Integration of Buildability Concept at Design Stage of Some Tertiary Institution Buildings in North East Nigeria

MS Soji[1], OM Oraegbune[2], CH Salihu[3] and PW Zakka[4]
[1,2,3]Department of Building, Modibbo Adama University of Technology, Yola, Nigeria
[4]Department of Building, University of Jos, Nigeria
[1]sschidama83@yahoo.com

Abstract– **The design process is considered as the most important stage in the project life cycle. Throughout this stage the level of involvement between design and construction team will affect the building quality. Therefore, this research investigates the level of integration of buildability at the design stage. The objectives specifically explored the buildability concept influencing quality of building design, identify the factors that causes buildability problem due to designers and identify the factors that influenced thedesign process. Three institutions were reviewed in North East states of Nigeria these include: Taraba State University, Jalingo, Gombe State University, Gombe and Modibbo Adama University of Technology, Yola Adamawa State. 45 structured questionnaires were issued and 30 valid ones were analysed representing a 67% response rate. The data were analysed using percentage analysis; relative importance index and spearman rank correlation coefficient. The results showed that the buildability concepts influencing the quality of building design are: ease of change of plans or scope by the owners with average relative important index of 0.291and lack of proper site investigation to avoid subsequent delay with average important index of 0.813. The research further showed that error and omissions by the design team with average relative index of 0.481 had the highest adverse effect on the integration of buildality concept. The study therefore recommends that designers should integrate buildability concept during design implementation process and also have close working relations with other project participants to produce quality building with cost effectiveness.**

Keywords– **Buildability, Design, Energy Efficient Buildings, Integration and Quality**

I. INTRODUCTION

Buildability concept should be considered from the initial preliminary design and discussed the requirement into the design by the clients. Identification of the client's needs and objectives will enable the designer to use the experienced of construction knowledge from the outset to the completion of a project. It is recommended that integrating methods of construction into the design process is providing benefits and solutions to achieve the design intent in a cost effective and timely manner (Mohammed and Abbas, 2014). It is recommended that integrating methods of construction into the design process is providing benefits and solutions to achieve the design intent in a cost effective and timely manner (Mohammed, et al. 2014).The construction industry review committee, (2001) highlighted that little emphasis has been placed on buildability in the construction industry and also pointed out that at the start of a project, emphasis on buildability of designs would lead to wider adoption of cost-saving and labour-saving technologies as well as concurrent minimization of material wastage. In fact, low productivity has been attributed to insufficient attention being paid to producing buildable design and changes in plan and financial stands of the clients (Construction Industry Development Board, 1992).

In the project management field, Integration is defined as "the sharing of information between project participants or melding of information sourced from separate systems" (O'Connor and Yan, 2004). Heising (2012) opined that personnel, technocratic and financial integrations are positively related to project success. The proper management of project stakeholders, including early identification and on-time integration, leads to increased project front-end success. In addition to the involvement of stakeholders in the planning and design stages, there is some other evidence showing how the concept of integration can lead to project success. Dodin and Elimam (2008) stated that the sequencing of equipment in the project planning stage results in various trade-offs in expenses. It generates practical schedules at the lowest costs.

