



Performance of Technical Supervision and Its Evaluation on Transport Constructions

Petr Suchánek ^{1*}, Zdeněk Dufek ¹

¹ Faculty of Civil Engineering, University of Technology, Brno, Czech Republic.

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Abstract

The aim and purpose of the research are to analyze the performance of the technical supervision of the investor within the Czech construction industry during the construction, particularly focused on transport line structures. It is about clarifying the meaning and role of technical supervision in the public sector in transportation structures. In the first phase, a literature search is carried out on the current state of performance of the technical survey, and its work content is determined, including the method of its evaluation within the framework of a public contract. On the basis of these conclusions, a questionnaire is designed, which determines the real time-consuming activities during the performance of supervision and, at the same time, examines the tools used in its performance. Conclusions from the questionnaire research are examined, and steps for possible streamlining are proposed. As part of the examination of the proper evaluation of performance, a more suitable model of evaluation of these services is sought based on the previous analysis of the time-consuming nature of the technical supervision activity and according to the existing evaluation methods.

Keywords: Technical Supervision of the Investor; Construction Manager; Evaluation of Technical Supervision; Transport Lines.

1. Introduction

The article deals with the role and importance of supervision in the Czech construction industry. It accentuates its role in public procurement and provides a comprehensive view of its activities. The article also clarifies the function, content, and duties of supervision or the importance of supervision for the construction life cycle.

The performance of technical supervision for the contracting authority of the Directorate of Roads and Highways is carried out exclusively using the methodological instructions for the performance of supervision issued by the Minister of Transport. However, this methodological instruction no longer establishes the optimal time frame for individual activities. It is still necessary to reflect the entire range of services for the performance of technical supervision as set out in the implementation contract, but neither the solution to the resolved time fulfillment issue nor the tools with which the performance of technical supervision is carried out. As part of the performance of supervision, only the time intervals for individual supervisory positions are monitored, the content side of the activity, its effectiveness, and possible optimization are not monitored. Furthermore, the Directorate of Roads and Highways uses external consulting firms, which provide technical supervision; however, the position of The Engineer is performed by the contracting authority of the Directorate of Roads and Highways with its own employees. As part of the performance of supervision, two forms of permanent and occasional supervision are analyzed, but this division is not expected by the real needs on the construction site. From the point of view of the Building Act, the supervision function is always only a permanent form.

* Corresponding author: petr.suchanek@infram.cz

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In the case of public contracts, the performance of technical supervision should be carried out by external workers. The external performance of not only individual workers, but also the positions of The Engineer will ensure independent and technically expert control of the contractor's work. The contracting authority should only supervise this external performance, and this supervision should be carried out exclusively on the content side and by checking the fulfillment of the essence of the supervision. The performance of technical supervision should be viewed as a comprehensive service. There must be a departure from the current situation, where the time interval of the performance of technical supervision is mainly monitored at the expense of the content side of the performance. At the same time, this should result in the abolition of the distinction between permanent and occasional forms of supervision.

2. The Position of Technical Supervision

2.1. The position of technical supervision in the Czech Republic

The public contracting authority of the Directorate of Roads and Highways, currently exclusively uses business conditions of contract for construction that are standardized by the International Federation of Consulting Engineers (FIDIC) [1, 2]. It is necessary to note that the employer has the right to choose the type of conditions of contract for construction when awarding a procurement procedure and, at the same time, can freely change individual provisions in the special business terms and conditions of contract at its own discretion. According Conditions of Contract for Construction the FIDIC, the Engineer has two main roles:

1. Role – acts and represents The Employer. He does not have the authority to change the contract for the work, but he is the bearer of most of the approval and approval processes within the construction;
2. Role – to be a neutral expert determining a fair solution.

It is also evident that the overall content of the performance of technical supervision and the Engineer is not only about the performance of one individual; therefore, a team of The Engineer needs to be defined. This is a multi-member team of experts, where the powers, competences, and overall performance of supervision (The Engineer) will be divided among several people, which will ensure proper performance of the service. Determining the exact number of members of the Engineer teams is entirely up to the Employer, which the Engineer team defines during the preparation of the selection procedure for the supervision service [3]. At the same time, the employer must reflect the complexity and technical parameters of the given building. In the case of large-scale transport constructions, it is possible to list some positions more than once; on the contrary, for example, if the planned construction does not include, e.g., bridge structures, there is no need to consider the position of specialist for bridge structures. For the overall determination of the members of the Engineer team, it is necessary to reflect on:

- Expected financial volume of the construction;
- Defined type of construction – new construction / reconstruction under existing operation;
- List of construction objects;
- Technical specification of the building.

2.2. The Position of Technical Supervision Worldwide

It is evident from the conducted global research that even if a country has its own contractual standards that correspond to the laws of the given country and the appropriate customs in the given country, the world-recognized standards of FIDIC, ICE [4], or AIA [5] are still the most commonly used. Furthermore, it is necessary to reflect that not only in Europe, but also in the world, contractual forms of a different type are often used, e.g. EPC [6] and Turnkey. When analyzing the performance of technical supervision around the world, it is also necessary to take into account its supervision terminology and what the scope of supervision should be. A great variety of terms and their interpretations, including different contents of the activity, were found:

- The Engineer – this is the performance of The Engineer as stated in the FIDIC Conditions of Contract for Construction [1];
- Engineer representative – this is a representative of The Engineer according to FIDIC Conditions of Contract for Construction and we can consider him as a permanent supervisor [1];
- Site inspector - usually appointed for larger projects, he is supposed to inspect construction works and represents The Employer. The construction inspector provides an independent assessment of the works and usually provides appropriate information to The Employer. For the largest projects, it is advisable to elect several building inspectors according to their focus and fields. In this context, building inspectors do not take over construction work and are not responsible for it, they only inspect the work and provide an independent view [7];
- Technical supervision - monitors public construction projects, such as highway construction, airport and bridge construction. The activity of the technical supervisor is directly related to the implementation of construction works

and at the same time he is familiar with all aspects and contractual relationships on the project. The technical supervisor checks and monitors that all construction stakeholders are working as they should and performs a visual inspection of the work performed. Technical supervisors can provide monitoring reports and construction reports. [8];

- Resident engineer - is responsible for ensuring that the construction work on the project is carried out in accordance with the contractual requirements for quality, time and cost. He is responsible to the Project Engineer and is often the intermediary between him and the Contractor. The exact responsibilities of the Resident Engineer will vary according to the extent of authority delegated to The Engineer. He must keep The Engineer informed of current work on the site and keep detailed records of all matters that may affect The Engineer's instructions. Under the terms of the contract, The Engineer may choose to delegate additional duties and responsibilities to the Resident engineer [6, 9, 10]. This term is mainly used in the Institution of Civil Engineers (ICE) terms and conditions, which are the most widely used worldwide [11];
- Consulting engineers - provides engineering services and expertise for both the public and private sectors. Consulting engineers act as independent workers and representatives of their clients. They are responsible for finding solutions to technical problems and provide management consulting services [12];
- Project manager – this is a person other than The Engineer, in particular, he is not independent. He can perform many similar duties as The Engineer, and his actions are understood by the Contractor as those of the Client [11].

3. Research Methodology

The research methodology includes three phases. The first phase focuses on the current state regarding the performance of technical supervision in the Czech Republic and abroad, and its work content will be determined, including the method of its valuation within the framework of a public contract in the Czech Republic (see Figure 1).

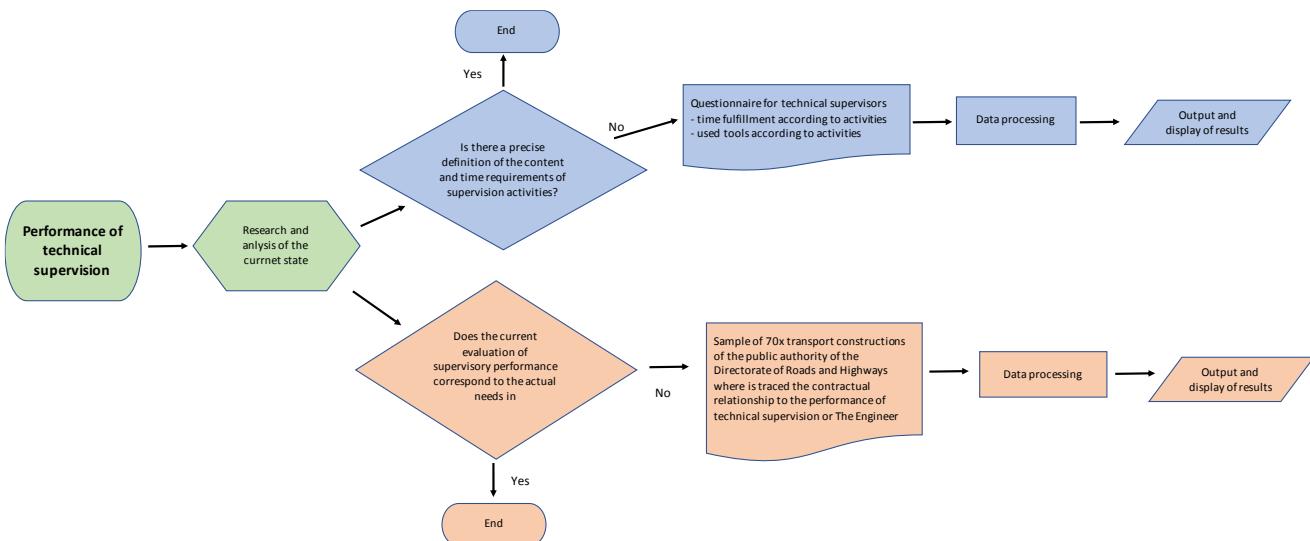


Figure 1. Flowchart of the research methodology

Phase two deals with data collection and analysis processes, which include the real-time requirement of activities during the performance of technical supervision and, at the same time, an examination of the tools used in the performance. The last phase is the analysis of the data found from the questionnaire research, and new measures will be proposed, which will be evaluated and commented on. Theoretical methods are mainly used for research, such as analysis, induction, deduction, or comparison. Furthermore, basic scientific, mathematical, and statistical methods are used in the work. A questionnaire survey was conducted as part of the research among workers performing technical supervision in both the Czech Republic and Slovakia. This is an anonymous questionnaire among independent technical workers who hold various functions of technical supervision and at the same time work on different construction sites. The questionnaire contains a list of 28 supervisory (see Table 1) activities that a properly qualified technical supervisor should perform. This list of activities corresponds to the scope of services according to standardized contractual relations for the provision of technical supervision services in the Czech Republic [13, 14]. The persons carrying out technical supervision then added time data to the individual activities, indicating how long they performed the given activity per week, and at the same time indicated what tools they needed and used for this activity. The persons addressed work on various detailed and large-scale transport constructions, i.e., some of the filled-in data relate to activities on the construction of a highway section with an investment value of over 40 million EUR, and this is the position of permanent supervisor. Another person, on the other hand, supervises smaller constructions and takes into account that he is in

charge of more of these buildings, and therefore it is a type of occasional supervision. At the same time, the persons addressed work in various positions performing technical supervision. They were included in the questionnaire, and both the head of a multi-member the Engineer team and, for example, the position of Quality Manager, the position of assistant the Engineer for bridge structures, or, as mentioned earlier, the technical supervisor for smaller-scale constructions, which is in charge of the entire range of these activities, were approached. This division was chosen on purpose, as it is intended to be a summary overview of the position of technical supervisor. Individuals filled out the survey independently of other individuals, and it was recommended that the interviewed person monitor (ideally measure) the time spent on the given activity during the working week and then fill in the data. The weekly interval was chosen as a sufficiently representative time data, which can also be converted to a monthly interval.

