

Work Breakdown Structure Scheduling for Repetitive Construction Projects with Soft Logics

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Abstract: Construction site condition often deals with situation that the preplanned work pattern has to be changed. But due to the lack of knowledge about the after effect of that change the work team hesitates to do so. This paper presents a work breakdown structure for scheduling repetitive construction projects with soft logics. Soft logics relations are non-fixed work sequence which can be reordered for getting changes in cost, duration and resources usage. With the help of soft logic consideration in work breakdown structure of repetitive construction projects the site working team can find the after effect of change in work pattern through various sequence of the proposed work. Primavera P6 software makes it easier to apply that change and also to track the overall progress of the work. Final result clearly shows that planning the work in different pattern, before execution, will help the project manager to select an optimum sequence of work breakdown structure.

Keywords: Construction scheduling, Repetitive projects, Soft logics, Work breakdown structure, Primavera P6

1. Introduction

The work breakdown structure (WBS) is described as a hierarchical structure which is designed to locally subdivide all the work elements of the project into a graphical presentation. The upper levels of the WBS typically reflect the major deliverable work areas of the project, decomposed into logical groupings of work. The content of the upper levels can vary, depending on the type of project and industry involved. The lower WBS elements provide appropriate detail and focus for support of project management processes such as schedule development, cost estimating, resource allocation, and risk assessment. The lowest-level WBS components are called Work Packages and contain the definitions of work to be performed and tracked. These can be later used as input to the scheduling process to support the elaboration of tasks, activities, resources and milestones which can be cost estimated, monitored, and controlled.

Most of the construction works can be considered as repetitive construction works in some aspects. Even for a single storied building the construction work of the column is a repetitive process. In the case of high rise buildings each floor is a repetitive activity. Construction activity associated with other construction works such as bridge, road, railways

etc. surely comes under this category. Activities associated with the construction work can be repetitive in length wise and/or in height wise.

The relationship between activities can be fixed or non-fixed. Non-fixed activity relation is known as soft logics. Soft logics are the types of dependencies we like because it gives us the ability to move tasks or schedule activities based on our discretion.

As shown in the Fig 1, the dotted arrows represent the soft logics (i.e. non-fixed job sequence) and the other arrows represent the hard logics (i.e. fixed job sequence). Excavate order of area 1, 2, 3 and 4 can be changed as per convenience. But form can be set only after the completion of the corresponding area excavation.

More than one WBS model can be prepared for a single work considering various sequential order of work pattern with the help of soft logics. Analyzing all such sequential order helps to choose the optimum sequential order of WBS.

There have been several methods for scheduling a construction projects. Primavera P6 makes it easy to schedule and alter the work breakdown structure. It's a good platform for resource allocation and levelling also.

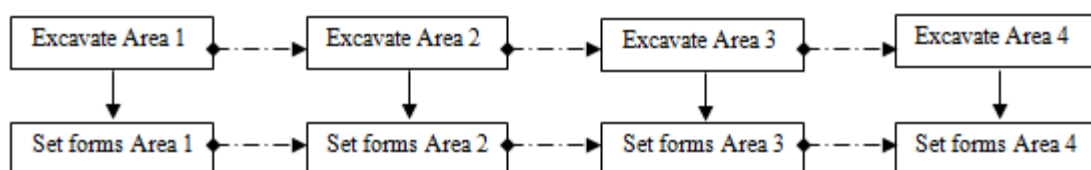


Figure 1: Example of soft logics

2. Importance

The importance of this paper is that it can give a complete solution to problems such as resource deficiency, managing the deadline and limiting expenses inside the budget amount. It can be easily applied to all repetitive construction works such as buildings, bridge, railway, road and so on. Application of Primavera professional software makes it more compactable and less time consuming.

3. Literature Review

3.1 Genetic algorithm based optimization model

This paper presents a Genetic Algorithm (GA) based optimization model for repetitive projects when considering soft logic. There have been several models developed for Time–cost Trade-Off optimization in repetitive projects and these models were set up to search for optimum output rate that yields the minimum total cost for each project. Previous researches are based on the assumption that work sequence cannot be changed for different work zones. In reality, work sequence between work zones are not fixed (actually, constantly adjusted) throughout the project. Instead, they are often changed to shorten the construction time and minimize the total cost. Scheduling with the non-fixed work sequences between work zones is known as the soft logic method. Considering the soft logic in repetitive projects, the proposed GA model aims to assist the project team to find the minimum overall cost subjecting to different output rates and logical sequences.

