CHALMERS

Construction of low cost houses in informal settlements

A case study of the Nairobi region

Master of Science Thesis in the Master's Programme Structural Engineering and Building Technology

DAVID KVARNSTRÖM

Department of Civil and Environmental Engineering
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CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover:
Kambi Moto neighbourhood, Huruma, Nairobi: walking between the old shacks and the new houses.

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ABSTRACT

Many African countries have experienced a large increase of urban population during the last 50 years. The proportion of people living in informal settlements is in some cities as high as 60% (Muraguri 2011), which clearly demonstrates how the demand for low cost housing has been urgent for a very long time. The main aim of this thesis is to analyse the slum upgrading situation in Kenya, focusing on house design, implementation methods and alternative building materials, with the purpose to present advantageous approaches that can be enforced in future development.

The project was carried out as a field study in Nairobi during September-November 2013. It evaluates four current or recently completed slum upgrading housing projects in this region. It has a technical perspective, while other also important aspects, such as political and economic influences, are not included in the scope.

The results show that many appropriate house designs, implementation methods and building materials are available, but not always all applicable or suitable in any given housing project. Highrise concepts have proven to be devastating for the social and commercial environment of its tenants, while smaller multi-storey houses, with one household living in each, represent an alternative in densely populated areas. Long-term, incremental expansion can also be an advantageous concept.

Findings clearly confirm the importance of community involvement in slum upgrading projects. This may create extensive self-sufficiency to community members, and bring wider sustainability within slum upgrading development, thanks to achieved self-help abilities that reduce the need for external support.

The results indicate how labour intensive construction methods and local production of building materials can be very advantageous in housing projects. Approaches that partially allow unskilled labour during construction can be very cost-effective, and simultaneously brings employment and skill training opportunities.

The study found alternative, low cost building materials being available, such as stabilised soil blocks, but not yet fully established. Certain alternative materials can be advantageous in terms of cost, production, construction implementation, capacity building and sustainability in terms of self-sufficiency and raw material consumption.

Lean concrete floor slab elements, such as "landie" slabs or "waffle" slabs offer many advantages in multi-storey house construction, such as possibilities for prefabrication, a reduced use of concrete and reinforcement, as well as simple, manual construction methods that does not require any form work.

Key words: slum upgrading, implementation, informal settlements, house design, low cost, construction methods, planning approaches, building materials

Konstruktion av lågkostnadsbostäder i slumområden

En fallstudie av Nairobiregionen

Examensarbete inom Structural Engineering and Building Technology

DAVID KVARNSTRÖM

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SAMMANFATTNING

Många afrikanska länder har upplevt en stor ökning av stadsbefolkning de senaste 50 åren. Andelen av befolkningen som bor i slumområden är i vissa städer så hög som 60% (Muraguri 2011), vilket tydligt demonstrerar det akuta behov av bostäder till låga kostnader som länge existerat. Uppsatsens huvudsakliga syfte är att analysera situationen för upprustning av slumområden i Kenya med fokus på hustyper, metoder för genomförande samt alternativa byggnadsmaterial, och har som avsikt att presentera fördelaktiga tillvägagångssätt för framtida utveckling.

Arbetet genomfördes som en fältstudie i Nairobi i september-november 2013. Det utvärderar fyra pågående eller nyligen avslutade projekt för slumupprustning i denna region. Det har ett tekniskt perspektiv, och andra aspekter med stor inverkan på utvecklingen, så som politiska och ekonomiska influenser, är ej inkluderade.

Resultaten visar att det finns många lämpliga hustyper, metoder för genomförande och byggnadsmaterial tillgängliga, men att de inte alltid är tillämpliga för varje enskilt projekt. Höghus har visat sig förödande för den sociala och kommersiella miljön för sluminvånare, medan mindre flervåningshus för endast ett hushåll representerar ett alternativ i folktäta områden. Stegvis och långsiktig utbyggnad har också varit ett fördelaktigt koncept för många hushåll med mycket begränsad inkomst.

Studien bekräftar tydligt betydelsen av att involvera de lokala invånarna i projekten. Detta kan skapa ökad självständighet hos dessa invånare och medföra en mer hållbar utveckling tack vare ökad förmåga till självhjälp vilket minskar behovet av externt stöd.

Resultaten indikerar att byggmetoder som innebär stor arbetsinsats och lokal materialproduktion kan vara väldigt fördelaktiga för husbyggnadsprojekt i samband med slumupprustning. Metoder som delvis tillåter oerfaren arbetskraft under byggfasen kan vara väldigt kostnadseffektiva och samtidigt medföra möjligheter till sysselsättning och praktisk utbildning.

Studien visade att alternativa relativt billiga byggnadsmaterial finns tillgängliga, men att etableringen av dessa har varit väldigt långsam. Vissa alternativa byggnadsmaterial kan vara fördelaktiga beträffande kostnad, produktion, utförande och hållbarhet.

Relativt små betongelement för byggande av bjälklag i flervåningshus, s.k. ”landie-plattor” och ”waffle-plattor”, kan medföra flera fördelar, så som möjligheter till prefabricering, minskad användning av betong och armering, samt enkla, manuella byggmetoder som inte kräver temporära gjutformar.

Nyckelord: slumuppgradering, slumområden, bostäder, tillvägagångssätt, låg kostnad, konstruktionsmetoder, byggnadsmaterial, designprocess, husdesign

Contents

Preface

In this Master's thesis, the slum upgrading development in Kenya has been studied with a structural engineering perspective. The main areas of focus are house design, construction project implementation and alternative building materials. The thesis work was carried out as a Minor Field Study (MFS) project at the Department of Civil and Environmental Engineering, Chalmers University of Technology, Gothenburg. The MFS programme is managed by the Swedish International Development Cooperation Agency (SIDA), and the concept of an MFS project is to "study issues of importance to third world countries' economic, social, political or scientific development." (Internationella Programkontoret 2012). The field study was carried out in September-November 2013 in the Nairobi region, and was financed by SIDA. The overall thesis work comprises 30 ECTS-credits and was performed during the fall term of 2013.

The supervisor and examiner of this study has been Mario Plos, Associate Professor and Head of Division at the Division of Structural Engineering.

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I would like to express further appreciation to all the people who assisted me on my field study in Nairobi, including; Zeltia Gonzalez Blanco, for preparatory and initial support as well as assistance in putting me in touch with the University of Nairobi; Yvonne Anyango, for extensive help with networking, meetings and study visits; Dan-Eric Archer and Jonas Barman for initial support; Nicholas Mungai & Henry Kinuthia for showing me around in Ngong; David Kahoro, Peter Murigi and Patrick Mwanzia at Practical Action; Peter Chege, Steve Gome, Christopher Kaniiru, Muraguri Kariuki, Joseph Mukeku, Salma Sheba and Aaron J. Wegman on the Kambi Moto project; Jesinta Atieno and Nickolas Ohinge for taking me to the Langata Decanting Site in Kibera; Iscar Jemutai, Irene Karanja, Esther Maiga and Moses Mwangi at Muungano Support Trust/Muungano wa Wanavijiji; Moses Kiptoo, Daniel Migwi and Joseph Mugwanga at the National Cooperative Housing Union; Emma-Liisa Hannula, Christophe Lalande and Grace Lubaale at UN-Habitat; Lawrence Esho at the Nairobi University of Technology; Adams Namayi at the Kenya Building Research Centre; Jackson Mutua, Zakayo Nguitu and Francis Omondi on the Soweto East upgrading project; Kenneth Nyaseda and Father John Webosa on the Korogocho improvement programme; and Otieno Nickson Otieno for initial tips and suggestions.

Many thanks also go out to all the friendly people I got to know and meet in Nairobi, the hospitable informal settlement communities I had the privilege of visiting, and everyone else that made my stay in Kenya such a pleasant and exciting experience.

Gothenburg, Sweden, in January 2014

David Kvarnström

Terminology

This section presents an overview to common terms and abbreviations in this thesis.

Organisations, institutions and programmes

GoK	Government of Kenya
IEK	Institution of Engineers of Kenya
KENSUP	Kenya Slum Upgrading Project
KISIP	Kenya Informal Settlement Improvement Programme
MuST	Muungano Support Trust
MwW	Muungano wa Wanavijiji
SIDA	Swedish International Development Coordination Agency
UN-Habitat	United Nations Human Settlements Programme

Technical terms

ha	hectare (1 ha = 10,000 m^2)
ISSB	Interlocking Stabilised Soil Block
km	kilometre
m^2	square metre
mm	millimetre
MPa	Mega Pascal (N/mm^2)
N	Newton
RC	Reinforced Concrete
SSB	Stabilised Soil Block

Other abbreviations

CBD	Central Business District
KSh	Kenyan Shilling (KSh 1,000 ≈ US$ 11 per January 2014)
MFS	Minor Field Study
NGO	Non-Governmental Organisation
MDG	Millennium Development Goal

1 Introduction

1.1 Background

Many African countries have experienced a large increase of urban population during the last 50 years. Even though the shortage of low cost housing in urban areas became a problem in Kenya already during the 1960s, due to massive urban migration, the population living in informal settlements has increased dramatically ever since. The urban population is expected to reach 50% by 2015, and the proportion of people living in informal settlements is in some cities very high, such as in Nairobi, with an estimated 60% (Muraguri 2011). Despite numerous efforts from non-governmental organisations (NGOs) and recent governmental activities, the trend is yet to be reversed.

In order to meet the accelerating demand of low cost housing, and to improve the living conditions in informal settlements, various organisations are involved in slum upgrading projects. Some are small-scale, community initiatives carried out with support from NGOs, while others are large-scale, governmental programmes. Unfortunately, some projects provide new accommodation that is unaffordable to many low income households, and thus failing its true cause.

In many developing countries, building material compose the main part of the total cost in residential construction projects. Reaching around 68% in Kenya (Syagga 1993), it is obviously a factor with great cost reduction potential. Field demonstrations and real life housing projects have proven certain designs to save up to 50% of the building material cost, including material acquisition and labour. Nonetheless, the use of alternative, low cost building materials and methods is still very limited, and the critical demand for affordable housing for low income households continues.

1.2 Problem description

The general situation that creates the problems analysed in this thesis is the accelerating prevalence of informal settlements in Kenya. The demand for low cost housing in urban areas has been critical since the 1960s, with relatively little efforts made to produce a sufficient supply. Although residential construction costs are extensively dependent on the choice of building materials, the dissemination of low cost alternatives has been very slow.

1.3 Aim

The main aim of the thesis is to analyse the slum upgrading situation in the Nairobi region, from a structural engineering perspective. The study focuses on house design, implementation methods, alternative building materials and effective structural solutions with the purpose to present advantageous approaches that can be enforced in future development. The thesis also intends to describe the general conditions that make slum upgrading such a complex and difficult problem to resolve.

1.4 Scope

The thesis focuses on current or recently completed slum upgrading housing projects in the Nairobi region. It has a technical perspective, and other aspects that have significant impact on the development, such as political and economic influences, are not included in the scope. Similarly, other important areas of physical infrastructure, for instance roads, sanitation and drainage systems, are not integrated in the evaluation.

The scope is further limited to the small timeframe and the actual data that could be accessed during the thesis progress. Certain desired information was unavailable due to practical restrictions, like denied research inquiries or non-existent documentation.

1.5 Thesis outline

This section presents the overall report structure.

Chapter 1 – Introduction
This chapter gives a brief overview of the project. It presents the background, the aim, the problem description and the scope of the thesis.

Chapter 2 – Method
This chapter explains the methodology chosen for the project process, and describes the different procedure phases. It intends to inform the reader of how the thesis has been realised.

Chapter 3 – Slum Upgrading Construction in Kenya
This chapter forms the literature review related to the thesis scope. It aims to provide the reader with a contextual background to the subsequent chapters.

Chapter 4 – Case studies
This chapter introduce the four housing projects analysed as case studies. They all relate to slum upgrading in the Nairobi region, and are analysed in line with the thesis scope.

Chapter 5 – Evaluation
This chapter constitute an assessment of the main subject, in which the practical situation represented by the case studies is reconnected to the literature review.

Chapter 6 – Discussion
This chapter aims to interpret the results of the thesis, and discuss it in terms of relevance, validity and application.

Chapter 7 – Conclusions
This chapter summarise the major findings of the thesis, with the purpose to provide a brief overview of the project outcome.

2 Method

2.1 Introduction

This chapter presents and evaluates the methodology of the thesis work. It explains the overall conditions to the study and clarifies the approach that was used to analyse the various issues in line with the thesis aim. The main factor that determined the methodology for this thesis was the field study concept, described below.

2.2 Procedure

The thesis work was carried out as a Minor Field Study (MFS) project at the Department of Civil and Environmental Engineering, Chalmers University of Technology, Gothenburg. The MFS programme is managed by the Swedish International Development Cooperation Agency (SIDA), and the concept of an MFS project is to "study issues of importance to third world countries' economic, social, political or scientific development." (Internationella Programkontoret 2012). The actual field study, where the main part of the data was gathered, was carried out in Nairobi, Kenya. The project was divided in three parts: the planning phase, the field study phase and the analysis phase, described below.

2.2.1 Planning phase

The planning phase focused on specifying the project tasks, gathering background information on slum upgrading in Kenya, establishing contacts in Nairobi, and preparing documents and practicalities ahead of the field study. The main areas of work were:

- Determination of scope
- Literature review
- Establishment of contacts in Nairobi
- Problem formulations
- Field study practicalities
- Proposal for alternative approach

2.2.2 Field study phase

The field study phase was performed during eight consecutive weeks in Nairobi with surrounding areas, during the fall of 2013. The research topics were investigated through interviews, site visits, access to project documentation, and continued literature studies. Site visits and interviews were performed at various locations and with various persons involved in slum upgrading, such as planners, contractors, engineers, project managers, government officials, building material producers, labourers, slum dwellers, etc. (further presented in the reference section).

The site visits were chosen to study different approaches to slum upgrading, such as self-help housing, informal construction, government programmes, and the use of manual labour. Buildings currently under construction were studied, as well as

recently completed projects, examining both implementation and final results, respectively.

2.2.3 Analysis phase

The analysis phase was mainly performed back in Sweden, after completion of the field study. The obtained information was sufficient in order to include and analyse a few projects as case studies in the report, but could have been much more extensive. It was, however, adequate for the intention to present results that comply with the aim of the project. Further data could have made additional projects applicable as case studies, but also would have improved the analysis of those presented. Nevertheless, the remaining timeframe of the thesis work was very limited, and accordingly also an influencing factor in the analysis phase.

2.3 Reflections on the method

The reason to why this thesis has been produced originates from the author's personal interest in development work in third world countries. The specific study has not been requested by any organisation or institution, but rather created by the author to represent an interesting subject for his master thesis work, with the intention to contribute to current research. Problem description, aim, scope and method have to a very large extent been chosen by the author, with necessary assessment and approval from his supervisor at Chalmers as well as academic contacts in Nairobi.

The main project phases were determined by the MFS programme concept and applied roughly according to the anticipated work progress. Apart from a few guidelines and criteria, such as the field study timeframe, the methodology could be decided as deemed appropriate. Because of many uncertainties regarding the actual data gathering work, prior to the field study, a general, adaptable approach was chosen. The intention was to have certain flexibility in terms of areas of focus, data gathering methods, and possible case studies, but aim for a specific range of information to obtain on each case.

Because of the author's limited prior knowledge on the subject, the major issues to be analysed were initially assumed, and at a later stage either confirmed or considered less relevant. The field study phase was obviously very rewarding in terms of an overall understanding of the subject, and provided an opportunity to partially experience the context in which it exists.

