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Quality Management of Special Purpose Buildings: A Case of National Forensic Laboratory in Ljubljana

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Abstract

Quality management represents an important and complex task in construction business. Difficulty of quality management in construction projects is often increased on account of different factors, such as short deadlines, limited resources, high level of market development and strict requirements for contractual quality achievement among many others. In this way, advantages of systematic quality management may particularly come to the fore in cases of construction of special purpose buildings. The aim of this paper is to present the quality management for such buildings based on specific implementation of ISO international standards for quality assurance. A case of National Forensic Laboratory in Ljubljana is addressed in the paper to show suitability of proposed quality management approach.

Key words: *ISO standards, special purpose buildings, quality management, National Forensic Laboratory in Ljubljana*

1. INTRODUCTION

Construction management often strives to generate an adequate balance between three competitive goals: to build a construction facility in accordance with requirements and expectations of the investor, to finish agreed works in due time, and to complete the project within agreed price range. In this respect, an alternative to achieve such balance is to implement a systematic quality management in construction.

Difficulty of quality management in construction projects is often increased on account of different factors, such as short deadlines, limited resources, high level of market development and strict requirements for contractual quality achievement among many others. However, important support to establish systematic quality management in construction may be found in well-known and widely distributed standards from International Organization for Standardization (ISO) [1]. ISO represents the world's largest developer of voluntary international standards, founded in 1947. Since then, more than 19500 international standards have been published covering various fields, including ISO 9001 and 14001 which are often considered in the construction sector.

Published research works in the field of quality management in construction are often focused on practical implementation of ISO standards [2-8], comparisons between countries and companies with established ISO standards [9] and analysis of advantages of incorporating ISO standards in business operations [10]. Many published studies have shown, that implementation of ISO standards can benefit business success through the improvement of management control [11], efficiency [12], strengths [13] and implementation of information system [14].

Nowadays, the attainment of business profit is often significant for successful development and growth of construction companies. With appropriately established standardization, construction enterprises can achieve constant quality, decrease in wastage and increase the total profit due to fewer mistakes during project realization. Still, troubleshooting in construction process is many times associated with extra costs because the segment of quality management was not suitably taken into account. In addition, error corrections are frequently very disturbing for users of built facilities and have a negative impact on goodwill of the construction firm.

Taking featured complexity of projects into account, advantages of systematic quality management may particularly come to the fore in cases of construction of special purpose buildings. Such buildings are frequently appropriate for one or limited use and often demand considerably more rigorous quality requirements than the conventional ones. In this way, special purpose buildings can be hardly suitably rearranged for another use

without large capital investment. The aim of this paper is to present the quality management for special purpose buildings based on implementation of ISO international standards for quality assurance. A case of National Forensic Laboratory in Ljubljana is addressed in the paper to show suitability of proposed quality management approach.

2. QUALITY MANAGEMENT

In May 2004, Slovenia became part of the European Union and after that date, it was necessary to harmonize all existing technical regulations with the regulations of the EU Council. In the field of construction products, Slovenia first adopted the Construction Products Directive (89/106/EEC) [15] from year 1988, which has been replaced with the Regulation (EU) No. 305/2011 [16] in year 2011. This directive provides, inter alia the essential requirements of European standards and technical approvals. In the field of services, Directive 2006/123 EC [17] aiming at establishing a single market for services within the European Union was introduced in year 2006 and adopted in 2009. Irrespective of the statutory requirements, construction enterprises can decide for the introduction of different ISO standards.

For instance, one of them is a group of standards ISO 9000 [18] that prescribe basic requirements for quality system. Part of this group is also standard ISO 9001:2008 [19], which is intended primarily for establishing a process approach in developing, implementing and improving the quality management for the purpose of meeting the customers' requirements and increasing their satisfaction. ISO 9001:2008 contains general requirements and regulate that the organization shall: (i) determine the processes needed for the quality management system and their application throughout the organization; (ii) determine the sequence and interaction of these processes; (iii) determine the criteria and methods needed to ensure that both, the operation and control of these processes are effective; (iv) ensure the availability of resources and information necessary to support the operation and monitoring of these processes; (v) monitor, measure where applicable and analyse the processes; and (vi) implement actions necessary to achieve planned results and continual improvement of these processes [19]. Accordingly, the construction companies have to form quality management system documentation which includes principled quality manual, documented procedures and detailed technical instructions for performing individual activities.

