KENYA GREEN BUILDING SOCIETY

Build Green Save Kenya

ALTERNATIVE BUILDING MATERIALS & TECHNOLOGIES (ABMT) REPORT

[ANNEXES]

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Annex 1: Understanding the Structural Element Concepts in Low Rise Buildings (up to 3 storeys) and more details on the costing of various building elements

1. Foundations

Building foundations ensure that the building load is transmitted to the underlying terrain in order to maintain the structural integrity and stability of the above-ground superstructure.

Foundations should be flexible and able to move, as in the case of earthquakes where flexible foundation structures can rise and fall but they do so uniformly

There are two approaches to foundation design which have been considered in this analysis – these foundation types are suitable for low rise buildings up to three (3) storeys:

a. Reinforced Raft foundation

This is a flat concrete slab placed directly on the surface of the terrain after a small amount of topsoil has been removed to form a cavity for the slab.

The structural design is usually a slab slightly larger than the footprint of the building, with one or two layers of steel mesh or steel bar reinforcement in both directions. The slab can be 50mm to 200mm and usually has a thickening at the bottom around the edges (called a toe) which can be up to 400mm thick and 400mm wide. The toe acts as an anchor for the foundation.

The principle of structural design is that the building load is spread by the raft foundation over the whole area of the building footprint, or beyond. This means that the underlying terrain experiences a Uniformly Distributed Load (UDL) from the overlying building. By distributing the load evenly over a large area, the bearing pressure on the underlying terrain is reduced, thereby enabling the building to be constructed even on terrains with poor load bearing capacity (eg. black cotton, swamp, bogs etc.).

An additional advantage of the raft foundation is that the foundation, the building's ground floor and the floor finishes can be constructed as a single operation if power floated concrete is used as the finish, saving time and cost. The drawback of this foundation type can manifest in the form of differential seasonal movement between the building and its environs, particularly the underlying terrain on which the raft foundation sits.

b. Deep Strip Foundation

This type of foundation is usually placed approximately 700mm to 1,500mm deep into the terrain, at a level where the load bearing capacity of the soil strata is sufficient to support the foundation and where the soil strata has a stable moisture content to avoid seasonal movement (i.e. the soils do not undergo expansion and contraction).

The structural design is usually a concrete strip of circa 500mm to 1,000mm wide and 100mm to 200mm thick, sometimes with reinforcement bars added for improved load distribution.

Strip foundations are designed to have high bearing capacity since the smaller footprint of the strip foundation on the underlying terrain increases the pressure exerted on the foundation by the overlying building.

Key takeaways: A disadvantage of raft foundations is that they can be more expensive than other types of foundations such as pad footings, combined footings, strip footings, etc. This is because they require more concrete and steel reinforcement. The raft foundation is also less well known and used in Kenya. However, for this particular housing typology, the raft foundation was found to be the more cost effective alternative and, due to its flexibility and adaptability to various soil types, has been used in conjunction with all the walling technologies in the ABMT Report.

2. Ring Beams

A ring beam serves three purposes:

a. To provide lateral restraint to the tops of walls
b. To distribute the upper floor load evenly on the load bearing walls below the ring beam
c. To provide vertical wall load support over openings (windows and doors)

Ring beams are often cast on top of a 200mm wide block wall and therefore they are 200mm wide for convenience and usually 200mm deep and reinforced heavily. The structural purpose of the ring beam can also be achieved on small buildings using continuous reinforcement in the block mortar beds.

In single storey buildings, if a ring beam has been provided for, additional lintels over openings can be avoided by the use of storey height window and door frames or if constructed with a 2mm steel plate on top of the window or door to act at permanent shuttering to the ring beam, whose purpose then is solely to provide lateral restraint.

Key takeaway: A ring beam in required for most of the walling technologies considered in the ABMT Report. The three technologies where a ring beam is not required are cross laminated timber (CLT), aluminium formwork and 3D Printing. Elimination of the ring beam results in a saving of approximately Kshs. 45,000/= per the typical single storey 2-bedroom house (refer ABMT Report Excel File).

3. Roof typology

The housing typology considered in the ABMT report is a gable roof.

