Optimal Planning and Efficient Adjustments of the Terms of Constructions

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Abstract. Effective planning and implementation of large capital investments, hundreds of millions of dollars can be saved. After completion of the project, it is extremely difficult to make adjustments: even the most talented plant Director, increasing labor productivity, will not be able to compensate for the costs and losses caused by the unsuccessful arrangement of equipment and irrational design of the areas. Companies often trust the choice of optimal technology and configuration to construction organizations. The article deals with the issues of effective optimization of construction scheduling. The specific methods of it mechanisms of reduction of construction time, prevention of overspending of resources, increase of economic efficiency of construction in general are offered.

1. Introduction

Technological progress and the ever growing focus on specialization is making the issues of the planning for high-rise and long-span construction more and more diversified and complicated. At the stage of detailed design specifically, the top management of the project have to deal with some challenges of how to systematize and mutually wrap up the great number of design and construction works from the angle of their practicability, construction terms, and rational use of material and human resources. These problems get even more complicated due to some strict requirements to the terms of the objects’ construction and completion deadlines.

To meet these requirements, now it is not enough to define the terms in work projects by a mere linear wrap up of the processes in time. The targets of the design contractor should be wider and, along with the planning of the terms proper, they should also cover their optimization and efficient adjustment. Because of such extension of targets setting, the methods and supplementary means of planning should also be rationalized.

2. Materials and methods

Nowadays, there comes a more and more urgent need for the systematization about determining the time especially targeted at building permanent structures that would guarantee maximal efficiency paired with simple use and low expenses. Also, it is essential that the problems of setting up the time of construction of an industrial object are critically viewed from the angle of the design contractor and that the setting up of the targets, the methods, and the supplementary means of construction should be optimally harmonized with the requirements and concrete conditions of the design of the management and construction and erection works.
The schedule may be regarded as a most vital regulatory element of construction planning. The systematized recordkeeping and analysis of completed works and their distribution in time should unite the three important factors of planning the construction of an industrial object:

- technological concept of the project;
- logical interrelation and technological sequence of design and construction processes;
- indispensable resources of design and construction.

It is quite typical that an especially tight bond among these aspects occurs at designing and erecting long-span industrial and sports facilities, where amendments in one section of the project may often critically affect other sections. This primarily relates to time analysis and the need for resources.

To timely observe the time of construction, it is important to have sufficient human resources and material and technological facilities, otherwise these data should be contained in the arrow diagram. Practically, this requirement is often neglected. Even though there is a variety of software programs for determining the required resources and making some relevant amendments to the arrow diagram, the key interrelation here is treated basing on an example of a regular hand calculation of a section of the arrow diagram. Stage One: the time required to complete the works of each process is entered in the arrow diagram.

Each section of the arrow diagram receives its own schedule shaped as selection of work time expenditures to fulfill each work encoded in the diagram. If possible, works should start on the days that correspond to the before-schedule commencement of works in the arrow diagram to avoid using the imbedded time reserve. Determination of the theoretically required human and material resources is made by means of summing up the figures in the vertical columns that stand for the number of workers engaged in each operation during the day (separately by professions and types of supplementary means).

For each arrow diagram there is a weekly schedule of introducing the manpower and equipment; moreover, the peak load leveling in arrow diagrams is achieved by a more uniform introduction of resources. To achieve this, reserved time and manipulation of peak values is applied. It is essential to stick to keeping some minimal changes in human and technological resources during the work week.

When compiling the schedule of engaging the work power and equipment one should make sure that leveling peak values is done at the expense of time reserve with the processes or critical path works being intact. Such instances require that there should be used reserve resources provided for small originally unaccounted extra or subordinate works. Within the framework of time planning, a relatively rough estimate of the need for resources is made; also, an approximate schedule of introducing work force is compiled. Basing on this schedule, the job captain or the senior manager of works or assembly only has to make timely corrections in the engagement of work force in view of concrete changes occurring in the construction process.

