Saimaa University of Applied Sciences
Faculty of Technology, Lappeenranta
Double Degree Program in Civil and Construction Engineering

Denis Kotov

DEVELOPMENT OF WORK SAFETY AND QUALITY CONTROL ON A BUILDING SITE

Bachelor's Thesis 2010

ABSTRACT

Denis Kotov
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Instructor: from Saimaa University of Applied Sciences Mr. Pekka Roitto
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The purpose of the investigation was to define work safety and quality control procedures on building site in the earliest stages of housing construction. Also the aim was to find out the problems, which interfere proper realization of work safety and quality control and give suggestions on what improvement measures should be taken. The Thesis was written for the company NCC Construction in Russia.

To get right results it was necessary to study state building norms and regulations and others documents. Then comparing and analyzing theoretical and practical knowledge gotten from working on site are the defined problems, which decrease a level of work safety and quality control.

The recommendations and suggestions for improving the level of work safety and quality control are made as a result of this study, which can be applied in further construction or projects.

Keywords: work safety, quality control, building site

CONTENTS

1 INTRODUCTION

Nowadays all around the world there is a huge number of new buildings projects which are under construction. There are a lot efforts involved in building any structure mainly human and material. On the one hand successful construction is possible only in safe environment in which people can realize the most complex projects. On the other hand the quality of future buildings (e.g. houses, factories, shopping centers) depends not only on the quality of building materials such as concrete and reinforcement, but also the quality of work performed, which in turn depends on the continues supervising and monitoring by experienced engineers. Thus looking after two parameters, safe production and quality control, we can build any structure as planned without delays and stops of construction, without additional costs, and this facility will comply with all current rules and regulations in construction.

The purpose of this thesis is to investigate the processes involved in ensuring the safe production and quality control on an existing building site, provide examples of how the requirements of building codes and regulations are implemented in practice, give them an explanation and most importantly to define the problems associated with failure to comply with regulations and to find actions to improve work safety and quality control on building sites.

The structure of thesis is based on the targets set and it consists of three parts:

1. Theoretical description of the requirements of SNIP and other regulations. First in my work I refer to work safety of pile and concrete work, general requirements for all persons on site (requirements for process organization, admission system, etc.), individual protection facilities and some other items. Secondly I refer to control quality of performed works and materials needed to be supplied to the site (mainly I focused on cases that are most important to the process of construction and also where there are complexity)
2. Examples of how the requirements of building codes and regulations are implemented in practice (pictures, graphs, tables, charts, etc.) are given

3. The problems connected with the implementation of work safety, as well as effective quality control of performed works and supplied materials, are highlighted based on the analyzed information
4. Recommendations how to solve problems and improve work safety and quality control are given.

To get right results during the investigation it is needed to follow the next steps:

1. Study of state rules and regulations (SNIP,GOST)
2. Analysis of received information
3. Practical approach for obtaining empirical data (direct work on site)
4. Finding out the problems and giving the recommendations of improving work safety and quality control.

The company for writing the thesis is “NCC Construction” JSC and the project is residential community “Swedish Krona”, which includes 5 lines (10 buildings). The construction period for the first line is 1,5 years from 22.01.2010 to 30.06.2011 and in this way the thesis is limited by the time, which influenced the thesis content. In the report period from the beginning of the site till the erection of ground floor is reflected.

Figure 1. View of the residential community “Swedish Krona”

Figure 1 shows the preliminary view of the residential community “Swedish Krona” which is planned to be completed in 5 years in the fourth quarter of 2014. This community will include 10 buildings with 9-14 floors for 900 apartments. This facility is located in Russia, St. Petersburg, Fermskoe Highway 22, letter B.

Geographically it is the northern area of the city, a ten-minute walk from the subway station “Udelnaya”. This area is very advantageous to build a residential community due to the location near the city center (7 km). There is a park (a very important element in urban conditions), subway and train station. There is an aerial view of the future buildings presented in Appendix 1.

It should be mentioned that the company “NCC Construction” JSC has created suitable conditions for writing this thesis. It gave a workplace on site, provided the writer with a computer and camera, access to the Internet resources of the company (system “Projectia”, data bank “SokoPRO”), and most importantly, all employees, who are highly qualified engineers, were always helping during the process of writing the thesis and provided all necessary information and helped with technical issues.

Below the reader can find a list of expression and abbreviation definitions which are mostly used in the thesis:

1. GOST – state standard
2. PPR – project of work performance
3. PPB – rules of fire safety
4. POS –project of construction organization
5. SNIP – building norms and regulations
6. TSN – local building standard

2 WORK SAFETY TARGETS

Work safety is one of the most important requirements for all activities: for working in an office, for using any kind of machinery at a factory, for using special building equipment and machinery on site and, of course, for construction activity in general, which involves a wide range of rules, requirements and parameters needed to be complied and strictly controlled.

First of all, the meaning of work safety in general should be determined in accordance with special literature. So, work safety is a system intended for

protecting a person's health and life during working processes. Work safety includes juridical, social, economic, organizational, technical and sanitary management and other procedures (Centre of Work Safety LLC, 2008). This defenition is rather wide and contains all main necessary safety realizing points for work. The key issues among these are:

1. Juridical. Each worker should be protected by the State and laws with complete loyalty of his rights
2. Economic. It is necessary to plan and draw the company's budget properly with taking work safety costs into consideration. It is not correct to save money in this important process, because human life cannot be measured in monetary terms

The next important step is to define the goals of safe working performance, because it is not possible to achieve high level of safety without a throughout understanding of them. So, the reasons for safe working performance, which prove and help to admit it's necessity, are:

1. Need to provide safe working places for all employees without any dangers and risks of accidents, because human life is priceless
2. To improve employees' productivity
3. To avoid additional costs of medical care
4. To avoid delays in construction time due to accidents occurring with employees
5. Avoid workers absences on working places due to injuries obtained at the construction site

Safe working performance affects the quality of the final product in general. In our case it is a house, and the result is a qualitative construction completion without urgent or emergency incidents during the entire construction period.

The problems that exist in achieving the necessary level of safety and lead to the occurrence of different kinds of accidents on building sites are:

1. Low level of juridical knowledge and basic discipline of managers and staff and their lack of awareness in the field of labor law
2. Low level of promotion of safety issues
3. Flaws in the organization and in holding safety trainings for employee

4. Poor organization of production processes
5. Failures in technological processes
6. Using defective machinery and equipment
7. Unsatisfactory maintenance and organization of working places
8. Insufficient funding for working conditions and safety improving

This list proves that the number of problems is rather large. In support of this, Chart 1 is given below. It shows the number of accidents in period 2002-2007 in one typical industrial city in Russia.

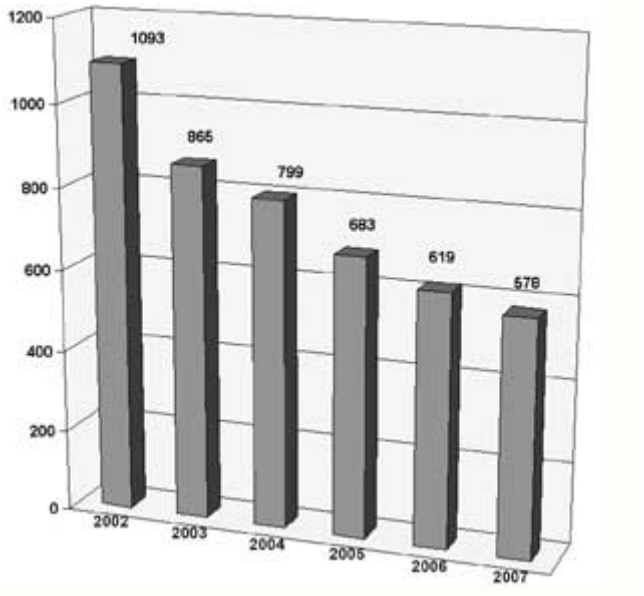


Chart 1. Number of people who suffered from injuries during work time

The vertical axis of Chart 1 shows the number of people who suffered from accidents and the horizontal axis shows a year. As the data concerns only one city, we can note that the number of injured people is large enough in 2002: 1093 people. By 2007 this figure decreased to 578, or roughly 50 percent. Of course, the number of accidents should tend to zero but it is not realized today.

Everyone, from a worker to a director, must realize his involvement in solving the problems of safety. This is the only way how the positive results in such an important for society matter as prevention of occupational injuries can be achieved.

After analyzing obtained information and determining work safety goals, as well as its problems, it is possible to make conclusions about the methods of safe production operations and thus improve and reduce the number of accidents at working places:

1. Proper organization of work safety at construction sites
2. Control of safe working performance (employees, machinery and equipment should be controlled);
3. Fulfillment of the requirements of SNIP, GOST, PPR and other regulatory standards
4. Providing information concerning work safety on weekly meetings with staff;
5. Make observations and record them in the journal;
6. Organize trainings, courses, seminars
7. All staff members should be instructed, and if necessary several times;
8. Preparation and keeping of journal for possible risks recording and prediction

Methods that are used on our construction site are presented in Chapter 5 "Work safety control", which includes many items of foregoing list. It should be noted that the implementation of all of these arrangements should be done throughout the entire construction period - from the design phase to construction and exploitation of the building.

