Scheduling and Cost Optimization of Multi-Storey Building
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Abstract: Now a days construction gets delayed in the site due to the factors such as inefficient management, design issues, economic variation, coordination failure between time schedule and execution etc. The major problem faced by the construction sector is not able to manage the fund allocated for the work and not able to complete the work in targeted days. This can be overcome by the implementation of scheduling and cost optimization process in the construction field. Scheduling is a critical component of successful time management. Optimizing cost should be carried out to aware the building cost is kept within the estimated cost limits. This paper deals with scheduling of multi-storey building and cost effective method to find required cost for completion of the project. On going project is located at Nagar Kovil and Manual scheduling data collected from the site. Scheduling of the project is done with primavera p6 software. Cost required for the project is also computed with primavera P6 software. For reducing the cost of the project, required actions are taken. The cost is reduced by proper use of resources, such as manpower, materials and machines. Computerized scheduling provides clear scheduling data for execution of the project. Cost required for the project execution is also reduced with proper scheduling process. Cost is optimized by using a dynamic programming method. Microsoft excel is used for dynamic method of cost optimization. In this project cost is considerably reduced by using the dynamic programming method of cost optimization techniques.

Keywords: Scheduling, Cost optimization, Dynamic programming, Execution, Primavera P6,

I. INTRODUCTION

The scheduling of resources in a project and multi-project environment is a complex process, but the focus should be to make it simple by scheduling a few vital resources and drive the forecast of the remaining resources.

Construction industry is the leading industry that pushes forward the developing progress in all over the world. It is well known that successfully completed construction project are a result of careful planning, execution and established techniques, such as critical path method and bar charts are commonly used to enable this to be done in a systematic way. Although every project has its own resource requirements but the type and quantity of resources vary considerably during the project implementation.

Now a days the competition in construction industry is usually very strict and serious. The project are scheduled using some software’s such as Microsoft project, primavera p6, etc., which are based on activities precedence and use appropriate optimization program to find the decision variables at cost total minimal.

In this paper execution of multi-storey building is scheduled by using primavera p6 and cost is optimized by using dynamic programming method via Microsoft excel solver implementation.

W. Eric Showalter, Ph.D; and Daniel W. Halpin, October 1, 2008: The work presented here uses cost as a decision variable in restoration projects. A methodology has been developed that will optimize the selection of remediation technologies based on cost. This methodology uses geostatistics and dynamic programming to break a site into discrete cells and then select the optimal sequence of remediation technologies.

Y.Gholipour;2013-03-27: The research includes investigation of some real multi-storey buildings during their execution periods and surveying the history of the activities. It is shown that the common resource demand variation curve of the projects may be expanded or displaced to achieve an optimum distribution scheme. Of course, it may cause some delay to some projects, but it has minimum influence on whole execution period of all projects and its influence on procurement cost of the projects is considerable.

C.K.Georgekutty, Dr.Georgemathew (July-Aug 2012): Researchers are trying to find out the reasons why projects could not complete in time. An exhaustive Literature review has been conducted. The research problem is identified and derived from the literature study.

Li, Heng and Chan, Neo and Guo, H.L. and Lu, Weisheng and Skitmore, Martin(2009): This paper describes the use of virtual prototyping to optimize construction planning schedules by analyzing resource allocation and planning with integrated construction models, resource models, construction planning schedules and site-layout plans. A real life case study is presented that demonstrates the use of a virtual prototyping enabled resource analysis to reallocate space, logistic on access road and arrange tower cranes to achieve a 6-day floor construction cycle.

Ming Lui and Heng Li, August 1, 2003: In this paper a sample application of the proposed RACPM for planning a footbridge construction project is also given to demonstrate that practitioners can readily interpret and utilize a RACPM schedule by relating the RACPM to the classic CPM. This paper is to study the feasibility of producing UHSC using available local materials with the inclusion of steel fibers and investigate its properties and durability.
Different mechanical properties are evaluated. Microstructural investigations of UHS-FRC concrete were also performed. The microstructural investigations shed some light on the nature of interfacial bond of fibres and the cement paste and its effect on its mechanical and fracture properties.

