

Experimental prototypes for emerging housing constructions in Addis Ababa, Ethiopia

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ABSTRACT: Currently the government of Ethiopia operates a housing programme to address the high demand for affordable housing brought about by the fast growing rate of urban expansion, especially for households with low and medium incomes. The majority of citizens fall between these two categories as there are comparatively few high-income households.

The article describes research into affordable housing in Ethiopia by implementing architectural prototypes. The use of architectural prototypes in the development process is discussed in terms of the role they can play throughout the entire building process. The paper discusses the potential for experimenting with new architectural proposals at true scale and under real conditions, and is illustrated using a case study at the EiABC in Addis Ababa.

Low cost or affordable construction technologies and materials are often the critical part in meeting the ever growing demand for rapid housing delivery in developing economies. The central objective of the project is to develop appropriate building and construction systems for affordable housing in Ethiopia. The project outcome is informed by urban and design issues but focuses predominantly on aspects of construction examined through descriptive studies and experiments. We present an approach that integrates basic design patterns and construction details and proposes the use of new and natural building materials for housing. This could create new outlets for agricultural production and opportunities for generating income.

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“Our current sense of self is no more sustainable than our current use of energy or technology.” (Jensen 2006)

1. TRADITION VERSUS MODERNITY IN ETHIOPIA

The search for solutions for appropriate housing methods has existed since the construction of the first primitive shelters. Proposals and experimental approaches for housing are almost always strongly dependent on cultural context: on traditions, social circumstances and the available resources. The situation in the rural areas of Ethiopia is in this respect very specific.

The rural population in Ethiopia has a strong traditional way of living oriented around models handed down from the past. The country consists of a number of different cultures and ethnic groups with marked contrasts in the landscape and locations that often lie far apart and in isolated areas. Compared to other areas of the world, the natural conditions and climate are almost luxurious. Daily life is characterized by close-knit social structures, with strong family orientation and hierarchical structures. The primary work and income in rural areas is through farming and agriculture. Modern resources and infrastructure and technology as well as long-distance communication systems are lacking. Nevertheless people are rapidly becoming connected to the modern world but lack any background knowledge of the consequences of their use. It is generally acknowledged that there has recently been serious focus and growth towards the use of eco-materials and sustainable architecture in Ethiopia. The government and foreign organizations have invested much to change the situation, but often in a rushed way and without a clear long-term concept. However the paradox remains; that the majority of populations remain steeped in traditional construction methods.



Figure 1: Traditional housing in Ethiopia using only natural and locally-available materials

2. WAYS OF LIVING IN ETHIOPIA

In our analysis we have tried to focus on house types that are representative of the typical ways of living in Ethiopia. The different housing types were analyzed according to different criteria. Dwellings in Ethiopia vary from traditional huts to contemporary slums, simple houses to single-family detached houses and in recent years modern western-style apartments (G+4 to G+7) in high-rise buildings in larger cities. There is a noticeable move away from small individual houses towards multi-storey condominiums as an expression of economic status. In the past and until recently, most forms of housing had a strong relationship to the ground, a characteristic shared by both the traditional *Tukul* houses and the cooperative detached houses. Most housing in the country lies between the traditional and ground floor plus two storey houses (G+2) – including slums and detached housing units.

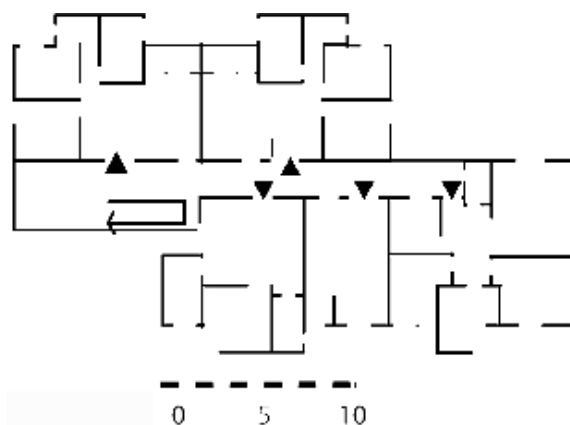


Figure 2: Floor plan of the housing program in Addis Ababa, G+4 and G+7, 2011, Architect: pace consult

Even when Ethiopians live high above the ground, much of their way of life has a strong relationship to the ground. Many social interactions and people's daily activities like baking traditional bread (*Injera*), washing and drying clothes, grinding seeds and coffee, drying ingredients for cooking and the related social and daily activities are conducted mostly on the ground. Living and working likewise is strongly connected with being outdoors. In many cases, the way of life indoors is not especially partitioned into separate areas and sanitary facilities are separate, outdoors or non-existent (Schreckenbach 1980).

