Integration of Buildability Issues in ConstructionProjects in Developing Economies

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Abstract

This paper addresses buildability issues in consideration with the economic constraints of developing economies. The discussion entails the extent to which the design of a construction project facilitates the ease of construction. This relates to how the following aspects are integrated, namely: customer objectives of time, cost, and quality, the design technology, simplicity, rationalisation, and innovation. The need to adopt the four main buildability objectives, namely: customer led design decisions and needs, achieve designs for efficient and effective construction, define efficient execution, and seek continuous improvement and innovation to achieve the above integration during design and subsequent construction is emphasised. A case study of a successful commercial project in Kampala is presented.

Keywords: Buildability, customer led, efficient and effective construction, integration.

INTRODUCTION

Buildability is increasingly becoming a major requirement in building practice. The industry’s clients are continuously demanding the best value for money, in terms of the efficiency with which the building is carried out. The integration of good buildability into good overall design is the responsibility of the design team. Research in Uganda and elsewhere in the world has shown that good buildability leads to major cost benefits for clients, designers, and builders (Tindiwensi, 1996; Gray, 1990). Secondly, the achievement of good buildability depends upon both designers and builders being able to see the whole construction process through each other’s eyes. This is the biggest problem because it requires expertise in the two aspects by both roles and moreover the procurement practices in developing countries do not favour this.

Definition

Buildability has been defined as ‘the extent to which the design of a building facilitates the ease of construction, subject to the overall requirements for the completed building’ (Gray, 1990). The definition has two major implications:

1. Buildability exists on a scale from good to bad. A design with good buildability takes close account of the way it is to be constructed and vice versa.

2. Each building has overall requirements which may necessitate the acceptance of less than good buildability.
Why consider buildability in developing economies

Clients are increasingly becoming aware of the benefits of fast construction. They require buildings to be completed on time and within the tender price. These buildings should be of sufficient quality and easy to operate and maintain. Good buildability has been shown from experience to speed up construction, improve standards and lower costs. The time or cost ‘saved’ in the design process by, inadequate attention to buildability is, lost over and over again during construction. Poor buildability can lead to lower standards of construction. The more complex the assembly of the structure is, the greater the number of operations and specialist trades required. New developments in the construction industry highlight the importance and continued relevance of buildability. There are specifically six factors that will continue to call attention for buildability in design of buildings and structures in developing economies:

- **Congestion:** The increasing population has put a premium on inner city sites. The building that occupies virtually the whole site area is commonplace. It is common knowledge today that the fastest growing cities in the world are found in developing countries (e.g. New Delhi, Jakarta, Bogota, and many smaller cities in Africa).

- **Technical Innovation:** While the plant, equipment and techniques available to the builder have increased, so have the options open to the designer. He can now set the builder a much more wider range of tasks involving new materials, larger components, taller structures and a multiplicity of prefabricated items. It is important to note that these developments have occurred in developed economies but with considerable spin-off impact in developing economies. It has for example put designers and contractors from developing countries at a disadvantaged competitive end compared with their counterparts in developed countries even for contracts in developing countries.

- **Prefabrication:** There is a growing trend towards pre-fabricated construction. This means that a large proportion of the building is now made off-site with many components coming from different sources. The builders’ emphasis, therefore, is changing towards being a co-ordinator, making sure that all parts are put into production so that they are ready and appear when needed.

- **Mechanisation:** There is an increasing trend of builders expecting to use available new equipment which coupled with the prevailing global market conditions appear to be replacing labour from sites.

- **Information:** Adequate investigation of the site is necessary to identify items, which could prove critical. A design which is tolerant of change, may well be the most buildable.

- **Subcontracting:** It is apparent that the general trend is that subcontractors are becoming increasingly specialised and their role is changing from supply only, or fix only, to manufacture, supply and fix. The main contract therefore, is being left to ensure that the components fit together properly to achieve the whole project.

Maximisation of efficiency and technology

There is an earnest need to identify the route for modifying the culture of the industry in order to achieve improved efficiency, productivity, and profitability. In developing this strategy, it is important to follow a philosophy that:

Simple Objectives + Simple Actions = Sound Results

The key words, which apply to any aspect of construction, are the customer, cost, time, quality, design simplicity, rationalisation, education and innovation. In trying to achieve his project, the customer will employ professional organisations and contractors. It is, therefore, important to understand the role, input and influence that each of the organisations have in the specification and execution of the project. If the professions are ill informed on the matter of how to get the best out of a particular trade sector, then it is up to that sector to educate them and not just criticise them for their faults and weaknesses. Similarly, if the general contractors do not make best use of their subcontractors’ skills and experience, then it is again for the subcontractors to integrate their activities with those of the general contractor. It is with these agents that the customer has entrusted his project therefore as professionals, we must influence these agents.
Having defined the customer, it is then most important to understand and reflect on his needs. Every customer has a right to expect quality and flexibility or responsiveness to his needs. What has to be recognised, however, is that with regard to cost, speed and certainty, this will change depending on which business sector the customer belongs, e.g. a chemical process customer has a very different expectation of his building from a commercial developer, as he has from a fast food restaurant owner.

