# DECISION SUPPORT FOR TOWER CRANE PLANNING BASED ON BIM & OPTIMIZATION TECHNIQUE-A REVIEW

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**Abstract -** Site layout planning is exercised in early stages of project for allocating the temporary facilities and major construction equipment such as tower crane on site for improving the productivity and efficient utilization of workspaces. For transportation of heavy materials and machineries on building construction site many types of hoisting equipment are used but tower crane is popular among them. Reinforcement steel, formwork and shuttering, concrete, fabrication steel and other weighted equipment are mainly lifted by tower crane. Resources such as man hour, time, cost and energy are associated with each lift of tower crane, number of lifts by tower crane and model of tower crane. wrong Selection of tower crane position on site solely on the compilation of constraints, governing factors and past experience could lead to extra cost and even delay to the projects. Utilizing the modern BIM technology accompanied with optimization techniques can make the process of tower crane selection more accurate, logical and scientific. Main motive of this paper is to study the work done by researchers in the area of tower crane optimization for selecting the type, number and location on construction site.

**Keywords**: - Tower crane, BIM, Feasible Region, optimization method.

## I. INTRODUCTION

Men and machines transform a project plan into reality, and as machines evolve there is a continuing transformation of how projects are constructed. Machines are a vital resource to the accomplishment of a construction project. One of the most obvious problems in constructing a project is how to transport heavy building materials. Machines provide the solution to that problem and to solve a number of such problems there are variety of equipment's used on construction site for performing number of activities. Now it becomes the responsibility of the project estimator or the engineer to allot right machines and combination of machines at right position on site for minimum duration. Efficiency of the equipment is measured from the quality of the service obtained from its operation in compare to the cost incurred for its operation. Continuous efforts should be drawn to increase the efficiencies of deployed equipment.

Tower crane is a device used for hoisting and placing materials and machinery. It is used to facilitate handling of materials such as formwork, reinforcements, concrete and structural steel items. Many a times tower cranes are operating within the limits of time, cost and labor. Identifying required units and position of tower cranes is an important issue to be solved on the basis of qualitative analysis rather than taking decision only on the factors and the constraints governing it.

## II. TOWER CRANES SELECTION FOR BUILDING CONSTRUCTION PROJECT

In the present era projects under construction industries are becoming more mechanized and Automated. Subsequently, Material handling and hoisting equipment now dominates the building construction sites for achieving the desired productivity. Tower cranes are such hoisting equipment which are now becoming more conspicuous in Indian real estate industry which was far common in European countries for decades. Among the available alternatives in cranes, tower crane has gathered much popularity for high rise building structures and it is becoming the most selected choice by the project stakeholders.

