TIME REDUCTION TECHNIQUES AND MANGEMENT IN CONSTRUCTION OF HIGH RISE STRUCTURES

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ABSTRACT

High rise structures are buildings that have to be constructed using particular methods and techniques as various factors from the load of the building to the finishing required is quite different from other buildings. Delay or time overrun will affect all parties involved in the project. It will affect the profits which would be obtained if the project can be completed on the schedule. But due to the time overrun, contractors had to spend more money on labor, plant and may lose the opportunity to get the next project. Hence, effective time management is very important and crucial to achieve successful completion of construction projects. Hence, there are numerous time management techniques and software packages used for construction of high rise buildings worldwide. Each of the techniques has different functions and process in providing a list of dates on which certain item s are to be completed. The main controllable causes of the projects time and cost overruns include formulation, Planning and Contract administration failures. A section explaining all the related techniques or methods and available software packages used for time management are in capture. A designed model was used on an Industrialized Building System (IBS) components or products (off-site) other than the conventional method usually adapted in-situ method, Microsoft project was used for the analysis were constructability check was done and work breakdown structures were also adopted which basically analyzed improvement involving reducing the production time, identifying and eliminating unnecessary wet works, which is can optimize production line according to a specific layout. Findings from the research revealed labour productivity must be given extreme importance in calculating activity duration and for its improvement, The relationship between the tasks should be identified by defining the predecessor/successor relationship between activities and the constraints and understanding the techniques involved in scheduling, Identifying the possible cause of delay and a quick solution should be anticipated in event of occurrence.

KEYWORDS: SCHEDULES CLASSIFICATION, TIME REDUCTION TECHNIQUES, TIME MANAGEMENT TECHNIQUES, WORK BREAKDOWN STRUCTURE, WORK SCHEDULING FUNDAMENTALS

1.1 INTRODUCTION

Time is the most precious asset available to man which cannot be stored, recovered or transferred (Adebisi, 2012). Every human activity uses time, but time is limited in supply i.e. we have only 24 hour in a day, 7 days a week etc. So the supply of time is perfectly inelastic, and due to this nature of time, need for optimal utilization of time is imperative (Odumeru 2013). Time management is the act or process of planning and exercising conscious control over the amount of time spent on specific activities, especially to increase effectiveness, efficiency or productivity (Buck, Lee et al. 2000).

This specialization requires more focused project planning and controlling techniques that prove to be better for certain type of projects while providing specialized construction services. The benefits of effective planning, scheduling and control of construction projects are to reduced construction time, reduced cost overruns and the minimization of disputes. These benefits accrue to the contractors, owners, suppliers and workers in the form of improvements in productivity, quality and resource utilization. Time management is important in any construction project. Without proper time management, many problems will occur such as extension of time or time overrun. Some of the researchers describe time overrun as delay and some of them describe that the time overrun is an effect from the construction delay, no matter what it was described, time overrun become the most general problem in construction industry worldwide. Client Inaccurate budget cost estimate, Client or the owner estimates, depending upon the purpose, can be categorized into the project proposal indicative cost estimate, preliminary estimate for budgeting costs, detail estimate for controlling costs, definitive estimate to assess cost at completion and the final closure cost estimate. The types of estimates, their nomenclature and the methods of estimation vary considerably.

The multiple problems arising from such project delays are usually aggravated by their cost implication. Overheads incurred by all participants, as well as the potential claims for progress disruptions by contractors, and/or liquidated damages by clients are the most common consequences. Recent time savings by reducing a 6-day floor concreting cycle to a 4-day cycle were not dependent on new technologies, but on reprogramming and tighter controls (Maria 2000). However the potential impact of innovative technologies and construction methods on a step-wise (rather than gradual) reduction of overall construction times cannot be disregarded. However, the usual increased cost of new technology has to be balanced with the need to achieve reduced times. Recognizing 'construction time performance' as critical, many investigations have been focused on factors that reduce the overall duration of the construction process of tall buildings.

High rise structures according to building code of Hyderabad, India gives it definition as a four floors or more building or 15 to 18 meters in height, while Emporis a real estate data mining company with headquarter in Germany defines it as a multi-story structure between 35-100 meters tall or a building with 12 to 39 floors. They also are buildings that have to be constructed using particular methods and techniques as various factors from the load of the building to the finishing required is quite different from other buildings. These methods and techniques have to be fast enough to complete the project on time and make it a success. Unfortunately, the methods and techniques we have been using have not been able to achieve project completion on time and one of the major problems in high rise structure construction is project delay which results in cost overruns. Of all the activities in the project of development of a high rise structure, the execution of the structure takes up the major time involving process. Today we have endless possibilities in any field because of the major technological advancements the same can be said for execution of buildings.

