

# SCHEDULING OF THE HEAVY CONSTRUCTION EQUIPMENTS ON THE SITE: A REVIEW

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**Abstract:** The competition in the construction industry has seen new heights as the companies are getting advances and using different strategies in order to make the project more economical and complete within the time frame to achieve greater success and profit in this competitive world. Scheduling of heavy construction equipments consume lot of time and hence affects the completion time of the project and the expenses used for working with these equipments. Lots of researches have been conducted over the years by different researchers and different algorithms, software's, techniques (DSM, CPM & BDM) were tried to make the working of machines and equipment more efficient so that project remains within time frame. Therefore, the need for this review paper is to review current research and to evaluate important points which can bring out a technique to improvise and develop a method to schedule the equipments to increase the efficiency in the work.

**Key words:** Scheduling, Heavy Construction Equipment, Construction Company, Efficiency, Competitive World.

## 1.1 INTRODUCTION

In the 21<sup>st</sup> century, the construction industry has been drastically evolved with time. Every year new technologies are getting introduced in the industry so that the construction industry can get benefitted and grow at a higher rate. Competition in the construction industry has increased a lot over the past few decades. So for the company to remain in the competition they have to improvise and advance their techniques, one of the major and most important aspect to grow big in this industry requires that the management staff and the work force of the companies are highly professional and their work is precise. The management of the resources and equipment is one of main factors which decide the fate of the company as if the resource management/resource allocation is not up to the mark then the company may face delay in the work and economical losses. So over the year's different researchers have introduced different theories, algorithm, and systems like DSM, CPM, Linear Algorithm, Beeline diagram method (BDM) and have also tried various combination of algorithms to enable the schedulers and the managers to successfully manage the resources, and prepare the schedule of the activities that are to be conducted during the project. However there is also

an important factor which most of the companies don't take into the account i.e. scheduling of the construction equipments. This research paper lays an emphasis on this topic and how can a site manager or scheduler manage the construction equipment's to their advantage without spending huge amount of capital making the project more economical. Different software's and technologies are now present in the market which can help in the management of the machines. There are still easy ways to manage the work force which are 1)to determine the usage of the construction equipment 2)specialization is required in using the machine or not 3)the maintenance and idle time is to be noted 4)whether to purchase/lease/rent an equipment 5)the time for which the equipment will be required at the sites 5)security and safety of the equipment's at the site. The project manager can make a project calendar for the equipment's so that it is easily available at the time of requirement. This calendar will also help in preparing deadlines which will help the manager to remember that the work is to be completed within the given time frame. Software's such as Microsoft project helps in managing this type of conditions and resource leveling. Construction schedule technology is also a very useful method which helps the manager in calculating the amount of time a

Activity will consume and in how much the activity will be completed. When the construction equipment's are handled right and are managed perfectly it helps in completing faster and on-time by eliminating all problems. But during the construction project there are some situations where problems occur which cannot be resolved easily, that's why some floating time should always be kept so that the project does not delayed and the project finishes on time.

## II. REVIEW OF LITERATURE

**Sou-Sen Leu, et. al, (2000)** according to the researchers the old techniques for managing the resource leveling has been proved inefficient. They used an algorithm based computational technique for the optimization of the drawbacks related to the resource leveling. They laid an emphasis on the implementation and the requirement of the usage of the resource planning and leveling. He recognized that these analytical methods were not applicable in every construction situation. So the researchers researched on a new approach i.e. genetics algorithm to overcome the drawbacks of the heuristic methods. This algorithm was used to reduce the resource utilization and to finish the project within a time frame. The researchers found that although the Genetic algorithm has its own imperfections, but nevertheless it surely resolved the problems that were faced in the heuristic algorithms.

**EDEM O. P. AKPAN, (2014)** in this paper, the author showed concern on the utilization of the resources in the construction industry and to develop a method in achieving optimal condition for resource usage by avoiding deep valleys and high peaks in the project resource profile. Therefore, the author used a technique known as 'Resource Smoothing' so as to minimize the cost usage for making the project more economical. This technique follows a simple concept with a simple variation i.e. cost of the activity in question is considered. This process is continued until all the floats are exhausted. This process is used by the author as most of the construction companies face problem in establishing the optimal resource

utilization. As a result, of the experimentation it is found that the method is of great use in resource levelling. The results obtained are far better than the traditional existing techniques.

