TECHNOLOGIES AND DESIGNS FOR COST EFFECTIVE HOUSING

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ABSTRACT

The provision of housing that is fully serviced and affordable remains a major challenge for most developing countries. A lot of settlements still comprise of poor housing structures that are prone to damage during inclement weather, with poor or no utilities, few community facilities and poor roads.

Several third world governments have attempted to address the issue through housing policies or programmes such as provision of serviced sites and extendible units. Other measures include housing schemes such as subsidized home loans, distribution of (free-) house plans, and through promoting private sector involvement.

These attempts have not addressed the issue in full; indications are that the main problem is that all systems that have been tried are aimed at providing conventional housing units using inadequate resources – skills, equipment, materials and finance. The reality though is that most developing countries do not have adequate capital resources to construct conventional dwellings.

Clearly there is need to look for alternatives; this paper examines and suggests alternatives building techniques and designs that while still providing acceptable housing, do so at reduced costs.

Keywords: *Skills, equipment, materials, design, technology.*

Introduction

Major causes of high building costs have been identified as use of expensive materials, lack of necessary building skills and lack of guidelines in selection of appropriate building packages (designs, materials, methods, equipment). Fathy (1973) contends that the basic philosophy on housing in developing countries should be to provide people with appropriate and attractive architectural designs that make use of native materials. This apart from promoting the use of locally available skills, would provide housing that also serves "indigenous needs while being at the same time socially and aesthetically satisfying".

Lack of consolidated and ready-to-use information is also a major contributing factor; several alternative building materials are continually researched and developed – several model housing units have been put up to demonstrate new designs, materials and techniques; A lot of work has been carried out on the use of compressed earth blocks, interlocking blocks, alternative stabilisers (research on the use of admixtures and fly ash currently being undertaken by RIIC), roofing tiles, equipment (cinva ram, tile making machines) etc. To a larger extent these never pass beyond this stage, findings are normally documented but usually only to serve as references for academic and intellectual purposes.

Some of the many technologies and designs are discussed in this paper and recommendations are proposed on how to make effective use of this information.

Building technologies

This section looks at building materials, skills requirement and equipment in the context of cost effective systems.

Building materials

Building materials may be classified as traditional, conventional or adapted.

- traditional materials mainly consist of earth construction (see figure 1.)

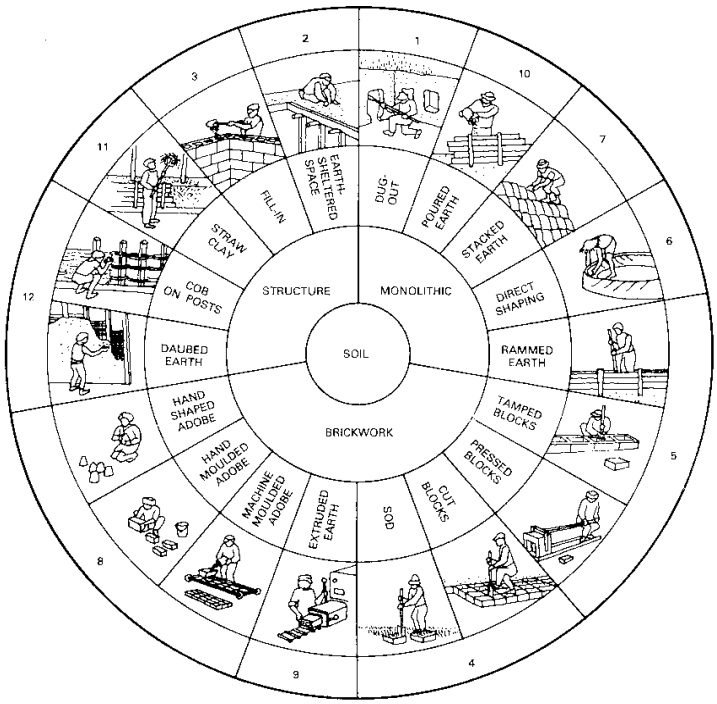

Figure 1. Earth construction methods (Earth Construction, 1994)

- conventional materials refer mainly to cement and concrete based building methods and tiled or corrugated sheets roofing.

- adapted materials : these are the several new methods comprising mainly of combinations of the other two methods. Examples include Ferro cement, fired clay bricks, timber panels, rice husk and lime stabiliser, sisal fibre reinforced roofing sheets, etc.

In a recent study carried out in the North West Province in South Africa [Housing in Southern Africa April 1999] the following were some of the findings regarding the use of upgraded construction technologies:

⇒ Although conventional methods appeared more acceptable, communities were generally willing to consider using upgraded traditional construction technologies.

⇒ Traditional construction methods were more cost-effective than conventional methods in rural areas.

⇒ The most prevalent building method use in one area known as Lekgopung is earth blocks with an earth and dung plaster and a corrugated iron roof.