2.1 LITERATURE REVIEW

Construction management is a professional service that uses specialized, project management techniques to oversee the planning, design, and construction of a project, from its beginning to its end. The purpose of CM is to control a project's time, cost and quality. Construction Management is compatible with all project delivery systems, including design-bid-build, design-build, Construction Management At-Risk and Public Private Partnerships. Professional construction managers may be reserved for lengthy, large-scale, high budget undertakings (commercial real estate, transportation infrastructure, industrial facilities, and military infrastructure), called capital projects.

2.2 TIME REDUCTION TECHNIQUES

The two commonly used techniques for reducing time overruns are ‘compressing the critical path’ and ‘determining time cost function for trading time with cost’. The time and cost functions enables crashing of project time at the least cost.

2.2.1 Time Compression of Critical Path

Time compression is the process of reducing the project completion time without making any appreciable change in the cost activities. It involves splitting (wherever feasible) of the critical activities into smaller activities, either by using different methods of execution without any appreciable change in resources or by changing to lower levels of activity details. Some of these smaller activities may form a chain of activities while others may be parallel. Generally, it is the parallel component of the critical activity that is responsible for compressing the project’s

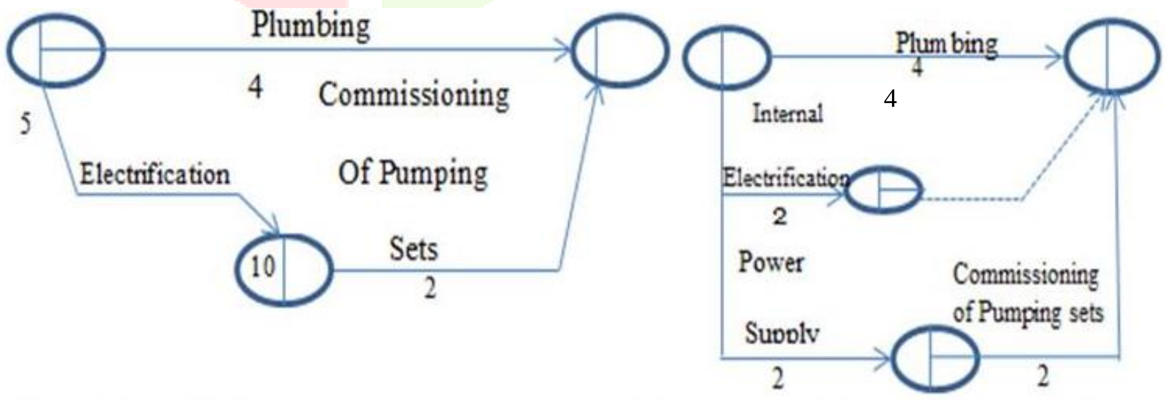

Fig 2.1: Part of the network showing the significance of resolving an activity 5-10 into two parallel activities

The network showing time compression of critical activities reduces the project duration from 41 weeks to 35 weeks, and the new critical paths resulting from time compression are shown above.

Time Compression of networks can also be examined by reviewing lead and lag logic and constraints imposed on the network.

2.2.2 Time Crashing Technique

Normally, completion period of a project should be determined from the network. The question of increasing the project duration beyond optimum completion time should not arise as it will add to the project's overhead cost. But some of the circumstances listed below may compel to set the project's completion time objectives lesser than the analyzed completion time:

- To meet the management's need for the early completion of the project with acceptable cost to be paid for gaining time;
- To avoid delays which may attract heavy penalty or loss of goodwill;
- To venture on another project;
- To earn bonus for early completion if found feasible;
- To transfer the resources needed elsewhere; and
- To conform to a given resource's availability schedule.

The project cost curve which shows the pattern of cost variation with time, provides a ready reckoner for assessing the increase in cost of the given project's duration. All crash point corresponds to the possible maximum time crashing.