Table 1. List of activities during the performance of technical supervision and their categorization

I. Categorization	Description of technical supervision activities		II. Categorization routine / non-routine manual / knowledge	III. Categorization CDE distribution
Physical inspection of the construction	1	Physical inspection of construction work - a general overview of the construction process	routine / knowledge	Construction activities
	2	Physical inspection of construction work - requirement for inspection of partial units (acceptance of reinforcement, acceptance of backfill)	routine / knowledge	Construction activities
	3	Physical inspection of construction work - presence during the fulfillment of the inspection test plan (compaction test, concreting tests)	routine / knowledge	Construction activities
Administrative inspection activity	4	Photo documentation processing	routine / knowledge	Processes
	5	Registration in the construction diary	routine / knowledge	Processes
	6	Approval of the amount of work performed by the Contractor - measuring diary or other method	non-routine / knowledge	Processes
	7	Control of the financial performance of the construction - financial schedule of the Contractor and invoicing of the Contractor	non-routine / knowledge	Processes
	8	Checking the time performance of the construction - time schedule of the Contractor	non-routine / knowledge	Processes
	9	Quality control - approval process of newly issued technological regulations and control test plans	routine / knowledge	Documents
	10	Quality control - approval process of embedded materials	routine / knowledge	Documents
	11	Review and approval process Project documentation	routine / knowledge	Documents
	12	Control of project documentation with respect to the detected condition on site	routine / knowledge	Documents
	13	Checking the documentary part of already completed construction works	non-routine / knowledge	Documents
	14	Inspection of the documentary part of already completed construction objects - acceptance procedure	routine / knowledge	Documents
	15	Checking the incorporation of comments on documents already submitted	routine / knowledge	Documents
	16	Coordination meetings - physical presence	routine / knowledge	Documents
	17	Coordination meetings - video conferencing	routine / knowledge	Documents
	18	Coordination meetings - creation of record, preparation, etc.	routine / knowledge	Communication
	19	Processing of statements technical supervision and others	routine / knowledge	Communication
	20	Control of the correctness of Variation and Claim during construction	routine / knowledge	Communication
	21	Internal meetings - physical presence	non-routine / knowledge	Communication
	22	Internal meetings - video conferencing	non-routine / knowledge	Communication
	23	Internal management or other internal agenda	routine / knowledge	Communication
	24	Email communication - Contractor / Client	non-routine / knowledge	Communication
	25	Email communication - internal	non-routine / knowledge	Communication
	26	Telephone communication - Contractor / Client	non-routine / knowledge	Communication
	27	Telephone communication - internal	non-routine / knowledge	Communication
	28	other activity	various	various

4. Performance of Technical Supervision

4.1. Performance of Technical Supervision in the Czech Republic

In the Czech Republic, the performance of technical supervision on procurement procedures for public contracts is assigned and legally obliged to be ensured by The Employer of the public contract. Among other things, two forms of supervision are distinguished in the case of public procurement, i.e., permanent supervision or occasional supervision [15]. At the same time, it is necessary to reflect the fact that the performance of technical supervision can also be carried

out by the Employer own capacities. Therefore, it is also necessary from this point of view to distinguish three basic types of performance in technical supervision.

- The Engineer and his entire team are composed only of the Employer 's employees \Rightarrow the Employer completely ensures the performance of supervision himself.
- The Engineer and dedicated assistants are employees of the Employer, but part of the assistants is from an external consulting firm \Rightarrow supervision is handled by the Employer and at the same time by external workers based on a contractual relationship.
- The Engineer and his entire team are composed only of external employees, i.e., an external consulting firm \Rightarrow supervision is performed only by external workers based on a contractual relationship.

4.2. Determination of the Optimal Price for the Performance of Technical Supervision

The optimal and adequate price for the technical supervision service cannot be determined exactly. The unit price for the performance of technical supervision is a numerical evaluation of complex performance, including adequate technical expertise, and is not only about direct profit and labour costs. Especially if it is a person in an employment relationship, a considerable part of the unit price for services falls to the employer, who has other costs that, on the other hand, must be included in these unit prices. The unit price then corresponds to the company's overall approach to performance, e.g., further professional growth of employees, adequate IT equipment, company innovation, competitiveness, etc. The unit price must possibly include the costs associated with housing at the construction site and travel expenses, which are pointed out by the contracting authority during the procurement procedure. In the case of a physical person who has the appropriate authorizations to perform and is the holder of a trade license to perform supervision, the side costs that must be included in the total price for the performance are diametrically different.

