A REVIEW ON BENCHMARKING AUTOMATION IN CONSTRUCTION INDUSTRY

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Abstract - *This paper evaluates the earlier works in benchmarking, benchmarking models, and automation. Using various literatures the benchmarking models were analyzed and automation in construction industry were identified. This is for the future analysis of benchmarking automation in construction industry. Construction Industry is developing by the use of technology and it should be benchmarked. Benchmarking automation will increase the productivity of the company and also the efficiency in terms of automation. The study includes earlier works in benchmarking, benchmarking models, automation in construction industry, and the developments in automation. This study will help in benchmarking automation in construction industry.*

Key Words: Benchmarking1, BIM2, Automation3, Total Quality Management4, CSPB5, CII6, Business Automation7, Quantity Surveying8.

1. INTRODUCTION

There is a critical need for manages to increase company's productivity and performance. This can be helped by automation of construction industry. Construction industry is rapidly and continuously grasping new technologies and is dependent on computer technology and equipments as well. Slowly it is mechanised and computerised. Robotics in construction industry is now increasing in the field of execution. Due to robotics it is easier to gain need based feasibility, technological feasibility, and economical feasibility to evaluate benefits there by inviting future robotization for Indian construction sector [1] (V. S. S. Kumar, 2008). Automation enhances worker safety, productivity, efficiency and quality. It can be used in production, performance in dangerous environment, maintenance and operation. There is need for further innovations to address the upcoming demands in the construction industry. Benchmarking automation in the construction industry will help in increasing the productivity of the companies. It is relatively new concept that captured the interest of many business and gain popularity among the executives and the managers [2] (N. M. Lema, 1995). More and more companies are adapting automation, but for specific types of constructions as automation needs high investment value. Many contractors in India use labour force as India has a higher amount of manpower. Automation is emerging field in India, as most of contractors often use labour force to decrease their investment value. Benchmarking automation in construction sector will help the companies to grow and compare their skills and automation process and the areas where they lack with respect to the other competitive companies. It will enhance them to get high productivity output, high labour safety, accuracy and quality. Benchmarking automation in construction industry will make an efficient move in making high level of labour safety and performance of the companies.

2. PRACTICES IN BENCHMARKING

Benchmarking is done in many areas of construction industry. It is now very essential part of management. It have been occupied the areas like

2.1 Cost and Scheduling

[3] F. Deborah (1995) explained the process of benchmarking and steps taken by the roundtable. It stated that in the construction industry, tendency is to make an additional estimation of total cost by 8% and lessened the schedule by 8%, while change orders average +11%. It also explained concept of benchmarking and its classification. The Houston Business Roundtable is also discussed which explains their concept of process of benchmarking.

2.2 Total Quality Management

[2] N. M. Lema (1995) discussed the definitions, scope, types and application of benchmarking. It states that benchmarking is the tool that makes internal activities of competitive organizations to external organizations, till the date no any competitive potential has been brought in to limelight and makes an effective tool for TQM. The relationship between TQM and benchmarking is showed.

2.3 Safety

[4] S. Mohamed (2003) gives a way of balance scorecard tool for benchmarking organizational safety culture in construction. He explains the importance of this tool of scorecard as a medium to fragment the safety culture in management, operational, customer and learning to set a clear goal. Another belief made was many organizations may take lead to implement a BSC, to create their own baseline and they can benchmark them with other competitive organizations. [5] D. P. Fang (2004) identified the key factors which influence safety management and developed a method

for measuring safety management performance. A survey of 82 construction projects in china was done in order to evaluate a safety management index. Benchmarking with this index a safety assessment method was developed for 6 construction projects in china. They found that organization structure, economic investment and labour management relations relatively affected safety performance on construction sites.

2.4 Information Technology

[6] E. D. Love Peter (2004) explained IT in construction sector and also designed a questionnaire to find out benefits, cost and risk in IT investments for 126 enterprises in the Australian construction industry. They found that the investment done in industry does not depend on firm size. Strategic benefits and the employee adaptation for IT differ with organization types and firm size respectively. The benefit of adapting IT was to improve service quality and process flexibility. They concluded that benchmarking IT is an integral part of management to ensure improved IT performance in industry.