A monopitched roof was also costed to see if it would be cheaper than a gable roof. The results showed that, contrary to common perception, a monopitch roof is *marginally more expensive than a gable roof* because the savings in the roof structure are outweighed by the extra walling material needed for the back wall. A monopitch roof can only be used in buildings less than 6 metres wide. Monopitch roofs are typically used to cover smaller external structures like toilets and storage barns.

Annex 2: 3D printing costing obtained

3D printing COBOD costs

3D Printing COBOD Brochure

The attached documents serve as references for the 3D printing walling technology included in the ABMT report.

Annex 3: Geographical and Labour Skills Considerations

Each alternative building material presented in the ABMT report will be more or less suited to different regions based on the climate, terrain, soil type and distance from urban centers (impacts availability of the material in light of the transport factor).

This analysis does not go into detail on which ABMT is suitable to which part of Kenya.

It is a given that soil stabilized blocks (SSBs) and interlocking soil stabilized blocks (ISSBs) require soils with 60-70% sand content so are suitable to areas like some parts of Eastern and Northern Kenya such as Machakos, Kitui and Central Kenya, while burnt or sundried bricks require a high clay content so are suitable to areas like some parts of western Kenya (Kisii, Kakamega and Bungoma).

While ISSBs have historically been supported more by the Government of Kenya, and the local manufacturer, Makiga, sells more ISSB rather than SSB machines, the ABMT technical team has evaluated that ISSBs require a higher skill level to install due to the need for very precise workmanship. As such, if installers are not adequately trained, the resultant ISSB walls may be skewed. It is for this reason that SSBs are seen to be a more suitable technology for adoption by the general public. ISSBs are more suitable for developer driven housing where the labour can be trained to acquire the requisite skills.

Sundried bricks have not been studied separately because they are not as water resistant and may degenerate over time with water infiltration. The process of 'burning' sundried bricks makes them more water resistant as there is a chemical change upon burning, however, it also increases their carbon footprint (alternatively, the bricks can be 'stabilised' using some form of cement, which again has an impact on their carbon footprint).

Most of the technologies that require pre-manufactured materials are more suited to locations closer to the urban centre(s) where the manufacturing facilities or available supply chains are located.

Some of the technologies that have been included are more suitable for urban high-rise development, specifically due to the high upfront cost of investment in equipment or skills required. Many of these technologies offer advantages of more precision and speed.

Annex 4 – Early Development and Promotion of ABMTs in Kenya

Active research, development and dissemination of appropriate or alternative building materials and technologies (ABMTs) in Kenya can be traced back to the 1970s & 1980s.

The National Government of Kenya set up a Housing Research & Development Unit (HRDU) in the University of Nairobi and supported it with a budget of Kshs. 600,000/= annually. In 1984, HRDU was converted to Housing and Building Research Institute (HABRI), to enable some level of autonomy. HABRI ceased to operate in 1994.

The key building technologies being promoted by HRDU and HABRI were fibre concrete roofing tiles and micro concrete roofing tiles (FCR / MCR), as well as soil stabilised blocks (SSBs).

The FCR/MCR technology was pioneered and developed by Intermediate Technology Workshops (ITW), a private firm in the United Kingdom and a subsidiary of John Parry & Associates (JPA). JPA was the original inventor of the small table vibrator powered by a car battery that was used to vibrate a thin section of cement/sand mortar(*6-10mm*) screed to produce a light-weight concrete roofing tile.

Partners in Promotion of ABMTs

The use of these ABMTs was promoted with support from several pioneering partners:

1. **HRDU/HABRI**: Promoted development, testing and identification of what binders and stabilizers are required in FCR/MCR and SSBs installation for adoption by local communities, and supported training through Youth Polytechnics. The Ministry in charge of housing was hands off in project implementation in the 1970s and 1980s unlike the current scenario where the Ministry is actively promoting the use of ISSBs[1].

2. **GTZ:** The cooperation agency of the Federal Republic of Germany provided long term funding to HRDU/HABRI.

3. **John Perry Associates (JPA):** Developed the FCR/ MCR technology and supported its adoption in Kenya through technical assistance and workshops.