The involvement of the user in the design and construction of housing varies greatly in Ethiopia. In the slums the involvement is very high, for condominium buildings very low. Even low-rise cooperative and private housing schemes involve the user in the design and construction at a smaller scale. The condominiums by contrast do not involve the user in either the design or the construction.

3. DESIGN STRATEGIES FOR SUSTAINABLE HOUSING

Finding ways of fitting into existing systems is a complex problem fraught with difficulties and misunderstandings, even though it may have clear benefits, such as better living conditions and better chances for society.

In our research project we have tried to come up with new options and variants (often called improvements) that can make a change today. It is important to maintain cultural traditions and typical ways of living on the one hand while providing opportunities for more education, public social space, infrastructure, sources of income and better health and hygiene on the other. Both aspects are a matter of social responsibility. There is perhaps also an opportunity to make this a profitable business for all involved. These are ultimately quite straightforward needs, needs which the global society has been discussing ever since mankind became aware of 'global society'.

Activities and initiatives in the field of housing and urban development can be divided into three broad approaches:

1. *The umbrella model*
The provision of basic facilities and know-how, e.g. provision of infrastructure, upgrading of skills and education, supply facilities, introduction of financial models, all with the goal of providing the background and motivation for greater awareness and options for changing housing conditions.
2. *The awareness model*
The introduction of individual components to existing structures that through the use of other materials and technologies, through learning by doing and skills upgrading help to improve the overall durability, practicability and quality of existing houses in rural areas.
3. *Fly-in model*
Placing new house types, building systems and technologies by parties and interests from outside which are not normally used there with the firm conviction that those products will be immediately accepted and adopted.

Our research and practical experiments at the Chair of Building Construction at EiABC fits into the awareness model (Donath 2012).

We cannot examine housing on its own, isolated from the larger context. In Ethiopia, the rate of migration from rural to urban areas is rising rapidly due to the poor conditions and work opportunities in countryside regions. This shift looks set to increase in the immediate future. Architectural concepts need to create chances for better living conditions in rural areas as well as in the urban areas to strengthen people's relationship to where they live. Architectural concepts have to offer answers that respond to the specific situation and resources in Ethiopia for sustainable and long-term development by reinforcing the living and working environment instead of eroding it.

One answer is to use locally available building materials and practical construction techniques that make use of or improve on existing skills and knowledge. Another criterion is the way land is used for housing even in wider and open countryside outside of urban areas. The creation of two storey houses, for example, would provide greater density, compact neighbourhoods and maintain social interaction while preserving the wider landscape for agriculture purposes.

4. DESIGN PATTERNS FOR ETHIOPIA

In the context of the housing situation in Ethiopia we present various design patterns which we have investigated over the last three years.

4.1 Pattern: "Open space versus built space"

Open space in housing – semi-private outdoor areas that are sheltered and partially concealed – must offer similar qualities to enclosed space defined by walls. Rural cultural activities are characterized by outdoor living and working with only small built enclosures that are suitable for the respective climate.

Consequence:

Provide a housing arrangement with a much larger proportion of open space and a smaller amount of enclosed space. The open space should directly adjoin the private enclosed space, be able to provide shelter from rain and sun, be flexible in its construction and offer the possibility for further (built) extension.

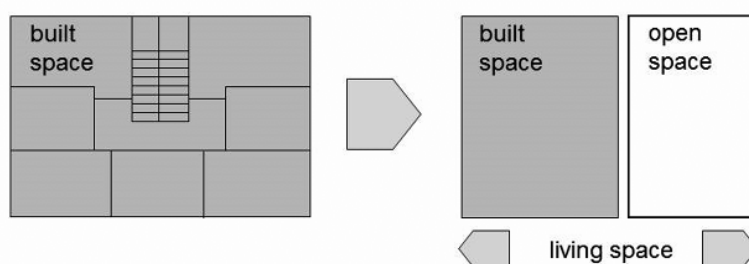


Figure 3: A housing arrangement with a more equal proportion of enclosed and sheltered open space

4.2 Pattern: "Let the water out"

In Ethiopian housing culture and tradition, sanitary installations are not as ubiquitous as they are in the West. The quality of these installations is often poor resulting in damage to the adjacent construction and in health and hygienic hazards.