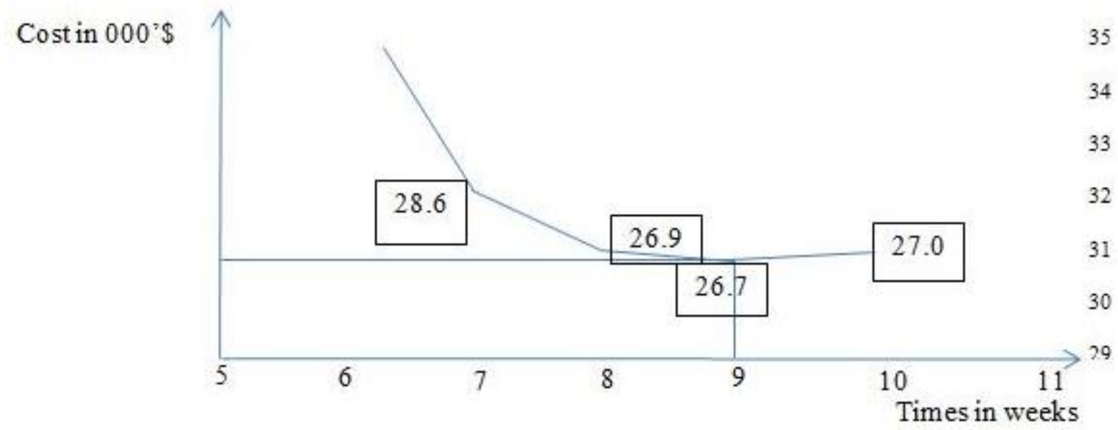

Fig 2.2: Time-Cost Trade-off Function

But the technique of minimizing cost by crashing of activities, although mathematically feasible as explained, has great inherent practical difficulties. One of the main reasons in that it is not possible to predict activity cost-time data accurately. In addition, the advantage gained by economizing the project cost is nullified by the fact that optimization of resources becomes extremely difficult, resulting in increased cost and idle resources.

2.3 TIME MANAGEMENT TECHNIQUES/METHODS:

Time management is one of the keys to effective project management as weaknesses in the time management will cause delays in project completion. Hence, time in construction projects need to be controlled from the beginning of the construction process until the project is totally completed. The time scheduling methodology varies with the nature of projects. Simple projects can be scheduled using the 'bar chart methodology', whereas, complex projects need project network to prepare a schedule. Broadly the work schedules can be categorized into Bar Chart Schedules, Network Based Complex Projects Schedules and the LOB schedules for repetitive project. The types of schedules vary with the nature of project, time, and resource constraints.

2.4 WORK SCHEDULING FUNDAMENTALS

Work scheduling serves the following purposes:

S. NO.	Nature of Project	Planning Techniques	Schedule Displaying Techniques
1.	Simple projects a. Non repetitive work b. Repetitive works	 Bar Chart LOB	Bar chart LOB/Bar chart
2.	Sub projects a. Deterministic b. Probabilistic	 CPM PERT	Bar Chart Network
3.	Complex projects a. Non repetitive works b. Repetitive works c. Probabilistic	 PNA PNA PERT	Bar chart and T S Networks LOB and Bar chart Networks

Table 2.1: Commonly used time planning technique and schedules techniques

2.5 SCHEDULES CLASSIFICATION

Broadly the work schedules can be categorized into Bar Chart Schedules, Network Based Complex Projects Schedules and the LOB schedules for repetitive project. The types of schedules vary with the nature of project, time, and resource constraints.

Example of network-based projects. Consider the Network of Site Development Project, it contains 12 activities, labeled A to L, where each activity requires one machine per day. Time and resource constraints in this work can result in varieties of schedules.