4. **Action Aid-Kenya** used the technologies for their school construction program. They set up three youth groups into businesses producing and selling FCR/MCR tiles in Kibwezi, Kiboswa and Webuye. They also built several schools across the country using SSBs. Action Aid-Kenya was instrumental in introducing SSBs and FCR technologies to the then Nyahururu Municipal Council for their low-cost housing project. Some funding was provided by **USAID.**

5. **Practical Action** (formerly Intermediate Technology Group (ITDG)[2]) engaged private sector building materials manufacturers to adopt and promote ABMTs as a business and succeeded in setting up over seven such enterprises in the country producing FCR/MCR tiles.

6. **Humama Women's Group which then became Jamii Bora:** Humama was a women's group in Mathare / Kibera slums, which was founded by Ingrid Munroe, a Swedish Architect, with support from the African Housing Fund (a subsidiary of Shelter Afrique). Humama invested in over 1,000 acres of land in Kisaju, Kajiado county, to create a self-contained sustainable city for the women, with each member owning a house. The vision was to use vibrated hollow concrete blocks (HCB) and MCR tiles to build the entire city, using equipment from JPA. The project stalled very early on

[1] Source: Interview with Dr Sangori

[2] SKAT, a Swiss NGO known as *Swiss Centre for Appropriate Technologies* has promoted the use and adoption of MCR tiles in developing countries worldwide and has been heavily working in Rwanda to develop and promote the same.

– potentially because of the remote location which made moving the women to the new site unfeasible. The Jamii Bora Bank emerged from this organisation. **The key takeaway here is that all new technologies need to be seen in the context of the full value chain.**

7. **UN-Habitat:** UN-HABITAT was also an active promoter of ABMTs, facilitating review of building by-laws and standards so that national governments and local authorities could incorporate the new ABMTs in their building codes. To this end, KEBS (*Kenya Bureau of Standards*) developed performance standards for both SSBs and MCR.

8. **Komarock Phase 1:** This project was delivered by Housing Finance, when it was largely owned by GoK and CDC). Phase 1 was delivered in 2017consisting of 1,272 townhouses built using FCR/MCR roofing tiles.

9. **Makiga Engineering Works:** This private sector firm was set up in 1991 to produce locally made equipment for the production of SSBs, ISSBs and MCRs. Makiga has not received any government or NGO support as far as is known. As at September 2021, Makiga had sold a combined total of almost 100,000 of block presses (for SSBs and ISSBs) in the East African region with the majority being deployed in South Sudan. The ISSB machines are more popular than SSB machines. **There is a need for skills development for the operation of these machines in order to scale the technologies.**

10. **Hydraform:** Promotion of ISSB technology from 2003 onwards by the government of Kenya in selected regions where it provided Hydraform block making equipment. Under the government program, a total 204 block making machines were bought between 2003 and 2009 from Hydraform in South Africa and distributed to the 47 Counties. Many of them are lying idle, having broken down and lacking spare parts for repair.

11. **ABMT Centres at County levels**: About 93 constituency ABMT Centres have been established across the Country since the formal launch in 2006. The regional ABMT centre is at Mavoko.

Some of the ABMT centres as located in the respective Counties and are listed below.

Table 1: Select ABMT Centers

	Counties	ABMT Centers in the Constituencies
1.	Taita Taveta	▪ Voi Town / Taita Taveta Town
2.	Kwale	▪ Matuga
3.	Mombasa	▪ Mvita (Tononoka)
4.	Lamu	▪ Lamu West (Mokowe)
5.	Elgeyo Marakwet	▪ Marakwet East (Rorok) / Chepkorio / Keiyo (Iten)
6.	Uasin Gishu	▪ Eldoret North (Kipkaren) / Ainabkoi
7.	Transzoia	▪ Saboti (Birunda)
8.	Kericho	▪ Kipkelion
9.	Narok	▪ Narok North (Narok Town)
10.	Nyamira	▪ Borabu (Mwongori Youth Polytechnic)
11.	Kisii	▪ Kitutu Chache South (Kioge)
12.	Migori	▪ Kuria West (Kehancha)
13.	Homa Bay	▪ Karachuonyo (Kendu Bay) / Homa Bay Town (Imbo)
14.	Kisumu	▪ Kisumu West (Maseno)
15.	Kitui	▪ Mwingi Central (Mwingi Town) / Kitui Central (Kitui Town)
16.	Makueni	▪ Kaiti (Kilala)
17.	Muranga	▪ Mathioya (Gitugi)
18.	Kirinyaga	▪ Ndia (Sagana)
19.	Embu	▪ Manyatta (Embu Town) / Runyenjes (Runyenjes Town) / Mbeere South (Siakago Town)
20.	Tharaka Nithi	▪ Tharaka (Kanjuki) / Igamba Ng'ombe/Chura (Weru)

