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Utilizing TQMandBIM for Developing Sustainable Buildings through Co-Ordination during Construction inthe Maldives

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Abstract:*Lack of quality control and errors during building process in the Maldives has resulted in poor construction implementation and planning towards sustainable buildings in the resorts. Attainment of acceptable level of quality in the construction industry has long been a problem. Great expenditure of time, money and resources, both human and materials are wasted each year because of inefficient or nonexistent quality management procedures. The manufacturing industry in Japan has developed TQM concepts and in recent years many other countries have abided TQM. These concepts have increased productivity, decreased product cost and improved product reliability. These concepts are also applicable to construction industry. However quality costs consist of cost prevention, cost appraisal and cost deviation. Sustainable development can significantly reduce adverse human impacts on the natural environment while simultaneously improving quality of life and economic well being. BIM will increase construction productivity and prefabrication with less rework on site. Incorporating TQM concepts with innovative planning to improve construction implementation will be focused in the study. Therefore the construction industry needs to integrate TQM and BIM for the successful implementation of construction projects towards sustainable buildings.*

Keywords*: TQM, BIM, Construction, Sustainable buildings, Co-ordination*

I. Introduction

The main contributor any country's economy and infrastructure is the construction industry. However the industry faces many problems of high fragmentation, instability, low productivity, poor quality and lack of standards (Metri, 2005). Total quality management (TQM) is often termed a journey, not a destination (Burati and Oswald, 1993). As building projects gets larger and complex, clients are also demanding increasingly higher standards for their delivery. TQM concepts provided the organization with improvements, information, andlearning that occurred only because of the TQM process. This is in addition to positive customer responses and client referrals that the organization received as a result of implementing TQM.These concepts likewise will be embraced in the construction industry to help enhance quality and increase productivity (Pheng, et al, 2004).TQM and it is believed that the benefits of higher customer satisfaction, better quality products, and higher market share are often obtained following the adoption of TQM by construction companies(Quazi and Padibjo, 1997).

There is an urgent need to integratequality control system and minimize errors during construction process in the Maldives to plan towards sustainable buildings in the resorts. Such obstruction will cause cost overruns and exceeded time schedules due to conflicts and controversies concerning project design and implementation during construction. TQM involves everyone in the construction industry. It is achieved through an integrated effort in the different phases of the project including planning, design, construction, operation and maintenance (Arditi, 1997). A case study consisting of two projects will be undertaken to investigate how the problems of managing the concerns of integratingTQM in an actual construction project. Utilization of 3D models for co-ordination during building process in Maldives and the impact on the projects will be studied. The growing demand for 3D tools from the design and construction community to adopt the current industry has changed dramatically. Utilizingbuilding information management (BIM) on an actual project is a complex process that involves a well co-ordinated attempt. It was found that BIM can have a significant impact on the execution of a project. One o the fundamental principles of TQM and BIM is the concept of continually improving the work process. The relationship among the parties involved in the process. The supplier, the processor and the customer is very important for the quality of work process and therefore for the quality of product itself (Arditi et al, 1997). Project delivery in construction is highly dependent on the effectiveness of the team put together to implement the project. The organizational priorities for collaborative working will be considered together with project needs, users' requirements and technologies to develop a decision making framework that can facilitate the strategic planning and implementation of effective collaborative working policies and practices (TQM).

Sustainable development can significantly reduce adverse human impacts on the natural environment while simultaneously improving quality of life and economic well being. BIM will increase construction productivity and prefabrication with less rework on site. Incorporation of technology with innovative planning to improve construction implementation will be focused in the study. To achieve sustainability through interaction, integration by identifying relationship between ecological and socio-economic systems will be the main contribution to the construction industry.

Background Problem

Most crucial environmental issue challenging the small island nations like Maldives is the climate change. Growing demand for sustainable buildings in the resorts has impacted on all aspects of the built environment. The use of prefabricated modular design systems in resort will make a dramatic change. Construction design and building process can contribute greatly to make Maldives build a sustainable, eco-friendly and green/lean construction industry.

Significance of good planning, how it affects the quality of design and the end product by identifying changes and adjusting the schedule in the most efficient manner will benefit all parties involved in building processby TQM. Minimizing errors from a well co-ordinated interaction and achieving common objectives that could lead to significant decrease in capital cost. The evaluation process through BIM can help the design team for better interpretation of future buildings and realization of their visions by utilizing sophisticated programs like Autodesk Revit, 3ds Max and VR4Max (Ku, Spiro, Pollalis, Martin, Fischer, Dennis and Shelden, 2008). The primary cause for the decline of construction productivity directly or indirectly involves poor management practice. Quality is part of productivity, hence the first step for the organization to recognize the problems (Arditi et al, 1997).

