

# A hybrid approach to house construction – a case study in Botswana

## THE POSSIBILITY OF INCORPORATING APPROPRIATE CONCEPTS FROM INDUSTRIALIZED HOUSING TO TRADITIONAL HOUSE CONSTRUCTION IS DEMONSTRATED BY A CASE STUDY IN BOTSWANA

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**This paper examines the strategy of employing a hybrid combination of indigenous and modern housing construction technologies. Using a Botswana village as a case study, this paper examines four traditional house types in relation to the household income, skills, materials and aspects which could be improved by adapting industrialized methods. Using experimental houses, the case study provides the costs, benefits, potential problems and implementation considerations. The paper discusses the weaknesses and virtues of traditional construction technologies, how appropriate aspects from modern technologies can be incorporated or adapted into traditional methods and the implications for developing appropriate, affordable housing technologies.**

Dans cette communication, l'auteur s'intéresse à la combinaison hybride de techniques indigènes et modernes de construction de maisons. Il prend comme étude de cas un village du Botswana et examine quatre types de maisons classiques en termes de revenus du foyer, de compétences, de matériaux et d'aspects que l'on pourrait améliorer en faisant appel à des méthodes de construction industrialisées. L'auteur, se basant sur des maisons expérimentales, indique les coûts et les avantages, met en garde contre les problèmes possibles et prend en compte les considérations de mise en oeuvre. Il oppose les points faibles des technologies de la construction classique aux avantages, explique comment des aspects appropriés des technologies d'aujourd'hui peuvent être intégrés ou adaptés aux méthodes classiques et examine les conséquences que pourrait avoir la mise au point de technologies de construction de logements appropriées et économiques.

**Keywords:** traditional construction, industrialized construction, appropriate technology, hybrid construction, human factors, affordable housing

### Introduction

The quest for suitable housing is one of man's oldest activities which started as soon as he left the shelter of the cave for less hospitable areas {1}. Compared to most species, man inhabits an extraordinarily large portion of the earth. From the Inuit who circle the Arctic to the Bushmen who range across the Kalahari desert, man has found ingenious ways to live in climates for which his biology does not predispose him. Given the length of time over which man has provided these ingenious solutions, it would seem that

the accumulated knowledge would enable provision of adequate and even better housing for each subsequent generation. However, the reality is contrary to this assumption. A combination of natural and man-made disasters, migrations from rural to urban areas, changes in lifestyles and dwindling resources has caused housing scarcity which is today an acute universal problem.

The world community has tried several approaches to solve the housing problem, but the right solution has been elusive and, given the exponential rise in populations and dwindling national economies, it will

remain so for a long time to come {2}. This reality has prompted the United Nations to strengthen its earlier statement of 'Global strategy for shelter to the year 2000' {3} by declaring that 'housing is a basic human right', hence nations across the world are expected to observe it {4}.

To be able to house the global population, which is estimated to reach six billion by the year 2000, a combination of traditional building technologies and industrialized building construction needs to form the basis of any worthwhile strategy. To start with, the gap between traditional and modern construction technologies needs to be narrowed so as to enable universal application of high technology in housing production {5}. Ural {6} argues that application of construction management schemes to the planning process is necessary for any successful shelter provision. While this is evident in industrialized housing construction {7}, it is lacking in the majority of traditional construction technologies despite the fact that the resources which the schemes seek to optimize are dwindling.

### Traditional housing construction

All over the world, many built environment traditions have remained viable, and continue to contribute solutions to building and planning needs because they can still rely on available resources, skills or materials and because lifestyles and expectations can still be satisfied by traditional approaches. Traditional construction methods have been able to produce affordable and relevant housing solutions to people of many societies. These methods developed from their place and inhabitants, the *genious loci*, climate, geomorphologic situation, available materials, hazards, needs for comfort and protection, skills, socio-cultural values and ethnic context and the economic system. This gave rise to diversity in housing solutions depending on local conditions. It is the 'unity in diversity' of these solutions which made traditional housing sustainable.

In traditional societies, construction relied on the environmental resources of land, climate and collective local skills to create shelter forms which reflected a precise and detailed knowledge of local climatic conditions on one hand, and on the other, a reasonable understanding of the performance characteristics of the building materials available {8}. In traditional construction there was a clear understanding of how the processes of designing, building and operating affect each other, the occupants and the environment. Usually, these methods grew out of countless experiments and accidents and the experience of generations of builders who continued to use what worked and rejected what did not. They were passed on in the form of traditional, rigid and apparently arbitrary rules for selecting site, orienting the building and choosing the materials, building methods and designs {9}. As the people could not expend huge quantities of oil, coal or other sources of energy, the methods which evolved used very little energy.