3 REQUIREMENTS FOR A PROCESS ORGANIZATION

Like any other process, safe work production needs to be properly organized because it cannot be implemented properly if it is originally incorrectly configured. Some general rules should be observed by all the people on the site in order to create an environment in which the builders will be able to comply with work safety requirements. Therefore, this section describes the responsibility of the participants of construction, activities to be carried out by all staff members before they are allowed to execute work, proper organization of the construction site to avoid any combustion and fire, as well as the reasons for construction site fencing and how all these items affect work safety on site.

3.1 General regulations

First of all, it is necessary to determine who must comply with safety requirements and who must control how the things are going on. There are representers from main contractor, subcontractor and customer companies working on the building site. There are certain regulatory, financial and juridical relations between them, which are fixed in the contract. The questions, concerning work safety, are defined in details in this contract. The major work safety related task of the customer is the developing of a general instruction and coordination of work actions of different parties on site (Centre for occupational safety, 2006).

SNIP 12-03-2001 provides a list of regulatory documents, which serve as a base for work safety requirements. Norms and rules for construction and design processes, standard work safety instructions, state standards, rules for the safe using of construction machinery and equipment, state sanitary rules (SNIP 12-03-2001 paragraph 4.1). These documents are kept in the office of Work Safety Engineer and each worker has the right to examine them, if necessary.

The prime responsibility for safety at the construction site lays on Work Safety Engineer of the main contractor company, who should provide instructions for all staff members (all main contractor's and subcontractor's workers), ensure proper work safety organization and control fulfillment of all requirements. Each employee must observe the rules and regulations of safety, and subcontractors must monitor their implementation. Each subcontractor is responsible for the actual implementation of the requirements of fire prevention and safety, requirements of routine operations on construction site, site-traffic regulations and other instructions.

The participants of construction (customer, designers, contractors, suppliers and manufacturers of building materials and structures, manufacturers of construction machinery and equipment) bear responsibility for the fulfillment of all requirements which are defined by the legislation (SNIP 12-03-2001 paragraph 4.5). This paragraph of SNIP should be strictly observed by all participants of the construction process.

In this sphere of general requirements the following problems arise:

1. The requirements of regulatory documents and other regulatory laws are not satisfied
2. Lack of awareness and (or) incorrect understanding of building codes and regulations
3. Initial instructions for workers are not provided and areas of risks for workers are not identified
4. No control for the work and technical conditions of machinery and equipment is provided by Work Safety Engineer.
5. No information about accidents and risks at the construction site is provided

Possible ways of improving the situation:

1. Regular instructions for all staff members should be provided, this must be recorded in the journal and signed by both parties
2. On the early stages of construction zones of possible dangers and risks should be observed, and all responsible staff members should have this information. Also, the forecast of the possible risks on early stages of work should be done
3. Managers should be informed about all the incidents and the situations on the construction site to have the possibility of taking measures to prevent or eliminate hazards
4. Modern methods of work safety control, such as TR-meter, reports and photographic images of risks and accidents should be used
5. Introducing penalties for failure to comply with work safety requirements. Also, encouraging and promoting the fulfillment of all requirements with various bonuses (additional salary, additional holidays, certificates)

Figure 2. Work safety information at construction site

Figure 2 shows a board with various materials related to work safety control, instruction on health and safety, TR-meter chart, act of health and safety checking, journal of trainings, observations with their photo fixing and other helpful instructions.

Measures for improvement are always needed, and many construction companies are aware of this. Unfortunately, not all Russian construction companies understand the importance of safe work production, and a major obstacle to the implementation of safe work performance is remains the funding.

3.2 Safety instructions

Inductive safety instructions are provided by Work Safety Engineer for all officials who are on site. This stage is one of the key moments in the implementation of safe production work, because each employee receives important information regarding all aspects and features of the building site, meet with people in charge of fire safety, electrical safety and with people responsible for various types of work (concreting, excavation, piling etc.). Also an act is drawn up - the admission for implementation of construction works, without which it is impossible to begin work (SNIP 12-03-2001 paragraph 4.6).

Table 1, given below, shows an example of a journal form for the confirmation of induction safety instructions with the subcontractor's staff.

NCC

Журнал инструктажа 1 (3)
Субподрядчики

Информация об объекте	Название проекта/ стройплощадки: Projektin nimi				
	Название организации-работодателя:				
Инструктируемый	ФИО сотрудника:				
	Должность:				
	Опыт работы в строительстве (лет):				
Квалификация:	☐ EA 1 ☐ EA 2	☐ Сертификат по ТБ	☐ Сертификат на выполнение огневых работ	☐ Инструктор производственного обучения	☐ Прочее, указать
Срок действия					

ИНСТРУКТАЖ ПРОВОДИТСЯ В ПЕРВЫЙ РАБОЧИЙ ДЕНЬ ПЕРЕД НАЧАЛОМ РАБОТЫ	Дата прохождения инструктажа и ответственное лицо
ОПИСАНИЕ СТРОЙПЛОЩАДКИ	
Исполнительная организация: заказчик, ГП, независимые подрядчики, субподрядчики	
График проекта	
План строительства объекта	
Описание возводимого объекта (что строится)	
ТЕХНИКА БЕЗОПАСНОСТИ	
Получение индивидуального пропуска с фотографией и внесение в кадровый реестр стройплощадки	
Сертификат по ТБ, правила ТБ и рабочие обязанности	
Запрет на нахождение в нетрезвом состоянии или под воздействием наркотических веществ	
Использование СИЗ: защитная каска, обувь и пр., уход и хранение	
Рабочая и защитная одежда	
Обязанность по предоставлению отчетности и информированию начальства о выявленном браке/перед ответственными за руководство строительными работами в NCC, книжка «Риски, связанные с безопасностью» (обязанность каждого)	
Инспектирование при вводе в эксплуатацию, текущем обслуживании и проведении замеров уровня качества (ТР-барометр)	
Вредные вещества: указания по безопасному использованию (показать, где находятся)	
Меры при несчастном случае, готовность к оказанию первой медицинской помощи, специалисты по оказанию первой помощи	
Изложение результатов оценки рисков и рекомендаций по ТБ для данной стройплощадки, план по ТБ **Особую опасность на данной стройплощадке представляют:**	
ПОЖАРОБЕЗОПАСНОСТЬ	
Пожарная безопасность	
Огневые работы, план контроля за проведением огневых работ, разрешения на проведение, наблюдение по завершении работ	

Table 1. Journal for safety instructions

Table 1 show the first page of the journal for safety instructions, which is held for all subcontractors on site. In the left column the topics to be covered are specified. In the right - the date of instruction and responsible person. As can be seen in the table, the following items are covered in details during the inductive safety instructions session: description of the construction site, work safety, fire safety, organization of the territory of the construction site, external factors. After the procedure of the instruction has passed, two signature are written: the engineer's who provided the instruction and the worker's who was instructed.

It should be mentioned that each subcontractor company makes his staff familiar with the conditions of safety work production on site individually, so the Work Safety Engineer does not have to carry out this instruction to all employees of the subcontractor. That significantly simplifies the procedure of instruction and provides an opportunity for decision makers (head foremen, section chiefs) to get as full information as possible.

The following problems may concern this procedure:

1. Late or postponed instruction until an unspecified date
2. The states in the journal for instructions do not conform to normative documents: SNIP, GOST, PPB, PPR and others
3. Misunderstanding between Work Safety Engineer and the subcontractor worker (due to poor preparation, lack of experience or knowledge of both of them)

To achieve a positive result of the induction of safety instructions a number of measures must be applied:

1. Checking of a list of all topics which should be covered during the instruction and their conformity with the requirements of normative documents
2. Analyzing the material to be used for instruction, to avoid misunderstanding of this information
3. Correctly organizing a system of instruction with the subcontractors: making a list, which will reflect the existing subcontractors who have already been instructed and a list, which will include new or not yet instructed subcontractor

Inductive safety instructions are the first step of work safety realization, if they are not properly performed, the result would be corresponding - the occurrence of emergency situations, personal injury, illness, etc. Therefore, this procedure should be well planned, analyzed and be available for all employees.

3.3 Fire protection organization

Organizing fire protection is, perhaps, one of the most important topics of any industry, including the construction sector. Great attention to fire protection actions has been recently given in Russia. In recent years there have been terrible events because of the fact that the system of fire protection was poorly organized or absent. This section outlines the organization of fire safety on the construction site.

Thus, as for the fire organization, all the requirements in this case are specified in the regulations: fire safety rules (PPB 01-03), and SNIP 12-03-2001. The first requirement for the construction site is the presence of separate entrances to all facilities that are located there. At least two entrances on opposite sides should be provided on the construction site the area of which is 5 hectares or more. Roadway covering must be suitable for the passage of fire trucks during all seasons of the year. The gates for entry must have a minimum width of 4 m (PPB 01-03 2003).

