# SPECIFICS OF CALCULATIONS FOR DETERMINING WORK TIME EXPENDITURES FOR PERFORMING SURVEY OPERATIONS IN CONSTRUCTION

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The normative documents relating to the construction technologies contain instructions for inspection and acceptance of construction works, but such documents do not contain information on the estimation of work time expenditures and cost of survey operations in construction.

The existing standards on work time expenditures and cost of engineering surveys in construction [1, 2] do not represent the characteristic features of survey operations as part of a construction process.

When determining the basic parameters characterizing the efficiency of geodetic support works, such as time, labor content, and production costs, it is necessary to consider the relationship and interdependence between survey operations and construction-assembly works.

Depending on the effect of construction-assembly works and working conditions at the construction site, the same survey operations performed at different construction objects will have different time length and, as a result, will be of different productivity.

The labor productivity ($P$) of a surveyor may be defined as follows:

$$P = f(x_1, x_2, \ldots, x_i, \ldots, x_p),$$

where $x_i$ is the quantitative estimate of the $i$-th factor from the factors that affect the labor productivity.

These factors include working conditions at the construction site, weather conditions, characteristic features of construction-assembly works, relationship between survey operations and construction-assembly works, and other factors.

Because of the specifics of survey operations, one of such factors is interruptions in survey operations occurring due to the necessity to perform construction-assembly works. Such interruptions are considered as technological interruptions because the surveyor must be present at the construction site, but there cannot be the possibility to perform survey operations concurrently with construction-assembly works. Technological interruptions may be reduced by choosing the optimal variant of performing survey operations, modern surveying instruments, or measurement methods. If possible, technological interruptions should be combined with other interruptions or other works. In this case, technological interruptions are classified as overlapping and nonoverlapping interruptions.

The total work time in performing survey operations may be divided into two parts, that is, work time (productive time) and interruption time (unproductive time). In contrast to unproductive time, productive time can be rated. Figure 1 illustrates the work time expenditures in performing survey operations.