21.	Meru	▪ Tigania East (Muriri)
22.	Isiolo	▪ Isiolo North (Isiolo Town)
23.	Marsabit	▪ North Horr / Saku (Marsabit Town)
24.	Nyeri	▪ Nyeri Town / Mukurweini (Mukurweini Town)
25.	Laikipia	▪ Laikipia West (Rumuruti) / Laikipia West (Nyahururu Town)
26.	Samburu	▪ Samburu West (Maralal Town)
27.	Nakuru	▪ Nakuru Town / Kuresoi South (Olenguruone)
28.	Nyandarua	▪ Ndaragwa / Kipipiri (Miharati) / Kinangop (Ndunyu Njeru)
23.	Baringo	▪ Baringo Central (Central Talai) / Baringo
24.	Mandera	▪ Mandera East (Mandera Town) / Mandera North (Rhamu)
25.	Wajir	▪ Wajir Town / Wajir West (Griftu) / Wajir South (Habaswein)
26.	Siaya	▪ Bondo / Alego Usonga (Liganwa)
27.	Busia	▪ Funyula (Funyula Town) / Nambale (Nambale Town)
28.	Bungoma	▪ Kimilili (Kimilili Town) / Webuye (Webuye Town) / Kenduyi (Ndengelwa)
29.	Kakamega	▪ Lugari (Panpaper) / Butere (Butere Town) / Mumias East (Mumias Town) / Malava (Malava Town)
30.	Vihiga	▪ Sabatia (Lunyerere)
31.	Nandi	▪ Chesumei (Lelmokwo) / Aldai (Kaptumo)
32.	Garissa	▪ Dujis (Garissa Town) / Ladgera (Modogashe) / Fafi (Bura)
33.	Turkana	▪ Turkana Central (Lodwar Town)
34.	Kilifi	▪ Kilifi North (Bahari) / Malindi (Casuarina)
35.	Tana River	▪ Galole (Hola) / Garsen (Garsen Town)
36.	Bomet	▪ Sotik
37.	Machakos	▪ Machakos Town / Yatta (Matuu) / Mwala (Mwala)
38.	Kiambu	▪ Gatundu South (Wamwangi) / Thika Town / Githunguri (Githunguri Town) / Lari (Rukuma)

Annex 5 – Review of ABMT projects built in Nyahururu using SSB, ISSB and FCR technology

The ABMT technical team visited Nyahururu, which had adopted SSB and FCR early on with support from Practical Aid. Owners and tenants living in those houses were interviewed to express their views on the two technologies.

While the evaluation of FCRs/MCRs is included, this technology has been superseded with time and is no longer feasible (due to the higher amount of timber required for the framing, making it much more expensive than mabati covered roofs).

The technical team visited:

(i) the Demonstration House built in 1985 in Maina Village with support from Action Aid and USAID
(ii) Core 4 Estate (a few kilometres from Nyahururu Town)
(iii) 3 other houses made with ISSB in Maina Village by private efforts without any governmental or NGO support from 2006 onwards

The overall learning from the site visits is that the SSB wall technology has fared well over the past 36 years, despite limited maintenance. Patches of weathering of the walls were seen, which can easily be repaired with plaster. It appears this weathering could be reduced by having optimally sized (longer) roof overhangs.

Another take away was that a ring beam structure should be included in the house design to help to tie the whole building together. Ring beams have been included in the analysis of alternative technologies presented in the ABMT Report.

This demo building is a great testimony of the durability and effectiveness of SSBs (and FCRs) as alternative and appropriate building technologies if effectively disseminated and backed up with the right technical assistance.

The re-introduction of SSBs and ISSBs in areas like Nyahururu is a critical strategy for sustainable and affordable housing construction. The area previously relied heavily on timber offcuts for construction, but timber is no longer sustainably available due to deforestation and several old sawmills have since closed. Natural stone is most prevalently used, but this material is transported from Ol-Kalao, which is 40kms away and comes with a high transport cost. This renders ISSBs and SSBs as the most optimal and cost-effective walling materials which are environmentally sustainable and can create youth employment opportunities in appropriate regions of the country.