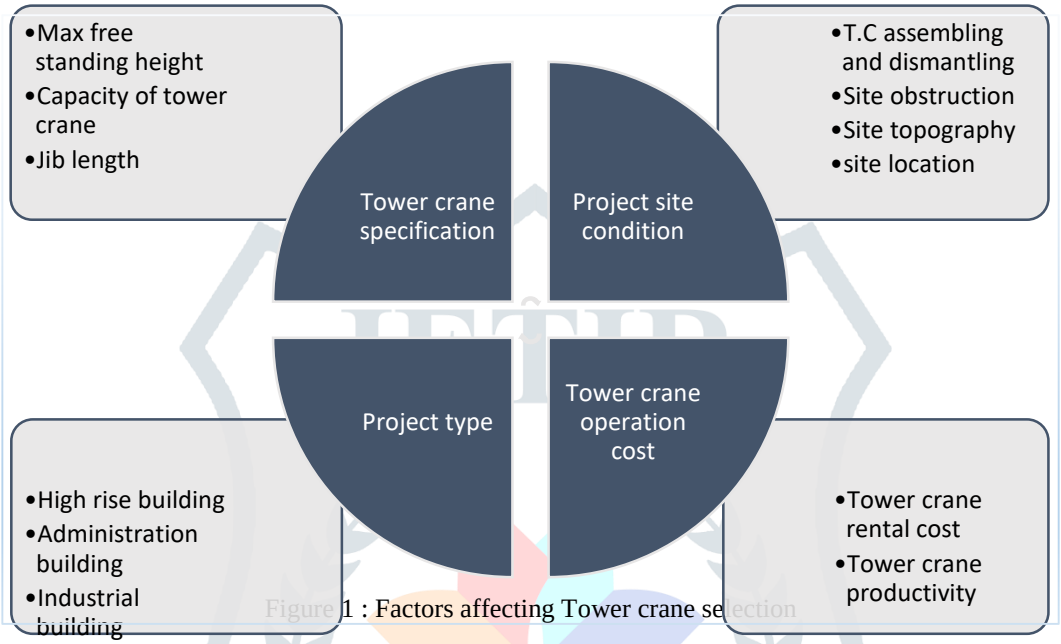


Figure 1 : Factors affecting Tower crane selection

**Doraid Dalalah et al. (2010)** defines decision as choice out of several options chosen after evaluating important factors and situation witnessed on site. A well framed structured matrix is to be formed in hierarchical manner with available alternatives to help the person in taking alternatives to the tower crane may include derrick and mobile cranes which are having slightly different performance properties. For Making the decision from building model An Analytical Hierarchy Process (AHP) was used. Software such as Expert Choices was used for arranging the experimental assessments. most of the focus is made on safety and site condition criteria among the AHP priority stack, hence an immense importance is given to these two criteria while carrying out the selection [**5]**

**Simo Sudic (2017)** overviewed and analysed major area of tower crane crane engagement analysis, calculation and management in high-rise building construction. They suggested that problem should always be analysed from the planning perspective as productivity and duration of crane engagement at the construction site have a considerable impact on various facets of construction process. For the optimal use of Tower cranes, project phases are to be appropriately defined, and the necessary units of cranes should be closely managed for each phase. For the approximate estimation of crane engagement duration, planning tools like Microsoft Project, Primavera, Asta Power Project were used. Maximum concrete poured per month = number of cranes x number of workers per crane [average number of workers per crane = 70] x production/worker/month Number of cranes = square meter of slabs poured per month/ average production per crane. Using methodology of supply and demand points, as well as an analysis of conflicted areas and bearing in mind calculated production rates, it was concluded that the proposed units of tower cranes was unnecessarily high and that there are many conflicted areas between cranes. In their case study by proper designing of the project in two different phases they have reduced the usage of tower crane from 12 numbers suggested by consultant to 7. **[15]**

**Ghang Lee et al. (2012)** This investigation presents a recently created crane route framework that gives three-dimensional data about the structure and environment and the situation of the lifted item continuously utilizing different sensors and a structure data displaying (BIM) model. framework quality was assessed regarding two viewpoints, "usability" and "handiness," in view of the Technology Acceptance Model (TAM) hypothesis. The crane route navigation framework was conveyed on a genuine building site for 71 days, and the utilization designs

were video recorded. The outcomes plainly demonstrated that the crane administrators depended intensely on the navigation system of crane route framework with visually impaired lifts (93.33%) contrasted with the content based anti-collision system (6.67%) **[6]**

**Yuanshen Ji1 et al. (2018)** in this study two things are integrated for planning of tower crane position on site that are rule based checklist and BIM modeling of either 2D or 3D model for visualization, this article intends to explore the provableness of combining parametric modeling and rule-based checking for the tower crane planning task. After conducting case studies on 6 building construction projects, which examined over 30 design alternatives, the research team identified major modules for design models. **[16]**

**Malaska, M. et al. (2013)** A special tower crane modeling and simulation tool, Tekla Structures was used by contractor into the structural BIM model. location and installation point of the crane was planned using the simulation tool. BIM models were in active use on this construction site and they have also been used for designing lifting operations. The precast concrete elements were modelled in different colors. The color depended on the self-weight of an element. For example, elements which are heavier than 10 tons were modelled in red. The tower crane was modeled into the BIM model and the lifting capacity curves were visualized on plan in the model.[3]

**Myunghoun Jang et al. (2013)** used augmented reality to select proper position of tower cranes. A protype in augmented reality was launched in smart device to examine the developed model. These researches used a laptop, computer that is heavier than a smart device. The development of IT (information technology) enables the smart device to replace the laptop computer. The model prepared in this paper employs a smart pad with a camera to develop a tower crane selection model in augmented reality. AndAR1, NyARtoolkit2, QCAR3 are tools to displaying a unique view in augmented reality on the Android based smart devices. Each tool displays 3D models overlapped on an image or icon called a marker via an attached camera. 3D Tower crane models were made and were easily visualized with help of SketchUp6 This research uses QCAR that provides augmented reality libraries for Eclipse. method developed in this paper to select tower cranes using augmented reality does not included the measures to minimize duration and cost for tower crane planning. **[10]**

