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FACULTY OF CIVIL ENGINEERING
Department of Construction Technology

MASTER THESIS

Occupational Safety and Health on Skyscrapers Constructions

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2017

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I hereby declare that I wrote this master thesis independently only under mentoring of the supervisor of the thesis Ing. Rostislav Šulc, Ph.D and using only the sources and literature listed in references.

In Prague January 7, 2017

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1. The state of the art of OSH management in the Czech Republic and the People's Republic of China.
2. The state of the art of current legal regulations and standards for the Czech Republic and the PRC.
3. Historical development of OSH management on skyscrapers constructions in the Czech Republic and the PRC.
4. Historical development and current situation of skyscrapers constructions in the Czech Republic and the PRC.
5. Comparison of OSH management on skyscrapers constructions between the Czech Republic and the PRC at specific construction projects. Defining differences, pros and cons of each system regarding to their effectiveness.
6. Recommendations for improving both systems of OSH management.

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ANNOTATION

As civil engineers complete new goals in building higher with reaching new boundaries, at the same time they have to concentrate on building safer. This thesis deals with issues of safety on constructions of high-rise buildings. It is divided into three main parts, first there are described skyscrapers and their history in general, the second part is about safety, its development and especially specific issues connected to construction work in height, at the end there is an example of implementation of safety measures to a specific project.

KEY WORDS

SKYSCRAPERS

HIGH-RISE BUILDINGS

OCCUPATIONAL SAFETY AND HEALTH

CONSTRUCTION SAFETY

SAFETY MANAGEMENT

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1. INTRODUCTION

In my thesis I would like to focus on occupational safety and health (OSH) in the construction industry. I had an opportunity to write my thesis at the Zhejiang university in the People's Republic of China (PRC). There is an incredible diversity in construction industry between the Czech Republic (CR) and the PRC. The Zhejiang university is located in Hangzhou, it is close to Shanghai where the second tallest building in the world and many others skyscrapers are located. In Prague the maximum height of a building is 109 m, in Shanghai it is 632 m. [33] Because of this fact I want to concentrate on OSH at skyscrapers construction with my thesis. Goals are to compare the differences between the PRC and the CR, to describe specific issues on skyscrapers and their solutions, and to look for safety measures that could be applied on construction sites back in the Czech Republic.

2. THE SKYSCRAPER

2.1. Definitions

The skyscraper can be defined in various ways depending on the point of view. Often a skyscraper is also called a high-rise building. Basically it is a very tall building, from its name scraping the sky. But how tall is enough for calling a building a skyscraper?
We are mostly defining buildings by its height in meters or number of floors, but important is an effect on observers too. A tall building won't have the same effect when surrounded by many taller buildings as in a city where it is the highest one.

2.1.1. The Council on Tall Buildings and Urban Habitat

The Council on Tall Buildings and Urban Habitat (CTBUH) is the world's leader in informataion on tall buildings. It is an international not-for-profit organization, founded in 1969. With support by professional architects, engineers, and urban planners it facilitates the exchange of the latest knowledge available on tall buildings around the world. The Council developed the international standards for measuring tall building height and is recognized as the arbiter for bestowing such designations as "The World's Tallest Building". Its free database on tall buildings "The Skyscraper Center" available at http://www.skyscrapercenter.com is daily updated. Beside the website they also publish many books related to the topic and quarterly the CTBUH Journal, a calendar offers information about events such as world congresses, conferences, symposia, and workshops. [8]

Figure 2.1. The CTBUH Logo [8]

2.1.2. The CTBUH Height Criteria

According to the CTBUH we can consider as tall buildings those who have at least 14 stories or more than 50 meters.

There are already more than 3 700 buildings over 150 m completed worldwide. [33] For more precise resolution the CTBUH defines also "supertall" as a building over 300 meters in height, and a "megatall" as a building over 600 meters in height. Unlike large number of tall buildings, the number of supertall is noticeably lower only 110 buildings completed in November 2016 and megatall are just three (Burj Khalifa in Dubai, Shanghai Tower and Makkah Royal Clock Tower in Mecca) and other three megatall are under construction (Jeddah Tower, Wuhan Greenland Center and Merdeka PNB118 in Kuala Lumpur). Interesting numbers are that from all supertall buildings completed or under construction, the whole half is in the People's Republic of China. Although the USA are the cradle of high-rise buildings only one tenth of supertall buildings is located here, mostly in the New York City. [32]

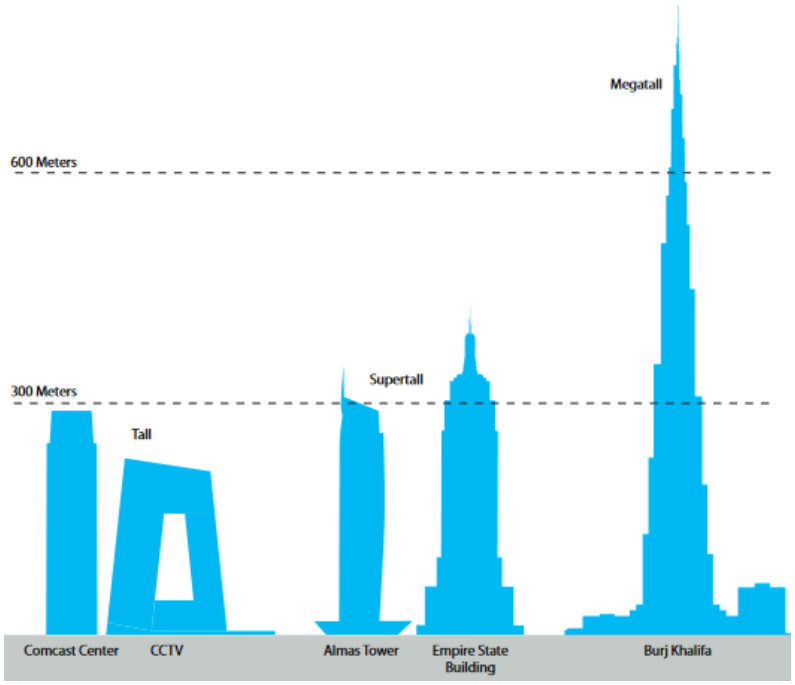

Figure 2.2. Tall, Supertall and Megatall Buildings [32]

Height can be measured in three measurement points:

- the architectural top (used for the CTBUH ranking),
- the highest occupied floor.
- the tip (including functional-technical equipment). [32]

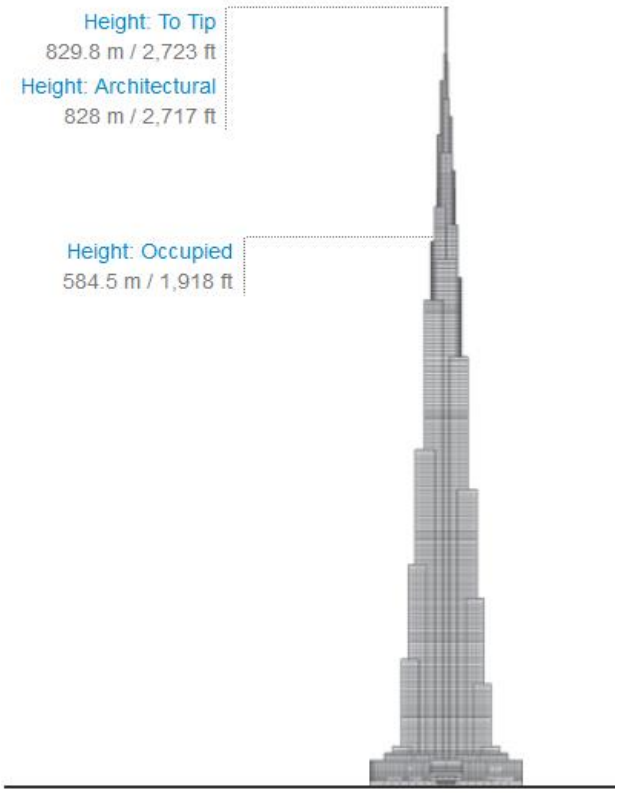

Figure 2.3. Height Measurement Points [33]

2.2. Why build up?

There are many reasons why we are trying to build taller buildings.
In the first place is the money. In highly built-up areas as Shanghai are developers trying to get maximum out of their land due to the high price per square meter. In Prague there are still undeveloped areas so there is not so much pressure on the height.
The second reason is for world companies with a large budget to show up. Headquarters building can be kind of an advertisement and a proof for customers and partners that this company is doing well.

2.3. Designing Skyscrapers

There are many points to be deeply considerate while planning a new skyscraper construction. The first is to decide the building appearance and distribution of a space. Therefore, following questions must be answered by developer and architect:

- Is the building designed for offices or apartments?
  Follow-up with decision if the building will suit also retails and restaurants.
- Will there be underground parking, how many parking spaces is needed, on how many floors?
- Will there be just a single user or more?
- Who is the target market if known? A general corporate market or specified businesses?
- Will tenants be large companies renting several floors or small occupants with a floor or even less?
- What clear ceiling height is needed for each office floor?
- Questions related to green building issues.
- What are available energy sources and what are their costs? [28]

2.3.1. Structural Systems

Answers to the questions above strongly influence a structure and a mechanical design, a vertical transportation, plumbing and electrical systems and available space for their location. Main issues are to decide whether the structure will be steel or reinforced concrete, followed by core design and floor-to-floor height.

- **Structure**

  A steel structure can shorten construction time, because it can be ordered in an advance and erected immediately after foundations are prepared, it allows more flexible space design, it can handle future changes in loading by reinforcing and reframing and its weight is lower than the weight of a reinforced concrete which influences costs of foundations.

