

JASMINA RADOSAVLJEVIĆ<sup>1</sup>  
ANA VUKADINOVIĆ<sup>2</sup>

## WORKER SAFETY DURING CONSTRUCTION WORK AT HEIGHT

<sup>1</sup>University of Niš,  
Faculty of Occupational Safety in Niš  
<sup>2</sup>University of Niš,  
Faculty of Occupational Safety in Niš

<sup>1</sup>*jasmina.radosavljevic@znr fak.ni.ac.rs*  
<sup>2</sup>*ana.vukadinovic@znr fak.ni.ac.rs*

**Abstract:** *In construction work, most severe or fatal injuries are caused by falls from a height. This paper discusses construction work at height and the personal protective measures and equipment for work-at-height construction workers, which ensure their safety. The paper also describes temporary and auxiliary structures that are used for work at height.*

**Keywords:** construction work, work at height, occupational safety, protective equipment.

### INTRODUCTION

With the development of science and technology, construction became an important branch of economy, connected to numerous other economic activities. Due to the large number of participants in the overall construction sector, the complexities of their working together, and the relationships between the workers, their materials, tools, machinery, and operations, risk identification and quantification in construction is considerably more complex than in other industry branches. Construction workers are prone to a wide variety of occupational injuries, which are often severe or fatal. The large number of severe injuries, which often result in death, are due to a failure to provide safe work conditions and lacking or inadequate personal protective equipment (PPE). In construction, the majority of fatal injuries occur due to falls from heights. In Serbia, from 2013 to 2016, there was a total of 37 fatal injuries due to falls from a height, which is 58.7% of the total number of fatal injuries in the same period [1]. In 2017, there were 67 severe and fatal injuries in the construction sector, or 7.39% of the total number of injuries in other sectors [2].

Risk and hazards on construction sites during work at height are ever-present, so it is necessary to implement all available measures to ensure safe work conditions and workers' well-being. The Regulation on Occupational Safety during Construction Activities prescribes special occupational safety measures and rules to be implemented during construction work.

The Act on Occupational Safety and Health at Temporary or Mobile Construction Sites prescribes the minimum requirements that the investor, the OSH coordinators in the design and construction stages, the employer/contractor, and other parties involved have to meet in order to ensure that the safety measures are implemented at temporary or mobile construction sites. Prior to actual construction operations, the investor is

obligated to coordinate the development of a plan for preventive occupational safety and health measures to be implemented during construction [3].

According to the Regulation on Occupational Safety during Construction Activities, work at height refers to any work performed by a worker with the use of a support system at a height of 3m or more above solid ground, when the work space has no fall protection. According to the Act on Amendments to the Act on Occupational Safety and Health at Temporary or Mobile Construction Sites, work at height is any work performed by a worker with the use of a support system at a height of 2m or more above solid ground, when the work space has no fall protection [3,4]. Solid ground refers to a base with negligible deformations under a load, which does not affect its stability. Workers perform work at height using mandatory occupational safety equipment. Work at height can only be performed by experienced workers with verified knowledge and skills to perform such work.

### CONSTRUCTION WORK AT HEIGHT

When doing construction work at height, workers might fall, which could lead to fractures, serious head trauma, severe bodily injuries, and in some cases even death. Therefore, it is essential that workers at heights be properly protected. Construction work performed at heights includes the construction of smokestacks and similar structures, such as silos, dam intake towers and spillways, brick or block masonry, roofing, installation of steel and other structures, plastering and cladding, cleaning of building façades and monuments using sandblasting or hydro-blasting, wall chasing on concrete or other walls, façade painting, certain demolition work, etc. (Figure 1). Work at height is also accompanied by hazards such as dust, hazardous materials, electricity, vibrations, as well as noise due to the nature of such work. These all require proper occupational safety measures for workers, which include the use of PPE [2].



Figure 1. Construction work at height [7-11]

## SAFETY MEASURES DURING CONSTRUCTION WORK AT HEIGHT

Construction workers working at height are vulnerable because they operate at elevated positions and in small spaces, and because they are exposed to the elements (strong sunlight, rain, cold, wind, etc.), all of which warrants a plan for collective and personal occupational safety. This includes the following requirements:

- falls from heights are prevented by means of designated physical barriers for the work spaces at height;
- work at height can be performed only with the use of adequate personal protective equipment or collective protective equipment, such as man baskets, working platforms, scaffolding, or safety nets. If the use of such equipment is impossible due to the nature of the work, other measures have to be used to ensure worker safety;
- the scaffolding used by workers has to be properly erected and reliable;
- electrical and water/sanitary installations have to be safe and protected;
- workers have to wear safety helmets, proper protective clothing and footwear, protective gloves, and, if needed, protective goggles, fall arrest systems (belt/harness and rope), etc.;
- during the construction of a high-rise structure, fall arrest platforms or safety nets, which are integrated with the scaffolding, have to be placed underneath the working platforms;
- when the interior of a smokestack is being constructed, working platforms are erected at a vertical distance of no more than 3m, as protection against falling objects;
- access to work-at-height positions is developed and organized so as to eliminate the possibility of objects falling on workers climbing to or descending from the work space;
- the perimeter around a high-rise structure where there is a possibility of accidental falling objects has to be enclosed, and the warning signs, including 'employees only beyond this point' signs, must be placed at perimeter entry points;

- the machinery used at the construction site can only be operated by qualified personnel [4-6].

### Personal protective equipment for work at height

Personal protective equipment for work at height includes every piece of equipment that workers wear, hold, or use in any other manner during work in order to protect themselves against one or more simultaneous hazards and/or harms, and to eliminate or reduce the risk of injury and health issues. Work at height requires the use of equipment aimed at protecting the following body parts:

- the head;
- the eyes;
- the respiratory system;
- the feet;
- the trunk;
- the arms and the hands;

and the entire person against falling from a height (safety belts, harnesses, ropes/lines, etc.) [4-6].

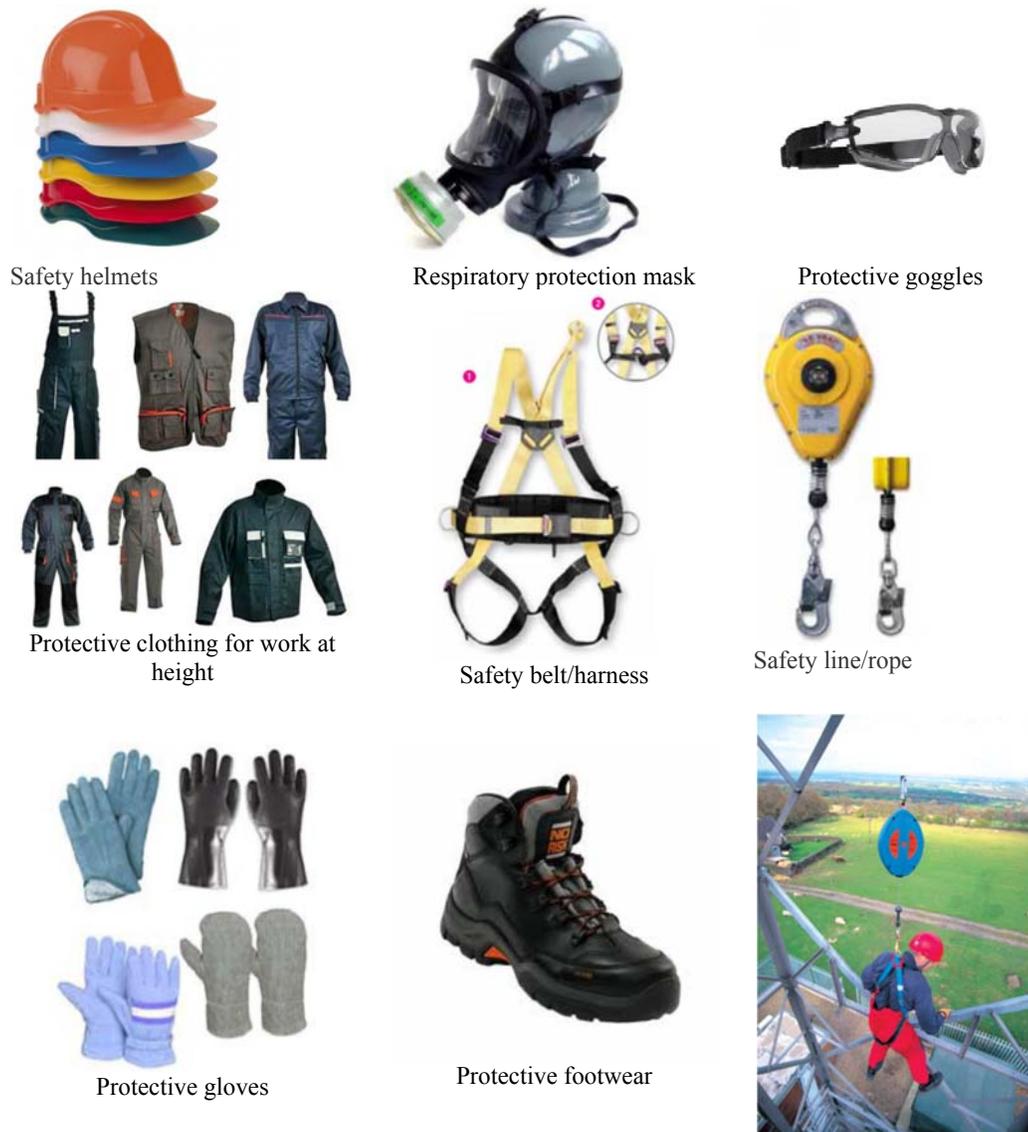
Figure 2 shows the equipment used during construction work at height.

