

**THE MINISTRY OF EDUCATION**  
**Bucharest POLYTECHNIC University**  
Doctoral School for  
Industrial Engineering and Robotics

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# **DOCTORAL THESIS**

## **IDENTIFICATION AND MONITORING OF SPECIFIC RISKS IN CONSTRUCTION SITES WITH ATYPICAL VOLUMES FOR BUILDINGS WITH VENTILATED FACADES**

Doctoral advisor,

Professor Oana-Roxana CHIVU PhD Engineer

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# **SUMMARY DOCTORAL THESIS**

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**Author: Cristina I. MEIȚĂ (GOGELSCU)**

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## ABSTRACT

The occupational health and safety stands for one of the most important field of the social policy in the European Union. According to the European Union statistics, every three and a half minutes a person dies in EU because of labour accidents; this thing leads to over 170,000 deaths every year, caused by either labour accidents (9,100) or occupational diseases (158,000). It is not only due to these reasons that it is worth studying the occupational health and safety as an independent subject which should begin on getting to know general issues based on the risks of accidents and occupational diseases which may occur during labour activities and should also be based on establishing the main measures to remove or mitigate these types of accidents.

Within the doctoral thesis based on the data taken from the analysis of the present stage I managed to identify the relevant collective protective measures related to the workload, in such a way that construction sites would become safe for the workers exposed to the risk of falling from height (employers, employees, supervisors, people performing an independent activity, personnel having as tasks to inspect the workwear equipment and the working activity).

The focus of the theoretical-experimental research was set on identifying the factors that influence the conclusion of a construction project without any incident and also the creation of a safety working model for the construction activity of buildings with ventilated facades based on the hierarchy of controls. In the past 10 years one could witness the development of the concept of „buildings with ventilated and atypical facades” in which the metal and the concrete join together.

The results of the research and the main contributions shall help managers to prioritize the risks on taking into account the probability of occurring an accident and the injury characteristics and to focus more on balancing the considerable risk situations to prevent accidents in order to achieve safer working environments.

## ***Foreword***

With over 15 years experience in the field of occupational health and safety and a persistent concern to carry on this field to a higher level within the construction companies, therefore I established and developed “Construct A1” and “Construct A2”, only two of the business where I coordinate the occupational health and safety activity, I made the decision to render my experience in the pages of the thesis that I am presenting to you today.

The thesis encompasses all the theory and practice that I gathered throughout the time, as well as my moral and ethical duty to find and suggest as many solutions as possible regarding the workwear equipment, the workload and the environment, as well as related to contractors, and all these are made in order to prevent any labour accident on the construction sites. .

I would like to express my gratitude and highest respect to Professor Solomon GHEORGHE PhD Engineer and to Professor Oana Roxana CHIVU PhD Engineer, the doctoral advisors of this very doctoral thesis, for the trust and advice they offered throughout all 4 years of PhD studies.

I would like to express my gratitude to the professors at Bucharest POLYTECHNIC University, with whom I passed all doctoral studies exams and who offered valuable information that I used and I will continue to use in the activity I perform.

I sincerely express my gratitude to my family, my mother and father, Ioana and Ioan GOGELSCU. Thank you for your encouragement and unconditional support.

I also express my sincere gratitude to all practitioners whom I encountered during my working career which offered the opportunity to adopt useful practices and lessons. I impart this very doctoral thesis to my colleagues in the occupational health and safety field, be them practitioners or theorists, and especially to my daughter, Cristiana, who decided to follow my footsteps. .

As DuPont would say “You only reach that level of occupational safety that you prove you intend to”.

***Cristina I. MEIȚĂ (GOGELSCU)***

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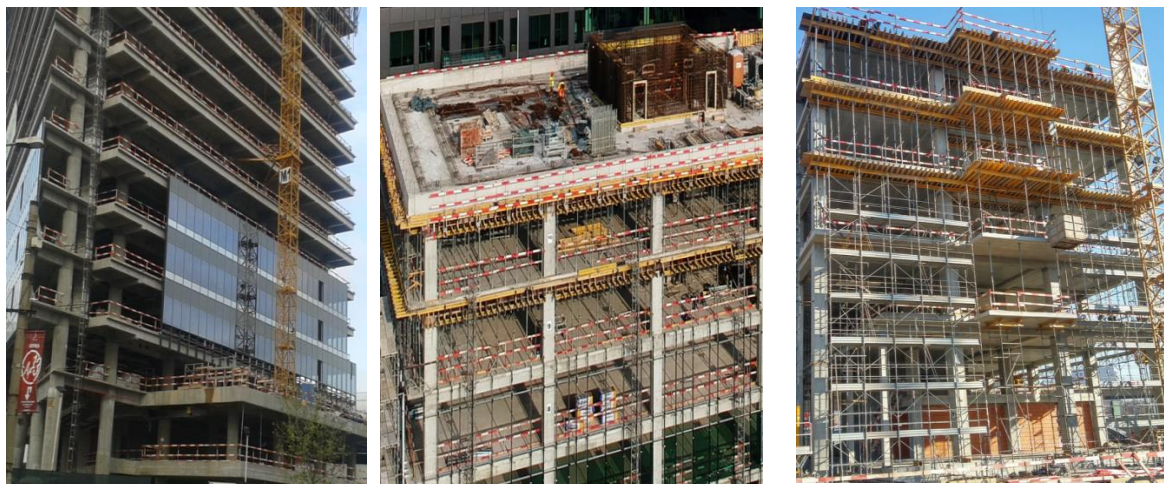
## **Chapter 1. Health and safety specific requests, related to the way of setting collective protection means and workwear equipment**

### **1.1. Introduction in the typology of workwear equipment and the collective protective means used in construction works and which are specific to stable or mobile working stations, located at height**

The constructions industry became developed in the last decades and resulted in improving the company profit, the financial accessibility and increasing in merchandise demand. The construction designs are described as dynamic and highly elaborated. They are also described as temporary and transitory [11,12]. For instance, usually the labour force in construction companies is hired on a temporary basis. Due to the fact that construction teams focus their working time where construction sites are located, these teams are exposed to a high probability of facing accidents or deaths [13].

Occupational accidents in the constructions industry are frequent and can lead to permanent disabilities and to a high rate of deaths [14].

As one can notice in picture 1.3. on construction sites there can be distinguished three main collective protections groups [2]:



Picture1.3. Temporary protection systems on the edge of buildings

## 1.2. Issues in getting safe working conditions for construction works related to height work

The lack of efficient coordination for various workers and the simultaneous activities that take place while performing a construction work is illustrated in picture 1.9.



**Picture 1.9. Lack of coordination, overlapped works, workers lacking the minimum individual workwear equipment**

## 1.3. The framework for regulations and normative deeds related to the safety of height works

### 1.3.1. Regulations issued by the European Community

Based on the Treaty of Rome, there are two sets of Directives and the comparison between them can be seen in table 1.1.

Table 1.1. Comparison between the two sets of Directives: economic and social

Article 100A (renumbered 95): “economic» directives	Article 118A (renumbered 137): “social” directives
Design	Working places
High level of protection for the European consumer	Minimal prescriptions
The entire Directive, nothing else but the Directive	The possibility for a state to ask for augmented guarantees
The entire Directive, nothing else but the Directive	The possibility for a state to ask for augmented guarantees

### *1.3.3. National and international standards*

EU Directives establish the minimum health and safety standards at the working place. These are implemented through the national legislation of the member states [16]. The member states can adopt stricter norms to protect workers, but their legislation has to respect the minimum standards. Therefore, the national legislation on health and safety present differences at European level [16]. In this way one example may be represented by *The standardized bracings or modular bracings*. These terms describe the bracings that are according to standards EN 12810 and EN 12811.

### *1.3.4. Health and safety plan*

The health and safety plan is elaborated according to the Specific Directive 92/57/EEC correlated with the national legislation through the Government Decision 300/2006 related to temporary and mobile construction sites. In general it relates to collective protections both in the Health and Security Plan, as well as in the Internal Health and Security Plans elaborated by the Contractor/Subcontractors.

### *1.3.5. Occupational health and safety internal instructions*

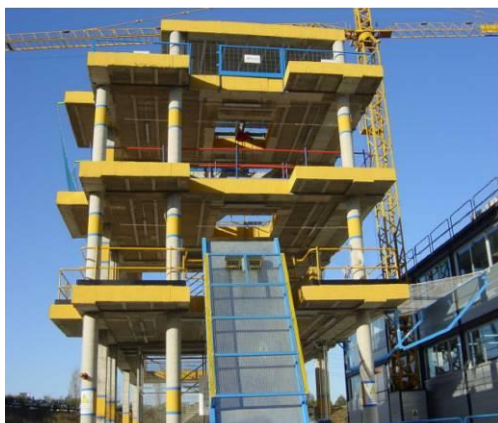
According to the legal requirements, the employer has to take measures in such as way as the workers to receive all necessary information on the risks related to Occupational health and safety, the prevention and protection measures and activities both on the enterprise level, and on the level of each working station and/or each job position. Likewise, the employer has to ensure the necessary conditions for the worker to benefit of an adequate and comprehensive training in the Occupational health and safety field, especially as specific instructions and information for the work position/working station.

## **Chapter 2. Characteristics for assessing the conformity of collective protections at the design stage**

### **2.1. Tests for assessing the conformity of collective protections at the design stage**

The matters regarding the safety of construction works have to be rightfully studied since the design stage. The workwear equipment and the collective protection means for performing height works have to fulfil the specific technical disposals in order to guarantee that all health and safety requirements are met.

The workwear equipment and the protection means have to be delivered to construction works together with the instructions manual from the manufacturer, comprising both the usage and the fitting ways. In pictures 2.1. and 2.2. one can notice a laboratory (a testing centre in Spain) with safety elements both outdoor and indoor where there are performed test on collective protection means.



Picture 2.1. Outdoor scaffolding of the Safety Elements Laboratory for dynamic tests of impact in real size.



Picture 2.2. Indoor area of the Safety Elements Laboratory for static resistance tests and accelerated ageing tests.

## 2.2. Contributions to improving working conditions at the design stage for a construction site in Bucharest.

### 2.2.1. Improved solutions for height work enforced since the design stage

In order to create the maximum level of safety on and around the notion of atypical building, there also have to be elaborated a safety project, that is appealing, lasting, and with high fiability, project that is elaborated after having performed an analysis of the height work on mapping the threats within the design.

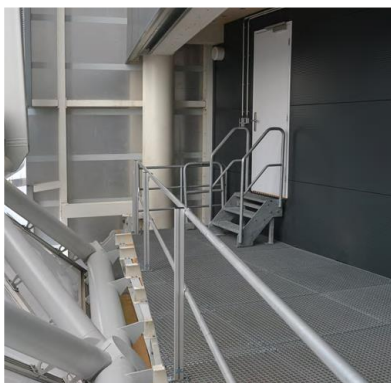
On including from the very beginning the protection solutions in the design process it will allow the cost control, the easiness of using it and the adequate aesthetic appearance.

### 2.2.2. Collective protection systems – working in safe conditions on buildings roofs.

In picture 2.8. one can notice the design of a banisters system, which is a simple, efficient solution that guarantees a maximum safety for an unlimited number of persons. The horizontal “railway” system provides the users a maximum safety, without affecting the building appearance. In picture 2.9 one can notice that the users can strap to the railway with a special rolling device for safety work on the trajectory of the railway [52].

The lifelines system provide a highly safe solution with no impact on the faced appearance, as one can notice in picture 2.10. Once attaching the lifeline, the users can work under safety conditions at height, under any circumstance.

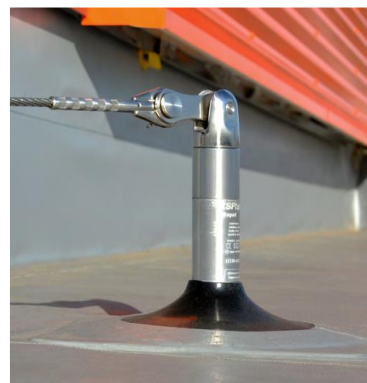




Picture 2.8. Banisters



Picture 2.9. Horizontal  
“railway” system



Picture 2.10. Horizontal  
“lifeline” system

### 2.2.3. Solutions for facades access.

When people work on facades, the maintenance systems for facades have to ensure a safe environment for workers. They have to take into consideration the solutions adjusted to the structure of the facades, no matter whether they are straight, bent, or round.

## **Chapter 3. Conclusions on the current stage of health and safety specific requests, related to the technics and the way of setting collective protection means and workwear equipment used for construction works**

On analysing the present stage of the research-development for health and safety specific requests related to the technics and the way of installing collective protection means and workwear equipment used for construction works, there can be emerged important conclusion, as follows:

The Management of Occupational Health and Safety urges for personal protection against falling from various heights for workers, depending on the workload.

The protection and safety on the construction site are important not only for people who develop the activity there, but also for visitors or people who pass by that area. Threats are present everywhere and, no matter how many measures are taken, there is always the risk of the unforeseen, but... the unforeseen becomes smaller once the rules are respected. The most serious accidents on construction sites are caused by fallings from height – according to the international statistics, these represent over 40% of the occupational accidents, the most affected trades being that of fitters and those who lay roofs and facades, who register one quarter of the deaths caused by fallings from height!

The workers have to know at every moment what they have to do, to get clear instructions adjusted for every single work. An important part is played by those who ensure the bracing and the construction management, the suppliers of material and specific equipments, which is compulsory to be professionals. Any improvisation or missing item can lead to tragedies. Most of the falls occur by unbalancing at the edge of the construction, through uncovered openings or pits, because of degraded or frail materials. Likewise, many accidents occur

because of materials that fall or are thrown from height, therefore the activity at height may affect not only the constructors, but also those on the land who work on, inspect, visit or ensure the maintenance the construction site.

The prevention measures are comprised in legislation, but often these are described as principles and on a general basis, while within the construction site there appear a lot of unique situations that may jeopardise the life. Each construction has its unique characteristics related to the nature of the surface, adhesion, slope, degradation stage, obstacles, and stability. The environmental conditions also play an important part: the wind (which sometimes is unpredictable, especially for constructions with sophisticated architecture, and is more intense at huge heights), the freezing cause by the general temperature or even by an “insurgent” draught which may cause locally a very slippery surface. In case the worker lacks the necessary protection means, the work will not be performed! In case there are certain deficiencies, these are being repaired and it is only afterwards that the work starts. It does not matter if the repairing last for one hour or one week, the necessary measures are the same; a lot of accidents occurred because ”all they had to do was to fasten a screw at the bracing”.