In brief, equipment planning and project scheduling are inseparable. Aina and Wahab (2011) identified that the occurrence of buildability problem is increasing in proportional to the period of time. Hence, the occurrence is increasing in ascending order with period of time (the highest occurrence of buildability problem occurred at period of one year and descending from six months, three months one month and lower at one week period of time). The very high causes of buildability problem from the comparison of the result of three different parties of respondent are: Complexity of the project, faulty defective of working drawings, resistance of client to buildability programmes, budgetary limitation, non-standardization, incomplete specification, separate design and construction operation, lack of awareness of construction technology, lack of awareness of buildability concept, poor communication skill .Other causes such as no document of lesson learnt, adversarial relationship between designer and contractor, construction input is request too late to be of any value, discontinuity of key project personnel are between high cause and average causes of buildability problem. Poor buildability, if not improved at the design process can force contractors to spend time and cost to resolve problems rising from inconsiderate designs. Cost, Schedule and quality are the main indicators for project performance during the project implementation. Therefore, for projects to be good buildability concept should be integrated into the overall design. Francis, Chen, Mehrtens, Sidwell, and McGeorge, (1999) found that better buildability could contribute to early completion of projects similarly Jergeas and Put (2001) showed that buildable designs would lead to saving in project costs and costs of change orders. Wong, Lam, Chan and Wong (2006) listed the items below as factors that cause buildability problems due to design; Insufficient knowledge, experience in construction, designing without input or the involvement of contractors, projects with increasingly demanding coordination, requirements (such as sophisticated building services and building automation systems), ignorance of contractors' proposed changes, a lack of communication between the parties involved, time taken for a plan to be approved by the government and tight timeframe for designing and tendering. Wong, et al. (2006) claimed that the implementation of buildability management can lead to significance quantifiable improvements in project performance in terms of time, cost and quality.

Similarly according to Combbs (1993), the benefit of buildability on projects are varied, these includes; the clients could have their building project completed within time and budget, without additional major costs to variation, minimum disruption, efficient operation on site, aesthetically and functionally pleasant. The designers could have less design problems on site during construction as well as when commissioning since their designs will have been evaluated based on the operational requirements on site. Therefore the aim of this study is to investigate the integration of buildability concept at the design stage of buildings with the view of identifying its benefits and prospects for its use in the Nigerian Construction Industry. The Objectives specifically assessed the level of integration of buildability at the design stage, examined the factors influencing the adaptation of buildability at the design stage and highlighted the constraints and prospects of integrating buildability at the design stage.

II. RESEARCH METHODOLOGY

The survey adopted purposeful sampling technique' covering professionals working in selected institutional construction sites in North East Nigeria (Facility Department). The method of description and Spearman rank correlation coefficient range method was used for the analysis of the collected data.

The following formulas were used for the analysis of the Data collected:

A) Percentage Analysis

$$R \,/\, N \;x\; 100$$

Where, R= No. of respondents
N = Total no. of respondents.

B) Relative Important Index

$$\text{RII} = \frac{\Sigma W}{A \, x \, N} (0 \le RII \le 1)$$

Where: W – is the weight given to each factor by the respondents and ranges from 1 to 5, (where "1" is "strongly disagree" and "5" is "strongly agree");

A – is the highest weight (i.e., 5 in this case) and;

N – is the total number of respondents.

Spearman rank correlation coefficient can be calculated using the value of the Spearman rank correlation coefficient ranging from +1 (perfect correlation), to 0 (no correlation) with the aim to determine the degree of relationship or agreement between the selected case areas.

According to the following formula in (Assaf and Al-Hejji, 2006):

$$\text{Rs} = \frac{1 - 6\Sigma d2}{N\,(N2 - 1)}$$

Where:

Rs = Spearman rank correlation coefficient.

d = Difference in ranking between the contractors and the consultants

N = Number of variables

III. RESULTS AND DISCUSSION

Out of the 45 questionnaires distributed, 33 were returned. Three (3) of the returned questionnaires were poorly completed as such they were discarded. This brought the responses effectively to 30, representing a response rate of 67%.

The organization where respondents were apportion questionnaires covers mainly facility department of the various institutions selected, and out of the 30 respondents 11 (36.67%) was from the Taraba state. 12 (40%) are respondents from Modibbo Adama University of Technology, yola and 7 (23.33%) are respondents from Gombe State university. The different case areas are represented as follows:

- Case study A with a response rate of 11 (36.67%) represent Taraba State University, Jalingo
- Case study B with a response rate of 12 (40%) represent Modibbo Adamawa University of Technology Yola
- Case study C with a response rate of 7 (23.33%) represent Gombe State University.

