REINVENTING PROTOTYPE BUILDINGS: THE SIGNIFICANCE OF PREFABRICATION IN MASS HOUSING CONSTRUCTION

Lateef A.T. Lawal[1]
Department of Architecture, Federal University of Technology PMB 65 Minna, Nigeria

Increasingly, high quality housing remains a problem of the housing industry. Compared to the feat recorded by electronic and automotive industries, most prototype mass housing generally reveal a great deal of variability in the end products. which differs greatly from the original model. The variability is manifested in building components such as walls, floors and finishes, which compromise both quality and uniformity. Prefabrication is considered as a better approach to the production of mass housing. .A number of visits was made to mass housing construction sites in Minna, capital of Niger State, Nigeria to assess discrepancies of work in the prototype buildings. A model prefab system was highlighted and other applications of innovative methods and techniques especially at the Massachusset Institute of Technology (MIT) House_n Research Consortium on open source buildings were discussed. The approach can engender high quality construction, increase standardisation of repetive work and reduce time spent on construction.

Keywords: mass housing, prefabrication, prototype, quality.

INTRODUCTION

In an age where increasingly, it is difficult to have high-quality houses, a need thus arise to explore innovative and unconventional method of housing construction (Singh et al, 1999). There is immense housing shortage that is yet to be constructed globally. Yet, many existing mass housing stocks generally fall short of quality in their erection. According to Singh et al (1999), the world is in short supply of about 200 million dwellings. In Nigeria, the housing stock to be constructed is estimated to be about 16 million (Federal Housing Authority, 2011). Peterside (2005) notes that an average of 1 million housing units will need to be constructed annually to replenish decaying housing stock and to meet rising demand. In effect, this constitutes a gigantic task to be accomplished considering that only about 10,000 housing units are constructed on an annual basis (Adejumo, 2008). The seeming failure of delivering adequate quality housing coupled with the housing shortages requires that new housing construction for the future needs to adopt innovative method and enlightened production management that will detach from the conventional method of production of mass housing.

It is frequently observed that mass housing construction predominantly has a deluge of prototype buildings. Their designs are tailored in manners that reflect simplicity and flexibility. This is important for the simple reason of mass-producing for different owners.

[1] latiadelawal@yahoo.com

Lawal, L.A.T. (2011) Reinventing prototype buildings: The significance of prefabrication in mass housing construction *In:* Laryea, S., Leiringer, R. and Hughes, W. (Eds) *Procs West Africa Built Environment Research (WABER) Conference,* 19-21 July 2011, Accra, Ghana, 819-825.

Fig 1: Prototype buildings in Minna showing variations of building components.
Source: Author Field work, 2011

The aim thus, is to have economies of scale for mass production and save time in construction. Ironically, this is often not the case since a great deal of prototype buildings shows marked variability among the building components such as walls, columns, roofs and finishes: these do not only affect quality but also compromise uniformity among individual building prototype. (For instance, see Figure 1).

This is primarily due to lack of standardisation in the production method as compared to feat recorded in electronic and automotive industries. Incidentally, mass housing construction is still fragmented, resistant to change, labour intensive, inefficient, unresponsive, and slow to embrace new technologies of construction. According to MIT white paper on Open Source Building Alliance (OSBA), the industry is way behind other industries in the adoption of new process and technology innovations. It is thus imperative to examine how prefabrication can help to bring about efficient erection method that promotes high quality production of mass housing in Nigeria's construction industry.

OBJECTIVES

The objectives of this paper are to bring to fore the concept of prefabrication technology that is fast and cost-effective for the production of mass housing in Nigeria. This could further reduce wastages, guarantees accuracy, standardisation, and robust production.

RESEARCH METHOD

The research reported in this paper involves series of visits to mass housing construction sites in Minna, capital of Niger State, Nigeria. Primarily, on the spot physical observations were made involving random survey of the housing units. This paper focused on the elements of physical variability recorded in the housing units such as walls, floors, columns and beams variability. The paper also relies on a

literature research covering the Open Building Approach at *Massachusset Institute of Technology (MIT) House_n Research Consortium* for mass housing.