The cultural and physical setting was very crucial on how the field study phase was carried out. Factors such as unpredictable commute, misunderstandings, lacking follow-up or deficient communications could complicate or prevent intended work. The reception from contacted persons and organisations ranged from very helpful to dismissive, and sometimes not even contactable. In order to ease communications, the author got support in his networking attempts from a local Kenyan, which turned out to be very advantageous.

3 Slum Upgrading Construction in Kenya

3.1 Introduction

The aim of this chapter is to present the general complexity of slum upgrading, by describing the current and historical situation in Kenya. Structural engineering is just one aspect that influences the development of urban infrastructure, and is hardly the most determining factor. It has to be studied in a broader perspective, including social, political and economic issues. The mere existence of new, appropriate technology is not sufficient for its dissemination; it often needs political backing, but also profitable qualities in order to get fully established.

Housing is, in a similar manner, only one area in a larger context of physical infrastructure, among roads, sanitation and access to water. These aspects are all essential for successful slum improvement, but are not included in the scope of this thesis. It is, however, important to understand how all those factors influence and determine the outcome of upgrading activities.

3.2 Background

3.2.1 History

In their report *An Inventory of the Slums in Nairobi*, the NGO Pamoja Trust (2009) describes the inception of informal settlements in Kenya. When the British colonial government established urban centres in Kenya, the residential areas were divided with regard to ethnic origin of the inhabitants. Natives required a pass to visit the white residential areas, and native travel to the city was restricted. Thus, population increase within the city was controlled, and public services such as schools, hospitals and roads were maintained in all residential sectors.

Following the independence in 1963, the urban centre management changed from a colonial to a national administration. The planning standards were, however, practically unchanged, and the unfair distribution of land continued. Because people now were able to freely move to any part of the country, the urban migration increased dramatically. The demand for residential land was not met by the new government, and informal settlements arose as a consequence.

The urban population continued to grow rapidly during the 1970s, and the housing and public service situation became even worse. Due to political indifference and insufficient public efforts, slums expanded and were not officially recognised. Throughout the 80s and 90s, the change to multi-party politics created a patronage system, and land ownership was becoming a political advantage. Slum dwellers were forcefully evicted from their homes, leading to increased protests by the general public, demanding change.

Improved political recognition and governmental accountability, civil society demands, international influences, and efforts to promote collaboration between the government departments, NGOs, and other establishments, have all supported the development in slum areas since the end of the 20th century. The problem is nevertheless far from being solved, and many obstacles are left to overcome.

3.2.2 Informal settlements

There are many conditions that can be used to describe informal settlements/slum areas. Slums in Kenya are characterised by overcrowding, high unemployment and crime rates, unhealthy environmental conditions, and insufficient access to basic infrastructure, such as water, sanitation, housing and roads (UN-Habitat KENSUP Team 2008). The United Nations Human Settlements Programme (UN-Habitat) uses a model to measure the degree of deprivation of basic infrastructure for households in urban areas. The model is designed to facilitate quantitative assessment of an area's living standards and is based on five conditions:

1. Durable housing of a permanent nature that protects against extreme climate conditions.
2. Sufficient living space which means not more than three people sharing the same room.
3. Easy access to safe water in sufficient amounts at an affordable price.
4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people.
5. Security of tenure[1] that prevents forced evictions.

The model is applied on separate families, who are considered to be slum households if they lack at least one of the conditions. Since security of tenure is not directly related to living standards, the household is regarded as being in a state of shelter deprivation if it lacks at least one of the first four conditions. According to analyses based on this model, the most deprived slums in the world are located in Sub-Saharan Africa. In comparison with other regions, it represents a 2-5 times larger proportion of households lacking three or more conditions (UN-Habitat 2006).

As stated by Mungai (2013), the most common house structures in Kenyan slums have mud or iron sheet walls, earth or concrete floors and iron sheet roofs. The iron sheet design is the easiest, quickest and cheapest alternative, but results in very uncomfortable indoor temperatures. Iron sheet roofs are also problematic during rain, because it can become very noisy indoors. Both materials have limited durability and subsequently have to be replaced relatively often if not maintained regularly.

Slums are usually very congested, with many people sharing a limited area. The shacks are often built with no or very little distance to adjacent structures, forming long rows and large blocks separated by narrow alleyways. Many homes consist of only one room, commonly with the standard dimension 3×3 m^2, and it is not unusual that large families share such a small space. E.g., in Soweto East, a village in the Kibera slums, each household consist on average of seven people, according to Calas & Fernandez (2011).

3.3 Main issues

The prevalence of informal settlements in Kenya is continuing, and the effort to reverse the trend, and eventually provide the whole population with decent housing and living conditions, is complex and very long-term. The problem can be roughly

[1] Security of tenure: "The right of all individuals and groups to effective protection by the state against forced evictions" (Augustinus & Benschop 2003).

divided in three decisive aspects: political, economic and technical. Considering that informal settlements were not officially recognised by the Kenyan government until the 1990s, and that the republic still is struggling to become self-sufficient, the slum situation today is not very surprising.

While the political and economic climate slowly increases its support of the marginalised population, the technical development has been more active, and presents new technology as possible means to improve the situation. Alternative low cost materials, easy-to-implement construction methods, and approved structural designs are all technically available, but slum improvement is obstructed by many complex issues, such as the socio-economic status of slum dwellers, regulations, physical conditions, land and structure ownership, dissemination of convenient technology, and corruption.

3.3.1 General

One common issue in slum redevelopment is the security of tenure. According to Omondi (2013), the land and structure ownership, respectively, can sometimes be uncertain, and resistance to redevelopment may arise from structure owners, fearing loss of their income. Some projects which are planned to improve the living situation for the whole neighbourhood are sometimes delayed by a few individuals, refusing to relocate or claiming compensation. And as stated by Webosa (2013), the inability to provide land title to the inhabitants may create reluctance to housing projects because the new houses might be unaffordable and consequently become occupied by higher income people instead.

Physical conditions, such as lack of appropriate land for new construction, congestion and limited area access, make implementation difficult. Sometimes temporary relocation of the residents is required, which can be a very troublesome process (further presented in case study 4). As mentioned by Calas & Fernandez (2011), many slum dwellers earn their incomes as vendors and often use the fronts of their homes as kiosks, and might lose necessary business conditions if disregarded in the planning process.

In an article presenting the Kambi Moto slum upgrading project (World Habitat Awards 2009), the enforcement of a bottom-up management approach is discussed as essential in order to integrate community influence, opinions and needs. Neglecting this aspect may result in uncertainty and dissatisfaction among the residents, and subsequently inability to reach set goals. A close collaboration between the residents, local authorities and other stakeholders also promote capacity building within the community, such as organisational, financial, practical, and self-help skills – abilities all important for further development.

3.3.2 Maladjusted and inadequately enforced regulations

An evaluation of the Kenyan building code can be found in a conference paper published by the Institution of Engineers of Kenya (IEK) (2011). The construction regulations have to a large extent been based on the British building code, including irrelevant regards to the environment, such as snow. The climatic differences have caused many structures to collapse, due to unexpected material performance. The building code includes mostly conventional materials and technologies, such as concrete, steel reinforcement, sawn timber, clay tiles, and bricks. A few recent

updates have introduced new technology, e.g. stabilised soil blocks, but use of other methods has in general been discouraged.

As a result of the inadequately adopted building regulations, Kenyan houses are to a large extent in poor structural shape. Both traditional and new materials and techniques have been neglected, even though they would remarkably improve the conditions to create new residential buildings. Local culture and experience, regional climate, natural resources, available tools and labour are all significant factors that need to be considered and integrated in the planning regulations.

Efforts to revise the building codes emerged during the 1990s. Updates such as Code 95, which introduced modifications of the old codes, resulted in large reductions in building costs, and an increased activity in residential construction. According to the Construction Business Review (2012), The British Standards are currently being replaced by Eurocodes, and in order to achieve the millennium development goal (MDG) No 7 (ensure environmental sustainability), further revision and adaption to Kenyan conditions are still needed. IEK recommends the building code review to focus on the following, in short:

- Increased use of local materials and technologies.
- Accommodate new alternative technology.
- Compatibility between design and technology.
- Consideration of the entire life span of structures.
- Various local conditions should influence the choice of design and technology.

IEK (2011) states that other areas within the construction industry also need improvements. Building permits and other application processes should be simplified, and operations to make sure that the revisions are embraced are also of great importance.

Although the facilitation of new construction techniques in the building code is an important aspect for the renewal of the construction sector, the regulations are far from being completely enforced in practice. According to Namayi (2013), all construction - in particular public buildings and structures located in urban areas - have to follow the regulations. This applies to rural construction as well, but it is rarely enforced or controlled in that setting. The building code is thus not necessarily a barrier to contractors or individuals who carry out construction work. A large proportion of practitioners are either unaware of the regulations, or simply disregard them.

The division is mostly determined by geographic location, rather than actual size of the building. Structures such as hospitals and shopping malls have been constructed without approval, and there have been several collapses, sometimes with human casualties. It is often the consequence of having non-professional contractors carry out low quality construction, without inspections.

The situation is created both by the ignorance of the regulations, as well as the authorities' incapability to inspect every single project. There has been a recent shift of responsibility, from the former Ministry of Public Works to the National Construction Authority, which likely will lead to more strict regulations and control.

3.3.3 Application of appropriate technology

In his report *Promoting the Use of Appropriate Building Materials in Shelter Provision in Kenya*, Syagga (1993) analyses the dissemination of alternative building materials with regards to the demand for low cost housing. Development of innovative, cost saving technologies was initiated during the 70s, but little has changed in the actual practice of the construction sector. Conventional building materials, as concrete and quarry stones, are still dominating the sector, providing insufficient alternatives for low income households. Locally produced building materials, such as stabilised soil blocks (SSBs), may have an abundant supply of raw material, create more job opportunities, require less skill, capital and means of production, are more economically and environmentally sustainable, and use smaller amounts of imported products.

In many developing countries, building material compose the main part of the total cost in residential housing construction projects. Reaching around 68% in Kenya, it is obviously a factor with great cost reduction potential. Field demonstrations and real life housing projects have proven certain designs to save up to 50% of the building material cost, including material acquisition and labour. Nonetheless, the dissemination of alternative, low cost building materials and methods has been very slow, and partially restrained, due to several reasons.

The beneficiaries of low cost housing are in general low income households, with very limited economic conditions. The construction industry, like most other industries, is based on economic gain, making low profit activities unfavourable. The main constraint on the dissemination of appropriate building technology, however, is and has been insufficient political support. Subsequently, the development is inhibited by the lack of institutional services, obsolete planning regulations and limited social acceptance. Slum dwellers may additionally be constrained by insufficient access to credit, quality control and equipment.

According to Namayi (2013), some governmental housing campaigns in Nairobi have made use of SSBs, e.g. in Mathare and Kibera. The authorities have approved the constructions, provided machines for SSB production, as well as suggested construction methods. Quality controls have been carried out by government officers. The technique has been around for about 20 years, but has first since the last couple of years been more accepted. Many public buildings, such as schools, have been constructed with SSBs, but baked bricks are still used to a large extent. The accessibility of the SSBs is not meeting the demand, but the technique, along with other alternative building materials, will be more established when manufacturing in the private sector increase, along with continued engagement from non-profit organisations.

3.4 Upgrading activities

As mentioned in the introduction, the urban population in Kenya is expected to reach 50% by 2015, according to Muraguri (2011). The proportion of people living in informal settlements is in some cities very high, such as Nairobi, with an estimated 60%. Despite numerous efforts from NGOs and recent governmental activities, the trend is yet to be reversed.

3.4.1 Governmental

Anderson & Mwelu (2013) states, that even though informal settlements were not officially recognised in Kenya until the 1990s, international influences and opinions made the government to take action on slums already in the 70s. Various approaches to resolve the problem have been applied since then, but the main strategy became forced evictions. As deemed by the UN Office of the High Commissioner for Human Rights (2007), this is an unjustified strategy since it violates several internationally recognised human rights, such as "the human rights to housing, food, water, health, education, work, security of the person, freedom from cruel, inhuman and degrading treatment, and freedom of movement".

As further discussed by Anderson & Mwelu (2013), the MDGs were established in 2000 by the UN member states, as an international joint effort towards a better and more equal world. As defined by the UN (2000), the seventh MDG, "to ensure environmental sustainability", addresses in target 7.D slum dwellers, and the improvement of their living situation. This event initiated the Government of Kenya (GoK) to change its approach towards slum issues, and new strategies were introduced to resolve the problem.

As presented in a strategy document by the UN-Habitat KENSUP Team (2008), collaboration between GoK, UN-Habitat, the former Ministry of Housing, and local authorities and communities, has since established two main initiatives; the Kenya Slum Upgrading Project (KENSUP) and the Kenya Informal Settlement Improvement Programme (KISIP). Anderson & Mwelu (2013) describes the differences between the two initiatives. KENSUP is a long-term (2005-2020), nationwide strategy that aims to "… improve the livelihoods of people living and working in slums and informal settlements in the urban areas of Kenya through the provision of security of tenure and physical and social infrastructure, as well as opportunities for housing improvement and income generation".

KISIP is a short-term (2011-2016) strategy, limited to 15 municipalities, and focuses on security of tenure, infrastructure, urban management strengthening and participatory urban planning. In regards to housing construction, KENSUP provides new residential buildings, while KISIP provides the prerequisites for housing development to the local communities, along with infrastructure services, such as roads and access to water and sanitation.

Both strategies have encountered several problems in implementation, even though the government is fully involved. The general approach to include the targeted local communities in the planning process has not been successfully enforced, creating lack of information, top-down decision making and distrust among the beneficiaries. Coordination between the strategies, and between the involved institutions, respectively, has been insufficient, making the planned complementary collaboration not fully utilised, which consequently complicate the progress. Another main issue is the unsustainable funding basis, which mostly was covered by donors.

3.4.2 Non-governmental

There are many non-governmental organisations involved in slum development work in Kenya. They range from small, private donor initiatives, like school support and savings groups, to larger national and international establishments, such as UN-

Habitat and various slum dweller networks, with extensive activities. Many are community or faith based organisations, having close collaboration with the communities in the areas in which they operate.

There are many examples on housing projects in slums carried out by NGOs. Some are immediate actions because of forced evictions; others are neighbourhood redevelopment projects; and some are large scale programmes where slum dwellers relocate to ad hoc towns set up on acquired land. Many housing projects embrace the concept of community coherence, facilitating self-help through organisation, saving schemes, and establishment of dialogue with local authorities.

Some of these NGOs have been around since the 1970s, and many new ones are established continuously. E.g., in Kibera, with a population of about 170,000 (Karanja 2010), estimates show that several thousand NGOs are active here, as discussed by Mwaniki & Mwau (2012). These organisations have various agendas, and their work has very different actual impacts on the lives of the beneficiaries. Unfortunately, and obviously, with regards to the high number of existing NGOs, many have little or no impact in the end, due to various reasons. Some are plain scams, set up only to bring in donations, while others suffer from inefficiency, sometimes making their work outdated.

Although there also exist plenty of legitimate NGOs that accomplish great improvements for many slum dwellers, there is a general lack of coordination amongst them. Instead of collaboration and transparency, sometimes a state of competition may emerge, which clearly counteracts the original goodwill intention. This flaw makes many initiatives end up as one-off, subjective efforts, with little follow-up potential. Lots of knowledge and experience could be shared to a larger extent, and thereby make planning and implementation of future projects more effective.

