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### Assessing construction risk factors and ensuring safety

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**Abstract.** Construction is one of the most dangerous industries, which in physical terms is associated with the highest load. Trauma and accident statistics are high. Due to the multidisciplinary nature of employees in the construction sector, considering the impact of harmful and dangerous factors and difficulties of operating construction and transport equipment, construction is one of the most dangerous areas. During the 2020-2021 pandemic, various problems arose in the construction sector. The problem of the construction industry, delays caused by pandemics, the main causes of safety breaches, hazard detection, risk management outcomes are discussed in the article and recommendations are given to improve them. Research methods: Analysis of the theoretical and practical experience of existing means of occupational safety, working on statistical data on traumas and accidents, develop methods for identifying hazards, and assessing risks based on specific examples. Based on theoretical studies and analysis of existing conditions, measures have been developed to improve occupational safety. The importance of the mechanism for predicting unforeseen delays in the construction sector, the cause-and-effect relationship between high statistics of injuries and accidents in conditions of excessive working hours. The complexity of the construction field is presented and analyzed with all clarity, taking into account the multitude of existing risk factors, the stages of risk assessment and management are schematically depicted, the criteria for determining the probability of events.

**Keywords:** risk management, dangerous factors, occupational risk, identify the threat, prevention.

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## 1. Introduction

Construction is one of the most hazardous industries, which, in physical terms, is related to the highest work-load; injury and accident statistics are high. Due to the multi-profile nature of employees in the construction sector, considering the impact of harmful and hazardous factors, and the difficulty of operating construction and transport equipment, construction is one of the most dangerous areas [1].

Workers can be exposed to a high risk of health problems during construction. For instance, dropping from heights, injuries, hand and arm vibration syndrom, cement burns etc. Various problems emerged in the construction sector during the 2020-2021 pandemic, as an accurate execution of a pre-planned daily schedule of works is a principal goal of any construction; this guarantees completion within the set timeframe. The reason for the disruption of the arranged plan-schedule is frequently related to the problems in the supply of building materials and products to the construction sites. This article discusses the issues of the construction industry, delays caused by the pandemic, the principal reasons for the breach of health and safety, hazard detection, the results of the study of risk management mechanisms, as well as the recommendation on the improvement of those mechanisms [2].

**The purpose of the study is** the result analysis of the research of protection methods and mechanisms against sharp fluctuations, instability, harmful and hazardous factors characteristic of the construction industry; review of laws and regulations.

**The methods of the research are connected to** the analysis of the theoretical and practical experience of existing means of occupational safety, processing of the statistical data on traumas and accidents, identifying hazards based on particular instances, development of risk assessment methods.

**The development** of measures that are aimed at increasing occupational safety on construction sites, on the basis of theoretical research and a comprehensive analysis of existing conditions, is important; as well as the arguments supporting the importance of the mechanism predicting the “unforeseen” delays in construction sector and recommendations. The analysis of cause-and-effect relation of high statistics of trauma and accidents.

Construction is of one of the major areas of the economy in the world. According to the data of the International Labour Office, the statistics of accidents in the workplace are quite high, including the number of fatal cases on construction sites. The loss of working hours due to the traumas considerably exceeds the relevant figures in other sectors of the economy.

According to the UN data, construction sector creates approximately 18 million workplaces, and the gross domestic product constitutes about 8.6 per cent. In this respect, there has been a 0.3 per cent decrease compared to the figures of the recent years. This is related to 2019 regulations (permission of K1, K2, K3 ratio increase), as well as the various problems that arose in the construction sector during 2020-2021 pandemic [3].