THE CONCEPT OF PREFABRICATION FOR MASS HOUSING

Prefabrication is a method employed for the manufacture of components such as panels or in modules that can be disassembled and transported to site for purposes of construction. Prefabrication's root lies in ancient Egypt as an ingenious method by which boat makers of that era attempted to standardise their craft (McQuaid, 2003). Nevertheless, experimentation by architects and engineers in prefabricated housing systems only began in the late nineteen century and gained momentum after Henry Ford's mass production of the Model T in the early twentieth century (McQuaid, 2003; Batchelor, 1994). McQuaid (2003) describe prefabrication as the manufacturing and assembly of standardised parts prior to construction; these parts are later transported and assembled at a specific site. Thus, a prefabricated construction is "a quick and clean method of construction in which components or groups of components are made under workshop conditions and transported to site for installation. (Jokiniemi and Davies, 2008).

As pointed out by Phillipson (2001), prefabrication, whether full volumetric application or based at component level, need only affect the construction process and not the end-product. The use of prefabrication offers an alternative way to procuring a building, which comes with opportunities and benefits due to change in the construction process. The benefits of using prefabrication include may thus be summarized as follows:

1. Higher quality products for clients;
2. Improved productivity and profitability for contractors;
3. Environmental benefits associated with its use.

However, the quality of construction works by the builders perhaps has not yielded much in terms of expected quality output. This explains a need for prefabrication in which standardisation plays a significant role in mass housing construction. The experience from automotive and electronics industries could be apposite because buildings are also products that people (customers) would buy, rent and expect optimum users' satisfaction

OVERVIEW OF PREFABRICATION IN MASS HOUSING IN NIGERIA

There have been a limited number of mass housing construction sites involving the application of prefabrication. Among the few ones, is the Dolphin Estate in Lagos where precast panels were employed for the construction of the dwelling units (Alade, 2010). Similarly, Olusanya (2003) proposed the first documented prefabricated housing impliedly in the form of interlocking masonry, comprising of 60-unit housing experimented in 1991 at the University of Lagos. The system features a prototype design that represents a "marriage of architecture design, materials and technology" where the product and the process was made as an integral whole.. This effort, although very minimal has developed into an urban housing prototype with public patronage in an industrial scale where a 60-unit housing estate for Home Ownership Scheme of Lagos State Government Staff Housing Board, in Alausa was constructed (Olusanya, 2003). Thus, it offers a strategic approach to housing delivery in Nigeria (Adedeji and Ajayi, 2008). Recently too, a move has been initiated by a firm known as Structuracasa International LLC.construction firm into the Nigerian housing industry

with a new building technology aimed to mass-produce housing at reduced cost and increased speed. The technology known as modular system rested on the use of prefabricated aluminum frames for mass housing. (http://www.structuracasa.com) Already, this effort has culminated in the signing of memoranda between the firm and some state governments in Nigeria.. Notably, this system of mass housing has been successfully applied in Mexico, Brazil and elsewhere.The acceptability of this innovation is gaining momentum in India and presents a different approach to modern construction especially for mass housing in Nigeria. Above all, the implementation of prefabrication in Nigeria's construction industry has been very minimal with generally few construction industries showing interest in the use of prefabrication and standardisation techniques aim at improving productivity. There is therefore a need to move towards leaner construction.