**Amr A. Oloufa, et. al, (2003)** in this paper, the author discussed about the different combination that different researchers experimented with CPM for the optimum utilization of the resources and scheduling of the construction. However, the combination always displayed some drawbacks and could not be used at every construction site. The author came up with an algorithm which was a combination of DSM & CPM. The author chose DSM system as it can handle parallel, sequential in addition to coupled activities. The aim of this algorithm was to optimize the planning of designed project. During the research it was observed that the combination of the process can lead to increased initial cost and duration. After the completion of the research it was concluded that as the two tools (CPM & BDM) are powerful tools for project scheduling, so the combination of such two tools will be overpowered that can lead to huge benefits to economical, managerial and technical sections of the project. It helps in providing a useful insight of the project work in easily workable and manageable form and indirectly benefits the contractors and the project team. This leads to minimization of the rework to be done on the sites which benefit the companies as the competition is very tough.

**Heng Li, et. Al, (2009)** in this paper, the author brought up issue that traditional way of scheduling had some drawbacks, and the computer-based technology had some benefits but the limitations were also present. So in this research paper, the author introduced an advanced technique i.e. virtual prototyping that enabled the project managers in visualizing the construction activities via computer simulation. The author used virtual prototyping in order to optimize the scheduling process of the construction by analyzing resource allocation, planning with integrated construction structure. The author researched on a real life case study in order to resolve the problems faced during the scheduling of the project. As a result, it is seen that the VP system is capable for the specified purpose and analysing of the resources allocation like allocation of tower cranes and space to avoid collisions and allocating problems faced during the use of traditional techniques. It was also noticed that the VP system helped the managers in dealing with problem of delaying in the construction period.

**Khaled El-Rayes, et. al, (2009)** this paper shows that the author pointed out the flaws and drawbacks of the of the network scheduling techniques which can lead to undesirable fluctuation in the resource allocation making it impractical to and inefficient to be used on construction sites. For resolving this issue, the author introduced two innovative resource levelling metrics that helps in directly measuring and minimizing the negative impacts caused due to resource fluctuations on construction productivity and cost. The first metric deal with the amount of fluctuation in the quantity of resources during high and low demand periods. The other metric is used to measure total no. of idle and non productive days that is caused due to resource fluctuation. The results display a drastic difference in the output as the metrics outperformed existing metrics and also eliminates resource fluctuation and idle time of the resource.

**Seon-Gyoo Kim, (2012)** in this paper, the author discussed about the traditional technique i.e. CPM and how it could not be used for scheduling in every conditions as it had drawbacks. The author gave a detailed explanation on how the Arrow diagramming method and Precedence Diagramming method were unable to represent all the schedules within a hierarchy in same formats. So the author proposed another technique i.e. bee line diagram technique for enabling the schedulers to schedule the work at the project without any major problems in a real construction project. The author made four different combinations that connect the starting and ending points of the two activities. As the research progressed it was noted that ADM&PDM techniques were unable to show the relation when the two activities in the hierarchy overlapped each other. On the other hand, the BDM technique showed exceptional results in scheduling within the schedule hierarchy of the activities in the project while following the same format as CPM.

**Hong-Hai Tran, et. al, (2014)** in this paper, the author discussed on the fluctuations caused due to the traditional critical path method which make the projects not only impractical but also costly for the contractors to execute. The author, proposed a new approach for resource leveling, known as resource leveling based on differential evolution (RLDE). The author researched that the competition in construction industry has increased over the years and survivability of the contractor essentially depend on his capability to manage the resources. The author found out that the RLDE method demonstrated that it can overcome commonly used Microsoft Project software's and other algorithms. This software displayed that it has potential of helping project managers and schedulers in management of the resources and resource leveling.

**Sharmin Khan, (2016)** in this paper, the author discussed that various methods, techniques and programming have been done over the years to increase the efficiency of the on-going of the work in the project and to make the optimum utilization of the resources. So the author did an experiment in two stages. Firstly, to check from the point of view of view of constructability a list of thirty activities were gathered. Then, these thirty activities were surveyed with a sample group of thirty architects so that the data related to their dependency are collected. After the data is collected, the result is then used by the author to form a Design Structure Matrix (DSM). This paper issued by the author to display the different advantages of using the DSM techniques. The result displayed showed that the DSM technique is very efficient in solving the complex construction projects.

