INTRODUCTION

The increasing utilisation of high-power and costly machines necessitates new planning methods. The operation of a modern machine by itself cannot usually result in the shortening of the construction term as far as this operation is integrated into a package of relatively slower, conventional building processes. Such a situation will be more complicated if part of the structure is executed by a subcontractor who will not be able to adjust the operational speed of a modern mechanism according to the overall planning. The software support of time planning by means of network-based critical path methods does not solve problems that arise (Barrie, Paulson, 1992). In many cases, the float of an activity becomes longer in relation to other tasks and activities. Such a solution will not be accepted if it gives rise to the discontinuity of an important building process in the construction spaces.

CHARACTERISTICS OF THE PRIORITY ACTIVITY METHOD

The structuring of the progress of construction is one of the conditions for success in the planning and control of activities. The spatial structures of realisations that assign the main directions of building flows within technological stages are of primary importance.

The spatial division of a single-storey hall of a large commercial centre may serve as an example (see Figure 1). The scheduling of the successive accomplishment and handover of its zones to the investor determines the directions of the building flows.

An other spatial characteristic is the task of determining the area or volume of the executed structural element by a production unit (labour gang or machinery crew) per shift. So the speed of the activity results from the technology used by the contractor and his appropriate norms of time consumption.
The shift production of a gang may be estimated as:

\[ v = \frac{hspd}{\sum cp} \]  

(1)

where \( v \) amount of production in physical units (units of measurement - m.u.) per one work shift,

\( \Sigma cp \) number of standard hours of all the participating professions (time consumption) per 1 m.u. in relation to the contractor’s mechanical plant,

\( h \) number of hours per shift,

\( s \) ratio of time utilisation within the shift,

\( p \) coefficient of the norm’s fulfilment,

\( d \) number of workers in accordance with the size of the gang.

The presented method of planning and control corresponds with the needs of building technology and classifies construction activities in compliance with their importance. In a successively erected structure, the priority activities create the space for realising other activities.

The priority activities are conceived as activities that demand the increased attention of the construction manager in order that their continuous progress may be ensured. The reasons for introducing priority activities are connected with the necessity to maximise the use of high-cost machines on a building site and to provide for the assembly of important structural elements without any stoppages.

Secondary activities usually involve ordinary work carried out using conventional technologies in order to provide the readiness of the construction for subsequent primary activities. In the case of secondary activities, their continuous progress is not completely necessary.

Finally, there are compensatory activities that are inserted in time plans to accelerate the construction and to fill longer gaps, the rise of which in schedules is given by changes in technology for a more efficacious production. The compensatory activity is defined as independent of the completion of the priority activity in the given technological stage. However, the construction readiness of a compensatory activity must have been finished and the realisation of such a task in advance is conditioned by fulfilling all the demands for the quality and safety of the work.

The mathematical description explained in the following paragraph serves for one of the technological stages of construction.

**MATHEMATICAL DESCRIPTION**

The mathematical relations that describe the priority activities method enable the construction manager to prevent delays in building flows usually caused by the lesser speed of secondary activities realised by conventional “slow” technology. As noted above, the secondary activity involves the steps necessary for construction readiness for the priority activity.

The following equations (2) – (6) determine the progress in one technological stage. The meanings of the symbols in these equations are:

- \( a^i_j \) cumulative duration determining the completion of the priority activity \( P^i_j \) in the task \( i \) according to the accomplishment of the construction readiness by the secondary activity \( S^k \) regardless of the continuous progress of the priority activity (notation of tasks \( v = 1, 2, \ldots, i, \ldots n, \))

- \( P^i_j \) progressive priority activity up to the task \( i \)

- \( S^k \) progressive secondary activity up to the task \( i \):

\[ a^i_j = \sum_{k=1}^{n} S^k_P + P^i_j \]  

(2)

\[ b^i_j \] cumulative duration determining the completion of the priority activity \( P^i_j \) in task \( i \) relevant to the time-linked progress of priority activity in a given sequence of tasks (\( v = 1, 2, \ldots, i, \ldots n, \)):

\[ b^i_j = S^i_j + \sum_{k=1}^{n} P^i_j \]  

(3)

\[ c^i_j \] time difference whose positive value signifies the priority activity is delayed due to the failure to complete task \( i \) - previous building readiness has not been accomplished:

\[ c^i_j = a^i_j - b^i_j \]  

(4)

\( d^i \) delay in the start of the priority activity in 1st task:

\[ d^i = \max c^i_j \]  

(5)

\( \Delta^i_j \) delay of the start of the priority activity in the other tasks:

\[ \Delta^i_j = d^i - c^i_j \]  

(6)

The presented method quantifies the time value \( \Delta^i_j \), which serves for compensatory activity or it may be taken as the flow of the secondary activity.

The given basic relations (2) – (6) are generally true regardless of the speed of the activity. (The negative value of \( \Delta^i_j \) signifies that the area of task \( i \) is unused and waiting for the priority activity.)
VERIFICATION OF THE METHOD IN PRACTICE

As an example, the executing phase of constructing industrial floors of a large single-storey supermarket is presented. The floor structure parameters depend on different functional requirements in the zones of the supermarket. The directions of production units within the space of the building were adjusted in compliance with the sequential zone handover.

For the purpose of laying concrete slabs, modern technology based on using a laser guided machine (Laser-Screed) was selected (Hrazdíl, 2003a, b).

In this case, the above-defined activities comprise the operation:

Secondary activity:
- trenches below the floor, storm and sewage drainage, coolant distribution and cable channels,
- laying the sub-base.

Priority activity:
- insulation, laying fibre-reinforced concrete (with synthetic high-tensile-strength fibres) by means of Laser-Screed technology, cutting joints.

Compensatory activity:
- mounting air-ducts and air-conditioning equipment under the cover (roof).

The laser-controlled machine enables large outputs, and accurate levelling and vibrating of the concrete. The parameters of the machine (Somero Laser-Screed S – 160) that was used on the reported construction site (Figure 1) determine the width of the so-called working task (an approximately 5 m wide bay). The concreting must run continuously from one bay to another within an area given by the daily output determining the planning method task. The daily rate of concreting is more often limited by the possibilities of the transport of the concrete from a central mixing plant to the work place – usually by means of truck-mixers that enter into the roofed and partially sheathed hall construction in progress.

The application of the given method is shown in the time–space diagrams (Figures 2–4) that render the progress variants of the construction and its optimisation.

Fig. 1 Example of a division into zones
Parking and communications: G – supply yard, H – communication of supply, I – communication and parking of personnel, J – communication and parking of clients.

Fig. 2 Disconnected course of the priority activity P due to the slower rate of the secondary activity S

Fig. 3 Continuous course of the priority activity P
The activity duration is based on a shift production according to parameters of structural components. For instance, the priority activity tasks of storage zone were chosen smaller than their extent in other zones because of a more demanding surface treatment and bigger thickness of the concrete slab.

The following figure shows the idle time of the concrete laying machine standing by for the readiness of the floor slab carrying out.

CONCLUSIONS

The aspects of space, time and technology of building construction is considered in the presented planning and control method so that the construction progress of priority activities may be continuous. The activities in the time plan should be put in the following order: The priority elements are put first, and the other activities are subsequently inserted with respect to the stages of the construction technology. The graphic solution and its mathematical expression used within a package of building works is a significant acquisition to a new computer model corresponding to the development of construction production. The application shows greater validity of the deduced solution in practice.

REFERENCES

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