A GA optimization model has been developed for generating optimal schedules for repetitive projects. Unlike available models, the proposed model is capable of incorporating cost as an important decision variable and taking soft logics into consideration in the optimization process. This model is capable of offering valuable support to project team members in minimizing the overall cost of the project. For each repetitive activity in the project, the model assists the planner in selecting the optimum output rate and NAOT from a set of possible alternatives. As such, the model can be used to evaluate the impact of different project acceleration strategies (i.e., increased NAOT, increased crew size, overtime policies, or additional shifts) on the overall cost. A numerical example from the literature is analyzed in order to demonstrate the application of the model and illustrate its capabilities. For future research, it is suggested that more construction projects can be investigated to examine the cost structures after NAOT increases in order to broaden the application of this proposed model in the real world.

3.2 Line of Balance Method

The line of balance (LOB) method has long been used to model construction projects with repetitive units. Critics, however, indicate two major shortcomings of applying LOB in the construction industry: (1) it has not yet been adapted to numerical computation as readily as network methods; and (2) it relies on restrictive assumptions and therefore cannot treat the practical concerns concluded in this paper. To treat all the practical concerns and provide necessary calculation

power, a new scheduling system is proposed: the Repetitive Scheduling Method (RSM) and its computerized implementation, Repetitive Project Planner (RP2). RSM includes necessary modelling elements (i.e. activity and relationship types) and a set of computational algorithm to calculate the start time of every activity as well as the minimum project duration. RP2 automatically calculates and generates RSM diagrams that are particularly useful in serving as a test-bed for project managers to perform what-if analyses for different crew utilization strategies. A real-life pipeline project is used to demonstrate the application of RP2 and to compare that with the critical path method (CPM) and traditional LOB models.

RSM is presented here to handle the deficiencies above. RSM incorporates the necessary activity and relationship types to model repetitive projects. The attributes associated with activity types in conjunction with the proper relationship types provide the necessary modelling power to represent practical situations encountered in real-life. This modelling power makes RSM have a profound effect on the way that millions of dollars of construction work is scheduled.

The computational algorithm of RSM is programmed into computer software, RP2, to replace the tedious manual preparation of conventional LOB models and hence allows project managers to rapidly test various strategies or perform what-if analyses by varying production rates, crew sizes, work sequencing, etc. This has been validated by scheduling a real-life pipeline project.

3.3 Fuzzy linear programming

Scheduling problem for repetitive construction projects involves three conflicting objectives. These objectives are project duration, project total cost, and project total interruption time. This paper presents a multi-objective fuzzy linear programming model (FLP) for resolving this problem. Literature concerned with scheduling problems for repetitive construction projects was reviewed. Multi-objective fuzzy linear programming was then explained. The proposed model formulation was then presented.

An individual optimization for each objective was performed separately with linear programming software (Lindo) that gave the upper and lower bounds for the multi-objective analysis. Two scenarios for multi-objective solutions were adopted. The first scenario considers the three objectives simultaneously, whereas the second scenario considers each two objectives in a single run. Examining the results of the case study revealed that; (1) fuzzy linear programming is simple and suitable tool for multi-objective problems; (2) the model can be extended to any number of objectives by incorporating only one additional constraint in the constraint set for each additional objective function; (3) in scenario 1; project duration, project total cost in fuzzy linear programming were deviated by 7.2% and 1.8%, respectively as compared to ideal values in the crisp linear programming. On the other hand, the percentage of total interruption time to project duration in FLP is 5.3% against zero in LP; and (4) scenario 2 explains that the model enables construction planners to generate and evaluate all optimal tradeoff

solutions between any two objectives: project duration and crew work continuity; project duration, and project total cost; or project total cost and crew work continuity, that suit their ordering of preferences and demands.

3.4 Discrete time – cost trade off problem

The discrete time/cost trade-off problem (DTCTP) is commonly encountered in repetitive project scheduling. The current models for this problem assume that logical sequences of activities cannot be changed in different units. However, logical sequences are often changed to shorten the project time and minimize project total cost in many practical situations. This characteristic of repetitive activities is referred to as the soft logic. This paper presents a mixed integer nonlinear programming model that combines the general DTCTP and the concept of soft logic. The execution modes of an activity in different units are also considered. The DTCTP is known to be strongly NP-hard, and the introduction of soft logic makes it even more complex. A genetic algorithm (GA) is proposed to resolve the problem. The effectiveness of the proposed GA is verified using the example of a bridge construction project presented in the previous literature. The model proposed in this paper provides more edibility to reduce the total cost and time of a repetitive project for the planners.

4. Method

Methodology followed in this paper work is that, first the work breakdown structure of the whole work is prepared and

scheduled. Change in completion time and budget is then observed by changing the order of soft logic relation.