In parallel with efforts to obtain the quality certificate, the need of certain documents arises, which are to be in accordance with ISO 9001:2008 covering construction site management directly. The achieved quality level of finished building represents an outcome of a certified company and it is also an indicator of the state of quality assurance. Quality assurance in construction can be reached with several controls, namely with intermediate control of individual stages and with final control, including business contractor acquisitions. After completion of each individual stage of the project, the introduction of a new subcontractor is made. The task of the next subcontractor is to review and record the findings of its predecessor in the construction diary.

The initial step for construction firms in further development of the quality system is obtaining a certificate from the external auditor for quality. At this point, well-conducted audit provides all important information about the ascertained actual state of quality management in the construction enterprise to responsible persons. This becomes the basis for taking corrective actions to reduce costs and increase the quality level.

Implementing requirements based on the compliance of the ISO, paper administration and consideration of all written rules pose a great challenge to companies' management to satisfy the investor. The illustration bellow (Figure 1) shows that costumers (investors) play a significant role in defining requirements as inputs. Due to uniqueness of construction, subcontractors are not constantly present by the implementation of all projects. Moreover, different projects and sites usually require employment of different subcontractors since construction represents a complex process with a large number of participants with different levels of knowledge, skills, working habits, affiliation and motivation. Irrespective of required documents, rules and work instructions by management, construction firms are facing the emergence of defects during the warranty period of built facilities. Due to the above mentioned facts, it is necessary to provide continual improvement of the quality management system (Figure 1).

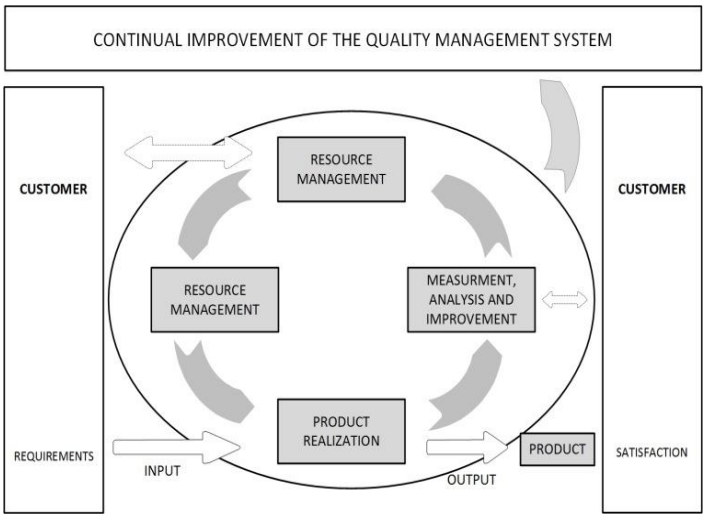

Figure 1. Model of a process-based quality management system [18]

In this work, the data about errors reported during the warranty period, collected in years between 2007 and 2012 for various types of actually built facilities and other types of executed construction projects, were analysed for the aim of improvement of companies' quality management. Statistics of reported errors was conducted for four different groups of completed construction projects, i.e. commercial, infrastructure, institutional and residential projects (Table 1).

Table 1. Errors reported during the warranty period by type of construction project from year 2007 to 2012