There is also a need for better coordination with the government, in order to further decrease the risk of unknowingly repeat already performed research, clarify separate responsibilities and establish a joint forum for evaluation and development work. Even though every upgrading project is unique, with different conditions and problems, the importance of sustainability, transparency and efficiency has to be fully emphasised.

3.5 Alternative construction techniques

3.5.1 Background

The high demand for low cost housing in Kenya has, as mentioned, pushed the research on alternative construction techniques forward since the 1970s. The research has, however, had a relatively small impact on the construction industry as of yet, as stated by Syagga (1993). New materials and methods may get little attention even though they have many advantages compared to conventional design. This depends on a number of reasons, further described in Section 3.3.3.

Many different alternatives to conventional building materials can be used for housing construction. Among those are stabilised soil, bamboo, lean concrete elements and recycled composites, as mentioned by Mungai (2013). Cost, production simplicity, raw materials availability, previous successful utilisation and social acceptance all affect the propagation of a new building material. Alternatives that have become more

established in Kenya the last couple of years, e.g. stabilised soil blocks and “waffle” slabs, are presented below.

3.5.2 Stabilised soil

Soil has been used as building material by several cultures for thousands of years. Unprocessed earth materials are very sensitive to erosion, but developed forms, such as sundried earth blocks (adobes) and kiln-fired bricks, can be very durable. Today, brick construction is still common, but the production is considered unsustainable because of deforestation related to the burning process. Stabilised soil technology offers an alternative in regions where this poses environmental degradation.

Stabilised soil is a technique using basically earth materials, water and a small cement content to create strong and durable construction elements, such as blocks, tiles and foundations, as described by Andabati (2010). It represents an economically favourable alternative to many conventional building materials, thanks to a number of properties. The main raw material, soil, is cheap, and the cement proportion is relatively small. The products can be produced on site, hence reducing transportation costs, and possibly facilitating work opportunities. Labour costs can be decreased, e.g. by using interlocking stabilised soil blocks (ISSBs, see Figures 3.1 and 3.2) for walling, which require less mortar work and are fast to lay, compared to quarry stones.

Figure 3.1 *Left: demonstration building of ISSBs. Right: close-up showing block assembly. Photos: author.*

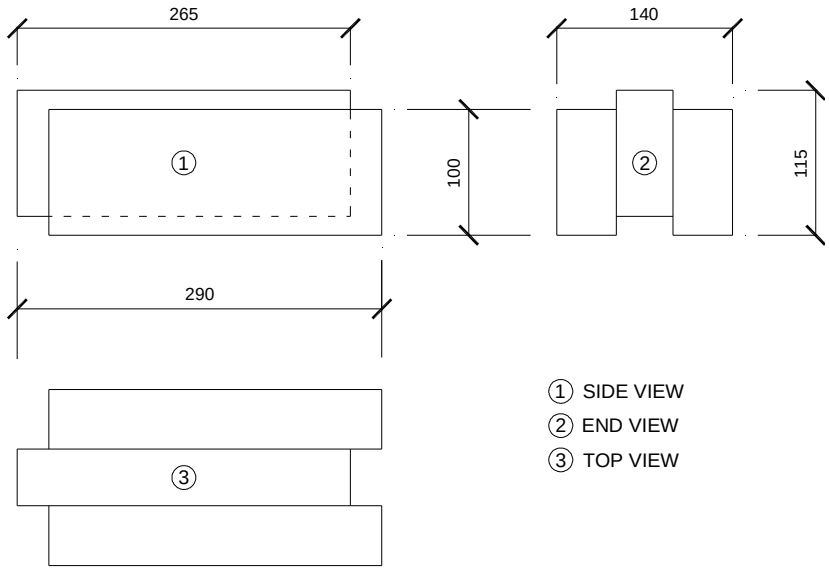

Figure 3.2 Drawing showing details for a typical straight double interlocking stabilised soil block. Adapted from Andabati (2010).

Apart from economic and environmental benefits, the technique is favourable in many other aspects as well, such as availability, versatility and simplicity. Suitable soil can be found in many places, often close to or sometimes even on the actual construction site, and means for production can be completely manual, although block presses can be too expensive for small scale, individual use.

The wide extent of application makes the technique very flexible. Rammed soil can make solid foundations and floors (see Figure 3.3), and various block types can be produced for many different purposes. Wide blocks can compose load bearing walls, thinner blocks for lighter partitions, or curved blocks for round structures, such as water or septic tanks. Material production and construction implementation can be relatively simple, and does not necessarily require skilled labourers. The methods are easy to learn, which facilitate self-help opportunities and capacity building within the local community.

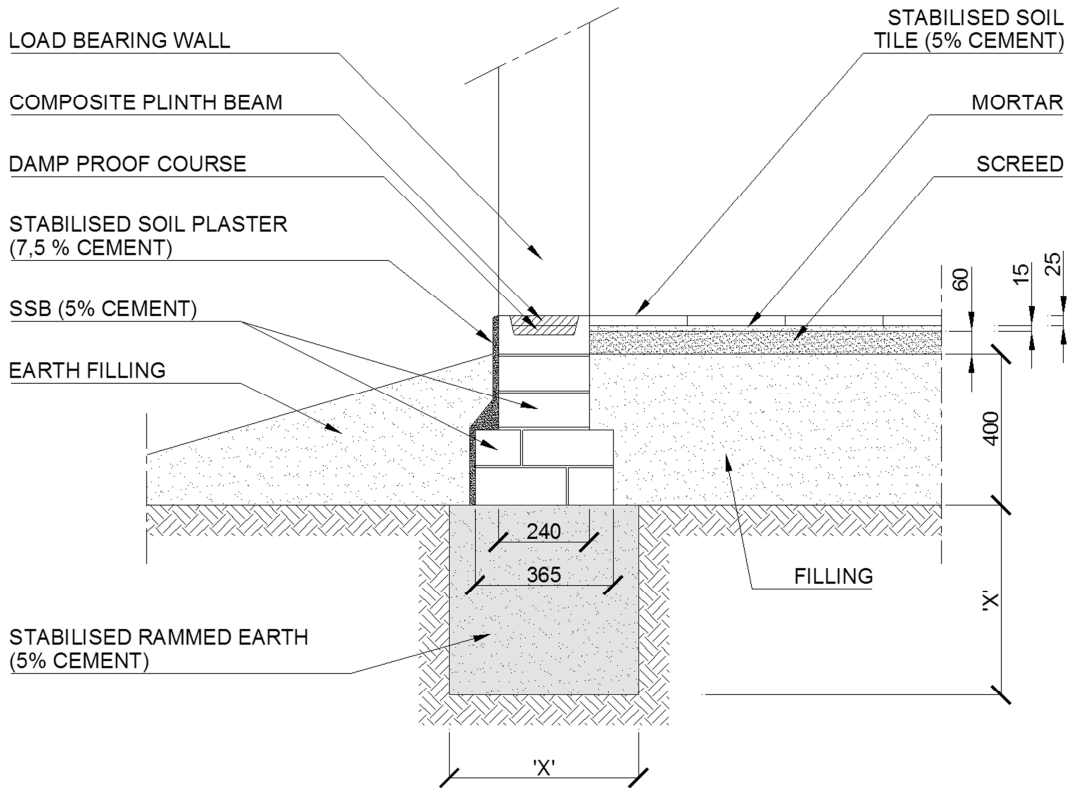

Figure 3.3 *Section demonstrating rammed earth and SSB foundation. Dimensions in mm. Distance 'X' indicates varied dimensions depending on number of storeys. Adapted from Auroville Earth Institute (2009).*

As described in an ISSB publication by UN-Habitat (2009), manual block presses only require little maintenance, and 2-4 workers can produce about 400-600 blocks in an 8 hour work day. The machine uses leverage to create a compressive force of around 80-100 N. Cement is most commonly used as stabiliser for sandy soils, and one 50 kg bag gives about 130 blocks. The soil/cement ratio varies depending on the soil properties. A sandy soil requires in average 5% cement as stabiliser, as specified by Auroville Earth Institute (2004). Typical soil proportions can be 15% gravel, 50% sand, 15% silt and 20% clay. The dry compressive strength after 28 days of curing is in the range of 2-7 MPa.

Production can be initiated by performing tests to determine the properties of the soil being used, as presented by Rigassi (1995). Sedimentation, shrinkage, laboratory or field analyses can be carried out depending on requirements. The results will determine the choice and amount of stabiliser to be added. Soil preparations such as pulverisation and screening can modify the grain size distribution and prevent lumps and undesired materials in the mix.

The dry materials (earth, sand, gravel and cement) should be thoroughly mixed before adding the water. This can be carried out manually by putting all the dry materials in a pile and then turn it over at least 2-3 times with a shovel. The water should then be added successively and carefully, e.g. through sprinkling, during further turning of the pile at least 2-3 times. Optimal moisture content can be tested by shaping a fistful of the wet mix into a ball and drop it from about one metre onto a hard surface. The

behaviour of the ball will then determine if the mix is too dry, too wet or in a suitable state. Another way of ensuring optimal moisture content is to produce blocks with different amounts of added water, and proceed with the proportion that resulted in the highest block density.

A proper amount of the finished mix is then added to the block press mould for compression. The force applied on the lever should be set with regards to the block press specifications, and the removal should be performed carefully since the blocks are still fragile. The freshly moulded blocks should be checked for weight, appearance and dimensions (see Figure 3.4). The curing environment depends on the stabiliser content. Cement or lime stabilised blocks require presence of water within the blocks during this stage for optimal strength, and high temperatures are also beneficial. These blocks should subsequently be kept sheltered from direct sun and wind, in a hot and humid environment. Stacked ISSBs can be seen in Figure 3.4.

Figure 3.4 *Left: freshly moulded ISSB ejected from block press. Source: Makiga Engineering (2010). Right: ISSBs stacked for curing/drying after moulding. Photo: author.*

Although relatively simple, the production must be carried out with great care to ensure sufficient quality, as further described by Andabati (2010). Appropriate mix proportions for the material components, thorough mixing, proper use of the block press, and then curing under optimal conditions, are all important in order to achieve strong, well-shaped and durable blocks. If the block surface holds sufficient quality, finishing work might be reduced or even unnecessary, which further reduce labour and material costs.

The dissemination of the stabilised soil block (SSB) technique in Nairobi has mostly been to middle income households, according to Esho (2013). The limited propagation among low income households might be due to unawareness. As mentioned in Section 3.3.3, an example of contemporary use of SSBs in Nairobi is public buildings constructed by the government. The technique is gaining more recognition, and will likely be more common in the future (Namayi 2013).

3.5.3 Concrete slabs

Reinforced concrete slabs are a common flooring design in multi-storey houses in Kenya. It is an expensive design, since it usually requires lots of form work, raw materials, steel and cement, machines, transports, and skilled labourers. Because of both cost and potential complexity in implementation, standard concrete designs can be unsuitable for low cost housing projects.

As stated by Mungai (2013), neither wood nor steel are generally any alternatives in construction in many regions of East Africa. This calls for better, more material efficient concrete designs. The use of concrete plate elements for flooring is becoming more established, thanks to many advantages. The general technique is based on relatively small sized concrete plate elements, manually laid on top of floor beams, and then covered by a layer of mortar or concrete.

One method uses pre-fabricated concrete units, so-called “waffles”, which are assembled on and between completed floor beams (see Figures 3.5 and 3.6), as specified by Vista Concrete Works (2013). The waffles are supported by temporary props, while the reinforcement is placed; members placed in recesses along the slab borders and a top grid. A concrete layer is then cast, covering the waffles and the reinforcement. Thus, the waffles functions as a permanent formwork, and the bottom side of the assembly becomes the ceiling on the floor below.

Figure 3.5 *Multi-storey construction using waffle slab floor design: waffles supported by beams, reinforced concrete layer on top and reinforcement members between the slabs. Photo: author.*

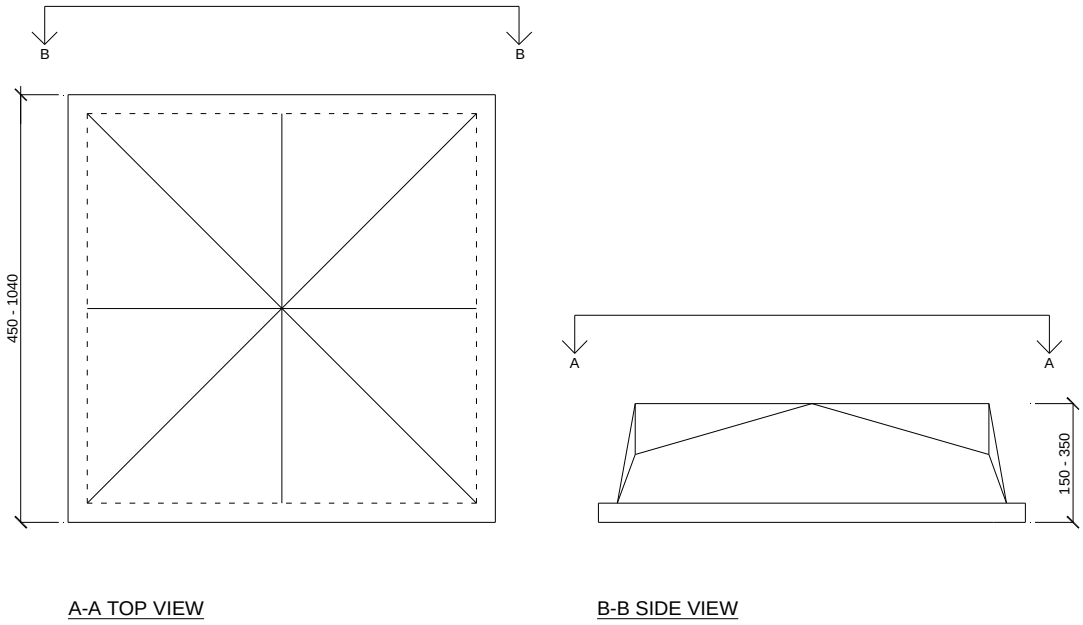

Figure 3.6 *Drawing showing general, square waffle slab design. Various forms are available, including rectangular shapes, as indicated by the dimension ranges. Adapted from Vista Concrete Works (2013).*

A similar method, developed for slum upgrading projects in India, uses so-called "landie" slabs, as described by Chege (2013). The slabs are reinforced and precast in wood frames with an attached piece of heavy linen cloth, making the concrete form a small dome by its own weight (see Figures 3.7 and 3.8).

Figure 3.7 *Multi-storey construction using landie slab floor design: landies supported by inverted T-beams. Photo: author.*

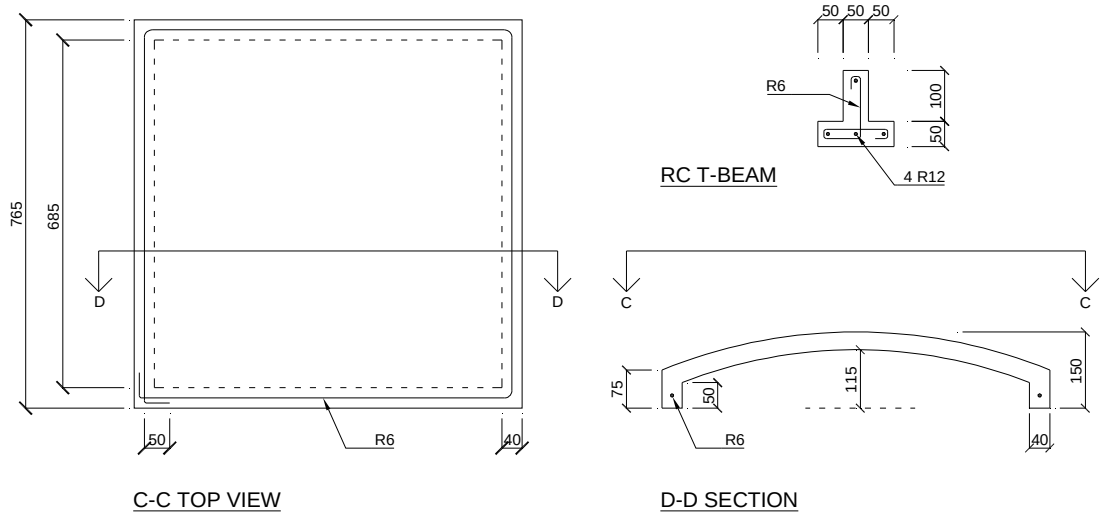

Figure 3.8 Drawing showing details for landie slab (left and bottom right) and RC T-beam (top right). Adapted from J. M. Kariuki Consultants Ltd. (2002).