Table 1 shows that the five (5) top concept of build ability integrated at the design stage areease of change of plans or scope by the owner ranked first with an average important index of 0.291 for all the institutions under review, followed closely by knowledge and expertise of designers with an average importance index of 0.258. Owner's financial problems ranked third with an average importance index of 0.238, Errors and omissions in design was fourth with an average importance index of 0.241 which was same with the Scope of work of designers not clearly defined with average importance index of 0.241 while Acceleration of work and Site Investigation with an average important index of 0.187 and 0.142 were ranked 14th and 15th respectively by the respondents.

Table 1: Level of integration of buildability concept in all cases

Integration of Buildability Concept at Design Stage	Important Index			Average important index	RANK
	CASE A	CASE B	CASE C		
Technology change	0.213	0.207	0.147	0.189	13
New government regulations	0.193	0.26	0.14	0.198	12
Errors and omissions in design	0.253	0.273	0.167	0.231	4
Differing site conditions	0.226	0.233	0.153	0.204	10
Designers Knowledge and expertise	0.287	0.3	0.187	0.258	2
Simplified and standardized construction details	0.24	0.233	0.147	0.207	8
Use methods and Materials that allows for ease of reconstruction, renovation or deconstruction.	0.233	0.26	0.173	0.222	7
Ease of change of plans or scope by the owner	0.293	0.327	0.253	0.291	1
Owner's financial problems	0.28	0.287	0.147	0.238	3
Co-ordination of Design information (Drawings, Specification, Documentation and Management)	0.24	0.267	0.18	0.229	6
Difficulties with designing team	0.227	0.26	0.133	0.206	9
Scope of work of designers not well defined	0.227	0.26	0.207	0.231	4
Site Investigation	0.147	0.18	0.1	0.142	15
Communication between Design team members	0.22	0.22	0.16	0.2	11
Acceleration of work	0.173	0.227	0.16	0.187	14

Table 2: Factors influencing adaptation of buildability concept at the design stage

Factors	Important Index			Average important index	RANK
	CASE A	CASE B	CASE C		
Review designs regularly to ensure that the requirements of the definitive project brief are met in (the schedules of areas, room data sheets, specifications and cost).	0.617	0.620	0.618	0.618	6
Submission of design information that can be readily understood	0.610	0.608	0.609	0.609	7
Site condition should be investigated to avoid subsequent delays	0.810	0.813	0.815	0.813	1
Check that the designs have efficient use of space	0.596	0.597	0.595	0.596	8
Check that the designs are positive environmental impact	0.436	0.434	0.436	0.435	15
Check that the designs meet security and safety regulations	0.489	0.493	0.491	0.491	12
Check that the designs are energy efficient buildings	0.812	0.810	0.813	0.812	2
Check that the designs are improvable	0.623	0.628	0.626	0.626	5
Check the material that can be easy to maintain	0.567	0.570	0.568	0.568	9
The client is satisfied on design when all the element of the design are discussed and approved	0.641	0.639	0.636	0.639	4
Developing standard checklists-completeness of information on drawings	0.553	0.555	0.553	0.554	10
Ensure designs are considered by the contractor resource	0.556	0.553	0.553	0.555	11
Check the site condition and soil test	0.687	0.687	0.689	0.688	3
Sharing the knowledge of other professionals and team work during the design stage	0.453	0.454	0.451	0.453	14
Making design decision on time	0.476	0.480	0.477	0.478	13