Safety nets for fall arrest are used to protect workers in the event of a fall during work at height (Figure 3).

### Auxiliary and temporary structures for work at height

Construction work at height can only be performed with the use of proper protective equipment and the use of collective safety measures, such as working scaffolds, man baskets, working platforms, or safety nets.

All scaffoldings have to be designed, erected, and maintained in accordance with the applicable rules. Working scaffolds are temporary auxiliary structures that contain the working platform, the working surface, and stairways or other access structures, at a height of 3 or more meters above solid ground, in which workers move, perform their work, and manually carry or transport equipment, tools, and construction materials.



**Figure 2.** Personal protective equipment for construction work at height [7-11]



**Figure 3.** Fall arrest safety net [7-11]

Working scaffolds are erected, maintained, used, and dismantled according to technical documentation, which has to contain the following: load analysis and calculation of every load-bearing element of the

scaffolding; calculation of element connections and the proof of stability of the entire scaffolding; calculation and image of scaffolding tie-in support; drawings of positions and details of the tie-ins, details of stiffness,

bracing, and other elements used to ensure scaffolding stability; drawing of the working surface and the guard rails; drawings of details of the coupling of working surface to the scaffolding and the coupling of the guard rail with the working surface or the scaffolding; drawing of the access to working levels of the scaffolding; definition of the maximum allowed load and the instructions for use and maintenance; order and manner of erecting and dismantling in accordance with occupational safety measures; etc. Working scaffold erection and dismantling has to be performed under the supervision of a designated qualified person on the construction site.



**Figure 4.** Working scaffolding [7-11]

Suspended scaffolding is erected on parts of the building or structure where it is impossible to erect a tower scaffolding or where a tower would incur higher costs (Figure 5).

The elements of these scaffolds have to meet the following requirements:

- a guard rail at least 1 m high with a smooth surface and no sharp edges;
- guard rail elements with gaps of no more than 35cm;
- a toe board at least 20 cm high;

- working surface elements (boards) that completely cover the space between the standards;
- scaffolding board placed no further than 20 cm from the building wall;
- at least 80 cm of uninterrupted width of the board;
- safe ingress/egress point at every scaffolding level [4, 5].

Load-bearing scaffolding is a temporary auxiliary structure whose purpose is to transfer to the ground the load from construction site traffic, machinery, equipment, installations, materials, and temporary buildings, as well as the weight of a part of the building under construction (fresh concrete in formwork, steel or concrete structure fitting, etc.), until the structure is able to transfer the load to its own permanent support elements (walls on a building, bridge pillars, etc.) (Figure 6).



**Figure 5.** Suspended scaffolding and work-at-height platform (platform moving along a scaffold column) [7-11]



**Figure 6.** Load-bearing scaffolding [7-11]

A safety scaffolding with a fall arrest platform or safety net underneath is so positioned that the fall arrest platform does not exceed 3 m below the edge over which a worker could fall. A safety scaffolding with a protection fan above, intended for protecting workers against falling objects, should be placed at least 2.5 m above the surface on which the workers move. Safety scaffolds with a fall arrest platform underneath and with a protection fan above are designed and constructed so as to retain the heaviest object that could fall and prevent its bouncing and shattering. Dimensions and construction of such scaffolds depend on the possible fall height and path and the weight of either a worker or an object, whichever is heavier. The width of the fall arrest platform or the protection fan must not be lower than 1.5 m [3-6].

To prevent falls from roofs or roof access points, a regulation guard rail has to be fitted before the roofing work above the open edges where the work will be performed and in places designated for the transport of tools and materials. Likewise, safe access to the working surface has to be provided. In case it is not possible to fit guard rails during roofing or other work at height, safety belts, harnesses, and ropes are used as personal fall arrest equipment, or fall arrest platforms, nets, or fans are used as collective fall protection (Figure 7).