The cured slabs are manually laid upon inverted reinforced concrete T-beams, and a cement screed is then added to complete the floor structure (further demonstrated in Section 4.2). This design consumes less concrete compared to a regular floor slab, and saves a lot of labour since no individual moulds are required for each floor. The implementation is also cost and labour efficient, because the beams and the slabs are put in place manually.

The main differences from the waffle design are that each landie is supported on at least two parallel sides, no reinforcement is used for the top layer, and no temporary support is required. The landie design uses the arch principle only for load distribution to the supporting T-beams, and the waffle design uses the arch principle for the waffle elements as formwork, while the permanent slab carries the loads mainly through bending of the reinforced beams formed as an integrated part of the slab between each waffle. In between the integrated beams, the slab act in combined bending and arch effect in transferring the loads to these beams. Consequently, the waffle elements acts as permanent formwork, but does not contribute to the final load carrying capacity. The waffle design allows, however, larger spans between the main support beams, since several waffles can be used between the main beams.

Both designs are well suited for small scale projects, and waffle slabs are also being used for larger buildings (Mungai 2013). Chege (2013) explains how the landies have been successfully utilised in the Kambi Moto housing project in Nairobi, for construction of 3-storey buildings (see Section 4.2). The moulds for the concrete plates and the floor beams can be assembled and used on site, creating employment and capacity building within the community, as well as offering very flexible and adaptable production.

4 Case Studies

4.1 Introduction

There are many housing projects related to slum upgrading in the Nairobi region, as described in Section 3.4.2. Some are small-scale, community initiatives carried out with support from NGOs, while others are large-scale, governmental programmes. Since each project has unique conditions, there is no optimal concept or design that can be applied in general. Aspects such as financing, physical setting and access, community participation, preferences and potential relocation, as well as project resistance and land ownership, are all determining in the planning process.

Due to the extent of the thesis, the number of case studies had to be limited. Not only time and scope were limiting factors, but also, to a large extent, access to information on potential case study projects, as described in Section 1.4. Occasionally, available data was insufficient, or even non-existing, and assistance inquiries could at times be ignored or denied. Limited follow-up opportunities were also common.

The four case studies presented in this section are just a few out of many projects that could be analysed, evaluated and compared in this context. They represent, however, various conditions that are common in slum upgrading, and, to a certain extent, different concepts chosen for house design. A brief overview of the cases is shown in Table 4.1 and the geographic locations are displayed in Figure 4.1.

Table 4.1 Case studies overview

	Kambi Moto [I]	Ngumo Mbega [II]	Nyamarutu [III]	Soweto East [IV]
Scope	middle-scale, 143 houses	small-scale, 20 houses	small-scale, 40 houses	large-scale, 912 apartments
House concept	vertical expansion	horizontal expansion	horizontal, individual	highrises with 1-3 room units
Relocation	within area	remote, permanent	within area	remote, temporary
Implemen-tation	self-help	contractor	self-help	contractor
Organisation	community & NGO	community & NGO	community & NGO	governmental
Financing	individual saving scheme	individual saving scheme	individual saving scheme	government and donors
Land tenure	collective	individual	individual	governmental
House/unit tenure	owned by tenant	owned by tenant	owned by tenant	owned/rented by tenant

Sources: [I]Chege (2013), [II]Kiptoo et al. (2013), [III]Jemutai et al. (2013), [IV]Omondi (2013)

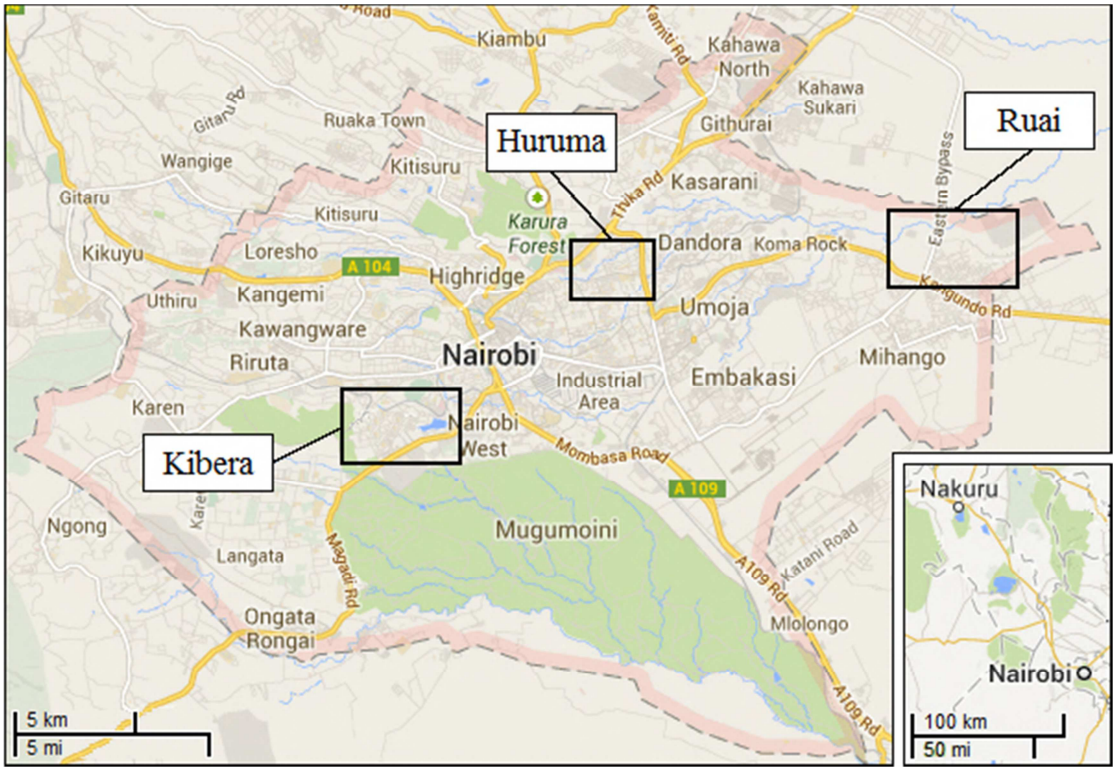

Figure 4.1 *Map displaying Nairobi with the Huruma, Kibera and Ruai areas shown. Bottom right: map displaying the location of Nakuru. Adapted from Google Maps (2014).*

4.2 Case study 1 – Kambi Moto

4.2.1 Background

Kambi Moto is one out of six informal settlements in the Huruma neighbourhood, located about five kilometres northeast from the Nairobi city centre, consisting of approximately 270 households, as stated by Chege (2013). The area suffered from several fires during the 1990s, and one particularly severe in 1999, destroying the whole neighbourhood. The inhabitants subsequently nicked the name "Kambi Moto", meaning "place of fire", and decided to organise themselves in order to improve their living situation. A brief project overview is presented in Table 4.2, and a photo displaying one of the completed units can be seen in Figure 4.2.

Table 4.2 Project overview

Kambi Moto neighbourhood
Located 5 km northeast of Nairobi CBD
Land area less than 1 ha
350 beneficiaries
143 new houses planned
Individually owned plot and house
House cost KSh 200,000-400,000
Individual savings plan for financing
Incremental, self-help construction
Implemented 2005 – ongoing
Three out of four phases completed

Source: Chege (2013)

Figure 4.2 Completed 3-storey house. Photo: author.

The NGO network Homeless International (2010) presents in an article how the Kambi Moto residents were given the opportunity to finance and build their own homes. This was carried out through collaboration between many stakeholders, including local NGOs, the Nairobi City Planning Department, Nairobi universities, and a team providing free technical support. The residents also received sectional title over their respective land plots, each the size of 20.25 m^2, significantly improving their living situation.

A local savings group, with support from the NGO Muungano wa Wanavijiji (MwW), was created in 2000, according to World Habitat Awards (2009). It made loans available for the residents to purchase building materials and hire skilled labourers. The technical team presented various house designs for the residents to choose from, and provided professional support during construction. A three storey house concept, which can be built incrementally over time, was chosen.

4.2.2 House design and construction implementation

The main condition determining the house design was the plot size, further described by Chege (2013). Each household received equally sized plots, and the buildings were dimensioned thereafter. Each unit was designed in order to be built incrementally over time, letting the households progressing at their own pace (see Figure 4.3). The first construction phase consisted of the ground floor, the first floor staircase, and a toilet on the second floor, being built for all 34 units. This made relatively fast occupancy possible for all households, letting them continue with the subsequent floors when affordable.

Each household was expected to participate with at least 80 hours of labour for the ground floor, being supported by the technical team as well as skilled labourers. The subsequent floors were then supposed to be built by the households themselves, with technical support. Finishings, like wall plaster and paint, were also decided by the households, according to preference and financial conditions.

The structural design includes so-called landie slabs (see Section 3.5.3, and Figures 4.3 and 4.4). This has facilitated manual floor construction without any machines or formwork, saved on building material costs and brought employment to the community. The landies are also used for the top floor ceiling structure, creating a roof terrace for additional space.

The excavation and foundation work for all houses were performed simultaneously. The foundation consists of an in-situ cast RC floor on hardcore filling, quarry stones and RC strips. The walls and chimney are made out of machine-cut stones laid manually with mortar, with additional RC beams at openings. Landies, T-beams and the additional beams were all prefabricated on site by the community.

4.2.3 Outcome

The first construction phase started in 2005, and by 2007, 34 houses were completed, according to Chege (2013). The second and third phase consisted of 28 and 24 units, respectively, and each took only six months to complete. As of November 2013, the fourth and final phase, including 57 units, is ongoing, with expected completion by 2014.

Each completed three-storey house cost initially about KSh 200,000, but has doubled since then due to increases in material and labour costs. E.g., the cost for one 50 kg bag of cement has increased from KSh 400 to 750, and the salary for one labourer has increased from KSh 350 to 800 per day. The cost increase has led to an extension of the loan repayment period, from two years to a maximum of eight years.

The construction project has greatly improved the community's living situation, including security of tenure, increased living space, as well as access to electricity and clean water. The successful outcome is evidence of how community organisation, saving plans, and hard work can change things for the better. Kambi Moto has functioned as a pilot project in Huruma, building capacity and showing results that have benefitted and inspired other neighbourhoods in the area, as well as other informal settlements.

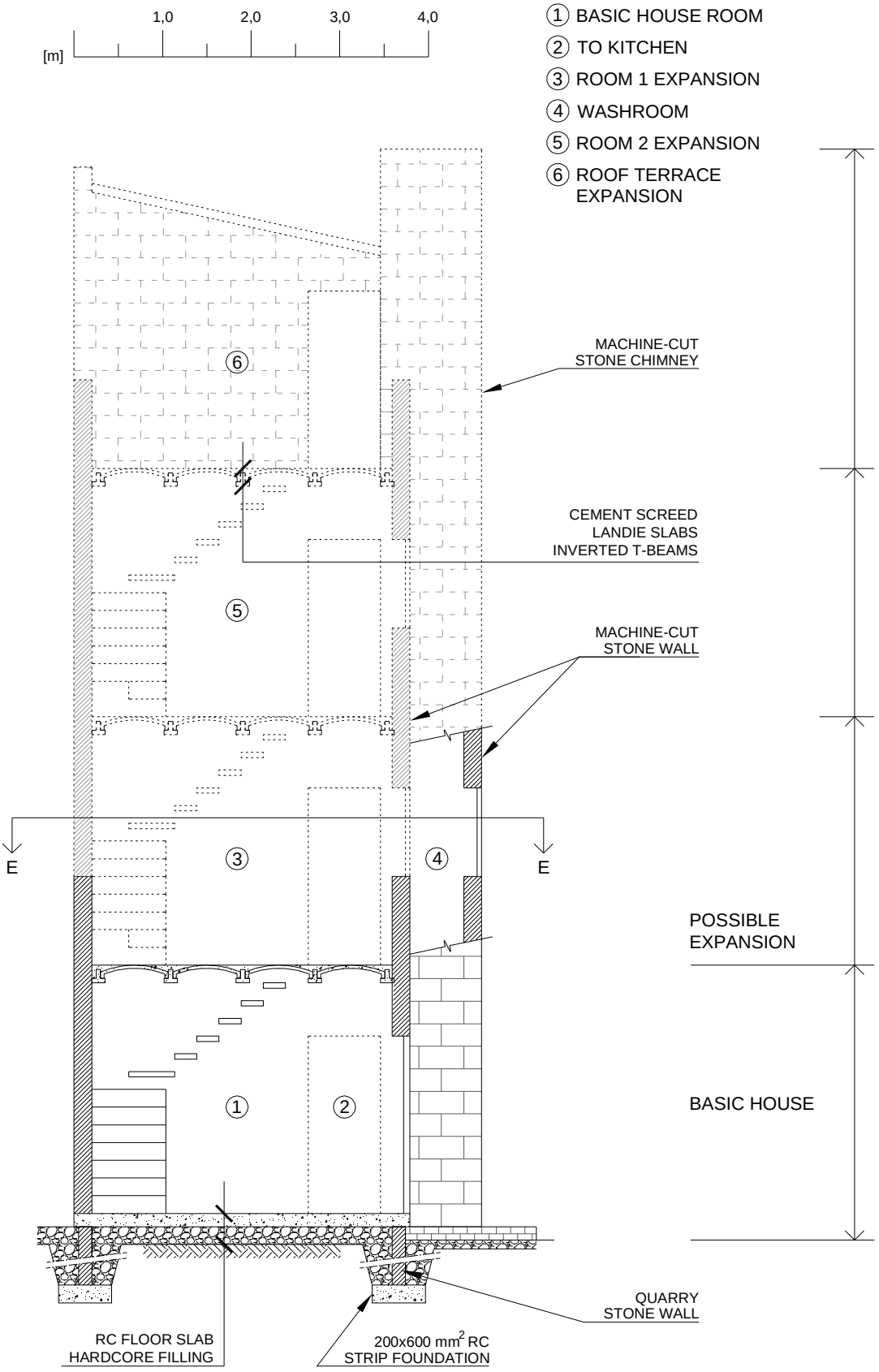

Figure 4.3 Typical section showing the 1st floor and possible extension (shaded). See Figure 4.4 for E-E floor plan. Adapted from Tecta Consultants (2008).