Consequence:

Relocate the sanitary installation out of the core of the house. Make them robust, easy to access and to maintain. Provide models of shared use with enough privacy for individuals.

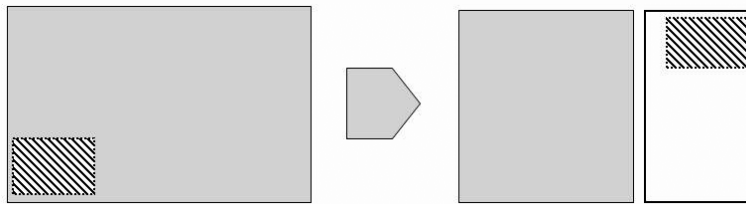


Figure 4: Placing sanitary units out of the core of the house

4.3 Pattern: “Participation”

Providing housing also involves creating a means of identification with one’s surroundings. Ready-made (designed) constructions don’t offer their inhabitants the chance to contribute themselves, to express their social standing and acquire cultural acceptance.

Consequence:

Involve people in the construction from the beginning. A minimum variant would be to provide a basic core structure that offers inhabitants the ability to complete it on their own. This provides an opportunity to contribute practically and to involve the surrounding community.

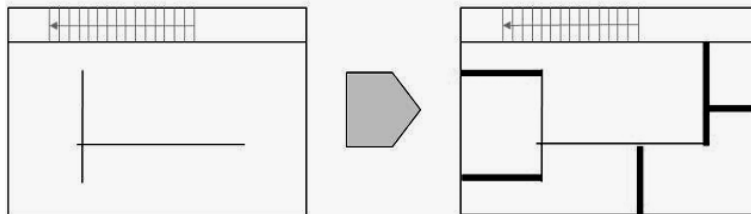


Figure 5: Core construction – half-finished

4.4 Pattern: “Improved and innovative use of natural materials”

People like what they know. People like modern innovations too.

Consequence:

New technologies and converted materials processing methods can help improve on local methods while employing locally available materials. (Kuchena, Usiri 2009) The creation of new materials and principles based on traditional, available and affordable raw materials and knowledge can also act as a ‘technology bridge’. Straw, for example, is a natural product that is well known and used by rural people but would never be accepted as a new and modern material for housing. The same problem applies to earth construction (*chicka*) or thatched roofs on vernacular houses too. People believe in modern construction methods, despite the fact that concrete and corrugated iron sheeting is neither appropriate nor sustainable.

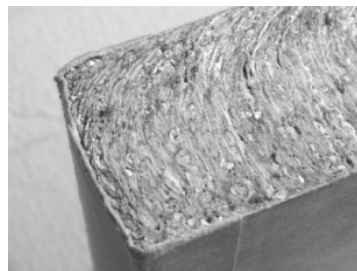


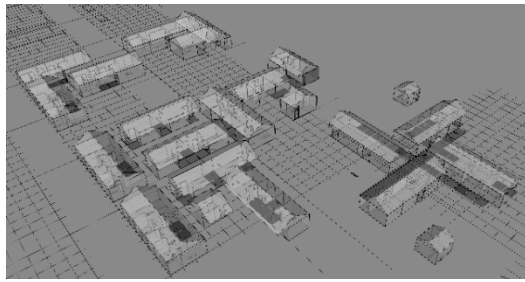
Figure 6: Traditional and modern building materials: strawboard (STRAWTEC ©)

4.5 Pattern: “Modularized and prefabricated building elements”

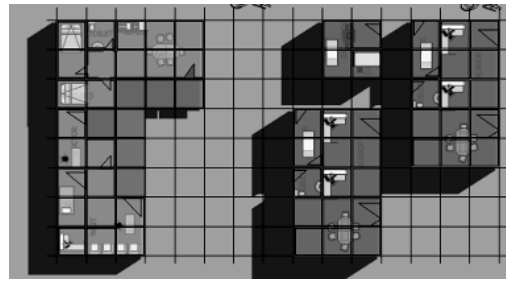
Using new techniques for on-site construction without the necessary skills, tools and experience can lead to quality problems, misuse and misunderstandings that can undermine the construction.

Consequence:

Build on traditional techniques improved using modern technologies or products. Provide pre-prepared templates and guidance, easy to make prefabrication-lines and flexible and modular systems.