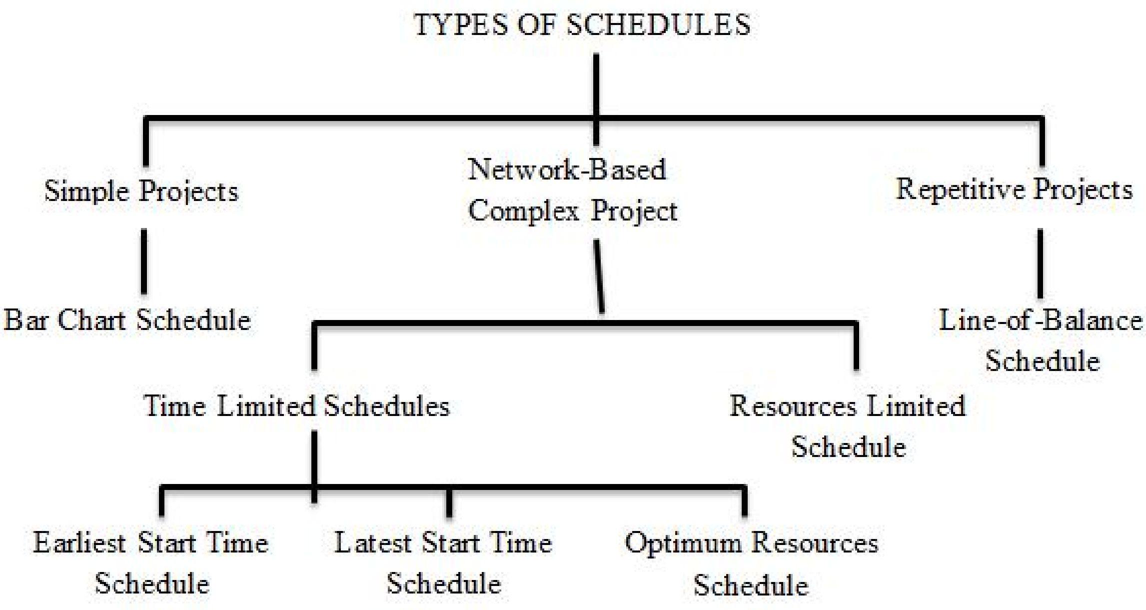

Fig 2.3: Schedules classifications

Earliest start time (EST) schedule. It is based on earliest start dates of activities as determined from network and shows daily requirement of machines, when all activities are scheduled according to their EST.

Smoothened resources time schedule. It is based on employment of resources in a manner that smoothen requirement of resources by evenly distributing their employment over a time period; and minimizes peaks and valleys in the resources requirement profile.

Note: Resource optimization implies scheduling of resources according to a given pattern of their availability.

Resources limited schedule. It is based on availability of three dozers instead of four dozers that are needed for smoothening resources.

Note: in this case the time duration of the project has increased from 20 weeks to 24 weeks.

2.5.1 Bar Chart Method

Simple projects can be scheduled directly in the bar chart format by experienced hands. However, it is the network plans of complex projects and large size repetitive projects that needs to be scheduled using scheduling techniques. Nevertheless, all time schedules are finally presented in the format of bar charts.

In the bar chart method, work is first split into activities and then these activities are listed in the order of their construction priorities, generally on the left hand side column, while the time scale shows project calendar, which can be plotted horizontally on the top and / or bottom of the chart.

The chart can be vertically divided into two divisions. While, the left division group activities are generally listed in the sequence of their execution and contains the data relating to activities, on the other hand, the right division depicts calendar and bars of scheduled activities.

- Activity description, data and calendar – this is a commonly adopted sequence;
- Activity description and calendar – this is used where data is omitted;
- Calendar with activity (or work package or task) only with description written inside or at the end of the bar – it is particularly useful for making a schedule for a large project; and
- Data followed by calendar with description inside or at the end of the bar- this facilitates scheduling of long duration projects.

2.5.2 Network based complex project scheduling techniques

Significance of Floats of an Activity in Scheduling Network

In complex projects, activities are sequenced using network techniques. A time analysed network depicts the start and completion times of critical and non-critical activities. The difference between the early and late time of a non-critical activity is called as 'float' or 'total float'. Critical activities by definition have zero floats (or defined least floats). Floats provide the time margins, which can be utilized during scheduling of activities without affecting the time objectives for optimizing resources utilization.

2.6 WORK BREAKDOWN STRUCTURE

The work breakdown structure (WBS) of a project is one of the most valuable tools of project management. It is designed and created during the initiation and planning phase. WBS finds wide and varied applications in the various phases of a construction project from inception to close out. It forms the basis for defining the scope of work and change request, identifying activities, developing time schedule, structuring the organization, assigning responsibilities, organizing costs and budgeting, monitoring performance, codifying systems, organizing data, managing information flow, closing project on completion and analyzing the sources of risks.

The current WBS definition has the following implications when applied to construction projects:

- Deliverable orientation. The deliverable orientation includes both internal and external deliverables. The deliverable orientation implies a given configuration of deliverables and shows a unique and verifiable process, product, service or a combination of these that must be completed to achieve the specified outcome.
- Hierarchical decomposition. Decomposition is a planning technique that subdivides a work scope component into meaningful smaller unit (similar to a parent child relationship in a family), which can be easily understood, verified, and monitored.

- 100% Rule of work scope. This rule implies 100% of the scope of work must be included in the WBS. It means the decomposition of all deliverable is processed till the complete scope of work is linked in the WBS; and all the deliverable can be easily understood, planned, monitored, verified, and accepted. The WBS should not include any work that is not within the project scope.

2.6.1 TYPICAL WBS APPLICATIONS

2.6.1.1 Managing Project Scope

WBS is a simple basic tool that defines the entire scope of the project. WBS separates items of work into deliverable components and establishes the relationship of the deliverables with the scope of the project to be completed. WBS creates a deliverable oriented hierarchical top down structure that provides the view of the entire project work scope.

2.6.1.2 Managing Project Time Schedule

WBS is the basis input for developing project time schedule. It is the backbone for developing and managing the time schedule. The deliverables in the WBS are decomposed into tasks, work packages and activities. It enables identifying, arranging and listing the project activities in a sequential order. WBS simplifies time progress.

