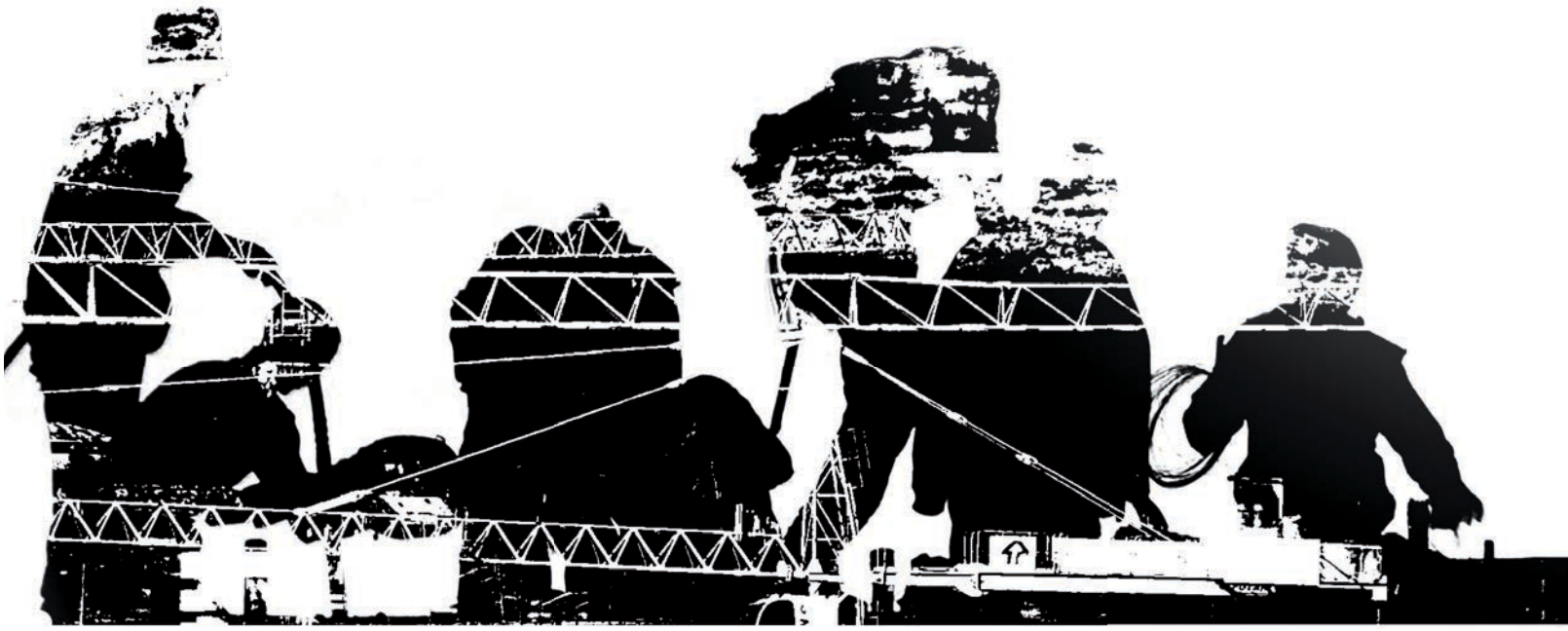

BUILDING ETHIOPIA

SUSTAINABILITY AND INNOVATION IN ARCHITECTURE AND DESIGN

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CONTENT

The world's 35 fastest growing cities and urban areas from 2006 to 2020 (by cityMayors.com)

BUILDING THE FUTURE
THE APPLICATION OF LOCAL CONSTRUCTION TECHNOLOGIES AND MATERIALS IN ETHIOPIA

>> DIRK HEBEL

African cities have growth rates of up to 5% per year; which makes them the fastest growing cities in the world today. Extrapolations show that the urban population in Africa currently doubles every 10 to 15 years. The reason for this urban population growth is high migration rates into African cities. This migration occurs on a broad scale because of two main factors. Aggravated conditions for agricultural production in the global market combined with local mismanagement result in food shortages and difficult conditions for even subsistence farming. Repeated local and regional conflicts deprive an ever-growing part of the rural population of their means of existence and jeopardize their security. In the hope of better living conditions, many people move into urban environments.