Table 1. Construction-Statistical Information.

|   | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020<br>I | 2020<br>II | 2020<br>III | 2020<br>IV |
|---|------|------|------|------|------|------|-----------|------------|-------------|------------|
| <b>Turnover,<br/>billion. GEL</b>                       | 4.0  | 5.4  | 6.9  | 7.1  | 7.2  | 8.3  | 1.5       | 1.4        | 2.3         | 2,5        |
| <b>Output,<br/>billion. GEL</b>                         | 4.2  | 5.7  | 7.4  | 7.6  | 7.8  | 8.9  | 1.6       | 1.5        | 2.4         | 2,7        |
| <b>Additional<br/>Value,<br/>billion, GEL</b>           | 1.5  | 2.3  | 2.8  | 3.1  | 3.2  | 3.6  | ...       | ...        | ...         | ...        |
| <b>Intermediate<br/>Consumption,<br/>billion, GEL</b>   | 2.7  | 3.4  | 4.6  | 4.5  | 4.6  | 5.3  | ...       | ...        | ...         | ...        |
| <b>Fixed Assets,<br/>billion, GEL</b>                   | 2.1  | 1.8  | 1.8  | 2.0  | 2.0  | 2.7  | ...       | ...        | ...         | ...        |
| <b>Number of<br/>Employees<br/>thousand,<br/>person</b> | 68.9 | 71.1 | 75.0 | 76.2 | 74.2 | 70.0 | 59.2      | 57.8       | 62.0        | 67,7       |

It is quite unfortunate that hundreds of employees in Georgia suffer injuries in the workplace every year, developing occupational and work-related diseases; fatal outcomes are also frequent. According to the statistical information, the number of the deceased or injured in the workplace is quite high; the majority of the casualties occur in the construction sector.

As a result of work-related accidents, 1167 people were injured in Georgia in 2011-2020, 400 cases resulted in death. Comparing the percentage data of the injured in the construction sector, it becomes obvious that this sector is characterized by high risk factors.

Due to the spread of COVID-19 in 2020, the provision of occupational safety in the workplace has become especially urgent. In 2019, 38 died and 135 were severely injured when performing work duties. In January-April 2021, 7 employees died and 70 were severely injured. This happened when most of the sectors of the economy have not been working for several months during the global pandemic [3].

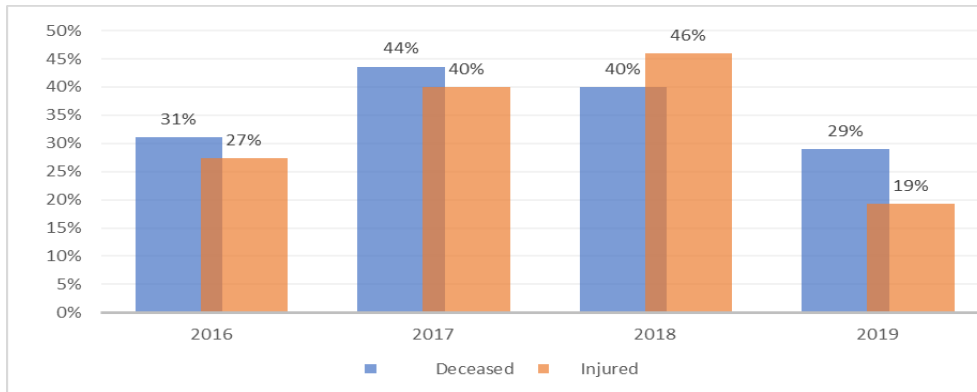
Table 2. Statistical information on the deceased and injured.

| Years       | Deceased                                | Injured                                 |
|-------------|---|---|
| <b>2016</b> | 58/18 of which on the construction site | 84/23 of which on the construction site |
| <b>2017</b> | 39/17 of which on the construction site | 55/22 of which on the construction site |

| Years                | Deceased                                   | Injured                                     |
|----------------------|--|---|
| 2018                 | 40/16 of which on the construction site    | 37/17 of which on the construction site     |
| 2019                 | 38/11 of which on the construction site    | 135/26 of which on the construction site    |
| 2020 (January-April) | 7 (number of employees in various sectors) | 70 (number of employees in various sectors) |

In spite of many positive reforms implemented in the occupational safety field, some issues still remain; thus, the statistics of the injured or deceased in the workplace are high. The number of the deceased in the workplace in Georgia 3.1 times exceeds the average figures in the UN. It should also be noted that occupational diseases, and many other cases that are not exposed as a result of the employer’s endeavors’, and are therefore unknown for the higher authorities, and are not included in the statistics.