2.6.1.3 Managing Project Costs

WBS aids in developing a hierarchical view of cost breakdown. It helps in costing, cost planning, budgeting, accounting, monitoring and controlling costs. Such structures are used for developing a cost codification system in BOQ, bill of materials and accounting cost.

2.6.1.4 Design Organization

2.6.1.4.1 Structuring the organization.

WBS indicates how the project organization structure can be designed and how the reporting structure can be established.

2.6.1.4.2 Assigning Responsibilities.

WBS is cross-referred with organizational functions to define individual and department assignments in the Responsibility Assignment Matrix (RAM). WBS pinpoints individuals responsible for a given work assignment. Name of the responsible persons can be entered against each work element in the WBS.

2.6.1.5 Data Codification and Organisation

A project organization handles large varieties of data. This data includes activities, resources, costs and documents. The project management system is codified primarily to serve a four-fold purpose:

- To identify the data connected with each work package and activities, as these form the data base for managing various project functions.
- To aid in the organization of data into various levels of WBS, management and functional units.
- To computerize the data processing system.

3.0 METHODOLOGY

The researcher identified time reduction and management technique in the construction of high rise structures by using a designed model that will be used on an Industrialized Building System (IBS) components or products (off-site) compared with the conventional method usually adapted in-situ method. The study basically analyzed improvement involving reducing the production time, identifying and eliminating unnecessary wet works, which can optimize production line according to a specific layout or even less speculated time. The following steps were used:

- Using Revit, an Industrialized Building System (IBS) products (off-site) compared to the conventional method usually adapted in-situ method to design a G+25 High Rise structure Model, each floor having a 4 Bed room Apartment and two 3 Bed room apartments.
- Microsoft project software was used for plan and assigning resources to tasks, tracking progress and analyzing the workload.
- Developed a work breakdown structure of all basic construction activities for the developed model

3.1 Constructability checks for Model and Activity Schedules

Constructability is a project management procedure to analyze construction process from start to finish, during the pre-construction level. It is to spot the difficulties before a project is truly constructed to cut back or stop errors, cost overruns, and delays.

4.1 IMPLEMENTATION

The implementation of the methodology of research which identified time reduction and management technique in the construction of high rise structures and labour reduction has been detailed as such.

- Revit, an Industrialized Building System (IBS) products (off-site) compared to the conventional method usually adapted in-situ method was used to develop a High Rise structure Model.

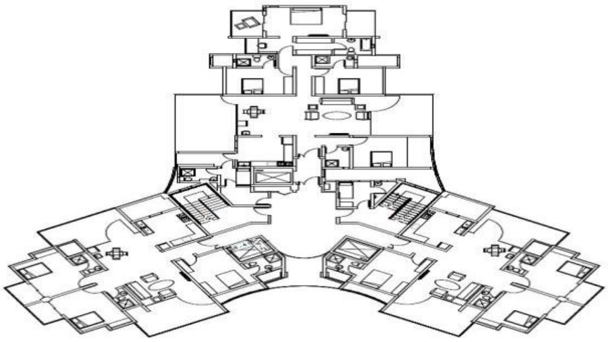

Figure 4.1 G+25 Floor Plan

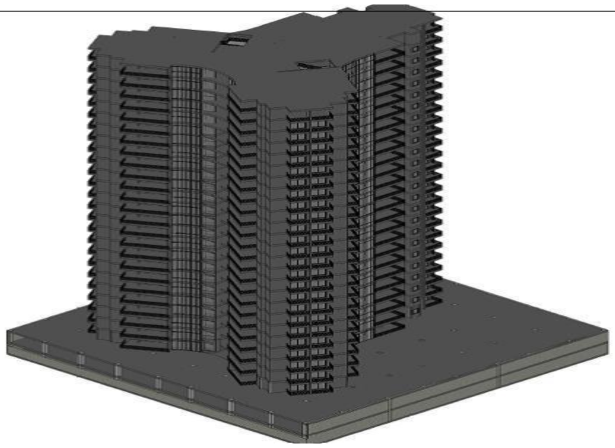

Figure 4.2 G+25 3D view

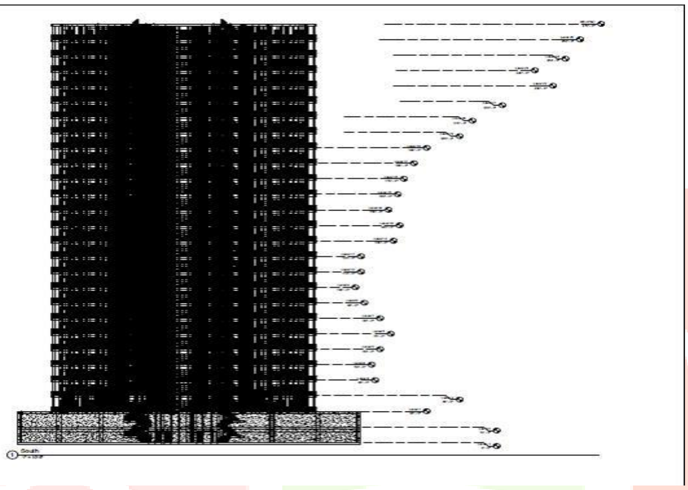

Figure 4.3 G+25 Elevation View

- Microsoft project, a project management software used to plan the construction process, assigning resources to tasks, tracking progress and analyzing the workload.