Ethiopia will be confronted with a population increase of 45 million people over the next 15 years, along with increased demand for basics like food, water, safety, and shelter which are not yet existent, or already over stressed urban settlements. The decades to come will certainly be formative in the further long-term development of the country. Given this challenge, Ethiopia has to invent its own modes of 21st century urbanization, rather than relying on outdated models from the so-called 'developed world'. It must re-invent its indigenous building methods, construction technologies, and material use. Ethiopia must also reduce its dependency on imported materials, if there is any hope of an escape from its satellite status as a part of the global economy.

The capital of Ethiopia, Addis Ababa, represents an ideal situation where the urban phenomena of growth, expansion, and densification can be experienced and investigated. This can be accomplished firsthand through its geographic location, demographic development, and most importantly, its unbelievable potential in people, ideas, and interactions.

With a population of approximately 2.8 million people,[1] composed of 78 ethnic groups, Addis Ababa is the undisputed metropolis of the country, and is also the location of the headquarters of the African Union (AU). Experts predict the population will reach 6 to 8 million people by 2025. Addis Ababa has the potential to function as an experimental urban laboratory for the country as a whole, through its position as the political and social centre of Ethiopia. Questions of density, health care, safety, social coherence, psychology, economy, and above all, ecology must be answered. The questions of which building materials and techniques are appropriate for the urban development of a country need to be considered, and Addis Ababa is an ideal location for this. Newer developments in Addis Ababa show the contrary: it has been infected with the so-called 'Dubai Fever' – the desire to copy or import an image of economic growth and associate it with political power. Glass and steel towers are misunderstood as manifestations of a positive economic development and as the singular aesthetic outcomes of a modern looking city.

The 'Dubai Fever', manifested and virally transmitted in seductive flashy high-gloss magazines, has reached all African cities, among which Addis Ababa is one. In reality, though, the city is anything but prepared for such a speculative boomtown urbanism, considering that more than 60% of Addis Ababa's population live below the poverty line. The copy/paste of architectural strategies brings a myriad of serious problems. Instead of using locally available materials, more than 80% of the construction materials in Ethiopia, including steel and glass, are imported, mostly from Eastern Asia. Investment capital, both foreign and domestic, know-how, entrepre-

1 >> Official census of 2008

Cover image:
The world's 35 fastest growing cities and urban areas from 2006 to 2020 by City Mayors.com

neurship, and the possibility of sustainable growth of local markets, all leave the country without becoming links in a value chain process. In addition, big construction sites are usually led by foreign know-how and leadership. Ethiopians are mostly seen in lower day-labourer ranks. The glass towers symptomatic of 'Dubai Fever' have a big impact on the energy consumption of the city and resultantly on the ecological footprint of the whole country. Instead of taking advantage of, and designing for the ideal climatic conditions of Ethiopia, which fall between 10° Celsius minimum and 30° Celsius maximum, the glass facades force the necessity of technical cooling systems, depleting one of the goods that Ethiopia does not have: energy. Hence interruptions in the electricity supply are the norm, rather than the exception in Addis Ababa.

b >>

c >>

a >>

THE GRAND HOUSING PROJECT

To generate conditions, geared toward sustainable urban development, Ethiopia needs to develop regulations for, and visions of, how to use its rich culture and its reliable resources. These are, first and foremost, locally available construction materials and know-how, such as natural stone, loam brick technology and rammed earth construction techniques. The population increase of 20% in the last decade in Addis Ababa has dramatically illustrated the limitations of the thinking and urban planning thus far. It has neither been possible to develop infrastructures and homes for a fast growing population, nor to establish a sustainable means of existence for the newcomers to the city. As a 'solution' for this desperate situation, the Low Cost Housing Technology (LCH) was developed with German support. Since its introduction into the local construction sector in 2002, it has led to visible results. Over 40,000 accommodation units for approximately 200,000 persons have been built. At the same time, almost 40,000 jobs were created in the local construction sector, arranged mostly in the form of small business enterprises. Based on the LCH-principle, the government is trying to promote this kind of development with the recently launched "Addis Ababa Grand Housing Program" – an ambitious project aimed at the construction of further 50,000 accommodation units per year until 2014. However, the construction technologies used for the program are based on a concrete pillar and slab system. This construction relies upon principles developed in the re-construction period of post-war Germany. Enormous amounts of cement and gravel are used on the construction sites and hollow concrete blocks are applied to fill the structures.