There shall be used working platforms with elevation, that would allow workers to act without effectively climb on top. When the activity cannot be performed without climbing on that susceptible construction element, there shall be installed an edge protection system and banisters all around and there shall be used a scaffolding to take over the loads. Depending on the construction site situation, there shall be used protection nets underneath or there shall be used a system of protection harnesses. The protection harnesses have to be caught in solid, rigid anchorage support, and their right usage is possible only in case the users are adequately trained and supervised.

The passing culverts must be sized in such a way as to have all necessary support (making sure it does not lean on frail materials) and to allow workers to move and to use the necessary equipment and materials under safety conditions. It is true that the culverts need at least two horizontal summer beam for support, but it is preferable to be done more than just that.

Workers are forbidden to walk by o horizontal summer beams or along the corner ridges of buildings, or to jump from one deal board to the other. It is recommended that the passing culverts to be placed at the very location throughout the entire duration of the work and not to be moved from one place to the other in order to avoid their frequent manipulation. These culverts need edge protection systems (superior banister, intermediate banister and guard rail).

The height work is one of the biggest causes of accidents and deaths at the working place. On construction sites and in warehouses, the risk of falling means that there is the possibility of serious body injury. Although it is not a pleasant thought, it is important for workers and managers to adopt a proactive approach for the adequate usage of the safety equipment.

The safety belts and harnesses must be worn while performing any activity where there is a risk of falling. It goes without saying that any working place should have in place a complete and updated risk assessment. Before performing a task that requires height work, it is important to thoroughly assess all risks.

The harnesses must be thoroughly inspected in case they were worn during falling, they were worn on a regular basis for a period of time or have not been worn for a long time. Before

each usage, you should inspect the harness in order to detect any sign of wear and tear. There shall be verified the buckles or the shims and you have to make sure that the equipment is in perfect condition, look for wear and tear signs in the straps and for any deformation in the strong parts of the harness.

It is important to make sure that the anchorage support is safe and stable. It is no good having a good quality harness unless it is attached to an adequate anchorage support. In case we need a certain degree of mobility, when we climb or pass between floors, for instance, it is possible for an anchorage support not to be enough. If we use a flexible anchorage support, there may be necessary to take into consideration using a retractable lifeline.

Every time it is possible, there shall be taken the necessary measures for all frail materials located at a distance of up to 2 metres from workers who are in a risk situation to be covered and secured, potentially with physical barriers, nets, cage-like protectors and there shall be posted warning signs. Under certain circumstances, it may be not possible to ensure these protection devices, especially if the proximity to the frail material is at intervals and for short periods of time. In these cases it is recommended to use protection harnesses which may be used with potential permanent anchorage systems.

Objects and materials falling from height represent a frequent cause of accidents on construction sites which may, sometimes, have severe effects. A simple calculation on using the formula of free falling shows that an item dropped from 30 meters height reached the ground by the speed of 90 km/h, which can be fatal for a person once the impact area is on the head. It would be good for the implemented prevention measures to overpass the potential threat, because on construction sites there can occur a lot of unique situations, sometime difficult to foresee.

Where possible, the works with a potential dangerous character shall be performed at times when pedestrians do not pass by (for instance at night or during school breaks), but, of course, this situation is hard to be controlled. We also have to say that the measures need to be taken not only in case of constructions or demolitions, but also in case of renovations or major interventions, when there is an important risk for construction elements to collapse.

The falling prevention can be managed in various ways in order to protect workers developing height activities, there can be built banisters, barriers, bracings or mobile platforms.

Where it is not possible to use these devices, there shall be used the personal protection equipment against falling, such as: harnesses, connection elements and retractable lifelines.

Removing the falling is always better than stopping the fall. The systems for removing the falling prevent most of the secondary injuries caused by the falling and ease saving the person, because the worker can still be caught.

Developing and implementing comprehensive programs to protect against falling at the working place can prevent a lot of the injuries and deaths that take place on construction sites.

Once the threats of falling have been identified by a competent person, first of all there has to be taken into consideration to remove the threat of falling. This thing is usually known “removing the threat” and stands in redesigning the working environment, the working processed and procedures. If these solutions are not efficient because of multiple modifications and high costs, it is taken into consideration to prevent the fall.

On following the researches that were made, there emerged the following conclusions:

- there were mentioned the main aspects encountered in practice on construction sites regarding the collective protections;
- there was made a comparison between the European legislation, the national legislation and the one in another European country (Spain), on highlighting the elements for which there is NO correspondence and applicability in the Romanian legislation;
- there are described the fundamental principles of the so-called “new approach” related to European Standards, which represents an innovative technical harmonization method by sharing responsibilities between the European lawmaker and the European standardisation bodies;
- there are analysed the specific technical requests for collective protection means according to standards UNE EN 1263-1:2004 and UNE-EN 13374:2004;

By the content of this very thesis, my intention is to establish a way to guarantee the minimum level of resistance for “the systems for safety networks, the provisional systems for edge protection, bracings and working towers”, since it is necessary to perform the verification by the tests set up in the disposals of the normative deeds. In this way, there have been presented the tests that have to be performed to assess the conformity of the collective protections in the design stage, that is: dynamic tests of impact at size, static resistance tests and questionnaires regarding the occupational diseases.

To create maximum of security on and around the notion of building with atypical and ventilated facade, there were presented perfected solutions for height work applied since the design stage, that is: the banisters system, the horizontal “railway” system, the “lifeline” system.

There were identified adequate collective protections on taking into account the workload, in such as way as construction sites are a safe place for workers exposed to the risk of falling from height.

Assessing the risks of accidents and/or occupational diseases implies 5 stages:

- identifying activities depending on the elements of the working system;
- establishing the risks of accidents and occupational diseases at the identified working places;
- determining the level of prioritizing the actions;
- developing The Prevention table per work position;
- elaborating prevention measures, other than the ones already in place.

The first step to efficiently implement when assessing and hierachising the control stages against falling was to perform a study regarding the threats of falling in order to identify and prioritize the threats of falling and to recommend mitigation measures based on the regulation requirements and the protection standards against falling.

On following the performed study there can be considered that the controls hierarchy for risks on height working can be also described as:

- The design safety – removing / replacing / substituting / control engineering



- The workers' safety - administrative (organizational)/ personal protection equipment

It is presented a model of the controls hierarchy for height work, on performing the detailed analyses of each stage on highlighting the adequate solutions;

There are mentioned the initial compulsory solutions in designing stable and mobile scaffolds, as well as the right manner safely assemble/disassemble them on the construction site;

There were analysed the systems for restricting and hindering the falling and there were elaborated instructions on how to use, inspect and maintain these and there were exemplified two cases of errors that may appear when working on height, on using an incomplete protection system and the incorrect usage of the personal protection equipment, on highlighting the adequate measures that have to be taken.

The results of the researches presented in this chapter shall help the managers to prioritize the risks on taking into account the probability of occurring accidents and the injury characteristics and to focus more on balancing the significant risk relations to prevent accidents and to benefit of safer working environments.

## **Chapter 4. Research-development directions, main goal, and methodology to identify and monitor specific risks on the construction sites with atypical volumes for buildings with ventilated facades**

### **4.1. Research-development directions**

Based on those that emerge from the analysis of the present stage, the below research-development directions are considered as current for identifying and monitoring the specific risks on construction sites:

- continuous, lasting and homogenous mitigation of working accidents and occupational diseases, on taking into account that every year almost 4,000 employees lose their lives in working accidents, and over three million workers are victims of serious accidents at the working place;
- improving the implementation of the legislation in the occupational health and safety field, as well as clarifying the European Union regulations, on knowing that 24.2% of the employees considered that their health and safety are threatened because of the activity they perform, and 25% state that their professional activity has a negative effect on their health;
- the constructions represent a dangerous economic activity because, beyond the fact that it is characterised by a high risk level, the temporary and mobile construction sites represent high chains of different subcontractors and participants within the same emplacement, situation that leads to dispersing responsibilities;
- the lack of efficient instruments for reporting and monitoring the working accidents and the occupational diseases as well as the workers' medical supervision, it is a situation that leads to difficulties in collecting statistics data;
- identifying the risks is one of the main stages that has to be achieved in order to remove or mitigate the professional risks;

- adopting implicit protection measures, actions performed since the project and design stage of production means and labour process, that have as purpose to prevent risks of accidents and occupational diseases, through technical and ergonomical measures;
- choosing the best measures for implicit and collective prevention, removing risks and accomplishing the full protection;
- clarifying some aspects related to the way the “controls hierarchy” apply in selecting the protection equipments;
- conceiving a procedure for height work which establishes the employers’ tasks and responsibilities in such a way as to ensure a safe working environment under any circumstance.

#### 4.2. The main goal of the research-development activity

On taking into account the data and conclusions that emerge from the analysis of the current stage, as well as the research-development directions for identifying and monitoring specific risks on construction sites with atypical volumes for buildings with ventilated facades, the main objective of the doctoral activity is: to design an efficient hierarchy controls model for height work, as well as to design, elaborate and test the technology for assembling a scaffolding/bracing under maximum security conditions.

The Occupational health and safety is an integrated part of conceiving, organizing, and developing labour processes and has as role that, through specific measures and means, to prevent the potential disfunctionalities within the working system, in such a way as the working process to be developed under maximum efficiency conditions.

The main objective of the research activity in this very doctoral thesis is to identify measures to protect the life, integrity and health of workers against risks of accidents and occupational diseases that may occur at the working place within construction sites with atypical volumes for buildings with ventilated facades and to create working conditions meant to ensure the workers the physical, mental and social comfort.

In order to accomplish the general objective, the following **specific objectives** were advanced:

**1<sup>st</sup> Objective** – To establish the need of identifying the main requirements for working under safety conditions at height on construction sites;

**2<sup>nd</sup> Objective** – To establish ways of using the personal protection equipments and collective protection necessary when working on height;

**3<sup>rd</sup> Objective** – To establish a compulsory control on the workers’ state of health through Occupational Medicine questionnaires;

**4<sup>th</sup> Objective** – To establish the need of identifying and managing the risks of accidents and occupational diseases specific to activities n constructions performed at height;

**5<sup>th</sup> Objective** – To establish the need of having a new calculation algorithm for a bracing used for buildings with ventilated facades under conditions of maximum efficiency from the occupational health and safety point of view;

**6<sup>th</sup> Objective** – To design and implement the technology to assembly a scaffolding/bracing on the construction sites with atypical volumes for buildings with ventilated facades;

**7<sup>th</sup> Objective** – To test and assess the efficiency of the applied bracing model on a construction sites for buildings with ventilated facades;

**8<sup>th</sup> Objective** – To establish future directions at national level to identify and monitor specific risks on the construction sites with atypical volumes for buildings with ventilated facades.

### **4.3. Research-development methodology**

The research-development methodology is conceived as a reference system for actions to be performed in order to achieve the main objective of the doctoral thesis, as well as for future developments.

The methodological reference elements are as follows:

(1) *To investigate what we already know and that may be relevant to the Occupational health and safety field on which I set the focus of the research topic.* To accomplish the objectives I set, I read and analyzed a series of biographical sources represented by books, monographs, newspapers, specialty volumes legal regulations, as well as studies and publications in the Occupational health and safety field elaborated by various national and international entities or institutions.

There was carried on a factual and bibliographical documentation/research based on:

- knowing fundamental data, well established in the field of scientific research for identifying specific risks on construction sites;
- updated documentation, on reading speciality bibliography, regarding the current stage of the scientific research in the field of workwear equipment and collective protection measures, used in construction works and which are specific to mobile or stable working stations, located at height;
- the responsible, moral, and intellectual-scientific involvement of the author of this doctoral thesis, on following the critical assessment of speciality bibliographical materials published both in Romania and at international level, on regarding the innovation that can be brought in order to have safer working conditions on construction works, especially when working on height.

(2) *To establish the methodology for the research activity.* The research methods I used were structured into: *quantitative research methods* – with a positivist-explanatory direction (on using investigation, experiment) and *qualitative research methods* – with phenomenological direction (on calling for participative observation, case study). On concluding the general research plan there were used traditional strategies: survey poll, investigation, case study and experiment, each method emerged on using specific instruments, such as questionnaires, observation guides, and exploratory studies.

The following aspects were envisaged:

- shaping working hypotheses;
- choosing working techniques for gathering and analysing data to be used for explaining the phenomena related to identify the main working requirements under safety conditions at height on construction sites;
- establishing a list with the necessary means for the research, which are connected to the research techniques;
- designing the organization and development logistics for field research that had in view the dialogue with representative groups of subjects on the construction sites that attended the scientific research study.

(3) *To gather and process data resulting from the performed field research.* The investigation was the research strategy applied, action that ensures gathering information on the basis of a questionnaire created to verify whether the workers understood and identified the risks to which they are exposed on the construction site. The defining element for the investigation is the *size of the group*, which depends on the desired preciseness degree, but also the financial and professional available resources. To the questionnaires there were received answers from 100 workers, having different trades, from 6 studied construction sites.

Likewise, there was performed a study for knowing the role of the Occupational Medicine doctor and the medical services among workers, on creating a synthetic questionnaire, filled in by about 100 workers in 6 different construction sites, the results focusing on verifying the working conditions related to Occupational Medicine.

In order to verify whether the workers understood and identified the risks on the construction site, there was elaborated a questionnaire (Annex 4), and were received answers from 100 workers, having different trades, from 6 construction sites.

After having filled in the questionnaires and the data processing, there resulted the knowledge degree of working conditions related to potential risks that are present on construction sites and the outcome was that over 60% of the interviewed subjects have knowledge on the activities regarding the Occupational health and safety services and the risks at the working place.

There was performed a case study to identify and assess the risks for the job *builder and assembler of metallic structures-ventilated facades*, where it was pursue to identify and mitigate the risks either by reducing the probability value or the severity value, or by reducing both reference factors.

The research continued with designing and performing the technology for assembling the scaffolding on starting from the four major threats identified in the analysis of security factors for bracing: falling from height, upturning/falling the entire scaffolding/bracing, harming the workers/visitors by falling materials off the bracing, electrocution.