- **Core Design**

  The core design is extremely critical because it has to resists large part of a wind and seismic load to which building will be exposed at the same time it has to meet space needs of tenants as well as space needs of mechanical and electrical systems. The core strongly influences available renting space, so it has to be designed very effectively. Possible locations of the core are: central core which is the most common solution, in some cases a single-sided core can be designed, or multiple cores might be needed. Although main function of the core is to incorporate fire stairs, vertical transportation elements, restrooms, electrical and communication closets, air shafts, space for risers etc., its alternative function is a structural support. In warm regions can even help with insulation of the interior by locating core to east and west sides. The percentage of gross area may define effectiveness of core design but with comparison to total floor area, although on large floor effective core can take 15-20% of gross area, on smaller floors it can be up to 30%.

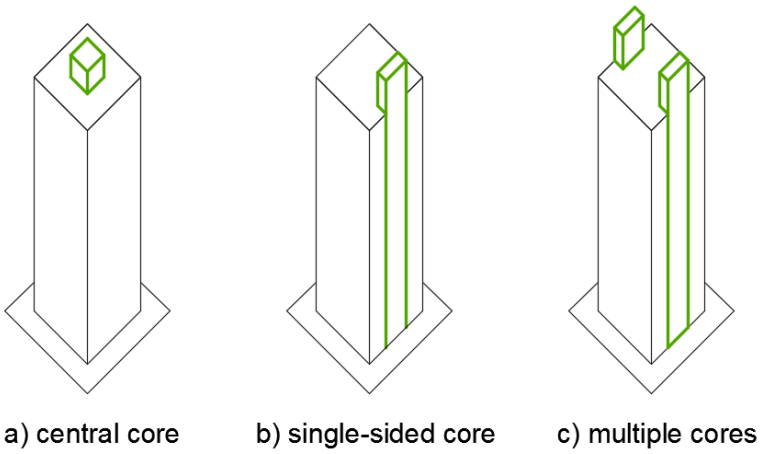

Figure 2.4. Core Locations

- **Floor-to-floor Height**

  This height strongly influences costs of exterior wall and length of other vertical elements, a small difference in few centimeters per floor rise by multiplying with the number of floors and circuit of the building. The height of each floor with special function as dining facilities, stores, data centres etc. should be considerate separately from offices. The most common values of ceiling height are between 2.6 and 2.75 meters, in China new average minimum standard is 3.00 m, which means floor-to-floor height for all new tall commercial buildings between 4.4 – 4.5 meters. Important factor is the decisions whether to include or not a raised floor. [28]

3. HISTORY OF SKYSCRAPERS CONSTRUCTION

3.1. Late 19th Century in the USA

The journey for the conquest of the skyline began in the New York City in 1880s. The first “skyscraper”, Tower Building, was constructed in Broadway and had 11 stories. “The architect, Bradford Lee Gilbert, realised that supporting a super-tall building using conventional techniques would require walls so thick that there would be little floor space left. So he created an iron frame for the building, after which the only function of the walls was to keep the rain out.” [34]

On 22nd May 1888 another American architect Leroy Sunderland Buffington received his patent for a system for skyscraper construction. The concept was to use load-bearing iron frames. He designed 28-storey building. [2]

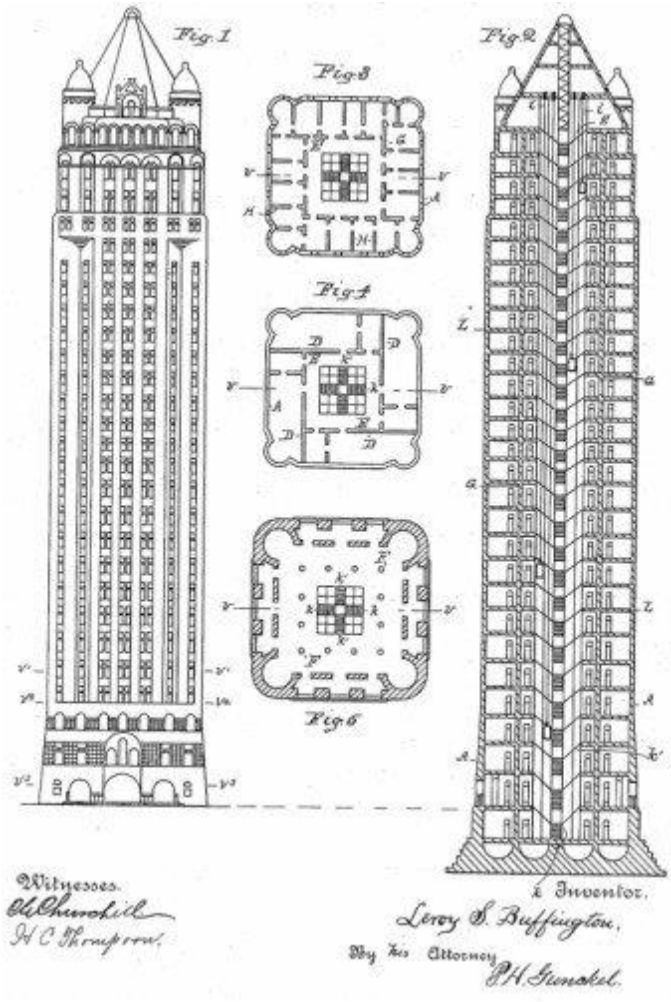

Figure 3.1. Leroy S. Buffington's Architectural Patent [2]

3.2. Skyscrapers in the Czech Republic and Europe

The Czech Republic currently has only 12 tall buildings. The first one was completed in Prague in 1959, this is 80 meters high building of Telefonica O2. Only three buildings reached 100 meters boundary, the tallest one is AZ Tower in Brno (111 m) and the other two, City Tower and City Empiria, are in Prague. [33]

Figure 3.2. AZ Tower [24]

Actually whole Europe has low number of skyscrapers comparing to America, Asia and Middle East. Only five supertall buildings are completed and from that four are in Moscow and just one in London, this is iconic tower redefining London skyline The Shard. [33]

Figure 3.3. The Shard

3.3. Skyscrapers in the People's Republic of China

Chinese construction industry is rapidly developing and with it grows also a number and height of Chinese skyscrapers. Shanghai is the city where the first Chinese tall buildings were build, the very first one was Peace Hotel in 1929. This luxury hotel stands on The Bund which is a historic part of the city centre, across the Huangpu river from here is Pudong District with skyscraper-stuffed skyline. Among the others here currently stands the world's second tallest building, Shanghai Tower (632 m), creates signature trio of the skyline with Jin Mao Tower and Shanghai World Financial Center. Construction project of the Shanghai Tower reached several records and was highly focused on sustainability. [33]

Shanghai's Tower Points of Interest:

- the first Chinese building rising over 600 m, it has 127 floors above ground and 5 floors below,
- the tallest green building, LEED Core & Shell Platinum Certified,
- world's fastest elevators with speed 18 m/s, these allows to reach observatory in height of 546 meters in just 55 seconds,
- the heaviest single building, 850 000 tons, built on soft-ground foundation,
- V Shape Notch in the curtain wall winding up along the building accentuates the spiralling geometry, enhanced by LED lighting display,
- the world's heaviest damping system (1 000 tons),
- the highest wind turbines, 270 turbines installed at a height of 565 – 578 m with total capacity of 1,19 million KWH,
- curtain walls system,
- the highest swimming pool with a view,
- the first high-rise to have cloud data computing center,
- world record by pumping concrete at one-time to reach a height of 620 m.

Figure 3.4. Shanghai's Skyline [33]

Another important skyscraper is under construction in China, Wuhan Greenland Center will overgrow by several meters Shanghai Tower. Outside mainland of the PRC Taiwanese TAIPEI 101, these days the third tallest building in Asia, it is a symbolic skyscraper as the number 101 represents the first day of the year 1st January and its shape is evoking the form of a Chinese pagoda. [33]

Figure 3.5. Taipei 101 [33]

3.4. Reaching One Kilometer Boundary

The future tallest building of the world and first building crossing magical milestone of 1 000 m height is currently under construction in Jeddah, Saudi Arabia. It will replace on the first place Burj Khalifa in Dubai, which reaches height of 828 m and was completed in 2010. Before Burj Khalifa the leader was Taipei 101 which was the first to reach 0.5 kilometer height. The project of the Jeddah Tower is exceptional in many ways. Its value is 1,2 billion USD. Covered area of almost 244 thousand m^2 in 167 above ground floors will include a large retail centre, conference centre, Four Seasons hotel, 3 lobbies, apartments, offices and luxury residences. It will contain 65 elevators with maximum speed 10 m/s. Construction started in 2013 and project is planned to be finished in 2019. [33]

Figure 3.6. Jeddah Tower [33]

4. THE SAFETY

4.1. Safety Management

Each construction site has a specific safety plan developed by a construction manager or a general contractor. Compliance of the plan is responsibility of a site safety manager. Content of the plan might be ensuring, maintaining and inspecting proper equipment, holding safety meetings, training workers, an investigation of accidents and actions to minimize its appearance.

Injuries and fatal accidents in the construction industry have a widespread impact on the contractors whose workers are injured on the job site. When an accident occurs it leads to a threat to human life, a possibility of economic losses and a time delay of a project. When a major accident does occur on the job site, the construction manager must be prepared to act immediately according to the seriousness of the injury, he should have an on-site team trained to act in an emergency situation. Contact list with emergency numbers should be available on-site and in a construction manager office and should include contact informations to hospital, doctor, police, firefighters, building department, company safety director, local first aid center and site safety manager. [26]

4.2. Risk Management

Risk is frequency or probability of occurrence of a hazardous event and its consequences. Each process and decision is connected to some risk. Risk management is part of project management in each project phase. It contents of risk analysis, assessment, treatment, review and monitoring. Goal is to avert potential danger.