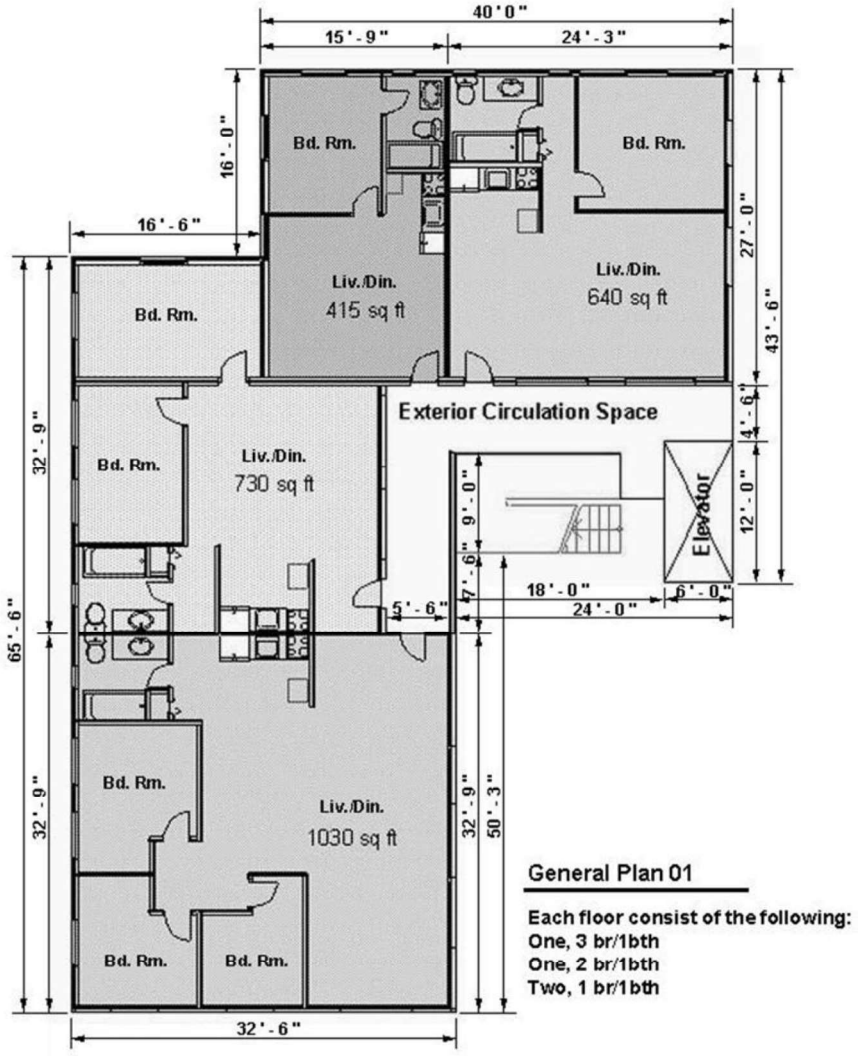
A MODEL PREFAB SYSTEM APPLIED TO CONSTRUCTION

Since the system is firstly developed to tackle much-accustomed problems of quality and standardisation in mass housing construction, therefore it should present a unique set of approaches that aim at providing lasting solution. Singh et al (1999), argued that for a mass housing to be attractive, three parameters have to be present; first is the architectural flexibility; second manufacturing flexibility and third is the erection flexibility. These are vital for an agile production. Further, architectural flexibility is essential so that each dwelling unit can be of different design to address monotony typical of mass housing.

Singh et al (1999) detailed a prefabricated modular housing, which has a fully embedded cam-nut/cam-screw for the joining of concrete components. The approach allows for easy repetition of work tasks for shell erection that can be undertaken using a single crew. The prefabricated system in question has the architectural characteristics of one and two bedroom units or modules arranged on seven storeys. The layout can be used to develop larger units as there is in-built architectural flexibility. The modules can be placed in different locations to cater for various needs. The modules are also standardized to allow for efficient manufacture (Figure 2).

Further in the model, provision of the mechanical joint such as cam-nut/cam-screw for the assembly of walls, floors and columns helps to increase the speed and quality of construction as compared to day-to-day conventional methods. This proves advantageous because there is ease of assembly of component parts that also minimises labour use. The cam-nut/cam-screw was adopted mainly because of its better performance and faster assembly benefit over other methods (Singh, 1998).

The structural characteristics of the system are an all panel system comprising of wall and floor panels, or slabs. The panel consists of 6"thick structural section, a 1.5" thick insulation section and a 2.5"thick facade section. The panels are joined with mechanical joints along the panel's vertical and horizontal edges. The mechanical joints clamp the panels together with sufficient force to allow them to work together as a monolithic element. A gasket is placed between each panel and between the panels and the floor slabs to ensure a weather tight seal.



General Plan Layout After Singh, et al, (1999)

The floor system consists of solid precast floor slabs, designed as one-way slabs. These slabs lie on top of the wall panels and are held in place by passing the cam-screw of the lower wall panel through the floor slab and into the upper wall panel.