Understanding the complex process of producing a quality building which involves technical knowledge to create a set of specific instructions for the construction and where the production is the responsibility of contractors, they tend to perceive project as simple as possible for easy production. Contractors often recognize TQM as an extra cost, but they do not realize that it is not the quality that costs but rather the nonconformance to quality that is expensive. The sources of costs associated with the no achievement of quality include the costs of rework, correcting errors, reacting to customer complaints, having deficient project budgets due to poor planning, and missing deadlines (Culp, 1993).The resort developers in the Maldives still tend to use traditional construction methods such as coral masonry, where coral is taken from the island reef. This has a negative impact on the vulnerable environment and surrounding of theisland. Introduction of new materials and technologies will be incorporated during implementation and building process. Clients should move away from the usual practice of awarding tenders to the lowest price and advocate rewarding the best designers and suppliers who could provide the best service (Pheng et al, 2004).The competitive pressures will lead to the adoption of TQM and organizations should create supplier partnerships by choosing suppliers based on quality rather than price.Construction industry is in need for innovation in planning and implementation which allows the project team to identify the order of extent that different technological characteristic that have had on construction productivity (Mawdesley et al, 2010). BIM has transformed the way buildings are designed, constructed and managed (Hardin, 2009; Azhar et al., 2009). Prefabrication and modular designs will lead to sustainable buildings, eco-friendly housing and green/lean construction. Prefabricated modular systems have greater energy efficiency, lower construction waste, faster construction time, and better structural stability, which results better long-term investment. The greater the capital investment in construction is, the less the amount of money remaining to operate and maintain the facilities and to spend on other things. The lower the amount spent on construction, the slower the development, the lower the quality of the facilities provided, the smaller the benefits and the smaller the opportunity for improvement (Mawdesley et al, 2010). The main objective of sustainable buildings in Maldives is to avoid resource depletion, environmental impacts and create built environment that is comfortable, safe and productive.

Utilization of TQM and BIM

All buildings constructed are unique. Quality is seen as consisting of those product features which meet the personalized needs of the customers and thereby provide product satisfaction, supplemented with a provision of freedom from deficiencies (Sommervilleand Robertson 2000).

Sunesson, Allwood, Paulin, Heldal, Roupé, Johansson and Westerdahl, 2008, state that 3D/VR models in the evaluation process can help the design team for better realization of their visions and the parties involved to enhance their need for information about the future building and how these models are well interpreted . Identifying the areas in which the knowledge can be improved with 3D and VR modeling, dealing with the issues from conceptual stage to execution on site. Allowing interacting with building designs, concepts and allows to view different perspectives. Health and safety issues can also be effectively tackled. The integration of 3D/VR models will have an impact on architectural profession and the involvement of different professionals in

the urban construction process shows that it provides a better window to the general public to understand the construction planning process. Building Information Modeling (BIM) is an innovative technology that has transformed the way buildings are designed, constructed and managed (Hardin, 2009; Azhar et al., 2009). It provides a framework that combines visualization and parametric modeling that allows simultaneously consider the interdependent processes of planning, analysis, design and construction (Casey, 2008; Azhar et al., 2008). BIM is a shared knowledge about the information for decisions making during its lifecycle (Kumar et al., 2009). The construction analysis module reads from an external database of available equipment and labor, and formulas for the duration calculation. However there are certain factors that can affect the planning process by the 3D generated model and order. Knowledge representation was initially followed by a computational approach to research how far this approach can go to produce a reliable planning (Vries and Harink, 2007). The complexity of construction projects makes construction planning a particularly difficult task for project managers due to the need to foresee and visualize possible future events. Virtual prototyping offers an improved method through the visualization of construction activities by computer simulation. This enables a range of 'what-if' questions to be asked and their implications on the total project to be investigated (Li, Guo, Skibniewski and Skitmore, 2008). The successful implementation of complex-shaped buildings within feasible time and budget limits has brought attention to the potential of computer-aided design and manufacturing technologies (CAD/CAM). From two-dimensional (2D) paper-based representations to three-dimensional (3D) geometric representations in building information models (BIM), architects and engineers have streamlined 'inner' design team co-ordination and collaboration. It was found that BIM (3D and 4D modeling) can have a significant impact on the execution of a project (Ku et al, 2008). However quality teams are necessary for successful utilization of TQM and BIM in construction process. Training for TQM and integration of BIM should be executed through well planned team structure. The ultimate goal of the team approach is to get everyone involved including contractors, designers, suppliers, stakeholders and owner to be part of the TQM process and BIM for effective co-ordination or communication during the building process.