- Risk Analysis

  During analysis all potential risks are identified and listed, used methods and materials are brainstorming, questionnaires, questioning experts, historical data, existing lists, experiences etc.

- Risk Assessment

  For risk assessment is important the size of impact of potential loss and probability of the loss. It cannot be measured precisely, e.g. methods of multi-criteria decision making can be used.

- Risk Treatment

  Depending on the probability of occurrence either risk retention or active risk management is applied. As treatment can be used an insurance, a risk sharing or a transfer, financial market tools, a diversification, creation of reserves or expert estimates.

- Risk Review and Monitoring

  Review and monitoring are processes of regular identifying new risks, revision of existing risks, controlling and reporting.

During construction risks might be in project documentation, construction itself, cost overruns, site contamination, environmental impact, power supply interruption, availability and ownership of a site, archaeological or cultural heritage. [23]

A list of risks affecting costs of a construction project:

- Injury to valuable workers,
- tragic deaths,
- liability insurance increases,
- builder's all risk insurance increases,
- worker's compensation rate increases,
- delay of the project,
- investigation by local authorities,
- potential lawsuits,
- depositions that also require extensive time away from the project,
- fines and penalties,
- loss of productivity,
- investigation reports required, which take valuable time away from the project manager and superintendent,

- retention of new workers to take the place of injured workers (lost time for getting up to “speed” on the work involved),
- new workers training,
- work reschedule,
- paying of wages while an injured worker is out on leave,
- any repair or replacement caused by the accident,
- increase in bonding premiums or total rejection by the bonding companies. [26]

4.3. Construction Safety Factors

We can identify four general factors affecting construction safety:

- Policy
  All project managers have to follow legislation framework. Crucial is to have very well processed legislation base by government. Advanced option of improvement is in securing Occupational Health and Safety Management System certification.

- Process
  The most challenging about the process is to manage the large number of subcontractors and unification of safety policies. Main contractor can pass on subcontractors safety responsibilities but has to make sure they are capable to provide safe working environment.

- Personnel
  Workers bad behaviour and poor attitude is difficult to control. Supervision is the task for safety and site managers. Safety training need to be taken more seriously and first aid training should be added.

- Incentives

  Most often used are monetary incentives. Although all contractors don't agree it is the right way to insure better safety, in some companies its implementation brings results. Individual attitude directly affects success of bonus policy. [5]

4.4. Accidents

Accidents on construction sites are caused by:

- unsafe working conditions at heights,
- stepping on, striking against or tripping over objects,
- poor lighting conditions,
- burial by earth collapse during excavation,
- collapse of scaffoldings and working platforms,
- hazards in lifting operations,
- electrocution,
- fire hazards,
- lack of proper access,
- inadequate education and training.
- engagement of poor tools and equipment. [5]

In the PRC several work-safety accidents happened recently, it is blamed on corruption, weak regulations and pressure to increase production. The worst safety accident in last two years was on 24th November 2016 when scaffolding collapsed during construction of a 165 meters high concrete cooling tower in eastern China and killed 74 workers. [1]

4.5. Legislation

In this chapter are listed both Chinese and Czech laws connected to the issue of occupational safety and health and described its important points related to OSH at height.

4.5.1. Czech Legislation

Default rule for safety is defined in Act No. 89/2012 Coll. the Civil Code: "…everyone is obliged to behave in their actions so as to avoid unreasonable harm to freedom, life, health or property of another." [35]

In law of the CR is Occupational Safety and Health regulated in particular in following laws:

- Act no. 262/2006 Coll. Labour Code,
- Act no. 309/2006 Coll. ensuring other conditions of OSH,
- Act no. 251/2005 Coll. The Labour Inspection.

For the construction industry main implementing regulations are:

- Government Regulation no. 591/2006 Coll.
  specific minimum requirements for OSH on construction sites,
- Government Regulation no. 362/2005 Coll.
  on detailed requirements for OSH at workplaces with danger of falling from height or to depth. [31]

Act no. 309/2006 Coll. determines OSH conditions in employment relationships and outside them. Among other things closer deals with OSH conditions at construction sites. OSH coordinator has to be on each construction site with more than one contractor. [36]

Government Regulation (GR) no. 591/2006 Coll. specifies minimum requirements for OSH on construction sites, essentials for notice about work initiation, work with increased danger on life or health, other activities compulsory for OSH coordinator and requirements for OSH project. For all constructions where is risk of fall from height or to depth 10 m and above OSH project is required. That should be main tool helping OSH coordinator to coordinate all measures securing safety, containing procedures proposed for individual work activities. [18]

GR no. 362/2005 Coll. specifies work conditions which is employer required to ensure on workplaces where danger of fall from height or to open depth appears. These conditions are that employer has to ensure protection against the fall for all workplaces in the height 1,5 m and above. He must prioritize collective protection over individual. All holes with at least one dimension over 0,25 m has to be covered immediately after its formation or there has to be fall protection installed on its edges. All surfaces not secure against breaking has to be secure against forfeiture. Working height cannot be increased by unstable objects and others intended for different use. Work at heights can't be done while adverse weather conditions might endanger lives of employees. [19]

4.5.2. Chinese Legislation

The legislative system of OSH in the PRC is based on the Constitution, saying that the State enhances occupational safety and health. System consists of laws enacted by the National People's Congress (NPC) and its Standing Committee, administrative regulations made by the Central People's Government of China (The State Council), local regulations by the People's Congress or its Standing Committee, departmental and local rules, and OSH standards. All these needs to be unified across the country and it is in charge of the Standardization Administration of China. [13]

Instructions for construction safety legislate State Administration of Working Safety (SAWS) and Ministry of Construction (MOC). There are three main laws related to construction safety:

- The Labour Law of the People's Republic of China,
- The Construction Law of the People's Republic of China,
- The Law of the People's Republic of China on Working Safety.

  "Construction units shall set up organizations or be manned with full-time persons for the control of work safety." [6]

And one important regulation:

- The Regulations on Safety Management in Construction Projects.

4.5.3. The International Labour Organization (ILO)

More regulations ratified by countries worldwide are provided by the International Labour Organization. This is the United Nations agency dealing with whole working environment. Since founded in 1919 in Versailles the ILO connect employers, employees and government in order to improve working and living conditions for everyone. It was even awarded the Nobel Peace Prize in 1969. Among other things law and policies, statistics and standards can be found on their website http://www.ilo.org/. The PRC is one of founding members of the agency. By its technical and advisory assistance and normative work cooperate with the Ministry of Human Resources and Social Security.

Figure 4.1. The International Labour Organization Logo [13]

Safety and Health in Construction Convention, 1988 (No. 167) is ratified by both the CR and the PRC. Article 18 about work at heights including roof works says:

"1. Where necessary to guard against danger, or where the height of a structure or its slope exceeds that prescribed by national laws or regulations, preventive measures shall be taken against the fall of workers and tools or other objects or materials.

2. Where workers are required to work on or near roofs or other places covered with fragile material, through which they are liable to fall, preventive measures shall be taken against their inadvertently stepping on or falling through the fragile material." [13]

4.5.4. Occupational Safety Health Administration (OSHA)

Occupational Safety Health Administration is American government organisation founded in reaction on number of accidents in construction industry, it is responsible for the USA Safety and Health Regulations for Construction but they also publish a pocket guide "Workers Safety Series". Although Regulations are not mandatory worldwide, informations, guides, rules can be applied on all constructions to improve its safety. [26]

5. DEVELOPMENT OF SAFETY

Even though improvements in construction worker's safety are increasingly implemented, the construction industry still has statistics that make it one of the most dangerous industries in which to work. OSH is a worldwide issue wherever a construction site take place.

First mentions about safety are in one of the oldest preserved law code of humankind. In The Code of Hammurabi dated to 18th century BC are paragraphs regulating punishment for builders. These regulations are from today's perspective cruel, but certainly effective.

Figure 5.1. The Code of Hammurabi [17]

§ 229 "If a builder build a house for a man and does not make its construction firm, and the house which has he build collapses and causes the death of the owner of the house, that builder shall be put to death.",

§ 230 "If it causes the death of a son of the owner of the house, they shall put to death a son of that builder."

§ 231 "If it causes the death of a slave of the owner of the house, he shall give to the owner of the house a slave of equal value". [9]

In medieval Europe appeared first indications of safety standards under feudalism thanks to guild organizations, organizations of journeymen etc. First real occupational safety standards caused the Industrial Revolution, which took place in the early 19th century. At this time began in manufacturing processes massively used machines and new technologies that replaced manual work, which raised number of accidents and injuries. [11]

5.1. Safety in the Czech Republic

In the Czech lands in 1300 king Wenceslas II released "Ius Regale Montanorum", the code for mining and processing of silver also containing rules to ensure safety work. For the construction safety were responsible carpenters, who were in charge of timbering shafts. Code with adjustments applied to 1854, when was issued a new Austrian mining code.

In 1518 was issued Mining Order of Jáchymov in which is firstly reflected an accident at work.

The year 1811 was the year when were firstly issued general rules for the Czech lands. The first regulations on work safety are recorded in the Civil Code of Austria "The Allgemeines bürgerliches Gesetzbuch" published during the reign of the Habsburg Monarchy. This includes the obligation of the employer to protect the life and health of employees. 1852 was also under the Habsburg Monarchy adopted Penal Code, which contained several provisions related to OSH. There were introduced penalties for offenses, when serious injury or even death of a person occurred.