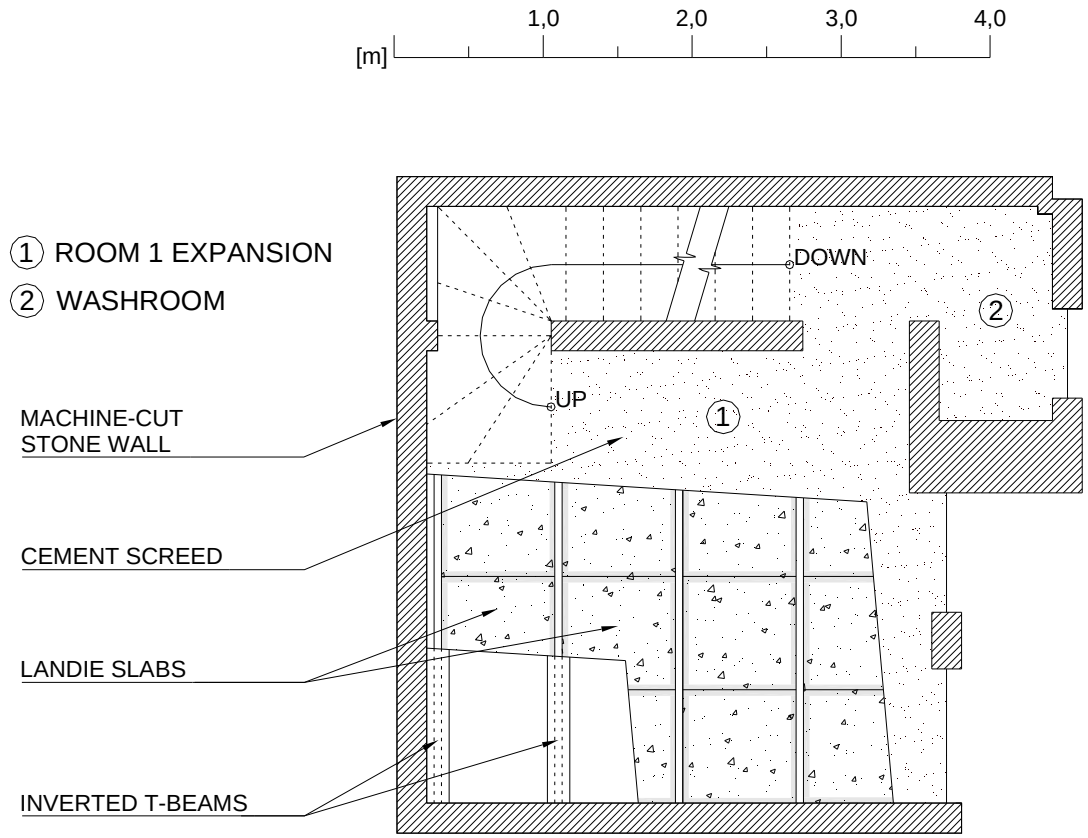

Figure 4.4 Typical second floor plan demonstrating floor structure (ref: E-E in Figure 4.3). Adapted from Tecta Consultants (2008).

4.3 Case study 2 – Ngumo Mbega

4.3.1 Background

Ngumo Mbega is a cooperative of former slum dwellers that were evicted from their homes in the Mitumba informal settlement in 2011. They had six months prior to the eviction engaged in a savings plan, and could be relocated to new houses in an area outside Nairobi. A brief project overview is presented in Table 4.3, and photos displaying a temporary structure and a permanent house, respectively, can be seen in Figure 4.5.

Table 4.3 Project overview

Ngumo Mbega cooperative
Located in eastern Nairobi
Land area 2 ha
~100 beneficiaries
20 new houses
Individually owned plot and house
House cost KSh 441,000 / 462,000
Individual savings plan for financing
Possible individual expansion
Implemented 2012
Four families have initiated expansion

Source: NACHU (2013a)

Figure 4.5 Above: temporary house Below: basic 1-room house. Source: NACHU (2013b).

The Mitumba informal settlement was located at the southeastern edge of Wilson Airport, about three km south of the Nairobi city centre. As described in a court petition published by the High Court of Kenya (2013), the former residents were relocated there in 1992 from another location nearby. They claim to have been promised the land title of the area, and applied several times for allocation, but never received a response. Nevertheless, they stayed and rebuilt their old settlement on the new land, and 19 years later, the population had grown to 15,325 individuals.

On September 15 2011, the Kenya Airports Authority (KAA) gave the residents a seven day notice to vacate the area. A representative of the community took the case to court, and an order restraining the eviction until further hearings was issued shortly. The KAA proceeded in spite of the court order, and initiated the eviction and demolition of the structures a few weeks later. As stated by Masaya (2012), the affected residents had to behold their homes being flattened by bulldozers, and then tried to gather what could be saved of their belongings. Some families returned and rebuilt their houses, hoping that the KAA would respect the court order, but another eviction occurred in January 2012. The case was eventually concluded in April 2013,

and directed the respondents to resettle and compensate all the members of the community, within 60 days, according to the court petition (2013).

Kiptoo et al. (2013) describes how 20 households from Mitumba formed a cooperative called Ngumo Mbega, because of the eviction threat, and initiated a community savings plan with support from the National Cooperative Housing Union (NACHU), a Kenyan NGO. The savings started about six months before the eviction, and the aim was to facilitate loans for the members to afford decent housing. A piece of land was acquired in Ruai, located in the eastern outskirts of Nairobi, on which temporary houses were built for the families to move into, following the eviction. Obtaining land title for their individual plots, and having sufficient savings to afford the loan mortgage, they could now proceed with building their new, permanent houses.

4.3.2 House design and construction implementation

In order to shelter the evicted families as soon as possible, the temporary houses were set up during about two weeks, Kiptoo et al. explains. The structures are very simple, consisting of a concrete floor and iron sheet walls and roof. The iron sheets have an alternative box profile design, making them relatively strong and durable, better corrosion resistant, and provide higher reflectivity of heat. The permanent houses were constructed during June-October 2012, a time period chosen to avoid rainy weather. The area consists of black cotton soil, which can be very difficult because of its shrinking/swelling properties when in contact with water.

The permanent house layout is designed for potential expansion, as shown in Figures 4.6 and 4.7. Initially, one room and a toilet were built, and then a kitchen; one, two or three rooms; as well as an additional toilet can be added to the building. The foundation and walls were constructed using manually and machine cut stones, respectively, taken from a quarry close to the site. The floor is a RC slab above murram (laterite) blinding, hardcore filling and a RC strip foundation. The box profile iron sheet material was utilised for the roof structure, supported by pine wood rafters and purlins. Each room is $16m^2$ and has a very basic interior. Both the temporary and the permanent houses have been constructed by a contractor, and all work was carried out on site.

Approval to build fully expanded four room houses was acquired for each household. 20 houses were constructed on a land area of about five acres, including roads, community areas, and other infrastructure. Each unit shares one wall with the potential adjacent unit in order to save on building material and space.

4.3.3 Outcome

The beneficiaries were initially reluctant to relocating, according to Mugwanga (2014), but have eventually adapted well to the new area. Training sessions have been held, emphasising on the importance of adequate housing, and the benefits it brings. It is a confidence building process for the members, and a more positive attitude towards the houses has been obtained. The beneficiaries are now proud of their new accommodations, and the project is considered a great achievement.

The saving scheme has been operating smoothly with prompt and sometimes even faster than planned repayments. Some of the residents have turned their temporary houses to rental units to increase their income, while others use it as additional bedrooms. Four households have initiated expansion of their houses. The cost for one additional room is approximately KSh 250,000-300,000.

Apart from some irregular rainfall, the project did not encounter any major problems. It was, however, a very experiencing event for the NACHU team as well as for the community. The importance of close collaboration and transparency between planners and beneficiaries has been apparent, and enforced accordingly, which has created trust and confidence in the collaborative work.

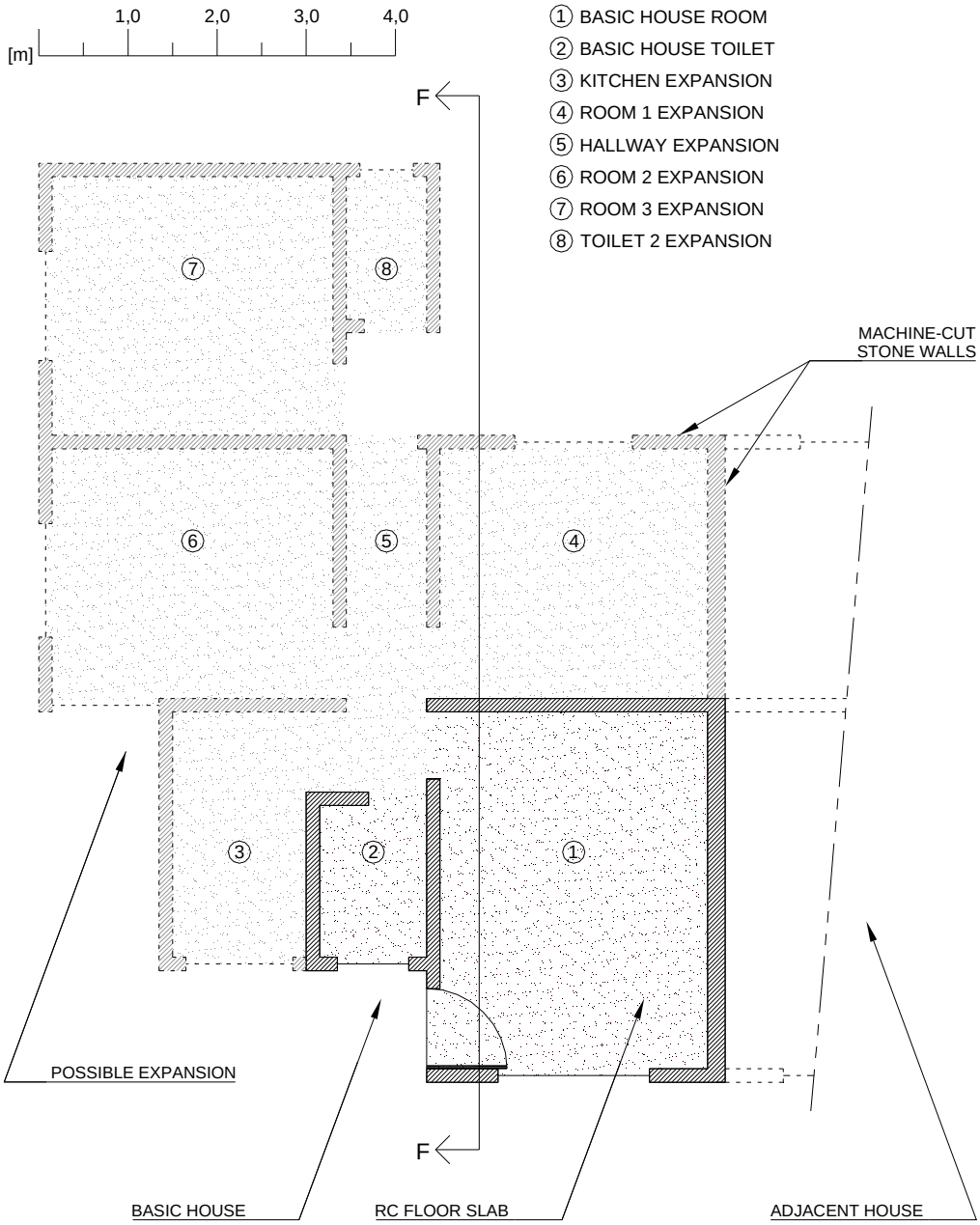

Figure 4.6 *Typical floor plan showing the initial basic house and possible extension (shaded). See Figure 4.7 for F-F section. Source: adapted from the National Cooperative Housing Union (2013a).*

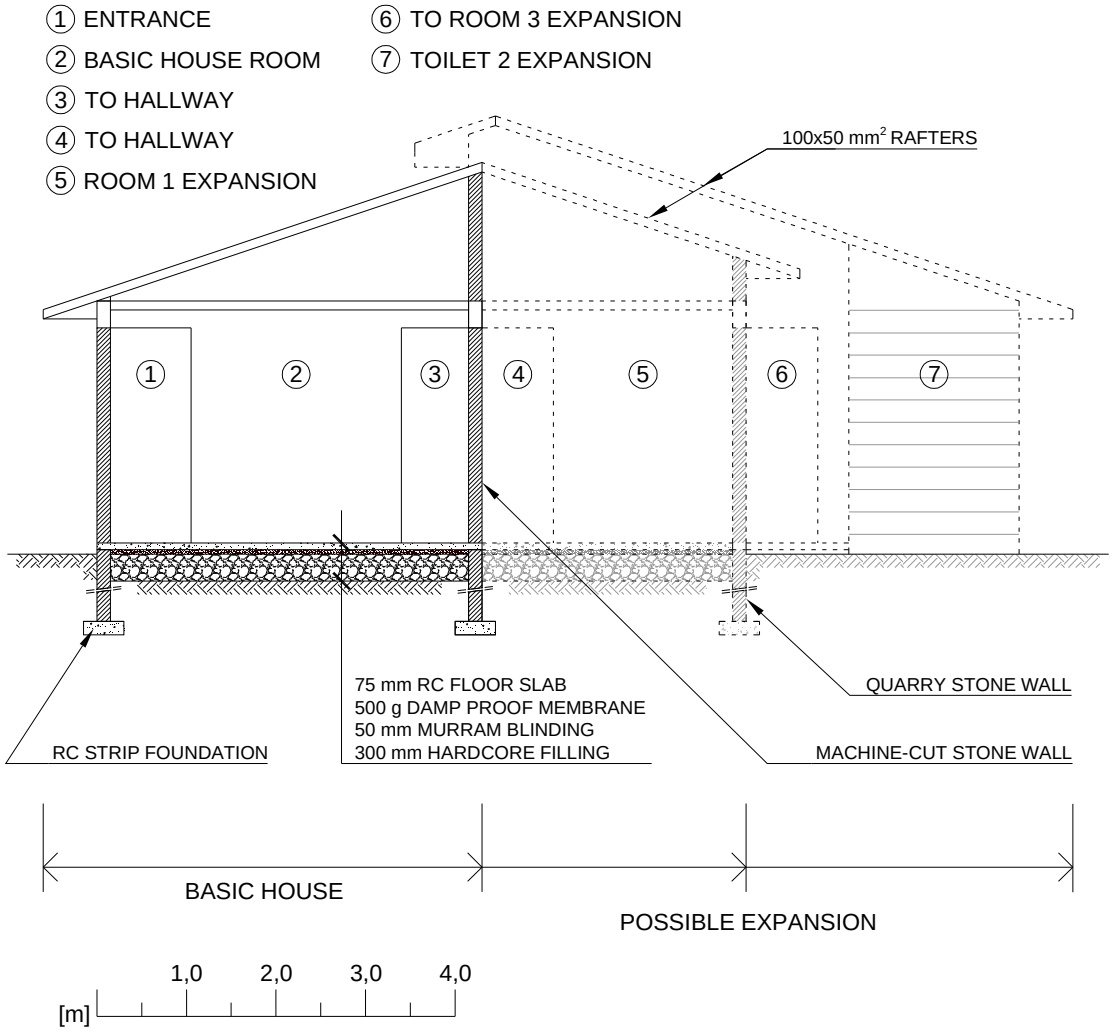

Figure 4.7 *Typical section demonstrating main load bearing structure (ref: F-F in Figure 4.6) and possible expansion (shaded). Source: adapted from the National Cooperative Housing Union (2013a).*

4.4 Case study 3 – Nyamarutu

4.4.1 Background

Nyamarutu is an informal settlement located about five kilometres east of the city centre of Nakuru, the fourth largest city in Kenya. As described by Jemutai et al (2013), the settlement has existed for 30 years, and is by November 2013 populated by approximately 200 families. People of higher income have successively encroached on the land, due to its lucrative location, forcing some households to relocate. Consequently, the land area has been reduced from 25 to 18 acres. The residents lack basic infrastructure such as proper housing, water and sanitation, and have established a neighbourhood improvement project with support from a local NGO. A brief project overview is presented in Table 4.4, and a photo displaying one of the completed houses can be seen in Figure 4.8.

