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Eureka Journal of Civil, Architecture and Urban Studies (EJCAUS)

ISSN 2760-4977 (Online) Volume 01, Issue 02, December 2025

https://eurekaoa.com/index.php/8

IMPROVING NETWORK-BASED CALENDAR SCHEDULING IN CONSTRUCTION WORK PLANNING

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Abstract

In this article, the significance of network-based scheduling in the planning of contemporary construction works is examined, methods for improving such schedules are analyzed, and, based on the results obtained, recommendations are developed for their wide-scale practical application in accordance with construction norms and regulations, along with several specific proposals..

Keywords: Construction, planning, Gantt charts, linear schedules, network schedules, calendar plans, management, sequencing, model.

Introduction

In construction, there are specific constraints related to the sequence of executing works, which are determined by the distinctive characteristics of construction products and their production processes, as well as by particular production conditions. In addition, such constraints are also identified due to the need to

Eureka Journal of Civil, Architecture and Urban Studies (EJCAUS)
ISSN 2760-4977 (Online) Volume 01, Issue 02, December 2025

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reduce the duration of certain technological processes to the maximum extent possible. These constraints can be taken into account by considering the interdependencies between different activities.

The classification of types of interrelationships between various activities and their characteristics has been presented in the works of a number of authors, whose studies have been analyzed in this research.

In the course of this analysis, the emergence of specific relationships and their application in models for organizing construction works were examined in chronological order. According to available data, the representation of interdependencies in work execution schedules was first proposed in 1909 by K. Adametski.

In his works, A.A. Gusakov noted that the use of a network model accounting for interrelationships between construction activities was recommended by A.A. Erasmus. At the same time, particular attention was not given to the types of relationships between activities in that work. It is not difficult to imagine that interdependencies always exist between individual activities and their complex assemblies, since the construction processes of any facility are carried out according to a defined sequence and based on specific interrelationships [1-5].

Nevertheless, until a certain period, these interdependencies were not taken into account, were not thoroughly studied by specialists responsible for organizing works, and, as a result, the potential to use these interdependencies as a tool to improve work efficiency did not exist.

A calendar schedule is a planning document that represents the sequence of execution of construction works, their start and finish dates, duration, and time distribution based on a calendar.

It serves to ensure that construction activities are carried out within the specified time frame and according to the technological sequence.

The essence of calendar schedules is primarily manifested in the following:

* Organizing construction processes over time;

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* Clearly defining the start and end of activities;
* Ensuring technological sequence;
* Coordinating activities with each other;
* Providing control and management over the construction duration.

Materials and methods

Network Schedule is a planning method that represents construction processes in a graphic-logical form based on the sequence of activities, their interdependencies, and time parameters. In practice, the following methods are widely used:

*CPM (Critical Path Method)** – Critical Path Method

*PERT (Program Evaluation and Review Technique)** – Probability-based scheduling

These methods help determine the optimal duration and resources while taking into account the complexity of construction processes.

The calculation of a network schedule can be performed manually or with the aid of EXM software and computers. There are three main methods for calculating network schedules:

1. Tabular method
2. Sector (division) method
3. Potentials method

To‘rsimon taqvimiy rejani hisoblashda quyidagi ko‘rsatmalarga amal qilish kerak:

1. The early start time of an activity (Ti-j) is equal to the maximum early finish time of the preceding activity:

$$T_{i-j}^{эб} = мах T_{h-i}^{км}$$

2. The early finish time of an activity (Fi-j) is equal to the sum of its early start time and duration:

$$T_{i-j}^{эб} = T_{i-j}^{эь} + t_{i-j}$$

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3. The late start time of an activity (Li-j) is equal to its late finish time minus its duration:

$$T_{i-j}^{кб} = T_{i-j}^{км} - t_{i-j}$$

4. The late finish time of an activity (Lj-j) is equal to the minimum early start time of the subsequent activities:

$$T_{i-j}^{км} = \min T_{i-k}^{кб} + t_{i-j}$$

5. The total float (Ri-j) is equal to the difference between the late and early finish (or start) times of the activity:

$$R = T_{i-j}^{км} - T_{i-j}^{эм} = T_{i-j}^{кб} - T_{i-j}^{эб}$$

6. The free float (Chi) is equal to the difference between the early start time of the subsequent activity and the early finish time of the considered activity:

$$Ч_{i-j} = T_{i-k}^{эб} - T_{i-j}^{эм}$$

Calculating Network Schedules Using the Tabular Method

Before calculating a network schedule, its correctness is first verified. Then, the event sequence numbers and the durations of the activities are recorded. Once correctness is confirmed, the early and late start and finish times of activities, as well as total and free floats, are calculated using the formulas presented above [6-10].

This table structure corresponds to the stages of network schedule calculation:

- Stage I – Recording the event numbers and activity codes.
- Stage II – Noting activity durations.
- Stage III – Calculating early start and finish times.
- Stage VI – Calculating late start and finish times, as well as total and free floats.

You can fill in the actual activity data and computed values according to the formulas described earlier.