Construction Implementation with TQM and BIM

In developing a total quality culture in construction, one importantstep is to develop a construction team of a main contractorand subcontractors who would commit to the quality process anddevelop a true quality attitude (Low and Peh, 1996). Thus, themain contractor should only select subcontractors who have demonstratedquality attitude and work performance on previous jobs.Merti(2005) outlined the following success factors to implementingTQM in construction implementation:

1. Top management commitment
2. Quality culture
3. Strategic quality management
4. Design quality management
5. Process management
6. Supplier quality management
7. Education and training
8. Empowerment and involvement
9. Information and analysis
10. Customer satisfaction

Love et al. (2000) noted that organizations in the construction industry have abstained from implementing TQM practices because they feel that the short-term benefits are relatively minimal. Due to the complex nature and ever-changing environment of construction projects, the BIM is flexible and sensitive to effective communication, and continually improving through TQM.Gibson, (2000) stated that, a negative attitude to a construction project by stakeholders can severely obstruct its implementation. Such obstruction will cause cost overruns and exceeded time schedules due to conflicts and controversies concerning project design and implementation. A project stakeholder is a person or group of people who have a vested interest in the success of a project and the environment within which the project operates. The implication is that a stakeholder is any individual or group with the power to be a threat or a benefit. Thus, project management must be able to analyze the various demands presented by stakeholders so that communication between them is facilitated. Hence, the dilemma for the project management is to balance the use of resources with the appropriate strategy towards each individual stakeholder group (Olander et al, 2005). For the construction industry to survive the current turbulence in the economic atmosphere, it has the option of integrating new initiatives to march the uncertainties. Program management is seen as an efficient vehicle to successfully deliver the improvements and changes (Shehu and Akintoye, 2010). However, the implementation of any new system or change initiatives has always been a challenging task; some of these challenges can be faced during the implementation or at practice stage. Due to the lack of clarity surrounding program management in the construction industry, the understanding of these major challenges remains vague (Shehu et al, 2010). The methods by which small firms

overcome the disadvantages of their size to implement innovation on construction projects are found that such methods include working with advanced clients, prioritizing relationship-building strategies and using patents to protect intellectual property. Key obstacles to innovation implementation by small firms on construction projects are found to be bias in the allocation of government business assistance and regulatory inefficiencies under federal systems of government (Manley, 2008). Therefore the answer to the construction industry's continuing problems is said to lie in building a stronger innovation culture to improve the rate and quality of innovation across the construction system, particularly given increasing client demands for integrated services (Hartmann, 2006). TQM is a different approach of thinking aboutgoals, organizations, processes, and people to ensure that the rightthings are done right the first time. Implementing TQM is a major organizational change that requiresa transformation in the culture, process, strategic priorities, beliefs,etc. of an organization (Motwani, 2001).

Innovation is new or significantly improved product (good or service), process (production or delivery method), marketing method (packaging, promotion, or pricing) or managerial method (internal business strategies) (OECD, 2005). Improvement in productivity will not be achieved without bearing in mind that there is an enormous number of factors affecting productivity and that there is a necessity to locate the most influential ones among them (Mawdesley and Al-Jibouri, 2010). The twenty-first century is now seen as the time for the construction industry to embrace new ways of working if it is to continue to be competitive and meet the needs of its ever demanding clients. TQM is an approach to improving the competitiveness, effectiveness, and flexibility of the whole organization. It is essentially a way of planning, organizing,and understanding each activity that depends on each individualat each level. Ideas of continuous learning allied to concepts such as empowerment and partnership, which are facets of TQM, also imply that a change in behavior and culture is required if construction firms are to become learning organizations (Phenget al. 2004).

Collaborative working is considered by many to be essential if design and construction teams are to consider the whole lifecycle of the construction process (Shelbourn, M., Bouchlaghem, N.M., Anumba, C., and Carrillo, P. 2007). Much of the recent work undertaken on collaborative working has focused on the delivery of technological solutions with a focus on web (extranets), CAD (visualization), and knowledge management technologies. Visualization allows stakeholders to view detailed and often complicated sets of information in a format that is easily recognizable. Particularly give clients and end-users the ability to see the finished facility before onsite activities begin. This means that changes (from the client or conflict resolution) can be made earlier in the process (Caneparo, 2001; Sriprasert and Dawood, 2005; Whyte, 2005). It combines technology with the people and business aspects of collaborative working to provide an approach which can enable stakeholders in a project to benefit fully from having a collaborative working approach to their projects. The negative side of a construction project can be deterioration of the physical environment for the affected stakeholders (Olander, 2002). It is worthy of note that although many of the respondents described their organizations as working towards collaborative and strategic partnerships with their supply chains, there is actually little evidence of this actually being achieved (Shelbourn et al, 2007). The innovation in organizationwanting to implement TQM and utilize BIM would include considerationto be given to the following: customer focus, continuous improvement, leadership, employee involvement, teamwork, customer–supplier relationship, and process improvement.