On the other hand, it is very difficult for these persons to obtain reference sheets from large construction projects and thus to meet the qualification requirements in the selection procedure for more significant constructions. The invoicing of the performance of supervision corresponds to the actual performance of services and is determined according to the implementation contract, where the terms of payment and the price for the services are stated, which is based on the public contract that took place. Usually, the total price for a public contract is determined on the basis of the financial rate and the time interval. The choice of a unit of measure that will be fully optimal for the performance of technical supervision cannot be determined exactly. The time interval as a unit of measurement does not fully describe the performance itself; on the other hand, the performance of technical supervision does not describe the number of performed actions either. E.g., during supervisory activity when checking the variation sheet, performance cannot be measured only according to the supervisor's opinion submitted – whether they agree/disagree with the variation / claim. The performance of supervision is not defined only by the normative side of the submitted opinion; this action includes many other activities such as the study of documentation and documents (project documentation, construction diary, financial drawdown of items, etc.). The approach where the unit of measure for the performance of supervision will be the directly given activity, or task evaluation, would be possible provided that it was clearly defined how exactly this activity should take place, including clearly defined input parameters E.g., in the laborer profession, when digging the soil, it is possible to clearly determine what kind of soil will be the subject of the activity, how much of the activity there will be, and what tools the worker should use for it. Therefore, the measurement unit EUR/m³, or only the monetary evaluation of EUR, can be determined.

In the case of professional activity, which includes the performance of technical supervision, the input parameters of the activity are not clearly defined, and the primary activity itself is conditioned by another activity that must be performed in order to fulfill the primary activity. It is also a matter of course that the worker in question has professional knowledge and skills that he uses for the given activity. On a sample of 70 transport constructions of the public employer, the Directorate of Roads and Highways [16], it is also possible to trace the contractual relationship to the performance of technical supervision, or The Engineer. From the value of the contractual relationship for the performance of technical supervision, the percentage ratio of the costs of the performance of supervision to the contractual value of the construction activities is calculated. From the values found, it can be stated that if it is necessary to flat-rate the price of technical supervision, the average cost of technical supervision amounts to 3.69 % of construction costs. A proportional percentage determination was carried out for the flat-rate evaluation of the performance of supervision on 70 transport constructions of the public employer Directorate of Roads and Highways, and it can be observed that even if the performance of technical supervision can be flat-rated and averaged from a financial point of view, an individual approach to each construction as such must still be maintained. From these data, it is also possible to observe the trend that the higher investment construction costs of the building are not directly proportional to the assessment of the performance of technical supervision. The relationship does not apply; the more expensive the building, the more expensive the performance of supervision. On the contrary, according to the data found, it is possible to observe a downward trend in the valuation of the performance of technical supervision for buildings worth 28 to 40 million euros. This observed trend can be attributed to the fact that for the performance of the technical supervision and the entire team,

it no longer makes a fundamental difference whether the investment costs are 40 or over 120 million EUR. The variable is only on the side of the contractor for the volume of work performed, i.e., after a certain volume of supervised and controlled work, the volume of work ceases to be decisive for the performance of technical supervision (see Figure 2).

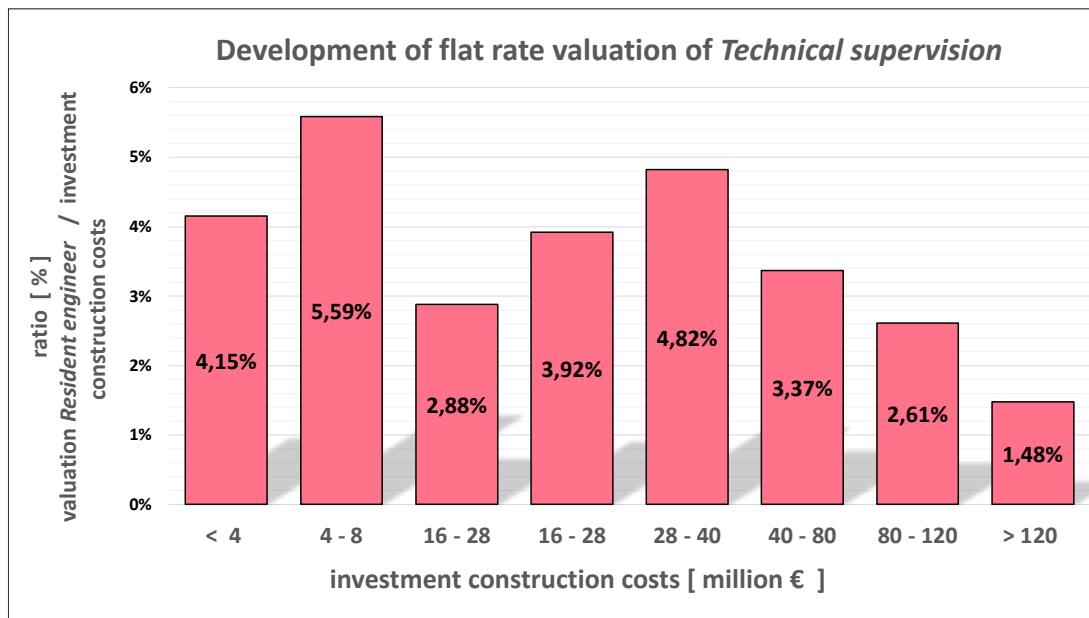


Figure 2. Flat rate valuation of technical supervision

4.3. The Value and Role of Technical Supervision

In the case of non-performance of independent (external) technical supervision on public contracts, there is a risk that the contractor's interest is to complete the work as quickly as possible and at the same time at the lowest possible cost. With the knowledge that quality parameters are not entirely a priority and that imminent malfunctions of the work will only become apparent after the warranty period has passed, thus without the risk of subsequent complaints. Even though the length of the warranty period has increased significantly over the last decade and the usual warranty period is already 120 months, we cannot expect a situation where the warranty period will be equal to the design life. And that is precisely why the performance of independent technical supervision is an important aspect, which is the first control body over the work performed by the contractor and thus even if it indirectly affects the quality of the work itself.