Likewise, it was conceived a height working procedure which establishes employers' tasks and responsibilities in the following order: Avoiding height working, Insuring that all those who work on height are Adequately trained and supervised, Selecting the safest workwear

equipment to prevent falling from height, Making sure that the workwear equipment is in conformity with the workload and it is Stable, Regular verification and Maintenance of the related protections, Insuring the Personal protection equipment and the Height protection one of harnessing type or belt, as well as the connection elements, Insuring a safe working environment under any working condition, Elaborating a Saving Plan in case of height fallings.

*(4) To analyse and interpret the data coming from the research*

The obtained data confirm the knowledge presented in the speciality literature, validates scientific theories which apply at this very moment in the Occupational health and safety field, underlying once more that identifying and monitoring the specific risks on construction sites shall continue to be an updated research domain both from the theoretical and experimental point of view.

The performed researches bring new elements, enriching the knowledge on the current level of collective protections met in practice on construction sites, the clarification of some aspects related to the fundamental principles of the innovative technical harmonization method by sharing responsibilities between the European lawmaker and the European standardisation bodies.

*(5) To present conclusions and recommendations*

At the end of the doctoral thesis there are presented the conclusions, in a synthetic, concise manner, on underlying the scientific results obtained. Out of these conclusions there shall develop the future scientific theories related to the fact that the occupational health and safety implies existing and functioning a pluridisciplinary system of theoretic concepts, legislative deeds, technical, socio-economic, organisational, hygiene measures and means and the Occupational Medicine. Part of the results coming from the researches comprised in this very thesis were communicated during the scientific events organised both in Romania and abroad. The recommendations focus, on one side, to the directions that value the results of the research, the designed pluriocetagonal SM8 system offers the possibility or the scaffolding to expend in all directions, to adjust to all heights, on also varying the interaction between pillars, depending on the need to have a different capacity or to adjust to different types of compound structures.

The innovations brought in SM8 allow the users to save labour force and to use them in challenging conditions. At this very moment, it is the only system when the usage of metallic floors can be integrated with beams and access stairs to work under safe conditions.

On the other side, the recommendations are guided towards identifying the premises that would support future research projects, supplementary to the finalised scientific research such as the execution of the stages of risk controls hierarchy on construction sites, thing that may represent a tactic to introduce a new occupational standard “*Occupational health and safety responsible on construction sites*”, having the role of safety supervisor.

## **Chapter 5. RESEARCHES AND CONTRIBUTIONS ON ASSESSING AND HIERARCHIZING THE CONTROL STAGES FOR RISKS OF ACCIDENTS AND OCCUPATIONAL DISEASES ON CONSTRUCTION SITES**

### **5.1. The analysis of control stages for risks of accidents and occupational diseases on construction sites**

Within this chapter I studied the hierarchy of risks control stages, a step by step approach to remove or mitigate risks where there are classified risks controls from the highest level of protection and reliability to the lowest and the least reliable protection. The research study begins from the belief that the most important aspect of the Occupational health and safety is to prevent risks and not to manage the situation after the risk which caused incident and work accidents.

Once with updating the OHS management system, after having implemented the requirements of ISO 45001, the organisation has to plan, implement, control, and maintain the necessary processes to carry on the requirements of the OHS management system and to implement actions established when approaching risks and opportunities.

### 5.2. Risk Management

There are assessed the risks associated with each type of height work and there are established the necessary control measures to make sure the very activity and the ones in the closed areas can be performed under safety conditions. The risk analysis is achieved even if there are in place protection systems against falling and, whenever possible, the prevention shall be used instead of protection against falling.

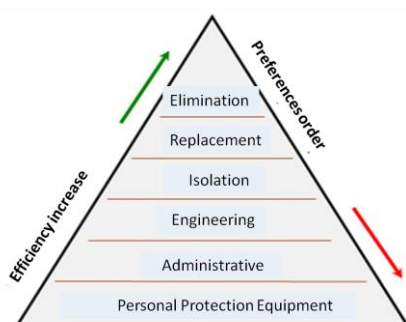
### 5.3. Minimum occupational safety requirements that must be followed when performing height works

All workers developing activities at height are subject to periodical medical examination. The periodicity and clinical-functional examinations are set up by the Ministry of Health on taking into account the characteristics of the working place [23].

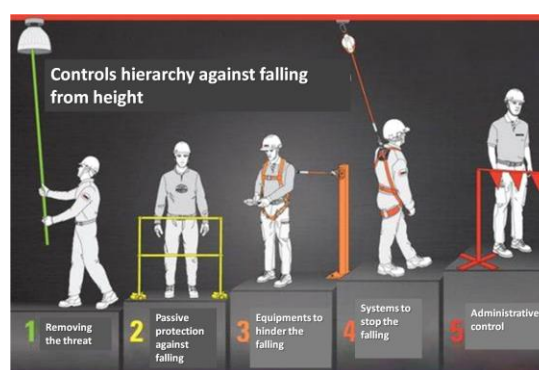
### 5.4. Preliminary action – the hierarchy of controls

There is considered to be a hierarchy for the risks control methods. The notion “hierarchy” indicates the fact that there is a series of risks controls modes, some of them being more efficient or more preferred than others.

The hierarchy of controls methods is the following:



Picture 5.4. The hierarchy of general controls.



Picture 5.5 Hierarchy stages of controls against falling from height.

There shall be elaborated adequate usage, verification, and maintenance instructions for equipments to hinder and stop the falling. The inspection and maintenance of equipments related to height work are performed by those persons trained and appointed by decision.

All protection equipments against falling are visually inspected before usage. Likewise, the representatives of the management or the security department perform random inspections of the equipments;

The inspection criteria include checking for cracks, cuts, pierces, twist, excessive wear and tear, as well as malfunctioning;

The equipments are stored in a cool location in order to maintain their integrity. All flaws must be repaired immediately;

There will not be performed repairing to equipments that require special training or repairing at the producer's authorised service centre. All security harnesses, anchorage tapes or straps that present flaws are cut in a half and thrown away. No one will attempt repairing or using them. In case the producers' plates or registration number have been removed, the device will be thrown away and will no longer be used.

## **Chapter 6. CONTRIBUTIONS RELATED TO THE CONTROL AND IMPROVEMENT OF OCCUPATIONAL HEALTH IN CONSTRUCTIONS, FOR ACTIVITIES DEVELOPED AT HEIGHT**

A specialised construction company gathers a wide range of risks factors, and the employees with diverse trades and types of training/suppliers/visitors may all be exposed to toxic emissions that might, in some cases, lead to affecting people's health. In order to ensure the medical supervision conditions for the personnel, it is important for the Occupational Medicine doctor to cooperate with the employer/employee.

The research within this chapter is focused on analysing the role played by the labour medicine service in supervising the workers' health in such a way as they are able to develop the activity under normal conditions.

### **6.1. The workers' health supervision at the working place through Occupational Medicine**

Some of the objectives of occupational health are presented here below:

- placing and maintaining the employee in an environment adjusted to everyone's physical and mental abilities, adjusting the activity to the person and the person to his/her trade, protecting workers against the risk factors present at the working place.
- the main role is to inform the employer on ways to obtain and maintain those working conditions that will not affect the employees' health.

### **6.2. The purpose of medical analyses in discovering/setting the working ability**

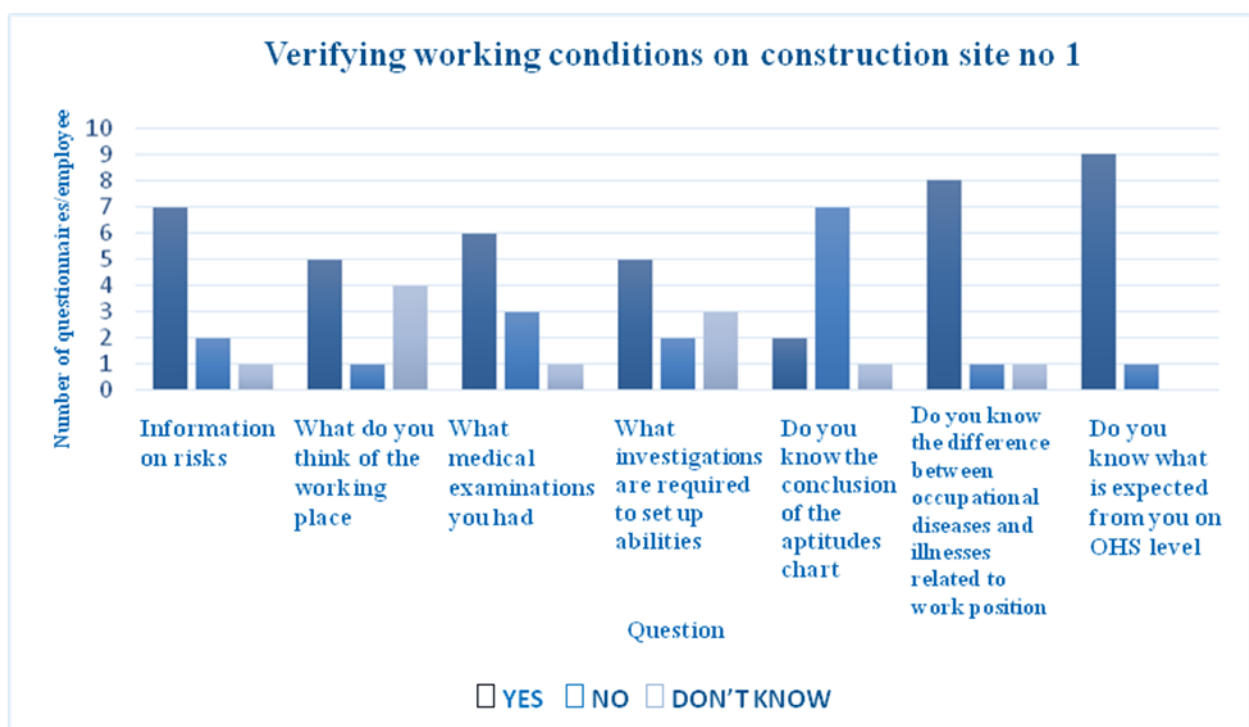
In order to get to know the role of the Occupational Medicine doctor and the medical services among workers I summarised in a verification list with 11 questions, presented in Annex 3.

This verification list/questionnaire was filled in by about 100 employees in 6 different construction sites.

Out of the analysis of these questionnaires, there result that the workers benefit of Occupational Medicine services, are aware of the risks to which they are exposed, as well as the prevention measures imposed/recommended regarding the potential diseases at the working place.

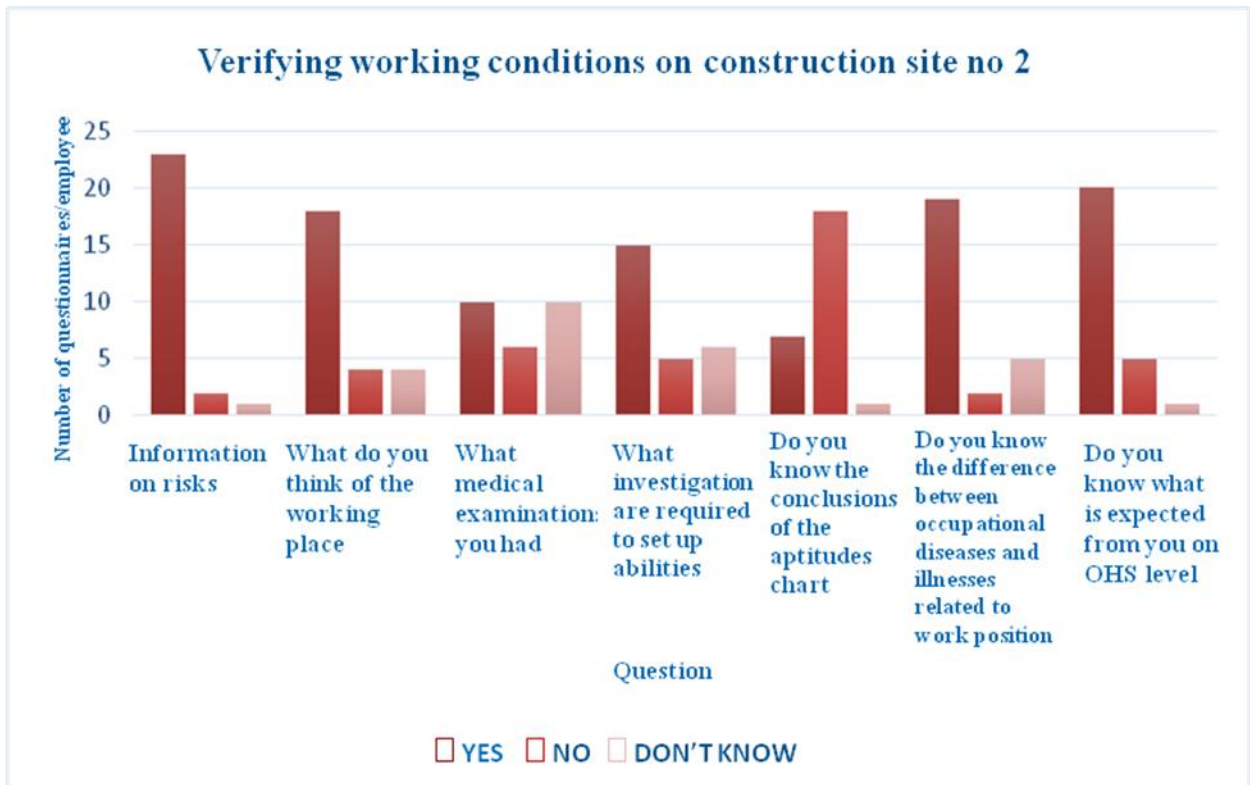
On following the Occupational Medicine periodical controls and the questionnaire filled in by the selected employees, some of them discovered medical conditions on which they had no idea – blood pressure, diabetes.

