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# THE EFFECTS OF BUILDING FEATURES ON BUILDABILITY OF URBAN HOUSING DEVELOPMENT

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## ABSTRACT

*The purpose of this paper is to report on the effects of building features on Buildability. A survey was conducted on construction practitioners using questionnaire, aimed at understanding the relative importance of a number of building features on Buildability of urban settlement in Nigeria. The data collected was analysis using the Relative Importance Index method. Findings from the research reveal that the most important Buildability considerations for building features is "Design simplicity". The survey findings offer a practical reference for design professionals by ranking their designs, to comprehend the degree to which various building features impact on the ease of construction.*

**Keyword(s):** Buildability, Buildings, Building features, Design, Simplicity.

## INTRODUCTION

The poor 'Buildability' in the Nigeria construction industry has inspired this study on the importance of building features on building designs, since the designers are not explicitly concerned with production, they do not carry implicit reference to how the building will be produced, thus, causing a building to be constructed inefficiently, uneconomically and below an agreed or specified quality standards from its constituent materials, components and sub-assemblies. Buildability was first defined as, "the extent to which the design of a building facilitates ease of construction, subject to the overall requirements for the completed building" (Construction Industry Review Committee, 1983). The definition pointed out that design outcomes have significant impacts on ease of construction. (Wong, Lam, Chan and De Saram, 2004, 2006) put building features succinctly as the design attributes that are manifes ted in an attempt to alleviate perceived problems or raise productivity in the construction process. The theoretical basis lies in two maxims: (a) "Practice Makes Perfect" in that standardisation resulting from repetition and prefabrication increases productivity. (b) "Simple is Beautiful" in that the learning curve of workers would be shortened when construction details are simplified. These attributes are highlighted and further explained as follow: Standardisation, Prefabrication, Simplicity, Details, Flexibility, Installation, Reliance on shop drawings or contractors' design.

Standardisation can be manifested as the repetition of grids, sizes of components and connection details (Building and Construction Authority, 2005). A sufficient number of repetitive building components enhance ease of construction (Griffith and Sidwell, 1995; Low and Abeyegoonasekera, 2001; Nima, Abdul-Kadir and Jaafar, 1999; Egan, 1998). Site personnel find it easier to acquaint themselves with the repeated working logistics (Griffith, 1984). Standard size components, e.g. columns, beams, doors and construction details, also allow saving of time and efforts because of less variation in formwork based on common dimensions. Abortive works due to setting out errors are kept to a minimum. Similarly, use of repetitive horizontal grids from floor to floor, modular layouts, and standardised storey heights would facilitate dimensional coordination on site. Factory-made pre-cast elements or prefabricated self-contained bathrooms and kitchens, reduce the amount of wet trade activities on site. Since, building elements are then made under the controlled factory environment, messy and polluting works vulnerable to adverse weather conditions are eliminated. The advantages further manifest themselves when standardisation and prefabrication are used together, thereby facilitating better management (Gibb, 2001).

To enhance Buildability, however, considerable attention should be given to design co-ordination at the very beginning if prefabrication is adopted. For example, the detailing of reinforcement incorporating lifting lugs should be thoroughly worked out to avoid costly design changes at later stages as the induced stresses during lifting can be vastly different from the permanent position of the components. Problems of transporting the pre-casting products to the site and managing the site storage capacity should be carefully planned. Irregular shapes, complex geometrical profiles, complicated installation details and multi-disciplinary designs could burden contractors with additional resources for co-ordination and site assembly. As such, building designs with simple configurations enable works to be executed in a straightforward manner and facilitate ease of construction (Griffith and Sidwell, 1995). This aspect must be balanced with the aesthetic requirements of clients and artistic aspiration of designers. Whilst, the drive for simplicity should not undermine creativity, "simplicity is a form of beauty" can be a school of thought worth exploring by designers. If complexity is necessarily required for any justifiable reason, the design process should be coordinated properly to ensure that minimum cross-referencing of construction documents is required, otherwise expensive errors are prone to occur on site. Installation details should be kept as simple where possible to reduce the learning curve effect of site tradesmen. Reasonable tolerances should be specified (Griffith, 1984; Ferguson, 1989). In particular, where possible clash in space is envisaged, blow up details should be provided to resolve the conflicts before construction begins. In the case of innovative details or combinations of materials, which are being used for the first time, it is beneficial to have mock-up models or prototypes erected to study the installation process and iron out possible problems before full scale production. To this end, computer simulation software packages can be of great help in speeding up understanding and enabling visualisation of difficult assembly tasks (Li, Ma, Shen, and Kong, 2003).