Also supervision of work safety has a relatively long tradition. In some form factory inspection already existed between 1790 and 1825. It was restored in June 1883 by Act no. 117 of the Code of the Reich, which established Trade Inspection.

In 1888 was adopted a law on accident insurance of workers and Health Insurance Act a year later.

In 1918, after the establishment of independent Czechoslovakia, the Austrian trade laws were taken over and inspection, under the Ministry of Social Welfare, continued to operate until the 1952nd.

Major changes appears and overall view of the safety changes after World War 2. After it had been rapid industrial and technological development, which also developed high-pressure on efficiency of work and production and with that had been increasing rate of accidents of employees, which was associated with the need to ensure better work safety.

The coup occurred in the 60s of the 20th century. The pressure on the productivity of workers is increasing but they are not yet adequately prepared and have almost no experience. Increasing pressure on efficiency gives rise to completely new efficient enterprises. Also the speed of progress and all requests for changes in the working process of employees lead to high demands on the quality of products and goods. This can be achieved only by ensuring safety and reliability of production, which is associated with security and protection of human health and lives. Here, finally, is a real change in the understanding of safety at work.

In 1951, following the Soviet Union model, OSH Act was published putting supervision over work safety to united trade union organization. Replaced 10 years later by Act no. 65/1961 Coll., on occupational health and safety.

In 1968 a Law no. 174/1968 Coll. established a unified state professional supervision over work safety and technical equipment. This supervision had power to enforce compliance for both employers and employees.

In 1981 was hold a conference by International Labour Organisation. Here was adopted the " Occupational Safety and Health Convention". On this convention is also based OSH policy of the Czech Republic, after convention followed the "National Action Programme" that specifies particular, direct and timed tasks and the establishment

of the "Council for OSH", which creates better conditions to improve the level of OSH in the Czech Republic.

1 January 2001 was incorporated into the Czech law the system of the European Union ensuring health and safety. [11]

For the CR are statistics about OSH provided by Occupational Safety Research Institute, a public research institution founded by the Ministry of Labour and Social Affairs of the Czech Republic, data are available on website http://www.bozpinfo.cz/.
According to data of the Institute in 2015 number of fatal work injuries increased on the previous year by 16 cases and reached a total of 132 cases. A very common accidents causing death were falls of people (from the height, to the depth, from the stairs, etc.) and falls on person (objects, load, machinery, soil, etc.). These cause 33% (44 cases) of the total number of fatal work injuries.

Figure 5.2. Development of Total Number of Fatal Injuries in the CR in Last 10 Years [21]

The construction industry has mostly the largest number of fatal injuries of all industries, the year 2015 was no difference there were 33 cases, same as in 2014. It is followed by manufacturing and the third place takes transport and storage.

In 2015 there were registered six falls from scaffolding, which in most cases was not complete, missing breakpoints, or even the railing. In one case, the scaffolding fell when the worker entered. Also four falls from roofs occurred. [21]

5.2. Safety in the People's Republic of China

One of the first mentions about assuring worker safety is from the Song Dynasty (1000 AD). Protective curtains were erected by carpenters during the construction of a wooden tower to prevent workers falling from heights.

In 1956 the State Council legalized three regulations the Factory Safety and Health Regulation, the Safety Technical Code of the Construction Installation and the Reporting Regulation on Injury Accidents of the Employees. These regulations decrease number of fatalities from 56 to 16.5 per 100 000 people in only seven years.

However during the chaos of the Cultural Revolution number rapidly increased up to 75 per 100 000 people in 1970.

After the revolution the government began to enact many new safety regulations and nowadays the PRC has a construction safety legislation framework. In 2001 was established the State Administration of Working Safety. [6] In 2010 there were 2,769 fatalities in Chinese construction industry. [13]

6. SPECIFIC OSH ISSUES RELATED WITH HEIGHT

At work in heights safety measures need to be taken against fall from open edge, slipping and forfeiture through roof structure. Further procedures must be designed for transport of material and specific ways of securing individual work activities in height. Measures against falling of workers has to be designed including the way of anchoring by individual protection if use of collective protection is not possible or sufficient. [18]

6.1. Fall from Height

Very common and the most frequent fatal accident is a fall from height. Various factors affecting causes and consequences of this accidents are described lower.

Workers might fall from:

- ladders,
- scaffolds,
- roofs,
- hole in the ground,
- moveable platform,
- non-moving vehicle.

As a prevention all fall hazards and potential tripping should be identified before work starts. Fall hazards might be an unprotected floor opening or edges, shafts, skylights, stairwells and a roof opening or edges. Further prevention is in selection, wearing and using fall protection equipment and its inspection for defects before use, securing and stabilizing all ladders before climbing them, use of handrails while go up and down stairs. [13]

- **Negative Force**

  A force exerted by the surface on the fallen person causes the adverse effect, it depends on height of fall, type of surface and fall protection systems.

  Three heights are recognized:
  - H1: h < 2 m,
  - H2: 2 m < h < 10 m,
  - H3: 10 m < h,

  and two types of surface:
  - G1: soft ground,
  - G2: hard ground. [20]

6.1.1. Fall Protection Systems (FPS)

Although we cannot change the strength of the gravity force, a height of fall and a type of surface are not negotiable, consequences of a fall can be positively influenced by FPS. There are two types, the first preventing workers from getting into the fall hazard area is called travel restrict system and the second fall arrest system which is employed to arrest worker's falls. For construction workers fall protection systems are further divided into individual and collective. Also we use active and passive systems. Health and safety manager has to design its right combination for specific conditions of a construction site and employers are responsible for ensuring a fall protection for their employees. [30]

- **Individual FPS**

  Also called personal fall arrest or restraint system. It consists of an anchorage point, a body support, a deceleration device, a lifeline and a lanyard. The anchorage bears forces during a fall. It is a point securing attachment of deceleration devices, lifelines or lanyards. Steel D-ring or eyebolt is common used but can be also more complex as posts and brackets or mobile devices as trolleys.

The body support is a gear dressed at worker with a D-ring on a back, old form is a body belt but full-body harness is more efficient as it spreads forces. The deceleration device is a mechanism limiting energy imposed on a falling person, such as a rope grab moving on a lifeline which automatically locks due a fall. The lifeline serves to connect a lanyard and an anchorage. Lifelines are vertical or horizontal. The lanyard is a strap connection between a body support and a lifeline or directly to an anchorage. It is preferable to use shock-absorbing lanyards. [4]

- **Collective FPS**

We can find probably the first known fall protection regulation mentioning the collective fall protection system in the Bible: "When you build a new house, be sure to put a railing round the edge of the roof. Then you will not be responsible if someone falls off and is killed." [7]

Its use gives workers more freedom of movement and therefore it is preferred. The most popular collective FPS are guardrails due to the freedom for workers and price.

Next are safety nets, floor or ground mats, work platform nets and others based on horizontal lifelines. Last and not so often used is administrative control. [30]

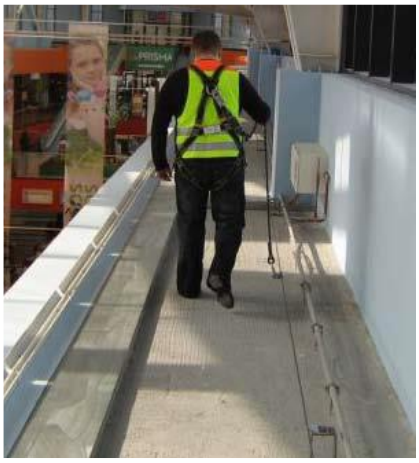

Figure 6.1. Horizontal Lifelines [15]

6.1.2. Guardrails

Guardrails are the most common version of collective protection due to its many benefits. It can be temporary or permanent from various materials.

Railing system benefits are:

- removing the risk of workers reaching a spot from where they could enter into a free fall situation,
- no training needed,
- no annual inspections and maintenance,
- no additional equipment or other hidden costs,
- works alongside with individual fall protection,
- acts as a passive barrier. [15]

Figure 6.2. Guardrails [22]

Modular system guardrails material is steel or aluminium; it can be coated in significant colour as yellow for better visibility. And it has various base options: free standing, toe board or ground socket. System sections are flexible, that means it can be changed on site as needed. The advantage of the modular system railing is that there is no need for welding. [15]

6.1.3. Safety Nets

Safety nets are another type of collective fall protection. Nets protect both workers above and below the work site but also public if the construction site can’t be in a closed area but also extends to a public space. They can be installed to catch falling personnel or debris. Personnel net can be overlaid with another so called debris net preventing fall of a tool or an equipment. Typical netting materials are polypropylene and nylon.