Plans for fire protection with all temporary and permanent buildings, structures, entrances, water sources and communications must be installed near the entrance to the building site. All firefighting equipment should be kept in suitable working conditions. Passages to the fire-fighting equipment must always be available and marked with appropriate signs. Working places, which have risks for fire and explosions, must be equipped with primary fire-fighting and controlling devices (PPB 01-03, 2003, SNIP 12-03-2001).

All above mentioned requirements are implemented on the existing site.

Figure 3. Plan of fire protection

Figure 3 shows the plan of fire protection on the construction site of the "Swedish Krona" residential complex, which has been developed to the first stage of construction. Road through the whole territory of construction site, entrance (exit), site of fire shields (fire extinguishers), fire hydrant, location of the tower crane, buildings being under construction, wheels cleaning equipment, warehouses, main contractor's and the subcontractor's barracks, outdoor parking and concrete fencing of the site are shown in this plan. Thus, the construction site meets all the requirements for the fire organization: existing road surface - asphalt, temporary roads surface - gravel, 3 entrances, width of the gate - 8 meters, fire hydrant and shields are located in proper places.

The plan of fire protection is installed right behind the entry to the building site, Figure 4, given below shows its location.

Figure 4. Location of fire protection plan

Also, the plan helps people, who are for the first time on this site, to orient themselves there. It is especially helpful for drivers who deliver construction materials, equipment, drawings and so forth.

The photographs of the fire boards, which are installed at proper places on the building site, are shown in Appendix 2. They are installed in four places: near the erected building, next to the barracks of the main contractor and the subcontractors, next to the sales office. Thus, all buildings are equipped with fire protecting devices.

Most fires occur because of the flaws of the electrical system, so the connection of the barracks to existing electrical network, as well as the laying of cables and the protection of electrical boards must be carefully checked on the construction site.

To prevent fire occurrence due to short-circuit the number of protective measures should be applied:

1. Wires and cables should not lie on the ground, because in this situation they will likely be damaged because of the using of construction machinery
2. Switchboards should be covered with canopies to prevent ingress of moisture (rain, snow, groundwater)
3. Switchboards should not be available for not authorized people.
4. Do not use prohibited electrical devices, such as heaters, dryers, irons, etc, in the barracks

Figure 5. Cable laying and electrical board protection

Figure 5 shows the connection of cable to the electrical panel. Here you can see how the cable is properly routed through the territory. There is a special wooden stand, which provides elevation above the ground and thus makes visible the cable for all people and the risk of its mechanical damage is decreased. The switchboard is also insulated, it is placed in a wooden structure, which is covered

by a profiled metal sheet, protecting from the wind (moisture, dust and sand particles in the inside of the shield), snow and rain. Besides this, warring signs indicates the danger zone. Examples of proper organization of electrical cables and electrical boxes in different parts of the construction site are shown in Appendix 3.

The organization of smoking area is one more important point. Unquenched cigarettes cause inflaming and as a result heavy fire. To avoid this event smoking areas should be define all around the site and equip them with ash cans and other arrangements if necessary (tents, benches). Figure 6, given below, describes an example of a smoking place near the main contractor's barrack.

Figure 6. Smoke place near main contractor barrack

We can see a sign of cigarette with fume on the wall which means that the area is intended for smoking. Also there is an ash can for smoked cigarettes and bench (in the lower right corner) which you use to sit. The application of these smoking areas reduces the risk of possible combustion from cigarette. There is also a proper electrical connection in the upper right corner of this figure. Here a special

electric device to supply electricity to the barrack and cover protect from moisture ingress is used.

The following problems may hinder the fire protection organization procedure:

1. Roads on building sites are in bad conditions (no proper asphalt or concrete covering, potholes), which makes transport traffic to combustion and staff evacuation complicated
2. No fire protection plan on site or it is incorrectly designed
3. Fire protection plan is located in an inconvenient place which makes it impossible to use
4. Electrical cables are insulated not in a proper way which increases risks of their damage and combustion
5. Smoking places are not planned
6. Protective fire boards are absent or incompletely collected
7. Employees do not know what to do (where to go or call) in case of emergency: any combustion or fire

To improve the fire protection system the following methods are recommended:

1. Arrange fire alarm system on site
2. Install protective fire boards in buildings and structures
3. Allocate places for smoking
4. Provide fire protective instruction for new employees and teach to use fire protective equipment
5. Provide correct material and substance store

You have to be sure that all arrangements are taken and all risks are foreseen for fire safety organization because it influences to human life which cannot be endangered.

3.4 Admission to the site

Industrial and construction territories in populated areas should be hedged in order to prevent the access of unauthorized people. This should be done in order to protect the objects, which are situated on adjacent areas (existing buildings and structures), and, of course, to protect people themselves. The case when a stranger is injured because of the constructor's activities is strictly prohibited. The fence is also detecting the construction area and the builders know exactly where the borders of the site are. It also helps to provide security system to control site area (SNIP 12-03-2001).

The fence structure should comply with requirements given below: the height of fence elements for industrial territories should not be less than 1,6 m and for the construction work not less than 1,2 m. The fencing structure should be without any openings except gates that are controlled during work time and are closed after the end of the working day. Such materials as concrete, timber or profiled metal sheet are used in dependence on site location and surrounding area (SNIP 12-03-2001).

Security controls all people, cars and machinery that enter the site. A check point is organized for this purpose. To enter the site it is necessary to show a permit and every person has to keep it while on construction area. The main contractor gives their employees and subcontractors permits, which provide a list of all authorized employees. The permit is issued after inductive safety instruction by safety Engineer.

Figure 7. Permit on site

Figure 7 above shows an example of the main contractor‘s permit on site and general requirements for it are: company and project name, employee's name,

position and photo, expiration date. The permit has to be showed in the check point before entering the site gate.

The following problems may affect the admission system on site:

1. Security does not check all permits of authorized employees
2. Permit, which is shown, is expired

To provide a proper level of admission system it is necessary to:

1. Organize an instruction meeting with security responsible for the site area
2. Name a person who is responsible for the subcontractor's permit distribution

4 WORK SAFETY REQUIREMENTS

When all necessary safety measures are implemented befoew the beginning of construction and proper working conditions are created, the question of what rules must be followed to perform a certain type of work without any injuries and accidents to employees arises. In this paragraph I investigate requirements for different construction works like piling, concrete works and also requirements for using individual protective facilities. The compliance with the requirements of safe work performance will minimize the occurrence of various hazards to the health of workers and increase the productivity of work.

4.1 Individual protective equipment

Individual protective facilities are used to prevent different mechanical, chemical and biologic damages. The selection and applying of any protective equipment depends on a risk analysis. A main contractor defines which individual safety equipment should be used on his site. Individual protective facilities, which are affected by specific aspects of the work, are obligatory (Centre for occupational safety 2006).

The most important protective facility on site is helmet. A contractor has to provide his employees individual protective equipment and control their usage.

Figure 8. Protective facilities

Figure 8 shows signs, which describe individual protective equipment. The blue color of signs means that they must be followed in area where they have been installed. The explanation of them in general is given below:

1. A helmet is used during works where there is a risk of head injuries. The helmet is necessary to be used almost in all constructions works
2. Hearing protection is used in construction works where there is the excess of normal noise level of 85 dB. Protective headphones are used to prevent harmful noise
3. Protective glasses are used to prevent eye injuries during building works, for example in hammering or drilling works
4. Protective shoes are used to prevent possible foot and leg injuries and slipping during construction works
5. Breath protection equipment is used to prevent breathing in poisoned gazes and dust

Examples of using individual protective equipment on a building site are presented in Appendix 4.

The following problems may hinder the usage of individual protective equipment on site:

1. Getting injuries and appearing of professional illnesses
2. Protective facilities not used because they are absent on site
3. Employees do not know what protective equipment they have to use, for example during works on height a helmet is used but not protective equipment from falling

To realize the usage of individual protective equipment in a proper way it is necessary:

1. Before work will be performed the subcontractor should organize an inductive instruction concerning protective equipment needed to be used in certain works
2. Work Safety Engineer should control the usage of protective equipment, put incorrect cases in the journal and tell observations to employees and to responsible engineers (foreman, section supervisor)
3. Contractor should be sure that all protective equipment to perform work is on site

The usage of individual protective equipment is one of the keys to realize safety work performance. An injury may occur because of not complying with this requirement in particular. That is why high level of control by Work Safety Engineer for proper the usage of individual protection during construction works is necessary.

4.2 Piling works

Nowadays pile foundations are extensively used in Saint-Petersburg to support multi-storey apartment buildings to prevent the effective structural loads transferring from the superstructure to the ground and to avoid the excessive settlement. Machineries and mechanisms with high risk of danger are utilized during the performance of pile works and that is why an increased attention to their

work is required. There are also physical risk factors such as noise and vibration from the impact of a drop-hammer.