Research significance

For using software primavera P6 for scheduling the activities of work for the site helps to reduce the completion time of the project. Mathematical calculations such as dynamic programming method is used for cost optimization is used to reduce the cost required for the project. Existing literature review is modified for getting cost effective technique for completion of the project.

II. DETAILS OF THE PROJECT

| S.No | Information                  | Project details       |
|------|------------------------------|-----------------------|
| 1    | Location of the building     | Nagar Kovil           |
| 2    | Type of the building         | Framed structures     |
| 3    | Duration of the project      | Three years           |
| 4    | Number of stories            | G+4                   |
| 5    | Cost of the project          | Rs. 6,84,92,085       |
| 6    | Type of soil                 | Hard soil             |

III. METHODOLOGY

A. Literature review

In this literature review a detailed study is carried out on the journals and get an idea about the project, what to do and how to prepare a project. Study the scope of work in detail from journals and decide on the sequence of preparing a project.

B. Collection of building resource data

The required data were collected from an on going construction site. Decide on the sequence of construction including methods to be adopted and equipment’s to be used. If available drawings do not give adequate information, obtain as much as possible from clients/consultants/design office.

C. Implementation

Scheduling is done by using critical path method and then this will be implemented on the primavera p6 software.

D. Optimization

Optimization is done by using dynamic programming method and then this will be implemented on the Microsoft excel software.

III. COLLECTION OF BUILDING RESOURCES DATA

The scheduling data for the on going project is collected directly from the site. From the collected scheduled data is used for the software oriented program such as primavera P6. This scheduling data is prepared by the project manager in the site. Preparing scheduling data is done with more accurate manner.

The scheduling table comprising of five columns. Each columns represent the serial number, activity details, duration time, starting and finishing time of the particular activity respectively. This work is done with more accuracy. This table clearly shows the total duration of the whole activity for the project and every activity starting and finishing time also clearly represent in the scheduling table.

Table - II: Scheduling Table

| S.No | Activity                  | Start       | Finish      |
|------|---------------------------|-------------|-------------|
| 1    | Sub Structure             | 09/12/2014  | 22/07/2016  |
| 2    | Basement Floor            | 09/12/2014  | 05/08/2015  |
| 3    | Earth Work Excavation     | 06/08/2015  | 24/09/2015  |
| 4    | P.C.C                     | 25/09/2015  | 09/11/2015  |
| 5    | Water Proofing            | 10/11/2015  | 14/12/2015  |
| 6    | Grade Beam/Raft Concrete  | 15/12/2015  | 23/12/2015  |
| 7    | R.C.C Column Concrete     | 24/12/2015  | 30/12/2015  |
| 8    | R.C.C Wall Concrete       | 31/12/2015  | 12/01/2016  |
| 9    | Earth Work For Above 6 Th Grid | 25/09/2015  | 13/11/2015  |
| 10   | R.C.C Raft Footing        | 16/11/2015  | 05/01/2016  |
| 11   | Basement P.C.C Laying     | 06/01/2016  | 25/01/2016  |
| 12   | Water Proofing            | 26/01/2016  | 18/02/2016  |
| 13   | Raft R.C.C                | 19/02/2016  | 21/03/2016  |
| 14   | Wall Concrete             | 22/03/2016  | 27/04/2016  |
| 15   | Column Concrete           | 22/03/2016  | 27/04/2016  |
| 16   | East & West Side Slab Shuttering | 28/04/2016  | 27/05/2016  |
| 17   | R.C.C Slab Concrete       | 30/05/2016  | 30/05/2016  |
IV. IMPLEMENTATION SCHEDULING DATA

Several softwares were used for scheduling such as Microsoft Project, Gantt Chart, primavera P6, ZOHO Project, Fast Track Schedule 9, Track Time. In this the scheduling is done by using critical path method and then this will be implemented on the primavera p6 software.

From the scheduling data collected from the site, the primavera P6 software output is obtained. Using the software of Primavera P6 the scheduling of every activities are done more accurately.

