MEASURING FLEXIBILITY DEGREE OF BUILDING CONSTRUCTION PROJECTS – A CASE STUDY

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ABSTRACT

Construction industry differs from other industries in many aspects. The product of a construction industry is unique and most of the process takes place in a turbulent and temporary environment that is vulnerable to environmental conditions. As a result, there occur frequent changes during the whole construction process creating a risk for managing things like design, contracts, suppliers, resource, etc. Due to the context specific characteristics of each new project, specific information is required for building each project and thus the routine process may be of little help for carrying out such projects. Uncertainty, interdependence and complexity are the key features of many construction projects. These need to be addressed in a different approach unlike other industries. This paper deals with the issues in facing this challenge of uncertainty and complexity of construction projects by bringing the approach of flexibility into the construction process. The authors discuss a case from the construction industry while searching for a possibility of incorporating a flexibility based approach for managing construction projects.

KEYWORDS: Uncertainty, Complexity, Flexibility Measure, Construction Projects.

INTRODUCTION

There is some or the other uniqueness in each construction project due to which change in the construction process is inevitable on most construction projects. Change is defined as any event or situations that results in a modification or alterations of the original scope, execution time, or cost of work, (Hanna et al 2002). Such changes occur on a project for many reasons, such as design errors, design changes, additions to the scope, or unknown conditions. Each such change has a high impact on the original cost and schedule of the project, (Hanna et al 2002). In most of the industries where there is a stable environment the changes are predictable and are not frequent. Due to which the critical variables can be identified and a plan can be developed for the same. However, in extremely turbulent and dynamic environments like construction industry where change is frequent and unpredictable, it becomes difficult to go through the routine process and follow the plan. Hence flexibility becomes inevitable for such environments, (Volberda 1997).
CONCEPT OF FLEXIBILITY

Making flexible arrangements in managing projects is not a new concept. Many studies show that to bring out the effects of uncertainty in planning, the project plan should be made flexible. But the practicability of this concept is not yet tested. Olsson (2006) observed in his empirical study of 18 Norwegian projects that as per the stakeholders, flexibility in the initial phase of the project life cycle is noncontroversial. There are examples of many projects where changes were made in spite of the foolproof planning and risk for cost overruns (Pundir, et al, 2008). Hence if during the whole period of the projects room for flexibility is given, it will surely be utilized. Cui and Olsson (2009) studied 82 public investment projects in Norway and found that if there is more uncertainty in project, it is more difficult to estimate how project planning can be applied in future. Due to the increasing complexity and dynamics in the environment of organizations, changes are required more frequently. The growing use of new technologies in front office and in back office of organizations is often considered as a main cause of complexity (Lehmann, 2010). Lehmann (2010) has made an attempt to establish relationship between project management and change management and tried to incorporate the assumptions of change management in the field of project management. The field of project management is not yet explored as it should have been and the concepts of management are not fully implemented in the area of project management. Cooper and Lyneis (2002) discussed some of the reasons behind the failure to systematically learn from the past project experiences, and presented an approach and framework for cross-project learning. Hence it is clearly seen from the literature that the projects are ready to adapt the changes, but the scrutiny of the theory and the practicability of the concept need to be tested.