Housing in traditional societies was an activity in which all members of the society participated. People participated in all stages, from planning to production and were able to integrate their values and them-

selves to reflect their cultures {10}. Since these people were the architects and the construction crews of the houses they built, they rarely ended up in something they did not like. However, traditional practice has usually been the subject of constant evolution to meet new needs, and this process is healthy. A general pattern has been changing of lifestyles where expectations are being redefined while resource availability is also changing. Migration from traditional settlements to find better opportunities in life has removed the skilled and even the unskilled labour that once met annual building or repair needs. Moreover, in many societies, rapid and sometimes radical changes have taken place in recent decades, to the extent that in the new or emerging context the traditional method no longer works as well as it did in the past, if at all.

### Industrialized housing construction

Provision of housing through industrialized construction dates back to the time Henry Ford developed the standardized production line for car manufacture. It was envisaged that housing, as any other consumer product, could be similarly produced and supplied through industrial mechanisms. Many attempts, driven by big business, have been made to transfer knowledge from mass production of automobiles and other consumer products to low-cost housing production. One of the earliest attempts included the Lustron home which was built of mass-produced steel parts shipped on one truck to the building site. All building products that were neatly stacked on the specially designed trucks were Lustron made including windows, separating walls, vanity walls, doors, ceilings, cladding, kitchen, etc. Very few items came from outside the production line. Although the company produced a house every 15 minutes, it disappeared from the scene in 1950 due to the following reasons which, according to Bender {11}, are still valid today: the company could not keep pace with demand and supply to sustain continuity; it could not organize a sound network of dealers to franchise the product; variable land, foundation and utility costs prevented the advertisement of nation-wide standardized price; banks could not cope with the company's time schedule in producing mortgages and were also reluctant to finance prefabricated houses.

Subsequent attempts were mainly driven by the economic forces from within the construction process itself which spurred the search for new methods. Contractors realized that prefabrication of standardized parts could cheapen components, reduce on-site labour requirements and speed up the construction process, and at the same time potentially provide the buyer with a higher quality product because factory tolerances were tighter than those achievable on site. The development of industrialized housing construction was thus underpinned by three main principles {12}: **standardization** – a scientific examination of component specifications which resulted in modular categories each representing a different attribute or function such as performance, structure, tolerance and installation; **prefabrication** – the production of components under factory conditions and their assembly on site, aimed to reduce costs, to

increase speed of construction processes and to improve quality; and **systems building** – adopted in the 1950s and 1960s and involved more extensive use of prefabricated components and attempts to introduce quality control, new relations with manufacturers, and use of programming methods for construction sequencing, together with new methods of documentation.

The invention of standardized, interchangeable prefabricated construction components had many similar effects on building works to those experienced in automobile production and manufacturing. Just as Ford's production system swept aside craft car producers, so industrialized construction techniques played a part in eroding craft skills (13). Ending craft practices was one of several goals of industrialized construction. Tasks were divided and subdivided, craft control was replaced by new management practices, and pace of work was often dictated by the need to maximize the use of equipment such as a tower crane (14). In spite of these changes, evidence from the 1960s suggests that systems building was rarely cheaper or much quicker than traditional construction techniques (13). In addition, lessons from 1960s industrialized high-rise housing programmes show that design, layout, choice of materials and construction resulted in products that were often socially unacceptable (15). Consumers had little if any choice in housing produced using standardized volume-production techniques available at that time. Moreover, due to the 'closed system' employed, component systems were often inappropriate for interconnection with systems produced by other manufacturers.

Current practice in industrialized housing production has witnessed a shift from 'closed systems' to more flexible and efficient production systems. The current systems as practiced mainly in Japan make products catering for wider degrees of consumer choice, which previously had been one of the major failings of the attempt at mass-manufacture of housing, especially in Europe and North America. In Japan, the industrialized housing producers have invested heavily in improving the flexibility of design to customize housing to individual consumer's choice (16). One interesting aspect is that most of the successful companies in industrialized housing construction in Japan did not evolve from traditional craft housebuilding firms; they were started by large conglomerates, which were able to invest heavily in factory facilities and R&D. These companies have R&D facilities employing several hundred scientists, technologists, ergonomists, architects and engineers. They are structured with varying degrees of vertical integration, from design and sales to materials and components fabrication assembly and erection on site (12).