After analysing the questionnaires, the results have been centralised in graphics from pictures 6.1-6.6 for all 6 construction sites

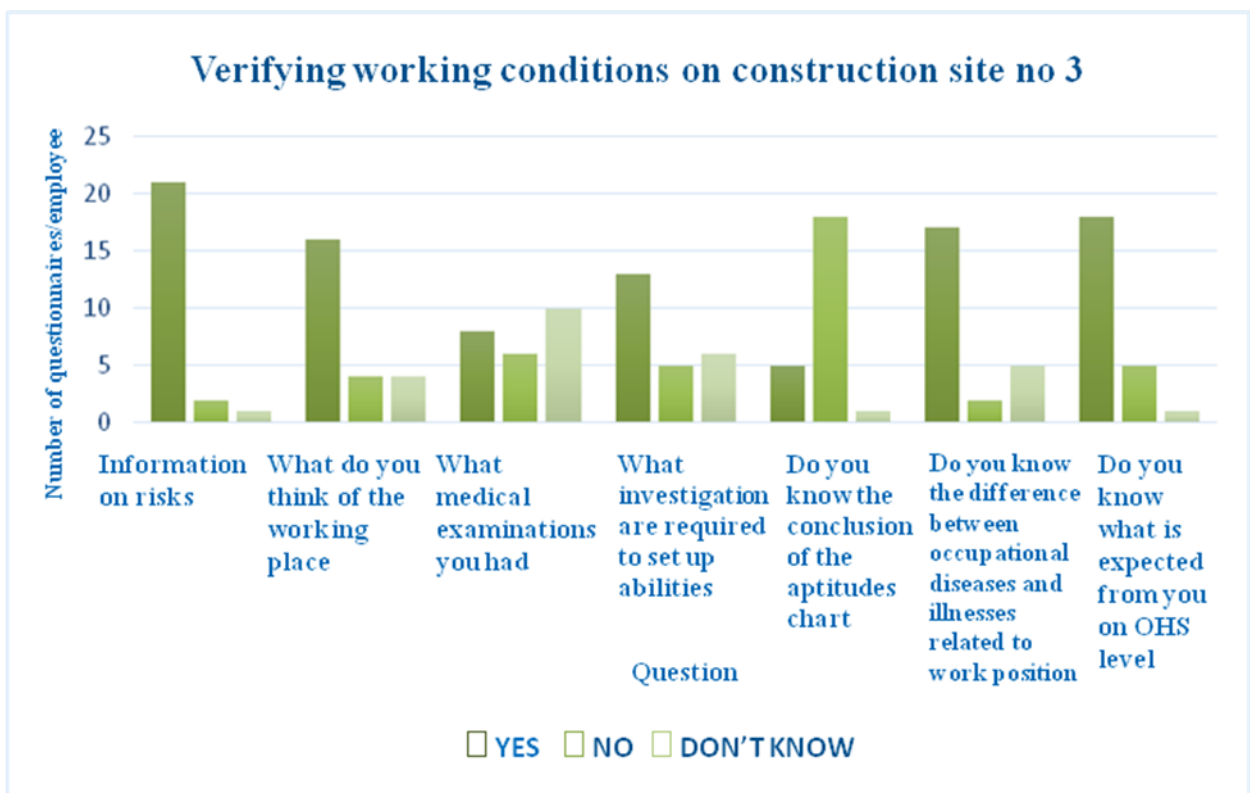


Picture 6.1. Results from questionnaire on construction site no 1

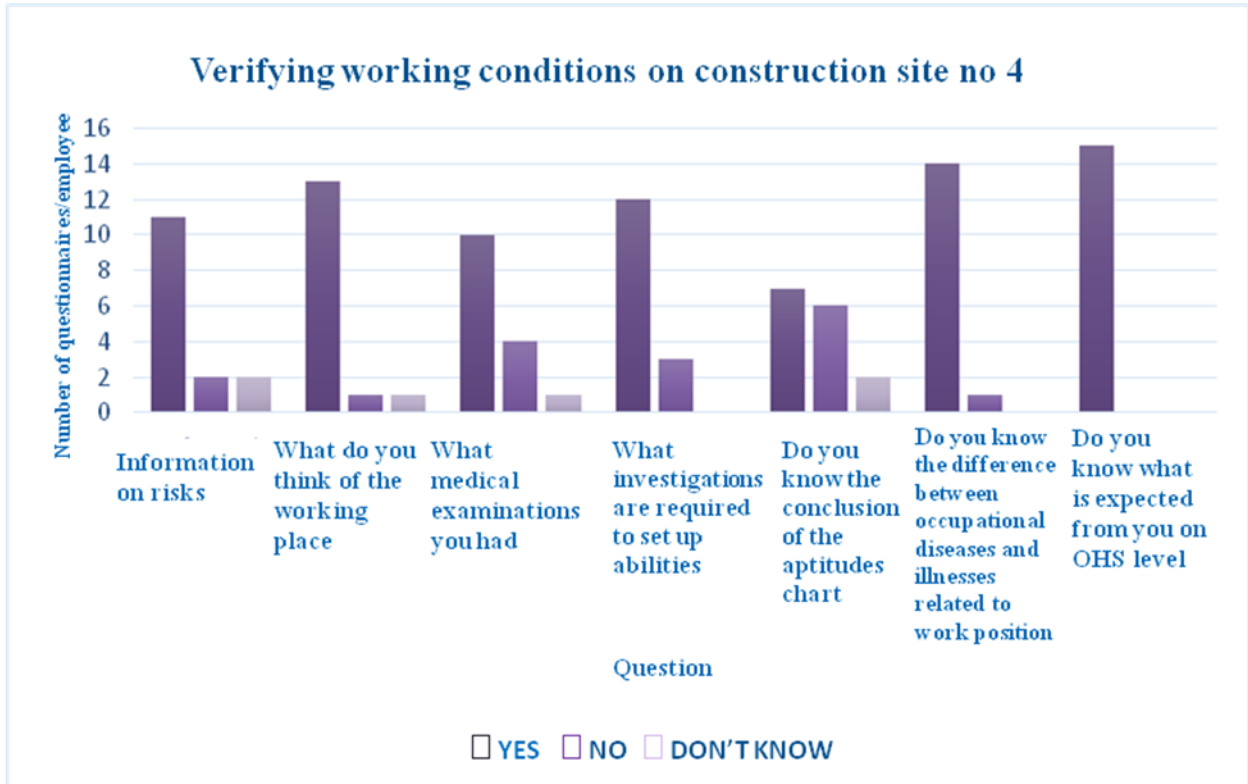




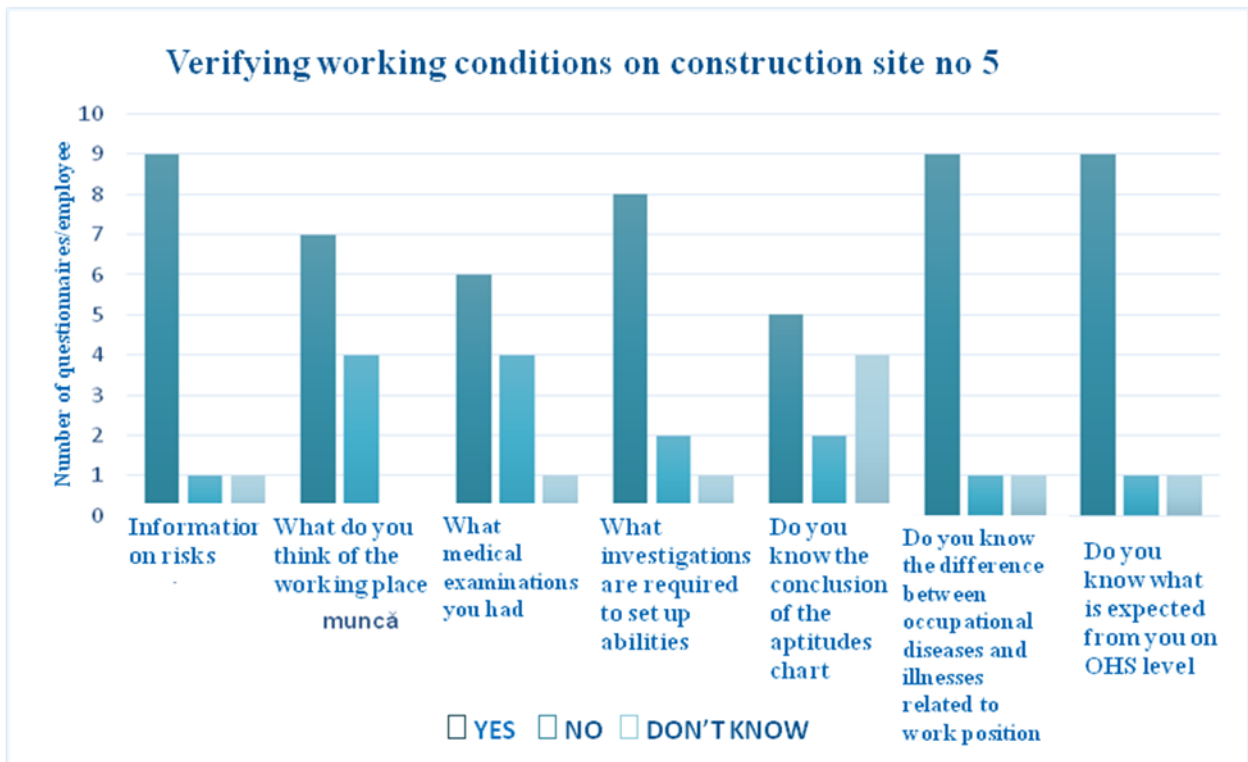
Picture 6.2. Results from questionnaire on construction site no 2.



Picture 6.3. Results from questionnaire on construction site no 3.



Picture 6.4. Results from questionnaire on construction site no 4.

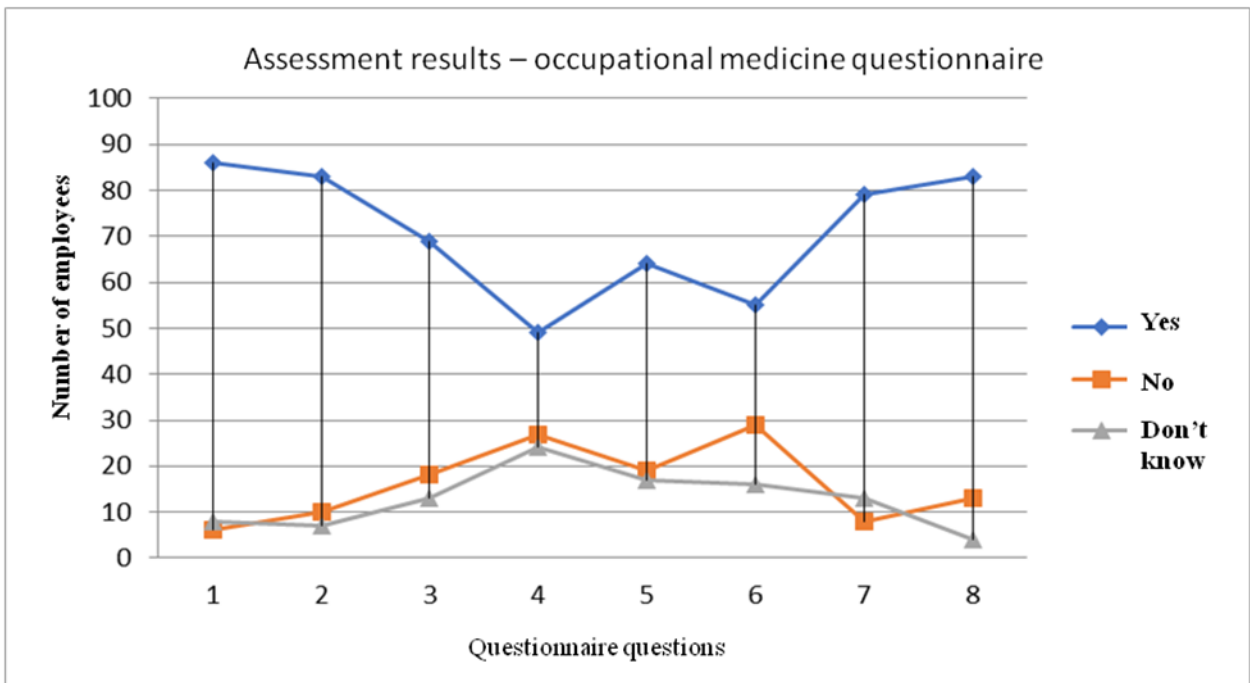


Picture 6.5. Results from questionnaire on construction site no 5.



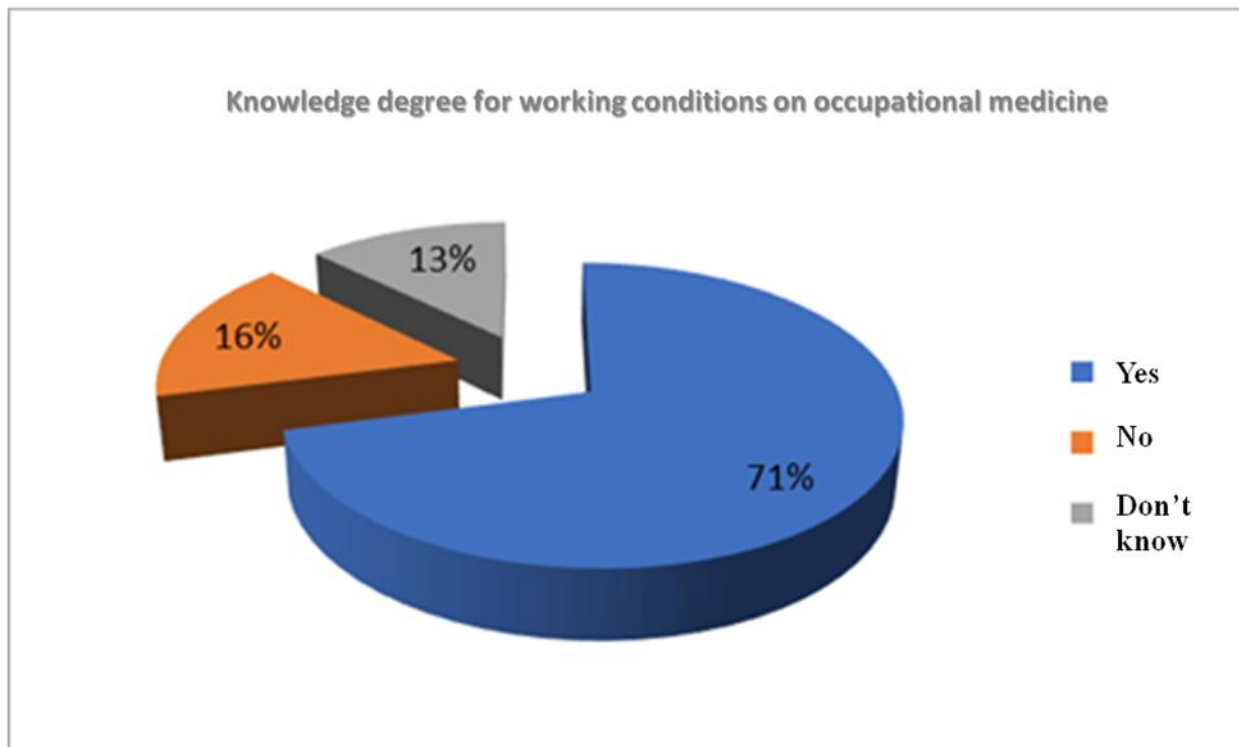
Picture 6.6. Results from questionnaire on construction site no 6.