The high adaptability of building elements help save resources and increase the flexibility for change according to actual site conditions being encountered. Interchangeable components, e.g. optional left/right orientation of cabinets, sanitary ware or universal assemblies that can be fitted in positions other than the designated ones shown on drawings, should be adopted. The sequence of installation should not be dictated in design document but left for the contractor to decide on the sequence for the entire works. For example, ground floor slabs can be constructed before or after superstructure construction to allow flexibility in the timing of underground drainage works. Buildability is about enhancing the ease of construction by contractors. Therefore, it is important that contractors' resources are efficiently and safely used. In this regard, as far as possible, specified materials and fittings, plant and equipment, know-how and labour skills, should be available for sourcing in the local construction market or through local builders' merchants (Adams, 1989; Ferguson, 1989).

Materials and components should be designed for easy and safe handling. In addition, constructors should be encouraged to submit alternative details or materials compatible with original qualifications to fully utilise their expertise and plant resources. To ensure construction operations are smoothly carried out, contractors' advice should be sought at the design stage. If design and build is warranted, the call for contractors' designs or proposals should be accompanied by clear performance criteria and guidance on submission requirements to avoid loss of control on contractors and sacrificing built product quality. It must be remembered that contractors cannot improve on designs which are badly conceived from the start. Worst still if the motivation for contractor's design arises from the consultants' lack of expertise or shedding of responsibility.

Apart from building features, other design components are also considered, These components include site-specific factors, various construction systems adopted for different parts of a building, i.e. structural frames, slabs, envelopes, roofs and internal walls. Likewise, the impacts on Buildability of various finishing systems, and building services systems which often forms a substantial proportion of total project cost and complicates construction coordination should be factored in (Lam, 2007).

The purpose of this paper, therefore, is to report on the effects of building sites features on Buildability in the Nigeria urban settlement development. In achieving this aim therefore the following objectives were set:

- To investigate means by which design professionals can comprehend the degree to which various building features have impact on the ease of constructing their designs.
- To rank building features in respect of Buildability, as revealed from the questionnaire survey.
- To make recommendations that will improve design to ease construction.

## METHODOLOGY OF THE RESEARCH

The survey instrument was designed to determine the effect of building features on buildability, A questionnaires was developed and administered to One hundred (100) practitioners representing clients, consultants and contractors working on public and private sector projects. 83 valid questionnaires were returned, representing 83 per cent response rate (Table 1). The Relative Importance Index (RII) method was adopted to derive the relative importance of buildability for building features. The formula for calculating the RII is shown in Equation 1 where: the *i* and *n* represent the smallest and the largest points in the Likert scale, respectively. 5-points Likert scale was used, the points are from 1 to 5; "Frequency" is the number of respondents who rated 1, 2, 3, 4 and 5, respectively; and the "maximum rating" is the highest point that can be given by the questionnaire respondents, i.e. 5

**Table 1:** *Response Rates per Construction Practitioner*

| Construction Practitioner | Questionnaires distribution (No.) | Response (No.) | Response rate (%) |
|---|---|---|---|
| Client Representative | 25 | 21 | 84.0 |
| Consultants | 30 | 28 | 93.3 |
| Contractors | 25 | 20 | 80.0 |
| Builders | 20 | 14 | 70.0 |
| Total | 100 | 83 | 83.0 |

**Source: Field Survey, 2010**

RelativeImportantIndex(RII): $\sum^{n}_{i-1}$(i x Frequency) / Total number of sample x Max. rating .................. Equation 1