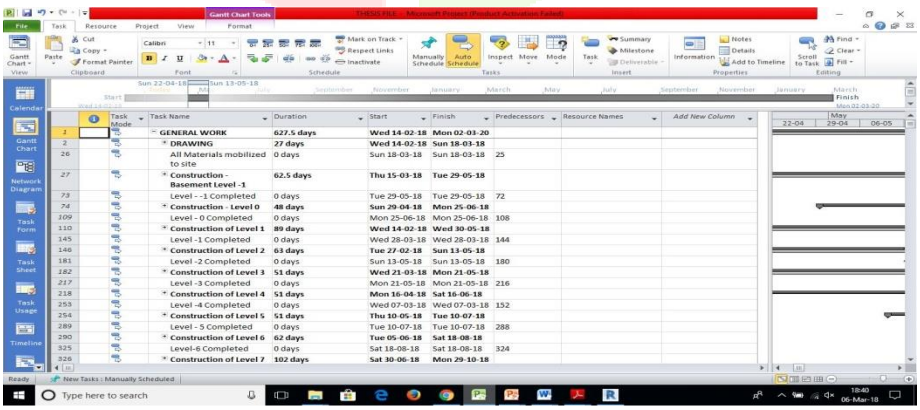

Figure 4.4 Analysis interface

- Adopt a Work Breakdown Structure (WBS) of all basic construction activities for the developed model.

The work breakdown structure (WBS) defines the work that is required in order to produce the product or deliverables. It is represented as a hierarchical subdivision of a project into work areas with the lowest generally being a work package or sometimes even an activity. The lowest level of the WBS should be consistent and agreed at the outset of the creation of the WBS. The WBS provides the foundation for all project management work, including planning, cost and effort estimation, resource allocation and scheduling.

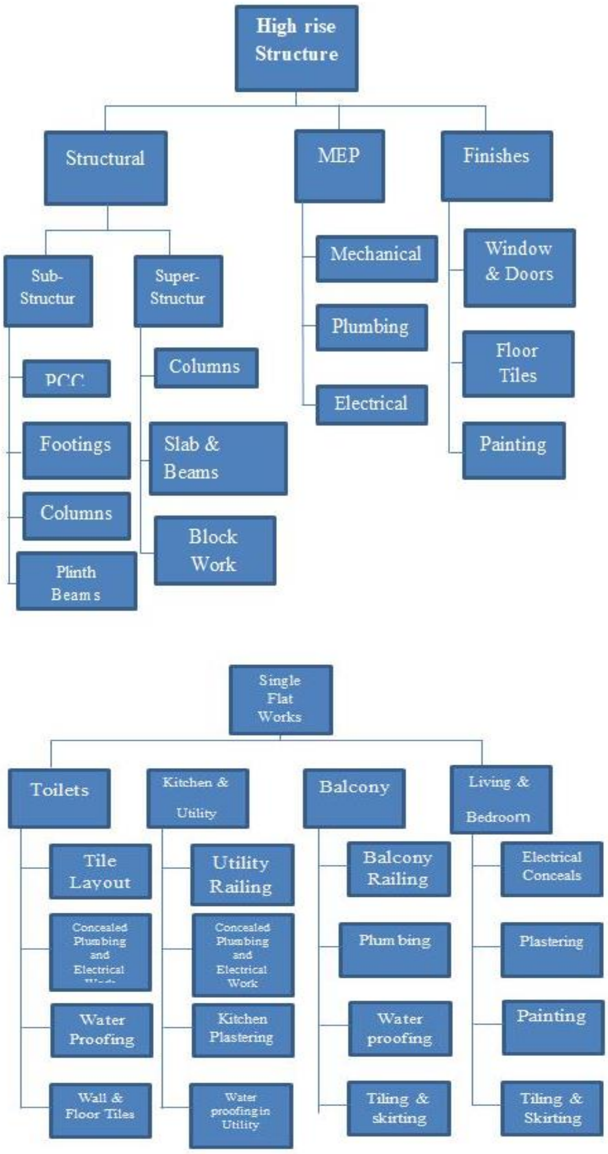

Fig 4.5 and 4.6 G+25 Work Breakdown Structure

- ➢ Propose planning & scheduling strategy from above scheduling simulation for High-rise Structures.
- List out all the activities included in the project.
- Identify the total time required for project completion.
- Identify the individual time required for each activity.
- Make adjustments based on project deadlines.
- Estimation and allocate resources for all the activities.
- Next leveling of the resources should be done.
- Based on the plan generated squeezing/relaxing of the resources should be done.
- Identify milestones within the project element.