The calculations are carried out in the forward and backward pass (IY) stages and are filled in Table 1 as follows:

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Network Schedule Calculation Table

Table 1

Stage I – Stage II – Stage III – Stage VI

Previous Activity Event Number	Current Activity Code	Activity Duration	Early Start	Early Finish	Late Start	Late Finish	Total Float	Free Float
1	2	3	4	5	6	7	8	9

In construction practice, network schedules have the following shortcomings:

- Insufficiently defined work volumes and technological interruptions;
- Lack of full integration with resources (labor, equipment, materials);
- The schedule is not adaptable to dynamic conditions;
- Risks and uncertainties are not taken into account;
- Absence of continuous monitoring between actual progress and the plan.

These issues lead to an extension of the construction period and an increase in costs.

During the analysis of the shortcomings of network schedules in construction practice and possible solutions, several options can be identified. The following tables systematically reflect the main problems encountered when applying network schedules in construction practice and practical solutions for addressing them [11-14].

Table 2.

Main Shortcomings of Network Schedules

№	Type of Shortcoming	Description of Shortcoming
1	Incorrect determination of work duration	The duration of activities does not correspond to actual conditions and standards
2	Weak technological linkages	The sequence and parallel execution of activities are determined incorrectly
3	Lack of resource consideration	No integration with labor, equipment, and materials
4	Low control over the critical path	Delays in important activities are not detected in time
5	Static nature of the schedule	The plan is not updated during the construction process
6	Ignoring risks and uncertainties	Climatic, supply, and financial risks are not taken into account
7	Errors due to manual preparation	The diagram becomes complex, reducing calculation accuracy

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Conclusion. Analysis of Results

Modern construction processes are distinguished by their complexity, multi-stage nature, and degree of interconnection. The successful execution of any construction project requires thorough planning and efficient allocation of time and resources. From this perspective, calendar scheduling in construction is one of the essential management tools.

Although traditional linear schedules (Gantt charts) are convenient in a simple form, they do not provide sufficient efficiency for complex, multi-activity, and multi-stage projects. Therefore, network-based scheduling methods are widely used today. This approach allows for identifying the interdependencies between activities, their sequence, and critical paths, while optimizing resource utilization.

The relevance of this topic lies in the fact that large-scale construction and reconstruction works, major infrastructure projects, and investment programs in various sectors in Uzbekistan require highly detailed planning.

Therefore, improving network schedules is important not only theoretically but also practically. Relevant data and examples are presented in Tables 3 and 4.

Table 3.
Recommended Solutions for Shortcomings

№	Problem	Practical Solution
1	Low accuracy of work duration	Calculate based on standards and analogous projects; apply the PERT method
2	Technological inconsistencies	Clarify interdependencies based on technological maps
3	Resource imbalance	Resource-linked scheduling (resource loading and leveling)
4	Late identification of critical activities	Continuous monitoring and optimization of the critical path
5	Schedule inflexibility	Implement weekly and monthly rescheduling
6	Ignoring risks	Use time reserves and scenario-based scheduling
7	Calculation errors	Use specialized software (MS Project, Primavera P6)

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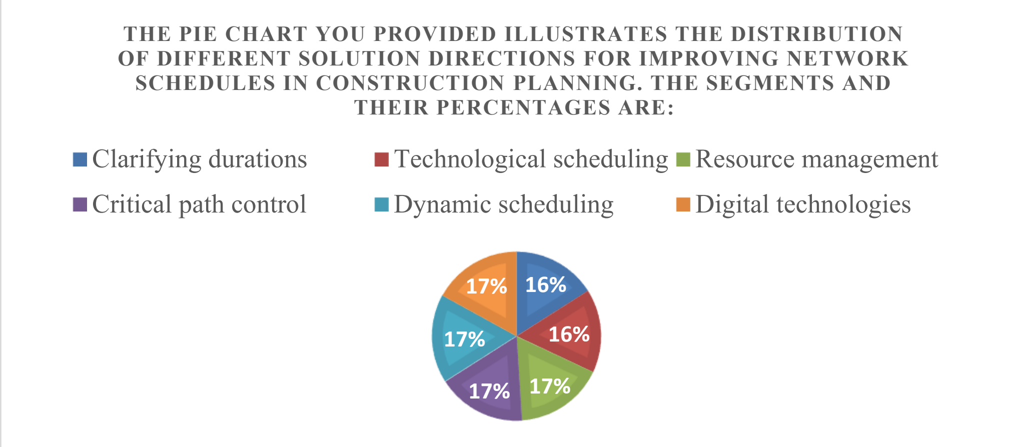
Table 4.
Practical Results of Implementing Solutions

№	Solution Direction	Result
1	Clarifying durations	Construction timelines become realistic and reliable
2	Technological scheduling	Activities are carried out continuously and logically
3	Resource management	Equipment and labor are allocated efficiently
4	Critical path control	Risk of delays is reduced
5	Dynamic scheduling	The gap between planned and actual progress is minimized
6	Digital technologies	Management decisions are made quickly and accurately



Conclusion

Based on the studied material, it can be concluded that the further improvement of scheduling methods for construction and installation works at the level of simple technological processes largely depends on the in-depth study of interdependencies between different types of activities. By analyzing these interdependencies, it is possible to account for nearly all constraints when modeling simple technological processes during the construction of a facility.

At the same time, studying these interdependencies is directly linked to a thorough understanding of the specific characteristics of construction products and their production processes. As a result, two main tasks are identified:

1. Studying the characteristics of construction products and their production processes;

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2. Investigating the types and descriptions of interdependencies that arise in activities of simple technological processes under the influence of these characteristics.

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