## RESULTS AND DISCUSSION

Amongst the respondents, 34 per cent were consultants. Clients' representative, builders and contractors accounted for the other 25, 17 and 24 per cent, respectively (Figure 1). The fact that consultants are adequately represented in the survey gives an assurance that the perceptions of designers are captured with a good level of accuracy. As for working experience, more than a half were experienced with over ten years of experience whereas 43 per cent of respondents were of ten years or less experience. More than half of the respondents (61 per cent) had worked in the private sector, whilst 39 per cent worked in the public sector. 89 per cent of the respondents had their major experience in building works. The remaining respondents specialised in civil engineering works or a mixture of civil engineering and building works. The majority of respondents were specialised in builder's works thus suiting the research purpose.

### Building features affecting Buildability

The building features affecting Buildability identified in the course of the research are listed as follows : Simplicity, Standardisation, reliance on shop drawings or contractors' design, Details, Flexibility, Installation, Prefabrication.

"Simplicity" was rated as the building feature with most important contribution to Buildability. In practice, easily-assembled components, which save contractors' resources for dealing with complicated detailing, were perceived to be of greatest importance for improving construction smoothness. Meanwhile, the second ranking went to designs which are complete and self-explanatory to make buildings easier to build without referring to clarifying supplements.

For this questionnaire survey, a higher
is more important toward Buildability than those with relatively lower RIIs. By working out the RIIs, the respective impacts on Buildability of individual "Standardisation" is the third-ranked important building feature towards Buildability. It comprises two attributes:

1. use of repetitive horizontal grids; and
2. use of standardised construction details.

By adopting standardisation, economies of scale can be achieved, resulting in reduced construction costs per unit area and shortened construction time.

The fourth important feature in respect of buildability is "reasonable tolerances being specified". In this regard, it is conducive to efficient construction if tolerance specifications are standardised and coordinated (Griffith, 1984). Furthermore, apart from sensible differentiation between factory tolerances and those of site construction, designers should allow for the problem of fit at the interfaces between different products (Adams, 1989).

The fifth important feature is "reliance on shop drawings or contractors' design". As contractors are well acquainted with construction technologies and on-site logistics in order to facilitate ease of construction, they are in the best position to offer advice on complicated specialist designs and detailing, provided that performance criteria are clearly communicated.

Comparison with the mean measure, both methods produce the same rankings of ordinal variables. Yet, as the RII method is able to derive relative indices within the range of 0-1, relative comparisons of variables with different rankings are possible. In contrast, mean values arising from different rankings with different maximum mean values cannot be compared directly (Holt, 1997).

RII indicates that a particular building feature
building features are ranked in the form of Buildability indices. The Buildability index of the achieved building features are computed as a fraction of the sum of the

Buildability indices of the achieved building features to the total of all indices comprising the complete list of building features. The weighting of the building feature is multiplied to the fraction to form the building feature component score of the overall buildability score. The Relative Important Index (or buildability indices) and rankings for different building features affecting buidability are given in Table. 2

