay mortar.	Can be stabilised or unstabilised	Need a block formwork	Hand compaction	Need fibrous material as reinforcement	No specific mix design found for load bearing walls	▪ Need post-treatment (drying) is required after casting. ▪ Fibrous materials are needed to reinforce the block. ▪ No standard develop specially for load bearing wall.	[1], [2], [3], [4]
Cob	Wall	Fresh lumps of mud [soil & water & local fibre materials] stacked on each other.	Can be stabilised or unstabilised	No need a formwork	No compaction	Need fibrous material as reinforcement	No specific standard found for load bearing walls	▪ Need post-treatment (drying) is required after casting. ▪ Fibrous materials are needed to reinforce the wall. ▪ No standard develop specially for load bearing wall.	[5], [6], [7], [8]
Wattle & daub	Wall	Woven work of sticks intertwined with twigs or bamboo covered with mud; framework system	Can be stabilised or unstabilised	No need a formwork	No compaction	Need a frame to hold the daub of sticky soil.	No specific standard found for load bearing walls	▪ Need post-treatment (drying) is required after casting. ▪ No standard develop specially for load bearing wall.	[9], [10], [11], [12]
Cordwood or Stone	Wall	Left over materials like slender shoot of a tree or tiny stone bonded with mud [soil & sand & paddy husk]	Unstabilised	No need a formwork	No need mechanical compaction	Reinforced with fibre materials	No specific standard found for load bearing walls	▪ Need post-treatment (drying) is required after casting. ▪ Fibrous materials are needed to reinforce the wall. ▪ No standard develop specially for load bearing wall.	[13], [14], [15], [16]

Understanding the research gap

Available Technologies	Block / wall	Raw materials & Construction Method	Stabilised/ Unstabilised	Formwork	Compaction method	Reinforced/ Non-reinforced	Load-bearing/non-loadbearing	Weaknesses in technology	Ref.
Rammed earth	Wall	Damp earth laid between formwork and moulded and compacted by ramming.	Can be stabilised or unstabilised	Need a formwork	Hand or mechanical compaction	Can be reinforced. But reinforcing is difficult, because wall need to compact properly.	load bearing or non- load bearing walling system. Minimum 300mm thick wall for load bearing wall.	▪ Rammed earth needs heavy compaction which leads to increase the embodied energy of the technology ▪ Need post treatments to prevent the dampness. ▪ Reinforcing is difficult due to compaction.	[16], [17], [18], [19], [20], [21], [22]
Earthen Bag	Wall	Stacking the bags of damp earth hooked up with thorn or barbed wire.	Unstabilised	No need a formwork	No compaction	Non-reinforced	No specific standard found for load bearing walls	▪ No standard develop specially for load bearing wall.	[23], [24], [25], [26]
Straw bale	Wall	Plastering the bundle of hay with mud	Unstabilised	No need a formwork	No compaction	Non-reinforced	No specific standard found for load bearing walls	▪ Need post treatments to prevent the dampness. ▪ Less fire resistance ▪ No standard develop specially for load bearing wall.	[27], [28], [29], [30], [31]
CSEB	Block	Mixing soil and cement to a specified composition and compacted to achieve the specified strength	Stabilised	Need a block mould	Manual or mechanical compaction	Non-reinforced	Can be load bearing or non-load bearing	▪ Need proper compaction during block manufacturing ▪ This will cause to increase the embodied energy of the product	[32], [33], [34], [35]