At first I will go through the main requirements which are based on state norms. They consist of two parts:

1. Work organization
2. Construction sequence

First about the requirements for work organization. The measures to prevent the influence of hazardous and harmful production factors, during pile works related to the nature of work, workers should be protected against:

1. Falling rocks (soils)
2. Movement of machineries and their working parts as well as transferring of different items
3. Location of working places near the height drop 1,3 m and more
4. Machinery overturning, falling of piles and their parts
5. Electrical cables with high voltage

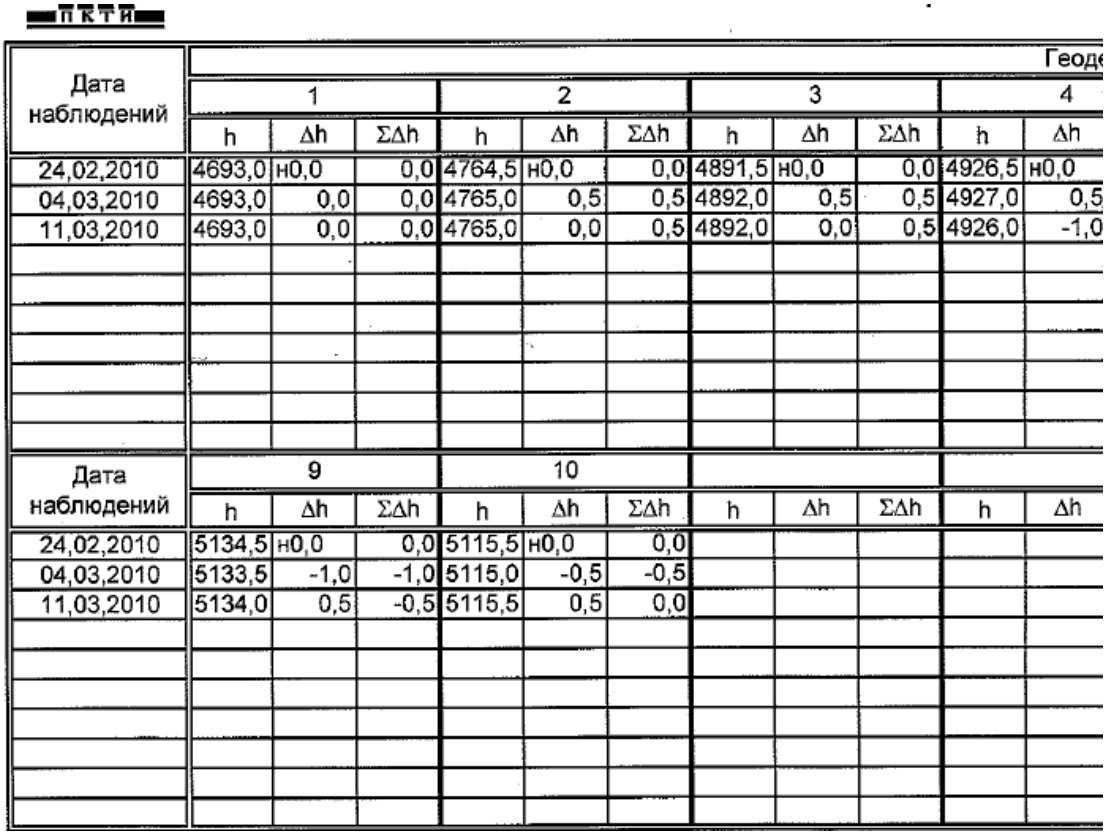
In the presence of dangerous and harmful production factors, the safety of pile works should be ensured by complying with the following decisions on health protection and safety work performance, contained in POS and PPR:

1. Determination of mechanisms to perform work
2. Determination of work sequence
3. Development of installation plane and equipment dismantling as well as his transfer on site
4. Determination of name and quantity of needed protective equipment which is necessary to be used during machinery work and also to organize working places

Ropes must be certified by the manufacturer or there must be an act with their test results; lifting equipment should be tested and have tags, which confirm their capacity and date of trial. The distance between the established piling machinery and nearest buildings is determined by PPR. The danger area should be

determined at a distance of not less than 15 m from the wellhead or place of piling when piling machinery is used (SNIP 12-03-2001 2003).

Below there is an example of the latest requirement about a danger zone. The first line of the residential community “Swedish Krona” is located near the administration house of “Udelniy Park”. The vibrations can reach the neighbor building located at distance 32-40 m (out of danger zone) during piling. It is necessary to analyze the impact influence of piling on the existing building. The settlement of neighbor building should not be more than 20 mm by TSN 50-302-2004 table 4.1.



Дата наблюдений	1			2			3			4	
	h	Δh	ΣΔh	h	Δh	ΣΔh	h	Δh	ΣΔh	h	Δh
24,02,2010	4693,0	н0,0	0,0	4764,5	н0,0	0,0	4891,5	н0,0	0,0	4926,5	н0,0
04,03,2010	4693,0	0,0	0,0	4765,0	0,5	0,5	4892,0	0,5	0,5	4927,0	0,5
11,03,2010	4693,0	0,0	0,0	4765,0	0,0	0,5	4892,0	0,0	0,5	4926,0	-1,0

Дата наблюдений	9			10							
	h	Δh	ΣΔh	h	Δh	ΣΔh	h	Δh	ΣΔh	h	Δh
24,02,2010	5134,5	н0,0	0,0	5115,5	н0,0	0,0					
04,03,2010	5133,5	-1,0	-1,0	5115,0	-0,5	-0,5					
11,03,2010	5134,0	0,5	-0,5	5115,5	0,5	0,0					

Figure 9. Settlement journal for neighbor building

Figure 9 describes a report of settlement for the building which is located near the erected structure and the distance is 40 m. The report has been made in a form of a table. In the first column on the left side the date of observation (in our case it is 3 days: January 24, Mart 4, Mart 11) has been written. The following columns presented are the values of settlings in different parts of the building (the total is 10 marks along perimeter). The plan of deformation marks location for settlement

investigation of the administration house “Udelniy Park” is given in Appendix 6. Thus from this journal follows that no value exceeds 20 mm (the largest from the list is 1 mm). That is why there is no danger and damage to existing building. This is a detailed example, which brightly describes the company approach to comply with safety requirements and, as a result, the fulfillment of other state regulations. All reports are stored on site at the Work Safety Engineer room as well as on electronic version in the system ”Projectia”.

Now about the requirements for construction sequence. The technical condition for pile machinery (reliability of knots fastening, proper links and working decks for walk) should be checked before the start of each shift. Employees who are not directly involved in pile works should stay out at a distance not less than 15 m during the period of work performance. The following items should be checked before piling is started:

1. Functionality of sound and light signaling devices and limiters of lifting equipment
2. Condition of ropes for lifting as well as condition of lifting equipment
3. Functionality of all machineries and hardware

Performing of other works, which are not related to these processes by piling machinery, is prohibited during lifting or lowering of a piling tool. Installation of piles and pile-driving equipment is done without a break until they are installed. Leaving the piles in the incomplete position (in the air) is not allowed.

It is also necessary to enclose the working area (along the perimeter) as well as the area for pile storing and put warring signs like “Danger zone”. This is done in order to warn persons who do not know what kind of work is performed here and what areas are dangerous. Personal protective equipment such as a helmet and headphones need to be used during pile works. Adjacent works should be planned in advance. A subcontractor should control fencing during work day.

Figure 10 given below shows the fulfillment of requirements in a pile storing area.

Figure 10. Pile storing area

Figure 10 describes an area where piles are stored. A crane which performs receiving and warehousing of the piles as well as supplying them to the place of piling is seen here. There are warning signs “Danger zone, pass is prohibited” in the foreground and the pit which has tape fencing located in the background. Thus all requirements for safe work performance are complied with.

The following problems may occur in pile works:

1. Dangerous zones are not defined, there are no fencing and warring signs
2. Technical functionality is not verified before using of machineries
3. Individual protective equipment is not used
4. Machinery and equipment have defects or they are out of service

To prevent accidents and increase safety the following instructions measures can be used:

1. Study the plan of infrastructure near the erected building e.g. the location of electrical cables and water pipes
2. Get familiar with piling machineries and their documents before their usage. The condition of lifting machinery and their elements should be supervised. Do not use defected equipment
3. Individual protective equipment is used and monitored
4. Dangerous zones are defined and fenced
5. All employees should have safety instructions concerning pile work

The performance of pile works is important to erect a strong foundation. That is why it should be done in a safe environment, and to achieve proper safety during piling it is necessary to follow the requirements of PPR and SNIP.

4.3 Concrete works

Concrete works are the most long-lasting ones during the whole period of construction, so the correctly planned and safely performed work will define the quality of the building in general. Complying with the requirements for safe work performance, workers at the same time meet the technological requirements for the production of works. This section presents the analysis of the basic requirements for safe production of concrete works, which include reinforcing, formwork arrangement and concreting.