This provides a strong starting point for a search for cost-effective acceptable building methods. Studies on adapted methods have shown that it is possible to provide low cost alternative building elements that are durable and sometimes of superior properties compared to conventional materials. For instance, the earth technology is not exploited to its full potential locally although it is now widely used throughout the world including the developed world; it is no longer a primitive or third world technique used mainly for artistical display (see figure 2.).

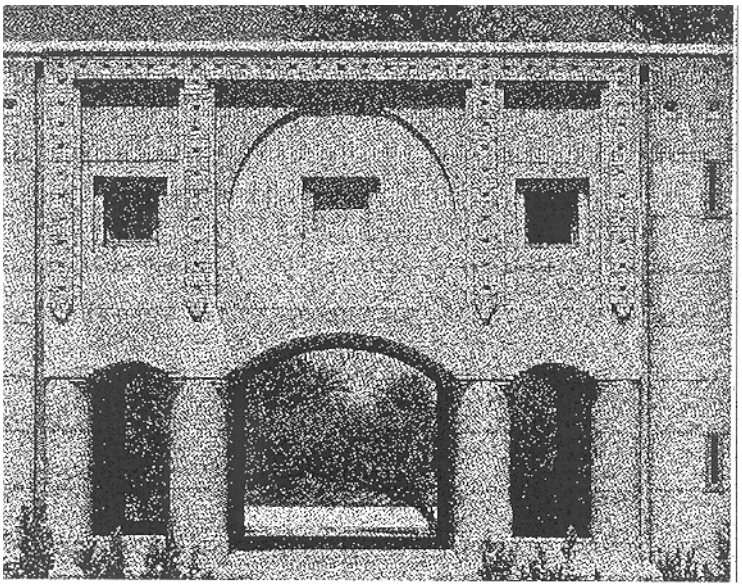

Figure 2: An earth-constructed building

This example shows that under differing conditions, it is possible to come up with several suitable building mixes that are cost-effective and acceptable. Below are some examples:

- with a good choice of a soil considerable savings may be achieved in the quantity of cement used, up to 50%, while maintaining the required strength conditions.
- lime stabilisation yields more wet compressive strength compared to cement stabilisation when the hold-back time, that is the time between mixing and moulding, is increased.
- the method of compacting (kneading, impact, vibration or static) moulded blocks influences the strength that can be achieved.
- Several other factors such as method of drying, crushing method, mixing time play a significant role in the cost of the final product for any given quality requirements.

Skills requirement

Most conventional methods require a variety of skill levels to undertake even the simplest of structures. In a recent survey of brick/block yards by [RIIC, 1999], lack of training (skills) was identified as a major weakness in the industry.

Thus any new or proposed techniques must aim at either provision of training as part of the package or must have a relatively low requirement for specialised skills. Techniques such as the use of precast concrete panels as building elements have shown a tremendous reduction in specialised skills requirements (see section 4.1).

Equipment

The choice of building equipment is very wide and reflects all the various technological trends at prices ranging from very low to the very high. In making a selection for the equipment to use the following guidelines will help to come up with a more cost-effective solution:

- The sophistication of the machinery does not necessarily reflect the quality of the work produced; in particular with presses it has been established that the quality of the basic material (e.g. soil) is more important than the level of sophistication of the equipment.

"Nowadays sophisticated hyper compression presses are available that add nothing in terms of the quality and performance of the equipment if the soil used is mediocre." (Houben & Goulliad, 1994)

- The increase in owner-builder market and the proliferation of small building contractors favours economically the setting up of small on-site production units rather than large on-site production units.

- "Turnkey" plants present enormous risks and do not appear to be any more feasible in the majority of industrial countries than they are in developing countries apart from the rare exception.

Housing designs

The preceding section looked at alternative technologies, equipment and skills for cost effective housing. This section further shows how simple designs such as precast construction, interlocking blocks and alternative roof design can achieve significant reductions in costs without compromising the quality of the product. The overall advantage of precast design is that housing delivery for repetitive units is greatly improved. Interlocking blocks result in substantial savings in mortar and the 'dry' construction method can be done by semi-skilled labourers.

Precast houses

There are several designs of precast units and they include wall panels, slab panels, columns and roofing units [FIP, 1994]. Wall panels come in different designs ranging from complete elevations of designed houses to discrete slab panels. Complete solid elevations usually have features such as doorways and window frames included but are rather costly because they are made under stringent quality control conditions. Discrete slab panels are suitable for providing cost-effective housing units.

The concept of designing houses with small slab panels is based on building the walls by stacking the panels between confining columns. The slabs are usually of a small size to allow for manual lifting. The concrete panels are made under factory conditions and hence the quality is high and they are designed to resist lateral forces. The vertical stress in single storey houses is very low but in any case vertical forces could be designed to be carried out by the columns through wall plates. The columns for use in precast design can be either in concrete or steel lipped channels. The latter is preferred because steel lipped channels are flexible compared to precast concrete columns. Additionally precast columns are bulky and cannot be extended easily on site and they would not be ideal for self build projects.