The results after verifying the working conditions from Occupational Medicine perspective have been centralised in picture 6.7.



Picture 6.7. Interpretation values for working conditions

After having filled in the questionnaires elaborated for the research and after gathering all data, there resulted the knowledge degree for the role played by the Occupational Medicine doctor and the importance of medical services among workers on construction sites who attended the study, as presented in picture 6.8.



Picture 6.8. Knowledge degree for working conditions on Occupational Medicine

### 6.3. Organizing the medical control for a constructions company

According to the medical control protocol upon employment, periodically, yearly, on work resumption in order to assess the workers' state of health and work ability, all employees were examined, according to the established schedule

The medical control upon employment is carried out in the occupational medicine clinic, and the periodic medical control is usually carried out on construction sites, in specially arranged spaces.

According to the number of medical examinations carried out in the last 5 years, I presented in table 6.1. the type of examinations performed.

Table 6.1. Record of medical examinations per categories between the years 2017-2021

Year	Periodical medical controls	Medical examinations upon employment	Adjusting examinations	Work resumption examinations	Special supervision examinations	Final clinical examination upon ceasing the activity	Other	Consultations on the spot	No employees
2017	322	368	0	1	1	1	2	0	694
2018	454	317	0	8	0	0	1	0	780

2019	387	266	0	2	2	0	8	0	665
2020	352	96	0	3	3	0	0	0	454
2021	373	47	0	2	2	0	0	0	424

#### 6.4. Analysing the workers’ state of health – Occupational Medicine Reports at a constructions company for a period of five years

When analyzing the general morbidity, the peak of morbidity is found in nutrition and metabolism diseases, followed by cardiovascular diseases and ophthalmological diseases as shown in table 6.3.

Table 6.3. General morbidity structure between the years 2017-2021

Condition category	2017	2018	2019	2020	2021
Nutrition and metabolism disease	14,41 %	12,82%	13,38 %	10,79%	10,61%
Cardiovascular diseases	12,25 %	10,90 %	10,38 %	12,11%	13,92%
Ophthalmological diseases	10, 81%	9,62 %	10,68 %	21,59%	21,93%
Respiratory diseases	2, 61 %	1,92 %	1,35 %	8,59%	8,02%
Osteoarticular diseases	5,04 %	4,49 %	4,51 %	9,69%	11,56%
ENT (ear, nose, throat) diseases	0%	0%	0%	5,07%	4,48%

#### 6.5. Determining the risk factors for workers who develop their activity on construction sites

Personnel working at height should be medically fit. Epilepsy, chronic diseases of the nervous system (including alcoholism), mental diseases, balance disorders of any kind, deafness, untreated high blood pressure, some heart diseases, some lung diseases, some chronic eye diseases, as well as acute eye diseases until cured are contraindications for working at height, even for a day.

The specificity of the work makes musculoskeletal disorders, and especially those of the lower back, to be particularly frequent. The presence in a unit of a large number of medical certificates for such ailments is an additional argument, along with the ergonomic analysis of the activity, for the need of changes in the technological process or in the organization of work. Modernization of the activity with the introduction of aids (levers, pulleys, conveyor belts, etc.) and health education of the staff are necessary. Workers must be educated to work together, to help each other, how to lift weights while maintaining a straight back and a solid base of support, which is the legal limit of the weight they can lift [36].

Smoking and alcohol consumption decrease the quality of work and its productivity. Smoking is a recognized risk factor for respiratory cancer and cardiovascular diseases.

#### 6.6. The collaboration between the physical rehabilitation doctors and the Occupational Medicine service

Recommendations on medical measures:

- Prompt treatment of chronic conditions, to prevent their aggravation and decrease the number of days of temporary incapacity for work;
- Monitoring of those with chronic conditions, through periodic check-ups, in order to make them aware of the need to follow the prescribed treatments, as well as to observe in time any changes that can influence both the state of health and the ability to work;
- Limiting smoking and observing individual and collective hygiene measures;
- Recognizing the risks that come from professional exposure;
- Carrying out the medical examination upon employment, the resumption of the activity, the periodic medical control according to the current legislation [23].

Compliance with these recommendations maintains work capacity at adequate parameters and obviously contributes to improving the health of employees [26].

## 6.7. Conclusions

The research in this chapter is focused on the analysis of the role of the occupational medicine service regarding the supervision of the health of workers so that they can carry out their activity under normal conditions and on the identification of measures that lead to the improvement of occupational health in constructions, for activities performed at height.

- The type of activity, age, trade, job satisfaction are the main factors that influence the existence of musculoskeletal disorders. The location in the lower back is the most common, in all occupational exposures. "Problematic" activities are those that involve physical effort with lifting, pushing, pulling, carrying, etc. of (heavy) weights.
- Ergonomic aspects are not a priority in the occupational medicine programs of companies, being often totally neglected in favour of monitoring chemical and physical toxic elements. Workers' training and health education are urgent imperatives, along with specific technical, organizational and medical measures.
- Acquiring the existing legislation in the field by employers, employees, following its application in collaboration with the medical service at the workplace, the work safety service, is imperative in order to reduce the professional risk.
- The work schedule, both in terms of duration and working regime, is structured to allow the restoration of the requested structures.
- For those with a prolonged orthostatic position, breaks in the sitting position are provided, and there might be analysed the possibility of performing some activities sitting down.
- Workers will be encouraged to take measures and initiatives to maintain their state of health. Often common solutions are the removing of lifting operations – manual handling, use of lifting equipment, sufficient staff, and teamwork.
- The resolution of existing, manifest or latent sufferings will allow the improvement of the general state of health, with the improvement of the professional activity and the work climate.

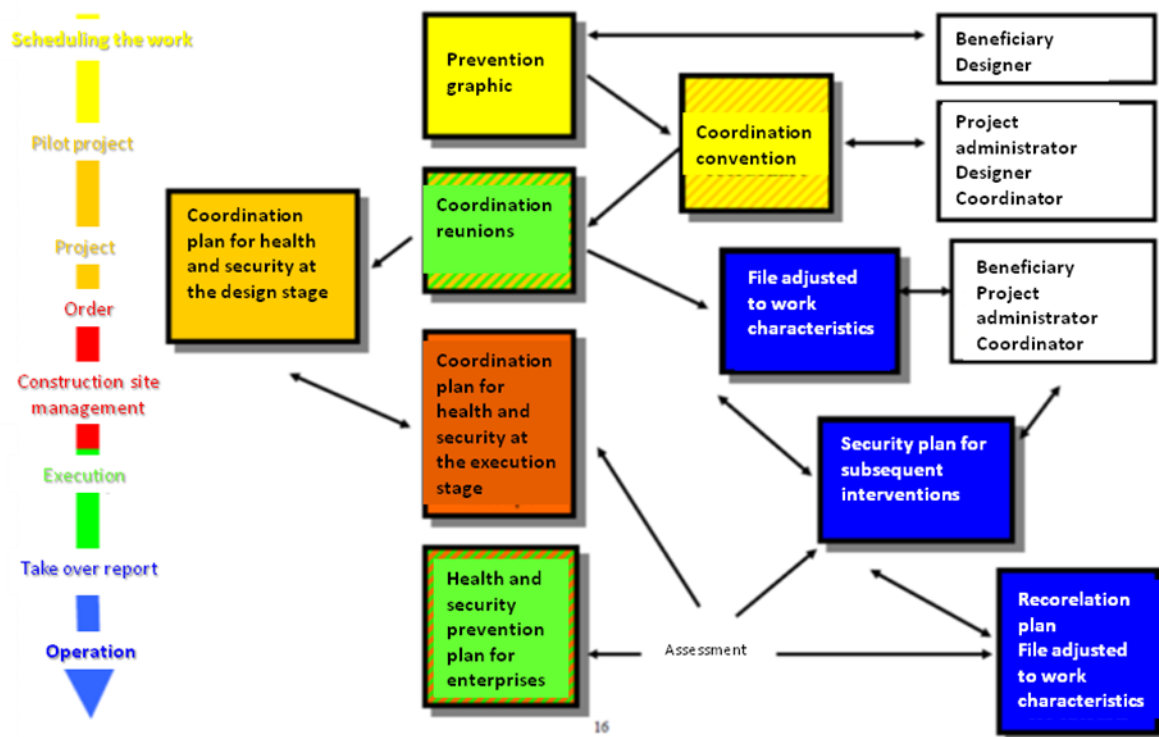
- The constructions activity is predominantly physical, involving travel, various movements, turning the body, lifting and carrying weights. It is necessary to strictly comply with the medical and occupational protection regulations regarding these aspects of activity.
- Administrative measures are required for personnel selection, training and qualification, rotation of activities, working time and its organization, increased control regarding the observance of the rules and making the right decisions, on time, regarding the recruitment, maintaining some workers, the way of working.
- The legislation does not cover all OHS problems, the solution of genuine problems requires a good collaboration between all the factors with attributions in this field, the turning point being the occupational medicine doctor, both through the legal attributions he/she has, and through the specialty, this having a pronounced interdisciplinary character, both in relation to other medical disciplines and to psychology, ergonomics, technical sciences, economics and legal sciences. For these reasons, the occupational medicine doctor, in addition to a solid specialized training, requires thorough knowledge both in the field of other medical specialties (clinical and preventive) and in the field of other sciences, as well as good communication and teamwork skills.
- In order to know the role of the occupational medicine doctor and medical services among the workers, we created a questionnaire, a checklist in which we concentrated 11 questions, presented in Annex 3. This checklist/synthetic questionnaire was completed by about 100 workers from 6 different construction sites, with the aim of following the evaluation of the activity regarding occupational medicine services applied in construction sites for buildings with ventilated facades. Following the performance of periodic occupational medicine examinations and the completion of the questionnaire proposed for evaluation, a number of workers were discovered to have medical conditions of which they had no knowledge – hypertension, diabetes.
- A centralization was made (table 3.1.) of the records of medical examinations by category carried out between the years 2017-2021 on a construction site. After a full analysis of the results of the medical examinations, there were issued aptitudes' charts, including both the occupational medicine medical opinion and the general medical recommendations.
- Following the analysis of the general morbidity carried out (2017-2021), the peak of morbidity is found in nutrition and metabolism diseases, followed by cardio-vascular diseases and ophthalmological diseases as presented in table 3.3;
- There were identified individual/particular factors that contribute to a good collaboration between the physical rehabilitation doctor and the occupational medicine service, reflected in the health status of the workers. Thus, the group of inherent-individual factors includes: weight, hypotonia, hyperlaxity, hydroelectrolytic disorders, endocrine-metabolic pathology, cardiovascular adaptation, age, sex, constitutional type, lifestyle; and the group of extrinsic - particular factors includes: physical stress, general stress, humidity and air currents, psycho-behavioural factors.

## Chapter 7. IDENTIFYING AND MANAGING THE RISKS OF ACCIDENTS AND OCCUPATIONAL DISEASES SPECIFIC IN THE ACTIVITY OF CONSTRUCTIONS PERFORMED AT HEIGHT

### 7.1. Coordination instruments, coordination principles in the Occupational Health and Safety

In 2006, there began transposing of the European Directives into laws and government decision. This is how Directive 92/57 was transposed into GD 300/2006, which establishes the minimum occupational health and safety requirements for temporary or mobile construction sites.

The coordination tools according to HG 300/2006 are exemplified together with the documents and the roles of each participant in the work process on construction sites (picture 7.2).



Picture 7.2 OHS coordination instruments

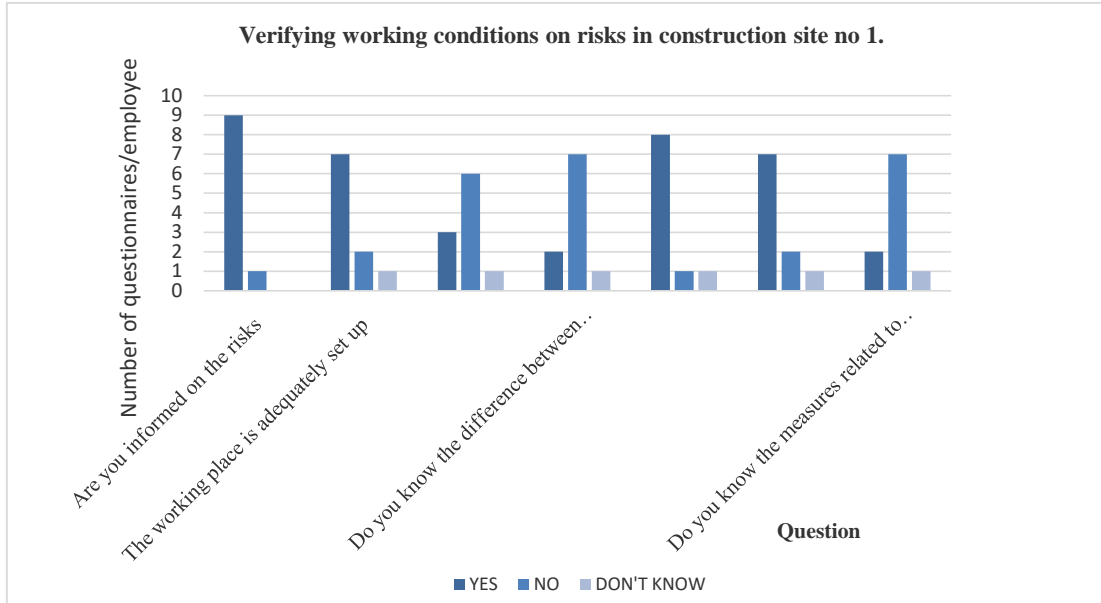
### 7.2. Works that may expose the workers to the risk of falling from height, due to the nature of the activity they develop

After analyzing the results of the questionnaire, it emerged that the workers are aware of the risks on construction site and are familiarised with the OHS Coordinator on the construction site.