This paper work makes use of a software method for computing the result faster with lesser chance of error. Primavera P6 is scheduling software which helps to keep an eye on the progress of the construction work from beginning till the end. Web application of this software makes it reachable to all level of employees. Other functions such as resource allocation, role assigning, estimating budget and resource levelling are also available in this software. Primavera P6 makes it easy to apply the soft logics consideration, just by changing the predecessor column only.

5. Sample Project Study

Sample data for conducting the proposed study was taken from a school construction project which consist of four building work. I.e. VHSS academic block, HSS academic block, Administrative block and Toilet block. Four different sequences are formed by changing the activity order as follows:

5.1 One by One construction

In one by one construction sequence, construction activity of a building is started only after the completion of the previous. This sequence can be adopted if there is a situation of limited resources and no deadline for completion. Fig.2 shows the Gantt chart of the WBS generated by the software for scheduling one by one sequence.

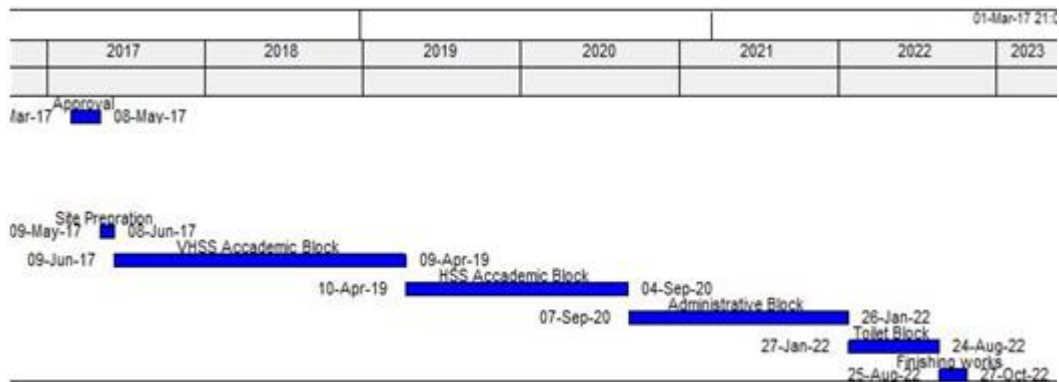


Figure 2: WBS Gantt chart for one by one construction

5.2 All building progress together

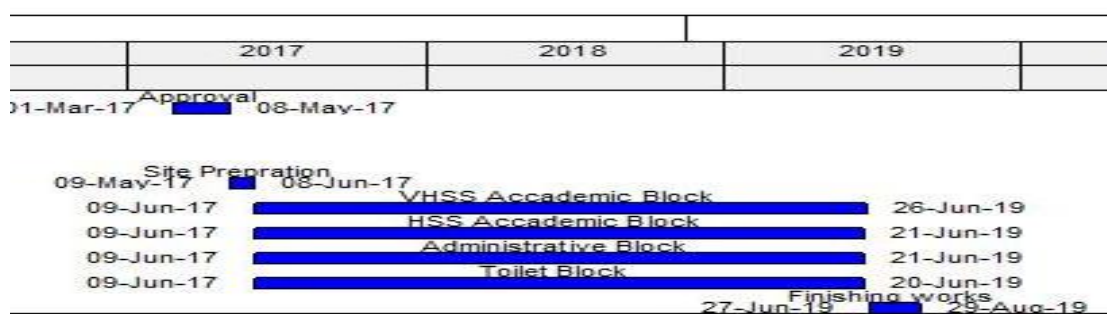


Figure 3: WBS Gantt chart for all building progress together

In all building progress together construction sequence, construction activities of all buildings are started together and each stages of work are progressed together. This sequence can be adopted for situation which consists of

limited time and unlimited resources. Fig.3 shows the Gantt chart of the WBS generated by the software for scheduling all progress together sequence.