- Identify separate projects or sub-projects between the milestones.
- Identify the interfaces between projects or sub-projects.
- Identify the information requirement for each of these events, projects, sub-projects, interfaces etc.
- Identify the highest responsibility levels requiring the information.

➢ Develop scheduling model base on conventional and IBS practices from the WBS adopted.

- Constructability checks

Constructability is a project management procedure to analyze construction process from start to finish, during the pre-construction level. It is to spot the difficulties before a project is truly constructed to cut back or stop errors, cost overruns, and delays. It is also the optimum use of construction knowledge and experience in planning, design, procurement and field operations to achieve the overall project objectives.

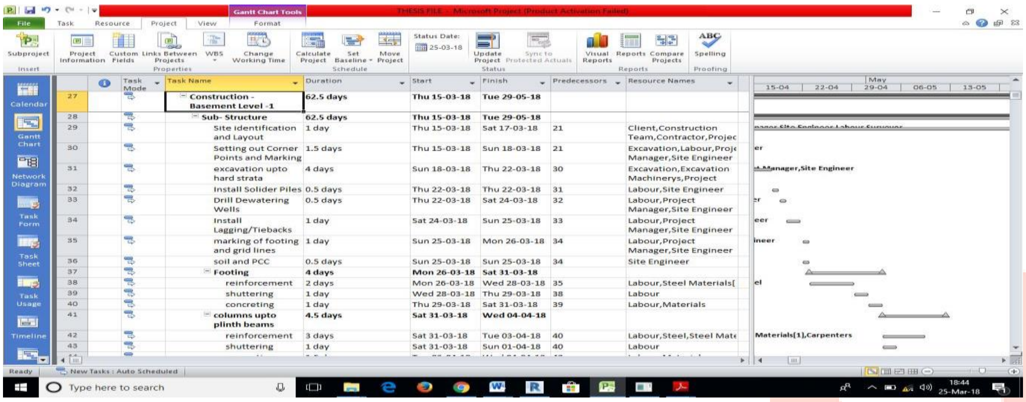

Fig 4.7: Microsoft Project Interface showing constructability check

5.1 RESULTS ANALYSIS

Scheduling of IBS components at site can also help to further determine the work duration of the entire project implementing IBS components, as compared to conventional methods. The assembly and erection of the conceptual high rise structure have been modeled and analyzed using computer software. Microsoft project was the scheduling software used for the scheduling purposes, and the results generated by the software been carefully analysed at this stage. As result, conventional method of construction required a total 627.5 days to construct G+25 high-rise structure, described in figure 5.1