The above aggregated estimates of the need for resources are normally made on the basis of arrow diagrams and never require extra expenses. They prove a viable auxiliary means of realistic planning of construction time and efficient adjustment of deadlines. Here are the key advantages of this approach:

- enables a more realistic estimate of schedule times and correlate it with some concrete requirements of resources; estimated deadlines may also be determined more realistically in view of expected resources;
- when optimizing the arrow schedule, some possible restrictions in attracted resources may be taken in account;
- resource requirement plans are an effective supplementary means of attracting the required resources;
- non-stop monitoring of the availability of resources for construction and erection operations (comparing actual and estimated indices) may reveal slight delays and help make relevant adjustments.
3. Results and discussions

Undoubtedly, the arrow schedule is a vital means of time scheduling. Its efficiency at planning the construction of an industrial object mainly depends on how the schedule is appropriately prepared and used.

The arrow schedule in construction should meet the following targets:

- set up the general construction time;
- detailed planning and coordination of works in time;
- determine the need for resources and monitor their use;
- control and coordination of the construction period.

While preparing arrow schedules and their tailoring to the requirements and their purposes, it is important to consider the following opinions and recommendations.

The basic condition of proper planning of construction time is a complete coverage of every work to be performed. In particular, this refers to those arrow diagrams that serve as the basis of detailed coordination and the determination of resources as well as the monitoring of the time.

Some especially dramatic consequences may occur due to some unaccounted works on the critical and subcritical paths.

Quite a frequent mistake is that some arrow diagrams neglect design works and only cover construction works being performed. Even though design works are assigned to the beginning of the path and, at first thought, are not limited by the time, excluding them from the diagram may cause bad consequences. The realistic evaluation and determination of the time required for design and planning, the strict coordination of work flow in relation to some separate sections of the project, the timely account and attraction of the required design efforts would hardly be possible without the period of construction being most carefully planned.

Visual presentation of works as a diagram is the prerequisite of a realistic estimate of works in view of the time and required resources. Coding the processes should ensure a realistic evaluation of each and every work in view of these two criteria.

The correct coding of works is also important for the precise evaluation of the total time spent. Positive or negative deviations in some values may be easily compensated for along the path, providing that a sufficient number of such values is produced.

Since the arrow diagram serves as a supplement to control and adjust the time, the works should be separated depending on the place, time and operators.

To control the time of operations relating to some major time expenditures, it is advisable to separate them with some intermediate results (events). Experience shows that the design should be accompanied with a stage-to-stage monitoring and coordination of the project documents. Still, some detailed characteristics of the event included should be observed [1-4].

The key requirement here is that the arrow diagram should include the sequence of only those processes that show a clear logical and technological interaction. All other processes should look as works performed in parallel. One may often make a mistake by creating logically and technically unrelated bonds when performing a structural analysis aiming at eliminating some anticipated bottlenecks in relation to resources. As a result, the arrow diagram indexes get distorted which, especially while adjusting the construction periods and searching for the ways of time saving, may bring about some wrongful conclusions. Similar consequences may occur due to the presence of some unaccounted dependencies.

It often happens that there only exists just a conditional bond between the successive large or complex works. A more detailed study may show that the end of the previous work and the beginning of the following one may overlap in time. Such opportunities may help perform an efficient optimization i.e. decrease the time of construction [2].

In the arrow diagram, the unit of time analysis equals a single eight-hour workday. At critical path scheduling, one should avoid overusing works performed overtime or on weekends. They should be saved as time resource to be further used to make up for delays.
It is critical that when evaluating the time, one should also take account the realistic values of the time of supplementary, preparatory and extra jobs. When planning operations, calculations basing on mean, maximal, and realistic values are performed quite rarely. To estimate realistic time expenditures, experts in construction work planning usually rely on some valid experimental data because, most of the time, those experimental data on the minimal and maximal time expenses are not quite clear.

Entering the data on time expenditures in the arrow diagram should be discussed and approved upon with the contractors. Experience proves that such consultations may give strength to the master schedule and act convincingly on the contractors who may rather agree than disagree with the deadlines suggested. This psychological effect may become especially effective as regards the time of construction.

The schedule prepared at the early stages of planning would seldom fully consider some separate details of jobs and processes. To compensate, time reserves should be envisaged.

Experience shows that complex processes hardly even run absolutely smoothly while, on the other hand, they rarely produce serious impediments. Any regular process produces multiple small problems to overcome which time reserves should be provided [5].