a >> Glass and steel constructions are currently the predominant models in Addis Ababa, driving the economy more and more in a backlog situation, since more than 80% of the construction materials have to be imported. Energy consumption in Ethiopia is on the rise, because those structures have to be cooled by technical means.

b >> Most construction sites use 100% cement products, most of the raw material is imported from India and China.

c >> Concrete constructions need formwork, in Ethiopia mostly Eucalyptus wood, which boosts the deforestation of the country.

Measures like the Grand Housing Project must be looked at with a critical eye. This widely praised strategy of generating housing, infrastructures and jobs for the poorest, all within a single program and construction methodology proves to be an economic pseudo-cycle. When any local economy becomes almost completely dependent on a superheated construction sector, a question can be asked: who can afford to build these structures in the future, moving from a government owned program to a private one? It would be considerably more promising and sustainable to develop diverse economic and construction models, which would allow poverty and infrastructure problems to be dealt with individually and specifically. It is also preferable to apply techniques and knowledge, originating from local habits, materials, and cultures, instead of those from the global market. The use of prefabricated and imported cement materials has been widely implemented in the production of housing in the Grand Housing Project, in order to facilitate building and shorten the construction time. However, the construction period of projects has usually been longer than it should have for multiple reasons. Shortages of materials, improper use of both material and technology, and unskilled manpower are among the primary setbacks to the timely completion of the projects.

The use of eucalyptus trees, applied as a scaffolding material and as a support during the production of the precast concrete beams, needs to be minimized and alternatives must be developed. An average of 800 eucalyptus tree logs were consumed while building each block of the Grand Housing Project. It can easily be argued that this facilitates the deforestation of the country as a whole. For the 60,000 housing units completed, with an average of 30 units per block structure, 1.6 million eucalyptus trees have been consumed so far. For a country like Ethiopia, struggling against poverty and unpredictable climate changes, it would be a tragedy to lose the already endangered and undersized forests. Here, alternative techniques and methods have to be applied in order to achieve a more sustainable kind of construction.

Sustainability requires the integrative thinking of various disciplines in design, the building sector and the urban infrastructure. Ethiopia should reconsider its tendency to copy misleading architectural images from the United States and cities like Dubai, which make it dependent upon imported materials and know-how. There is a need to enhance vernacular construction and material knowledge, both of which could be used to cope with the dramatic need for new urban dwellings. This knowledge must be based on integrative modes of thinking, combining design, construction, building physics, sociology, energy, ecology and economy. If new methods for low-cost, sustainably operating double-story building techniques can be found and introduced in African cities, the density of the current urban settlements could be almost doubled without wasting land valuable for agricultural use.

g >>

d >>

e >>

f >>

d >> Wood is used for formwork and scaffolding construction

e >> Concrete became the absolute dominant construction material in Ethiopia, despite the fact, that neither material nor know how is present in the moment

f >> The grand Housing Project introduced a so called “low cost” construction method, based on models from post-war Germany

g >> More tan 50.000 units shall be finished each year till 2014.

SUSTAINABLE URBAN DWELLING UNIT (SUDU)

a >>

In the summer months of 2010, the Ethiopian Institute of Architecture, Building Technology and City Development (EiABC), together with the Federal Institute of Technology in Switzerland (ETH) started to build on its campus a double-story Sustainable Urban Dwelling Unit (SUDU). The dwelling was designed based on the current urban conditions and needs in Ethiopia. It is a showcase for integrative disciplinary thinking and an experimental laboratory for evidence to convince decision makers, economists, environmentalists, urban planners and architects to re-think traditional building methods and social space requirements, in order to find new ways to build a city. As the example of Tokyo shows, a megacity can be based on double-story buildings.