Concept of Mud-Concrete Technology



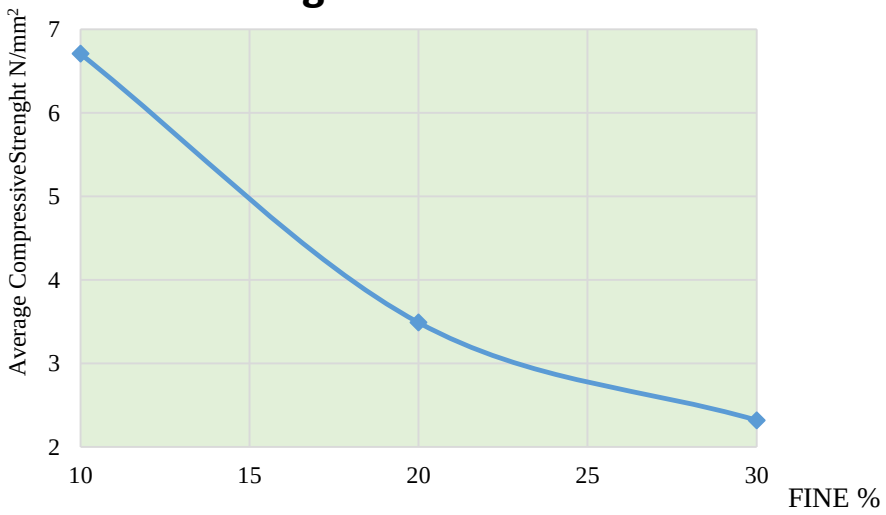
Fraction of Soil

Gravel - **Sieve size 4.25mm ≤ gravel≤ 20mm**
Sand - **Sieve size 0.425mm ≤ sand ≤4.25 mm**
Fine (Silt and Clay) - **≤ Sieve size 0.425 mm**

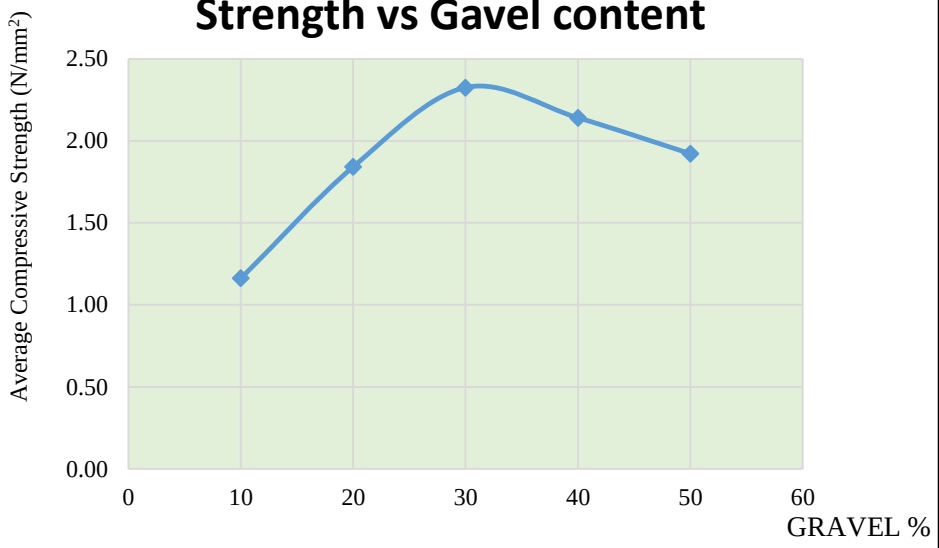
Research carried out to check the, **impact to the strength of mud-concrete** with varied compositions of each of the above components.