Safety nets must be drop-tested at the jobsite before being first used, whenever relocated, after major repair, at 6-month intervals if left in one place. [10]

Figure 6.3. Safety Nets

6.2. Scaffolding Safety

Scaffolding is an essential part of a construction site. Humankind use it since ancient times, it was used already for the construction of the Great Wall of China. Since then scaffolding was developing in used materials, structure of tubes and pipes changed from wood to steel and to aluminium, although on many constructions in Southeast Asia is still used bamboo. But the use remains the same, it allows people to work in heights. Other thing which remains is danger of work on scaffolding, it causes major part of construction accidents. There are three basic types of scaffolding: self-support, suspension and speciality. Basic measures to improve scaffolding safety are awareness of all dangers, providing of proper safety training and a manufacturing innovation. [29]

Safety points to do before work on scaffolding:

- consideration of alternative to scaffolding as extension ladders, planks and ladder jacks.
- verification that planks are not damaged or even missing,
- that there is proper distance between planks,
- that guardrails are fully functional and in place,
- assurance that the footing ground is firm and level,
- test safety accessories,
- stop work during bad weather conditions as snow falls, storms and strong wind,
- placing safety messages on tags and labels,
- use of netting to prevent fall of tools and equipment,
- use of outriggers to reduce tipping on free standing scaffold,
- construct scaffold to maintain four times anticipated load,
- assurance that components from different manufacturers fit together,
- provide safe access to all platforms,
- make sure all the workers passed scaffolding safety training. [29]

Figure 6.4. Metal Scaffolding [22]

6.2.1. Bamboo Scaffolding

In Southeast Asia, Hong Kong and South Asia is long tradition of use of bamboo as material for scaffolding. The history of using bamboo as a building material is long, according to Chinese legend the craft dates back five thousand years, when Yau Chao-Shi, a mythological character taught his people how to construct nest-like bamboo shelters in trees.

Bamboo is much cheaper than metal, but its safety is considerably lower. Among the price other advantages of bamboo are that it is light weight which is connected with easier manipulation and this leads to faster erection. The difference in its construction load also allows build scaffolding above ground level supported by steel brackets fixed to the main structure.

It is a green construction which goes well with effort for sustainable development. Its stems can be harvested every three years without replanting as it is self-renewing.

Same as on any other scaffolding also all bamboo scaffolders should be equipped with safety harnesses, fall arrestors and independent lifelines, as well as its construction must be inspected by a competent person before and regularly during usage. [25]

Figure 6.5. Worker Erecting Bamboo Scaffolding [25]

6.3. Personal Protection

Personal protection includes equipment protecting individual parts of human body. These are an essential part of any construction.

- Head protection
- Ear protection
- Eye protection
- Respirators
- Hi-Viz (High Visibility) clothing
- Hand protection
- Tool belts
- Knee protection
- Foot protection [15]

Figure 6.6. Personal Protection Equipment (PPE) [15]

Head protection is safety helmet; different colours can distinguish worker's profession on construction site. Ear protection are muffs or plugs. Glasses protect eyes. Basic Hi-Viz clothing is safety vest, for better visibility and comfort whole body clothing, jackets and pants or overalls, is available. Respirators are used against dust as well as against toxic particulates. Gloves protect hands. Tool belts main task is to accommodate hand tools. Knees are protected by pads. And working shoes are used for foot protection.

Safety helmet, safety vest and working shoes are the basic equipment which is supposed to have everyone entering a construction site.

6.4. Crane Safety

Cranes are powerful machines used for lifting, lowering and horizontal moving of material. Cranes are essential parts of high-rise building constructions but connected with enormous risk when not used and inspected properly.

On 5th February 2016 crane collapse in the New York City (NYC) led to new discussion on crane safety. Accident happened when workers were attempting to secure crane during windy and snowy conditions. Another crane fell in the NYC in 2008 and killed 6 people. Immediately after February collapse which resulted in one man's death and three other injured, Mayor Bill de Blasio announced new safety measures including restrictions during windy conditions, doubled fines for failure to safeguard equipment, increased enforcement of pedestrian safety and more notifications on crane activities to neighbouring buildings. [3]

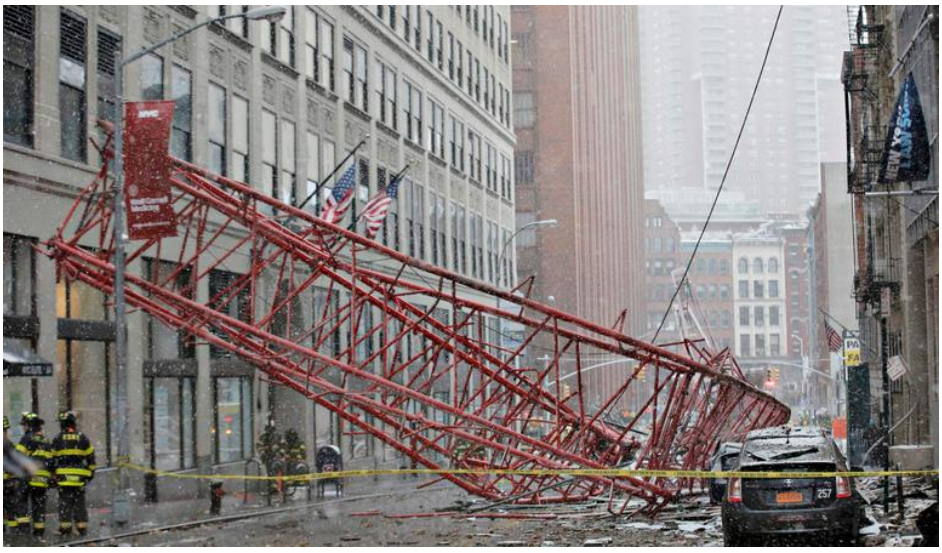

Figure 6.7. Crane Collapse in the NYC [1]

To minimize crane accidents following rules should be respected:

- Only qualified and trained person can operate a crane.
- Crane and all controls must be inspected before use by competent person.
- Barricade accessible area inside swing radius with fully extended outriggers.
- Make sure sections are blocked and stable before removing pins during assembly/disassembly.
- Maintain safe working clearance from electric power lines.
- Don’t wrap hoist lines around a load.
- Never exceed load capacity.
- Don’t move loads over workers.
- Follow manufacturer’s instructions.
- Consider if weather conditions are favourable for crane usage or assembly/disassembly. [26]

6.5. General Issues of Skyscrapers

As buildings rise higher there are upcoming specific issues for civil engineers. Crucial and the most difficult to deal with are wind and seismic behaviour which strongly impact not only construction itself but also safety of construction workers. For these factors the height is not so defining as a slenderness. Also very long time of construction brings more issues to deal with. [14]

6.6. Basic Safety Tips

To construct safely proper supervision needs to be ensured on whole construction site, particular jobs, machinery, secondary constructions and especially workers. The speed of work is not as important as its effectiveness. Following points should be always taken at aware. And safety is not to be compromised.

- Slow down or consider efficiency building alternatives.
  Time pressure has strong influence on safety in construction industry. The job needs to be done as fast as possible but that must not increase danger for workers. So the question is how to work fast and efficient while keeping safety. This calls for investment to more efficient techniques and for paying attention to time management, organization and communication.

- Keep the workplace organized.
  Take all available measures to prevent falls, trips and slips. Ensure supervision on worksite organization. Include system of tool placement so they are not lying on a random place.

- Identify hazards.
  Risks can be found in the project and on the site, evaluate both. Think about alternatives and solutions in advance.

- Proper training.
  Train workers consistently and regularly. Don’t underestimate importance of safety training.

- Review the site.
  Risks are changing during the construction, evaluate them again in each singular construction phase. Review helping constructions as a scaffolding and machines as cranes before usage. [27]

7. IMPLEMENTING OSH MANAGEMENT TO PROJECT "Residential Complex Nove Letnany - Buildings D + E"

In this last chapter is designed model approach to solution of safety risks on particular construction project.

7.1. The Project Introduction

This is a construction project of a new residential complex in Prague Letnany. Investor and also the author of the project documentation is CENTRAL GROUP a.s. Both buildings have 2 underground and 11 aboveground floors. Complex consists of 237 apartments and 28 non-residential units. The structural system is designed as a reinforced concrete transverse wall monolith with reinforcing core.

Figure 7.1. Residential Complex Nove Letnany [16]

7.2. The Occupational Safety and Health Plan for Risk Works

7.2.1. Simultaneous Operation of Several Contractors

The coordinator in cooperation with the general contractor shall coordinate the cooperation of contractors and people authorised by them when taking measures to safeguard OSH protection taking into account the nature of construction works and general prevention principle and activities executed at the construction site at the same time or, as the case may be, consecutively after each other, with aim at protecting health of people, prevent injuries a work and prevent occupational diseases.

All involved entities have to be demonstrably made familiar with risks resulting from working activities and concerned environment. The parties have to share information on risks in writing and all people have to be demonstrably trained in the field of OSH and fire prevention and they have to be provided with certain PPE.

Emergency call numbers including phone numbers of responsible site officers and trained first aid providers have to be posted at visible place.

No works may be executed at the same time above each other. [12]

7.2.2. Ground Works

Prior to the beginning of ground works, design data concerning technical infrastructure has to be checked and confirmed by their operators from the point of view of their direction and depth and the lines have to be marked at the site just before the beginning of works. Workers responsible for the execution of grounds have to be informed on the type of networks, type of installation any protective zones present.

Any works executed in protective zones of electrical, gas and other hazardous lines may be executed only subject to the implementation

of protective measures preventing hazardous approaching of workers or machines to such lines. Such measures have to be discussed with the operator of lines who have to confirm their scope and completeness. As a rule, such measures include the uncovering of such lines manually using suitable tools under supervision.

Preventing excavated trench/pit walls from collapsing and preventing people from falling to such trenches and pits using either coverage of trenches or erection of two-bar protective railing 1.1 m high or, as the case may be, creation of technical barrier at the distance of 1.5 m away from the trench edge.

Safeguarding the stability of vertical trench walls in a way prescribed in the design as a rule using supporting struts, in built up areas from the depth of 1.3 m, in not built up areas from the depth of 1.5 m. Technical requirements to trench wall supports (attachment wall supports, fore poling, strutted sheeting, sheet piling and the like) have to be included in the contractor´s documentation.

Should the excavations have skew walls, the angle of the wall has to be defined by the designer, too. Employees must enter tranches without protection. Slope undermining is prohibited. Excavations of adjacent roads have to be provided with warning signs and lighting.