Table 4.4 Project overview

Nyamarutu village
Located 5 km east of the Nakuru CBD
Land area 7,2 ha
320 beneficiaries
40 new houses planned
Individually owned plot and house
House cost around KSh 80,000
Individual savings plan for financing
Self-help construction
Implemented April 2012 – ongoing
12 out of 40 structures completed

Source: Jemutai et al. (2013)

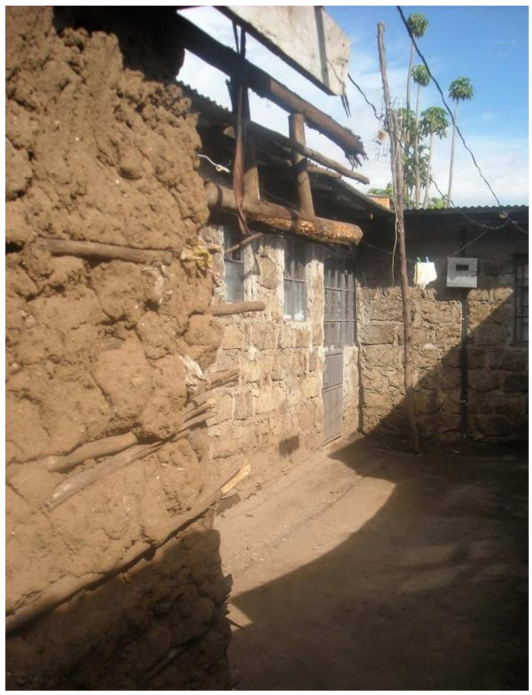

Figure 4.8 New house with old house wall façade in foreground. Photo: author.

With the aim to improve their living conditions, they organised themselves and started collaborating with the NGO Muungano wa Wanavijiji (MwW), as further explained by Jemutai et al. (2013). Dialogue with the government was initiated, and a savings plan was established in 2003, to facilitate individual families to afford new houses. The government has since allocated the land to the community, and each family obtained title to a 24x48 m^2 plot.

The families involved in the savings plan get access to a loan for financing their new houses, when they have saved 20% of the construction cost. They can then build the house, while paying off the loan successively over maximum five years. The organisation uses a rotating fund, which means that everyone has to repay their loan to facilitate subsequent borrowings. The financer is SELAVIP, a private foundation supporting improvement projects in many developing countries, while Muungano

Support Trust (MuST), the technical secretariat to MwW, provide professional assistance.

4.4.2 House design and construction implementation

Jemutai et al. (2013) explains how the community has worked on the planning process together with MwW and MuST, and that each family decides the layout of their new house. Architectural drawings are then produced, and submitted to the Municipal Council for approval. The house size depends on each family, but a regular unit has three rooms, a kitchen and a washroom, at a cost of about KSh 80,000.

The labour is carried out by the community, with support from a local artisan, and one house takes about two weeks to construct. The foundation and walls consist of quarry stones from a quarry nearby. The floors are made out of concrete, and the roofs are assembled from wooden poles and iron sheets. Ballast for the concrete is produced from the quarry stones, and locally available sand is used for the mortar.

4-5 units are being constructed at a time, in order to have casual labour available, but also to facilitate the rotating fund for the loans. When all completed, the construction of 4-5 new units can be initiated. If a family wants to build a new house, but cannot afford the quarry stone design, they can lay the foundation and build a temporary iron sheet house. They can then proceed with the quarry stone house when affordable.

4.4.3 Outcome

Jemutai et al. (2013) informs that the first construction phase was initiated in April 2012 and comprises 20 structures. 12 houses were completed by November 2013. When the remaining eight houses are finished, another 20 houses will be constructed, during the second phase. Eventually, a total of approximately 320 residents will benefit from the housing project. Another achievement is that the government has planned to support the community with infrastructure, such as roads.

The community has experienced great improvements and capacity building through the project, according to MwW (2012b). The members are aware of their capability to organise themselves, collaborate with support organisations, interact with local authorities, and impact their living situation. MwW (2012a) describes how the successful outcome in Nyamarutu is encouraging for MwW's future development projects in Nakuru. They are currently working on a large scale housing project, comprising 172 units. The planning and implementation concept developed by MwW has also received positive response from the Municipal Council of Nakuru, which plans to enforce similar projects in its work towards the goals of Kenya Vision 2030, the official Kenyan development programme.

4.5 Case study 4 – Soweto East Zone A

4.5.1 Background

Kibera is the largest informal settlement in Nairobi, and one of the largest in Africa, with a population of about 170,000 (Karanja 2010). Soweto East is a village located in the eastern part of the settlement, and has approximately 19,000 inhabitants (Calas & Fernandez 2011). As informed by Mutua (2013), the Government of Kenya chose this village as a pilot area for Kibera, as part of their national slum redevelopment initiative, KENSUP (further described in Section 3.4.1). The first planned construction phase consists of 21 six-storey blocks with a total of 912 apartments. A brief project overview is presented in Table 4.5, and a photo displaying two of the completed apartment blocks can be seen in Figure 4.9.

Table 4.5 Project overview

Soweto East – Zone A
Located 3 km southwest of Nairobi CBD
Land area 6,9 ha [I]
6,288 beneficiaries [I]
912 new apartments planned [II]
1-, 2-, and 3-room apartment blocks
Buying or renting of units, subletting [II]
Estimated KSh 1,000-3,000 rent/month *
Optional individual savings plan for households interested in buying [II]
Implemented March 2012 - ongoing [II]
Beneficiaries temporary relocated
70% complete, delayed since Dec 2012 [III]

Sources: [I]Calas & Fernandez (2011), [II]Omondi (2013), [III]Nguiti (2013), *Comparable amount based on renting fees at Langata decanting site (Calas & Fernandez 2011)

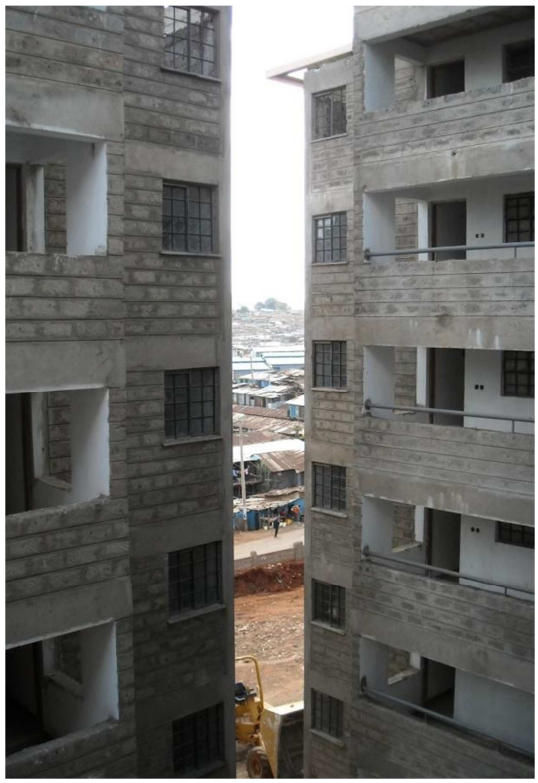

Figure 4.9 New highrises with Kibera Soweto East in background. Photo: author.

Physical mapping of the area and enumeration of the residents were carried out initially, and the village was divided into four zones, out of which Zone A was the first to be redeveloped. Because the settlement was so densely populated, an extensive temporary relocation of the inhabitants was necessary in order to facilitate site access for demolition of the existing structures, and redevelopment in the area. A new residential area, the Langata Decanting Site, was constructed for this and subsequent relocations. It is located at the southwestern border of Kibera, about 2 km from

Soweto East. The relocation started in September 2009, and 5,000 community residents have since then moved into the 600 apartments.

4.5.2 House design and construction implementation

Mutua (2013) informs that the area will consist of 1, 2 and 3-roomed apartment blocks, as well as corner shops, a community hall, a primary school and a youth centre. Each household can either buy or rent their new apartment, and the tenants may sublet one or two rooms, sharing kitchen and washrooms. Some units were initially planned for two families, with shared facilities, according to Nguiti (2013). This concept has proven to be troublesome at the Langata decanting site, and plans have been changed so that those units will be owned or rented by one family only. They can then choose if they want to sublet the other room, to people of their preference.

There will be eight 3-roomed blocks, seven 2-roomed blocks and six 1-roomed blocks, each six storeys high, and comprising 288, 336 and 288 apartments, respectively. See Figures 4.10 and 4.11 for demonstration of the 2-roomed. Each unit has a kitchen, toilet, sink and shower, and will have access to electricity. In order to accommodate all 1,200 relocated households, at least 144 apartments have to house two families.

The construction work is carried out by a private contractor. The site has been excavated by both manual labour (for the red soil) and machines (for the rock). The foundation, columns, beams and floors consist of reinforced concrete, all cast in-situ. Machine-cut stones are laid with mortar between the wall columns. The floors are cast with T-sections on top of the columns. The roof structure is made out of timber trusses with iron sheets, assembled in-situ. The work is mainly carried out manually, with machines to assist in excavation, concrete casting and lifting of material.

4.5.3 Outcome

The project has encountered several problems and received a lot of criticism, described by Calas & Fernandez (2011). Many residents are reluctant to the temporary relocation and the vertical building concept, since it has a negative impact on job activities and work places, as well as disturbing the neighbourhood unity and social networks. Many residents work as vendors, and were previously using the front of their homes as commercial space, and have lost this natural marketing place along with their customers. Mutua (2013) informs that plans have been made to build 236 market stalls along the access road, in order to compensate this loss.

Calas & Fernandez (2011) further describes that another source of criticism is the lack of community influence on the project. The residents experience the management as top-down, contrary to the KENSUP strategy, with many decisions being made without actually asking the future tenants. Access to information on the project is also considered insufficient, creating uncertainty and scepticism among the community members. The cost of buying an apartment, and the renting fees, respectively, are unaffordable for most residents, which obviously does not fulfil the beneficiary goals. This is an apparent problem at Langata, where some relocated households sublet their apartments to people with higher income, and find another place to stay in the informal settlement instead. A reason to why there are not more 1-room units

constructed is that plumbing would have been difficult to implement, according to Mutua (2013).

Another issue, which in general is very common in slum redevelopment projects, was the resistance from the structure owners in the previous informal settlement, as explained by Omondi (2013). 83 individuals, claiming to own land and structures in the area, refused to support the project without compensation, and took the matter to court in August 2009. The case was eventually resolved in December 2011, but had by then significantly delayed the project. Construction could finally be initiated in March 2012.

The implementation started in March 2012 and completion was planned for March 2014, Mutua (2013) informs. Due to disputes with a local NGO, managing informal schools in the Zone A area, the progress has been interrupted. The NGO was given notice to move and were supposed to be gone by the end of December 2012. The government has offered temporary space in Zone B for relocation of the schools, but the NGO has refused to move. They claim to own rights to the land, and the situation is probably a result of governmental corruption, likely collusion with members of the SEC. Some deem the NGO to be acting for its own benefit, rather than for the local community, because they receive funds for the school operation. If the conflict does not settle, the government has to remove the informal buildings by force.

As of October 2013, about 70% of the construction is completed, but due to the NGO dispute, the project is delayed since December 2012. When the Zone A project is completed, the relocated residents can all move in to the new buildings, and the Zone B project may be initiated.

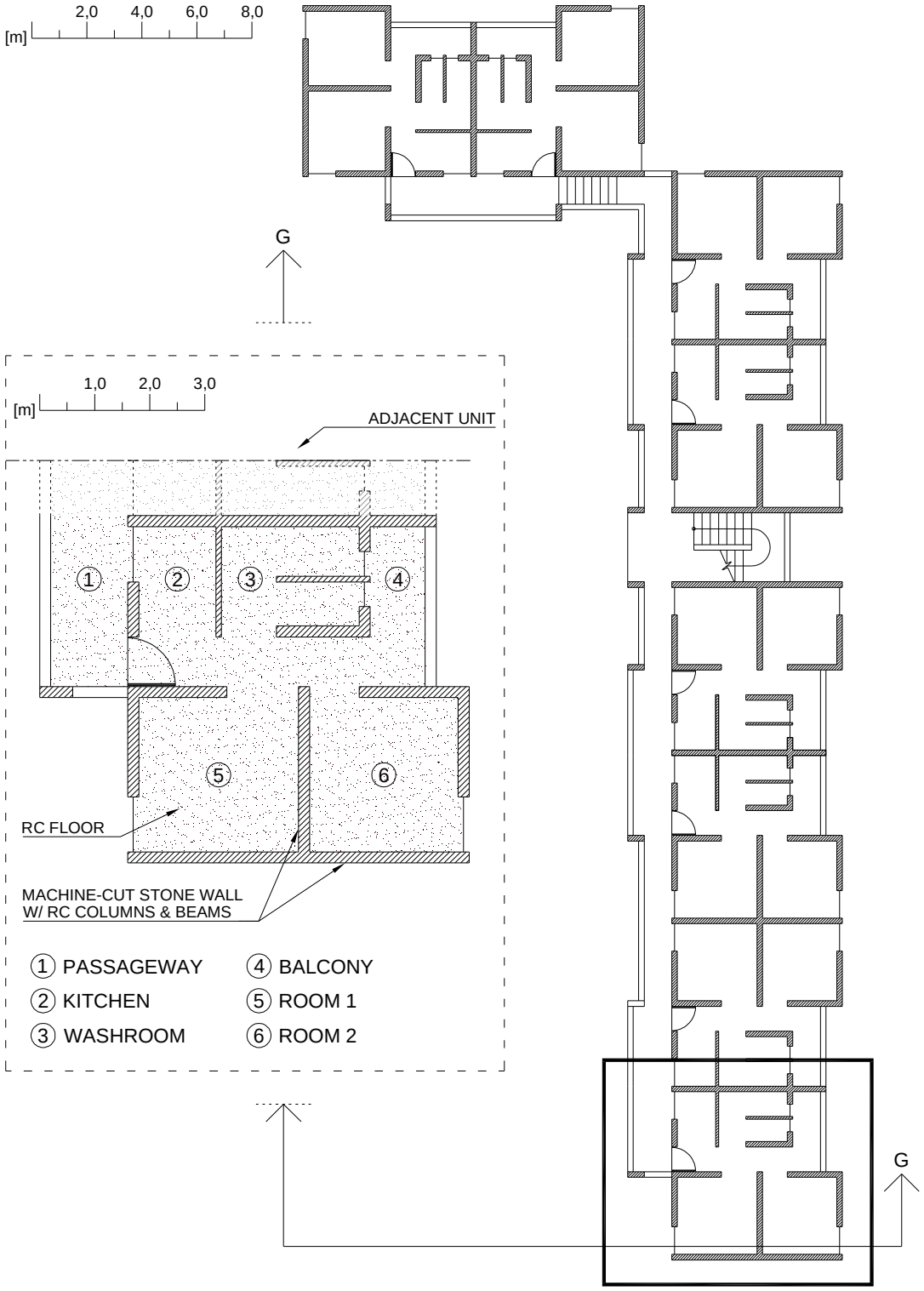

Figure 4.10 Left inset: enlargement showing main load bearing structure. Right: typical 2-room block floor plan. See Figure 4.11 for G-G section. Source: adapted from Lins Consult (2011) and Nguitu (2013).