The EiABC constructed the SUDU project as a collaborative process between researchers and students from the ETH in Zürich and from the institute itself. Students from different backgrounds, cultures and disciplines, worked closely together to plan, design and build the project in full scale. They also experienced first-hand, the network of participants needed in order to complete such a project. This all helped to enable trans-disciplinary thinking and action. The project was also instrumental as a test run between the organizational structures of ETH, in the field of sustainability. As a result, two departments, ETH Sustainability and the ETH North-South Centre have developed long-term structures for how to handle such projects in the future. The ETH plans to use the connections to EiABC and Ethiopia for further research activities.

The need to reduce global emissions, energy consumption, and material waste requires the systematic development of sustainable buildings at both large and small scales. Materiality, social space, water management, waste management, energy production and consumption, operation, and maintenance have to be designed in such a way as to be the most effective and efficient. With the SUDU project, performance standards have been established, emphasizing innovation and integrated design.

a >> Lara Davis on top of a small test vault. Here, already one layer is enough to support the human weight load

b >> The vault for the first ceiling is constructed in space, following a string guiding system

Ethiopia, once called the granary of Africa, has a rich soil, which contains high levels of clay particles. Almost all excavated material in the city of Addis Ababa is a possible source for the material needed to build new structures. The SUDU project used “rammed earth” technology to construct the first level of the building, with a 60cm wide wall structure. Using formwork, designed for multiple uses over consecutive layers, loam soil is loaded into the form and densified with small metal ramrods. Each layer is 120 cm high and when the first layer of the formwork is filled, the form is lifted up, thus filling and ramming on the next layer can start again. Openings for doors and windows are simply cut out. Using a specialized technique, a small ring beam was constructed on top of the last layer, to ensure the structural strength needed to support the ceiling.

b >>

The first ceiling of the SUDU project was done using a tiled vaulting technique, designed and introduced for the first time in Ethiopia by Prof. Dr. Philippe Block from the ETH Zürich. Dr. Block had previously gathered practical experience in similar techniques during the 2008/09 project for the Mapungubwe Museum in South Africa, together with architects Peter Rich and Henry Fagan, along with John Ochsendorf and Michael Ramage as structural engineers. The technique, also known as 'Guastavino' or Catalan vaulting, was already introduced at the end of the 19th century in many public buildings in New York, such as the Grand Central Station or City Hall Subway Station. The system was patented as "Tile Arch System" in 1885 by the architect Rafael Guastavino and supports robust, self-supporting arches and vaults using interlocking tiles and layers of mortar to form a thin skin. The tiles are usually set in a herringbone pattern layout with a sandwich of thin layers of Portland cement. Unlike much heavier stone construction, these tile domes, or barrel constructions, can be constructed in place without additional support. Each tile cantilevers out over empty space during construction, relying only on quick drying cement, known as "Plaster of Paris", (produced for centuries in Ethiopia), to secure it in place. With this technique, no scaffold is needed to construct the ceiling or dome, and only a string guide system is used to make sure the form is kept in an ideal structural line.

2 >> Lara Davis, Philippe Block: Earthen masonry vaulting: Technologies and technology tansfer; [SUDU][HEBEL], see page 219-231


c >>


d >>


e >>

The second floor of the SUDU project was constructed with loam stone produced in a hydraform press, which has an output of nearly 900 stones per day, operated with a local know-how and workforce. The first layer of stone is put in a loam mortar bed enriched by 5% of cement, and all other layers are simply placed on top. This technique also allows for additional structural support, if needed, by hollowing out an internal formwork for small columns, which secures the building against lateral forces, since the area around Addis Ababa is seismically active. Again, no additional formwork is needed and a combined technique of loam stones and the option for a columnar structural support allows for a heterogeneous construction method, customizable according to local and regional requirements regarding seismic activity.


f >>


g >>

h >>


i >>

c >> From two ends, the barrel vault is constructed.

d >> The herringbone layer system

e >> The workers were able after 1 week of training to do the work.