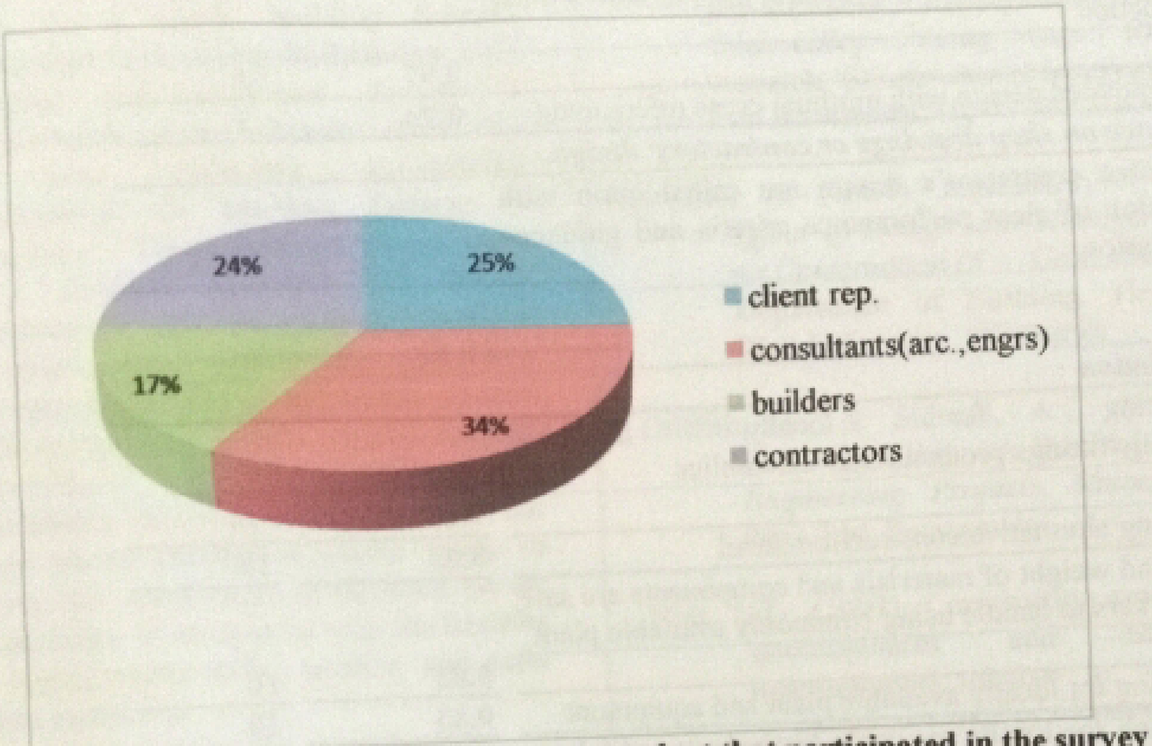

**Figure 1: Percentage distribution of respondent that participated in the survey**
**Source: Field Survey, 2010**

Table 2: Relative index and Ranking of building features as it affects Buildability

| **Building Features Affecting Buildability** | **RII (Buildability index )** | **RII Rank** |
|---|---|---|
| ***Standardisation*** | | |
| Use of standardized column with same cross sectional dimensions for a typical floor | **0.85** | **8** |
| Use of standardized beam size throughout all the floor | **0.83** | **10** |
| Use of standardized door size | **0.82** | **11** |
| Use of standardized window size | **0.85** | **8** |
| Use of modular layout | **0.83** | **10** |
| Use of standardized storey heights | **0.86** | **7** |
| Use of repetitive horizontal grid | **0.91** | **3** |
| Use of standardized construction details | **0.91** | **3** |
| ***Prefabrication*** | | |
| Finishes prefixed to prefabricate components | **0.85** | **8** |
| Use of prefabricate self contained bathroom/toilets with finishes, sanitary fittings and pipe work installed | | |

| | | |
|---|---|---|
| | 0.86 | 7 |
| Use of prefabricate staircase | 0.85 | 8 |
| Use of prefabricated vertical and horizontal shaft | 0.84 | 9 |
| ***Simplicity*** | | |
| Components are easy to assemble on site with simple instruction | 0.97 | 1 |
| Coordinated design with minimal cross referencing | 0.93 | 2 |
| ***Reliance on shop drawings or contractors' design.*** | | |
| Specialist contractor's design are called upon with provision of clear performance criteria and guidance submission | 0.88 | 5 |
| ***Installation*** | | |
| Designing for locally available materials/fittings/products/ sub-assemblies | 0.83 | 10 |
| Allowing alternative construction detail | 0.83 | 10 |
| Sizes and weight of materials and components are safe for workers to handle using commonly available plant | 0.83 | 10 |
| Designing for locally available plant and equipment | 0.83 | 10 |
| Designing for locally available know-how and labour skill on submission | 0.81 | 12 |
| | 0.88 | 5 |
| ***Details*** | | |
| Reasonable tolerances specified | 0.90 | 4 |
| Blow up details provided for possible clashes in space | 0.87 | 6 |
| ***Flexibility*** | | |
| Components and sub-assemblies are interchangeable | 0.82 | 11 |