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

Strength vs Fine content

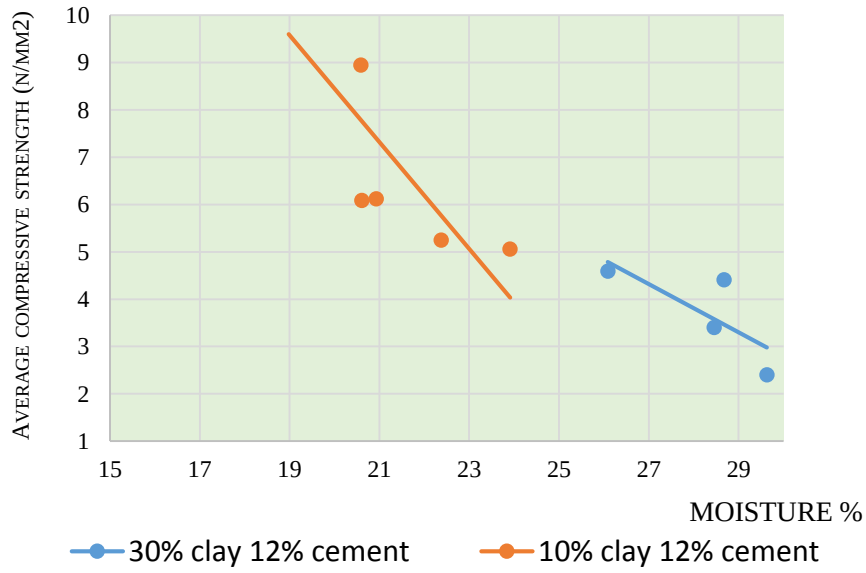


Strength vs Gavel content

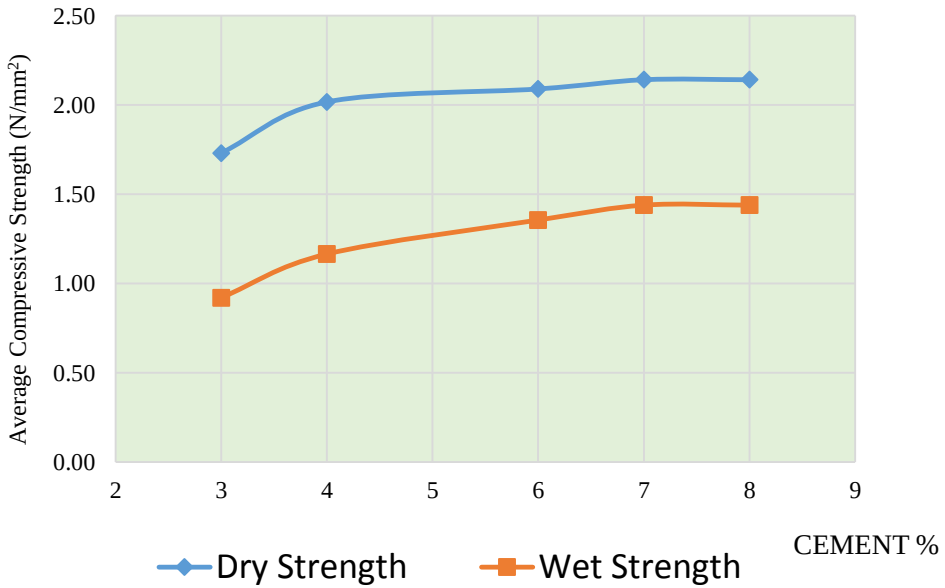


Impact to the strength of mud-concrete

Strength vs Moisture content



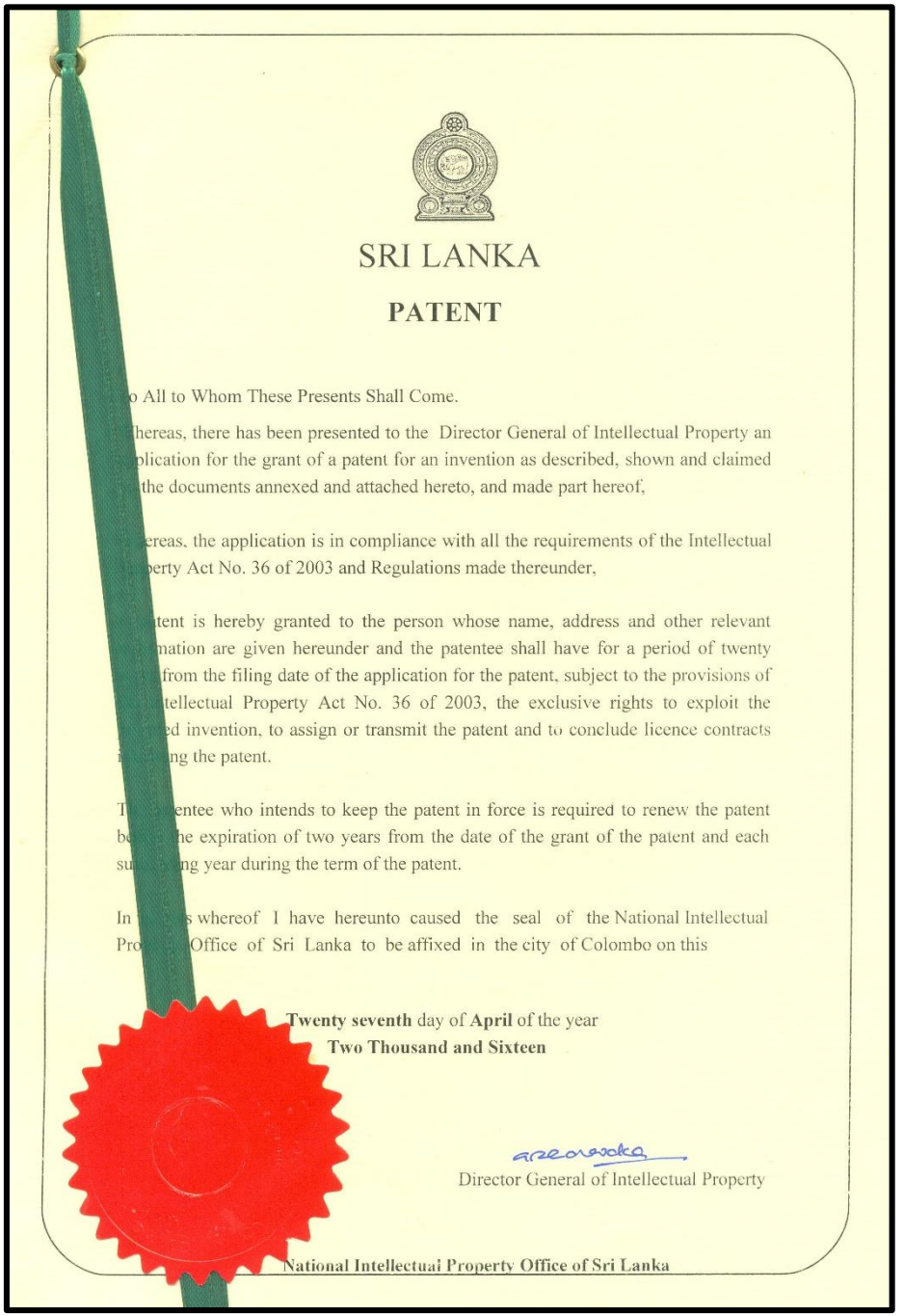
Strength vs Cement percentage



Patent
obtained for, Mud-Concrete Block

Details of Patent

- **Patent No: 17616**
- **Date of patent obtained: 27/04/2016**
- **Date of filing: 11/03/2014**
- **International Patent Classification(IPC) : E04C1/00**



SRI LANKA

PATENT

o All to Whom These Presents Shall Come.

hereas, there has been presented to the Director General of Intellectual Property an plication for the grant of a patent for an invention as described, shown and claimed the documents annexed and attached hereto, and made part hereof,

ereas, the application is in compliance with all the requirements of the Intellectual perty Act No. 36 of 2003 and Regulations made thereunder,

tent is hereby granted to the person whose name, address and other relevant mation are given hereunder and the patentee shall have for a period of twenty from the filing date of the application for the patent, subject to the provisions of tellectual Property Act No. 36 of 2003, the exclusive rights to exploit the ed invention, to assign or transmit the patent and to conclude licence contracts ng the patent.

entee who intends to keep the patent in force is required to renew the patent be he expiration of two years from the date of the grant of the patent and each su ng year during the term of the patent.