**C. M. Tam et al. (2002)** used the most widely used machine learning algorithm in IT industry like ANN artificial neural networks for designing a model to improve the efficiency of key site facility i.e. tower crane operation on site. case study undertaken in this research was for high-rise public housing construction. For degerming the exact location of tower crane on the basis of supply and demand points served by tower crane. Resources such as time and cost are undertaken for its decision making.it showed how modern algorithms such as AAN and genetic can be used by construction industry for predicting the practical problem, evaluating it and finding the optimal solution for it**. [3]**

**Yuanshen Ji (2018)** framed a method for deciding the type of tower crane to be choose and other planning criteria related to tower crane just on the basis of regulatory norms formed by national regulatory institutes, standards followed by professional experts those who are knowledgeable and experienced and integrated BIM and optimized model. Finally, this research shows the combination of the formalized criteria and norms that are imposed on case study of building construction projects with the help of BIM and combination of parametric modelling and optimization algorithms can result in forming a model that takes less time for analyzing the optimal position and which gives more accurate results. Visualization can be great option in improving information quality for the planning process of any construction activity.**[16]**

### III. OPTIMIZATION OF TOWER CRANE LOCATION

Civil industry has always been project-oriented as well as affected by inefficiency and ineffectiveness. Limited attention has been paid in practice to develop mathematically based approaches which are logical and scientific in nature for optimizing any existing method. Site layout planning is practiced during the establishing stage of project. It focuses mainly on the short duration on permanent facilities and equipment for improving productivity and utilizing space on the existing site within limited workspace.

**C. M. Tam (2001)** In this study, it is been shown that how the random decision for plotting the tower crane position a supply location can increase the transportation cost for the construction project by almost 5-6%. For high rise building construction projects, tower crane and supply locations optimization is targeted, as they are the major site facilities. For simulating the site plan layout practically and decide the tower crane position along with supply point a is developed with genetic algorithm.**[4]**

**Amir Zavichi (2013)** found that any decision when depends on judgement and assumption leads to delay same is the case while operating the tower crane for delivering number of items repetitively and continuously on construction site because as material-handling scheduling is also done by the crane operator or by an on-duty superintendent using his/her personal judgment. Therefore, it becomes important to form a system that can help in taking a decision for the tower crane operation which takes care for real time constraints, quite dynamic to adopt the corrections and changes. this leads to longer operation times and a negative impact on project cost. This paper presents the latest operational optimal services to be followed by crane operator or the in-charge superintendent which can be directly implemented on ongoing project at site. This system has several advantages such as maximizing the efficiency of crane operations, guaranteeing the best operation possible to reduce the crane's travel time, reducing crews and equipment idle time, and minimizing the dependence on subjective human judgments.**[2]**

**Jun Wang et al. (2014)** The optimal tower crane layout scheme is calculated based on a static and hypothetical scenario. In this project, the installation of each tower crane is divided into five times. BIM is used to calculate the installation height of each tower crane at a time in order to reduce collision. Tower crane were installed at different heights at various stages of projects. This paper has developed a well-defined approach, which integrates BIM and firefly algorithm to come up with an optimal tower crane layout for construction projects. The results show that: (1) less time is needed to create a tower crane layout scheme compare with traditional method, especially in multiple tower cranes layout; (2) the optimal tower crane layout scheme generated by the proposed method is better than the original scheme in less total material transportation cost and collisions; and (3) field workers can understand and perform the tower crane layout scheme easily and accurately due to its visualization and interaction**.[8]**