### **A hybrid approach to house construction**

The preceding sections have reviewed two approaches which are currently employed to supply housing. The review showed that the systems are based on different technical concepts and cater for

different markets. As the average investment to establish an industrialized housing construction system is about US\$ 200 million (12), it is almost impossible to establish such systems in the majority of developing countries. In these countries, traditional construction methods remain the only hope. Certain aspects can, however, be adopted from industrialized housing construction to improve traditional construction. Similarly, the virtues of traditional housing construction can be adopted for incorporation into the industrialized systems where this has not been the case. This calls for a hybrid approach which, although based on the traditional construction context in the case of developing countries, recognizes and adopts appropriate concepts from the industrialized system.

The following section reports on a study of housing construction in one of the major villages in Botswana. The study identified the basic weaknesses of the traditional construction system used in the village and discusses the measures that have been adopted from industrialized systems to address them.

### **Case study**

The study was carried out in response to government plans to improve housing in the major villages of Botswana. A major village in this case is defined as a settlement whose population does not qualify it to become a town and hence enjoy the benefits of urban planning. The major village selected for this study is called Teabong and has a population of 3000 (17).

Through the assistance of the village headman, a preliminary survey conducted by walking through the streets of the village identified four different types of houses in the village

- (1) mud walls with thatched roof supported on the wall or on poles independent of the wall (Fig. 1, left);
- (2) vertical poles with mud in-fill supporting a thatched or corrugated iron sheet roof (Figs 2 and 3);
- (3) sun-dried brick wall supporting thatched/corrugated iron sheet roof (Fig. 4);
- (4) concrete brick wall supporting thatched corrugated iron sheet or clay tile roof (Fig. 1, right).



**Fig. 1. Mud wall with thatched roof (left); and concrete brick wall supporting corrugated iron sheet roof (right).**



**Fig. 2. Vertical poles before in-filling with mud.**



**Fig. 3. Vertical poles with mud in-fill showing the damage caused by rainfall.**



**Fig. 4. Sun-dried earth block wall supporting thatched roof.**

## Objectives

The objectives of the study were:

- (a) to determine the household incomes in the village;
- (b) to identify the skills related to each building type;
- (c) to identify the materials used and the problems facing each building type;

(d) to identify aspects which could be adopted from industrialized building construction to solve the problems identified.

## Methodology

Information was obtained from three of each of the four different types of houses through a semi-structured interview based on household incomes, skills used in the construction work, main materials used and the problems facing the houses. The interviews were supplemented with personal observations and information from relevant government departments.

### Household incomes

This question intended to establish the average level of income in the village. The level of income indicates the extent to which the household can invest in housing. It was established that most households in the village do not have steady income as they depend on seasonal farming, which fails frequently because of lack of rains. However, most households keep cattle, goats and sheep at nearby cattle posts. There are no manufacturing industries in this village and construction activities do not give incomes as they are mainly done on a self-help basis. It was also established from the labour office that about 450 people are employed in various government departments and service companies and their average annual income was put at US\$ 3500.

### Skills used in construction in the village

The skills used in the construction of the first three types of houses are basically traditional skills which are passed from one generation to another. One acquires such skills through participation in building activities in the village. As each member of the community is expected to participate in such activities, everyone has an idea of how to build. No theoretical background is given when learning these skills; this makes it very difficult to improve them, as departure from the norm is interpreted as failure. The aspect of lack of theoretical background becomes very important during the transfer of technology from modern construction methods because it is sometimes taken for granted that if someone knows how to build in one system, then it is easy to adjust to a different system. Often, this is not the case with traditional systems.

Skills used to construct house type (4) (Fig. 1, right) – concrete brick walls roofed with corrugated iron sheets or clay tiles – were learned through formal building training in brigades. However, it was also established that some of the builders in this category acquired their skills through apprenticeship in large construction companies in the big towns. Builders in this category are more likely to benefit from transfer of technology than those with traditional skills.

### Materials used in construction

This question intended to establish the extent to which the various available building materials in the village

are used, and, if there are any which are not used, the reasons behind not using them. Personal observations established that there are large deposits of stone in the village but none of the houses are built in stone.

The building materials mainly used in the village are poles, thatching grass, corrugated iron sheets, soil (used for in-fill mud and sun-dried bricks), cowdung, cement and sand, which is used to produce concrete bricks and mortar. Poles and grass are obtained from a place located about 10 km from the village and are becoming more and more scarce. Most people are therefore resorting to sun-dried brick wall construction. Cowdung is collected from cattle watering points, and iron sheets, door and window frames are bought from local builders merchants.

On enquiring why stone is not used for construction in spite of its abundance, it was established that there are no skills for stone construction in the village or nearby. This seemed strange because the stone deposits have been there for generations and so one would expect the skill to build using them to have naturally evolved.

### **Problems facing the houses**

It was established that the main problems facing houses type (1), (2) and (3) are to do with the vulnerability of the building materials to weather elements. The problems were summarized as cracking of the walls, absorption of moisture by the walls leading to erosion and collapse, erosion of the base of the walls leading to general instability, and termite attack on the poles and thatching grass.