5.3 Two by two Construction

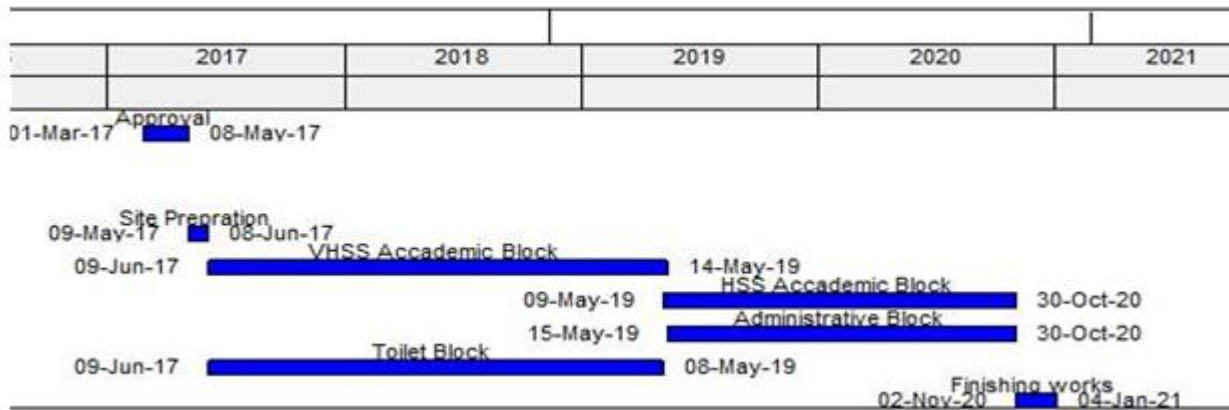


Figure 4: WBS Gantt chart for two by two constructions

In two by two construction sequence, first two buildings construction are started and progressed together, then the final two. This is a sequence which can be adopted under optimum situations. Fig.4 shows the Gantt chart of the WBS generated by the software for scheduling two by two sequence.

5.4 One by three construction

In one by one construction sequence, the building which has to be finished first is finished and then the remaining three is started and progressed together. If any of the building completion is an urgent need then this sequence can be followed. Fig.5 shows the Gantt chart of the WBS generated by the software for scheduling one by three sequence.

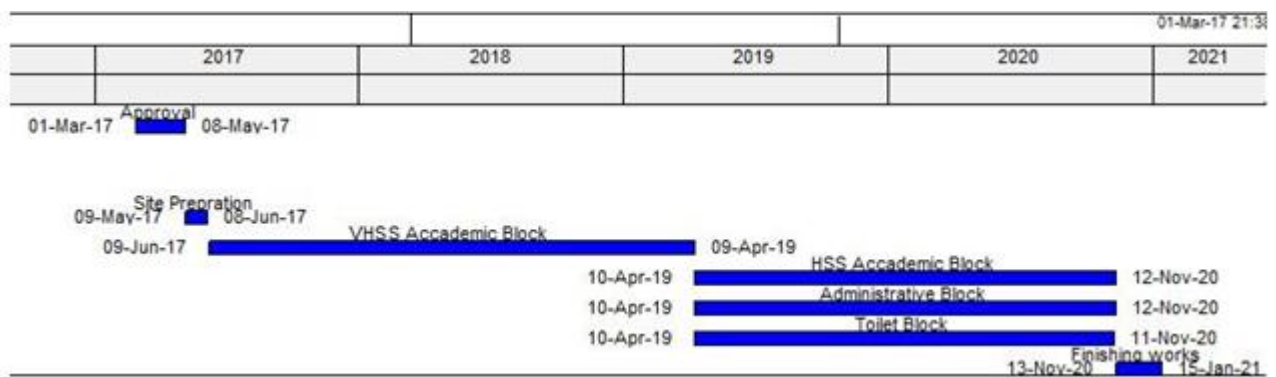


Figure 5: WBS Gantt chart for one by three construction

6. Result and Discussion

Final result shows that there will be changes in both completion time and expected budget while considering soft

logics relation in work breakdown structure. Table.1 shows that changes for the above mentioned sequences.

Table 1: Estimation of all sequences

Sequence	Estimated completion Time(Days)	Estimated Budget (INR)
One by One building sequence	1476	33283819.80
All building progress together	651	21532488.87
Two by Two building sequence	1012	11050103.02
One by Three building sequence	1003	1130823.63

Both duration and the budgeted cost are too high for the one by one building sequence. Hence it is not affordable. For the all building progress together, hence all work has to be done simultaneously; there arises a need of too much resource. Till

it can be adopted if there is plenty of resources and the deadline is too close. Two by Two building sequence is an optimum sequence. It gives an optimum duration and cost. One by three building sequence also need a little much

resource during the time of constructing three buildings together. But it is also comparatively affordable.

7. Conclusion

The study made using the sample project concludes that with the consideration of soft logics; duration, resource and cost can be adjusted even at the execution stage. Consideration of activity relations as fixed and non-fixed relation, and dealing the same separately helps to manage crisis in the construction site. Sudden changes can also be applied to the construction schedule by dealing with the soft logics alone. Application of soft logics relation in the work breakdown structure helps in dealing with the top to bottom level of the task. Difficult situations such as reaching deadline, lack of resources, cost control and so on can easily be managed by breaking the non-fixed relation among activities.

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