Project number	Type of project	Year of complaint	Type of error	Site manager	Error status
1	Commercial	2012	Finishing work: roofing	A (1)	Resolved
2	Infrastructure	2012	Finishing work: landscaping	B (1)	Resolved
3	Infrastructure	2012	Construction work: concrete	C (1)	In progress
4	Residential	2012	Installation work: plumbing	D (1)	In progress
5	Residential	2012	Finishing work: roofing	D (2)	Resolved
6	Commercial	2011	Installation work: plumbing	A (2)	Resolved
7	Commercial	2011	Finishing work: façade	E (1)	Resolved
8	Institutional	2011	Finishing work: joinery	F (1)	Resolved
9	Residential	2011	Finishing work: façade	D (3)	In Progress
10	Residential	2011	Finishing work: landscaping	C (2)	Resolved
11	Commercial	2010	Finishing work: façade	E (2)	Resolved
12	Commercial	2010	Finishing work: glazing	E (3)	Resolved
13	Infrastructure	2010	Finishing work: façade	B (2)	Resolved
14	Institutional	2010	Finishing work: assembly	F (2)	Resolved
15	Residential	2010	Finishing work: landscaping	C (3)	Resolved
16	Residential	2010	Finishing work: façade	B (3)	Resolved
17	Commercial	2009	Finishing work: roofing	E (4)	Resolved
18	Infrastructure	2009	Construction work: asphalt	F (3)	Resolved
19	Residential	2009	Finishing work: façade	G (1)	Resolved
20	Residential	2009	Finishing work: façade, roofing	B (4)	Rejected
21	Institutional	2008	Construction work: excavation	G (2)	Resolved
22	Residential	2008	Finishing work: joinery	C (4)	Resolved
23	Residential	2008	Finishing work: joinery	B (5)	Resolved
24	Residential	2008	Installation work: plumbing	D (4)	Rejected
25	Residential	2008	Installation work: plumbing	D (5)	Resolved
26	Commercial	2007	Finishing work: roofing	E (5)	Resolved
27	Commercial	2007	Finishing work: roofing	E (6)	Resolved
28	Commercial	2007	Finishing work: roofing	C (5)	Resolved
29	Commercial	2007	Finishing work: assembly	C (6)	Resolved
30	Institutional	2007	Finishing work: assembly	C (7)	Resolved
31	Residential	2007	Finishing work: flooring	D (6)	Rejected

The number of reported errors varied among the years on account of influence of different factors. One of them was the selection of site managers and project leaders. Namely, the data analysis has shown that the similar mistakes were repeated by same site managers who led the execution of contract works on different construction projects. Thus, it was reasonable to consider previous statistics of errors by assigning complex projects to those managers with fewer error complaints filed during the warranty period. Next factor for the error occurrence was less efficient control over the implementation of individual stages including final control after completion of group of works. From showed data it was discerned, that total number of errors during a six years period amounts 32 errors. Dividing the total revenues of the firm by the number of defects within the warranty period we got the average number of errors in relation to the turnover. On average, one error occurred on the 4 million € of turnover.

A noteworthy finding of data analysis was also the fact that the majority of reported errors were generated by subcontractors under supervision and guidance of same foremen as well as site managers and consequently the project manager. Engaged site managers are denoted in above presented table from A to G. In this way, it can be established that few of them made up to seven mistakes (values in brackets denote the number of errors for each site manager) while some managed to finish projects with only two errors during six year period. Taking identified difficulties in providing required level of quality into account, a new organizational scheme was developed for the aim of quality management of special purpose buildings where the quality claims are often significantly more rigorous than in common construction projects (Figure 2).