Planning towards Sustainability with TQM and BIM

In order to pursue sustainability in the construction industry, existing development-focused construction activities must be transformed via a new paradigm focusing on sustainable development through the adoption of sustainable policies by the government and the development and dissemination of sustainable construction technologies (Tae and Shin, 2009). Shen, L., Tam, V.W.Y., Tam, L., and Ji, Y. (2010) state that, the importance of incorporating sustainable development principles in conducting project feasibility study is not effectively understood by project stakeholders. Since TQM is a customer oriented organization to maximize customer satisfaction rather than internal efficiency, considering the next person in line who uses his output (Pheng, 2004). To enhance the effectiveness of internal efficiency in construction projects utilization of BIM tool will establish a strong co-ordination. Sustaining environmental viability is the subject of discussion for our global community today, and transition of architectural building construction toward a sustainable industry for the sake of preserving our Earth's environment is now a critical necessity. The governmental and commercial organizations that successfully innovate in sustainability go through eight consecutive stages of interorganizational innovation, and perform twenty-two interaction patterns that are part of these stages (Bossink, 2007). Recognizing the innovative nature of green niches at the policy level could lead to new approaches to governance of bottom-up community action for sustainable development (Seyfang, 2009). With reference to construction business, sustainability is about achieving a win–win outcome for contributing to the improved environment and the advanced society, and at the same time for gaining competitive advantages and economic benefits for construction industry. Most importantly implementing TQM is its ability to translate,

integrate ad institutionalize TQM into normal practice of construction industry (Pheng, 2004). The construction organizations should always look toward 100% client satisfaction and error free performance to achieve sustainability. Implementation of TQM will maximize organizational output and BIM maximizes construction productivity by minimizing errors and identifying problems prior to construction process. Sustainability concerns the interactions, integrations and significant relationships among ecological, social, and economic systems (Shen et al., 2010).

II. Importance and benefits

The benefits of BIM include, increased productivity, elimination of field interferences, increased pre-fabrication, less rework, fewer requests for information, fewer change orders, less cost growth, and a decrease in time from start of construction to facility turnover (Ku et al, 2008). This paper will help to create attentiveness on sustainable buildings among owners, stakeholders and designers. The significance of construction industry to embrace BIM technologies and innovative planning to be competitive and meet clients need will be recognized. Integration of prefabricated modular systems, recycled and renewable material will be enforced to bring into effect. Integrating changes in technology and productivity with innovative planning of TQM to improve construction implementation will be the most beneficial area of the study. Since sustainability concerns the interactions, integrations and significant relationships among ecological, socio-economic systems. This paper also emphasizes on establishing a network to exchange information and creating an effective chain of co-ordination involving stakeholders. Innovation in construction planning and implementation will contribute to make Maldives build a sustainable, eco-friendly green construction industry. In complex construction projects, the design team and the project manager will visualize possible future events that might have an impact on the project. BIM will increase construction productivity and prefabrication with less rework. There is still much to be learned about the opportunities and implications of this tool (Kumar et al., 2009)

III. Conclusion

In order to pursue sustainability in the construction industry, existing development-focused construction activities must be transformed via a new paradigm. Construction industry must realize that results of implementing TQM will take ample time. Since it is long-term achievement rather than short-term objective, the industry should develop a culture that will support TQM. Thus it was studied focusing on sustainable development through the adaptation of sustainable policies by the government and dissemination of sustainable construction technologies. Recognizing the innovative nature of green construction at the policy level could lead to new approaches to governance of bottom-up community action for sustainable development. Also the TQM aimed at sustainability, are modeled as interorganizational innovation processes. In parallel with green technology and techniques, the involvement by the stakeholders should be the most important factor for the preparation of green specifications. In particular, the project feasibility study should allow more focus on the methods for improving project quality, safety performance and eco-friendly practice for the future (Lam, et al., 2010). Maldives will achieve sustainable buildings through interaction, integration and by identifying relationship between ecological and socio-economic systems. Therefore effective co-ordination and integration through BIM during building process in the Maldives will improve construction implementation and planning towards sustainable buildings in the resorts.

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