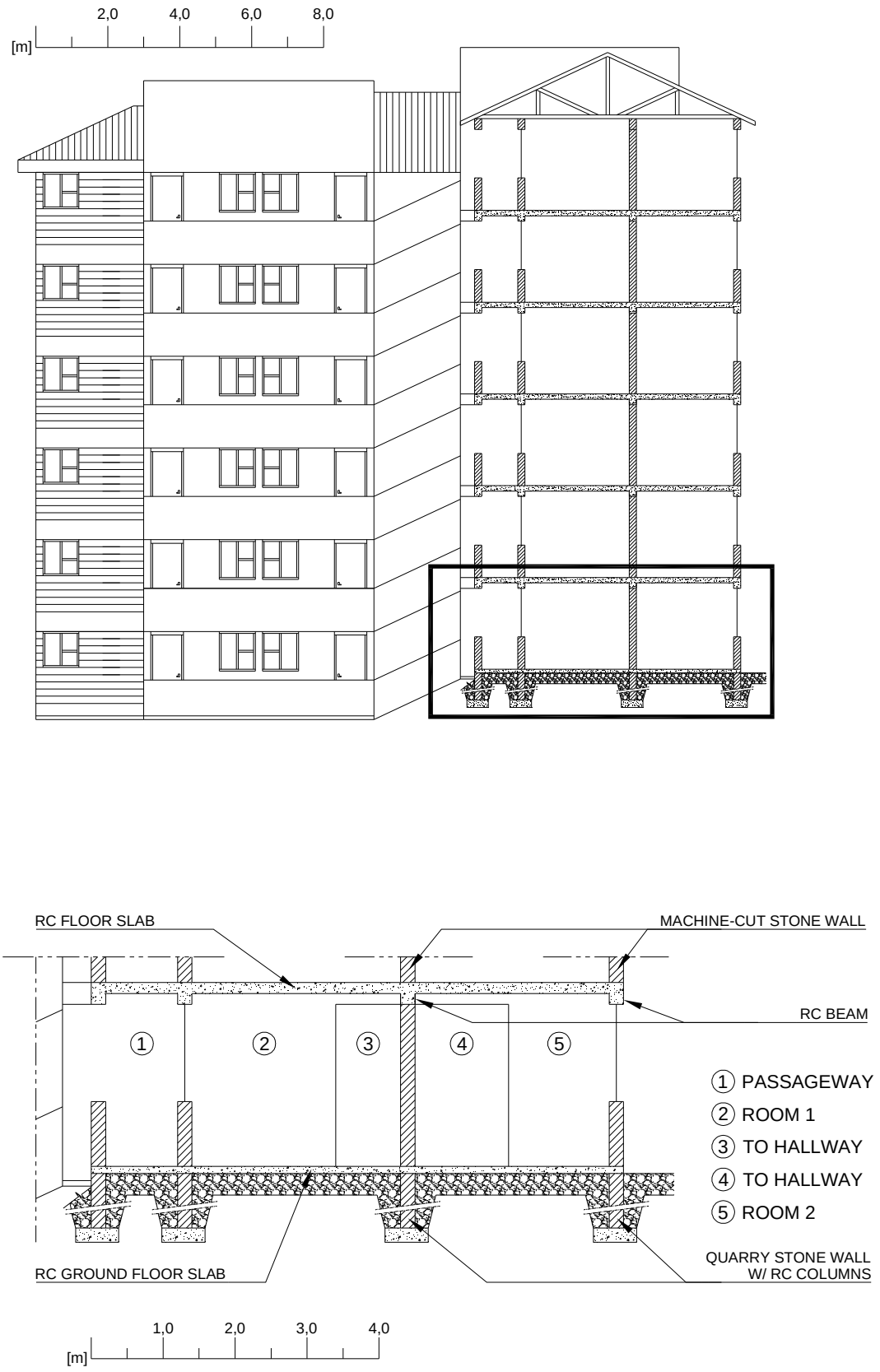

Figure 4.11 Above: typical 2-room block elevation/section. Below: enlargement showing main load bearing structure (ref: G-G in Figure 4.10). Adapted from Lins Consult (2011), Nguitu (2013) and field observations.

4.6 Comments

As mentioned in the introduction to this chapter, the information obtained on each case study was restricting the extent of the analyses. A more economic specific comparison was initially intended, but was not included due to insufficient data. It is, in any case, difficult to credibly evaluate projects with such different conditions, but certain reflections on the various approaches may still be interesting.

A rough comparison, demonstrated in Table 4.6, may, nevertheless, raise a few thoughts. The last row presents information from a housing project in the Rhonda settlement in Nakuru, called the Shikamoo self-help group. Insufficient information was obtained on that project in order to constitute a full case study, but some data is presented here for comparison purposes.

Table 4.6 Rough comparison of case studies

Project	House cost (KSh)	House size	Wall/floor material	Construction
Kambi Moto [I]	200,000 (2005) 400,000 (2013)	3 rooms 3 rooms	machine-cut stones/concrete	self-help
Ngumo Mbega [II]	441,000 (temp.) 462,000 (perm.) 200,000 (expans.)	1 room 1 room +1 room	machine-cut stones/concrete	contractor
Nyamarutu [III]	80,000	3 rooms	quarry stones/ concrete	self-help
Shikamoo [II]	200,000	3 rooms	ISSBs and quarry stones/concrete	self-help

Sources: [I]Chege (2013), [II]Kiptoo et al. (2013), [III]Jemutai et al. (2013)

Although the starting point for the Ngumo Mbega cooperative was forced eviction, and hence required immediate relocation and construction of temporary shelter, the cost for the subsequent, permanent houses indicate large cost differences in comparison with the other projects. The reasons are many, such as location, site conditions, cost increase due to inflation, implementation and house standards, but it clearly shows how much separate low cost housing projects intended for marginalised tenants may differ in total cost.

It would be interesting to know if the costs could be reduced in the Ngumo Mbega project, if it had enforced a self-help approach and maybe used different building materials. And, perhaps ISSBs could be an option in projects succeeding Kambi Moto, in order to reduce the already doubled costs, e.g. through cheaper wall material provision by on site block production, and less skilled labourers needed due to easier construction.

5 Evaluation

The following chapter evaluates different aspects in slum upgrading activities, based on the literature review and the case studies. Although three main areas of focus have been chosen to be presented in separate sections (house design, implementation and building materials), they are to a large extent interdependent. While cost usually is the determining factor in low cost housing projects, each project has unique conditions, which brings unique strategies in the overall approach. Despite many appropriate house designs, implementation methods and building materials being available, they are not always all applicable or suitable in any given housing project.

5.1 House design

As mentioned in Section 4.1, there is no optimal house design for slum upgrading projects in general. A design concept can be developed with differing decisive factors, such as affordability, simplicity or functionality, but also durability and sustainability. The economic aspect is, however, usually the most determining, and consequently setting the boundaries for other influences.

In densely populated informal settlements, with limited space for redevelopment, vertical construction might be necessary to provide accommodation for all residents, without some having to relocate permanently. Highrise concepts have, however, proven to be devastating for the social and commercial environment of its tenants, breaking neighbourhood and business networks as well as complicating conditions for income generation.

An alternative to highrise buildings is individual multi-storey houses, with one household living in each. Even a very small land plot can be sufficient to contain a horizontally limited house, with several storeys to provide decent living space. A concept that enables vertical expansion is obviously advantageous, facilitating flexibility to adapt the living space according to individual preferences and abilities. Multi-storey houses are, however, potentially more expensive and complex in implementation, since they require a storey structure and skilled labour to a larger extent. They are moreover not suitable for people with physical challenges.

Horizontal construction can be an easier alternative to multi-storey houses in areas with sufficient space. It allows more flexible layout and various opportunities for expansion. The possibility to incrementally expand on a long-term period of time enhances the feasibility of both vertical and horizontal construction concepts. Temporary structures can be an option in eviction situations, offering simple and relatively cheap shelter that can be constructed fast. This also applies in situations when households wish to build a new house, but cannot afford the planned design initially.

Considering the economic situation of most slum dwellers, it is, obviously, essential to realise their financial limitations. Long-term saving plans are not always possible for everyone, and low cost, renting options should also be available. If new apartments built for slum dwellers are subleased to people of higher income, and the beneficiaries choose to move back to the slums, then their priorities are not in line with the aims of the upgrading initiative. A different product is required.

Although accommodation providing basic conditions, such as decent living space, clean water and private washrooms, should be available to everyone, lower standard alternatives should not be completely rejected. Perhaps a very basic shelter with

communal access to water and sanitation in a safe environment can present an affordable alternative that provides sufficient living conditions, and makes the beneficiaries actually stay in the structures built for them. This is, however, an upgrading concept not included in the scope of this thesis.

5.2 Implementation

An essential approach in slum upgrading projects is to emphasise on community involvement. For a housing project to be truly successful, the opinions and engagement of the beneficiaries are obviously of great importance. The closer collaboration between community and support organisation, the better, and it should involve all project stages, from planning through construction. This is nevertheless not always attained, with several issues as potential consequence.

In addition to being a prerequisite for successful implementation, community involvement also brings extensive capacity building to its members, such as organising skills, long-term planning abilities, experience of communications with local authorities, and the knowledge of their own capability to improve their living situation. This aspect is essential in order to create sustainability within slum upgrading development, because it brings self-help qualities that reduce the need for external support.

Disregarding or insufficiently embracing community involvement in the implementation process may to a large extent impair both progress and results of a housing project. Top-down management can be very discouraging for the beneficiaries as it indicates a sense of indifference towards their opinions, and may lead up to improper decisions, lack of information, unfulfilled goals, and consequently widespread discontent with the project.

In countries with high unemployment rates and inexpensive workforce, the use of labour intensive construction methods can be advantageous in slum upgrading projects. Capital intensive methods, like employing a contractor or renting machines, are sometimes not even an option because of limited assets. A house design that partially allows unskilled labour during construction can be very cost-effective, and simultaneously brings employment and skill training opportunities to the members of the community. Moreover, the abilities acquired by the community members may subsequently entail future employment, and potential business opportunities.

5.3 Building materials

Considering the great cost reducing possibilities that alternative building material can provide, the slow dissemination and relatively limited utilisation may appear unreasonable. The main reasons described in Section 3.3.3, like the lack of political backing, make the situation more comprehensible, and show how appropriate technology can exist, even for a very long time, without actually getting recognised. It is obvious that the properties and qualities of a new technology itself are not enough for wide establishment; many other conditions are required.

Although steel and reinforced concrete might be necessary for certain structures, many relatively small houses can be built to a large extent using cheaper materials. The capacity of ISSBs can be well sufficient for load bearing walls, and a rammed earth floor might be an alternative to a concrete slab. In situations where multi-storey

houses are preferable, relatively simple and affordable concrete designs are available for storey construction, as further described in Section 5.4. Many low cost design solutions exist, and the amount of real life projects using these is increasing.

Some alternative building materials offer the possibility for local production, which may bring a more flexible supply, employment opportunities as well as lower costs. It can, similarly to house designs that allow unskilled labour, provide community members with new abilities that may be useful also after the project completion. While block presses required for ISSB-production might be unaffordable on a small scale project, if not available for rent cheaply or provided differently, other construction means, such as the moulds used for landie slabs, can be assembled at a very low cost.

Apart from the advantages that facilitate better feasibility to construction projects, the provision of certain alternative building materials may also have a smaller environmental impact. Transportations can be significantly reduced, and some raw materials might be available in abundance, avoiding depletion to a larger extent. While cement may be considered a less sustainable material, due to the energy intense production, it can in some situations present a qualified option. Especially if lean designs using relatively low cement content can be utilised.

The choice of building material may also have great influence on the construction implementation. ISSBs are compared to quarry stones easier to assemble thanks to their relative small size, and require less skilled labour and mortar work, given that the blocks hold high quality. Simplicity brings better opportunities for community involvement, with many subsequent advantages.

5.4 Multi-storey floor structures

As presented in Section 3.5.3, landie and waffle slab techniques offer an alternative to regular floor slabs for multi-storey structures. They can present comparatively lean designs, with possible savings from the reduced use of both concrete and reinforcement steel. They also facilitate an easier construction of the whole floor structure because it does not require any form work. This may save time and labour, as well as require less skilled labourers.

The use of landie slabs in the Kambi Moto housing project is great evidence of the many advantages related to the technique. The landies and T-beams were prefabricated on site by community members, in moulds assembled from low cost materials. The T-beams were put on the stone walls, and then each landie could be placed in position upon the beams. Thanks to the relatively limited sizes and weights of the components, the work could be carried out manually.

The concept of prefabricating the load bearing floor members also reduces the potential impact from weather during construction. The members are already sufficiently cured when assembled to form the floors, and won't require any special environment during and after construction. The landie slab design uses the arch principle to carry the loads to its sides and further to the beams, which eliminates the need for reinforcement in the domes and also in the floor screed. This brings the possibility to add the screed whenever most convenient, and the construction can proceed relatively fast without having to wait for any load bearing concrete members to cure.

Although both the landie and waffle slab methods can bring many advantages to construction of relatively small houses, the landie slab design might be most beneficial in terms of simplicity. The cheap and simple provision of the moulds for the landies and T-beams, the assembly that doesn't require any temporary supports, and the complete floor structure that doesn't require any additional reinforcement, are all great qualities that facilitate relatively easy implementation.

6 Discussion

This chapter aims to interpret the results of the thesis, and discuss them in terms of relevance, validity and application. It also presents the thesis in a wider context, where aspects such as similar studies, choice of methodology, work limitations and possible future research are brought to attention.

6.1 Thesis work evaluation

This report may, despite many limitations, hopefully serve as a rough overview of the current slum upgrading situation in the Nairobi region. In a field where potential bias may affect certain sources of information, it might represent an independent and objective study with critically evaluated material. The case studies may provide useful information on recent and current upgrading projects, and further emphasise on important aspects in overall planning approaches.

Considering the complexity of slum upgrading, the possibility to actually produce a report that may be useful in its research field on such a limited timeframe is questionable. The thesis scope is hence of great importance, but the magnitude of available information on the subject indicates how the overall comprehension sets the levels of relevance and validity of the research. The narrower scope, the larger comprehension of the context in which it exists might be required.

Still, a relatively narrow scope does not necessarily imply a complete overview of available research on the subject. Further delimitation may be required, which consequently affects the general validity. The intention was to include a few additional case studies in this thesis, but they had to be omitted due to insufficient obtained data. The lack of information also restrained the plans to evaluate the cases more detailed in an economic perspective.

Although intended to be objective and source critical, the use of potentially biased sources of information, such as personal interviews, obviously affects the credibility of the thesis. This has, however, been taken into account, and official sources of information have been consistently prioritised. There were, unfortunately, several occasions where reports or other documentation were unavailable or inaccessible.

6.2 Relevance to similar research

It is interesting to compare the technology dissemination situation in the early 1990s described by Syagga (1993) with the situation of today. Many then already existing issues are still prevalent nowadays, with more or less improvements achieved. The official recognition of informal settlements, and consequently also the since independence ever increasing demand for low cost housing, represents a major event in this development. It brought necessary political backing with attention to the needs of slum dwellers, and has subsequently created better conditions in many areas related to improvement activities, although much more effort is needed.

Even though stabilised soil technology possess scientific assurance, has many examples of successful application and is promoted by several organisations, lack of acceptance can still be found, and was noted during some interviews. Limited quality control, access to information and local availability are examples of reasons, but the scepticism may seem unexpected considering the many potential cost reduction

possibilities. While slowly becoming more recognised, further use and increasing proof of functionality are likely to enhance the establishment.