In s whereof I have hereunto caused the seal of the National Intellectual Pro Office of Sri Lanka to be affixed in the city of Colombo on this

Twenty seventh day of **April** of the year
Two Thousand and Sixteen

Director General of Intellectual Property

National Intellectual Property Office of Sri Lanka

Batticaloa District

- Batticaloa District is in the Eastern Province
- Total population 330,000
- 30,000 government armed personnel controlled most thoroughfares and towns
- Estimated 1,500 militants operated in 'uncontrolled areas' and villages
- 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

Local population:

- Tamil (60% - largely Hindu, with minority Christian sub-populations)
- Tamil – speaking ethnic Muslim (40%)

Methodology

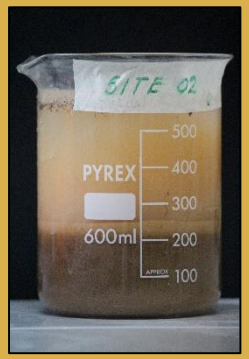
1. **Research through material innovation –**
   Testing in Laboratory

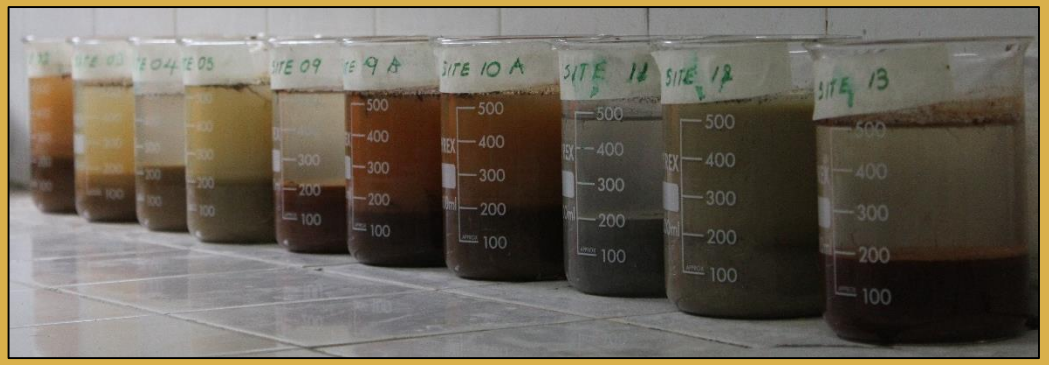
2. **Identifying the real wants, needs and constraints of the war victim community and adjusting the technology according to the context & people –**
   Taking part discussion of technology, people and interaction

3. **Research through building process –**
   Practice in field

Stage 01: Research through material innovation – Testing in Laboratory

Conducting soil test





Fraction of Soil:

Gravel, Sand, Mud

Prepared soil samples after sieve

Added cement

Mixture ready to add water

Development of form work

Form work made by plywood



Development of Form work - Form work made by Steel sheets



Stage 02:
Identifying the real wants, needs and constraints of the war victim community and adjusting the technology according to the context & people – Taking part discussion of technology, people and interaction

‘Community Architecture’ can be simply defined as, “architecture carried out with the active participation of the end-users”.