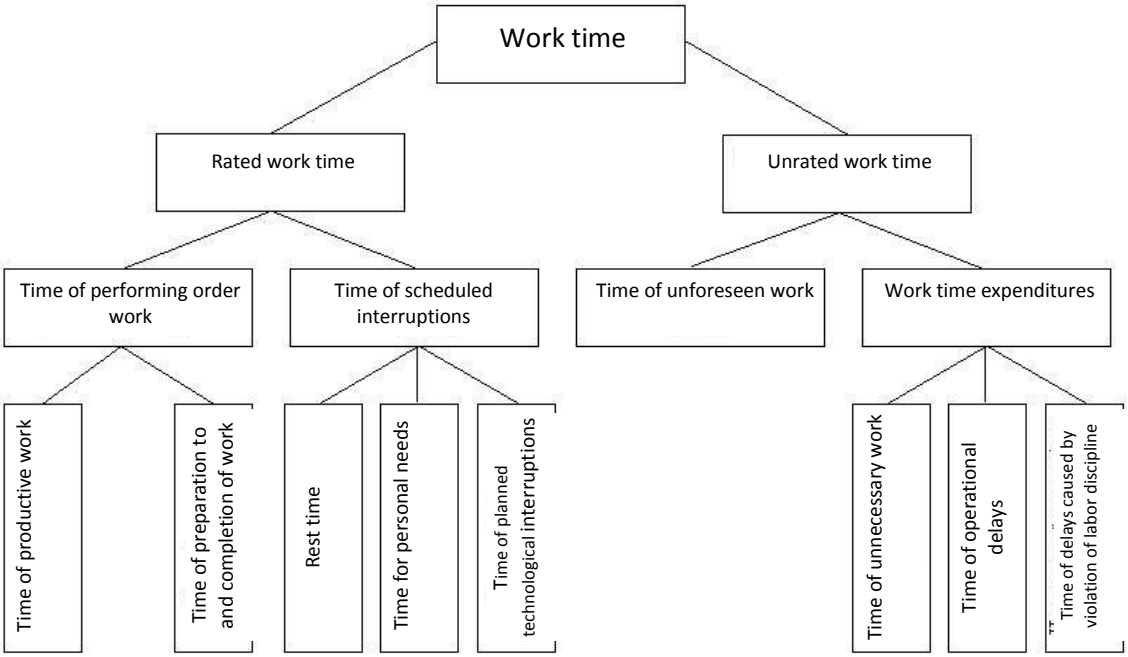


*Figure 1. Work time classification in engineering design*

The rated time for paid survey operations includes total productive work time, time for physiological needs including rest time, and nonoverlapping technological work interruptions which differ from overlapping technological work interruptions such as interruptions for satisfying personal needs.

Depending on the characteristic features of survey operations to be performed in combination with construction-assembly works, it is possible to consider various variants of arranging survey operations and, accordingly, the following methods for determining productive costs in performing such operations.

The simplest variant is in the case when survey operations are performed before construction-assembly works (see Figure 2).

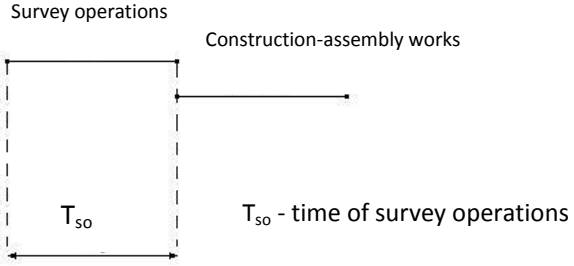


*Figure 2. Arrangement of the production process when survey operations precede construction-assembly works*

In this case, there is no technological work interruptions associated with construction-assembly works. The work of a surveyor is paid according to effective or individually-introduced rates of pay, with consideration for time of productive work and time for satisfying personal needs.

The work time expenditure rate ($H_{fp}$) per unit of final performed works is determined as follows:

$$H_{fp} = t_{pw} + H_{pc} + H_r,$$

where:

$t_{pw}$ is the time of productive work;

$H_{pc}$ is the time for preparation to work and completion of work, which may be determined as percentage of the productive work time depending on the complexity of the survey operations;

$H_r$ is the rest time and the time for personal needs, which may be determined as percentage of the productive work time depending on the complexity of the survey operations.

The most routine is the variant when survey operations and construction-assembly works interchange during a working shift (see Figure 3).

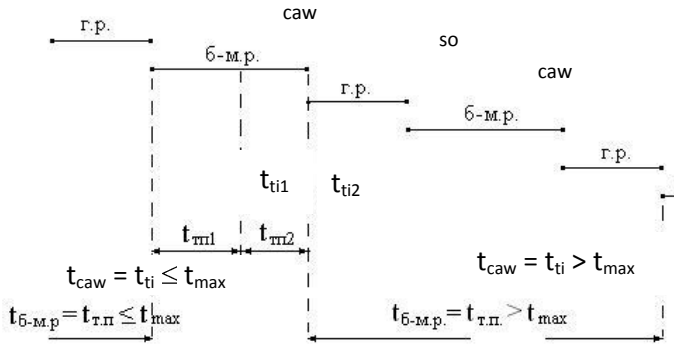


*Figure 3. Arrangement of the production process when survey operations and construction-assembly works interchange during a working shift*

so Survey operations
caw Construction-assembly works
$t_{so}$ Time of survey operations
$t_{caw}$ Time of construction-assembly works
$t_{ti}$ Time of a technological work interruption
$t_{max}$ Maximum allowed time of a technological interruption

In this case, it is necessary to compare the time of a technological work interruption with the existing rated time of an allowed technological interruption which is included in work time expenditures.

If $t_{caw} = t_{ti} \le t_{max}$, where $t_{caw}$ is the time of construction-assembly works, $t_{ti}$ is the time of a technological work interruption, and $t_{max}$ is the maximum allowed time of a technological work interruption, the time of a technological interruption shall be included in the rated time and taken equal to $t_{ti}$.

If $t_{caw} = t_{ti} > t_{max}$, the final time of a technological work interruption shall be determined by using an experimentally determined characteristic or results of special calculations.