Pictorials of each of the 3 site visits are presented on the next page.

Table 2: Demonstration house pictorials and learnings: The walls are built with SSBs and the roof with FCRs[3]. This house has fared well 36 years on.

No	Demonstration House Nyahururu built with SSB and FCR	Findings and Takeaways
1		• The house was found to be structuraly intact 36years later with evidently no maintenance. • It is currently used by the government as an office for the local chief. • The walls are intact despite the weathering away of some blocks. • **Future designs should incorporate a Reinforced Concrete Ring Beam above the openings, to help tie the entire building together.**
2		• Wearing off of the blocks on some parts of the wall. • This can be fixed by simply plastering the building.

[3] The equipment to make the SSB and FCR was supplied by a local firm Sihra Engineering. There are alternative suppliers of the equipment in the market.

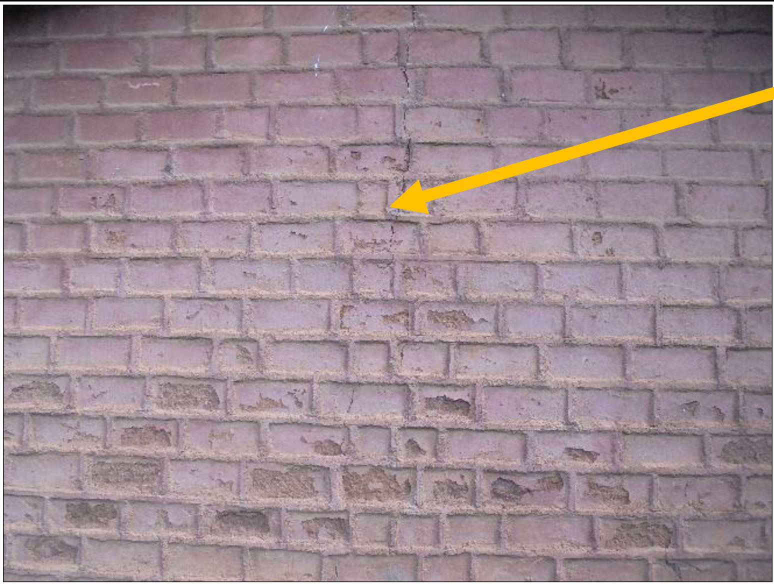
3		• A minor crack was observed on the middle side of the gable wall. • **This can be avoided in future designs by introducing a ring beam in the building that ties all the walls together.**
4		• The upperside of the FCR roof is intact • One side of the FCR roof has survived weather effects over the 36years. • The broken edge of the roof is due to lack of maintenance.

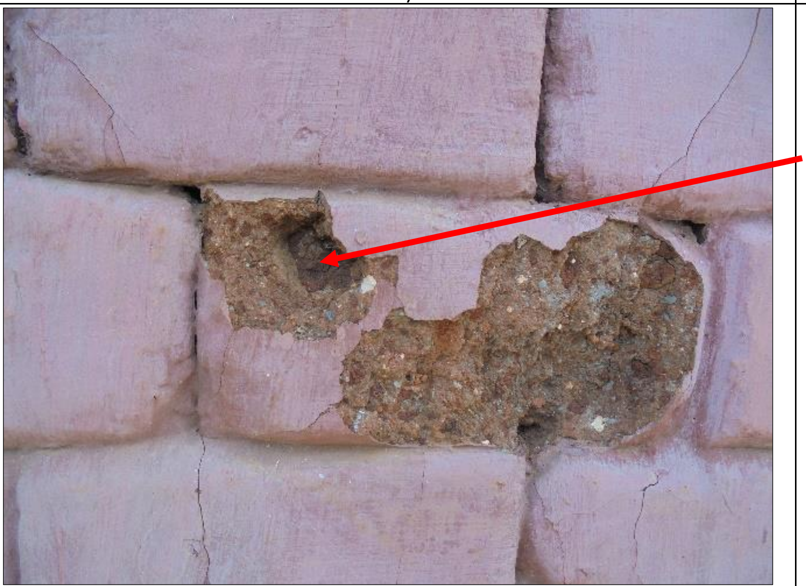
Table 3: Core 4 Estate pictorials and learnings - the County had built 12 other houses using SSB and FCR after the successful construction of the Demonstration House. The houses were difficult to spot due to the dense development, but some were identified. These houses were in a more dilapidated state, having received no maintenance over the years.