f >> Loam stones produced in interlocking Hydro-Form technique

g >> Filling the Hydaform press with local loam

h >> Taking a pressed block out of the form

i >> Drying of the stones


j >>


k >>


l >>

The roof construction followed a “Mexican Vaulting” technique, similar to the ceiling, but this time produced out of hand pressed small loam bricks. The roof structure is a double curved element; built only in one 10 cm thick layer. As the demands of a roof as an exterior element are different from those of a ceiling, it was covered with a special waterproof mortar, produced out of prickly pear cactus juice, salt, lime and loam soil. Since 2008, this method has been again implemented by an Ethiopian artist, Meskerem Assegued, on a project in the village of Harla, near the city of Dire Dawa, in Easternmost Ethiopia. She investigated the technique in Mexico and brought it back to Ethiopia, where she found historical evidence that it was used for centuries before falling into disuse and then forgotten. Because of this loss of knowledge and technique, the inhabitants of the village could not repair their roofs anymore. Over the last decades, the roofs were constructed with corrugated metal sheets, producing nearly unbearable interior conditions due to the almost direct heat transference from the exterior by the sun-attracting surface of the roof. Through her project, more and more of the villagers are replacing their roofs again, returning to the old techniques and traditions.

Micro enterprise and know-how developed fast in Harla and the technique was brought from Harla to the SUDU project. The technique uses prickly pear cactus, cut in small pieces, and left to soak for 5 days with water in a barrel. After this period, the slimy juice is filtered and mixed with salt, loam and lime, and is then ready for use. The Harla villagers already use the juice to paint all of the exteriors of their homes, sealing them against rain. Also, loam stone production was started in the area, with astonishing results in strength and durability. Some


m >>


n >>


o >>


p >>


q >>

j >> Meskerem Assegued with Jörg Baumeister, faculty member of EiABC, dicussing possible collaborations.

k >> The overview over the village, cactus plants in front.

l >> In the front corrugated metal roofs, in the back traditional roofing with cactus juice mortar.

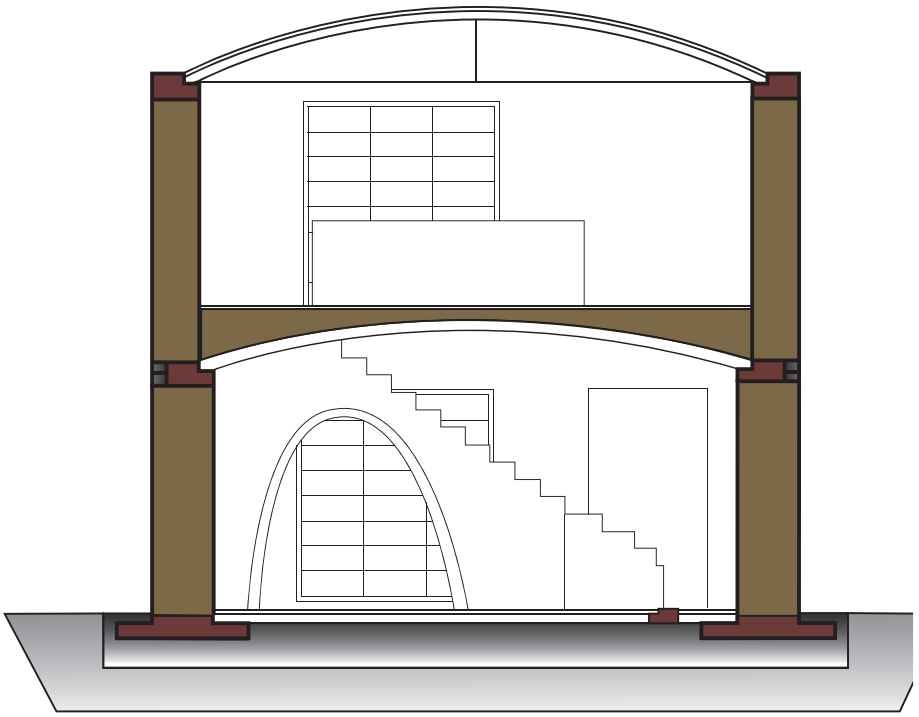
m-q >> The indigenous materials: cactus and loam soil, After 5 days of fermenting, a slime juice results, which has to be filtered for use, The juice is simply mixed with loam, lime and a bit of salt, The roofs are almost flat, the cactus juice mortar is 100% waterproof. The cactus juice is also used as a protection layer for the natural stones.