Requirements for concrete works are divided into three sections (SNiP 12-03-2001):

1. Work organization
2. Organization of working places
3. Construction sequence

At first I will consider the requirements for the organization of work. Hazardous elements in concrete works are (SNiP 12-03-2001):

1. Location of working places near the height drop 1,3 m and more
2. Moving machinery, transferring different items

3. Possible collapse of structural elements
4. Noise and vibration

In the presence of dangerous and harmful production factors, the safety of concrete work should be ensured by complying with the following decisions on health protection and safety work performance in POS and PPR:

1. Determination of mechanisms for making, transporting, feeding and casting of concrete
2. Determination of the carrying capacity of the formwork, as well as the sequence of its installation and dismantling
3. Measures and means to ensure the safety of works, performed on heights
4. Measures and facilities for concrete curing in cold and warm seasons

The mounting of the formwork, as well as the installation of reinforcement cages, should be guided by the requirements of the section "Installation work" of SNIP 12-03-2001.

The next step is to consider the requirements for the organization of working places. The placing of equipment and materials on the formwork, which is not mentioned in PPR, as well as the existence of unnecessary people on the mounted formwork are not allowed.

For moving from one workplace to another it is necessary to use ladders, transitional bridges and bridging boards. Walking on mounted reinforcement is permitted only on a special deck with width not less than 0,6 m, installed above a reinforcement cage. Preparing and preassembling of reinforcement should be performed in specially designated places. Standing at a distance closer than 1 m from the rebar, heated by electricity, is not allowed.

In Figure 11 there is a practical example, which shows that the requirements for the location of passages above the reinforcement cage are not fully complied with.

Figure 11. Absence of decks for walking above the reinforcement cage

Figure 11 shows the workers who perform the reinforcement and mounting of the formwork for the basement. As it can be seen, there is no flooring system for walking above the reinforcement cage. Therefore, the risk of injury increases significantly. If an employee slips or stumbles, he will fall on the reinforcement cage and at best only hurt his leg. There are also reinforcing rebars, which are not fixed, and if an employee falls on them, the consequences could be very dire. Flooring made for example of the wooden planks, can be done to avoid this.

One more example is given below.

Figure 12. Reinforcing steel shop on a building site

Figure 12 shows the reinforcing steel shop, which is located near the area of construction. Structurally it is made of a wooden frame and covered plastic coating (in case of rain, you can continue to prepare reinforcing products). Thus, all preparing procedures are implemented in one place. The store of the reinforcement, which will be used later, is situated nearby. With this centralization of production the possibility of a risk in the production of this type of work decreases.

Requirements for construction sequence are considered further. First of all, using mixing machines must comply with the following requirement: cleaning of drums and troughs of mixing machines is allowed only after their complete stopping and relieving the tension.

When carrying out preparation of the reinforcing rebars the following aspects should be taken into consideration:

1. Installation of the protective fencing of working places for unwinding skeins and straightening the rebar
2. When cutting machines are used for segments of length less than 0,3 m, special devices that prevent their spread should be used
3. Installation of the protective fencing of working places during the processing of reinforcing bar, which protrudes beyond the bench
4. Storing of prepared reinforcement in specially defined places
5. Closing of end faces of a reinforcing bar with shields in the walking areas, having a width of less than 1m

Bunkers for concrete mix should conform to state standards. The moving of a loaded bunker is permitted only when the shutter is closed. When laying the concrete mix from the hopper, the distance between the bottom edge of the bunker and the previously casted concrete or the surface, on which the concrete is placed, should not be more than 1 m. When a concrete is casted with a concrete pump, the following requirements should be complied:

1. All the employees should stand at a distance of not less than 10m from a concrete pipe during the purging
2. Concrete pipes should be laid on gaskets to reduce the impact of the dynamic load on the reinforcement cage and formwork during the concrete feeding

Figure13. Feeding of concrete through the bunker

Figure 13 shows the process of casting of concrete base for the pile cap performed by subcontractors. Note that the bunker meets the requirement of GOST. The distance between the bunker and the surface on which the concrete is laid is about half a meter, which is within the normative value. All requirements for safe work performance in this case are met.

Figure 14. Concreting with the help of a concrete pump

Figure 14 shows the process of pile cap concreting with the help of a concrete pump. The hose, which feeds the concrete mix, is laying on the reinforcement cage, thus the risk of danger from the dynamic effects of concrete feeding is reduced.

When concrete works are carried out some problems, which affect the safe performance of works, may occur:

1. Access to working places is limited or impossible
2. Concreting is implemented in a cold (or too warm) season, which increases the complexity and danger of combining the operations (the weather conditions are not taken into account)
3. Walking decks above the finished reinforcement cage are absent

4. Electrical wires are not laid on the site, making it difficult to use the tools
5. Not enough lighting in the dark time
6. The remains of the reinforcement, formwork and other items are not stored in a garbage container, which leads to clogging of the working area

The following measures for improving work safety can be assumed:

1. Implementation of the preparatory works beforehand: organization of the starting meeting with the subcontractor, checking the barracks on their compliance with the safety requirements, providing the inductive safety training for workers, installation of the protective devices
2. Preparation of working places: installation of the flooring system for walking above the reinforcement cages, trash containers, laying all the cables safely, preparing the equipment for installation of formwork and reinforcement, checking the adequacy of existing lightning
3. Composing a schedule of works, taking into account weather conditions
4. Testing of the depth of vibrators before concreting to ensure their reliability

There are many features that affect safety during the production of works associated with the formwork installation, reinforcing and concreting, therefore we must explore all possible risks and dangers, as well as monitor their compliance with safety rules. That is why the following chapter is dedicated to the work safety control.

5 WORK SAFETY CONTROL

Work safety control is an important element in the realization of safe work performance. The main contractor is responsible for this control and it organizes all the procedures to check work safety. The engineer who is responsible for work safety control has duties like making a weekly report which includes all failures data, calculation of TR-meter, which registers the level of work safety on site, providing safety instruction for new employees, composing the journal of photo failures based on daily inspections. Reports are posted on a special stand and

every employee can read them. This section presents weekly inspections and calculation of TR-meter.

5.1 Weekly inspections as a method of control

Work safety control happens every day by all engineer staff who are supervising work on site and monitoring a subcontractor's employees concerning work safety requirements like using individual protective equipment (helmets, protective glasses, shoes and headphones) or fencing of dangerous zones. Weekly inspections include supervision by Work Safety Engineer with the subcontractor's engineer e.g. a section head and foreman who signs the work safety list and this means that their employees follow all requirement of safe work performance.

Figure 15. Signing of work safety list during weekly inspection

Figure 15 shows a process of weekly inspection. On this photo there are two engineers. One of them is the subcontractor section head (in a blue coat) who signs the work safety list and the other one is the main contractor's Work Safety

Engineer. Such a control method is very important because Work Safety Engineer can not supervise all employees and this helps a lot to be sure that requirements of safe work performance are fulfilled.

Work Safety Engineer arranges every day the inspection, which includes the following positions:

1. Machinery and equipment
2. Fire safety
3. General organization of the working area
4. Protection from falling
5. Lighting
6. Electrification during working hours
7. Lifting equipment
8. Scaffolding and entrance ways
9. Individual protective equipment

During the inspection all failures are recorded by a camera and then photos are saved in reports with comments. This photo reporting is an effective method when it is necessary to give arguments during a meeting with the subcontractor about their failures. Photos with examples of the subcontractor is incorrect work safety are presented in Appendix 7.

5.2 Implementation of TR-meter

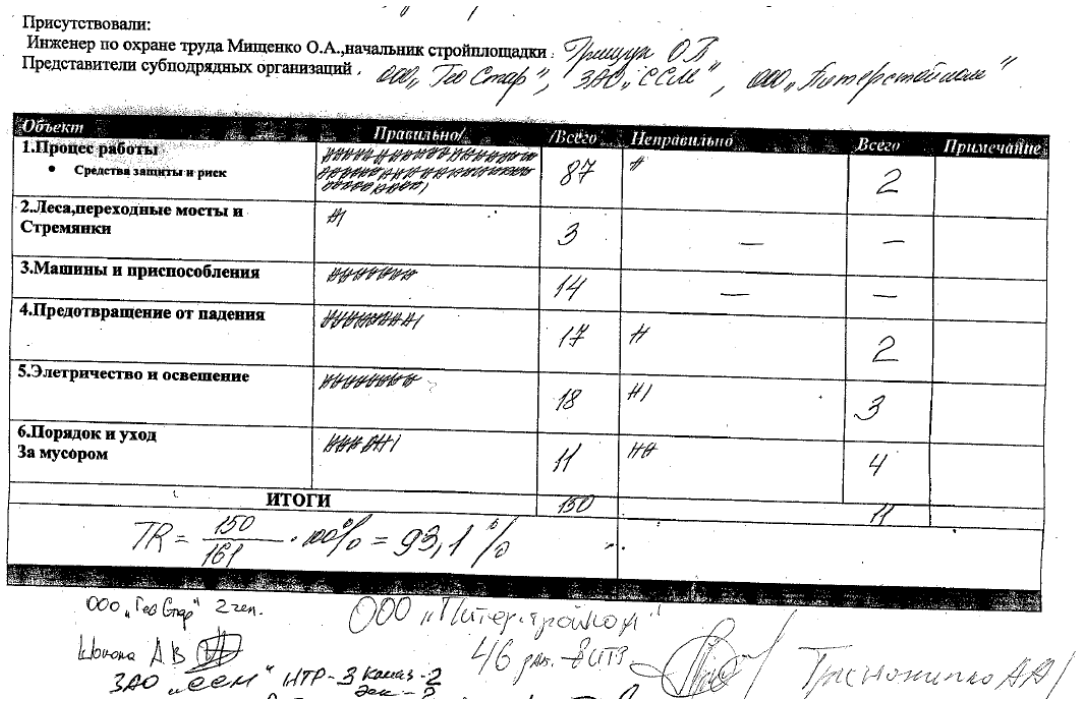
TR-meter is used to define the level of work safety that exists on site. It is calculated 4 times per month during a weekly inspection. The level of TR-meter should be between 85 – 95 per cents, and then it is considered that work safety peromance is properly implemented on site.