As part of technical supervision, one of the main tasks is to check the quality of the contractor's work. Technical supervision enters into the very process of checking the construction work even before its implementation. Before starting the construction activity, the technological work procedure chosen by the contractor and its compliance with the project documentation must be assessed. All subcontracts, products, construction materials and mixtures that will be incorporated or used in the execution of the work are also subject to assessment.

The technical supervision, with its presence on the construction site, checks and assesses the fulfillment of the approved technological procedure by the contractor's work, including the use of only materials approved by The Engineer. At the same time, he approves and takes over the work he has already done. In the event of a non-conformity being detected, whether in the contractor's work progress during the implementation or use/installation of non-compliant products, the technical supervision has the authority according to FIDIC to request remedial works, or in extreme cases, their rejection may occur. The beginning of the warranty period is determined by the acceptance of the work by the customer. However, this act is preceded by a final check by the technical supervisor of all the collected documents, e.g. test reports, geodetic surveying and evaluation of the defects and unfinished works that may or may not prevent the use of the work. Often, however, even with this act, the function of the technical supervision of the given work does not end, and only part of his duties are removed by putting it into operation. From the position of technical supervision, it is also important to keep continuous records (photo documentation, videos) about the work performed. After they have been covered up due to the ongoing implementation of the work, in many cases it is no longer possible to prove that the work was really carried out in the context of future doubts on the part of the control authorities. Photo documentation therefore serves as indisputable proof that all partial actions have been carried out.

All these performance activities are in favor of maintaining the quality of construction works and are intended to serve for the proper operational phase of the construction. When handing over the work, the technical supervisor together with the contractor not only hands over the physically performed work (construction work), but also a huge amount of data, documents and information that must be properly stored, processed and will need to be worked with in the operational phase of the life cycle.

5. Quality of Performance of Technical Supervision

The Even though the quality of services nowadays can also be defined numerically, i.e. measurable data, it is still a matter of sensory perception and a subjective view. A distinction must be made between product quality, which can be clearly defined by meeting a certain parameter, and service quality, which cannot be quantified about a person alone. Currently, service quality is commonly evaluated using a reference point of view communicated by the customer. Another perspective that can be used to look at the technical supervision service is based on the division of work tasks into the categories of routine activities and knowledge activities [17-19].

From this categorization, presented in Figure 3, it clearly follows that the easiest activity to automate and robotize is a routine and at the same time manual activity. It is based on simple manual tasks, in a predefined environment. The second possibility resulting from this categorization is a non-routine and at the same time manual activity, which is already more difficult to automate. These are predictable manual skills, but the action itself is unpredictable and requires adaptability, visual and verbal contact to further specify the action. Hairdressing is an example, it is a manual service, but every customer wants a haircut differently. Another example, a bus driver, even if he drives a pre-defined route and always uses wheel, there will always be a different flow of traffic, etc. The third category is routine and at the same time knowledge-based, which means that even if it is always the same action and activity, it must be performed by a qualified person. This group could mainly include office work for corporate companies, etc. The last category is non-routine and current knowledge activities. These activities require flexibility, creativity, organizational skills, use of judgment and decision-making skills. The performance of the technical supervision of the investor fully meets the knowledge category, and at the same time some of the actions could be classified as routine, but a significant part is still non-routine. Precisely routine actions can be considered as an opportunity to digitize and automate the performance of supervision using, for example, BIM (Building Information Modeling) or other applications, which then perform the given activity [20-22].

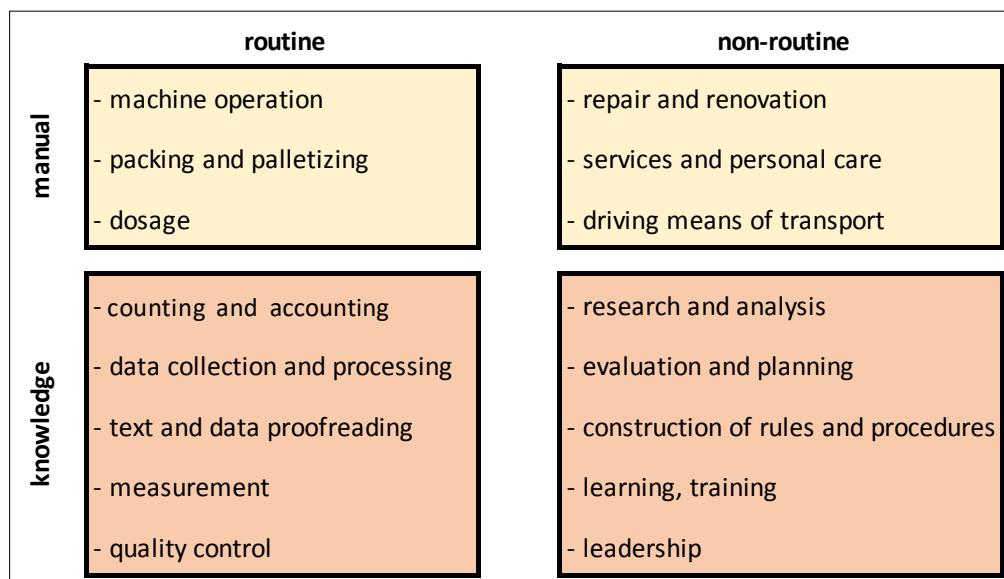


Figure 3. Categorization of work tasks [10]

5.1. Actual Performance of Technical Supervision Activities in the Czech Republic

The As part of the research, a tabulation of the display of individual activities that were listed in the questionnaire is processed and these are activities carried out during the performance of supervision. It is possible to carry out a categorization with regard to the method of performance, i.e. whether it is a physical inspection of the building or, on the other hand, whether it is an administrative control activity of the building. Physical control of the construction is understood as direct presence on the construction site, and administrative control activities are office activities outside the construction site. A categorization and breakdown of these activities can also be done, which activities are routine / non-routine and which are manual / knowledge. Further categorization of actions during the current performance of technical supervision can be done from the point of view of the future introduction of BIM and CDE (Common Data Environment). The common data environment has 4 main parts – 3D model / communication / processes / documents. [23-25].