Design matrix – Typology of a neighborhood made up of standard elements 1.2m × 1.2 m, EiABC 2011.



Design matrix – Basic modules (one to three stories). The dark gray blocks are open space units, EiABC 2012.

Figure 7: Fusing traditional and modern systems: prefabrication and modularization

These patterns for the design of housing have the potential to contribute to making housing liveable, comfortable and even affordable. Most of the condominiums are densely built-up. While this may be beneficial in terms of using urban land economically, it lacks adequate open spaces. Aside from the advantage of attaining maximum density, the neighbourhood design and upward direction of growth has its own impact on the socio-economic status of the dwellers. Because most condominium dwellers are middle- to high-income families the social mix declines (Low Cost Housing 2003). The reach this again has its negative impact according to Adamassie “the feeling of separation between the ‘us’ and ‘them’ and between ‘those who have’ and ‘those who have not’ will create an atmosphere of envy and resentment that ferments criminality in its most vicious forms.” (Adamassie 2010: 44).

5. PROPOSAL FOR A PROTOTYPE – A SET OF HOUSE TYPES FOR HIGH-DENSITY HOUSING

Dense settlements can be achieved with one up to three storey buildings without impacting on social interaction, urban density and quality. In cooperation with the German governmental development agency GIZ-IS, we developed a catalogue of sustainable sub-urban designs based on pre-aggregated modules. The proposal not only has a better connection with the ground; it also offers further benefits:

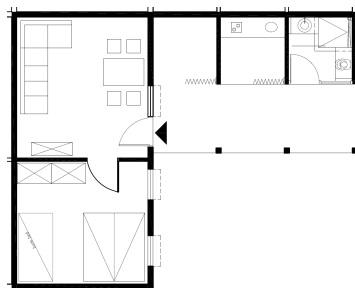
- A density of 530 people/ha,
- 67 housing units/ha housing density,
- Neighbourhoods with a social mix,
- Networks of shops and transport,
- A hierarchic progression of open spaces, from small individual space, to medium-sized neighbourhood space to large public open space)

For each housing design, various key construction typologies have been investigated (Donath 2010).

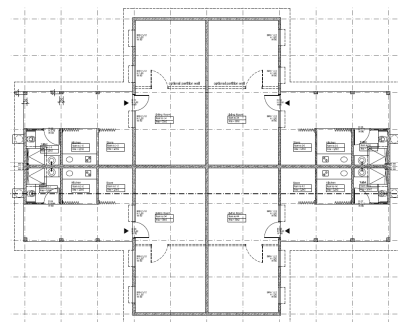
The main construction system consists of a load-bearing wall system. Its principal advantage lies in the reduced effort required for its structural design and the open arrangement of prefab wall and slab panels that affords flexible room arrangements. The walls are constructed out of locally available materials. This contributes significantly to reducing costs and generating jobs. (Alvarado et al 2009)



An example showing clusters of 500 units (Building Ethiopia 2010)



Floor plan of one of the house types 51.24 m² / house 3



Aggregation of house 3

Figure 8: model compound for small settlements, GIZ-IS 2010, Donath

All of the proposed housing types strictly adhere to the defined design and construction constraints.

6. EXPERIMENTAL PROTOTYPE FOR HOUSING IN ETHIOPIA MADE OUT OF STRAW PANELS

In Ethiopia, straw is a locally available material won from agricultural production. It is produced on site and normally tilted down or burned. As an organic, renewable material, it is inherently environmental friendly and recyclable. However straw alone is not well suited for contemporary housing construction. Modern production

technologies such as oriented strawboard offer a possible alternative: the straw is minimally processed and compacted into a board, in the process reducing the environmental impact of burning, e.g. on air quality and combustion fuel. The straw is reduced in a chopping mill for 25 minutes, highly compressed (250 bars) and heated up to 300 °C. Wheat or bale straw can be used, as can any other plant such as banana leaves. The production does not use any glue or bonding agent. The lignum instead acts as an adhesive and the pressed mass is then faced with two layers of cardboard (or another sheeting material such as a textile). In the context of rural houses it can be used as non-loadbearing and loadbearing elements.