**G. Emre Gurcanli, et. Al, (2016)** in this paper, the author laid an emphasis scheduling work of the heavy equipments as the delay/fault in the usage of these equipment's not only affects the project schedule or activity but also the cost of the project. For this specific problem, the author used and applied 'Monte Carlo' simulation technique which was used to calculate the productivity of the work at the construction site with specific parameters. During the research, the author observed that the Turkish construction industry had a very poor structure for managing the equipment's at the construction site. It was found out that they basically relied on the daily report from machinery department and extrapolation for future construction

work. After the implementation of the Monte Carlo Simulation, it was observed that it can not only be useful in calculating wide range of probabilities but also the errors in The project can be decreased. It was also evaluated that this technique is also beneficial in cost and productivity estimation of the project in order to make the project more economical by using the past data generated for the productivity and budgeting.

**Xue Liet.,et. al, (2016)** in their study to modernize the construction industry by using new and advanced software's (BIM & BIM 5D) to increase the efficiency of the scheduling of the project and in order to minimize the obstructions in the construction industry. They also researched different ways to monitor the flow of funds and usage of capital at every stage of the project. At first they discovered different major issues that were encountered during the implementation of the schedule at the construction site. After this process they discovered different aspects related to BIM & BIM5D software's and advantages related to their use. It was realized that the usage of these software's increased every year in the construction industry at a rapid rate. They also discussed about other software's also and their potential in increasing the accountability, efficiency and project and management. The researchers also discussed about the potential usage of 3D scanners and printers and RFID's and how they can be productive in the material entry scheduling of construction.

**Clyde ZhengdaoLi,et. al, (2017)** in this research paper the author, had developed a combination of the Radio-frequency identification device (RFID) and building information modeling(BIM) in order to resolve the problem faced by the Hong Kong government in providing Prefabricated House construction(PHC) to the population as they could not afford the highly expensive properties. Due to high cost of labor and resources the manufacturing of the PHCs were transferred to the outer area. This also had drawback as the delivery of projects delayed due to discontinuation and other reasons. So firstly, the authors determined the schedule related risks. After the identification of the risk was completed, the integration of the two methods was initiated. This integration of the two techniques (RFID & BIM) helped in improved in the track-ability and traceability of the work and visualization of the project resources including labour, equipment's and materials are realized by RFID enabled SCOs. With the help of these advanced technologies the real time information transfer efficiency among BIM system and on-site works improved.

**Hua Ke (2017)** in this paper, the author figured out a problem in which while scheduling a project if 'n' of indeterminacies comes into play, the schedule made for the resource levelling can hardly be executed as planned and the schedule may become not feasible. So the author made an imaginary situation with uncertain resource levelling problem in which the time duration are estimated by the experts. For this, the author had experimented with three uncertainty-theory-based project scheduling model to form an algorithm to search schedules for the problem. After the experimentation the author after considering the uniqueness of projects, it is observed that some activities are seldom or never executed before. Secondly, fuzzy set theory

may show counterintuitive results. Thirdly, to satisfy the demand of managers, we discovered that makespan does not correspond with larger resource fluctuation cost for RLP (Resource levelling Problem).

**Purva Mujumdar, (2018)** in this paper, the author displays his concern on the traditional techniques and their drawbacks which unable the project managers and schedulers for making resource levelling as these heuristic techniques fail to detect or show multiple overlaps in the schedule. So the BDM technique is chosen by the author for the representing multiple overlaps for construction project. Although there were certain drawbacks of BDM technique as it failed to distinguish partially criticality of entities. So the author is finding an alternative analysis for BDM for interruptible execution. After the study and research done by the researcher it was observed that although BDM had some drawbacks it highlighted the salient features of interdependency, iteration, overlaps along with their interconnectivity.

**Seon-Gyoo Kim, (2018)** in this paper, the author displayed the importance of line diagramming methods for scheduling the project in order to achieve optimal utilization of resources and to complete the project on time. However it was noticed by the researcher that these line diagram had drawback which led to delay of the project work. This technique could not express the relation at the exact point of interrelation if the point lied in between of the activity duration. So the author implemented a bee line diagram technique for resolving the problems faced during the use of the above line diagrams. The author after using the BDM method in a project observed that the BDM technique can overcome all the problems and inefficiencies faced during the use of PDM&ADM technique. The author hence concluded that the BDM can help in establishing more realistic schedule for the construction project.