TR-meter is calculated according to Formula 1:

$$TR = \frac{correct\ \ pcs}{correct\ \ pcs + incorrect\ \ pcs} \times 100 = \% \quad (1)$$

Formula 1 includes correct and incorrect items. Correct pieces are the inspected items that comply with requirements of work safety. Incorrect pieces are the inspected items that do not comply the requirements. Multiplying by 100 we received the value of TR-level in percentages.

Figure 16 given below shows an example where correct and incorrect positions are calculated.



Присутствовали:
Инженер по охране труда Мищенко О.А.,начальник стройплощадки
Представители субподрядных организаций

Объект	Правильно	Всего	Неправильно	Всего	Примечание
1.Процес работы • Средства защиты и риск		87	4	2	
2.Леса,переходные мосты и Стремянки	11	3	—	—	
3.Машины и приспособления		14	—	—	
4.Предотвращение от падения		17	4	2	
5.Элетричество и освещение		18	41	3	
6.Порядок и уход За мусором		11	44	4	
ИТОГИ		150		11	

$TR = \frac{150}{161} \cdot 100\% = 93,1\%$

Figure 16. Values of correct/incorrect positions

A scanned table with the recorded values of correct/incorrect positions, which have been noticed during a weekly inspection is presented in Figure 16. There are totally 6 stations checked by Work Safety Engineer. These stations are located in the first column:

1. The process of work (protection equipment and risks)
2. Scaffolding and step ladders
3. Machineries and devices
4. Falling prevent
5. Electricity and lighting
6. Cleanness and waste situation

The number of correct positions for each station inspected is represented in the second column. All correct positions for each station are summarized in the third column. For this example there are 150 correct positions. The same calculation is done for incorrect positions and the results are in columns four and five. Then these values are put in Formula 1 and the TR-meter level is calculated.

Figure 17 shows a chart with the fixed value of TR-meter, which is written down every week.

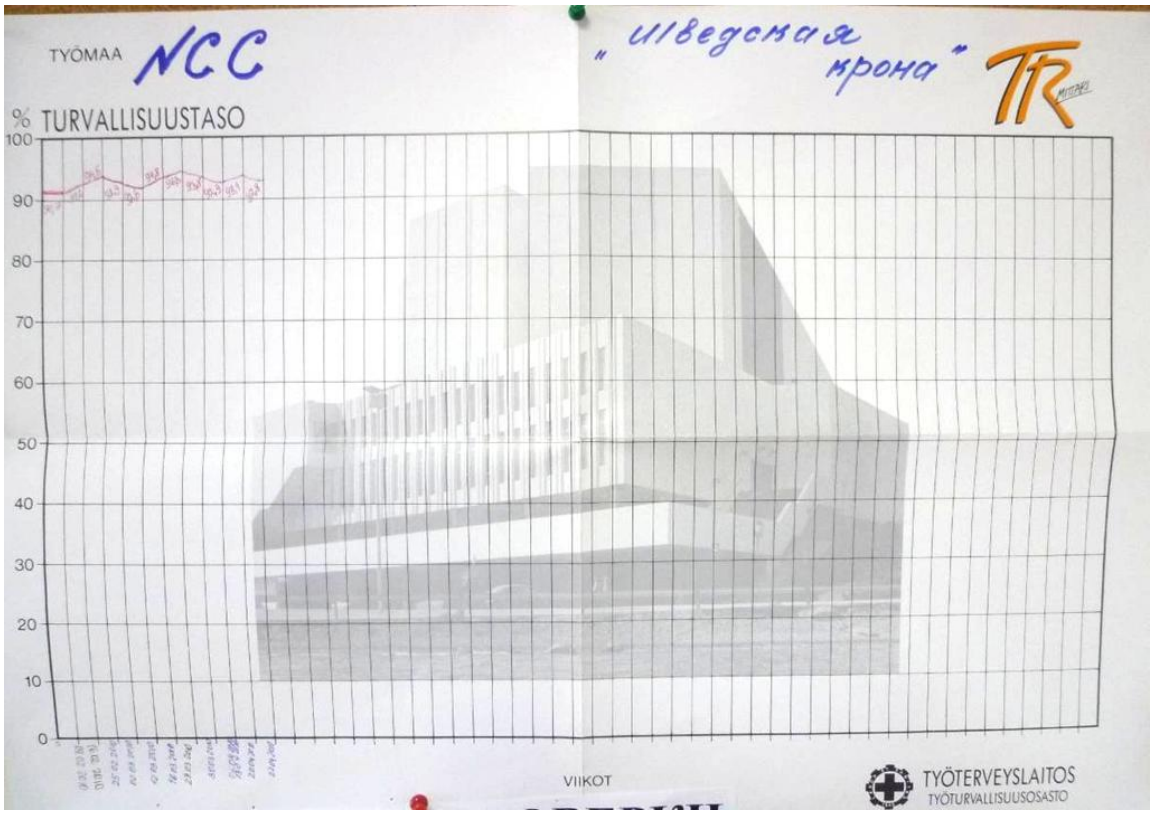


Figure 17. Chart of TR-meter

A chart with values of TR-meter is presented in Figure 17. Vertical axis of the Figure 17 shows the value of TR-meter level and on the horizontal axis dates when the value of TR-meter was defined are written. Therefore it can determine the dynamics of changing the level of TR-meter. Also the TR-meter chart can be compared with a general schedule to find out what kind of work is performed with failures and take necessary measures to increase the level of work safety.

The main benefit from knowing the value of TR-meter is that we can control the level of work safety on site and if the value of TR-meter goes down it means that some measures to increase work safety should be taken.

6 TARGETS OF QUALITY CONTROL

Quality control is an important process during the construction of any project. As a result of the implementation of the quality control during the construction we have a complete structure that meets the requirements for safety, durability, reliability and other parameters. A quality control engineer performs technical supervision on the construction site and has the authority to stop construction, if a particular item does not meet the requirements of SNIP or GOST.

First, we define the definition of quality control. For the better understanding of this phrase I will define these words individually:

1. Quality - the totality of characteristics of an object related to its ability to meet established and projected needs
2. Control - regular verification of any rules, laws, orders

Now, based on the above given definitions, I will determine the meaning of quality control: it is a sum of measures to verify compliance of the properties of the finished object with the requirements. That is, in other words, the totality of actions carried out to test products for compliance with the requirements of various regulatory norms. For example, in the case of a complete reinforcement cage we examine the diameter of the bars, spacing, etc. which have to be as it is specified in the project documentation.

Then we define the objectives, pursued by the quality control:

1. To ensure the compliance of specified design properties of the structure with the requirements of SNIP and GOST
2. To utilize only materials of high quality in construction
3. To carry out the construction on the first try, do not alter several times the same element. Thus not only money is safe, but also the construction period, which is one of the main objectives of the project, is decreased
4. To ensure that all structures comply with project drawings
5. To meet the requirements of the consumer
6. To consider the requirements for the environment safety

7. To make the object economically beneficial for the organization and to sell it to the consumer at competitive prices
8. To ensure safe production operations
9. To ensure the implementation of the planned construction period and budget
10. To fulfill all the requirements of the contract

The problems that may arise when quality control is not sufficient are as follows:

1. Excessive construction time
2. Additional costs that are not considered in budget: the cost of remaking structures and penalties for missed deadlines of construction
3. Risks of damage or collapse of the whole structure or particular element, which is still under construction, increase
4. Material that is used in the construction does not meet the requirements of GOST
5. Harm to the environment may occur

After analyzing the received information and the determination of the quality control purposes, as well as the problems that may occur with inadequate level of quality control, we can draw conclusions about the methods, which should be used to improve quality control:

1. Organization of quality control at key stages of construction: tender (the choice of qualified subcontractors and suppliers, which affects the quality of delivered materials and produced works) and working performance (the straight control for the procurements and performed works)
2. Following the requirements of SNIP, GOST, PPR, SP to avoid the majority of errors in the construction
3. Dividing the responsibilities of the quality control of supplied materials and quality control of performed works
4. Before beginning the works it is necessary that all aspects of quality were understandable for all staff members involved in construction processes
5. Carrying out necessary controlling measurements: angle of the slope of excavation, design position of the piles, level of vibration during pile driving,

capacity of the drainage system, surface temperature before concreting, proper reinforcing, protective concrete layer width, etc.