2.5 Productivity

[7] H. Park (2005) established a common set of Construction Productivity Metrics System. They focus upon a format for reporting norms for CPMS and explained the definition of productivity and productivity measurements in construction. They elaborated the concept of direct and indirect accounts and also developed construction productivity metrics which gave baseline productivity and a continuous productivity improvement through benchmarking. [8] Shehata M. E. (2005) explained construction labour productivity which includes definitions, aspects, measurements, factors affecting and techniques to measure it. By using these concepts project performance parameters (benchmarks) for a case study was developed. They concluded that to match the available load with capacity and maintaining workflow is very important aspect in productivity improvement.

2.6 BIM performance

BIM performance issues were to aware for all organizations, for that a variety of performance evaluation frameworks were designed to enhance technological maturity and capacity. [9] D. Jing (2014) developed a data collecting application of BIM performance from a wide range of users. It is also known as Building information modelling cloud score (BIMCS) as it is a cloud-based application. They utilized this software as a service that can identify their competitiveness with respect to BIM performance and used for collection, aggregation, and presentation of benchmarking of data gained from many users. [10] S. E. Mohammad (2007) also analyzed the measures of performance and the standards used earlier in construction industry and differentiated it with the modern construction performance practices.

3. BENCHMARKING MODELS

Benchmarking models were developed and explained as follows

CSPB model provides a framework for competitive strategic performance at an international level. [11] T. Ercan (2014) reviewed a broad literature on benchmarking studies and developed a competitive strategic benchmarking model. The key strategic performance parameter was identified. They divided parameters into competitive functional operational and competitive advantage indicators. Only Competitive advantage indicator factor has an alpha value of 0.5-0.6 which is considered poor acceptable. The binary logistic regression analysis was used to develop a scale. Development of this model helps to increase financial profitability, reduce the rate of errors and to benchmark the companies with other competitors.

[12] S. Lee et. al. (2005) explained about CII Benchmarking. This program was developed by CII which served as a third-party facilitator for the companies from a web-based portal system. It was to provide the industries with the common set of metrics and norms which will provide company tools for self-analysis. Quantitative confidential reports are provided to the company. It shows the owners their area of improvement for a specific performance metrics of interest.CII practices a real-time feedback with links which is truly benchmarking breakthrough by improving technologies.

Key performance indicators are used in the process of benchmarking. [13] F. Y. John Yeung (2013) assessed leading and lagging KPIs and apply reliability interval method for developing benchmarking model of a project in Hong Kong. They reviewed many works of literature and with the help of questionnaire survey evaluated KPIs to assess the success of projects in Hong Kong. Top three weighted KPIs were safety performance, cost performance, time performance with the weights 0.1086, 0.1058, and 0.1058 respectively with respect to RIM.

4. TRENDS AND PRACTICES IN BENCHMARKING

Benchmarking is a tool that makes companies to improve their performance continuously. Different analyses were made to find out and explore he trends of benchmarking. [14] R. R. Ricardo. (2002) practiced the first application of management evaluation system for benchmarking. They determined trends with the help of correlating the quantity evaluation from surveys. They explained the survey, performance indicators and quantitative benchmarking with the help of graphs. Correlation analysis between the process indicators and management dimensions were made which gave the conclusion that safety performance was highly related to companies having superior planning and control, quality management, const control and policies.

Benchmarking is often ended with an analysis which identifies the best practice but it is not implemented. [15] Richard E Belle (2000) explained all the best practices to the date. They also monitored the status of constructed civil infrastructure systems. They reviewed the data from nation-wide surveys and focused on specific areas of civil engineering currently on highest priority. They founded that the new level of commitment from the public sector is needed for industries to develop innovative business practices. Their main objective was to find out alternative means for developing benchmarks.

Performance measurement is very important in a construction industry. Still it is not practiced because of reluctant attitude and lack of training of managers.[16] D. B. Costa (2006) explained the scope of initiatives made by industrial groups for benchmarking programs and the lesson learned from that. They explained the role of performance measurement. They discussed the issues solved by analysis of benchmarking. National benchmarking systems for the Chilean construction industry was explained which consisted its initiatives like to implement performance measurement and to compare performance through meeting and visits. CIIBM&M and performance measurement system for Benchmarking in Brazilian Construction industry were elaborated. The kind of lessons learned were promoting training, practice exchanging, internal benchmarking, sharing information and discussion, etc. They recommended establishing a classification of performance measures developing a collaborative learning process.