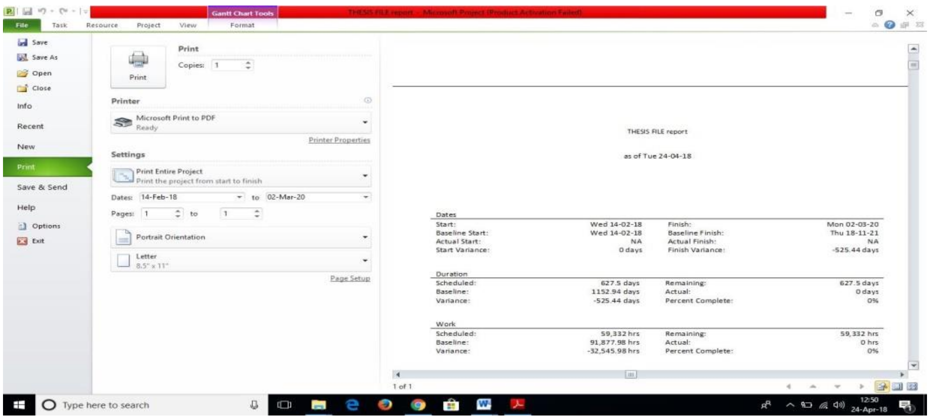

Fig 5.1: Microsoft project interface showing time reduction analysis

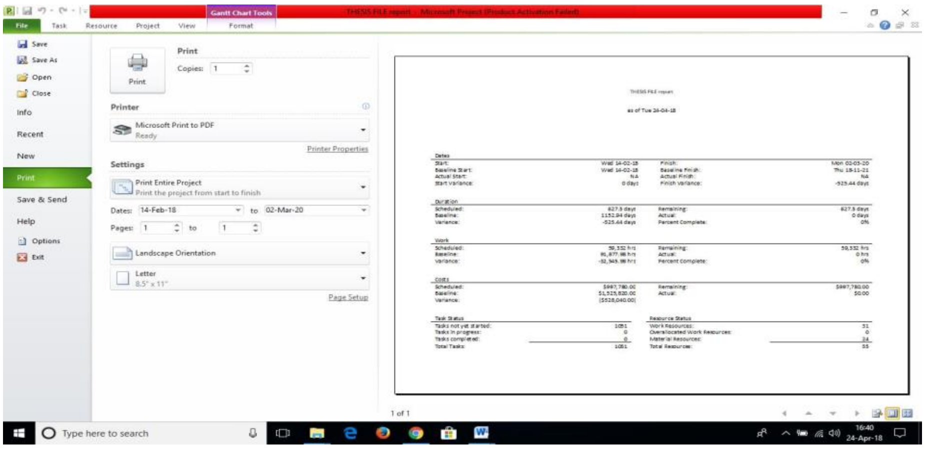

Fig 5.2: Microsoft Project interface showing labour usage and utilization

While a total 1152.94 days required for IBS method by adopted all the selected IBS components to develop the IBS scheduling simulator to complete the construction of the high-rise structure. Based on this research, it proved to the industries, by adopting IBS components, time was reduced. As result from this research shows, a total of 525.4 days or 35% of saving to the construction industry if the construction players considered to adopted IBS component in the project and the resource was also on a low usage and giving the maximum output required for the attainment of the best output. Conclusions from the above table it shown that not all IBS components/ products can improve to the overall construction duration.

5.2 DISCUSSION

The implementation of this method requires the use of specialized equipment. Innovative equipment with solutions that facilitate vertical and horizontal transportation within the high rise structures while being erected. Currently, to move materials and personnel vertically, there are several types of equipment that can be used according to the specific characteristics of the type of structure such as Hoists, gondola or swinging stages, work platforms, and elevators. Cranes provide vertical and horizontal movement. There are different types of cranes such as the truck mounted crane, the mobile crane, the tower crane and the climbing crane. Specific cranes are selected based on the carrying capacity, coverage, cost, and building geometry.

5.3 CONCLUSION

This study compared time performance of the conventional method of construction for high- rise residential and Industrial Building System (IBS) method by formulate benchmark measures of industry norms for overall construction period using scheduling simulation modeling. The major players in the are architects, engineers, town planner, developer, contractor and the supplier or manufacturer have to play their roles in enhancing their working system, management and administration to enable the modernization in the industry. Although the long-introduced IBS has promised to solve and improved the current construction method and scenario, but the IBS method has been low in gaining popularity, partly due to lack of awareness and coordination among the relevant parties. Currently, the level of IBS usage method is very low as compared to the conventional methods in building construction. In spite of its many benefits, the different perceptions among the construction players and practitioners towards its application in construction industry has led to the low usage of IBS components in the construction industry. There are many gains which can be achieved by the early completion of the project. The early project completion can yield added revenue, early release of capital and facilities, and in some cases can save idle time expenses of machinery. The non-financial gains can be earning goodwill, boosting of reputation and raising of morale.

5.4 RECOMMENDATIONS

- Labour productivity must be given extreme importance in calculating activity duration and for its improvement
- The relationship between the tasks should be identified by defining the predecessor/successor relationship between activities and the constraints and understanding the techniques involved in scheduling.
- Identifying the possible cause of delay and a quick solution should be anticipated in event of occurrence.
- Factors causing project delays that are man-made like labour shortage, poor sub-contractor and site management performance, late material delivery which results to material shortage, inadequate construction planning, financial difficulties, communication gap between working teams should be addressed at initial stage.

5.5 FINDINGS

Studies reveal that the main controllable causes of the projects time and cost overruns include, but are not limited to, the following:

- Project formulation,
- Planning and
- Contract administration failures.

These include:

1. Inadequate project formulation. Poor field investigation, inadequate project information, bad cost estimates, lack of experience, inadequate project formulation and feasibility analyses, poor project appraisal leading to incorrect investment decisions.
2. Poor planning for implementation. Inadequate time plan, inadequate resource plan, inadequate equipment supply plan, inter-linking not anticipated, poor organization, poor cost planning.
3. Lack of proper contract planning and management. Improper pre-contract actions, poor post award contract management.
4. Lack of project management knowledge and skills during execution. Inefficient and ineffective working, delays, changes in scope of work and location, law and order.

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