Cost Savings

A pilot project to demonstrate the cost-effectiveness of precast structures was conducted at RIIC. The structure was designed to be used as a storeroom and personnel from the Building Research Unit closely monitored construction. The structure measured 13.5 m^2 in area and Appendix A1 shows the different construction stages. The cost of this structure in terms of materials and labour was then compared with a conventional structure of the same area made using 4.5" blocks. This project proved that savings in materials by using precast panels were at least 10% and significant savings of up to 30% were realised in construction duration.

The potential for this design concept for residential housing is enormous. The skills level required for erecting walls is low and hence the system has potential spin-offs of generating employment. Skilled personnel are only needed in setting out, welding and erection of the roof.

Dry building concept

There are different types of interlocking blocks available but the underlying principle is that they do not use mortar. Most of the interlocking blocks on the market require special moulds and machines. The desired compressive strength is rather high and this means that they use high strength and costly materials such as cement. However, there are other forms of interlocking blocks such as the Hydraform type that are relatively cheap as they are made from soil. [Hydraform News, 1995]

Hydraform Blocks

These blocks are made from soil and cement in a simple machine that is run on diesel. The amount of cement required depends on the type of soil used but generally the most suitable types of soil to achieve economy are clayey sands. The moulds of the machine produce a block that has vertical interlock which allows these blocks

to be used for wall construction. The size of the blocks is 220 mm for external walls and 115 mm for internal walls and the length varies from 200 to 240 mm. Figure 3 shows typical use of the blocks for wall construction. The blocks can be used with other conventional materials for building and they are suitable for different types of buildings such as semi-detached houses, double storey or continuous units.

The advantages of this form of design and construction are:

- Greater savings are realised for materials such as cement and sand.
- Significant reduction in labour costs.
- The rate of construction is high and hence housing units can be delivered within a short period.
- Employment is generated from making the blocks through to construction of the houses.
- The thermal quality of these walls is good and they are ideal for semi-arid climates.

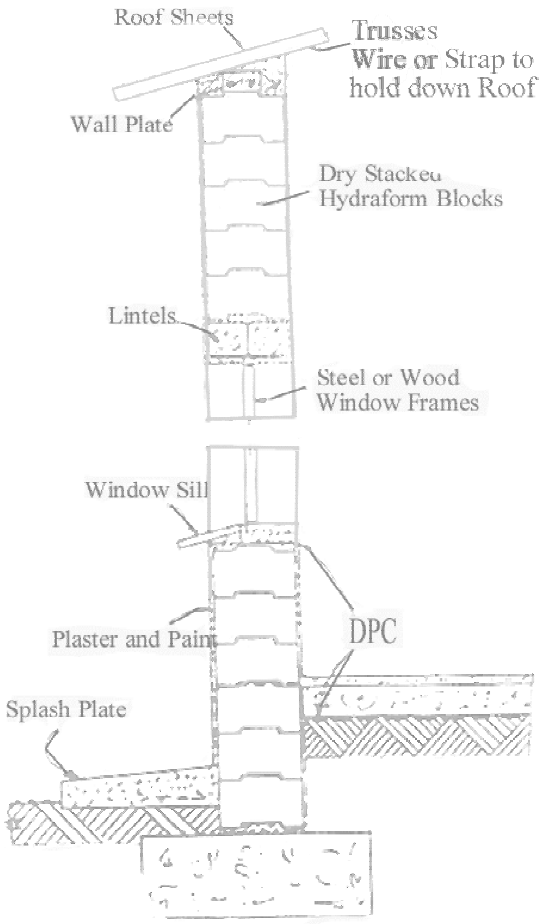

Figure 3: Hydraform Wall Detail

Conclusion

The reduction in costs for houses can be achieved through select use of appropriate materials, construction techniques and through design as well. The selection of a more cost-effective method depends more on the local conditions, available skills and equipment.

The examples given in the paper show that improving “traditional methods” by applying modern architectural techniques, developing suitable equipment and tools will open a potential avenue for low cost modern or adapted housing.

More effort should be put into development of adapted systems based on incorporation of new research findings on alternative materials and techniques into existing method.

Recommendations

The following must be noted in an attempt to provide affordable housing:

1. Developing guidelines for the cost-optimised use of different building technologies and processes such as compressed soil blocks in place of fired bricks and lime-based mortars instead of cement-based mixtures.

2. Developing a database of building design packages based on a wider range of construction technologies, materials, equipment and skills requirement.
3. Developing select packages such as technologies that require less skill could be specially developed for the owner-builder and small-scale sub-contractor sector.

4. Developing and promoting the use of small to medium scale equipment.

5. Governments should encourage the use of innovative materials by providing incentives to originators.

6. Government policy on housing to allow for and encourage the use of upgraded traditional building technologies.

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Appendices

Appendix A1

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b)

c)

d)

Figure A1: Construction stages of Precast Structure: a) Steel columns; b) Panels, doorframes etc.; c) “Wall plate”; d) Roofing