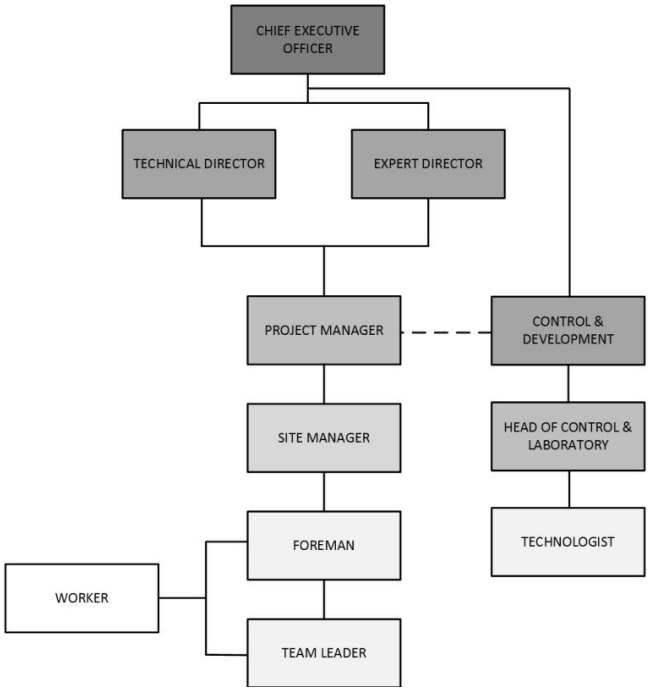

Figure 2. Organizational scheme for special purpose buildings

The organizational scheme links different jobs that appear in a construction company. At the top of the hierarchy is the chief executive officer (CEO) who leads the company. Bellow the CEO there is a technical director and an expert director that provide appropriate guidance in their fields. Project manager is responsible for the direct management of the project and the necessary coordination of participants. Project manager is constantly in connection with the department for control and development (DCD) for the purpose of cooperation in quality assurance (QA). However, the project manager does not affect the opinion and work of the DCD, so the connection between them is thus marked with a dashed line in the organization chart.
Site manager is responsible for uninterrupted workflow and is a superior to a foreman. Foreman and his subordinate team leader conduct various workers on site. On the right side of the organizational scheme is the DCD who is directly subordinate to the CEO. Head of laboratory and technologist carry out tasks on behalf of the head of the DCD. The DCD is responsible for the QA during construction and employs various experts for the purpose of ensuring the adequate implementation of the client's requirements.
An important feature of new organizational scheme is that the DCDis completely independent in implementation of QA from other functions in the company. Constant supervision by the DCD contributes to prevention of recurrent errors and reduction of possibilities for the creation of new ones. The control of work performance is done without prior notice and may be repeated several times in different time-lags by various appointed experts, including specialist for occupational safety and health.
The head of the DCD has special authorizations and has the power to stop all works at construction site if it is fund that the implementation does not take place in accordance with the regulations, project documentation or requirements of the investor. Crucial in the execution of surveillance is continuous analysing and reporting of the performed activities to the CEO, whose task is to give further guidance and transfer concise information to technical and expert directors.
Accordingly, a great deal of mistakes can be timely prevented for the aim of achieving positive impact on the project financial result.
Compared to special purpose buildings, conventional construction projects can be less demanding in terms of providing the QA, which is performed with fewer participants and on a smaller scale. Namely, in quality management of conventional project, the QA manager from the DCDis not necessarily obliged to report directly to the CEO and it is often less independent by controlling. In conventional projects, the QA manager usually reports to project manager and superiors and receives less feedback from the construction site. In this way, the QA in common construction projects is often primarily related to fulfilment of essential requirements referred to the field of legislation.
The main advantage of proposed scheme for special purpose buildings is impartiality of the evaluator who reports only to the superior in the company. The project manager has no direct impact on the evaluator which is an important advantage in QA. Another advantage is that chief executive officer is better informed about problems on the construction site and has a possibility of taking action timely. However, proposed approach toQA requires more time, because the communication path is longer but, nevertheless, brings advantages in comparison with conventional quality management.
Additional general performance review of the project is proposed to be performed by a questionnaire, filled out by the expert from the DCD.
A survey consists of different fields; external appearance of the building site, occupational safety and technical-economic part (Figure 3). Each field is composed of questions to which evaluator answers, writes an assessment and a review. Assessment is carried out electronically and directly on the construction site, in order to reduce the possibility of bias. Once the answers are recorded, they are sent to the database and can no longer be changed.