From the first categorization, it is quite clear that the activity of performing technical supervision is 90% administrative control activity and only 10 % of its actions are directly connected with control on the construction site. In other words, the activity of technical supervision is mainly carried out in the office, on the equipment of the construction site and outside of direct contact with real construction activity. This statement also corresponds to the fact that direct construction work is carried out by the Contractor and the performance of supervision is mainly a control activity. It follows from the second categorization that the activity of performing technical supervision is in all its parts

a knowledge activity and at the same time only 1/3 of the activities can be defined as non-routine, the remaining activities can be characterized as routine and can be considered as activities that could be optimized and solve more effectively.

6. Results and Discussions

As part of the research, the time point of view of individual technical supervision actions was monitored and at the same time a categorization was carried out with regard to the method of performance, i.e., whether it is a physical inspection of the construction or, on the other hand, whether it is an administrative control activity (Figure 4).

- 1) Physical inspection of the construction - The technical supervisor spends an average of 25.0 % of the working time on these activities. Expressed in terms of time, it is 540 min/week, i.e. 9 hours/week.
- 2) Administrative control activities of the construction - The technical supervisor spends an average of 75.0 % of the working time on these activities. Expressed in terms of time, this is 1583 min/week, i.e. over 26 hours/week.

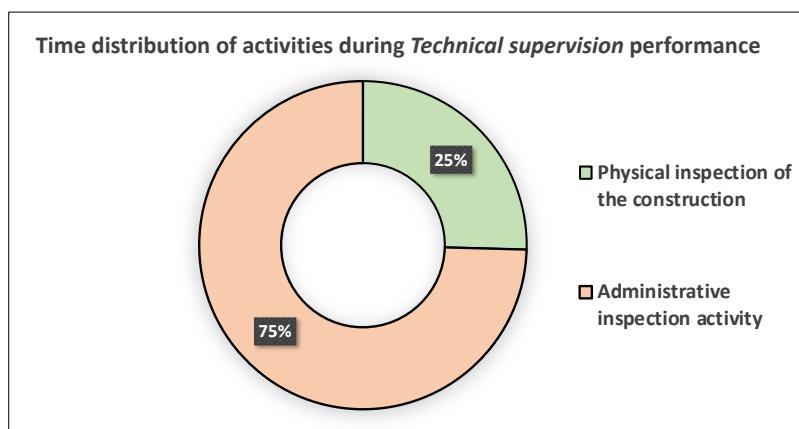


Figure 4. Time distribution during the performance of technical supervision

Another possible categorization of activities in the performance of technical supervision activities is carried out within the framework of the four main parts of the BIM method (Figure 5). The purpose of this categorization is to demonstrate the fact that the assumed BIM and CDE model is completely based on already current procedures and processes.

- 3D Model (Construction) can be assigned to 3 activities out of a total of 28. The technical supervisor spends 25 % of his working time on these activities.
- Communication can be assigned to 10 activities out of a total of 28. The technical supervisor spends 24 % of his working time on these activities.
- Processes can be assigned to 5 activities out of a total of 28. The technical supervisor spends 19 % of his working time on these activities.
- Documents can be assigned to 9 activities out of a total of 28. The technical supervisor spends 32 % of his working time on these activities.

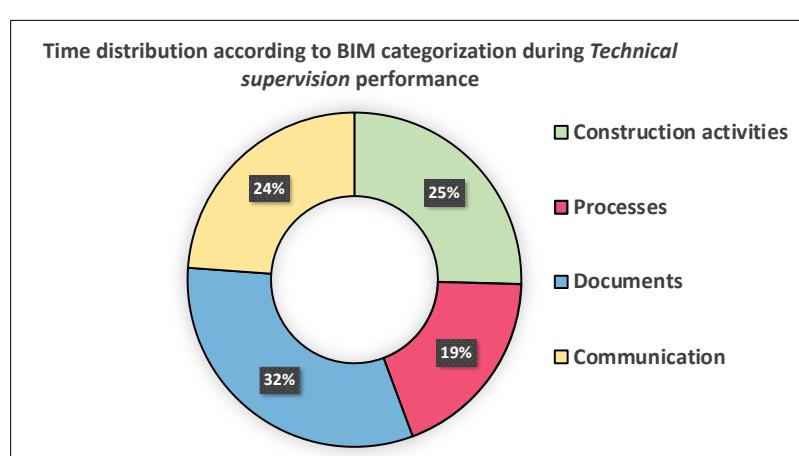


Figure 5. BIM time distribution during technical supervision

The sub-categorization carried out in this way is only indicative, as it is not possible to strictly assign all activities to this part only. Further, from the values mentioned above, it can be concluded that the ideal case should be an even distribution of administrative control activities at 3x 25%, but the difference found has no effect. All documents, processes and forms of communication must always be approached individually according to the specific construction. As part of the research on the performance of technical supervision in the Czech Republic, no studies were found that would divide supervision activities according to the BIM model, nor were any other studies dealing with the very categorization of actions during supervision found.