Any excavations and openings that have to be walked across shall be covered with pedestrian bridges, minimum weight being 0.75 m provided the trench is deeper than 0.5 m. Should the depth be more than 1.5 m, the crossing has to be provided with a protective railing at least at one side, in other case, the railing has to be at both sides.

The edges of the trench must not be loaded by the excavated rock or any traffic passing by. A free strip of at last 0.5 m has to be left and protected against possible fall of loose soil. Before employees enter the trench, all loose parts of material have to be removed from walls and any possible defects of the wall support structure.

Staffs working in trenches deeper than 1.3 m have to wear prescribed PPE and must not do any such works alone. The width of the trench bottom, if any people are working in it, shall be at least 0.8 m for the sake of safe handling, assembly or any other works on buried lines. Should the ground works be suspended (for at least 24 hours), the condition of the safety of the trench has to be verified by an expert worker.

Should the excavation works be done using machines, manual excavation works must not be performed in the risky zone of the working machine, i.e. within at least the reach of the working tool of the machine plus a safety zone of 2 m. [12]

7.2.3. Material Storage and Handling

Materials should be stored according to conditions specified by the manufacturer.

Places designated for tying, releasing and material handling have to have safe access.

When using individual crane types, the following has to be adhered to:

- requirements of ČSN ISO 12 480–1,
- requirements of current generally binding legal regulations and legislation,
- requirements specified in the manufacturer´s manual in their technical conditions.

A Safe Work System (SWS) for cranes and small hoists is to be prepared for the operation of operated cranes and small hoists used to hoist burdens with typing means subject to ČSN ISO 12 480-1.
The SWS has to include the following:

- design of the operation of cranes,
- selection, safeguarding and use of a suitable crane and accessories,
- maintenance, examination, inspection and the like of the crane and accessories,

- supervision by competent and trained staffs equipped with necessary authorisation,
- check whether all necessary and documentation is available,
- ban on any unpermitted handling during the entire time of crane operation,
- safeguarding of properly trained and competent people who are familiar with their duties and obligations of other parties involved in the operation of the crane,
- safeguarding of safety of people who are directly involved in the operation of the crane,
- coordination with other cooperating entities that are involved in works including the identification of measures that will eliminated risks,
- safeguarding of a communication system that will be made available to all people involved in the crane operation.

The requirements to the operation of the crane have to be completed with the preparation of the site, assembly and maintenance of the crane. Should any handling operations not described in the SWS be required during the operation of the crane, these have to be described in the form of an amendment to the SWS. All people involved in the execution of works or handling operations using the crane shall have clearly defined competences and duties and they have to be made familiar with them in a demonstrable way. All parties involved have to be made familiar with the SWS.

The crane operator shall inspect the system on daily basis and record entries on such inspections to the operational log book. [12]

7.2.4. Bricklayer´s Works

Machines used to produce, process and transport mortar shall be placed on the construction site in a way to avoid any risk to people by their operation.

Any materials necessary for bricklayer´ works shall be stored in a way to keep free working space the width of which must be at least 0.6 m. [12]

7.2.5. Assembly Works

Adhere to the defined technological procedures and manuals for the application of adhesives, levelling and covering materials or other materials, as the case may be.

All people present at the construction site where such works will be executed shall be made familiar with the timing of the works and the required safe behaviour during such works, safe collection of residual flammable materials and used materials and their disposal in a defined manner.

Execution of such works in staircase shafts from working platforms or ladders specially adapted for this purpose.

New boilers will be installed after the uncovering of the roof by a hoisting system – crane.

Prior to the beginning of works, contractors shall prepare separate technological and working procedures for such works. Emphasis will be placed primarily on the safeguarding of personal or collective protection of employees against falling, safeguarding of prefabricated structures against falling and collapse. The method of such safeguarding will be chosen with regard to local conditions, design and assembly procedure. The construction site for the assembly shall be duly handed over to the contractors based on hand over protocol. [12]

7.2.6. Working with Electrical Systems

Employees of individual contractors shall use only suitable and undamaged electrical systems that comply with all legal regulations and standards (cables shall always have a rubber coating with outdoor

designed endings). All cables shall be check prior to be connected for damage or lack of integrity or, as the case may be, whether plugs and sockets are not damaged. Should any cables be damaged, they must not be used.

Cables should be protected against mechanical damage by hanging them on flexible ties or, if placed on the ground, by protective systems (e.g. two wooden boards fixed together, protective pipes). The flexible ties have to be provided as high as necessary to avoid any risk associated with passing by vehicles (risk of tearing cables down) and walking pedestrians.

After the completion of works, switchboards have to be protected against unauthorised handling (fencing, locking).

No unauthorised electrical system handling (repairs, interventions in installation – only allowed to certified electricians).

All electrical tools have to be check prior to use by the tool user. Such checks should include tool idle running.

Use only reviewed electrical system and appliances provided with plates. [12]

7.2.7. Working at Height

Anytime workers work at a height higher than 1.5 m, they have to be protected against falling.

Preferably, any such works at height shall be performed from modular portable scaffolding systems according to the manual of the manufacturer.

Space as below the workplace that is exposed to the risk of the fall of people or objects shall always be safeguarded. Opening and holes that are not used have to be fixedly covered or delimited.

Any elevated working structures (scaffolding) have to be in compliance with the manufacturer´s manual. They will be handed for use based on a protocol by a person eligible for their assembly: any such structures shall be provided with an information board reading the name of the company using the structure, name of the person responsible for the assembly and date of the handover for use.

It is prohibited to drop any object from the elevated structures. [12]

A. Works Involving the Risk of Fall from Height or to Free Depth Exceeding 10 m

The above referred to risk may be faced at the construction site during:

- works on scaffolding and erection of scaffolding,
- any works performed less than 1.5 m away from the roof edge,
- assembly of structures and building roof cover,
- assembly of fills of openings in buildings (windows, doors, skylights),
- works nearby openings dimensions of which exceed in all directions 0.25 m,
- works nearby openings in walls the bottom edge of which is lower than 1.1 m,
- works nearby openings in walls with the width bigger 0.3 m and height bigger than 0.75 m. [12]

B. Works on Scaffoldings

Scaffoldings have to be erected by a qualified person in compliance with current standards and duly commissioned by means of an entry to respective operational documentation or construction site log book. Scaffoldings have to be checked on regular basis and results of checks have to be recorded.

Employees erecting scaffolding have to be protected against fall from height (a combination of collective and personal protection of employees).

Low interior scaffoldings and elevated platform supports are required to be equipped with protective railing provided the level of the working floor is more than 1.5 m.

When installing typified systems, operating manuals of the manufacturer have to be respected with regard to the completeness and stability (braces, wheel brakes etc.). [12]

C. Works on Roofs

Employees working on roofs have to be protected against fall from height. At the sides where the scaffolding is provided, it may be used as a collective protection means only if it is projected over the edges of the roof by at least 1.1 m and the gap between the scaffolding and building wall is not more than 0.3 m. At places where scaffolding is provided, the contractor shall prefer collective protection of employees.

Provided no such collective protection of employees is feasible, the contractor shall protect employees against fall by personal protection means - the contractor shall provide for the installation of suitable barriers at the distance of 1.5 m away from the free edge of the roof or shall install a fixed two-bar protective railing with a protective bottom bar at the edge of the building. Employees may work within such a protected space without personal protective and safety means. Should any work be performed closer to the free edge of the building than 1.5 m, employees shall be provided with personal protective and safety means preventing falling from height. The way such personal protection and safety means will be used and anchoring points will be defined in the working procedure.

Any opening in floors where employees are working shall be protected against falling through the openings. It may be done by installation of proper barriers at the distance of 1.5 m away from the free edge or installation of two-bar protective railing with a bottom protective bar at the edge of the opening. The risk of falling may also be prevented by installation of a suitable lid or safety nets – all has to have sufficient load carrying capacity/strength. [12]

D. Works on the Installation of Fills of Openings

When installation opening fills (windows, façade, skylights etc.), worker have to be protected against fall from height. Collective measures have to be preferred (railings, lids). Should fitters rise higher that the specified minimum railing height (i.e. 1.1 m), they have to be protected by personal protection means (harness, falling energy absorber, positioning cable and fixing means) duly fixed to a proper anchoring point. [12]

E. Works on the Assembly of Building Roof Structure and Cover

Works on the assembly of the roof structure and cover shall be executed in compliance with a prescribed technological or working procedure. Such a procedure shall be submitted to the OHS coordinator for approval prior to the launch of any works. [12]

F. Employee Protection Methods

Collective Protection:

- railing (scaffolding, unprotected building openings, floor edges prior to the installation of cladding etc.),
- barriers (1.5 m away from the place involving the risk of the fall from height in particular when working on the roof),
- lids,
- protective nets.

Personal Protection:

harness, cables, bonding means etc.

What may be used as the personal protection system on the roof is a timely installed protective retention system. The contractor should install such a system immediately after the roof decking so that it could be used for the protection of follow up trades (insulation fitters, installation of skylights and lighting conductors etc.). It is subject to the condition that the contractor responsible for the protective retention system has to hand over the system for temporary operation and guarantee its right installation. [12]

G. Work at Height and Above Free Depth

When working at height, employees have to respect the Government Regulation No. 362/2005 Coll. on detailed requirements to occupational safety and protection of health at workplaces involving the risk of fall from height or to depth.

Collective protection systems based on technical structures (railing, lids, networks, etc.) shall be preferred.