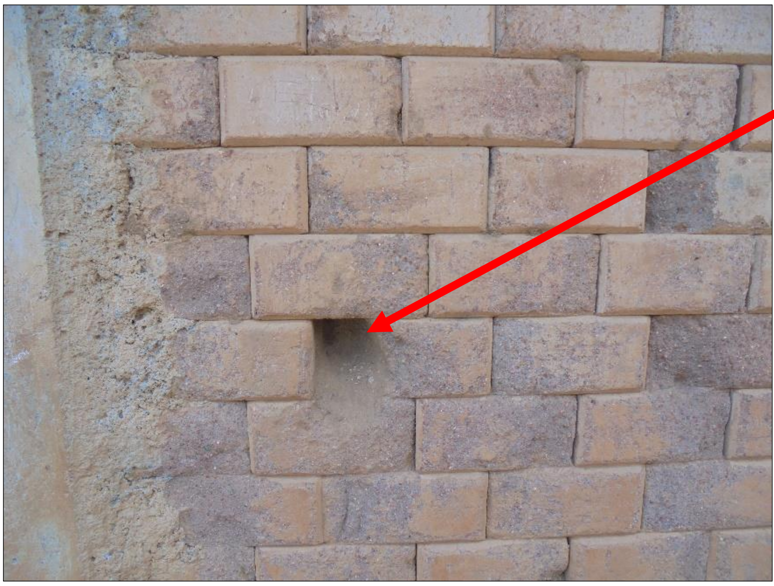
No	SSB houses in Core 4 Estate	State of the Buildings.
1		• Dilapidated walls though the building is still intact. • The SSB walls require only a coat of cement/sand plaster to protect and prolong their life. • **The walls would have fared better with more optimally sized roof overhangs.**

2		• The FCR roof was replaced with the now rusty corrugated ironsheets. • Dilapidated SSB walls that can be improved by plastering.
3		• One of the only few SSB buildings improved by plastering the walls.

Table 4: ISSB house and school built in 2006- a house and Nyahururu St Paul's Primary School where a school kitchen / dormitory built in 2006 with ISSB were visited. The ISSB technology was undertaken with support of the Community Development Fund (CDF). The house belongs to the Village Community Chairman of Maina Village, and the school is Nyahururu St. Paul's Primary school.

No	House and school built with ISSB in 2006	Condition
1		In good state with a few blocks wearing off.

2	 St. Paul's ISSB Kitchen	The ISSB building is still intact 15years later. It however requires immediate repairs to the weathering blocks destroyed by rains due to poor design and construction.
	 St. Paul's school dormitory built with ISSB in 2006.	The dormitory was found to be in a stable condition and the blocks were in a good state.
	 Poorly made ISSB's without sieving the soil eroding later.	• Weathering blocks made from un-sieved soil, poorly mixed with cement, with lumps of soil/mud are the causes of the block erosion. • This can be avoided through quality training and supervision.

		• Damage done on the ISSB wall by leakages through the unprotected chimney. • This is a result of poor design and lack of corrective measures when such defects were first observed.
	 A 2-block classroom built in 2005 under the CDF program in 91 Municipality in Nyahururu Town.	• The classrooms were built in 91 Municipality Primary School. • The walls were plastered internally and no single defect was observed. • Externally, some of the ISSB's are weathering from rainwater splashing and the wear and tear is further exacerbated by school children.
		• Blocks eroding at the bottom, prompting school children to destroy the blocks further as they have fun scratching the blocks. • The remedy to this is applying plaster to the entire walls externally.

Annex 6 – Review of ABMT Centre in Nakuru

The County ABMT Centre in Nakuru, which serves the South Rift Region, was visited. The Technical team met with the Director of Housing in Nakuru.

Learnings / observations from site visit:

a) The ABMT Centre was established in 2005 to demonstrate and disseminate the use of ABMTs in the South Rift region of Kenya. The ISSB technology using imported Hydraform equipment from South Africa was selected.

b) The ABMT Centre, a 2 roomed staff house, an ablution block, and the perimeter wall are made from ISSBs. The buildings are all in good condition, over 16 years after completion.

c) A total of 8 Hydraform machines were imported. Unfortunately, at the time of the visit, 3 were completely nonfunctional, while 5 were in a state of disrepair.

d) Currently there is no ongoing project in Nakuru County using ISSBs

e) The ABMT Centre also supports the dissemination of other technologies including EPS, and making solid floors by laying quarry stones without using concrete. The ABMT Center collaborates with the local TVET.