RII= Relative important index (Buildability index)

**Source: Field Survey, 2010.**

***Worked Example***

***For: Standardization-*** *Use of standardized column with same cross sectional dimensions for a typical floor*

Relative important index (RII): $\sum_{i=1}^{n}$(i x Frequency)/ Total number of sample x Max. rating

Maximum Rating = 5 (Likert Scale 1-5)

$$\text{RII} = \frac{5x35+4x31+3x17+2x0+1x0}{83x5} = 0.84578 = 0.85$$

## CONCLUSION

The poor Buildability in the Nigerian Urban housing sector has recently inspired the development of a Buildability Assessment report in the National Building Code. As a result, building features significantly influencing Buildability were identified and prioritised through a questionnaire survey. Results show that the most important Buildability consideration for building features is "simplicity". These findings would serve as a practical reference for design professionals, who can score their designs for Buildability accordingly and thus understand the degree to which various building features impact on the ease of construction. Relative rankings of Buildability indices determined from the study would provide a useful guide to clients and consultants to improve on the Buildability of designs to reap the benefits of higher productivity, quality, and safer urban settlement.

## REFERENCES

Adams, S. (1989). *Practical Buildability*, Butterworth-Heinman, London.

Building and Construction Authority (2005). Code of Practice on Buildable Design, Singapore, http://www.bca.gov.sg/, retrieved on 12 December 2009.

Construction Industry Review Committee (1983). *Buildability: An Assessment*, Construction Industry Review Committee, London.

Egan, J. (1998). *Rethinking Construction: The Report of the Construction Task Force to the Deputy Prime Minister, John Prescott, on the Scope for Improving the Quality and Efficiency of UK Construction*, Department of the Environment, Transport and the Regions, London.

Ferguson, I. (1989). *Buildability in Practice*, Mitchell Publishing Company Limited, London,

Gibb, A.G.F. (2001). Standardization and pre-assembly – distinguishing myth from reality using case study research, *Construction Management and Economics*, 19, 307-315.

Griffith, A. (1984). *Buildability – the Effect of Design and Management on Construction (A Case Study)*, Department of Building, Heriot-Watt University, Edinburgh, .

Griffith, A., & Sidwell, A.C. (1995). *Constructability in Building and Engineering Projects*, Macmillan Press Ltd, Basingstoke.

Holt, G.D. (1997). Construction research questionnaires and attitude measurements: relative index or mean?, *Journal of Construction Procurement*, 3(2), 88-96.

Lam, P.T.I.,Wong,K.W.H., & Wong, F.W.H. (2007). Building features and site-specific factors affecting buildability in Hong Kong *Journal of Engineering,Design and Technology*, 5 (2), 129-147.

Li, H., Ma, Z.L., Shen, Q.P. & Kong, S. (2003). Virtual experiment of innovative construction operations, *Automation in Construction*, 12(5), 561-575.

Low, S.P., & Abeyegoonasekera, B. (2001). Integrating buildability in ISO 9000 quality management systems: case study of a condominium project, *Building and Environment*, 36(3), 299-312.

Nima, M.A., Abdul-Kadir, M.R., & Jaafar, M.S. (1999). Evaluation of the engineer's personnel role in enhancing the project constructability, *Facilities*, 25(11), 423-433.

Wong, F.W.H., Lam, P.T.I., Chan, E.H.W. & De Saram, D.D. (2004) Improving buildability in Hong Kong – the practitioners' views, *Proceedings of ICCPM 2004*, Singapore: Nanyang Technological University and Building and Construction Authority.

Wong, F.W.H., De Saram, D.D., Lam, P.T.I., Chan, D.W.M. (2006). A compendium of buildability issues from the viewpoints of construction practitioners, *Architectural Science Review*, 49 (1), 81-90.