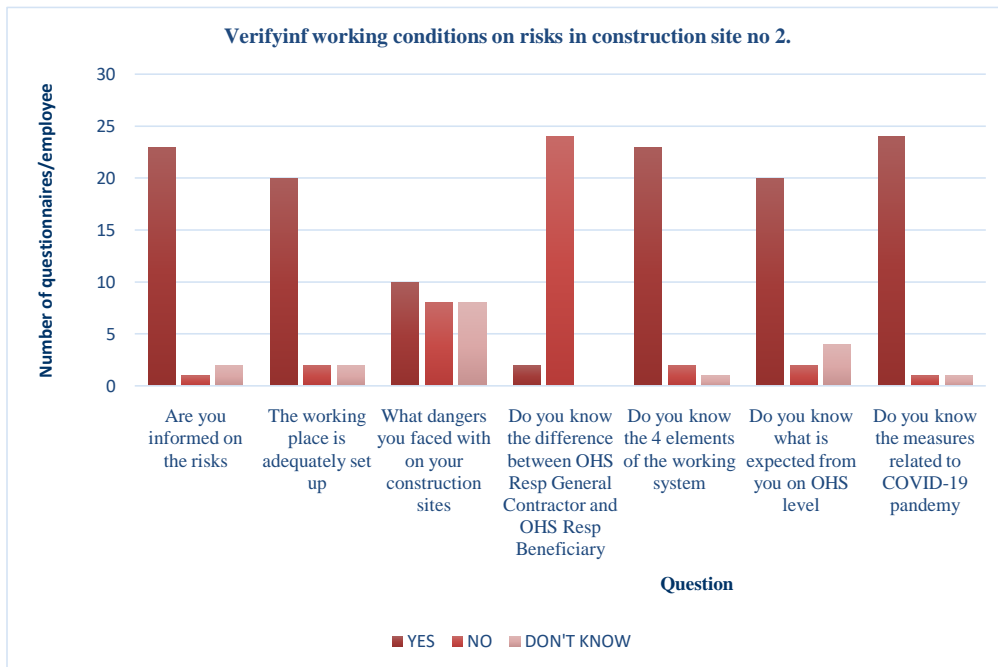
In order to check whether workers understood and identified the risks on the construction site, a questionnaire was drawn up (Annex 4), to which I received answers from a number of 100



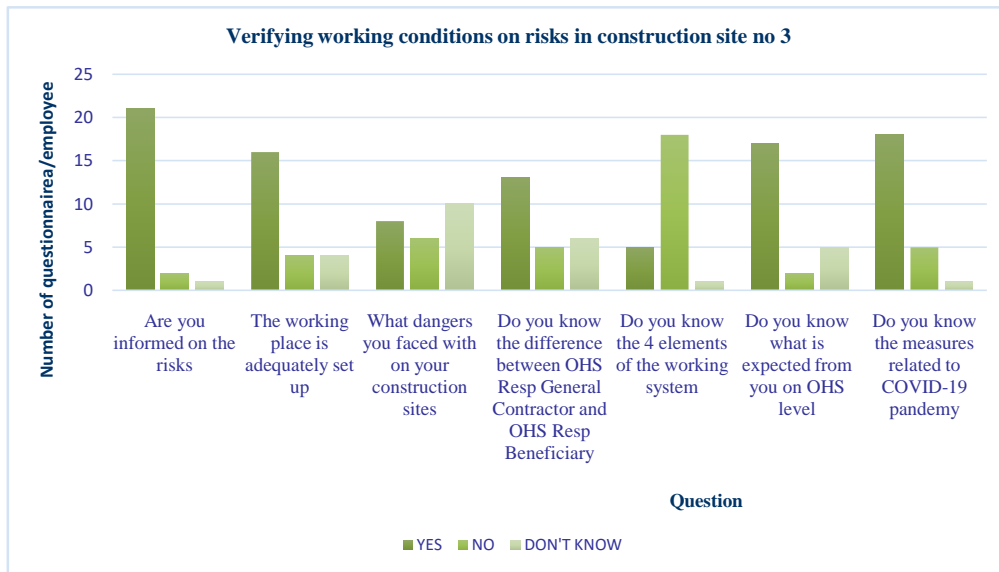
workers, of various trades, from 6 construction sites and the results can be seen in pictures 7.4 - 7.9.



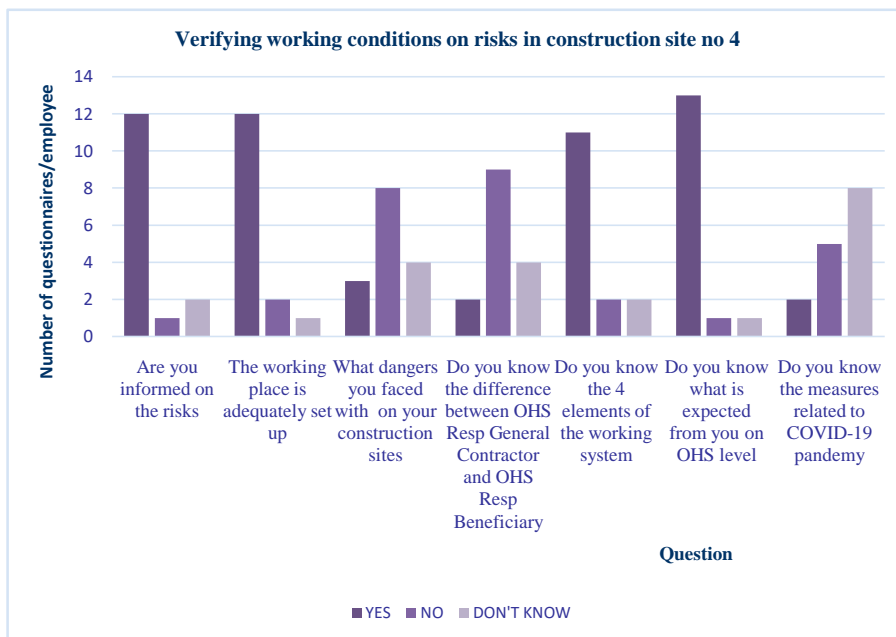
Picture 7.4. Result of questionnaire regarding risks on construction site no 1



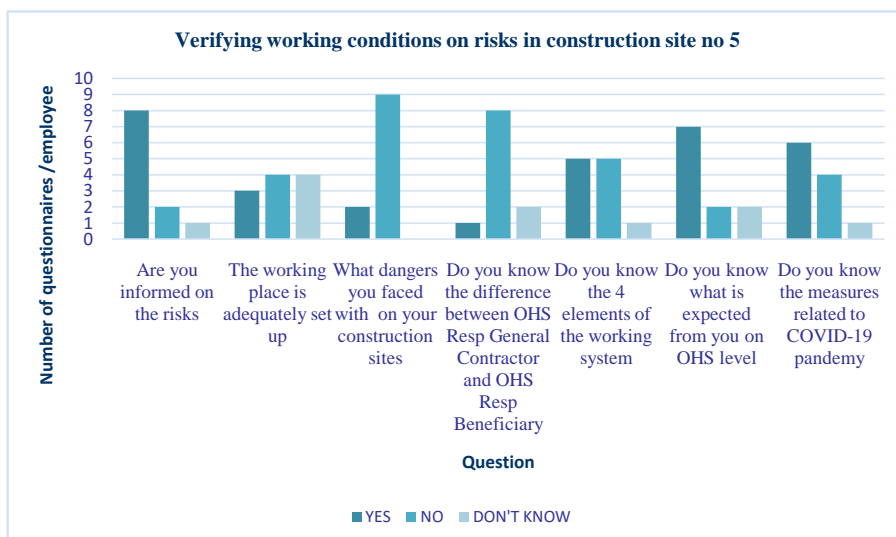
Picture 7.5. Result of questionnaire regarding risks on construction site no 2.



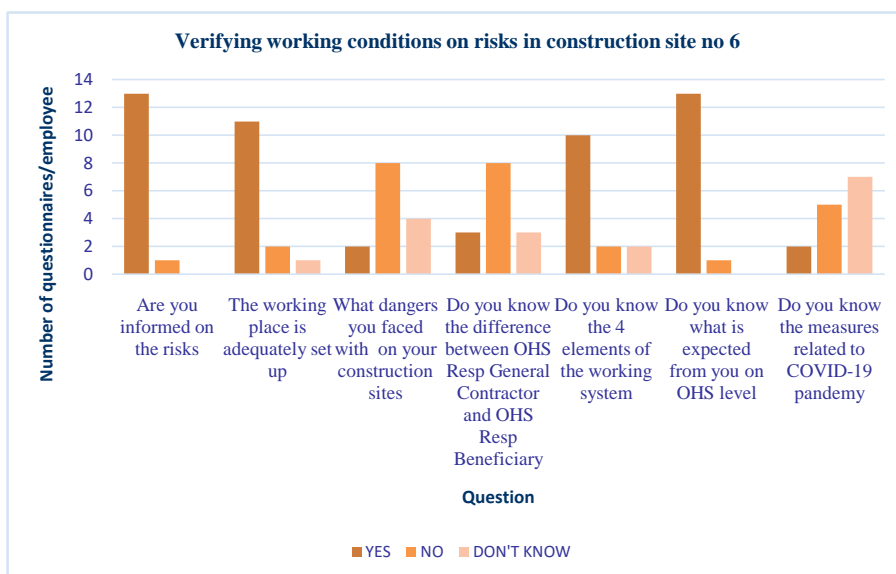
Picture 7.6. Result of questionnaire regarding risks on construction site no 3.



Picture 7.7. Result of questionnaire regarding risks on construction site no 4.

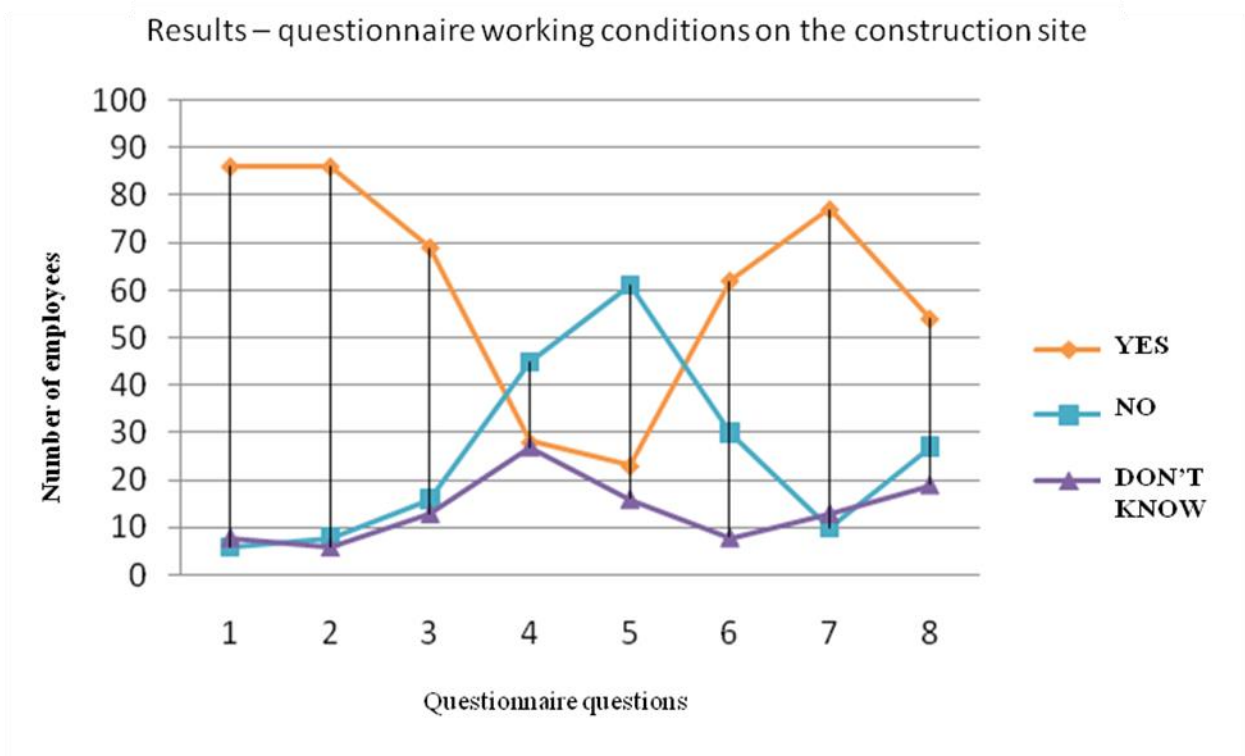


Picture 7.8. Result of questionnaire regarding risks on construction site no 5.