Community involvement in slum upgrading projects is widely considered as essential, but not always enforced. All case studies presented in this thesis represent actual examples of both scenarios, with clear consequences. Although the final results of the Soweto East project cannot be evaluated until completion, many reports indicate significant lack of community influence and inclusion as of yet, with subsequent issues. The other case studies, on the other hand, show examples of housing projects that have emphasised on broad collaboration with the respective communities, which likely represents a major part of the successful outcome.

It is, nevertheless, important to realise the limitation with evaluating only four housing projects. The extents of the compared cases are also very different, which obviously affects conditions for community involvement. It should, in any case, be sufficiently adjusted to each situation, in order to improve the possibilities to accomplish set goals.

6.3 Possible further research

In this section, possible topics for further research are presented. Some are directly related to the thesis main subject, such as follow-up to the case studies, while others are taken from a larger context.

Follow-up on KENSUP

The Kibera Soweto East project was initially planned to be completed by March 2014. The final results, including resident occupation of the apartments, their opinions on the new accommodations, compliance with set goals, potential subletting, comfort, the market stall compensation for lost business space, are all interesting to follow up on. The project's next phase, further highrises or change of approach, as well as other KENSUP activities are also possible topics.

Follow-up on KISIP

The other governmental initiative, KISIP, is a relatively short-term effort, with many possible aspects to study and follow up when completed. The main difference to KENSUP, as described in Section 3.4.1, is that KISIP aim to provide security of tenure and infrastructure, except housing, which will be up to individual communities to decide on. How this approach turns out in relation to KENSUP is an obvious topic of future evaluation.

Follow-up on Kambi Moto and Huruma

The Kambi Moto housing project is planned to be completed during 2014. Other neighbourhoods in the Huruma settlement have also been involved in the upgrading initiative, with various outcomes. Follow-up on the completion of Kambi Moto, further development in other neighbourhoods, as well as how the residents' situation has changed through the process and afterwards, could be interesting topics.

Dissemination of alternative building materials

- Further use of ISSBs in small and large-scale housing projects, also analysing the actual durability of the technique in real life structures.

- Further use of landie and waffle slabs in small and large-scale housing projects.

- Opportunities given from recycled building materials, and application in the construction of low cost houses.

Further case studies

A few housing projects that could have been relevant for the thesis were not included due to insufficient obtained material. They might be potentially interesting in further research, as well as the unspecified projects with certain properties, described below.

- *Kaputei Town*
  Large scale housing project carried out by Jamii Bora. A new town built outside Nairobi to house hundreds of households, mostly from informal settlements.

- *Mlolongo*
  Self-help housing project implemented by UN-Habitat, and another housing project carried out by the Government of Kenya.

- *Greenfield*
  Large scale housing projects carried out by Muungano wa Wanavijiji in several locations.

- *Shikamoo*
  Self-help housing project in Rhonda informal settlement in Nakuru. Supported by Muungano wa Wanavijiji and using ISSBs.

Other

- Evaluation of different projects/approaches with focus on specific costs of building materials, labour, etc.

- Housing projects with very basic conditions (e.g., one room, communal access to clean water and washrooms).

- More detailed analysis of the load bearing capacity and sizing methods of landie slabs. The possible range of application, support from regulations, and comparisons with waffle slabs and conventional concrete slabs.

7 Conclusions

This chapter presents the major findings of the thesis, separated in three areas; house design, implementation and building materials. It summarise the results evaluated and discussed in Chapter 5 and 6, respectively, and aims to provide a brief overview of the project outcome. The results are mainly confirmations of previous research, and exemplify many essential aspects to slum upgrading.

While cost usually is the determining factor in low cost housing projects, each project has unique conditions, which brings unique strategies in the overall approach. Despite many appropriate house designs, implementation methods and building materials being available, they are not always all applicable or suitable in any given housing project.

House design

There is no optimal house design for slum upgrading projects in general. A design concept can be developed with differing decisive factors, such as affordability, simplicity or functionality, but also durability and sustainability.

Highrise concepts have proven to be devastating for the social and commercial environment of its tenants, breaking neighbourhood and business networks as well as complicating conditions for income generation. Individual multi-storey houses, with one household living in each, represent a possible concept in areas with limited plot sizes. The possibility to incrementally expand on a long-term period of time enhances the feasibility of both vertical and horizontal construction concepts.

Temporary structures can be an option in eviction events and in situations when households wish to build a new house, but cannot afford the planned design initially. Most slum dwellers are not capable of purchasing a house, so other, lower standard alternatives should be considered, providing very basic shelter with communal access to water and sanitation in a safe environment.

Implementation

For a housing project to be truly successful, the opinions and engagement of the beneficiaries are essential in all project stages. Top-down management may lead up to improper decisions, lack of information, unfulfilled goals, and consequently widespread discontent with the project. Community involvement brings extensive capacity building to its members, such as organising skills, long-term planning abilities, experience of communications with local authorities, and the knowledge of their own capability to improve their living situation. This aspect is vital in order to create sustainability within slum upgrading development, because it brings self-help qualities that reduce the need for external support.

Labour intensive construction methods can be advantageous in slum upgrading projects. A house design that partially allows unskilled labour during construction can be very cost-effective, and simultaneously brings employment and skill training opportunities to the community members. Moreover, the abilities acquired by the community members may subsequently entail future employment, and potential business opportunities.

Building materials

There are alternative, low cost building materials available, but the dissemination has been very slow. Lack of political and economic backing is a main reason to this, and shows how appropriate technology can exist, even for a very long time, without actually getting recognised.

Relatively small houses can be constructed using low cost building materials. The capacity of interlocking stabilised soil blocks (ISSBs) can be well sufficient for load bearing walls, and a rammed earth floor might be an alternative to a concrete slab. Relatively simple and affordable concrete designs are available for storey construction.

Some alternative building materials offer the possibility for local production, which may bring a more flexible supply, employment opportunities as well as lower costs. It can, similarly to house designs that allow unskilled labour, provide community members with new abilities that may be useful also after the project completion.

The provision of certain alternative building materials may also have a smaller environmental impact. Transportations can be significantly reduced, and some raw materials might be available in abundance, avoiding depletion to a larger extent. Lean concrete designs using relatively low cement content can be utilised.

Simplicity brings better opportunities for community involvement, with many subsequent advantages. ISSBs are easier to lay, compared to quarry stones, and require less skilled labour and mortar work, given that the blocks hold high quality. A concrete plate design can be implemented with less cement, without formwork, and only manual labour, compared to a regular floor slab.

Multi-storey floor slabs

The landie and waffle slab techniques offer an alternative to regular floor slabs for multi-storey structures. They can present comparatively lean designs, with possible savings from the reduced use of both concrete and reinforcement steel. They also facilitate an easier construction of the whole floor structure because it does not require any form work. This may save time and labour, as well as require less skilled labourers.

The landie slab design uses the arch principle to carry the loads to its sides and further to the beams, which eliminates the need for reinforcement in the domes and also in the floor screed. This brings the possibility to add the screed whenever most convenient, and the construction can proceed relatively fast without having to wait for any load bearing concrete members to cure.

Although both the landie and waffle slab methods can bring many advantages to construction of relatively small houses, the landie slab design might be most beneficial in terms of simplicity. The cheap and simple provision of the moulds for the landies and T-beams, the assembly that doesn't require any temporary supports, and the achieved floor structure that doesn't require any additional reinforcement, are all great qualities that facilitate relatively easy implementation.

8 References

Andabati, Dan (2010), *Interlocking Stabilised Soil Block – ISSB – Construction handbook*. Good Earth Trust, Uganda.

Anderson M. & K. Mwelu (2013), *Kenyan Slum Upgrading Programs: KISIP & KENSUP*. Achieved from healthycities.berkeley.edu. Published 2013-07-18. Accessed 2013-10-01.

Augustinus C. & M. Benschop (2003), *Security of tenure – Best practices*, UN-Habitat. Achieved from www.un-habitat.org. Published 2003-06-12. Accessed 2013-02-08.

Auroville Earth Institute (2004), *Compressed Stabilised Earth Block* [www]. Achieved from www.earth-auroville.com. Published 2004-08-02. Accessed 2013-12-15.

Auroville Earth Institute (2009), *Stabilised earth foundations* [www]. Achieved from www.earth-auroville.com. Published 2009-07-20. Accessed 2013-12-15.

Calas B. & R. Flores Fernandez (2011), *The Kibera Soweto East Project in Nairobi.* (Slum upgrading programmes in Nairobi, Challenges in implementation, No. 44, pp. 129-145). Institut Français de Recherche en Afrique (IFRA), Nairobi, Kenya.

Clatworthy, Dave (2002), *Training notes for the 'beam and slab' system*. Intermediate technology development group – East Africa.

Construction Business Review (2012), *Kenya construction industry to adopt Eurocodes by 2013* [www]. Achieved from www.constructionkenya.com. Published 2012-02-25. Accessed 2013-02-18.

Google Maps (2014), Figure 4.1. Achieved from www.maps.google.com. Accessed 2014-01-29.

High Court of Kenya, The (2013), *Petition No. 164 of 2011*. Achieved from www.hakijamii.org. Published 2013-08-18. Accessed 2013-12-10.

Homeless International, *In-situ upgrading in Nairobi* [www]. Achieved from www.homeless-international.org. Published 2010-11-02. Accessed 2013-09-09.

Internationella Programkontoret (2012), *Minor Field Studies, MFS* [www]. Achieved from www.programkontoret.se/mfs. Published: unknown. Accessed 2012-09-18. Updated 2013-02-04.

Institution of Engineers of Kenya, The (2011), *IEK Engineers International Conference 2011 - Conference Papers, Proceedings and Resolutions*, Kenya.

Karanja, Muchuri (2010). Myth shattered: Kibera numbers fail to add up. *The Daily Nation.* 2010-09-03.

Masava Maxwell (2012). Mitumba slum dwellers evicted, land fenced off. *The Star*, 2012-01-09.

Makiga Engineering (2010), *The Makiga Stabilized Soil Press (SSB) Machine* [www]. Achieved from www.makiga-engineering.com. Published 2010-12-25. Accessed 2014-02-04.

Mitullah W.V. & I.N. Wachira (2003), *Informal labour in the construction industry in Kenya: A case study of Nairobi*. International Labour Office, Geneva.

Muraguri Leah (2011), *Kenyan Government Initiatives in Slum Upgrading.* (Slum upgrading programmes in Nairobi, Challenges in implementation, No. 44, pp. 119-127). Institut Français de Recherche en Afrique (IFRA), Nairobi.

Muungano wa Wanavijiji (2012a), *Muungano Launches Insitu Housing Projects in Thika and Nakuru* [www]. Achieved from www.mustkenya.or.ke. Published 2012-10-30. Accessed 2013-11-01.

Muungano wa Wanavijiji (2012b), *Land and Housing Projects* [www]. Achieved from www.mustkenya.or.ke. Published 2012-04-02. Accessed 2013-11-01.

Mwaniki D. & B. Mwau (2012), *The civil society in slum upgrading in Kenya: still civil?* [www]. Achieved from slumurbanism.wordpress.com. Published 2012-08-02. Accessed 2014-01-07.

Pamoja Trust (2009), *An Inventory of the Slums in Nairobi* [www]. Achieved from http://www.oxfamblogs.org. Published: unknown. Accessed 2013-02-16.

Rigassi, Vincent (1995), *Compressed earth blocks: Manual of production*. Deutsches Zentrum für Entwicklungtechnologioen – GATE.

Syagga M., Paul (1993), *Promoting the Use of Appropriate Building Materials in Shelter Provision in Kenya*. (Habitat Intl. Vol. 17, No. 3, pp. 125-136). Pergamon Press Ltd., Great Britain.

UN-Habitat KENSUP Team (2008), *UN-Habitat and the Kenya Slum Upgrading Programme - Strategy Document*. UNON Print Shop, United Nations Offices, Nairobi, Kenya.

UN-Habitat (2006), *State of the world's cities 2006/7* [www]. Feature document. Achieved from www.unabitat.org. Published 2006-06-17. Accessed 2014-01-03.

UN-Habitat (2009), *Interlocking Stabilised Soil Blocks – Appropriate earth technologies in Uganda*. Achieved from www.unhabitat.org. Accessed 2013-08-28.

United Nations (2000), *Goal 7: Ensure environmental sustainability.* Achieved from www.un.org. Published 2013-03-14. Accessed 2014-01-05.

UN Office of the High Commissioner for Human Rights (2007), *Forced Evictions*. Achieved from www.ohchr.org. Published 2007-09-01. Accessed 2014-01-06.

Vista Concrete Works (2013), *Waffle slab construction*. Product brochure. Matasia Town, Ngong, Kenya.

Wachira N. et al. (2008), *An investigation into informal craft skilling in the Kenyan and South African construction sectors.* (Proceedings of the 5th Post Graduate Conference on Construction Industry Development, 16-18 March 2008). Bloemfontein, South Africa.

World Habitat Awards (2009), *Technical Team Planning for Self-Help Housing in the Kambi Moto Community* [www]. Achieved from www.worldhabitatawards.org. Published 2009-08-17. Accessed 2012-11-21.

Unpublished materials

Chege, Peter, resident, housing project group supervisor and labourer in Kambi Moto. Interview 2013-11-13, Huruma, Nairobi.

J. M. Kariuki Consultants Ltd. (2002), *Kambi Moto construction details*. Achieved from J. M. Kariuki Consultants Ltd. 2013-11-15.

Jemutai I., Maiga E. & M. Mwangi, field officer, volunteer worker & federation leader at Muungano wa Wanavijiji, Nakuru, Site visit 2013-11-18, various sites, Nakuru.

Kiptoo M., Migwi D. & J Mugwanga, architect assistant, architect & quantity surveyor at The National Cooperative Housing Union (NACHU), Nairobi office. Interview 2013-11-12, NACHU office, Nairobi.

Lins Consult (2011), *Soweto East – Zone 'A' architectural drawing set.* Accessed at the Ministry of Land, Housing & Urban Development, Department of Slum Upgrading 2013-11-01, Nairobi.

Mugwanga, Joseph, quantity surveyor at The National Cooperative Housing Union (NACHU), Nairobi office. E-mail received on 2014-01-17.

Mutua, Jackson, architect at the Ministry of Land, Housing & Urban Development (MLHUD), Department of Slum Upgrading. Interview 2013-10-22, Department of Slum Upgrading, Nairobi.

National Cooperative Housing Union (NACHU) (2013a); *Floor, site plan, elevations & section*. Architectural drawing achieved from NACHU 2013-11-12.

National Cooperative Housing Union (NACHU) (2013b); *Brief on CLIFF Funded Project Ngumo Mbega*. PowerPoint presentation file achieved from NACHU 2013-11-12.

Nguitu K., Zakayo, clerk of works, Kibera Soweto East – Zone A, Ministry of Land, Housing & Urban Development. Site visit 2013-10-25, Kibera Soweto East, Nairobi.

Namayi, Adams, designer at the Kenya Building Research Centre (KBRC). Interview 2013-11-07, KBRC, Nairobi.

Omondi, Francis, secretary at the Settlement Executive Committee (SEC), Kibera Soweto East, Ministry of Land, Housing & Urban Development. Interview 2013-10-15, Chief's Office, Kibera Soweto East, Nairobi.

Tecta Consultants (2008), *Kambi Moto architectural drawing set*. Achieved from Pamoja Trust 2013-10-15.

Webosa, John, religious leader and neighbourhood spokesperson, Korogocho informal settlement. Interview 2013-10-10, private residence, Korogocho, Nairobi.