SCHEDULING IN TRADITIONAL CONSTRUCTION METHODS

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Abstract: There are many studies on construction planning of high-rise buildings. But, possibility of various division of building construction areas is not considered well in former studies. So it is difficult to apply their methods in practical projects, many of which have a different plan in every floor. There are few studies on construction planning of work using traditional methods. In this paper, the authors build a model for traditional construction methods. The optimization of the scheduling is obtained considering various divisions of building construction areas.

Keyword: division of building construction area, traditional work, construction planning, optimization

1. Research Background and Aim
In construction, it is necessary to make a plan of all the floors. This process is mostly done by trial-and-error basis. With the increase of high rise buildings and larger buildings this planning process has become increasingly complex such that PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) planning processes are no longer able to cope.

In light of the background described above, the aims of this paper are as follows:
- By considering past site-division techniques, a method to make possible a reliable construction planning process should be proposed.
- To show that the above proposed method can be applied for high-rise buildings in which the basic floor plan is repeated.
- In order to understand the proposed method, many construction sites will be investigated in order to create an optimized method.
- To apply the proposed method in a real project and investigate the effectiveness of the proposed method.

2. Construction planning in traditional construction method

2.1 Characteristics of proposed method
Definition of "site":
- The part where according to the timetable, the continuation of a given operation is stopped or interrupted.
- The part where the main operation changes.
1) Site-division policy
   For all processes site-division of multiple sites is done. For each process a maximum of two teams will be responsible. In the sites the combining or division of several operations can be done, such that there are more than three site divisions, the division ratio can also be changed, making possible a flexible construction planning process.
2) Increase of cost due to site division
   Due to site-division, the cost will increase because of having more steel joints and also due to the complex management required. In this article, the increased cost of each operation at a site is included.

2.2 Making construction planning process using traditional methods
1) The order of the planning process
   The following process plan shows the steps that are taken in deciding possible start times for all operations.
   1. The start of the whole operations, order of operations and next operations must be decided considering technological factors.
   2. The number and ability of concrete pump vehicles and heavy machinery must be decided.  
   3. Site-division and operations at each site and the amount must be decided.
   4. The number of teams required for each job type must be decided.
   5. The amount of workers must be decided according to the capability of the concrete pump vehicles.
   6. The number of workers in each team and their function must be decided.
   7. The function of each team (1 or 2 teams) must be defined.
   8. The leader of each team and functions must be decided.
   9. At the same time as process ‘8’, the number of the sites and the number of workers at each site must be decided.
   10. At the same time as process ‘8’ the amount of work at each site should be decided. (The job proficiency must be considered when determining the amount of work).
   11. At the same time as process ‘8’ and ‘9’, the amount of time to be taken for each operation must be decided.
   12. The order of operations not decided at process ‘1’ must be decided.
   13. The earliest possible time for each operation should be decided.
   14. Changes made in the time table and days of operation should be decided including the earliest starting day of operation.
   15. The start and ending time of all operations must be decided. Operations that can be carried out at the same time or combined should be selected and then operations time table decided.

2) Evaluation of the planning process
   After determination of all the operations, the whole process will be evaluated. Evaluation is done by the term and the cost as the base. Total cost includes Labor cost (LC), Heavy machinery costs (CC), Concrete pump vehicle costs (PC), Building material costs (ZC), Site expenses costs (SC), Increased expenses costs (aC) all totaled up.
   \[
   \text{Cost} = LC + CC + PC + ZC + SC + aC
   \]
   In this model, the cost and term are the dimensions and in order to accommodate large values cost will be decided by a parameter \( \gamma \):
   \[
   f = \lambda (Cost / \gamma) + (1 - \lambda) \text{Term}
   \]
   \( \lambda \) : parameter(0 < \lambda < 1)

3. Development of an optimal program
In order to develop an optimal program, the local search method made up of 2 stages is used. In this method, the initial variables are changed repeatedly.
1) First stage of optimization
   In this stage the order of processes that are not continuous,
optimization is carried out based on changes of the order of operations. Firstly, the turn points of each operation are decided. A search of all turn points is not carried out but instead search is carried out starting at 0 points and continuing in order of fewer points. By increasing the points, if there is no difference, the search is then stopped. This is because the final number of points will become more than the decide points.

This process is then carried out for all operations and individual searches are carried out. The best order of operations for optimum results is then recorded before moving to the second stage of operations.

2) Second stage of optimization

In this stage, the start times of operations are staggered based on two aims. The first aim is to stagger the times based on whether overtime is possible or not. The work that can be moved to the next day and continuous operation times are staggered. The second aim is staggering times of operations that are continuous and combination of more than one operation. The ending time of target operation may be delayed and the beginning of the next operation will therefore also be delayed, in this case time will have to be staggered. The result will therefore make it impossible to combine two operations. In this algorithm, it is possible to change the order of operations.

4. Application and verification of an actual project

4.1 Outline of actual project

Kind of building: Multi-dwelling houses (108 units)
Construction period: From December 2000 to February 2002
Structure: Reinforced Concrete
Floors: 14 floors, No basement, No penthouse
Total floor area: 10,966 m²

Table 1 Required variable, cost (yen) and construction term (days)

<table>
<thead>
<tr>
<th>Table 2 Labor leveling ratio (%)</th>
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<tbody>
<tr>
<td>Job Type</td>
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<tr>
<td></td>
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<tr>
<td>Frame</td>
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<tr>
<td>Steel</td>
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<td>Carpenter</td>
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4.2 Result

In Table 1 the required variable, f, cost and construction term are compared. In the proposed plan II, the optimal one is with two concrete pump vehicles. In the proposed plan III the cost is more than proposed plan I, but the term and the variable f is less than it. The number of teams is also less than proposed plan I.

By utilizing this method and comparing the result in an actual project, it is possible to have a planning process which is effective in reducing the construction term.

1) Cost

In proposed plan I, the cost is more than 0.6% of the actual project in result. In proposed plan II and III the cost is slightly higher.

2) Construction term

In proposed plan I, the term is reduced by 12 days and the construction process at floor level is reduced by 8%.

3) Labor leveling

The higher labor leveling ratio is obtained in proposed plan I than the actual project. In this planning process it is possible to provide a stable labor for construction industry. But due to the fact that total operation time and actual working is reduced, work days are more distributed leading to the higher labor cost.

From the view of construction term, proposed plan I is recognized as the best result. As for the cost, proposed plan III will be the best result. This is because the more the number of teams in each operation moved more smoothly and at the same time each team had more time left leading to a reduction in the rate of labor leveling. With more teams and the fact that work moves more smoothly fragmentation of sites occurs leading to an increase in the costs of site-division. This is why the proposed plan III has better results in terms of total costs.

5. Conclusions

1) Using traditional methods in the construction process a reliable method of process planning has been proposed. By using the proposed plan, time staggering and order of operations as variables, a local search method is used to get an optimized construction planning method.

2) The proposed method has managed to make possible to take into consideration both cost and term.

3) By using the above construction planning method and repetition type constructions and by using it together with the cycle process, in the whole construction planning process, a construction plan which is effective in terms of construction term.

6. References