Whenever possible, time reserves should be introduced at the end of the arrow diagram. Here's two reasons for that:

- unpredictable works often arise at the end of the paths (e.g. delayed or erroneous shipments, elimination of assembly flaws, issues in tune-up or testing equipment etc);
- time reserves provided at the start of the path are quickly used and so may even be completely exhausted later on.

On the contrary, those time reserves at the end of the path may be used to compensate for any previous time violations.

Beneficiary is a situation where, at the start of the path, the periods are slightly lower but at the end there are entered relevant reserves. Psychologically, however, time reserves in the arrow diagram should never be marked "reserves" but "tests", "tune-ups" or alike instead [1-3].

To effectively control the time and resources, it is essential to have an exact account of every need for labor force and supplementary means. As well as when making time analysis, an undocumented demand for labor force here equals the relevant job done without working hours spent.

Undoubtedly, it is possible to narrow the study of the need for resources and the continuous control over the labor force and supplementary means to choosing some most vital periods or types of jobs (e.g. only of electricians, plumbers etc.)

It is essential that the required resources listed in the arrow diagram be realistic and approved upon by the contractors. Special care should be given to mutual cooperation and work coordination by the contractors in a wide rage of profiles operating inside a single process. It should also be advisable to doublecheck if there is enough specified time provided for those cases where some specific works may not be performed simultaneously or where they are interrupted by other jobs being done.

While leveling peak requirements in resources, one should make sure that the critical and subcritical paths are kept intact. The accurately aligned time reserves and switching over the resources make no necessity here [6-8].

Practice proves that for those supplementary works that may not fall under a timely account there should be provided a 10-15% time reserve of resources. This can be easily done while leveling peak requirements.

Aligning the arrow diagram and the schedule of engaging the resources may be principally performed in two ways:

- adjustment of the arrow diagram to available resources by introducing intermediate time;
- redistribution of resources as per the requirements of an optimal arrow schedule.

As a rule, the second path is chose where a special care is given to the continuous flow of works, and shifting the final deadline may cause some substantial losses and extra expenses.
A most efficient way to ensuring the relevant resources in construction is to timely determine the needs and take steps to attract the required resources [9,10].

The recommendations stated above on how to perform detailed time planning when making an arrow diagram for constructing an industrial object should only be taken into account depending on how necessary it should be for each and every case. In the above Table with test questions one can see that the arrow diagram for the general planning of the time is much more simple than the one provided for the time and resource monitoring. Here there's a rule: detailed wherever required but as simple as possible.

While optimizing time planning performed for the purpose of ensuring (at least costs for engineering labor) the continuous flow of construction within shortest periods at minimal expenses, the following requirements should be borne in mind:

- simplicity of making the diagram - lowest expenses at data processing;
- sufficient completeness of the data - persuasion and visibility at use;
- development at a most appropriate moment; not before than it becomes possible after receiving the required initial data and not later than required (when the arrow diagram is required);
- avoidance of intermediate changes to ensure that the deadline remains intact).

A more efficient way of performing the above-listed requirements is rational separation of the process of scheduling into a row of subordinate processes.

4. Conclusions

At the earliest design stage it should be impossible to detalise on the arrow diagrams so that they already correspond to the requirements of optimizing the time or adjusting the time and resources from the beginning to the end of the works. For instance, it is hardly possible to draw detailed data on the nature of assembly operations at the start of the scheduling procedure because by then no supplier or machine types have yet been selected. The arrow diagram should be periodically checked as per the design results (added or restructured) or the system of time planning be divided into work phases that correspond to the operational concrete conditions and requirements.

The first approach features a drawback due to the fact that periodic corrections of arrow diagrams may result in additional works and expenses, and, at that, the psychological meaning of deadlines loosen its priority.

The starting point of planning the time of construction is an enlarged schedule containing some general approximate and key intermediate deadlines. This plan, if necessary, may be presented as a simple linear diagram to primarily serve as a supplement for the rough coordination of works among the designer team, the building contractor's top management, and the rest of its divisions (sales and trade, finance, accounting etc).

Alongside with the enlarged schedule, a detailed work program is prepared for the initial 6-10 weeks of working on the project of construction management, i.e. before the initial design data gets clarified. This stage features a huge list of separate small works, which may hamper the normal flow of operations later on due to a few well-known flaws. Therefore, to develop such programs it is advisable to prepare a wide-span table of test questions to be further used as a checklist.

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