**Javier Irizarry (2016)** This paper conferred a replacement approach for combining GIS and BIM that allows managers to ascertain the 3D model of tower cranes in their best locations. with abstraction analysis and visual image capabilities among one surroundings planned methodology utilized the idea of coverage of all demand and provide points to spot the bottom variety of tower cranes. Feasible areas for locating the tower cranes were classified underneath the criterion of decreased risk of conflicts between tower cranes and their surroundings. best locations are outlined as locations with bottom quantity of conflict. Considering the abstraction nature of the analysis being done, GIS not solely helps to ascertain the strategy statement in an exceedingly structured and standardized format, but also make it possible to link information from many different sources, in many different forms. Exporting he output of the GIS model to the BIM tool and generating 3D parts provided the model with the aptitude to simulate the operator's viewpoint. Therefore, it's potential to sight the potential conflicts in several 3D views. Commercial building project was used to illustrate the general methodology locations derived by the model, compared to the actual locations, resulted in a reduction of the conflict index by about 16%.[]

**P. Zhang (2014)** A computerized model to optimize location of a bunch of tower cranes is given. Location criteria are balanced employment, minimum chance of conflicts with one another, and high potency of operations. 3 sub models are given. First, the initial location model classifies tasks into teams and identifies possible location for every crane in line with geometric ''closeness.'' Second, the previous task teams are adjusted to yield sleek workloads and bottom conflicts. Finally, a single-tower-crane optimization model is applied crane by crane to look for best location in terms of bottom hook transportation time. additionally, to the improvement on safety and average efficiency of all cranes, 10–40% savings of total hooks transportation time can be achieved.**[14]**

**Zahra Sadat Moussavi Nadoushani et al. (2015**) that each tower crane consumes a fixed amount of fuel, man-hrs., maintenance for all its lift. It transports construction material, precast elements, machinery and many such things on site from supply to demand points which results in some operating cost for it. This paper apart from of crane hook travel time also take into consideration the cost bear for those lifting operations. Mixed-integer linear programing model is formed and implemented to live and hypothetical medium sized projects in order to optimize the problem of tower crane location at site and reduce the rental and operating cost for tower crane use.**[17]**

**H. Abdel-Khalek et al. (2016)** This paper aims at aiding the project planner within the choice of type and location of tower crane to be utilized on site based on the minimum total transportation time taken by tower crane for every cycle. Genetic Algorithms optimization technique is employed to resolve such a drag. A numerical example is conferred during this paper to elucidate the optimization technique.**[7]**

**T. Funtík (2016)** This paper had focused on the IFC file to compute the optimal position of tower crane on site by obtaining the data of all relevant parametric objects from IFC file. The proposed position is calculated from the perspective of the crane hook travel time, travel distance and length of jib needed to deliver all elements and

materials. Data obtained from IFC model are evaluated with workload curve of a tower crane to ensure constructability and safety.**[19]**

**Rongyan Lia (2017)** This paper analyses the relationship among attached tower crane, demand point and material supply point, then simulates the movement of hook travel. Based on mentioned above, an optimization model is generated in order to select the type of attached tower crane and find the optimal location of the crane and material supply point based on finding the minimal cost. Furthermore, to evaluate and visualize the outputs, simulating the layout planning to ensure the optimal scheme is feasible and guide the site manager fully understand it. Finally, this algorithm leads to a more cost-efficient result than the traditional method that determined based on experience.**[18]**

**Mojtaba Hosseinia (2017)** this analysis, they need projected a way to pick the appropriate form of crane and find the most effective place for crane erection supported a minimum radius for requested crane and minimum price. To fulfill the target, a computer program is intended to numerate these issues, demonstrating associate example explaining the way to apply the program and therefore the results are then discussed. **[12]**

#### IV. MAJOR FINDINGS

1. Tower cranes are considered most efficient equipment on high-rise building construction projects to perform lifting and hoisting activities
2. Tower cranes are primarily used for moving reinforcement, formwork, brickwork and concrete columns and for concrete pouring.
3. Construction managers face difficulties in planning tower crane operation on site as series of critical decisions are to be taken.
4. The planning procedures for tower cranes include selection, allocation and operation.
5. Location of the tower crane determines the travel time of transporting material between the supply and demand points and thus the operation costs.
6. Machine learning algorithms like Genetic Algorithms (GAs) and ANN artificial neural network are used to find the optimal solution for tower crane placement problem.
7. Building Information Modeling (BIM) helps managers to visualize buildings before implementation takes place through a digitally constructed virtual model
8. Adopting the optimization techniques average efficiency of all cranes can be raised along with 10–40% savings of total hooks transportation time.

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