FLEXIBILITY FOR CONSTRUCTION INDUSTRIES

“Flexibility can be defined as the ability to change or react with little penalty time, effort, cost or performance”, Upton (1994). This means that flexibility describes the ability of the project to cope with changes in the project definition or scope and compensate them with little influences on schedule (time), costs and quality by appropriate management policies and actions. Mandelbaum (1978) defines flexibility in relation to construction industry as the ability of the system to respond to change by taking an appropriate action and the inner capability of the system to function well in more than one state. This definition of flexibility of system explains that the system or organization should be adaptive in nature. Flexibility approach is laid on some of the known theoretical concepts like contingency theory, law of requisite variety and systems theory, (Paslawski 2008). This means making a system or a process more proactive so as to make contingency provisions and capability of a system to take necessary controlling actions by efficiently making adjustments to changes. Most of the large construction projects are planned at least 5-6 years in advance. During this time, demands on the infrastructure are likely to change significantly. Changing demands may result from new forms of construction technology, changes in government regulations, change of rules in funding agencies, etc. There are many key stakeholders who are directly linked with a construction projects like project owners, users, project management, architects, consultants, and contractors. With so many stakeholders playing a key role there is scope of frequent changes in the requirements of each stakeholder. This creates a need of flexibility in the construction projects.
As per the traditional thinking, construction projects are built for specific users whose requirements are well known in advance. Similarly, it has been assumed that users are able to define all their requirements during the project design stage and that, being aware of the details, they can thus approve the design solutions presented to them on paper. In addition, building projects are specifically prepared for particular uses and users. Large building construction projects are planned from 5 to 10 years in advance, and are typically designed to have a lifespan of more than 40 years. During this time, demands on the infrastructure are likely to change significantly. Changing demands may result from new forms of building technology, changes in regulations, the organization and funding of services, demographic changes, or changing standard of living patterns. It is common for building projects to have to accommodate several of these changes. High levels of uncertainty and changing technology create the need for flexibility. In addition, governing factors such as the prevailing general economic situation, conditions for financing, and the user requirement may change. These are typical factors that serve as a basis for all construction projects. Although certain flexible solutions are repeated from one project to the next, no serious thought is given to making flexible allowances for the potentially different needs of future users of the building, (Patrizi et al, 2006). Flexibility is a property of a building that is realized to some extent in all projects, even if it had not been actually taken into account in during the design phase. Until now the problem has been that flexibility has been perceived as an ambiguous, immeasurable concept. Moreover, it means different things to different interest groups. The user is typically interested in the flexibility of the spaces in building used in daily activities whereas the owner is interested to consider flexibility over the medium and long term goals, (Saari & Heikkila 2008). Unconsidered investment of resources in flexibility may lead to unnecessary expenditure that does not necessarily result in flexibility in connection with actual changes. On the other hand, rigid design solutions may increase dissatisfaction among users. Flexibility can be affected most effectively by controlling design and construction. When the building is finished, the possibility to have an impact on its flexibility is much more constrained since it is implemented through frame solutions, floor heights, building services ductwork, etc. which are expensive to change afterwards. Thus, flexibility is a key parameter in the building construction business. The user is interested in a different type of flexibility than the building owner. The different type of flexibility of building as given by Saari and Heikkila, (2008) is:

**SERVICE FLEXIBILITY**: This type of flexibility means how much a building can adapt to repeated quick changes in loading. A change in loading means change in the number of people who are using that space, changes in the occupancy of the space, etc. Service flexibility affects strongly the productivity of the activity in the space. Thus, it is especially important for users. It can be improved by, for instance, movable partitions and adjustable ventilation.

**MODIFIABILITY**: Modifiability of a building is the ability to meet the changing requirements of its occupants. For instance, user may want to change his business from hotel to education. This type of flexibility is an important property for the property owner. It can be improved by "loose" dimensioning of building services and system walls.

**LONG-TERM ADAPTABILITY**: Long-term adaptability of a building refers to the adaptability of a building to requirements that are not specified and unknown. Adaptability plays an important role during buying or selling of a building. The long-term adaptability of old industrial properties has been particularly good thanks to high floor heights and long spans.
conversion to office and residential use has been possible and relevant in several recent construction projects, (Saari and Heikkila, 2008). The adaptability of a building can be measured by comparing all the characteristics of a building with universal criteria of a building. The factors on which adaptability depends are floor height, spans, permissible floor loads and, a building’s location.

Clear phasing of the design process facilitates consideration of flexibility in the construction process. As earlier stated, today's construction methods are solution-oriented. The architect's space arrangement may allow a quite large flexibility, but, for instance, the principle of air distribution might not allow changes in the room plan without major changes in building services technology. Thus, designers and implementers offer universal technical solutions which they regard as flexible, (Blakstad et al, 2009).