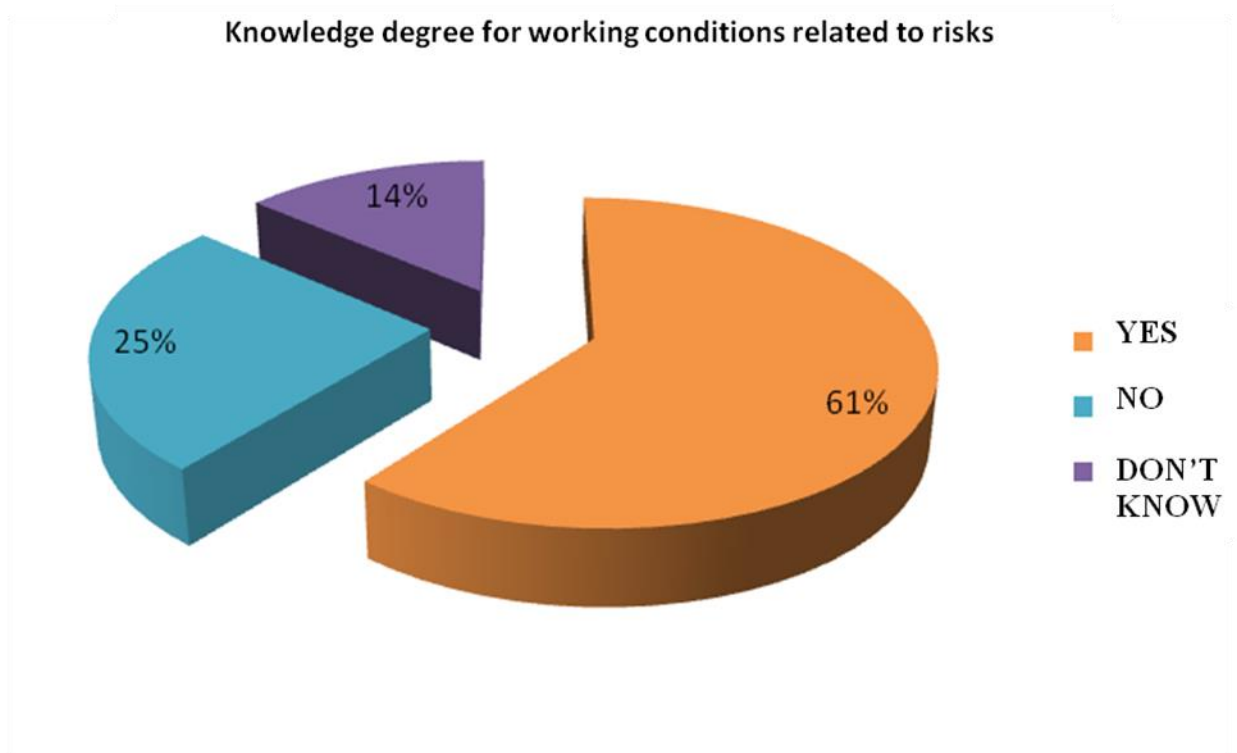
Picture 7.9. Result of questionnaire regarding risks on construction site no 6.

The results regarding the verification of OHS knowledge related to working conditions in construction sites with atypical volumes for buildings with ventilated facades are centralized in fig 7.10.



Picture 7.10. Results on verifying the knowledge of OHS.

After having filled in the elaborated questionnaires and the data gathering, the degree of knowledge of the working conditions related to possible risks on construction sites that we included in the study, presented in picture 7.11, there resulted that more than 60% of the surveyed subjects have knowledge about the activities regarding OHS services and the working place risks.



Picture 7.11. Results on the knowledge degree of working conditions related to potential risks on construction sites.

### 7.3. Applying the risk method in the construction site for the job “builder and assembler of metallic structures-ventilated facades”

Next, there shall be processed the results of assessing the risks of accidents and occupational diseases for each individual component of the system presented in Tables 7.2 and 7.3.

It was pursue to identify and mitigate the risks either by reducing the probability value or the severity value, or by reducing both reference factors.

### 7.4. Conclusions

In the construction process of buildings with ventilated facades there are specific accident risks that require adequate prevention and protection measures, the purpose of this chapter being to find answers to the question *"What are the options if I discover a risk?"*

- ✓ Risks of accidents at work exist permanently on temporary and mobile construction sites, important being the way of application and the efficiency of the organized and implemented measures, in order to avoid the occurrence of events with severe consequences.
- ✓ The four risk response strategies are reviewed: termination, treatment, transfer and tolerance.
- ✓ The tools of OHS coordination are exemplified, according to GD 300/2006, together with the documents and the roles of each participant in the working process on construction sites.

- ✓ There were identified the works that may expose the workers to the risk of falling from height, due to the nature of the activity carried out by them, being aware that any construction site presents, in any phase of existence, a high potential for accidents.
- ✓ Through the risk identification and assessment process carried out for the job “builder and assembler of metallic structures-ventilated facades”, the specific risk factors were highlighted and preventive measures were suggested so that the risks become acceptable.
- ✓ The recommended prevention and protection measures are the following: the use of collective protections for working at height, the provision and correct use of PPE, the organization of risk prevention measures on access and traffic routes, the provision and use for work at height of scaffolding, platforms, ladders or certified platforms, the installation of nets for the retention of materials that accidentally fall from big heights, the provision and use of workwear equipment in accordance with the activities carried out and the workers’ training.

The final conclusion out of this chapter is that the primary duty of any assessor is to remove the risk at source, where possible. If removing is not possible, the risk must be reduced as far as is reasonably possible according to the hierarchy of controls.


## **Chapter 8. PERSONAL CONTRIBUTIONS TO IMPLEMENTING ON THE CONSTRUCTION SITES PRACTICE OF THE PREVENTION AND PROTECTION MEASURES SPECIFIC TO CONSTRUCTIONS WITH VENTILATED FACADES**




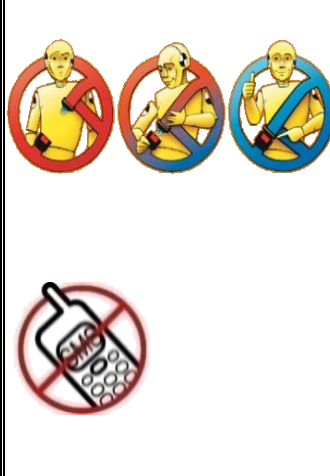
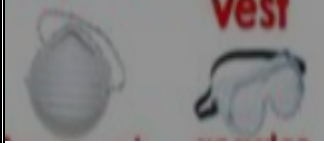
### **8.1. Applying the “hierarchy of controls” in selecting workwear equipment**

Specifications regarding the compliance requirements of PPE for the selection of PPE must comply with the provisions of Government Decision 115/2004 on setting up the main security requirements for personal protection equipments and the conditions for placing them on the market, with the subsequent amendments.

In table 8.1. I present an example on applying the hierarchy of controls method in choosing the PPE for construction sites.

Table 8.1. Example for applying the controls hierarchy method in choosing the PPE

Control methods	Actions to perform	Removing manner
Removing	Removing a threat, total removing of associated risks.	By removing the load 

Replacement	Replacing some products/ dangerous processes with safer products/ processes with small potential of generating a threat.	By selecting safer products/ processes	
Substitution (Isolation)	By isolating the worker from the threat.	By controlling the noise and/or enclosure	
Engineering (safety design)	On a structural change of the process or equipment in order to remove the threat to which the worker is exposed.	By protection	
Administrative (organizational)	By reducing the risk on adapting procedural instructions, workers' rotation or other administrative actions.	By implementing rules and trainings.	
Personal protection equipment	By recommending PPE for additional protection.	By offering PPE: dust mask, protection glasses, ear muffs	

## 8.2 Applying the “hierarchy of controls” in the interventions performed for electrical installations

Hierarchy of control measures in terms of safety at work in the field of electrical installations is the main approach to prevent accidents, as well as to protect electrical equipment. The hierarchy of threat control methods is the basic idea of all aspects of occupational safety, as it helps engineers determine and prioritize the best methods to ensure the protection of service/maintenance teams of electricians [67].

Table 8.2. The safety in electrical installations: controls for managing threats

Control methods	Actions to perform	Removing manner
Removing	Removing a threat, total removing of associated risks.	It is established to log off from the energy sources as preferred approach to work at or around electrical installations.
Replacement	Replacing some products/dangerous processes with products/processes with small potential of generating a threat.	Reorganizing the working place
Substitution (Isolation)	By isolating the worker from the threat.	Using monitors with bars, fuses for electricity restriction, or electro-mechanic relays.
Engineering (safety design)	On a structural change of the process or equipment in order to remove the threat to which the worker is exposed.	Otherwise there shall be used automatic protections, the worker will be isolated from electrical threats.
Administrative (organizational)	By reducing the risk on adapting procedural instructions, procedures, workers' rotation or other administrative actions.	The periodic training of electricians in order to test their technical knowledge, as well as to see if they have mastered the aspects of accident prevention in interventions at electrical installations.
Personal protection equipment	By recommending PPE for additional protection.	The personal protection equipment it should only be an additional level of protection and not the main level of protection.

### 8.3 The hierarchy of controls in case of using bracings/scaffolding

A combination of the controls set out above may be used if a single control is not enough to minimize risks. The decision of what is reasonably practicable includes the availability and adequacy of control measures, with a preference for the use of:

- *substitution controls,*
- *isolation*
- *engineering to minimize risks before use*
- *administrative controls or PPE.*



#### **8.4. Contributions to elaborating the technology of fitting the structure scaffolding**

The adequate fitting of scaffolding is essential to preventing this particular threat. Before erecting the scaffolding, a number of factors must be taken into consideration. There has to be paid attention to the weight that the scaffolding will need to support, including the weight of the scaffolding itself, materials and workers. Foundation stability, placement of scaffold boards, distance from the scaffold to the work surface, and connection requirements are just a few of the other elements that must be considered before building a scaffold.

The SM8 system consists of vertical sash bars ( $\varnothing$  48.3 – thickness 3.2mm) made of S355JR steel, which are fixed to each other and connected by a wedge stiffener in the octagons present on the sash bars. This solution offers the possibility to extend in all directions, to adapt to all heights, also varying the interaction between the pillars, according to the needs of a different capacity or to adapt to complex types.

Height adjustment with millimetre precision is carried out by operating the feet and adjustable heads, provided with square pitch threads and anti-threading device on the vertical side. The SM8 system is completed with a double series of multi-hole profiles to form the main support structure for the upper framework and the secondary beams. A system of connections and clamps allows all components to be connected.

The innovations suggested in the construction of the SM8 allow users to save working force, ensuring the possibility to use them even in complex conditions. Currently, it is the only system in which the use of metallic flooring can be integrated with crossbars and access stairs to operate safely.

#### **8.5. Calculating the bracing fitting**

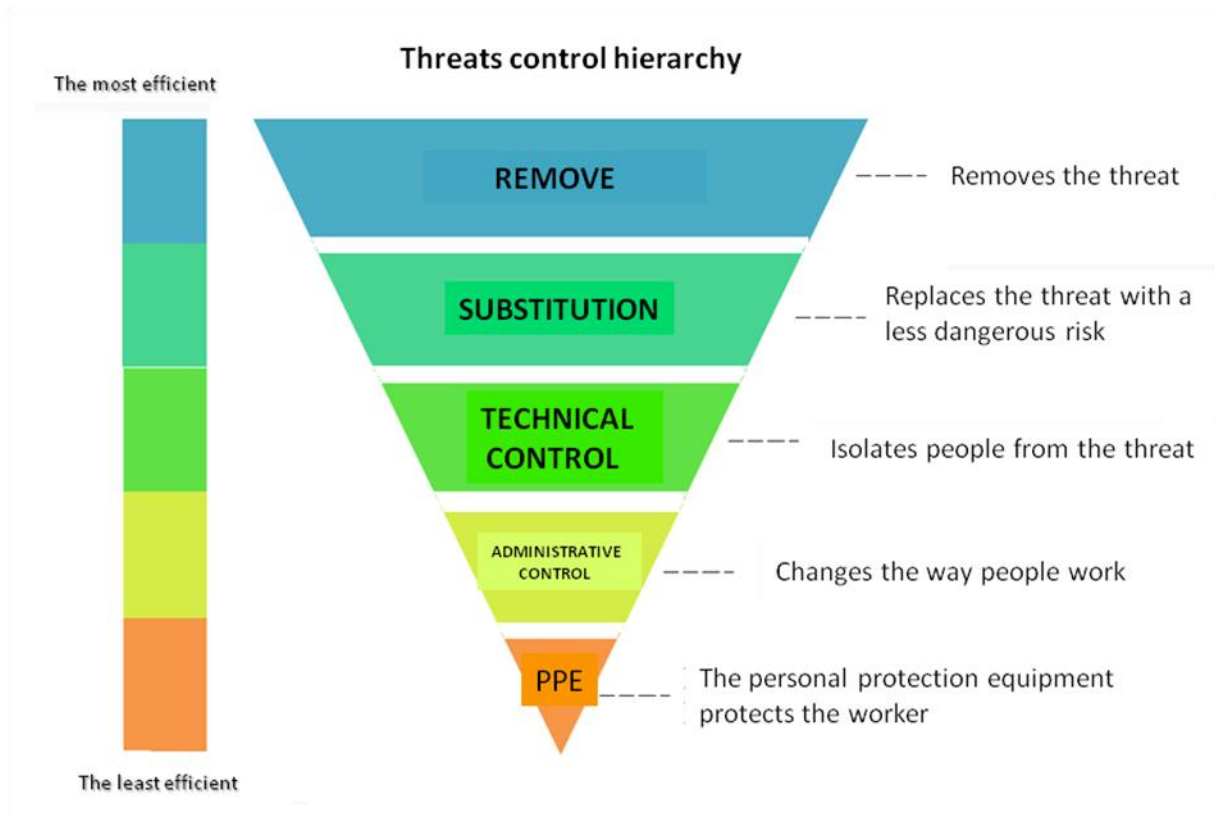
For the calculation we shall take into account the attached diagram which provides 7 levels, with a distance of 2 meters between them with a total height (measured from the support plan of the adjustable feet to the inner part of the highest plane (with the floor) of 20,00 m. The formulas used for calculation the scaffolding design were adapted according to the model proposed by the manufacturer Marcegalia on respecting the EN 12811 Norm.

The following diagonals are provided:

- a. - on longitudinal plane, the diagonal function is exercised by a plan bracing made up of an element like the parapet grill for each plan and field;
- b. - on horizontal transversal plane, the function of the diagonal is exercised by 2 metal bridge decks, for each field and plan arranged to create a continuous platform;
- c. - on vertical transversal plan, the plan bracing function is performed by the same frames of the scaffolding.

#### **8.6. Perspectives on the control of losses using the hierarchy of controls**

When it is used the threats control hierarchy, there should be avoided the *Five mistakes* [63] setting as examples in picture 8.6.



Picture 8.6. Mistakes on applying the controls hierarchy – the reverse pyramid

### 8.7. Conclusions

The main goal of safety is to have zero work accidents. The goal of "Zero" means zero deaths, zero injuries and zero incidents. Safety is a personal, shared and cultural value. Safety is the culture that truly values ethical and safe behaviour.

In this chapter, the research was focused on explaining what is meant by tolerable risk, in terms of workplace safety issues. It should be noted that tolerable risk is defined as bearable risk in a specific context based on current societal values.