Table 5: Pictorial from Nakuru ABMT Centre visit

No	Picture	Comments
1		The 5 Hydraform machines parked outside ABMT Center. Three others are locked in the store as they have broken down and lacks spare parts which have to be imported.
2		The ABMT Center built with ISSB in 2005 still in a good solid state.
3		Some ISSB's stacked outside ABMT Center since 2005 and still in good condition. These ISSBs retail for approx. KShs. 16 per block, which is very competitive compared to the burnt brick (below) which retails for Kshs. 13/- per block.

4		• Burnt bricks sold by a local hardware vendor on the outskirts of Nakuru town. • The brick measures L210xW125xH100mm. and is made at a place known as Kibunja 42Kms away from Nakuru town. • The burnt brick sells for 13/- and as is apparent is of a much poorer quality than ISSBs.

While the Nakuru ABMT Center staff are committed and passionate about promoting ABMTs, the uptake has been limited. The Nakuru ABMT Center chose to adopt the imported Hydraform machines as opposed to the locally manufactured block presses as the Hydraform could produce over 1,000 blocks in a day as opposed to the 400 blocks produced by the local press. Regrettably, most of the Hydraform machines, worth millions of shillings, are rusting and depreciating on the ground due to lack of spare parts.

Deductions made regarding the dissemination of ABMT's in Nakuru:

1. Accelerated dissemination of the ISSB technology has been limited due to lack of equipment as there lacks a clear strategy of a government body rolling out technologies and establishing a sustainable supply chain in the public domain, a role best played in a sustainable way by the private sector.
2. The ABMT Centre has only 2 engineers who can be relied on for training and supervision when rolling out the ABMTs, which is limiting.
3. ISSB affords several advantages over alternatives like quarry stones, timber and the poor quality burnt bricks. It needs to be aggressively promoted.
4. Block presses made locally are a more viable option to importing machinery that cannot be serviced as needed. The scale of production does not need the large as most of the blocks are used for a single or small number of buildings. Local machinery costs 25% of imported machinery and can be repaired locally in the event of breakdowns.
5. The successful dissemination of ABMTs requires a more comprehensive strategy that includes a better understanding of appropriateness of ISSBs and SSBs technologies for different uses and skill levels, as well as appropriate training of local contractors and labour in collaboration with TVET institutions.

The Evaluation Team:

The evaluation team comprised of Roy Githaiga and Louis Kariuki both of the Kenya Green Building Society (KGBS), accompanied by Dr. Solomon Mwangi a freelance construction expert in ABMTs who was involved in the construction of these houses during that period. The team also met with the Laikipia Public Works Officer and County Engineer in Nyahururu and the National Director of Housing in Nakuru County and discussed the potential role played by ABMTs and possible future collaboration in disseminating such technologies as future construction materials in their respective Counties.

Annex 7 – Deeper Literature Review and Full Bibliography

No.	Research paper.	Research objectives.	Key findings.	Recommendations.
1	Adoption of Hydraform ISSB technology in Nakuru and its impact on the environment. *By Robert Ogara Abbort Sangori-2012.*	The objectives of this study were: • To find out the extent of ISSB use in housing. • To establish factors affecting ISSB adoption. • To find out impact of ISSB on the environment. • To establish possible mitigating factors required.	Key findings were: • That ISSB is cost effective and competitive against conventional materials (concrete and steel). • ISSB has a wide adoption amongst the employed 30-45 years of age. • Influencing factors for adoption were: cost, ease of use, transport & availability of professional services. • The technology is environmentally friendly. • The main mitigation required was provision of protective clothing and protection of gullies created by soil excavation.	The study proposed the recommendations below: • Development of a policy for ABMTs adoption for housing. • Undertake wider public awareness of ISSB technology. • Inclusion of financial institutions. • Make it possible to access affordable equipment and trained technical workforce. • Introduce ISSB and other ABMTs in all tertiary/technical institutions for sustainability.
2	NCA report - Promoting models for affordable housing using ABMTs. June 2020. **Unfortunately this report is not public.**	The objectives of this study were: • To determine how local ABMTs can be harnessed to lower costs of housing. • To document locally available ABMTs. • To identify and propose solutions to technical and institutional hitches in adopting ABMTs. • To provide a basis and framework to promote ABMTs in self-development	Key findings of the study were: • That key shortfalls to affordable housing are finance, personnel and social. • ABMTs production processes are rudimentary. • That NCA has 14 Centers country wide serving the 47 counties. • That public awareness and capacity building are key	The study recommended the following: • Cost of materials, sustainability aspects and lack of technical knowhow and standardization in ABMTs manufacture limits uptake by professionals and developers and needs to be addressed. • Practitioners need to know that concrete based ABMTs are prevalent in urban areas while earth based and wood in rural.