From the above, it follows that the main benefit of the possible introduction of digitization and BIM will affect the performance of supervision especially in the way of communication, work with documents and mutual interaction between subjects (processes). On the contrary, it can be stated that the application of drawing models in 3D format will not fundamentally affect the performance of technical supervision. As part of the research, an analysis of the advantages and disadvantages for the time intervals used was carried out, and at the same time, the overall non-systematic solution is pointed out, since the performance of technical supervision is also carried out outside the time intervals that are not invoiced financially, but this is the period when the performance is contracted. There is also a situation where technical supervisors are appointed on construction sites and reported at the same time, but they also work on other construction sites at the same time, so they cannot actually be invoiced, and thus the supervision performance itself cannot be carried out in full.

In another case, there is a situation where the supervisor on the construction site is listed in the form of Permanent supervisor, i.e. every working day throughout the construction period, but his actual workload does not correspond to this. This can be caused either by an incorrect balance sheet during the public procurement, when the position is requested in full-time mode, or it is caused by the progress of the construction. The progress of the work itself is under the responsibility of the Contractor, i.e. the position of specialist supervisor for bridge structures will be possible to perform when the Contractor proceeds with the implementation of the bridge objects, which may be when the re-laying of engineering networks and other conflicting elements of the construction are completed. In this case, when the supervisory position is fully occupied, then it is not used quite effectively. This fundamental contradiction then leads to the newly proposed concept of financial performance, i.e. flat-rate performance of technical supervision. As part of the survey, the percentage ratio between construction investment costs and the costs of performing technical supervision is determined. This ratio can be used by the Directorate of Roads and Highways to determine the expected price for the supervision service.

The accepted contract price itself is determined by tender, but this price should now be paid by the Employer as a flat rate (monthly/quarterly) regardless of the actual number of persons performing supervision in the given period. The public contracting authority of Directorate of Roads and Highways should emphasize the fulfilment of all supervision activities as defined by the scope of services in the given contract, not monitoring how long and with what tools the person performing the supervision performs the activity. Clients should completely abandon the opinion that the performance of technical supervision is mainly carried out by physical presence on the construction site. The mere presence of a supervisor at the construction site without appropriate actions is an inappropriate and uninformative act that does not mean much. Another important part for pricing surveillance performance is the use of an appropriate time interval. The current model, where the public contracting authority Directorate of Roads and Highways uses invoicing time intervals - hour / day / week - is not fully indicative of technical supervision's performance. The chosen model of the Directorate of Roads and Highways is also approached with regard to compliance with the methodological instruction, where technical supervision is divided into Permanent and Occasional supervision.

The solution is to make the performance itself flat-rate, and the unit of measurement of the technical supervision activity should be a set or a flat-rate valuation. With this solution, both parties, both the contracting authority and the provider of supervision services, must be aware of the procurement parameters and study them very thoroughly and define what is included in the lump sum assessment and what is not. The aggregated values define for us the time limit when the technical supervision performs all the prescribed activities in the optimal time and it should then be a question of quality performance of the technical supervision of the investor. Contractual agreements are fulfilled that the performance is performed comprehensively, i.e. in the entire range of services and there is no situation where one activity is prioritized over another and also that one is not completely neglected. If the performance of supervision is viewed as a flat rate, not only during its evaluation, but also during the performance of supervision itself, it is then possible to combine the scope of activities, i.e. activities No. 1 to No. 28 into one set, i.e. from a mathematical point of view, the performance of technical supervision can be viewed as a continuous function, and the time requirements of individual sub-activities can also be merged. The graphic representation of the above is shown in Figure 6, i.e., the fulfillment of the total scope of activities during the performance of technical supervision, in this case a weekly time interval is considered.

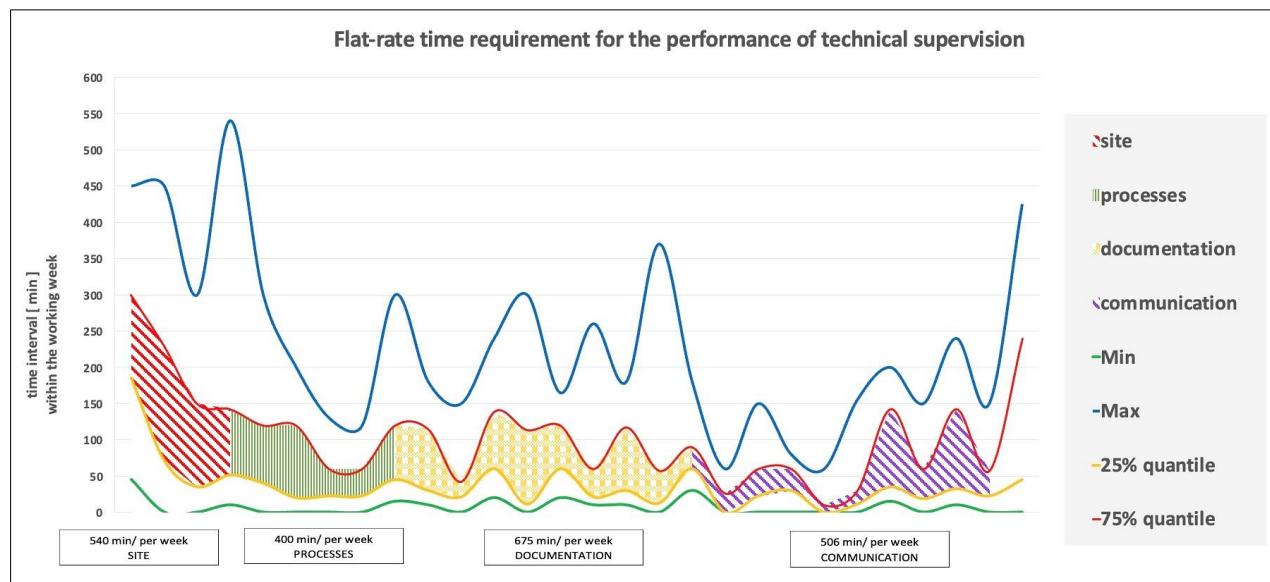


Figure 6. Flat-rate time requirement for the performance of technical supervision