6. To produce a double control, if it is necessary
7. Establishment of archive of quality assurance
8. Compiling a check-list, which is signed by quality control engineer, main contractor's engineer, subcontractor's engineer. After the signing of this document the structure is officially approved
9. Organizing the journal, in which the errors, revealed by the quality control, will be marked, to avoid them in future
10. All structures and materials must be checked in a uniform system, unsystematic control is not acceptable

Quality control is very laborious work that requires high level of responsibility, high qualification of an engineer, a great experience, because the quality of the final product (in this case a house) depends on how well it is done. This is especially important when it concerns the structure, which people will live in, as they must be confident of the safety of their apartments.

7 QUALITY CONTROL

Quality control consists of two parts: control for a product and for a process. The first includes quality control of materials, which are delivered to the construction site: piles, concrete, reinforcing steel, sand, etc. The second part is to monitor the quality of works, like piling, reinforcing, backfilling, concreting, etc. Therefore, this section provides examples of two parts: the quality control of delivered piles and concrete and the quality control of concrete works.

7.1 Control for the quality of supplied materials

This section provides an example of how the quality of the supplied materials has been monitored on the site, and in particular I will go through the control of the quality of concrete piles and concrete. First, the supply of piles is discussed. The

delivery of the piles as well as the primary responsibility for quality control was a duty of a subcontractor. The piles were supplied from two plants of one company, however, each plant has its own technology so the quality of different piles was not the same.

The main contractor's engineer, subcontractor's foreman and the supplier representative participated in taking over the piles. The piles, which were evidently defective were immediately rejected and delivered back to the factory. To piles with possible damages further testing was necessary. This included the measuring of the size of cracks, cavities and other openings and comparing them with the requirements of GOST 13015.0 and also the determination of concrete strength. This was done with the help of a special equipment - a dimensional line to determine the size of cracks and electronic sclerometer for measuring the strength of concrete. The conclusion on the suitableness of the pile is made on the base of these two parameters.

Figure 18. Pores and pile defects

Figure 18 shows the pile, which is delivered to the construction site. There are many pores, which may affect the strength of the pile on its lateral surface. According to the requirements of GOST 13015.0-83 (paragraph 1.3.13), about the quality of concrete surfaces and appearance of piles (including the width of the

opening of surface technological cracks), sizes of pop outs, local depressions on the concrete surface and spalling of concrete edges of piles must not exceed:

1. Diameter or a maximum size of pop outs - 20 mm
2. The depth of depression - 10 mm
3. The depth of spalling of concrete edges - 20 mm
4. Total length of the spallings of concrete in 1 m of the length - 100mm

As can be seen in Figure 18, not all parameters of this pile are within the norms on the state standard, and there are doubts about the strength of concrete. Examples of piles with defects are presented in Appendix 8.

Special devices, such as an electronic sclerometer, are applied to test the strength of concrete at the construction site. Figure 19, given below, shows the process of the piles concrete strength measuring by the main contractor's engineers.

Figure 19. Measuring of the concrete strength at the site

The reading of the sclerometer depends on the quality of the surface of the element. This method of determining the concrete strength is not always absolutely accurate, but it gives a general value of the strength. In this case, the

readings coincided with the design value. This procedure proves the responsible approach of the main contractor to control the material (pile) quality.

Another example of the quality control of the delivered piles is shown below. Figure 20 shows an evident defect of the pile length.

Figure 20. Defect of the pile length

As it can be seen, the left pile is shorter than the right for about 1,5 meters, which, of course, makes it not permissible for using. Despite that this defect is evident during the acceptance, the question arises how one could fail to notice this when packing them at the plant. So, even such a seemingly obvious defect can occur.

We now turn to the quality of the concrete and see what actions are taken to control the quality of this construction material. First of all, when the concrete mixer arrives on the site, a paper proving the quality of concrete, which demonstrates its mark and all the additives it contains, comes along.

Luja Бетон

Испытательная лаборатория ООО «Луябетон»
195253, г. Санкт-Петербург, Лапинский пр., д.3 лит. Х

Свидетельство об аттестации №СТ-0024 выдано ФГУ «ЦЛАТИ», действительно до 10 октября 2011 г.

Документ о качестве бетонной смеси № 137

ГОСТ 7473-94

Наименование организации-изготовителя:	производство «Коломяги», ООО «Луябетон».
Потребитель:	ЗАО, Экспа Строительство
Вид и условное обозначение бетонной смеси:	БСГТ В25 П4 W6 F100
Удобоукладываемость бетонной смеси на заводе-изготовителе, см:	16-20
Номер состава	732-3
Дата и время отправки бетонной смеси	16.04.10г.
Класс (марка) бетона по прочности на сжатие в возрасте 28 суток	25(350)
Коэффициент вариации прочности бетона, %	11,0
Требуемая прочность бетона, МПа	29,5
Наименование и кол-во добавок,в % от массы цемент:	Centrament N10- — % Sika 0,3 %
Класс материалов по удельной эффективной активности естественных радионуклидов и цифровое значение $A_{эфф.}$, Бк/кг	1 класс, до 370
Наибольшая крупность заполнителя, мм	20

Выдан: «16» апреля 2010 г.

* ООО "Луябетон" гарантирует, что прочность бетона (при хранении контрольных образцов в нормальных условиях по ГОСТ 10180-90) достигает требуемого значения, соответствующего проектному классу бетона по прочности на сжатие, в возрасте 28 суток со дня изготовления.

Начальник производства «Коломяги» (должность) (подпись) Латышев А.Т. (ФИО)

Зам.начальника лаборатории ООО «Луябетон» (должность) (подпись) Аникиенко В.Н. (ФИО)

ООО «Луябетон»
Лапинский проезд, д. 3, лит. Х
195253, Санкт-Петербург
РОССИЯ

Figure 21. Document, proving the quality of delivered concrete mix

Figure 21 shows a document proving the quality of concrete mix. The name of the company's distributor - Luja Betoni - is in the upper left corner. The most important points in this document are:

1. Customer: «NCC Construction» JSC
2. Type of concrete: B25 P4 W6 F100
3. The required concrete strength: 29,5 MPa

This document is delivered to the customer - NCC Construction JSC - then it is stored in the quality control journal and kept there during the whole construction period. When the document is delivered, manufacturing of trial samples, which are then sent to a laboratory for concrete strength testing, is executed. Figure 22 shows the process of manufacturing concrete blocks for testing.

Figure 22. Manufacturing of concrete blocks for the strength tests

Forms, in which concrete is poured, are shown in Figure 22. When the cubes gain the strength (in 28 days) they are sent to a laboratory where they are tested for compressive strength. It should not be less than 29,5 MPa, as indicated in the document of concrete mixture quality. That is how the main contractor performs control for the quality of supplied products. There is one more procedure that is performed after the concreting of the structures. In 2 days, when the formwork is removed, the strength of concrete is determined by means of an electronic sclerometer (the procedure is the same as for piles).

Figure 23 shows the process of the casted concrete strength measuring.

Figure 23. Casted concrete strength measuring

Casted concrete strength measurements were carried out 2 days after concreting to have the possibility to make conclusions about the dynamics of a concrete strength growing. The reading at the time of determining the strength was 17,5 MPa, which is a very good result and says that the concrete after 28 days will have required strength 29,5 MPa.

Thus, the quality of concrete is monitored by the main contractor's engineers in two ways: by the documents and verification of the completed products physical properties. These procedures prove that quality control is implemented and all its requirements are very seriously fulfilled.

The question of the quality control of delivered products and materials is one of the most important, because working with poor material cannot be performed properly. Therefore, most of the errors can be prevented at this stage with careful attention to the delivered materials.

7.2 Concrete works

This section presents the second aspect of quality control – the control of the quality of the performed works. As an example, I will consider one of the main types of construction work - concrete works, which include formwork installation, reinforcement and concreting. The production of this type of work should be especially quality demanding as the basic characteristics of the building (stability, durability, beauty, functionality, etc.) will depend on how accurately this work has been performed. As it was told earlier, one of the main purposes of quality control is the verification that the structure meets the requirements of not only state standards but also comply with safety and reliability, as the house is built for people whose lives are of the highest importance.

It is widely known that reinforced concrete is a building material, in which the steel reinforcement and concrete are combined in a monolithic unit. Concrete partially protects the metal reinforcement from corrosion and perceives the compressive stress while steel perceives tensile forces. That is why it is very important to observe the width of concrete protective layer in order to be sure that reinforcement will not be damaged later. You should also monitor the compliance with the required cage characteristics - spacing, diameter, overlap - to provide needed structural strength and project requirements. Figure 24 shows an example of monitoring of compliance with requirements for the thickness of a concrete protective layer for the pile cap.