A critical path method (CPM) is a network of events, each one of them linked to the following activities. Each activity is represented as a node on the network, and connecting lines are drawn to represent the time schedule to complete that activity.

A critical path method schedule must be completed using the following steps:

- Identify the activities
- Determine the sequence of the activities
- Connect or create a network of the activities
- Enter the completion time for every activity
- Identify the critical path or the longest possible path to complete all activities

One important and valuable component is the CPM update progress, allowing to track closely the performance and time used to complete the activities.
| Activity ID | Resources | Activity Name | Original Duration | Budgeted Cost | Start | Finish | Total Cost |
|------------|-----------|---------------|------------------|---------------|-------|--------|------------|
| A1000      | labor: B | BASEMENT FLOOR | 172              | 2.01           | 9-6   | 9-18   | 0          |
| A1010      | equipment | EARTH WORK/EDUCTION | 36              | 0.13           | 1-4   | 1-18   | 0          |
| A1020      | labor: F | PCI          | 32               | 0.04           | 1-4   | 1-18   | 0          |
| A1030      | equipment | WATER PROPOSAL | 25              | 0.12           | 1-4   | 1-18   | 0          |
| A1040      | labor: B | EARTH WORK/EDUCTION | 7               | 0.07           | 1-4   | 1-18   | 0          |
| A1050      | labor: F | PCI COLUMN 0 CONCRETE | 3              | 0.13           | 1-4   | 1-18   | 0          |
| A1060      | equipment | PCI VAAL CONCRETE | 3               | 0.13           | 1-4   | 1-18   | 0          |
| A1070      | labor: B | EARTH WORK/EDUCTION | 36              | 0.13           | 1-4   | 1-18   | 0          |
| A1080      | labor: F | PCI COLUMN 1 CONCRETE | 3              | 0.13           | 1-4   | 1-18   | 0          |
| A1090      | equipment | PCI COLUMN 2 CONCRETE | 3              | 0.13           | 1-4   | 1-18   | 0          |
| A1100      | labor: B | EARTH WORK/EDUCTION | 36              | 0.13           | 1-4   | 1-18   | 0          |
| A1110      | labor: F | PCI COLUMN 3 CONCRETE | 3              | 0.13           | 1-4   | 1-18   | 0          |
| A1120      | labor: B | EARTH WORK/EDUCTION | 36              | 0.13           | 1-4   | 1-18   | 0          |
| A1130      | labor: F | PCI COLUMN 4 CONCRETE | 3              | 0.13           | 1-4   | 1-18   | 0          |
| A1140      | labor: B | EAST SIDE DECK SLAB SHUTTERTING | 22              | 0.46           | 1-4   | 1-18   | 0          |
| A1150      | labor: F | PCI SLAB CONCRETE | 1               | 0.57           | 1-4   | 1-18   | 0          |
| A1160      | labor: B | STEP UP WORK AREA | 11              | 0.05           | 1-4   | 1-18   | 0          |
| A1170      | labor: B | ELEVATION | 2               | 0.07           | 1-4   | 1-18   | 0          |
| A1180      | labor: F | PCI          | 1               | 0.13           | 1-4   | 1-18   | 0          |
| A1190      | labor: B | WATER PROPOSAL | 2               | 0.10           | 1-4   | 1-18   | 0          |
| A1200      | labor: F | PCI                  | 1               | 0.13           | 1-4   | 1-18   | 0          |
| A1210      | labor: B | WALL COLUMNS CONCRETE | 6              | 0.35           | 1-4   | 1-18   | 0          |
| A1220      | equipment | SLAB SHUTTERTING (RENOVED) | 1              | 0.08           | 1-4   | 1-18   | 0          |
| A1230      | labor: F | PCI SLAB CONCRETE | 1               | 0.08           | 1-4   | 1-18   | 0          |

Fig. 2. Primavera P6 software output

Fig. 3. Output of Primavera P6 software
Cost of the project

Estimated cost of the project calculated from the Primavera P6 software is Rs.6,84,92,085. This cost is reduced by cost optimization techniques. Dynamic programming method is used for reducing the cost of the project. The required cost for completion of the project is considerably reduced.