Table 3. Statistical information on the deceased and injured on the construction sites (in %).



## 2. Determining the magnitude of the risk

Problems caused by unreported employment are characteristic of the construction sector, when the industrial relations evade the legal framework, and thus escape the responsibility of executing the rules [4]. The unreported employment implies employment in the unreported sector as well as any industrial relations approved by International Labor Office (ILO) standards, which is not determined by the national labor legislation, the income tax is evaded, there is neither a social security system, nor the rights for employee benefits, etc. [5].

The unreported employment is implemented through the evasion of legal standards, hence excluding the guarantee of providing elementary conditions of the legal norms of industrial relations. It also leads to the budget loss, which eventually affects the country’s economy.

Different problems emerged in the construction sector during the 2020-2021 pandemic. In spite of the high professional level of the arranged plan-schedule, the majority of disruptions were caused by the delays in the supply of construction materials and products to the facilities. The complexity of technological processes and other hindrances also protract the construction. Traditionally, contractors always manage to eliminate such delays efficiently and in time. But in the period of 2020-2021 pandemic, the entire construction sector faced completely new reality. It has become essential to adopt new, very restricted terms, and conduct work under radically different conditions [6].

Table 4. Difficulties in the construction business during the pandemic.

|  |     |
|--|-----|
| Demand reduction                           | 65% |
| Delays in the supply chain                 | 33% |
| Running employees on an unplanned vacation | 12% |
| Employees fired for quarantine or illness  | 15% |
| Closing borders                            | 28% |
| Difficulties in health and safety          | 4%  |
| Late payments from customers               | 26% |
| Exchange rate changes                      | 40% |

In order to reveal the problems that arose in the construction sector during the pandemic, it is necessary to review the ongoing construction processes consistently. The declaration of the pandemic by World Health Organization was followed by the necessity to implement publicly recommended and obligatory measures (the sanitation of closed spaces, the monitoring of body temperature, the use of masks, relevant personal distance etc.). Construction companies managed to do it successfully, in spite of the difficulties.

The first serious issues appeared in the construction field mid-March 2020, when all the stores and markets specializing in construction materials were closed. Minor objects which had a fewer number of employees, and were supplied with necessary materials on a daily basis, were especially affected. The ban on the inter-city transport appeared to be the second and much more serious problem for every construction site. The majority of the employees living outside a city could not reach their workplaces. This restriction had a serious impact on the construction works in Tbilisi. Some people working in the capital reside in other towns or villages. For instance, more than 200 workers employed in the building of the new business centre of TBC Bank commuted from different regions. Their few days

absence caused major delays. There was a similar situation in other cities (Kutaisi, Batumi, Rustavi etc.) [3].

In the third stage, when all kinds of municipal traffic in Tbilisi and other cities were restricted, and the curfew was imposed, construction companies were able to continue some works despite the restrictions of conveying only three people in one vehicle. The complete ban on the transport made it impossible to continue construction works, and brought them to a halt. The situation posed a great danger, as the majority of the installation work was unfinished, the construction had not gained enough solidity (pillars, walls, bridges, trestles etc.), and natural disaster (earthquake, storm, and others) could cause destruction. It was literally by chance, that many construction objects dodged serious damage. Luckily, this disadvantageous delay was soon over, and the companies managed to mobilize necessary workforce, and continued work, strictly following the recommendations of National Centre for Disease Control and Public Health.

It should also be noted that, despite the small number of restrictions in the construction sector during the pandemic, but in light of many unexpected problems, considerable delays were depicted, the eradication of which will require great amount of time and effort.