CURRENT PREFABRICATION APLLICATIONS IN MASS HOUSING

Recent development in the housing industry suggests new future for the production of mass housing. The applications of prefabrication technology are generally yielding results, notably in the UK and in the United States of America where innovative way of delivering high quality houses has begun. Currently in the UK construction industry, prefabrication is being applied to a wide variety of forms and applications ranging from the simple prefabricated site hut, which has been a long established application, up to volumetric units that can be delivered to site to integrate into the structure of the building (Phillipson,2003). Considerably, the types of prefabrication approaches that can be used include: Volumetric systems; Partial modularization of components; and Prefabrication of elements of the construction. Modularisation or modular design has been described as vital to prefabrication. Modular design refers to

construction using standardised units or standardised dimensions. Again, modular buildings do not have to be built using prefabrication techniques, but they are usually involved (Phillipson, ibid)

Further, work by the *Massachusset Institute of Technology* MIT House_n Research Consortium known as *the open prototype initiative* that developed series of four prototypical homes also lends weight to the argument for agile production method in mass housing construction. In the work, they aim to test 'a new model for the design, fabrication, and assembly of highly responsive places of living'. The first prototype referred as 'open 1' has been completed since 2006 at the Crotched Mountain Brain Rehabilitation Center. The project successfully implemented the following:

a. Design and construction employed a library of virtual components that could be combined to form unique structures, with data flowing directly to automated prefabrication processes.
b. The floor, wall and roof systems - complete with power, data, piping, ductwork, and finishes - were prebuilt in a factory.
c. The building consisted of distinct, disentangled and accessible layers that allowed for both efficient assembly and for change over time.

The finished shell, interior fit-out, and mechanical, electrical, and plumbing systems were completed in approximately 30 days.
Dey (2006) opines that open building could be a revolutionary approach to mass housing with the house separated into layers; and each layer has its own life span that determines its need for alteration or maintenance. Importantly, houses need to be viewed as parts that come together during construction and it is only logical to have such parts changed or replaced with much ease if they required so at any stage or life of the building. Thus, this is only possible having a method that integrates enlightened production techniques that combines a tripartite of architectural flexibility, manufacturing flexibility and erection flexibility (Sngh et al, 2003). This is very key to prefabrication.

CONCLUSIONS

In an ever-changing world where everything is all about improvements over what had been done in the past, the housing industry is resistance and unresponsive to change. The introduction of prefabrication for the production of mass housing in Nigeria is however, important in bringing about high quality housing units. It would also engender standardisation and uniformity, which generally is lacking in the conventional approach. Essentially, too, there is a need for the prototype design of mass housing to incorporate architectural flexibility, which assures product variety. The concept of prototype ignores variability to a large extent and should be so for prototype construction. Above all, the Nigeria's housing industry needs to embrace prefabrication for better production agility, reduction of wastage and time saving during construction.

REFERENCES

Adedeji, Y.M.D. & Ajayi, B. (2008) "Cost-effective Composite Building Panel for Walls and Ceilings in Nigerian" 11th International In-organic Bonded Fiber Composites IIBCC Proceeding, November, 5-7 2008 Madrid- Spain. Pp 151-159

Adejumo, A.A (2008) "Some Thoughts on Affordable and Social Housing in Nigeria"

Alade, B. (2010) Paper presentation on "Affordable Mass Housing Delivery: Possibilities within Nigerian Context" 5th Nigerian Real Estate Fair; Eko Hotel Conference Hall, Victoria Island Lagos, 12th October 2010

Batchelor, R. (1994). *Henry Ford: Mass Production, Modernism and Design*

Dey, A (2006) 'Reinventing the House' *Fine HomeBuilding Houses* October/November pp 5863

Jokiniemi and Davies (2008) *Dictionary of Architecture and Building Construction*, Architectural Press, UK pp 292

McQuaid, M (2003) Shigeru *Ban* Phaidon Press Limited, London. pp 152-181

Peterside, C S, 2005. "Ameliorating Housing Deficit in Nigeria ...The Role of Primary and Secondary Mortgage Institutions and the Capital Market". Available online at www.nigeriaworld.com 20 July 2005.

Phillipson, M. (2003) "Defining the Sustainability of Prefabrication and Modular Process in Construction" *Current Practice and Potential Uses of Prefabrication* BRE Environment Division Bucknalls Lane; Garston ,Watford ,WD25 9XX http://projects.bre.co.uk/prefabrication/prefabrication.pdf

Singh, A., Barnes, R, and Yousefpour, A. "High-Turnaround and Flexibility in Design and Construction of Mass Housing" Proceeding IGLC-7 University of California, Berkeley, CA, USA. 26-28 July 1999, Pp 181-194.