**Guofeng Ma, et. al, (2019)** this paper displays an issue that was identified by the researchers i.e. rework in the construction industry where all the other traditional techniques used to make schedules for the project failed. So in this paper, the author implemented critical chain design structure matrix (CCDSM) in order to solve the issue. The author used a max-plus algorithm in CCDSM to convert a complex logic relationship into simple matrix, reducing computational load of schedule generation. The author surveyed 381 projects conducted by 51 company and came to conclusion that 80% pf the project required Client-Related Rework (CRR). The author after the case study discovered that the CCDSM method outnumbered the CCPM-base technique on the basis of performance ensuring the competition of the case project that was faced during the rework project. In addition to the DES method, the CCDSM performed way better by providing smaller project duration with the same probability of on-time project completion.

**Avinash Pallikere et. al, (2019)** in this paper the researchers proposed a binary program for making an optimization model to create an actual occupancy algorithms or pattern for different sections in the building as well as the machines and equipment's used in the building for determining the optimal schedule for every machine while maintaining a lower service level. Then the data is simulated into optimization framework, where both the data i.e. historical occupancy data are used to determine the optimum frequency of schedule

updates. This also helped the researchers in developing a way in getting best design options for new buildings or the buildings that are to be retrofitted. The researchers discovered important practical insights of improving the common practices that follows the same routine or schedule for all the equipment's in the building automated system (BAS). This furthermore helped the researchers in concluding that the design options eventually depended on the minimum required service level. This research paper also helped in illustrating the need of updating and modifying equipment schedules according to the change in seasons throughout the year.

**Juan Diego Garcia-Nieves<sup>1</sup>, et. al, (2019)** in this paper the researcher has discussed about the usage of multiple linear progression model in order gain information related to the project for the practitioners. The researchers studied and came to a conclusion that the traditional techniques were criticized on their lack of efficiency to help the schedulers in managing the resources and time allocation of the work. Furthermore, these techniques failed to integrate resource continuity and to provide poor or no information about the location and the crew execution. So the authors, in this paper did the experimentation on the linear programming and to modify the flaws and limitations in the model which is to be used for resource allocation and scheduling of the work in order to increase the efficiency of the project work. After the experimentation work it was noticed that the projects with repetitive activities nature have demanded for the need of new algorithms and techniques that fully take the advantage of all the time and space information linear programming technique can offer. The authors found a mathematical algorithm that helps the schedulers in order to solve the resource allocation problem with repetitive activities in construction projects considering multiple methods of execution.

**Atilla Damci, et. Al, (2019)** in this research paper, the author displayed the importance of management of the resources equivalent to scheduling process. The author brought up a method so that managing of the resources and schedule can be done together with precision. The float method used to delay non-critical activities to their available float time. The author discovered two ways of the resolving the issues 1) Resource allocation 2) Resource levelling. The main objective hence was to develop a resources levelling model in which the scheduler could assign float consumption rate to each activity in order to achieve a balance in resource utilization and schedule flexibility. The research displayed an outcome in which it was observed that no new software is required for this process as the scheduler can use the Excel-based resource levelling Model. It was observed that the model provide a smoother resource histogram while Maintaining the schedule flexibility.

**Amin Alvanchi, et. al, (2020)** in this research paper the researchers were focused on reducing the release of harmful gases into the atmosphere near the on-going construction site caused by on-road traffic. They studied an on-going project in Iran where the situation was appropriate and was located in an urban location. They studied the execution of the work at the site and schedule which it followed. The accumulated all the

data related to construction timings and working hours. This helped to develop an alternative framework of the project so as to ease the flow of traffic near the site as to reduce the emission of harmful gases which caused air pollution and the potential risk to the locality which could be directly affected by the pollution. The researchers used computer based software's which helped in the micro simulation to tackle the on-road air pollution. In this the researchers made no assumptions in this scenario.

### III. CONCLUSION

In this review paper, the main objective is to figure out a way to schedule the construction equipment's so that the equipment's can be utilized up to their full efficiency. This will help in lowering and minimizing the overall delays and economical losses. In this review, it is seen that the researchers over the period of time came with different methodologies and algorithms in order to minimize the delays and increase the efficiency of the machine and decrease the economical losses. Resource allocation, Resource levelling, DSM, Bee Line Diagram and other techniques like CPM & CCPM, Building Automated System (BAS) were applied on different construction sites & questionnaires were prepared to check the efficiency of the different techniques. As a conclusion it is found that, there is still some areas and fields are present where changes can be made and improvements can be introduced in the research so as to save both money and time of the companies. The aim now is to figure out and assess all the situations that occur on a construction site including all the risk factors and reasons of delaying of the work and eliminate the factors to fasten the work force without any circumstances and delay.

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