Some objects, the building of which was sponsored by foreign partners, faced other problems caused by the pandemic that led to the delays in work schedule. Particularly, the ban of all types of international transport hindered the arrival of foreign specialists in order to complete special installation works.

Problems of communication with foreign partners occurred on different construction objects. A similar problem exists on the construction site of Kutaisi International University, where the reception of the first intake of students is announced this year, and the academic year at the university is to begin.

Table 5. What measures has the company taken in response to the difficulties encountered.

|                                     |     |
|-------------------------------------|-----|
| Reduction of production volume      | 65% |
| Suspension of business activities   | 33% |
| Reducing the number of employees    | 12% |
| Running employees on unpaid leave   | 15% |
| Change in business activities       | 28% |
| Use of available building materials | 4%  |

### 3. Results and discussion

In light of the experience gained from the problems that arose in the construction during the pandemic, it became clear that the assessment of risk factors in every area, and the implementation of the necessary measures, are essential.

Occupational hazards are to be revealed and assessed in every workplace, including public and private sectors, notwithstanding the size and area. The methods of discovery and assessment of hazards can be chosen based on the peculiarity of the workplace; all types of work and risk factors are to be considered [7].

Due to its danger, risk is the yardstick for potential damage. The aim of determining one is to identify the types and to arrange the danger factors according to their gravity. When identifying risk magnitude, in terms of safety, the highest risk factors can be distinguished, and the most problematic issues addressed.

Table 6. Criteria of identifying potential cases.

| Signs of case probability |  |
|---------------------------|--|
| 1.Improbable              | The case which occurs rarely and randomly. For instance, the surface of the pavement becomes slippery with frost in winter.                |
| 2.Probable                | The case which occurs occasionally, randomly. For instance, it is necessary to raise the load manually during the crane maintenance check. |
| 3. Highly probable        | The case which occurs frequently and regularly. For instance, a regular motion of the lift mechanism leads to the danger of collision.     |

It is impossible to achieve the absolute precision when determining the result significance and case probability. Hence, when determining the level of risk, the difference between various levels of risk and their outcome is more important than their absolute precision. In agreement with occupational safety regulations, the employer is obliged to provide every workplace with an account of hazardous factors, fully documented on a risk assessment form.

An account of hazardous factors must be updated and modified according to the change in working conditions, its results must reflect their actual state [8].

Table 7. British standard for determining the magnitude of risks (BS 8800).

| probability | results       |               |           |                  |                 |                   |
|-------------|---------------|---------------|-----------|------------------|-----------------|-------------------|
|             | Insignificant |               | Important |                  | Quite important |                   |
| Low         | 1             | Slight risk   | 2         | Low risk         | 3               | Moderate risk     |
| Medium      | 2             | Low risk      | 3         | Moderate risk    | 4               | Significant risk  |
| High        | 3             | Moderate risk | 4         | Significant risk | 5               | Inadmissible risk |

By means of systematic and continuous control, it is possible to provide occupational safety in a company, and to discover the threats and flaws which were not disclosed before.

When determining the risk magnitude, in terms of safety, the highest risks can be distinguished. This will allow us to focus on the most problematic matters more effectively [9].

Table 8. Risk reduction measures.

| The magnitude of the risk | Necessary measures to reduce risks  |
|---------------------------|---|
| Slight risk               | The risk is so insignificant that it does not require measures  |
| Low risk                  | No measures are necessary, but the situation must be taken into account in order for the risk to be manageable.   |
| Moderate risk             | Risk reduction measures are necessary, however their implementation can be planned and implemented according to schedule. If risk can lead to serious consequences it is necessary to examine the probability of events more accurately.      |
| Significant risk          | Measures to reduce the magnitude of the risk are necessary and their implementation should be started immediately. Under risk conditions, the work process must be stopped immediately and cannot be resumed until the risk has been reduced. |
| Inadmissible risk         | It is mandatory to start risk elimination measures immediately. Under risk conditions, the work process must be terminated immediately and cannot be renewed until the risk has been eliminated.  |