Examination of some abandoned structures revealed that rainfall has the greatest impact on the structures. Since the thatching grass wears out quickly when unattended, the walls become exposed to rain-water from the top, the sides through driving rain and the base, leading to rapid deterioration. This situation calls for regular maintenance which has to be carried out at least once a year.

The main problem mentioned for house type (4) was cracking of the walls and the discomfort experienced in living inside the houses during the hot season, if they are roofed using corrugated iron sheets.

### **Aspects which can be adopted from industrialized construction**

As a measure to improve the durability of the walls, soil samples were taken from the village and tested with various types of stabilizers. It was established that the addition of 5% cement by weight to the soil produced bricks/blocks which could withstand the effect of moisture and made water-resistant rendering (18).

As a result of the survey and the experiments, the following were recommended for experimental structures, two of which have been completed.

(1) Limit the use of timber to the roof structure only and discontinue its use on walls. As use of poison to control agricultural pests is not uncommon in the village, termite poison was recommended for application to all timber prior to use.

(2) Walls to be constructed using cement-stabilized blocks produced in the same process as the sun-dried bricks but in a mould which ensures consistent

pressure. Walls to be rendered using similar ratios of cement stabilization, ensuring that the wall is cleaned of debris and then wetted for proper adhesion of the rendering.

(3) Foundation of the houses to start at least 300 mm below the natural ground level and extend at least 150 mm above it. Apparently the traditional construction puts very little emphasis on the foundation, which can be as shallow as 100 mm below ground level. It is then enlarged above ground level, but is often washed away during heavy rains because it does not have intimate connection to the structure.

(4) 'Boer thatching', which was introduced into Botswana by Boers, to be used instead of the 'traditional thatching' because it uses a stronger type of grass and is carried out by a professional thatcher, which ensures higher durability (19). Otherwise, corrugated iron sheets or clay tiles to be used for roofing. The reason for this recommendation was to prevent water from gaining access to the top of the wall.

The cost of cement used in each of the experimental houses was US\$ 150, while pressed metal door and window frames cost US\$ 100. These were purchased by the owners of the houses from a local builders merchant. It was ensured that other materials were supplied using traditional mechanisms. Each house has two rooms, and their designs were decided upon by their owners. Bricks were produced using the labour of the members of the household assisted by friends. Grass for thatching was collected from a location about 50 km from the village and cost US\$ 25 to transport to the village. The construction work was done by the owners assisted by relatives and friends. Local brew and food was given to the builders according to tradition, but costs could not be established. Each house was thatched by a professional thatcher at a cost of US\$ 90. It took 10 weeks to construct each of the houses. Monitoring of the performance of the structures and the reactions of the users is ongoing, but so far no problems have been noticed.

### **Conclusions**

Housing shortage today is acute and will remain so as the global population is rising exponentially and resources are dwindling.

Two methods of housing delivery at opposite, extreme ends of the spectrum were reviewed. Traditional housing construction systems have been providing housing for many years and are still viable because they rely on available resources. Industrialized housing construction systems started as 'closed systems' which gave no options to users but are now producing more diverse products. Given the scale of housing demand, both methods will grow, but it is important that the advantages of one system are transferred to the other and vice versa. Important aspects, such as the durability of the structures and management of resources, can be transferred from the industrialized housing system to the traditional system, while such aspects as user participation will need more emphasis in industrialized housing of the future.

The study in Botswana showed that it is possible to make traditional housing construction produce more durable structures at affordable costs. The actual amount of money spent on each experimental house was approximately US\$400. This covered the items which could not be supplied or processed by household labour. Although incomes in the village are not steady, the majority of the households can raise this amount from the sale of livestock, which is often done under such special circumstances.

The materials and building techniques used in the experimental houses are closely matched to the skills and know-how available in the village and allow the approach to be well integrated into the society.

The major departure of the hybrid approach from traditional construction is the replacement of all timber work on the walls with cement stabilized bricks. Close supervision ensured that the cement ratio of 5% of the weight of the soil was used to produce the bricks used in the construction of the experimental houses. However, when this approach is finally adopted for wider application, it will be necessary to arrange training sessions for the users to ensure that the predetermined ratio is adhered to and to provide information on proper practice in handling termite poison. The training may be complimented with the use of simple methods of determining the ratios, such as equivalent volume containers.

It is anticipated that if similar hybrid approaches are taken for all traditional housing construction systems, there are good chances that the resulting structures will receive more acceptance even where local by-laws currently prohibit their use. This will undoubtedly make some contribution in the current housing backlog.

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