The method of applying the "hierarchy of controls" in selecting of protective equipment is presented. PPE offered in the organization are selected according to the risk factors assessed for the operations performed by the workers.

The hierarchy of controls method was applied in selecting PPE, indicating the actions that must be taken, as well as the way to remove the danger for each stage separately. The hierarchy of controls was also applied in the case study carried out regarding occupational safety in the field of interventions at electrical installations on construction site, the analysis emphasizing the actions to be taken and the way to remove the dangers, to ensure the protection of the service/maintenance electrician teams.

Potential dangers in the use of bracings and scaffoldings have been identified and there are listed measures to minimize the risks. If, after using the control measures presented, a risk is still present, the following additional measures are considered to minimize that risk:

administrative controls, use of PPE such as hard hats, hand protection, and high visibility protection and vests. In the case of research undertaken during the thesis "installation of ventilated facades", it is important the safe way to reach the work front. We set the focus on assembling scaffoldings as safe as possible for workers, taking into account the materials that are used for work, that is, their weight and volume. No scaffolding will be erected without an approved project and without authorized installers.

Scaffoldings are an integral part of the construction industry, with approximately 65% of workers performing the activity on scaffolding, which is why the 4 major threats associated with bracing or scaffolding safety have been analyzed in detail: falls from height, overturning/falling of the entire bracing/scaffolding, hitting workers/visitors by falling materials from the scaffolding, electrocution.

The technology for assembling a scaffold was developed starting from the four major threats identified in the analysis of the safety factors of the scaffold. Calculations were made for assembling the scaffolding on the facade, trying to reduce/remove the respective risks, for a specific case of a construction site in Bucharest. The designed pluriocagonal SM8 system offers the possibility for the scaffolding to extend in all directions, adapt to all heights, and also vary the interaction between the pillars, depending on the needs of different capacity or adapting to complex types of structures.

The innovations brought in SM8 allow users to save working force, ensuring the possibility to use them even in complex conditions. Currently, it is the only system in which the use of metallic flooring can be integrated with crossbars and access stairs to operate safely.

## **Chapter 9. Final conclusions and main contributions to identifying and monitoring specific risks on construction sites with atypical volumes for buildings with ventilated facades**

(1) From the analysis of the current state on the specific safety and health requirements, regarding the technique and the way of setting the means of collective protection and of the work equipment that are used in the construction works, there were drawn important conclusions, which are presented in chapter 3.

(2) Considering the data and conclusions from the analysis of the current state regarding the identification and monitoring of specific risks in construction sites with atypical volumes for buildings with ventilated facades, the directions of research and development as presented in § 4.1 are considered to represent the right perspective.

(3) In relation to the current state and the research-development directions on identifying and monitoring the specific risks on construction sites with atypical volumes for buildings with ventilated facades, it was determined as the main objective of the research and development activity within the doctoral thesis (see. § 4.2): the design of an effective control hierarchy model for working at height, as well as the design, elaboration and testing of a bracing/scaffold assembly technology under maximum safety conditions. The general

objective of the research activity of this doctoral thesis is to identify measures to protect the life, integrity and health of workers against the risks of accidents and occupational disease that may occur at the working place on construction sites with atypical volumes for buildings with ventilated facades and to create the working conditions meant to ensure their physical, mental and social comfort.

(4) The relevant conclusions regarding the research and development doctoral activity to achieve its main objective, in relation to the methodological reference elements (see § 4.3), are as follows.

○ *Safety and health at work stand for one of the most important areas of social policy in the European Union. Statistics at the European Union level show that every three and a half minutes, a person dies in the EU due to work accidents; this means over 170,000 deaths annually, resulting from work accidents (9,100) or occupational diseases (158,000). It is not only for these reasons that it is necessary to study the safety and health at work as a discipline and it must begin on knowing the general issues, focused on the risks of occupational accidents and diseases that may occur in the working processes and on the main measures to remove them or mitigate them.*

○ *Safety and health at work are integrated into the wide activities through which any state ensures the social protection of its members, as an essential component for guaranteeing a certain level of quality of life. More precisely, the safety and health at work ensure the protection of workers against the risks to which they may be exposed in the working processes.*

○ *Safety and health at work implies the existence and operation of a multidisciplinary system of theoretical concepts, legislative deeds, measures and technical, social-economic, organizational, hygiene and occupational medicine measures and means, etc.*

○ *From the study of the specialized literature and following the results obtained in the research regarding the increase in the level of safety and health at work on construction sites for buildings with ventilated facades, the following final conclusions can be formulated:*

- Currently, living with professional risks requires the application, within organizations, of some principles of safety and health at work, which aim to avoid or mitigate the risks of occupational accidents and diseases.
- Occupational risk refers to the likelihood and severity of an injury or disease that occurs as a result of exposing to a threat.
- From a preventive point of view, risk refers to the probability of occurrence of negative, unwanted and non-economic events, such as production interruptions, technical breakdowns, work accidents or catastrophes.
- Risk factors are specific factors (attributes, states, processes, phenomena, behaviours) to the elements of the working system, which cause, under certain conditions, work accidents or occupational diseases. The action of the risk factors is influenced by the duration or frequency in time to which the performer (worker) is exposed and the level of exposure.

- Risk identification is one of the essential stages that must be undertaken to remove or mitigate professional risks.
  - *For each risk, it is important to identify the people who may be affected. This will help finding the best way to manage the risk. Both workers who come into direct contact with the risks and those who come into indirect contact will be taken into account.*
  - *General measures to fight risks are applicable to all risk categories and consist of:*
    - endowing technical equipment with means of collective protection
    - employees' training
    - monitoring the workers' state of health
    - adaptation the activity work to people
    - minimizing the workers' exposure period
    - working place hygiene
    - endowing workers with adequate personal protection equipment (PPE).
  - *The prevention of work accidents and occupational diseases represents a set of procedures and measures, taken or planned at all stages of elaboration, design and development of work processes, in order to remove or mitigate the risks of occupational accidents and diseases. The prevention of work accidents and occupational diseases is achieved through: organizational measures, technical measures, integrated protection measures. The technical measures are grouped into three directions of action: inherent protection; collective protection; individual protection.*
  - *Inherent protection represents the action undertaken, from the stage of elaboration and design of the means of production or the working process, which aims to prevent the risks of accidents and occupational diseases, through technical and ergonomic measures. Inherent protection is a security measure that consists of:*
    - avoiding or mitigating risks as much as possible, through the adequate selection of some design features (e.g. shape, placement, assembly, operating principles, etc.);
    - limiting the worker's exposure to risks that cannot be avoided or that cannot be mitigated by limiting access to dangerous areas.
  - *Through the optimal selection of inherent and collective prevention measures, the risks can be removed by achieving full protection. In some working places, it is not possible to completely remove risks through inherent prevention or collective protection, therefore, it is necessary to ensure individual protection. Individual protection is a complementary measure to inherent and collective protection measures.*
  - *Individual protection consists in the use of individual protective equipment, being ensured when the worker is equipped with PPE adequated for the working place, which prevents any accident or professional disease having objective causes.*

- *Personal protection equipment may only be used for the purposes specified and in accordance with the instructions chart. The instructions for use are developed by the PPE manufacturer and are in accordance with the European and national standards in force. These instructions must accompany each PPE supplied by the manufacturer.*
- *The conditions of use, respectively the duration of wearing a PPE are established by the OHS specialists depending on:*
  - the seriousness of the risk,
  - the frequency of risk exposure,
  - the characteristics of the working place,
  - the performance of individual protective equipment
- *The workwear equipment plays an important role in the category of work means and can be found in almost all activities performed by workers. According to the European Union technical regulations, manufactured and used the workwear equipment must respect the following:*
  - comply with the standards in force,
  - have a declaration of conformity or a certificate of conformity,
  - have a technical manual translated into the user's language,
  - have instructions for use,
  - bear the CE conformity mark.
- *The workwear equipment can create dangerous zones for the worker, both inside and around them. For these reasons, since the design stage, there are provided safety and health requirements for the worker. These requirements are conceived as to ensure the safety of the worker, including during their execution and exploitation stage.*
- *The general requirements applicable when using the workwear equipment are:*
  - WE will be arranged and installed in such a way as to allow the mitigation of risks for users and other workers;
    - WE will be installed only by qualified and competent persons.
    - WE assembly and disassembly will be carried out according to the instructions provided by the manufacturer.
    - if there is a risk of breaking, detaching some elements of the WE, adequate protective measures will be taken.
    - the operating status of the WE protection, warning and signalling devices will be permanently checked.
- *Training is a necessary and mandatory procedure, it will be carried out before using a workwear equipment. The training procedure consists in disseminating information with the help of informal materials as well as the OHS own instructions.*

(5) To achieve the main objective of the doctoral research-development activity, this very doctoral thesis brings a series of contributions, out of which I present you the most important.

- systematization of knowledge regarding the current level of collective protection encountered in practice on construction sites;
- carrying out a comparison of the European legislation with the national legislation and from another European country (Spain), highlighting the elements for which there is no correspondence and application in the Romanian legislation;
- clarification of some aspects related to the fundamental principles of the so-called "new approach" regarding **European Standards**, representing an innovative method of technical harmonization by sharing responsibilities between the European lawmaker and the European standardization bodies;
- carrying out a study on the specific technical requirements for collective protection means according to standards UNE EN 1263-1:2004 and UNE-EN 13374:2004;
- it is presented a hierarchy controls model for working at height, with a detailed analysis of each stage, indicating the adequate solutions;
- the initial and mandatory requirements in the design of fixed and mobile scaffolding are indicated, as well as the correct way of assembling/disassembling them safely on the construction site;
- there were analysed the fall restraint and fall arrest systems and elaborated instructions for usage, inspection and maintenance;
- two cases of mistakes that can occur in working at height were exemplified, regarding the use of an incomplete protection system and the incorrect use of PPE, indicating the correct measures to be taken;
- there was carried out a study on the knowledge of the role of occupational medicine doctor and medical services among workers, by creating a synthetic questionnaire, completed by about 100 workers from 6 different construction sites (see § 6.7).
- it was performed a centralization of the record of medical examinations carried out between the 2017-2021 on a construction site in Bucharest, on highlighting the peak medical conditions;
- a questionnaire was drawn up to verify whether the workers understood and identified the risks to which they are exposed on the construction site, to which a number of 100 workers, of various trades, from 6 construction sites responded;
- there was performed a case study to identify and assess the risks for the job "builder and assembler of metallic structures-ventilated facades" (see § 7.4);
- clarifying some aspects related to applying the "hierarchy of controls" in selecting the protection equipment, indicating the actions that must be taken, as well as the method of removing the threat for each separate stage (see § 8.1);

- carrying out a case study regarding occupational safety in the field of interventions at electrical installations on the construction site, applying the control hierarchy (see § 8.2., 8.3);
- the design and elaboration of the technology of assembling a scaffold starting from the four major threats identified in the analysis of the safety factors of the scaffold: falls from a height, overturning/falling of the entire scaffold/bracing, hurting workers/visitors by falling materials from the scaffold, electrocution (see § 8.4);
- calculations were made for assembling the scaffolding on the facade, trying to mitigate/remove the respective risks, for a specific case on construction site in Bucharest. The designed pluriocagonal SM8 system offers the possibility for the scaffolding to extend in all directions, adapt to all heights, and also vary the interaction between the pillars, depending on the needs of different capacity or adapting to complex types of structures. Innovations in SM8 allow users to save working force and be used even in complex conditions. Currently, it is the only system in which the use of metallic flooring can be integrated with crossbars and access stairs to operate safely (see § 8.5).
- it was conceived a height working procedure which establishes employers' tasks and responsibilities in the following order: Avoiding height working, Insuring that all those who work on height are Adequately trained and supervised, Selecting the safest workwear equipment to prevent falling from height, Making sure that the workwear equipment is in conformity with the workload and it is Stable, Regular verification and Maintenance of the related protections, Insuring the Personal protection equipment and the Height protection one of harnessing type or belt, as well as the connection elements, Insuring a safe working environment under any working condition, Elaborating a Saving Plan in case of height fallings (v. § 8.6).

\* \* \*

This doctoral thesis, due to the presented issues, approach and results, develops the conditions for deepening and applying the process of identifying and monitoring specific risks on construction sites with atypical volumes for buildings with ventilated facades, through theoretical and experimental research, whose results were communicated and validated in various scientific events organized both in the country and abroad. Out of these conclusions, there shall arise future scientific theories related to the fact that safety and health at work involve the existence and operation of a multidisciplinary system of theoretical concepts, legislative deeds, measures and technical, social-economic, organizational, hygiene and occupational medicine.

The scientific importance of this doctoral thesis is supported by the contributions made to the design and elaboration of the technology of assembling a scaffold starting from the four major threats identified in the analysis of the safety factors of the scaffold, to the definition of the calculation algorithm of a scaffold trying to mitigate /remove the specific risks of working at height, when drawing up a questionnaire to verify the degree to which the workers understood and identified the risks to which they are exposed on the construction site. The research



undertaken brings new elements, enriching the knowledge regarding the current level of collective protections found in practice on construction sites, clarifying some aspects related to the fundamental principles of the innovative method of technical harmonization by sharing responsibilities between the European lawmaker and the European standardization bodies.

The practical importance of this doctoral thesis lies in the fact that the innovations brought to the pluriocagonal SM8 system designed allow users to save working force and be applicable even in complex conditions, currently being the only system in which the use of metallic flooring can be integrated with crossbars and access stairs to operate safely. The data obtained confirm the existing knowledge in the specialized literature, validate the scientific theories that are currently applied in the field of OHS, emphasizing once again that the identification and monitoring of specific risks on construction sites will continue to remain a research area both from a theoretical point of view as well as experimental. The researches carried out represent a scientific and practical material useful to students, professors, organizations, specialists in the field of occupational health and safety.

The issue of identifying and monitoring specific risks on construction sites with atypical volumes for buildings with ventilated facades calls for a research activity – a continuous and analytical development, to determine the means of fighting risk factors during working processes, likely to cause work accidents and occupational diseases, for setting up public bodies for control and guidance of preventive activity, which have at their disposal the legal, technical and financial means.

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The translation of the submitted document has 50 pages.

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