Risk magnitude depends on the probability of hazardous actions, and their outcome. The outcome conveys the severity of the damage to health, which is caused by some actions leading to it. A dangerous situation can cause various outcome. Risk assessment documentation must include risk magnitude, based on probable outcome. If necessary, the total magnitude can be determined by several different outcomes. The severity of the outcome is influenced by the following factors:

- The nature of incurred damage (insignificant/significant);
- Area of damage (the number of casualties);
- Repetition frequency/infrequency of hazardous influence;



➤ **Duration of hazardous impact (short/long).**

Identifying the danger is the initial and the uppermost stage of risk assessment. It considers the flaws in occupational safety, which can be harmful for our health and security [10].

Identifying of the hazard implies the determination of threats harmful for the health of employees, and the recording of the data, resulting from the nature of occupation, the working areas and conditions. It is important to take into account the dangers revealed earlier, as well as the hazard factors which can be harmful for employees, due to their individual character and other work factors.

Hazard factors are easy to recognize. To do that, it is necessary to interview the workers during the workplace rounds, monitor the working process, and study every operation and activity thoroughly. A system of hazard detection must be included in the questionnaire. The form is comprised of a range of hazards, formed into groups according to their nature. The form allows us to inspect whether these hazards exist in the workplace. When registering hazard factors, it is essential to record all specifications, comments and questions concerning the matter.

In order to study the hazards, analysis methods and hazard identification can be applied, apart from questionnaires. Sketches, photographs, and videos will also help to reveal hazards in the working process. They are part of the job, and some of the methods of recognition and recording of hazards.

It is important to define the reasons and outcomes of a hazardous situation when it is detected. A thorough search for the reasons, which can potentially cause hazardous situations, will help us develop effective preventive measures. It is also essential to determine the sequence of actions which lead us to dangerous situations.

The reasons for hazardous situations and events must be explored in various fields, considering the labor organization, its methods, working conditions. The hazardous work methods employed by workers must also be considered.

In order to decrease the risk, it is essential that we use selection criteria of measure efficacy. The efficacy of measures can be assessed by the following criteria:

- **The increase of safety level:** the more efficient the decrease of the highest risk level is, the more efficient the measure;
- **Area of impact:** the more risk-factors it includes, or the safety of more people is concerned, the more effective the measure;
- **Implementation of the requirements:** if the relevant legislative or normative requirements are accomplished by means of the measures, then they should be implemented;
- **Increase of work flexibility:** if the flexibility/ dynamics of work is increased as a result of the measure, but its impact on the work safety is minimal, then it must be implemented;
- **Expenditure effectiveness:** the best measures do not have to be expensive. Often times, we can achieve great results by slight improvement, at a low cost.

#### 4. Conclusions

As it has been noted, it is essential to accomplish the work in set timeframe. The global pandemic revealed a range of risk-factors which require due assessment and implementation of safety measures.

Consequently, when assessing risks, the possibility of a sudden announcement of pandemic must be taken into consideration; the possible risks must be depicted in legal documents (e.g. potential prolongation of construction period), as well as technical and organizational measures (strengthening of unfinished and insufficiently solid construction, supply of building materials, transportation of workforce).

More detailed definitions and obligations concerning risk assessment, besides labor protection law, are provided in the government decrees under a technical resolution.

Table 9. Recommendations based on the analysis of the problems.

|   |  |
|---|--|
| 1 | Consider all hazards before starting construction!                                 |
| 2 | Strengthen the construction during the sudden stop of the object!                  |
| 3 | Solve transportation problems!   |
| 4 | Providing the facility with the necessary construction materials                   |
| 5 | Registration of occupational diseases  |
| 6 | Strengthen the Labor Inspection Department in terms of safety and labor rights !!! |
| 7 | Accelerate the ratification of international conventions !!!                       |

Safety technique and occupational safety regulations constantly undergo processing, are implemented in construction business and constantly change according to the technical progress requirements and new regulations of occupational safety. This should be considered in practical work.

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