The collective protection system for employees working at height shall consist of scaffoldings or railings. Where collective protection is not practicable, personal protection means will be used. Methods and types of the personal protective means shall be defined by the contractor in respective technological or working procedure.

The anchoring point for the personal protective means against fall shall be specified in the technological or working procedure in writing by responsible employee of the contractor and the contractor shall inform his employees on the position of such a point in a demonstrable way.

The system shall prevent in particular falls from height and to depth, falling through or slipping using chosen personal protective means against fall (retention harness, falling energy absorber, connecting

cable, connection and anchoring elements) and collective protection systems such as two-bar protective railing of the minimum height of 1 m at each place where this height/depth is more than 1.5 m.

The protective zone delimiting space exposed to risk by railing shall extend from the edge of the workplace or working floor at least:

- 1.5 m when working at the height from 3 m to 10 m,
- 2 m when working at the height above 10 m to 20 m,
- 2.5 m when working at the height above 20 m to 30 m,
- 1/10 height of scaffold at the height above 30 m.

Employees working at height who establish or fit auxiliary structures shall undergo a special theoretical and practical training for the execution of such works. All personal protection means they use have to meet requirements resulting from respective standard. Any such means shall be checked at set forth intervals and the coordinator may ask respective documents to be presented to him. No mountaineering/ other sport systems may be used.

Assembly works at height have to be suspended during storms, heavy rain or snowfall, formation of icing, temperatures lower than 10° C, visibility lower than 30 and wind speed exceeding 8 m/s, for employees work on suspended structures, ladders higher than 5 m and when using personal protective means. In other cases, works have to be suspended at wind speed of 10.7 m/s.

When executing short-term assembly works inevitable for the installation of structural elements, such structural elements may be installed and combined of consoles, welded or otherwise fixed cross-arms, profiles bracing framed structures or similar walking surfaces if employee has the possibility to fix his personal harness to an anchoring point.

Employees working on the roof have to be protected against fall from the roof at free edge, against slipping or, as the case may be, against

falling through the roof. Roof edges shall be protected against fall of employees or material using any of protective and retention structures. Spaces that are not protected, have to be delimited by protective railings and provided with warning signs prohibiting entry.

If supporting structures of the covering or openings in the roofs are positioned in a way that free openings are between fixed parts and people could fall through such openings, technical structures have to be used as protection systems. Individual openings in the roof have to be covered or provided with railing similarly to openings in floors.

Employees may step on the roof cladding with a gap more than 25 cm between fixed parts of the supporting structure without any special protection only when individual roof elements are demonstrably safe and they cannot collapse if exposed to load from individual employees. [12]

7.2.8. Welding and Heating of Bitumen in Melting Vessels

When welding including melting of insulation materials and heating bitumen in melting vessels, the contractor shall provide for the adherence to fire safety conditions as specified by a special legal regulation.

Welding zones, reserved welding zones including protective zones below the zone shall be protected in a way to prevent unauthorised entry and provided with safety signage. Where electrical arc welding works are performed at a temporary workplace, measures have to be implemented to protect people in the proximity against effects of arc radiation.

If a stable and safe position of a welder working at height cannot be provided for in any other way than the use of personal protective means preventing fall, such means have to be protected against burn-out.

The contractor shall ensure that any working procedure that envisages that a worker melting insulation materials will proceed backwards cannot be used at a distance shorter than 1.5 m away from a free edge of a workplace at height.

Measures preventing burn-out when working with bitumen shall be defined by the contractor in the respective technological procedure.

The contractors shall ensure that welding works will not be executed by people who are not properly qualified in compliance with the special legal regulation and that works associated with heating of bitumen materials could not be done by people who are not familiar with the technological procedure and operating manual of respective systems. [12]

7.2.9. Gluing Floor, Wall, Ceiling and Other Structure Covering

Requirements to occupational safety when gluing plastic, rubber, crock and similar covering materials are considered complied when:

Prescribed technological procedure and operating instructions for the use adhesive materials, levelling materials and covering and other used materials have been complied with.

Effective ventilation has been provided for when gluing coverings in closed premises provided such ventilation has avoided any violation of admissible limits of concentrations of chemical substances in the working environment.

In case of use of adhesives that release flammable vapours, protection against explosion has been ensured subject to a special regulation including but not limited to the following:

- delimiting of the workplace including the endangered space and their marking with safety signs,
- prevention of unauthorised entry to such a space; the endangered space includes in this case as a rule floors where gluing takes

place, floor below it and above it or, as the case may be, other adjacent premises to which flammable vapours could leak,

- ensuring continuous intensive ventilation in order to prevent building of explosive concentrations for the entire period of gluing and at least 24 hours after end of such works,
- exclusion of any bare flame handling including smoking, welding or local heating and, depending on circumstances, closing down gas supplying pipeline and disconnection of electrical system for the entire period of such works.

Safe collection of residual flammable liquids and used materials and their removal in a way defined in advance in compliance with provisions of special legal regulations. [12]

7.2.10. Painting and Decorating Works Covering

Compliance with occupational safety when executing painting and decorating works is considered the following:

When finishing civil and other structures including painting (spraying of painting materials), adherence to specified technological procedures taking into account operating manuals and specified methods of the protection of people against pollutants generated during such works. [12]

7.2.11. Glazing Works

Compliance with occupational safety when executing glazing works is considered the following:

Condition when the working surface is flat, trimmed and reinforced when handling glass manually.

When taking glass panes from the transport vehicle, the panes will not move in a undesirable way and fall over.

Glazing and handling of glass panes bigger than 3 m by at least three employees.

Carrying glass panes longer than 2 m over using special preparations.

Collection of waste glass in specifically designated containers. [12]

7.2.12. Concrete Works

Protection of employees against fall shall be provided for using collective or personal means regardless of the height at all workplaces and roads above water bodies or other substances that could damage human health and starting from the height of 1.5 m at all other workplaces and roads. Should the nature of works and working procedure make it impossible to adhere to safety measures at workplaces or roads to the height of 3 m (when laying ceiling panels etc.), the protection against fall from height may considered the fact that such works will be performed by trained staffs in a way when the staffs will gradually create an area around them that may be used for safe working. The technological procedure shall include an enumeration and exact description of activities that have to be executed at distance shorter than 1.5 m away from the edge of fall. [12]

A. Installation of Reinforcement

When installing reinforcement, fixing formwork and executing any other works at height, employee shall be protected using adequate methods, i.e. they will work on scaffolding. Wherever collective protection is not feasible, employees shall be protected using personal protective systems. When working on ladder, they will be fixed by another worker who will keep the ladder so that it could not fall. When dividing materials using angle grinder, employees shall always wear protective means, i.e. protective shield or goggles. Formwork plate along the entire perimeter at free edges shall be provided with protective two-bar railing 1.10 m high. [12]

B. Concreting Works

Delivery and storage of concrete mixture shall be done in a way that will ensure good communication practices between the pump operator and concreting workers or, as the case may be, crane operator. Prior to the beginning of concreting works, the formwork and its parts have to be duly checked and inspected and any possible defects have to be made good. The inspection and take over shall be recorded by the responsible worker in the log book. Formwork elements shall be protected against fall in every phase of installation and dismantling. Prior to the beginning of concreting works, responsible worker shall take over the completed reinforcement together with investor´s supervisor by means of an entry to the construction site log book. The condition of the formwork and its parts has to be monitored during the installation. The concrete pouring procedure has to respect ČSN 73 24 00 Fabrication and inspection of concrete structures. Material and workmanship quality shall be checked in compliance with the plans of inspection activities. Formwork may be removed only if so instructed by a responsible employee and based on completed non-destructive concrete strength test. The area where removal of formwork will take place shall be protected against unauthorised entry. Openings in ceiling structure shall be immediately protected against fall. Removed formwork material shall be stored at a place defined in advance by the construction site manager. Individual concreting operations, e.g. transport, pouring and curing of fresh concrete etc. are detailed. [12]

7.2.13. Documentation Corresponding Expert Liability

Documentation corresponding expert liability from the point of view of OSH of employees of all contractors at the construction site is primarily required for the following professions:

- work at height (photocopy of the protocol on expert training and proof of good health),
- slingers (photocopy of slinger´s certificate and proof of good health condition),

- crane operators (photocopy of crane operator´s certificate and proof of good health condition),
- welders (photocopy of welder´s certificate and proof of good health condition),
- scaffolders (photocopy of scaffolder´s certificate and proof of good health condition),
- hoisting system operators, e.g. working platforms etc.,
- and other requirements to qualification as may result from the implementation of the work. [12]

7.3. Action Plan for Emergency Situation

Important numbers:

Emergency call	112
Fire Rescue Brigade	150
Police	158
Ambulance	155

A. Injury

- Help the wounded immediately: use first aid kit, support from trained first-aiders is necessary.
- Call the ambulance when needed: follow their instructions until the help arrive.
- Report the incident.

B. Fire

- Use available fire extinguisher or fire equipment to extinguish fires in enclosures.
- Evacuate the area. Call for help.
- Do not attempt to extinguish fire without stopping the fuel source.
- If possible, do so without greatly exposing personnel to injury.
- Call fire brigade when needed: follow their instructions until the help arrive.
- Report the incident.

C. Equipment malfunction

- Stop using the equipment.
- Secure the equipment against unauthorized use.
- Secure the area around equipment if necessary.
- Report the incident.

D. Structural damage

- Leave the area, warn others.
- Secure the area around damaged structure if necessary.
- Report the incident.

E. Leakage of chemicals

- Try to stop leakage if possible.
- If it is a leakage of flammable gas or liquids, don't use any procedures or equipment which can create spark.
- Secure the area.
- In case of small leakages use sorbents (don't forget wear PPE – gloves, masks, eye protection etc.).
- In case of major gas leakage evacuate the area, call fire brigade, warn neighbors.
- Report the incident.