**TOOL FOR MEASURING FLEXIBILITY IN BUILDING CONSTRUCTION PROJECTS**

How much flexible or adaptable a building is? This is a basic question which needs to be answered. Finding a flexibility measure of a building could help in knowing the adaptability or flexibility of a building. It can be calculated as, (Blakstad, 2001):

\[
\text{Flexibility measure} \% = 1 - \left( \frac{\text{renovation cost}}{\text{new construction cost}} \right)
\]

For example if a class room is to be converted in a library room, let us assume the renovation cost required for making the alterations was Rs 500/sq feet and let us assume that the new construction cost was Rs 1100 / sq feet. Then the flexibility measure of this can be calculated as

\[
\text{Flexibility measure} \% = \left( 1 - \frac{500}{1100} \right) \times 100 = 55 \%
\]

If we take another example where the same class room is to be converted into a computer room, assuming the renovation cost for making the alterations to be Rs 750/sq feet and the new construction cost to be Rs 1100/sq feet. Then the flexibility measure of this can be calculated as

\[
\text{Flexibility measure} \% = \left( 1 - \frac{750}{1100} \right) \times 100 = 32 \%
\]

From the above examples we can see that the classroom can be converted more flexibly into a library than that of a computer room.

Hence if the flexibility degree of any building is more it means that the building is more adaptable for new occupancy.

There is an increasing pressure on society to develop and construct sustainable buildings. Hence the flexible buildings and installations that are adaptable to changing conditions is the need of present society. Adaptable, recyclable and sustainable buildings will be major criteria in
assessing performance of future buildings. Among the factors that play a role in performance measurement are saving of base materials, minimizing waste production, ease of dismantling and adaptability. (Paslawski, 2008).

**CASE STUDY: RENOVATING AN OLD COMMERCIAL BUILDING INTO A MULTI SPECIALTY HOSPITAL**

**COST ANALYSIS**

A comparison of the cost of constructing a new hospital building with that of renovating an existing commercial building.

**EXISTING BUILDING**

1. Type of occupancy: Commercial.
2. Description:
   a. Ground Floor + First Floor.
   b. The building was constructed for commercial purposes. The building was to be leased out to companies interested in setting up offices, shops, showrooms etc.
3. Cost of construction: The per square feet cost of construction for the shell was Rs. 650/Sq.Ft. This did not include the costs for tenant fit outs. Rs. 1500/Sq.ft. was the estimated cost for plumbing, mechanical, and electrical systems.
4. Total unit cost of the building = Rs. 650 + Rs.1500 = Rs. 2150/ Sq.ft.
5. Area that was constructed = 20,000 Sq.Ft.
6. Total project cost = Rs. 4,30,00,000 (Rs. 4.3 crore)

Due to change of ownership of the property, the new owner converted the existing commercial complex into a multi specialty hospital. With the use of additional FSI (Floor space index) more built up area was allowable on the existing property.

**RENOVATED BUILDING**

A full renovation was done to this building to bring the building into general compliance with current building usage. Building envelope (windows, façade, interior finishes, exterior walls, etc.); plumbing, mechanical, and electrical systems were replace to current requirements, standards and program and functional spaces were made to approximate current space standards.

1. Type of occupancy: Multi specialty Hospital.
2. Total new area to be added = 1,00,000 Sq.ft.
3. Cost of construction: The per square feet cost of construction for the shell was Rs. 600/Sq.Ft. This did not include the costs for medical equipments. Rs. 800/Sq.ft. was the estimated cost for plumbing, mechanical, and electrical systems (due to availability of existing infrastructure and installations).

4. Total unit cost of the building = Rs. 600 + Rs.800 = Rs. 1400/ Sq.ft.

5. The total project cost after 100% completion was Rs. 14,00,00000 (Rs 14.00 Cr)

6. Actual cost of project if it was to be newly constructed with new cost of construction = (1000 + 1500) / sq feet = Rs 2500 / sq feet = Rs. 25, 00, 00000 (Rs. 25.00 Cr.)

7. Flexibility Measure % = [1 – (renovation cost / new construction cost)]*100
   
   = (1 – 14/25)*100 = (1- 0.56)*100

   = 44%

8. Savings in the cost of construction were due to the use of flexible existing building construction and services. Also with the availability of the existing infrastructure, costs were reduced.

CONCLUSION

Flexibility cannot be a universal property of a building. Thus, no universal aims and goals can be set for flexibility in building structures nor can "absolutely flexible" building be built. Flexibility is a property of a building which is very relative. We must determine which alternative use situations we should prepare for since it is not possible, in practice, to be prepared for arbitrary changes. Likewise, we must estimate acceptable conversion costs and disturbances to activities. This definitely will help us for preparing ourselves for the "unknown future" mainly by flexible solutions related to the building structure.

REFERENCES