Table 3: Factors that causes buildability constraints

Factors	Important Index			Average important index	RANK
	CASE A	CASE B	CASE C		
Inadequate buildability review of drawing	0.286	0.300	0.736	0.441	2
Inadequate effective management response	0.226	0.238	0.533	0.332	10
Errors and omissions in design	0.292	0.327	0.823	0.481	1
Deferring site condition	0.252	0.273	0.658	0.394	5
Inadequate designer technical knowledge	0.212	0.226	0.359	0.266	12
Poor specification	0.226	0.238	0.553	0.339	9
The lessons- learned that arising from construction field are not properly documented	0.146	0.180	0.314	0.213	15
Design changes	0.239	0.267	0.658	0.388	6
Available cash	0.232	0.253	0.603	0.363	7
Designers don't have adequate time to give sufficient attention to buildability.	0.239	0.260	0.798	0.432	4
Inadequate project definition	0.226	0.238	0.533	0.332	10
Scope of work of designers not well defined	0.172	0.206	0.332	0.246	14
Poor client briefing	0.212	0.226	0.359	0.266	12
Poor communication between design team members	0.232	0.242	0.553	0.342	8
Insufficient and unrealistic constraints of project time	0.286	0.287	0.736	0.436	3

The respondents were asked to rank the factors that influence the adoption of buildability concepts during the design stage. Table 2 shows the top five factors are site conditions should be investigated to avoid subsequent delays with importance index of 0.813, check that the designs are energy efficient buildings with an importance index of 0.812, check the site condition and soil test with an importance index of 0.688, the clients is satisfied on design when all the element of the design are discussed and approved with an importance index of 0.639, and check that the designs are improvable with an importance index of 0.626 accordingly.

Table 3 shows that the five (5) top factors that causes buildability constraints and problems are as follows: errors and omissions in design ranked first with an average important index of 0.481, followed closely by Inadequate buildability review of drawing with average important index of 0.441, insufficient and unrealistic constraints of project time ranked third with an importance index of 0.436, Designers don't have adequate time to give sufficient attention to buildability ranked fourth. Deferring site condition ranked fifth with an average importance index of 0.394 while factors with less influence as responded were the scope of work of designers not well defined and the lessons - learned arising from construction field which are not properly documented with average important index of 0.246 and 0.213 were ranked 14th and 15th respectively.

IV. DISCUSSIONS OF FINDINGS

Findings of the research shows that for all the institutions under review, change in plans and scope by the owners (clients) of the buildings has the most significant effect on the adoption of buildability concept in the design stage of the buildings, similarly, the research found that owners financial problems have great influence on the integration of the buildability concept in the design stage of the buildings this justifies the findings of Construction Industry Development Board (1992), which reported that low productivity of buildings results from insufficient attention and change and/or lack of funds by the clients. Furthermore the study revealed that actors such as lack of site investigation, lack of proper checking in the case of energy efficient buildings, inability to carry out soil test and lack of proper decision making on time act against the adoption of buildability concept during the design stage of the institutions under consideration. This agrees with the findings of Wahab (2011). The research further showed that most of the problems affecting the integration of buildability concept results from errors and omissions from the side of the designers, inadequate review of drawings by the design team, insufficient and unrealistic project time and designers inability to pay attention to buildability concept during the design stage. This supports the arguments of Wong, et al. (2006) who argues that ignorance of contractors and lack of communication between parties involved in the design stage leads to low productivity of buildings. Consequently, the implications resulting from lack of integration of buildability concept at design stage of buildings have serious disadvantage to the client as it results in high cost of maintenance and renovations in the future. The benefits however is to apply the strategies outlined by Combbs (1993) and supported by Wong, et al. (2006).

V. CONCLUSION

In this research, analysis of identified buildability concept was done to measure its influence on the quality of building design. According to findings, it is concluded that: Site condition should be investigated to avoid subsequent delays. Furthermore, there is need to reduce area distribution during construction to avoid additional landscaping costs. The study also concluded that training on buildability are not provided to designer, as well as lack of effective management response from the lessons-learned arising from maintenance due to lack of buildability review for design, inadequate contractor resource, and inadequate designers' technical knowledge.

VI. RECOMMENDATIONS

This research recommended that:

i). Design firms should integrate construction knowledge and contractor's experience in the design process as an approach to improve building performance.

ii). Barriers to constructability need to be identified and strategies planned, implemented and evaluated.

iii). Design firms are encouraged to adopt the framework developed by this research and its strategies to facilitate the integration of the constructability concept in the design process.

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