Cost optimization

Finding an alternative with the most cost effective or highest achievable performance under the given constraints, by maximizing desired factors and minimizing undesired ones. In comparison, maximization means trying to attain the highest or maximum result or outcome without regard to cost or expense.

Practice of optimization is restricted by the lack of full information, and the lack of time to evaluate what information is available. In computer simulation of business problems, optimization is achieved usually by using dynamic programming techniques of operations research.

Several softwares were used for optimization such as Function Designer, Microsoft Excel, SAMPL, MATLAB, AMPL, TORA. In this project cost is optimized by using dynamic programming method via Microsoft excel solver implementation.

Dynamic programming is both a mathematical optimization method and a computer programming method. In both contexts it refers to simplifying a complicated problem by breaking it down into simpler sub problems in a recursive manner.

Table - III: Cost optimization calculation

| AREA RESOURCE | Basement floor | Ground floor | Mezzanine floor | First floor | Second floor | Third floor | Fourth floor | Terrace floor |
|---------------|----------------|--------------|-----------------|-------------|--------------|-------------|--------------|--------------|
| Labour (A)    | 9631566        | 11657690     | 11087550        | 4048550     | 6001505      | 5231000     | 5219930      | 8231792      |
| Material (B)  | 3801000        | 4223000      | 430000          | 138500      | 175300       | 178000      | 166000       | 208000       |
| Equipment (C) | 748000         | 258500       | 281500          | 88500       | 112500       | 113000      | 107000       | 154000       |

Table – IV : Consolidation table

| Area Resource | Basement floor | Ground floor | Mezzanine floor | First floor | Second floor | Third floor | Fourth floor | Terrace floor |
|---------------|----------------|--------------|-----------------|-------------|--------------|-------------|--------------|--------------|
| G             | 13432566       | 12080109     | 711500          | 227000      | 288000       | 291000      | 362000       |              |
| H             | 4549000        | 681000       | 711500          | 227000      | 288000       | 291000      | 362000       |              |

Obtain the optimum sequence by using the steps in Johnson’s algorithm

Table – V : Total elapsed cost

| Optimum sequence | Resource A | Resource B | Resource C |
|------------------|------------|------------|------------|
|                  | Start      | Finish     | Start      | Finish     | Start      | Finish     |
| 4                | 4048550    | 4187050    | 4048550    | 4187050    | 4187050    | 4275550    |
| 5                | 4048550    | 4187050    | 4048550    | 4187050    | 4187050    | 4275550    |
| 8                | 10055055   | 10225555   | 10055055   | 10225555   | 10225555   | 10338055   |
| 3                | 18281847   | 29799397   | 18281847   | 29799397   | 29799397   | 3008097    |
| 1                | 29369397   | 39000963   | 29369397   | 39000963   | 39000963   | 43549965   |
| 2                | 50658653   | 50658653   | 50658653   | 50658653   | 50658653   | 51339653   |
| 6                | 55889653   | 55889653   | 55889653   | 55889653   | 55889653   | 56180653   |
| 7                | 61109583   | 61109583   | 61109583   | 61109583   | 61109583   | 61382583   |
V. CONCLUSION

- The data were collected successively from the proposed site and scheduling process are executed based on the concerned activities.
- The results obtained from the analysis of multistorey building is scheduled by using primavera p6 software and the cost is reduced by optimization method.
- Dynamic programming sequencing problem is used for easy calculation of cost optimization.
- Total cost for resources is Rs.6,84,92,085. The total elapsed cost is computed by cost optimization technique using dynamic programming method is Rs.6,13,82,583.
- The reduction in the cost variation shows Rs.71,09,502.
- Thus the cost of project can be reduced by appropriate planning, scheduling, execution and established techniques.
- Therefore implementation of scheduling and cost optimization techniques in construction field will be more effective in execution of building work in an economic manner.

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