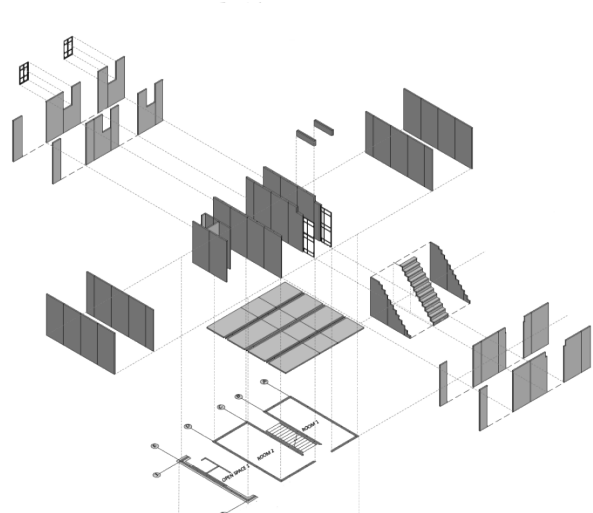
At present we are undertaking tests and experimental prototypes using strawboard for housing applications in Ethiopia (Donath 2012). The prototype SECU (SUSTAINABLE EMERGING CITY UNIT) is implemented in April and May 2012. SECU is a testing and experimental research project for fast emerging settlements and rural areas that examines alternatives to the standard housing concepts.

The basic research and related realization include:

- A construction system and building elements with modular dimensions,
- Integrated typology design matrix for the floor plan layout,
- design principles and criteria for cultural and social identification,
- Constructed from affordable and recyclable materials to reduce dependency on imported materials,
- Standardized connections and construction details (foundation walls, roof, open space etc.),
- Affordable and achievable on-site realization.



SECU – emerging city unit out of prefab straw boards
(realised in April 2012)



SECU – building system

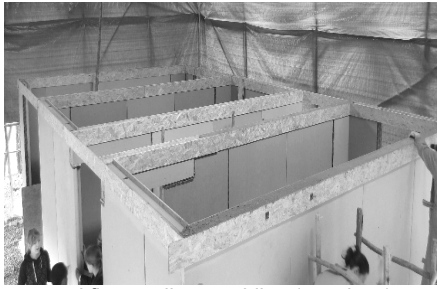
Figure 9: SECU – design and construction concept

All construction elements are made of prefabricated standard strawboard elements. The standard dimensions are 120 cm wide and 6 cm thickness, while the length is flexible. At present the boards come from abroad (STRAWTEC 2012) but production will start in Ethiopia in 2012. Since the SECU project used a material, which did not undergo any mechanical property testing for a load bearing structure yet, it was mandatory to develop test series, which could answer questions of the structural behavior and load capacities of the straw panels. The design followed consequently the material properties.

For the accomplishment of this work the following methodology was used:

- Suitable design pattern and construction details were identified and selected by an on-site survey to assess typical houses and living forms in Ethiopia;
- Intensive research studies by consultation and exchange dialogue were carried out to get the level of skills, affordability and identification with new materials and techniques for reasonable housing and comfort.
- The material behaviour and parameters under the climate of Ethiopia were gained through experiments and laboratory tests;
- The construction of loadbearing walls out of strawboards took place after various structural long term and crash tests, waterproofing test beds and a field analysis with a full scale model.

During the construction all steps are monitored and documented. There is a clear procedure to evaluate the developed design and details. Prepared questionnaires and templates help to figure out the problems and open questions to which we are confronted. A series of interviews and protocols will help to improve the design in the post construction phase. First improvements are figured out already like the connections for the pre-assembled building parts, cladding systems for the outer wall and the roof construction overall.



SECU – ground floor wall assembling (two days)



SECU – placing of hollow core slabs (two days)



SECU - Prefabricated roof elements made of two layers of straw boards



SECU – first floor with cantilevered roof (three days)

Figure 10: SECU – realization of an experimental prototype made of strawboards (EiABC 2012)

7. CONCLUSION

There have been many proposals, locally and globally, for this task of providing adequate and sustainable housing in Ethiopia. Theoretical proposals and research are necessary as well as practical tests and monitoring them. The SECU project represents a series of full-scale experimental prototypes aimed at investigating the practical implementation of theoretical ideas and solutions for housing proposals.

Future and more extensive tests will provide a better basis for evaluating the validity of this approach, and whether it could contribute to improving the housing situation in Ethiopia. A next step has to bring them outside of the academic campus and test them in a real environment. Further steps have to come up addressing beside principal design and construction question the level of involvement and identification by the user. This is often the basis of social acceptance and sustainable adoption of innovative low-cost solutions.

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