**Adopt customer led designs**

The description of the customer may at first glance seem rather simple and obvious but a lot of companies and individuals confuse the identity of their real customer, often believing that the main contractor fulfills this role this role. The customer is the person, who conceives the need, orders and pays for the overall project. In describing the customer, it has to be recognised that there are different categories, e.g. developers, occupiers, and owners. These different types will have fundamentally different expectations of their involvement in the operation of the design process, i.e. after the concept has been agreed. They also require a maximum of completeness from any trade.

**ACHIEVING DESIGNS FOR EFFICIENT EXECUTION**

The design sets the pattern for all that follows. A ‘good’ design will mean that a ‘good’ project will follow but a good fabrication and installation cannot compensate for a poor design. It needs to be recognised that design goes through various stages, i.e. concept, scheme, feasibility, detail and production drawings. Furthermore, between each of these stages there is often a break in time, sometimes a change in responsibility and there can even be a change in philosophy and priorities. What has to be achieved therefore is a transition between these various stages without a break, or at the very least with strong links and ties, whilst clearly identifying the responsibilities within each stage. It is important to identify those areas, which, the design must take cognisance of if maximum efficiency is to be obtained.

**Definition of good practice**

Every industry will get what it deserves. If in this case it is considered that the designs are inconsistent and do not reflect good and economic practice, then it is the responsibility of the industry to rectify the matter. This can quite easily be achieved by developing co-ordinated industry specifications and standards on a national and/or regional basis. The specifications should reflect practical tolerances and ‘fit for purpose’ workmanship. Similarly, standards can be defined to cover all aspects of design and construction. These can be put together in authoritative guides which, will achieve not only a rationalisation of the design process across the industry but will, in addition, provide the substance for those links between the various stages of design. The most important aspect in achieving this good practice is that it should be led by the industry but must fully involve all the stakeholders.

**Communication and education**

The major point here is to ensure that the professionals and academics adopt and apply this in design practice and not just in theory and research. The means to achieve this is by defining national and cross-industry training modules and to identify centres of excellence, which will take these modules as the basis of their programmes. In addition, there is a need to develop and promote continuing professional development programmes.

**Definition of efficient execution**

The previous discussion has highlighted the notion that the customer will purchase the product thinking that it has been designed for efficiency in execution and performance. It is at this point that a profit or loss is made. It is wrong to think that individual companies can achieve all of this by themselves. There has always been a large element of success in learning from each other. The Japanese, more than anyone else,
have demonstrated this fact. In any event, industry-wide efficient construction motivates the preceding design into efficiency.

**Benchmarking**

Benchmarking lies at the heart of good practice and continuous improvement. There seems to be no other method of establishing whether efficiency is being achieved and improvements being gained from process and product development. There is however, a necessity to establish which activities should be measured. The methods available to undertake such a study are varied but one should choose those that are simple to understand. Gray (1990) suggests Method Productivity Delay Model (MPDM), Activity Sampling Model (ASM), Foreman Delay Surveys (FDS) and Network Processing Systems (NPS) as some of the possible techniques, but he however, singles out NPS to be the most effective.

**Simplification and standardisation**

The basic point is to understand what leads to efficiency in operation, e.g. for a steel frame, the erection process is largely controlled by the attitude of the fabricator and welding productivity, is controlled by the efficiency and exactness of the way the components are assembled. The assembly process itself is influenced by the accuracy of the preparation and detailing by the draughtsman. It is, therefore, the standardisation, simplification and planning of the previous activity, which is the major control of efficiency. Equally, it is important that activities should be planned for completion once started. If the preparation of a piece of metal includes cutting, holing and shaping then this should be completed as a single operation and not a series of disparate activities. Each type of activity should go through this kind of analysis.

Before standardisation is adopted, it is important to decide what it is that is being standardised. Is it the finished product itself or is it the basic formulation? For most general buildings it will have to be the standardisation of the basic rules of design, detail, use of materials, which under the same circumstances will always lead to the same conclusion. Equally, however, more standard structures and especially in the single storey market lend them to standardisation of the completed product.

**Planning and control**

Planning and control should not only aim at a disciplined sequence of works but also to reduce costs and time and to increase efficiency. It is the means by which the needs of erection (for example for a steel structure) are balance with the economies of fabrication. Each operative, section, or department needs plans that recognise their individual horizons. These plans should not only be based on achievable work packages but should ensure that only completed work can be passed forward.

The secret of success lies in not just providing this management discipline, but in starting with installation and working backwards to the design, i.e. construction led. This will amount to the much-required synchronisation of the manufacturing and construction processes and each package will be on a just-in-time basis. One thing that should be noted is that we are in the business of designing, detailing, fabricating, and installing or constructing bespoke projects. We are not in the business of storing and stocking at any stage of our operations.