F. Finding ammunition

- Stop the work.
- Don't touch the ammunition.
- Evacuate the area.
- Call police, secure the area until police arrived.
- After police arrival, follow their instruction.
- Report the incident. [12]

7.3.1. Emergency Evacuation Plan

In case of a Fire or other Emergency, exit the building/project immediately.

As you are exiting, the first person to reach one of the Emergency Air Horns should sound the horn and continue to exit the building. 3-blast of the air horn indicates an emergency and everyone is required to evacuate the site immediately. Emergency Air Horns are located at the main entrances to the construction site at gatehouse. If you are unable to reach an Emergency Air Horn within the building, continue to exit the building and report immediately to the safety coordinator.

When the Emergency Air Horn is sounded:

ALL WORK ON THE SITE IS STOPPED

EVERYONE is report to the meeting point for a head count. It is the responsibility of every foreman for all contractors on site to ensure that everyone in their crew is accounted for and to report this information to the site manager or OHS coordinator.

It is imperative that foreman take an accurate head count at the beginning of each work day to ensure an accurate head count in case of an emergency.

Everyone should remain at meeting point or an area designated by the emergency response team until such time that the Emergency is under control.

In case of ammonia leakage every person must leave the dangerous area – this mean even beyond the meeting point. [12]

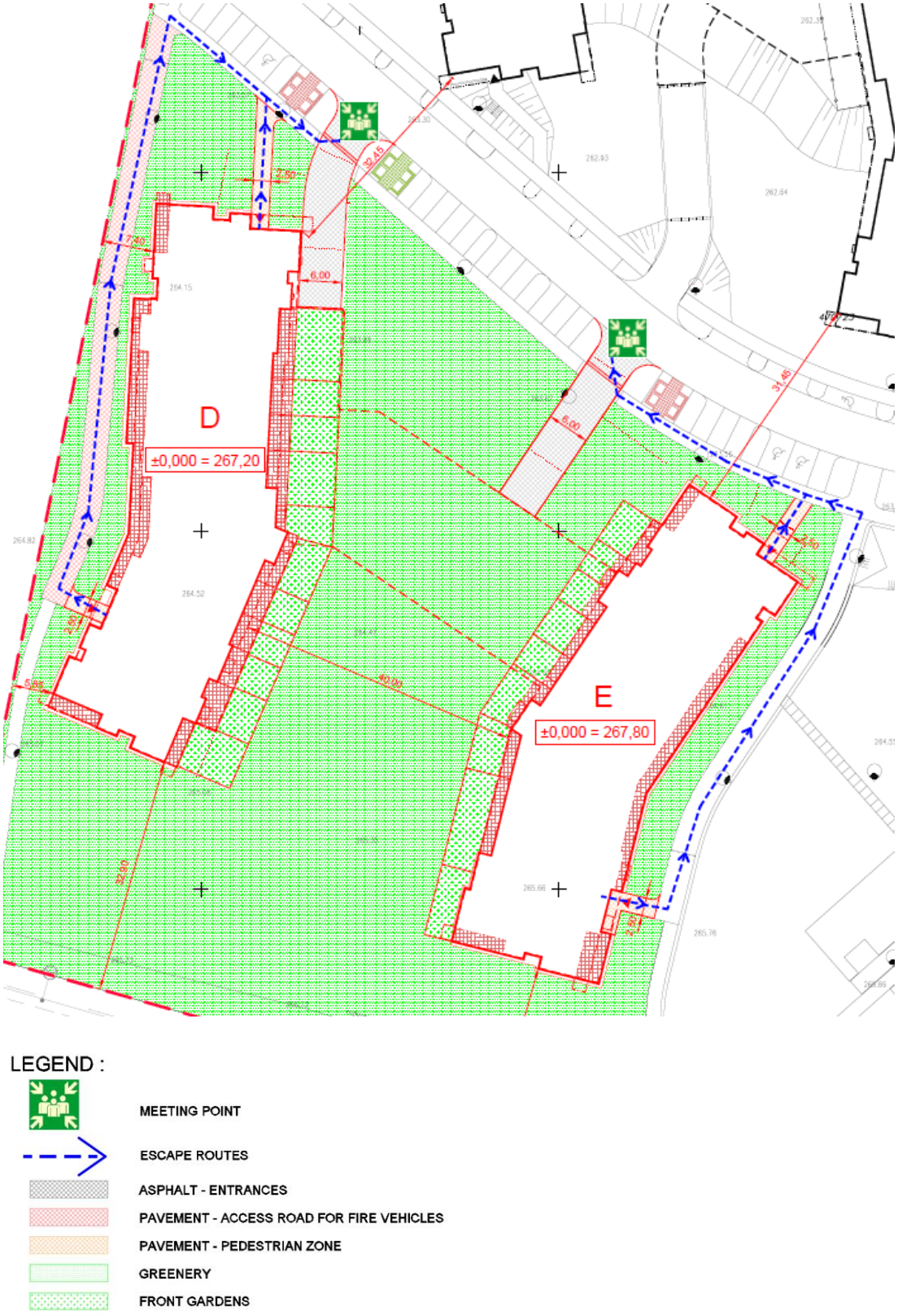

Figure 7.2. Emergency Evacuation Plan

7.4. Risk Analysis

In this chapter are chosen and evaluated some of the most possible or the most dangerous risks connected to work in height on this model project. For evaluation were used three criteria: probability of occurrence, threat to human life, and time delay of the project. All criteria have been assigned the same value. Risks were evaluated by a simple point method.

Evaluated Risks
R1: Fall from height from open edges
R2: Fall from roof
R3: Fall from scaffolding
R4: Injuries by fallen tools
R5: Accidents by load transmitted by crane
R6: Crane collapse during assembly/disassembly

Figure 7.3. Evaluated Risks

The most probable risk is fall of a tool on a worker standing beneath, this is also least dangerous of this six evaluated risks because threat of fatality is lower than in other cases, tool would more likely cause an injury. Otherwise crane collapse during assembly/disassembly is least likely but its impact on life and time delay would be serious. The value of falls from roof, scaffolding or open edge is similar, it would most probably cause one person's death or serious injury. Probability of these falls is sorted by a total number of workers in these areas, only fall from the roof has slightly higher value of a life threat because of the bigger height of fall and fall from the scaffolding has bigger time delay in case that it would be closed after accident.

	Probability	Life Threat	Time Delay	Value of the Risk	
R1	0,24	0,17	0,17	0,58	**V3**
R2	0,14	0,21	0,17	0,52	**V4**
R3	0,19	0,17	0,21	0,57	**V2**
R4	0,29	0,05	0,05	0,39	**V5**
R5	0,10	0,10	0,10	0,30	**V6**
R6	0,05	0,30	0,30	0,65	**V1**
∑	1,0	1,0	1,0	3,0	

Figure 7.4. Risk Analysis

7.4.1. Suggested Measures

Measures for previously chosen and evaluated risks are described below. In addition, all workers on the construction site must pass basic safety training, those whose work include a specific hazard must pass moreover appropriate training for their job.

- Crane collapse during assembly/disassembly

  Crane construction reacts on wind load differently when it is completed than when assembled, danger appears when work on construction takes place during extreme weather conditions. And therefore weather forecasts should be taken into consideration while time planning. Only qualified and trained workers for crane construction can be involved.

- Fall from scaffolding

  Scaffolding must be equipped with guardrails and all safety components must be inspected before usage and also planks must be inspected if not missing or damaged. Only workers trained for scaffolding can work on its construction.

- Fall from height from open edges

  All accessible open edges and openings must be secured against the fall with collective fall protection system using guardrails.

- Fall from roof

  Each worker going to work on the roof must be provided with a personal protection system using body support, a lifeline system shall be installed on the roof for all works ongoing here. Not using securing shall be fined.

- Injuries by fallen tools

  Tools used for work in height may not be put in places where the risk of its fall is, further tools should be attached to body support or construction, where possible safety nets may be installed to stop falling.

- Accidents by load transmitted by crane

  First of all, load capacity of cranes may not be ever exceeded. Secure swing radius area so nobody can occur under the moving load.

8. CONCLUSION

Although construction industry in the People's Republic of China is rapidly developing, focus on safety is not growing in the same speed. Better solutions and regulations might be found in the USA due to Occupational Safety Health Administration.

The primary objective of all safety programs is to obtain a zero accident project. To ensure worksite safety focus should be on organization, risk management and training. When an accident does occur on the job site, the construction manager must be prepared by having an emergency contact sheet and an on-site team that can react to the situation.

The greatest danger in the construction industry is the fall from height. To prevent falls attention always has to be paid to wearing and using personal fall arrest equipment in interaction with installed and maintained collective fall protection system, covering and securing floor openings and label floor opening covers and to safe use of ladders and scaffolds.

Further all cranes must be used properly by qualified workers and inspected before usage.

Safety training of all workers shall not be underestimated.

The best safety policy is to be always aware of all potential dangerous and to put maximum effort to minimize them.

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ABBREVIATIONS

CR:	Czech Republic
CTBUH:	Council on Tall Buildings and Urban Habitat
FPS:	Fall Protection Systems
GR:	Government Regulation
ILO:	International Labour Organization
MOC:	Ministry of Construction
NPC:	National People's Congress
NYC:	New York City
OSH:	Occupational Safety and Health
OSHA:	Occupational Safety Health Administration
PPE:	Personal Protection Equipment
PRC:	People's Republic of China
SAWS:	State Administration of Working Safety

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