Figure 24. Control of the thickness of the concrete protective layer

Figure 24 shows measuring of the thickness of a concrete protective layer. This fragment, showing the reinforcement cage of the pile cap, indicates that the thickness of a concrete protective layer (the distance from the surface casing to the surface of the reinforcing rebar) is about 80 mm. For the main longitudinal reinforcement the thickness of the protective layer according to SNIP 2.03.01-84 must be not less than 35 mm for cast-in-place foundations. Thus, this requirement is met with a wide margin.

Now I will turn to the performing of the reinforcement cage quality control. Figure 25 shows an example of the controlling measurements of the rebar spacing in the cage.

Figure 25. Controlling measurements of rebar spacing in a cage

Figure 25 presents the controlling measurement of rebar spacing in the reinforcement cage. According to the project, the step should be 200 mm. As can be seen in the photo, the step between the nearest axes is 200 mm, which is fully consistent with the project requirements; therefore, we can conclude that if the parameters of spacing and the diameter are kept, the strength of the whole structure will likely be provided.

Also, after formwork is removed, the protective layer is fixed. Figure 26 shows this procedure.

Figure 26. Concrete protective layer aftert he removial of the formwork

Figure 26 shows the structure of the pile cap after concreting. It should be noted that the protective layer of concrete preserved its size and is not less than 60 mm, which meets the requirements of SNIP 2.03.01-84.

The following problems, associated with the implementation of proper quality control (for performed works and supplied materials), may occur:

1. Not enough qualified engineers who provide quality control
2. Quality control is carried out with violations of the requirements of building codes and regulations
3. The works are carried out with violations of safety requirements, which limits quality control or makes it impossible to be done
4. Shortage of measuring equipment and instruments

5. Absence of a system of violations fixing and their recording in the quality control journal

To improve the quality control for supplied materials and performed works the following measures can be assumed:

1. Engineers responsible for the acceptance and quality control of delivered materials as well as for quality control of the performed works engineers should be positioned before the beginning of the works
2. Establish a document which will list all the defects and flaws in quality control
3. Check the presence of measuring tools on a construction site: roulettes, theodolites, levels, sclerometer, etc.
4. Organize training seminars on modern materials and technologies
5. Increase the motivation of responsiblity within quality control people
6. Establish a special check-list, which reveals that supplied material has passed quality checks and is suitable to use and is signed by three parties: the main contractor, subcontractor and supplier

Summarizing two sections - quality control of supplied materials and performed works – it can be said that these issues play a key role in the forming of qualitative construction, which in a modern market environment has a lot of advantages, since consumers want to be sure that their house and apartments are built in strict compliance with all building rules and regulations and meet the requirements for strength, reliability, stability, functionality and safety.

SUMMARY

Questions concerning safe work performance and quality control on site are among the most important in the construction of any structure. All these issues should be well planned, organized and realized and only in this case the construction can provide the proper complying with specified requirements for safety, quality, durability, functionality and other parameters.

This paragraph contains general conclusions to the main sections concerning WS and QC and the definition of opportunities of using this work in the future.

To achieve the goals of this work it was necessary to realize the following steps:

1. Study state building norms and regulations
2. Get practical knowledge and experience
3. Analyse and compare of the theoretical and practical material
4. Define problems which interfere with proper realization of work safety and quality control requirements
5. Define measures to improve the level of work safety and quality control on site

The realization of these steps allows to investigate exactly those issues, which are included in contents and clearly determine measures, which help to increase the level of work safety and quality control.

To summarize the main conclusions of work safety paragraphs it can be concluded that to achieve the correct safe work performance it is necessary to:

1. Organize a safety instruction sessions with new employees before they perform work
2. Define dangerous zones and fence them
3. Areas for smoking, fire boards, storages for materials, space for garbage collection should be planned and located.
4. The roads on site must be in good condition.
5. Building site should be fenced and the admission entrance system should act

6. Individual protective equipment should be used and controlled
7. All failures should be recorded in a special journal and then discussed on staff meetings with employees.
8. Functionality of machinery and equipment should be checked before they will perform work
9. Pass to workplace should be accessible and organized in proper way
10. Electrification should be planned taking into account the weather conditions
11. Compliance with the requirements of work safety should be controlled

Summarizing the main conclusions of quality control paragraphs, it can be stated that to achieve proper quality control it is necessary to:

1. Divide the responsibilities of the quality control of supplied materials and quality control of performed works
2. Organize quality control at the stage of tender as the contractor's liability reduces the risk of quality problems
3. Perform test measurements with instruments such as ruler, theodolite, leveling, sclerometer, etc.
4. Establish an archive of quality assurance
5. Organize a journal, in which the errors, revealed by the quality control, will be marked, to avoid them in future
6. Follow the requirements of SNIP, GOST, PPR, SP to avoid the majority of errors in the construction

This thesis can be used for the company NCC Construction as a visual aid to new employees who would like to know the requirements of work safety and quality control in detail and to know the measures to improve these two parameters. The received and analyzed experience will also help the company in other projects and in the next lines of construction: less mistakes, more profit. And finally this report will be useful as a study material for Russian companies with a low level of work safety and quality control or for new companies that do not have any experience in construction.

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Figure 1. Aerial view of the residential community “Swedish Krona”

Photo 1. Protective fire board near erected building

Photo 2. Protective fire board near main contractor's barrack

Photo 1. Insulation of switchboard near working area

Photo 2. Insulation of switchboard near working area

Photo 1. Using of helmets on construction site

Photo 2. Using of protective glasses and ear-protective headphones on pick hammer works

Photo 3. Using of respirators on saw works

APPENDIX 5
1(1)

Scheme 1. Plan of deformation marks location for settelment investigation of administration house “Udelniy park”

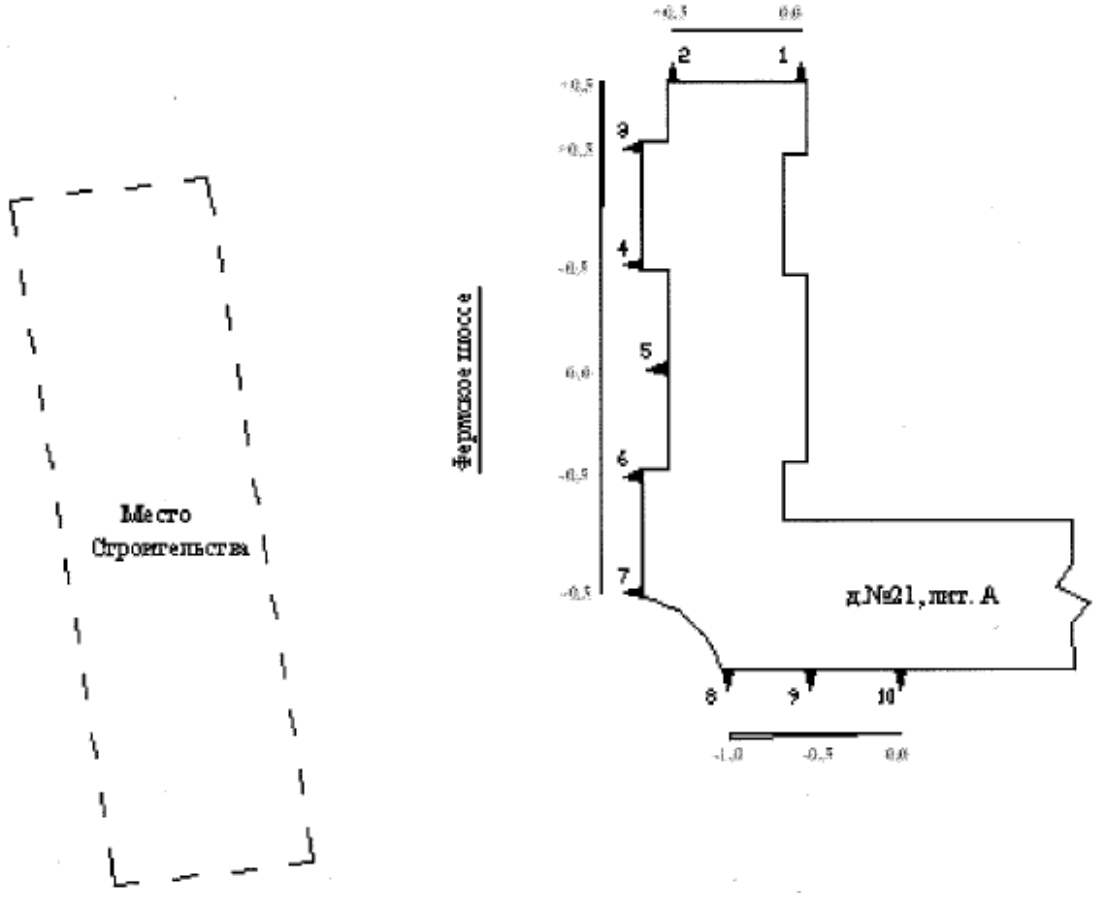

Photo 1. Worker without a helmet

Photo 2. No fencing and cover on the well

Photo 3. No fencing of pit

Photo 4. Wrong electrical connection

Photo 1. Correct fencing of well

Photo 1. Defects of supplied piles

Photo 2. Defects of supplied piles