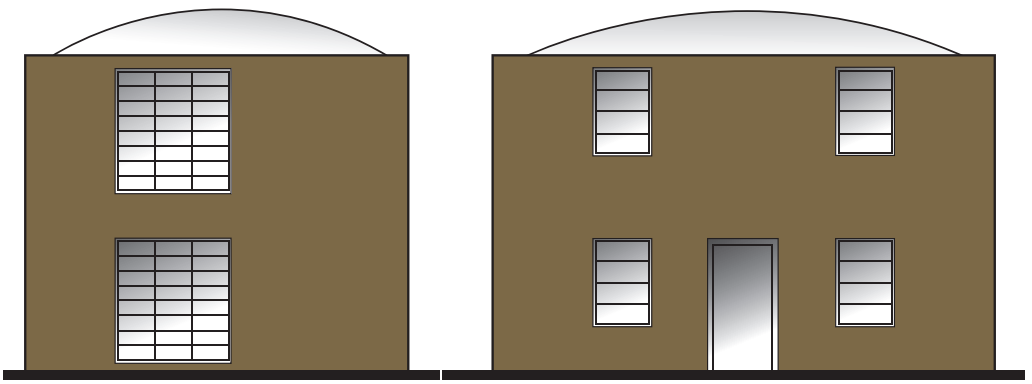
plastering on the walls and the roof of the SUDU project was done with the cactus juice mortar, which proved easy to handle and produce, without the use of any imported materials.

The SUDU project uses only a minimum of the cement that would have been needed for a hollow concrete block construction, the most common construction method, currently in use in Addis Ababa. Local materials such as loam or natural stone, local workers and local know-how led to the first case study building in the SUDU project. This can now be used to gather more information, and will hopefully lead soon to an implementation phase, at a larger scale, of the principles and techniques used in the project, and the knowledge gained through their implementation. The project will hopefully push the local industries and small-scale enterprises to think more and more about construction materials and methods, alternative to concrete. Less than 100 years ago, Ethiopia had a tradition of constructing seven story loam buildings, and it was almost forgotten. New technical infrastructures, in connection with those rediscovered traditional methods, will help to develop sustainable constructions for future generations, in urban as well as rural conditions. EiABC, together with the North-South Center at ETH Zürich and the Waser Foundation already started another research project called Sustainable Rural Dwelling Unit (SRDU) to investigate the possibilities to build a rural counterpart, commenced in 2011.

The SUDU project could be seen as a first step to re-search and re-apply, re-invented vernacular technologies in Ethiopia. Similar to Le Corbusier’s idea of a “mason-domino”, an easy to apply and almost everywhere applicable construction system for Europe after World War I, the

SUDU project unfolds the possibility to be seen as a so-called “proto-typology”[3] for Ethiopia, rather than a modernist approach of a “proto-type”. The modernist “proto-type” followed the idea of one “ideal” model configuration, applied in a serial way, while the “proto-typology” defines a flexible and heterogeneous form of organization, which can be changed and readjusted instantly and serve different cultural as well as contextual conditions. It is a process rather than a product. Ethiopia has the possibility to use such thinking, given the rich and different local material supply throughout the country. The Tigray area in the north traditionally uses natural stones and loam mortar, while the Southern Regions apply bamboo constructions in large scale. All those materials could be part of the SUDU “proto-typology” and help to answer one of the most critical questions that Ethiopia has to face in the decades to come: how to house 45 million additional people in a sustainable and economical as well ecologically feasible way, without falling in dependency on a global market. >>





3 >> Just as the prototype anticipates a product yet to be developed, the proto-typology represents a typological configuration in permanent state of evolution. Whereas a conventional typology defines a generic model of organisation, which becomes specific through its application, the proto-typology is specific from the beginning. On the other hand, it never really becomes generic as it continues to transform itself through the information it receives. As a pliable, learning matter it adapts to changing needs of programs and users. Hence a prototypology is not a model, but a transient phase of an evolutionary process, and therefore always ahead of its type.“ See: Ilka and Andreas Ruby, The Metapolis Dictionary of Advanced Architecture. City, Technology and Society in the Information Age, Susanna Cros (ed.), Barcelona 2003.

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the SUDU housing prototype at the compound of EiABC