**Continuous improvement and innovation**

If the improvement or innovation does not, in the final analysis, reduce cost for at least one member of the construction team, then the value is probably debatable. The immediate measure of whether the improvement is a gain is to assess this against the established benchmark and then, once a gain is established, to raise the benchmark. Clearly, the construction process cannot be indefinitely shortened, but
major benefits will arise from a smoother, cleaner start. This can also be linked to a much closer co-operation and interface with the ensuing trades.

CASE STUDY: CONSTRUCTION OF CONRAD PLAZA, KAMPALA, UGANDA

Project details

<table>
<thead>
<tr>
<th>Client</th>
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<tr>
<td>Project Manager</td>
<td>Mentor Management (U) Ltd</td>
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<tr>
<td>Design Architect</td>
<td>Symbion International</td>
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<td>Supervision Architect</td>
<td>5th Dimension Architects</td>
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<td>Lifts Subcontractor</td>
<td>Roko Technical Services Ltd (Schindler)</td>
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<tr>
<td>Foundations Subcontractor:</td>
<td>Frankipile South Africa PTY</td>
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<tr>
<td>Electrical Subcontractor</td>
<td>Central Electrics</td>
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<tr>
<td>Plumbing Subcontractor</td>
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<td>Gross Floor Area</td>
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The project is a 12 storey commercial office complex including three levels of basement car park, two levels of shops, one level of banking hall and six levels of offices. It is located on Plot 22, Entebbe Road, at the junction with Nasser Road, in the heart of Kampala City. The project is bounded by, Nasser Road to the North, Entebbe Road, and an unfinished structure to the West, Uganda Railways Goods Shed to the South and an Office development to the East. The difference in levels between Nasser Road and the Uganda Railways goods shed is 14 metres. The building covers the whole plot area and basement level three is at the same level as the goods shed. The project was completed in 1998 and is now fully occupied.

Problem

The structural engineer had initially designed a 1M deep raft foundation for the building. However what was not done was the specification for the construction of the retaining wall after the excavation of the 14M vertical excavations and before the construction of the raft foundation, and the three basement floors, particularly the protection of the vertical slopes. The structural engineer had recommended a provisional sum of US$ 100,000 for this purpose. The structural frame was in reinforced concrete.

The tender process was stopped at the recommendation of the project manager in order to obtain a clear solution to the excavation problem. All the returned tenders kept the provisional sum but the bidders had not described how they intended to support the slopes.

Buildability appraisal

The project manager carried out an appraisal of the project for buildability. The following principles were used for appraisal:
The investigation of site conditions and other circumstances likely to affect the course of the project should be thorough and complete to avoid the risk of subsequent expensive delays and alterations after construction has commenced.

The location of access to and around the site during construction should be carefully considered. This is often a crucial consideration for sites within our ever growing and congested cities.

Consideration should be given to the location of material storage and unloading facilities. On congested sites, it is frequently necessary to phase work so as to facilitate the use of part of the structure for storage.

Particularly where the ground is poor, hazardous or wet, it will facilitate speed and flow of the project to minimise the amount of time taken by work in the ground.

The construction of the building shell, including the roof, should ensure early enclosure. This will minimise hindrances from adverse weather.

The design should be arranged so as to facilitate safe working in foundations and earth works, when materials and components are being handled, and whenever traversing for access is necessary.

Solution

A number of strategies were devised to circumvent the above problem:

- A way leave agreement was sought and signed with Uganda Railways Corporation to use their adjacent land for access to the site, storage facilities, site offices space and workshop space.
- A design and build subcontract was let to FrankiPILE South Africa PTY to redesign and construct the foundations subject to the structural requirements of the superstructure. Franki designed perimeter piles, gunite wall and geonails to protect the cut slopes, and structural piles for the building foundations.
- As per the requirements of Franki, a site investigation was undertaken by Mowlem East Africa and counterchecked by Geo-Franki.
- The foundation design was reviewed and passed by the structural engineer and construction commenced after a delay of about 4 months.

Achievements

1. The foundations and the subsequent building were constructed without any slope stability problems or structural failures.
2. The construction project was finished two months ahead of schedule despite 4 months delay at tender. This was possible because the bored pile construction was very fast and the pile caps were made composite with the ground slab.
3. The foundations were overall US$ 150,000/= cheaper. This saving was used to improve the façade of the building.
4. The overall construction cost of US$ 800 per square metre was a phenomenal achievement and a class apart from competing buildings where cost oscillates between US$ 1200 to US$ 2000 per square metre.

REFERENCES

Plate 1: Construction of the structural piles. Note the gunite wall and geo-nails in the background

Plate 2: Construction of the pile caps. The perimeter piles are evident in the background
Plate 3: Finished pile caps with column starters. Note the slope of natural ground.

Plate 4: Another view of the foundations showing the starter bars of the lift shaft.
Plate 5: Structural layout on a typical floor

Plate 6: Front view of the finished Conrad Plaza
Plate 7: Side/front view of Conrad Plaza

Plate 8: Rear view of Conrad plaza seen from about 200 metres
Plate 9: A wider skyline of Kampala in the neighbourhood of Conrad Plaza