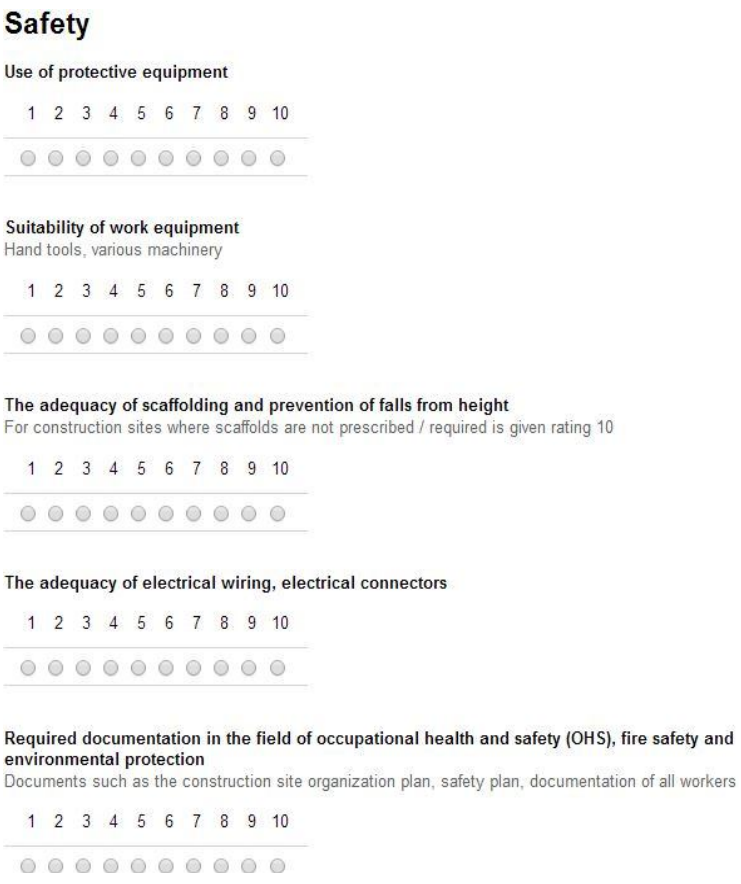

Figure 3. A part of electronic survey for general performance review

Performance reviews (Figure 4) are repeatedly executed during the year and analyses of results of companies' current projects are periodically presented at operational meetings at which the most and the least successful outcomes are exposed. The criterion for evaluation is known and written for all the participants. The results are recorded during the current year and in the end, a special prize is given to most successful project managers, site managers and foremen.

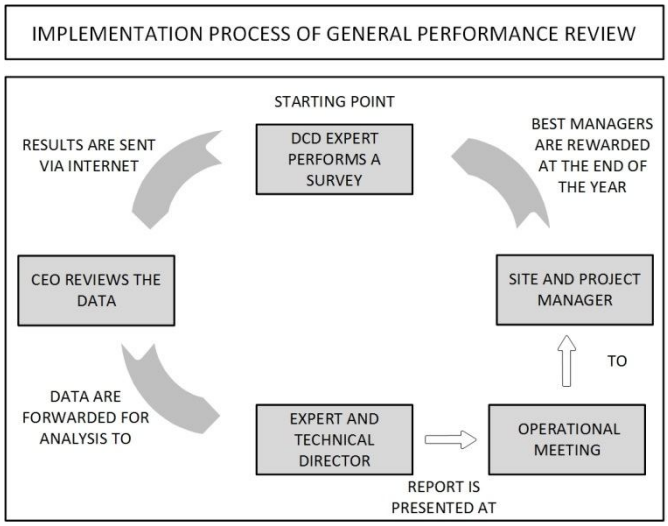

Figure 4. Implementation process of general performance review

The fact is that this way of continuous verification and reporting requires additional project costs. However, the total cost of QA, including error prevention and reviews, should be less than the total cost of repairs. Thus, the cost of operation of the quality system must be lower than the damage cost caused by poor quality taking a tendency to keep both costs as low as possible into account. In this sense, advisability of the proposed approach is greater in cases of special purpose buildings due to specific requirements of the customer and complexity of the construction or where defects are not acceptable.

3. CASE OF NATIONAL FORENSIC LABORATORY IN LJUBLJANA

The construction of National Forensic Laboratory (NFL) in Ljubljana, an example of special purpose building, is addressed in this section to show suitability of the proposed quality management approach. The original predecessor of NFL was established during 1950's in the former Republic of Yugoslavia and it was firstly named as Criminalist-Technical Laboratory (CTL) [20]. Before the establishment of CTL, technical departments in Ljubljana and Maribor have been used for the purpose of criminal investigating. As soon as the CTL was formed, its activities primarily comprehended dactyloscopic, chemistry and graphoscope research, although the equipment in those days was modest and simple.

A major step forward was taken in years between 1976 and 1982, when the laboratory acquired a lot of new equipment. Soon after 1990 the laboratory was renamed into Centre for Forensic Research (CFR). In 1998, the CFR was one of the first European forensic laboratories capable of establishing the records of DNA samples, which have been legalized in the same year by the Criminal Procedure Act [21] and the Police Act [22]. Later, in 2001, the system for electronic fingerprint identification was implemented. In 2010, the laboratory was renamed to NFL [23].

Since the number of NFL employees, especially researchers and technicians, increased over the years a lack of space has occurred. The existing building was built in 1980's and it replaced previous location of the NFL at Ministry of the Interior in Štefanova Street [23].Location of the building is in the centre of Ljubljana, in the northern part inside the city highway circle (Figure 5) in the industrial zone Brinje (Figure 6).