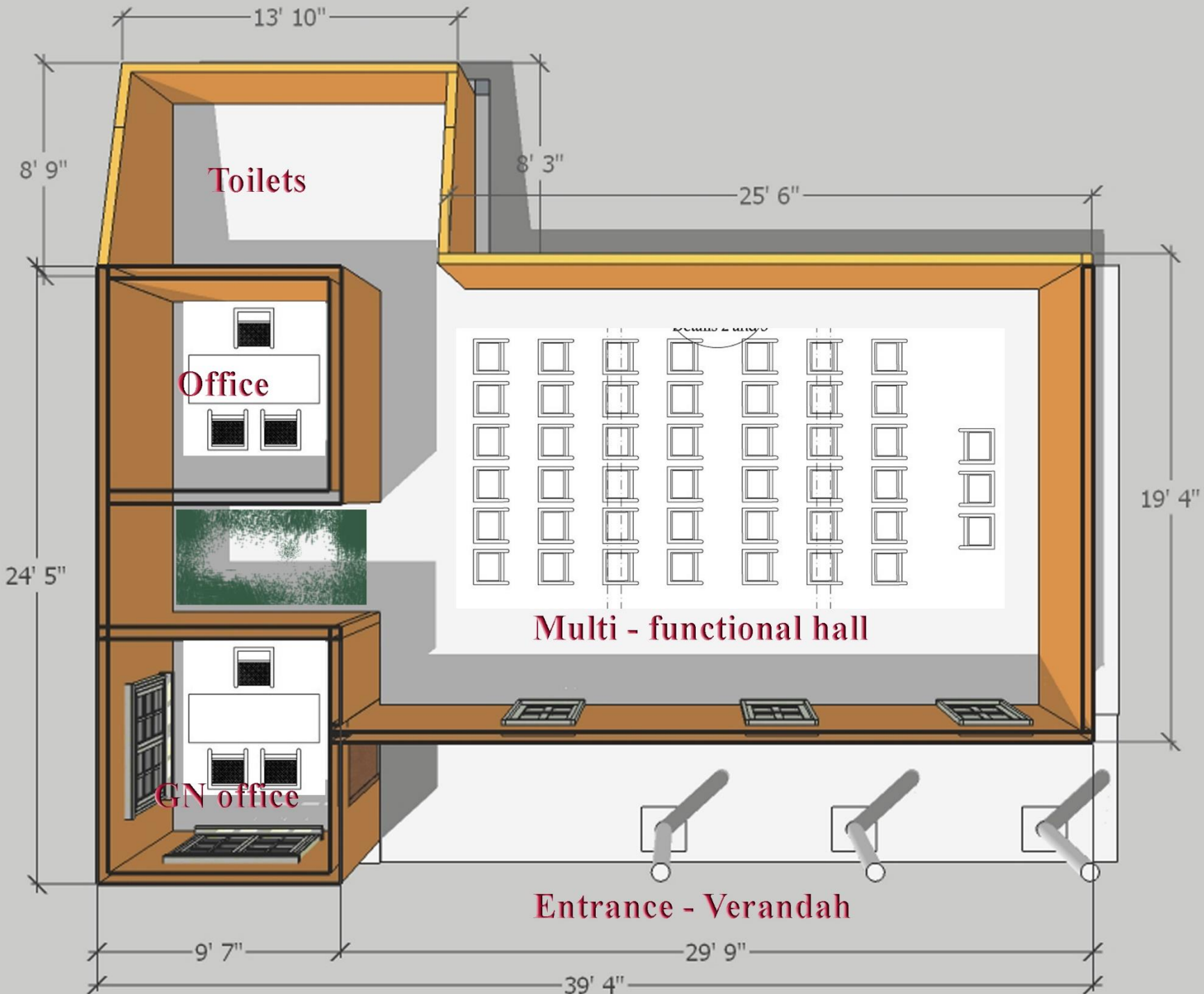
‘Community Architecture’

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

professionals joined hands with the people to improve their environment

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.


13' 10"
8' 9"
Toilets
8' 3"
25' 6"
Office
19' 4"
24' 5"
Multi - functional hall
GN office
Entrance - Verandah
9' 7"
29' 9"
39' 4"

Taking part in the discussion of technology, people and interaction

Community provided labour used to manufacture Mud blocks, hence community was empowered and educated for manufacturing their own material.

Stage 03:

Research through building process – Practice in field

Mud-Concrete block casting and curing at site

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

Soil sieved through 20mm & 6mm net

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

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

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.

Construction of walls








Cost comparison through optimizing added cement percentage

		Type	Masonry work	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%

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

According to the project records, Construction cost of typical prototype modelled community centers with different walling materials

Block Type	Cost
Sandcrete blocks	2.995million
Brickwork (rat trap bond)	2.966 million
Mud-Concrete block	2.840 million

03 community centres out of 06 were decided to construct using Mud-Concrete Blocks.