		and interaction of players in the industry.	fundamentals to ABMTs uptake. • Key ABMTs identified include: ISSB, Interlocking hollow concrete blocks (HCBs), EPSreinforced concrete (precast) panels.	• Building codes and regulations should be made more sensitive to ABMTs. • Creation of a national agency to promote ABMTs.
3	Affordable Housing in Kenya. A performance-based analysis of available technologies in Kenya and abroad. *By Engineering for Change in partnership with UN-HABITAT.*	The objective of this study was: • To assist the Kenyan government on the Affordable Housing Program of delivering 500,000 housing units by year 2022.	The quick analysis that studied a Brazil project only presented opinions on a few selected ABMTs. The study reported that ABMTs applicable in Kenya include: • Compressed earth block (CEB)/SSB • ISSB • EPS • Steel frame • 3D Printing.	The study concluded that: • Both CEB and ISSB would be the most ideal for affordable rural housing in Kenya. • Other technologies researched were not even available in Kenya making them more expensive.
4	An investigation on adaptation of ISSB in Kenya construction Industry. *By Ogonda Jackline Adongo – January 2017.*	This study objectives were: • To establish why ISSB has not been adopted for low cost/affordable houses in Kenya. • To establish whether construction professionals encourage the use of ISSB. • To establish challenges faced by the Building Contractors when using ISSB.	The study found out that: • Lack of availability and high cost of ISSB equipment is a barrier. • Builders do not understand the ISSB technology well and need training. • Developers only target upper high-cost housing bracket. • ISSB is not well known to many potential users.	The study concluded that: • A lot of promotion and awareness creation of ISSB is required. • Training of builders on how to produce and build with ISSB is required.
5	Factors affecting effective use of ISSB for reduced cost of shelter in Mombasa. *By Nganga Anthony Mwangi 2013.*	The objectives of this study were: • To establish factors affecting effective use of ISSB for reduced cost of shelter in Mombasa. • To find out how application of ISSB training affected shelter improvement.	The study findings were: • Mombasa had 5 Hydraform machines donated by the government. • Access to ISSB equipment remained the greatest challenge to	The study concluded and recommended the following: • The establishment of a national secretariat to disseminate ABMTs and allocate more funds on ABMT research. • Promote intensified training in requisite skills through youth polytechnics, tertiary

		• To establish accessibility and cost of ISSB equipment and raw materials. • To establish perception of ISSB technology for shelter.	many potential users. • ISSB was appreciated by many low-medium income homeowners as a good durable material for quality housing, while others perceived it as a building material for the poor. • Private developers were adopting the technology for multi-storey buildings.	institutes, women and youth based organizations and CBO's. • Engage Jua Kali/Informal sector to fabricate more affordable ABMT equipment.
6	Evaluation of EPS technology on its cost effectiveness and waste in Eldoret. *By: Clement K. Kiptum, Steve Ochieng and Victor. M. Mwrigi, Eldoret University Dept. of Civil & Structural Engineering. July 2020.*	The objective of this study was: • To determine the cost and waste generated in construction using EPS technology to build a 3.6x3.6M unit.	This study established that: • The unit cost of the unit constructed was Ksh37, 858/M^2. This was 34% more expensive when compared to a stone house costing Ksh25, 000/- per M^2. • EPS reduced construction time by 50% compared to conventional construction.	The study concluded that the only way to make EPS technology more cost effective was to bring it closer to the users.

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