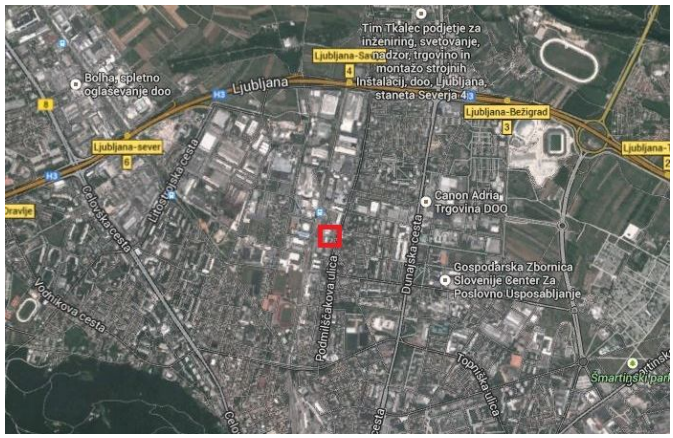

Figure 5. Macro location of the construction site [24]

Figure 6. Micro location of the construction site [25]

The Ministry of the Interior has decided to build the new laboratory and to reconstruct the old part of the building (Figure 7).

Figure 7. Existing building before reconstruction

The project works started in the year 2010 with the first building constructor. Due to insolvency and bankruptcy of the first construction company, the project was taken over by the second civil contractor. The story repeated itself and the Ministry of the Interior has chosen a third business partner for completion of the project with a public tender [26]. All of these actions reflect the global and local financial crisis which has especially affected the construction sector in Slovenia. The third contract for completion of the NFL was signed in the beginning of February 2012. The deadline for completion has been properly moved according to the above mentioned factors.
At the beginning, when the third contractor started working, the building was built to a certain stage, i.e. all preliminary works, demolition works, earthworks and partly also some construction works were completed [27]. The construction site has been taken over with a finished basement, ground and first floor without walls. Due to special requirements of the client, the project has been executed in accordance with specific regulations [28].
Namely, the opening of the construction site was possible upon the arrival of the concierge; however, work shifts of the required surveillance were suitably adapted to the needs of the scheduled construction plan. All participants in the project have been reviewed by the client for any past offenses. Based on past actions the attendees have been authorized to enter to the construction site for specific works. There was also controlled and secure access to the construction site for all other site visitors. Particular attention was also paid to the inspection of vehicles and cargo entering the construction site. All special works needed to be announced in advance so that processes in laboratories were not disturbed. Special emphasis was put on to the implementation of rough works for example concrete drilling or cutting due to the sensitivity of investigative equipment.
A quality management approach for special purpose buildings, presented in the previous section, was applied for the aim of meeting specific construction requirements. Firstly, a project manager and site manager have been chosen from superiors on the basis of previous experiences and the number of occurred errors in the conduct of past construction projects. Secondly, a selection of other workers and subcontractors was made by the project manager in the manner of performance and past reference.
Furthermore, a system of control with the help of an independent department, i.e. the DCD, was established for monitoring the quality of conducted construction works. Control included: (i) checking the consistency of a project with the actual situation on site; (ii) checking the quality of performed works; (iii) controlling the construction diary including reclamation records; (iv) review of declarations of conformity and certificates of supplied materials; (v) sampling and analysing of concrete and other controls that are necessary to ensure the legal and client requirements. Information about the non-compliance has been transferred to the CEO whose job was to give instructions for solving the problem to the project manager. Frequency of verification has varied, depending on the phase of the project implementation. On average verification was made five times per month.
On the construction site an internal control was performed, which was conducted by general project manager, while the site manager, together with the foreman, were responsible for the operational implementation of quality control in execution phases. Control was carried out on the basis of requirements from the designer. An important factor in the implementation of controls has been also level of experience of site manager and foreman. Effectiveness of their actions was reviewed at the operational meeting. Work stages were determined on the basis of time schedule of the construction [29] and by the foreman itself, according to the importance and complexity of the part. Control was conducted more frequently in the case of more complex stages of implementation.
Before starting the implementation of work stage, project manager and subcontractor signed introduction to work and the latter one was obliged to submit certificates and instructions for installed materials. After that, subcontractor carried out an example of offered works and project or site manager verified and validated the quality of performed work. During project execution, the control of every work stage was performed by several participants in construction.
Initially, an internal control was executed by subcontractor itself while the subsequent control was made by the foreman from main contractor. Afterwards, the next supervision was conducted by the DCD and the last one was performed by the contracting authority. If there was any non-compliance, each of the above mentioned quality controllers held the full authority to require complete cessation of subcontractors' activities and removal of errors as well as to allow the continuation of works after abolition of error.
After completion of all contracted works, handover was made and recorded in construction diary as well as signed by the project manager and contracting authority – supervising engineer. This document represented the starting point for the next subcontractor and his introduction to work. Further verification performed by a survey, which acquired also other aspects of construction, such as external appearance of the building site, occupational safety and technical-economic aspect, contributed to success of project implementation.
A survey was performed on average once a month by an expert from the DCD. The assessment was executed at the construction site, using electronic survey on a tablet. The completed survey was then transferred to the company via internet, where the CEO reviewed the data and sent it to the technical and expert directors for processing and analysis. After that, a report was made, which was presented on a monthly operational meeting.
The project has partly already been put into use to the investor, Ministry of the Interior (Figure 8). The second part, the reconstruction of the existing building, will be finished in the second half of August 2014.