7. Conclusions

The real evaluation of the performance of technical supervision is always dependent on the implementation contract and at the same time is determined by the technical composition of the construction work. The performance of technical supervision is a service provided by individual technical experts, and based on innovative processes, it is appropriate to automate repetitive activities. Therefore, within the framework of the research, it was necessary to define which activities are and which are not. At the same time, within the scope of supervision for the contracting authority of the Directorate of Roads and Highways, there is no time frame for individual actions defined as technical supervision. During the performance of technical supervision and the time-consuming nature of individual activities, there are still activities that cannot and will never be made more efficient, and it is precisely these activities that must be taken into account and given adequate time.

As part of the research, the performance of technical supervision was categorized from several points of view. The main categorization of the performance of technical supervision and its quantification were carried out with regard to the type of activity, i.e., it was analyzed that 3 activities out of 28 are connected with physical control directly on the construction site and at the same time technical supervision. They spend 25% of their working time on these activities.

The second part of the activities is collectively called the administrative control activity and it is 25 activities out of 28, and technical supervision spends 75% of the working time on these activities.

On average, the technical supervisor spends 25% of the working time physically inspecting the building; expressed in terms of time, this is 540 min/week, i.e., 9 hours/week. Technical supervision spends an average of 75% of the working time on the administrative control activities of the building. Expressed in terms of time, this is 1583 min/week, i.e., over 26 hours/week. The research found that the historical view of technical supervision, in which the performance of technical supervision is carried out only on the assumption that the person in question is directly on the construction site, is wrong. The performance of supervision is always technically linked to physical presence on the construction site, but physical presence on the construction site is not the only and main activity of supervision.

Another aspect of the categorization and quantification of the content of technical supervision activities is based on the planned introduction of the BIM model in the Czech construction industry. According to the BIM division, the administrative control activity can be further divided into documents, processes, and communication. Conversely, the last part of BIM, i.e., the 3D model, can be considered an activity corresponding to physical inspection. Communication can be assigned to 10 actions out of a total of 28. That is, 36% of technical supervision activities are based directly on communication.

Processes can be assigned to 5 actions out of a total of 28. That is, 17% of technical supervision activities are based directly on processes. Documents can be assigned to 10 actions out of a total of 28. That is, 36% of technical supervision activities are based directly on processes and documents. In conclusion, the obtained results show that, according to the BIM model, the main areas where the performance of technical supervision could be made more efficient are processes, documents, and communication. The streamlining of these activities does not need to be conditioned by the introduction of the BIM method. Even today, adequate IT tools can be used, which can be very beneficial and can simplify activities.

By summarizing the activities during the performance of supervision and its time frame for performance, the optimal time interface between individual activities that should be performed by the investor's technical supervision can be determined. The determined values define a time frame for us when the technical supervision will perform all the prescribed activities in the optimal time, and then it should be a quality performance by the technical supervision of the investor.

As part of the research, the total time required per week for the construction part was 540 min/week, Processes 400 min/week, Documentation 675 min/week and Communication 506 min/week. For providers of technical supervision services, these values should be authoritative, and when staffing the Construction Manager team, they can be reflected in terms of the number of supervisors and the time required. For possible subsequent research, it would be appropriate to perform time and content measurements for the performance of technical supervision, but already in the BIM and CDE modes of the environment, also with regard to the number of persons performing supervision on the given construction site. As part of this research, no similar studies were found, and no comparison was possible. The optimal time interface considered in this way should be considered only as an example, i.e., it is necessary to respect the fact that in normal practice not all activities take place at one moment or in one short time interval (a working week). The activities take place within the course of the implementation of the work, which in the case of significant transport constructions is a unit of calendar years. At the start of construction implementation and the handover of the construction site, the scope of the supervisory performance is not the acceptance procedure and the control of the documentary part of the completed works, as it is clear that no works have yet been carried out. On the contrary, these activities are carried out at the end of construction works, where the approval processes of project documentation and approval of technological procedures are not addressed, as they were all approved during the implementation. However, this simplification can be accepted for the basic representation of the activities and the time required for the performance.

This research clarifies and concretizes the time and content of the performance of technical supervision for the contracting authority, the Directorate of Roads and Highways, which is not stated anywhere or contractually stipulated. The obtained data is based on construction practice, and it is possible to implement them into departmental regulations, which should be reworked and newly formulated for the flat-rate performance of technical supervision. The existing division of technical supervision into permanent and occasional is wrong, as is the wrong approach to evaluating the performance of technical supervision. The time intervals for supervision—hours, days, etc.—are not informative. As was done in this research, it is also possible to set a flat rate when evaluating the performance of technical supervision. This flat-rate valuation is based on investment construction costs, and it was found that it is not possible to simply arithmetically average across all buildings, it is always necessary to take into account the technical specification of the building. It was found that the flat-rate assessment of supervision for buildings with a price of 28 million to 40 million EUR already has a downward trend; on the contrary, buildings of a smaller scale show a higher ratio between the price of supervision and construction costs.

Technical supervision and the entire scope of its activities should be flat-rate not only in terms of pricing, but also in terms of the time scale of individual activities, which the contracting authority, the Directorate of Roads and Highways, is currently not using.

8. Declarations

8.1. Data Availability Statement

The data presented in this study are available in the article.

8.2. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

8.3. Conflicts of Interest

The authors declare no conflict of interest.

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