Mud concrete technology saved nearly 0.1 million from a building and saved 0.3 million from three projects which constructed at Batticaloa.

Mud-Concrete Block (MCB) as a sensitive technology

Soil **will be slightly modified to form a concrete**, which can withstand high strength and is durable.

→ **Concrete which develop from soil/earth**

↓

The gravel acts as the strengthening agent, while clay and cement will act as the binder. High water / cement ratio used will reduce strength; however, it would be regained by the proposed mix proportions.

→ **Gravel as coarse aggregate in MCB**

↓

The proposed water content will allow the mix to flow freely, which would create a **mix that can compact itself.**

→ **Self – Compacting nature**

↓

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.

→ **Porous structure enhance the Structural Cooling**

Mud-Concrete Block (MCB) as a sensitive technology

The porous structure and the absence of compaction will ensure aeration which would cut down heat gain due to low conductivity.

→ **Low Conductivity**

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.

→ **No need curing process**

Since there is no burning involved, the block can be casted to any dimension, which matches the structural and architectural equipment.

→ **No burning required**

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.

→ **Clear & Smooth Surface, No need plastering**

The Social acceptance towards the Mud-Concrete (MCB) technology

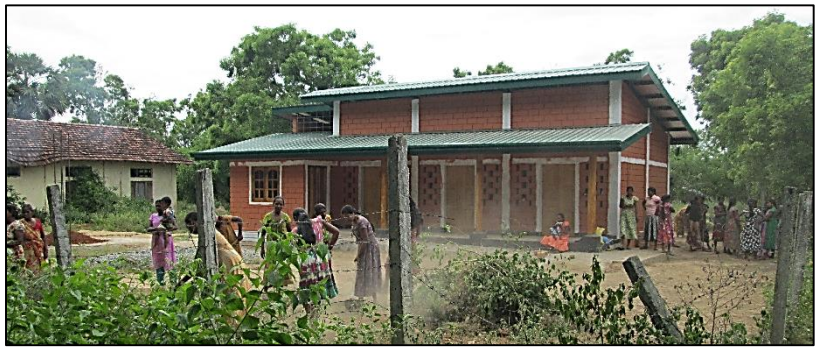
1. Challenge of designing for a war victim community was achieved through a **multi-disciplinary practice**

2. Intervene community members to the design process and educated them within the building process

3. 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.

4. **Achieved the challenge of developing the labour skills** among the community.

5. Sustainable solution for people who are rebuilding their communities



Mud-Concrete technology (MCB) as an appropriate technology in community empowerment process

DESIGN CRITERIA	DESCRIPTION
Systems-independence	MCB technology is capable enough to standalone, to fulfil the community needs. No need advance techniques or methods. Technology was developed through locally available materials and construction could continue with using simple tools.
Image of modernity	MCB technology is coming with new appearance, textures and colours. Technology is assured with strength & durability aspects. There is flexibility in finishing work, to achieve different Architectural languages.
Individual technology vs. Collective technology	MCB technology could practice either as an individual technology (ex: construction of individual houses) or as a collective technology (ex: construction of community centers). Technology is flexible enough to adapt according to the context and society.
Cost of Technology	Lot of strategies were used in cost reduction. Starting from raw material (ex: locally available materials) to end product, all the stages in construction were optimised to reduce the cost of block and the construction process. No need advance technologies or advance tools. Technology was flexible enough to make the skilled labour force through the construction process within the community.
Risk Factor	Strength & durability aspects were tested according to the universal standards when developing the technology.
Evolutionary Capacity of Technology	Technology has the capability to expand and be reconfigured to accomplish a higher volume of work and/or more sophisticated production processes. (Udawattha et al., 2016)

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Any options, findings and conclusions or recommendation expressed in this material are those of the authors and do not necessarily reflect those of University of Moratuwa.

Thank you !

Rizna Arooz - 07/06/2017 - WSBE17
Sri Lanka