When required technological work interruption times are included in the rated time, it is necessary to take into consideration that the additional rest time for a surveyor can be reduced because the surveyor can rest during the technological work interruptions.

As the surveyor must preform office operations, it is necessary, in every individual case, to analyze the possibility to perform such office operations at the construction side during technological work interruptions, so part of the technological work interruption ($t_{ti1}$) can be overlapped.

The remaining part of the technological work interruption ($t_{ti2}$), which is not overlapped with the time for satisfying personal needs and other works, such as office operations, may be defined as an operational delay which occurs for independent reasons, and shall be paid to the amount not less than 2/3 of a surveyor salary according to the effective legislation.

With characteristic features of production processes, it is reasonable to determine the rated time individually for every construction object, taking into consideration all factors which affect work of surveyors, If such rated time values are determined in sufficient number and individually verified, the rated times for standard construction objects can be averaged.

The work time expenditure rate ($H_{fp}$) per unit of final performed works is determined as follows:

$$H_{fp} = t_{pw} + H_{pc} + 2/3H_{ti} + H_{oo},$$

where:

$t_{pw}$ is the time of productive work;

$H_{pc}$ is the rated time for preparation to work and completion of work;

$H_{ti}$ is the rated time of technological work interruption;

$H_{oo}$ is the work time expenditure for possible office operations.

The variant with significant technological interruptions occurring during survey operations is illustrated in Figure 4.

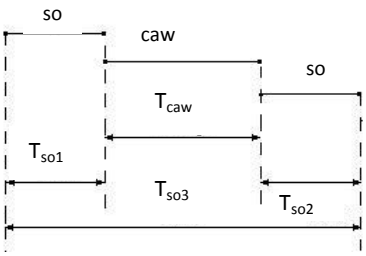


*Figure 4. Arrangement of the production process with significant technological work interruptions during survey operation*

so Survey operations
caw Construction-assembly works
$T_{caw}$ Time of construction-assembly works
$T_{so}$ Time of survey operations

In this case, it is reasonable to analyze work time expenditures in order to determine the possibility for the surveyor to perform survey operations at another object. If the time of a technological interruption is sufficient for performing survey operations at another object, the time of survey operations is determined as follows:

$$T_{so} = T_{so1} + T_{so2}.$$

The work time expenditure rate ($H_{fp}$) per unit of final performed works is determined as for the first variant:

$$H_{fp} = t_{pw1} + t_{pw2} + H_{pc} + H_r,$$

where:
$t_{pw1}$ and $t_{pw2}$ are the work time expenditures for productive work before and after the significant technological work interruption;
$H_{pc}$ is the time for preparation to work and completion of work, which may be determined as percentage of the time of productive work depending on the complexity of the survey operations;
$H_r$, is the rest time and the time for personal needs, which may be determined as percentage of the time of productive work depending on the complexity of the survey operations.

If the technological interruption is insufficient for performing other survey operation procedure, the time of survey operations is determined as follows:

$$T_{so} = T_{so1} + T_{caw} + T_{so2} = T_{so3}.$$

The work time expenditure rate ($H_{fp}$) per unit of final performed works is determined as for the second variant:

$$H_{fp} = t_{pw1} + t_{pw2} + H_{pc} + H_{ti}.$$

**Conclusion**

This paper specifies the procedure of calculations for determining rated work time expenditures per unit of final performed works, depending on the relationship between survey operations and obstruction-assembly works, for three basic cases which are possible in the practice of survey operations.
The data obtained may be used in the subsequent preparation of cost estimating documentation for survey operations in various construction processes.

**References**

1. STS-82, List of prices for prospecting works for capital construction; M., 1982
2. Uniform norms and prices for prospecting works - Part I. Engineering-surveying prospecting works; M., 1978

## Specifics of calculations for determining work time expenditures for performing survey operations in construction

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This paper specifies the procedure of calculations for determining rated work time expenditures per unit of final performed works, depending on the relationship between survey operations and construction-assembly works, for three basic cases which are possible in the practice of survey operations. The data obtained may be used in the subsequent preparation of cost estimating documentation for survey operations in various construction processes.