5. AUTOMATION

It was necessary to use developing technology in terms of construction. The construction industry started to show interest in adopting automation because the technology was expected to develop productivity and working conditions as well. Automation started growing in the fields of construction as follows.

5.1 Automated wood construction cost estimation

Using computer technology can help to automate cost estimation with reducing subjectivity and improving efficiency and accuracy of cost estimation. It is mostly done by BIM but is limited to interoperability and full automation. [17] T. Akanbi (2017) developed a method for fully automated cost estimation in wood construction. They reviewed many literatures regarding the use of BIM. The challenges acquired in current practices of estimation were collaboration, inputs. They proposed a method which contained reading IFC files and extracting values for QTO computation, which succeeded with computing the quantities of wood members and to generate the cost of wall. They extracted quantities of wood building objects by expanding the fundamental geometric representation of wood building in IFC model.

5.2 Administration process in Highway construction

Automating the administration process helped in developing an effective communication system in between administrative project management levels which eliminates all the documenting process held manually. [18] B. Josie (2016) presented a web component that includes a mobile application in automating the administration process for highway construction. This web based component helped in daily inspection and reporting with mobile devices. The research team developed a framework for the web based extension which included daily activities report, daily inspection report, monthly progress report, the schedule report. The main advantage of this technology was to decrease in errors in data manipulation and the faster report generation and data transfer.

5.3 Business automation

Increase in use of ERP, BPA has significantly improved business efficiency and productivity. [19]D. Lee (2006) introduced a system prototype for automating construction business process by workflow and object technologies. This system has CBPM, RN, WFMS, WSD, and legacy data as their modules. CBAS prototype was developed with the help of JAVA. They contributed in the object oriented reusable component technology for model basic management task, task based modelling technology for creating business process models, request driving technology, and technology with workflow engine for automation of business.

5.4 Earth moving machines

Earth moving machines mainly include vehicles with a robotic arm on it. Wheel loaders are often used on construction sites. [20] S. Dadhich (2016) focused on the automation of earth moving machine such as wheel loaders and LHD machines. They assessed the problem by making a step towards full automation which included manual operations, insight tele-operations, tele-remote operations, assisted tele-remote operations, and full autonomous. The short loading cycle, operator assistance functions like path planning, loading algorithm, and dumping algorithm helped in breakdown of problems in automation. Earth moving operation required safe operation and performance. They provided the background for the problem of excavation and concluded with identification of knowledge gaps for autonomous operation of earth moving machines.

5.5 Quantity surveying

Quantity surveying has an important part in construction. Manual method of estimating quantity requires more number of professionals as it need high cost surveying and most of all accuracy is needed. [21] A. E. Mohammed (1999) developed a computer program. They used AutoCAD as a drafting tool as AutoCAD needs to know quantity for input. It consists of

AutoCAD, a calculating program and database for material specifications. This program is capable of estimating bill quantities and providing a practical tool for designers, owners and contractors during decision making process.

5.6 Tracking and locating of materials

One of the major problems in managing construction materials is to track and locate them on a large construction site. [22] H. Nasir et. al. proposed an implementation model which defined tracking and locating materials. It included many literature reviews and identified the need for automated material tracking. The need for automation involved a large number of materials, complex supply chain management, difficulties to track materials due to environmental conditions. Combinations of primary subsystem like mobile reader kits, fixed arrays of readers, portals or gates were implemented. Within these different implementations evaluation of options was done by analysis based on implementation evaluation criteria, benefit/cost ratio analysis, risk analysis. Based on this analysis benefit/cost ratio analysis ranged 6/1 to 10/1 if risk avoidance benefits were included.

3. CONCLUSIONS

The construction industry is still fragmented into low productivity, conflicted decisions, divided responsibilities. From this study it can be concluded that benchmarking has lead in increasing productivity benchmarking construction industry in terms of safety by easy detection in poor safety management and implementation of measures. It is easier to explore the business processes like benefits, cost and risk by the process of benchmarking. It is also used in improving performance and thus being a tool for mitigating conflicts claims and disputes in construction industry. Construction industry is mainly depended on labours and benchmarking labour productivity will help in enhancing their performance and productivity. Automation has also grown in the construction industry. It has conquered the areas like design, planning and now in construction process. Benchmarking automation will help in increasing the productivity of the machines, software, and many areas of automation in construction industry as a whole. It will explore the areas in which the industry lacks in automation and help them in increasing the quality of work and decrease time schedule.

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