Figure 8. Current appearance of the building

With the reconstruction, extension and conversion of the National Forensic Laboratory an important building for the collection and examination of evidence from different crime scenes will be gained. The new building will provide better working conditions and the possibility for further development.

4. DISCUSION

The following section discusses advantages and limitations of quality management approach for special purpose buildings, found during its application in NFL construction project. The main identified advantage was that the number of errors occurred in special purpose building was smaller than using the conventional quality management. Consequently, this represented up to 5 % lower costs of total project value in comparison to conventional management and removal of errors within the warranty period. Considering the extent of contractual works, agreed price for the project completion and past statistics of reported errors in previous projects, at least two error reclamations were expected to appear in this project, but so far none have occurred.

Limitations of using the proposed quality management approach in this particular case are higher costs, approximately 1 % of total project value, in comparison to conventional management of introducing quality assurance in relation to the ISO standards. Construction is considered to be conservative industry in the adoption of novelties, so it can be expected that the implementation of proposed quality management approach may sometimes collide with certain resistance of employees, who are often less willing to make changes in their current way of working. In this way, it is recommended that the changes in quality management system should be performed attentively in order to achieve valuable results.

Although the above described quality management approach is primarily intended for special purpose buildings with rigorous requirements for quality, it can also be applied in conventional construction projects. However, the task of the contractor is to consider strengths and weaknesses of its implementation in particular project, because some additional costs may be required in comparison with application of common construction quality management systems.

5. CONCLUSIONS

The aim of this paper was to present the quality management approach for special purpose buildings based on implementation of ISO international standards for quality assurance which may help contractors to reduce amount of errors within the warranty period. A case of NFL construction project in Ljubljana was addressed in the paper to show suitability of proposed quality management approach.

Regardless of the successful completion of the first phase of the considered construction project it can be ascertained that the proposed approach has shown some advantages in terms of reducing errors during the warranty period. Consequently, this also represents a reduction in costs of remedying errors and has a positive indirect effect in terms of goodwill of the company. In the future, construction projects are expected to require more complex management and higher levels of QA. Taking the errors reported during the warranty period in construction projects where common quality management was applied into account, it is reasonable to consider implementation of the proposed approach also in some conventional projects.

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Menadžment kvaliteta zgrada za posebne namene: slučaj Nacionalne forenzičke laboratorije u Ljubljani

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Rezime

Menadžment kvaliteta predstavlja značajan i složen zadatak u građevinarstvu. Teškoće menadžmenta kvaliteta u građevinskim projektima su često povećane usled različitih faktora, poput kratkih rokova, ograničenih resursa, visokog nivoa razvoja tržišta i strogih zahteva za postizanje kvaliteta prema ugovoru, između ostalih. Na ovaj način, prednosti sistematskog menadžmenta kvaliteta mogu posebno doći do izražaja u slučajevima izgradnje objekata za posebne namene. Cilj ovog rada je da predstavi menadžment kvaliteta za takve zgrade na osnovu posebne implementacije ISO međunarodnih standarda za osiguranje kvaliteta. Slučaj Nacionalne forenzičke laboratorije u Ljubljani je istaknut u radu kako bi se pokazala prikladnost predloženog pristupa menadžmenta kvaliteta.

Ključne reči*: ISO standardi, zgrade za posebne namene,menadžment kvaliteta,Nacionalna forenzička laboratorija u Ljubljani*