Figure 7. Use of safety belts/harnesses and ropes during roofing and façade work [7-11]

Before any roofing activities on roofs covered with low load capacity materials (e.g. asbestos cement sheets, tin, etc.), special measures need to be taken in order to prevent roof cracking and workers falling through the roof. Fall protection of workers during roofing depends on the roof type as well as on the type of work to be performed. Roofing often involves small-scale repairs and interventions, which take less time, in which case the fitting of protection platforms, fans, or nets would be too costly (Figure 8).

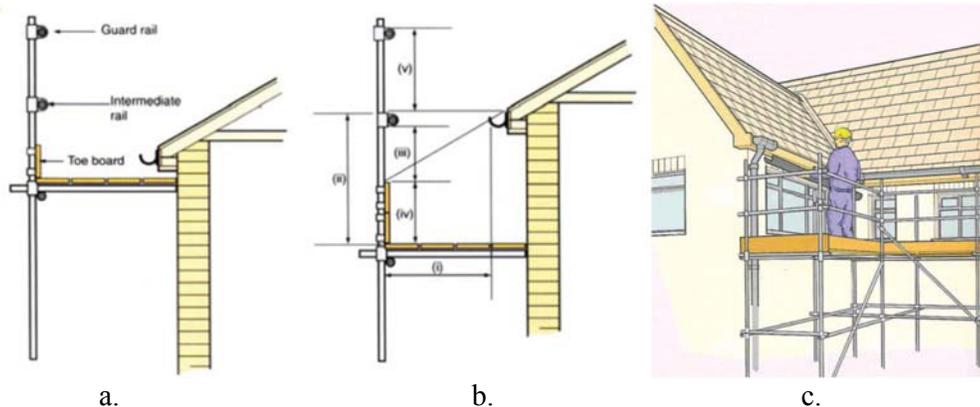


Figure 8. Fitting a fixed scaffolding for roofing: (a) Working platform fitted directly underneath the eaves; (b) Working platform fitted below the eaves (detailed): (i) minimum 60 cm; (ii) minimum 95 cm; (iii) minimum gap 47 cm; (iv) toe board reaching the line of the roof slope with a minimum height of 15 cm; (v) gap between the rails no more than 47 cm; (c) Working platform fitted below the eaves (appearance) [5]

The ladders used as scaffolding access and for similar purposes have to be placed at a 75° angle from the ground so that the horizontal distance between the feet and the top support is at least 75 cm. In case of wooden ladders, the rungs have to be made of a hardwood, with a round or square cross-section and wedged or inserted into the side rails. Ladders that are placed on a smooth or slippery solid surface have to be equipped with special anti-slip safety feet (e.g. rubber shoes) that completely prevent slipping. If necessary, the top ends can be equipped with hooks or otherwise attached to the top support to increase safety (Figure 9).

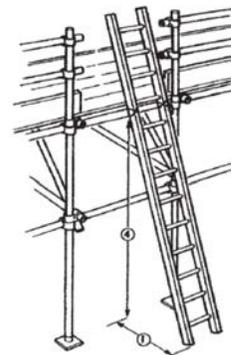


Figure 9. Proper ladder placement [5]

Safe ingress to and egress from the work space is mandatory for work at height. All working platforms, ladders, scaffolds, protection fans, transport lifts, and materials must be safe to use and have to be regularly inspected. Working platform surfaces should be thoroughly cleaned to avoid slipping [6, 5].

## CONCLUSION

In all parts of construction work, it is essential to consistently adhere to the rules regarding the use of all required personal protective equipment for specific construction site tasks. During work at height, it is necessary to use equipment that will protect the head, the trunk, and the legs (helmets, safety gloves, protective clothing and footwear, safety nets, safety belts/harnesses and ropes, etc.). Work at height also requires temporary and auxiliary structures for safety (erected scaffolding, working platforms, suspended scaffolding, ladders, etc.). The investor is obligated to provide the workers with all the necessary PPE and temporary and auxiliary structures and, more importantly, to provide supervision of work by appointing an occupational safety and health coordinator in the construction work stage of the project.

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## BIOGRAPHY

Jasmina Radosavljević was born in Niš, Serbia. She received a degree in Civil engineering from the University of Niš and the Ph.D. degree from the Technical Faculty “Mihajlo Pupin” in Zrenjanin. She is the author of over one hundred and fifty scientific



papers, five textbooks and two monographs in the field of occupational safety and environmental protection. She is currently working as a full professor at the Faculty of Occupational Safety in Nis, University of Nis.

## ZAŠTITA RADNIKA PRI IZVOĐENJU GRAĐEVINSKIH RADOVA NA VISINI

*Jasmina Radosavljević, Ana Vukadinović*

**Rezime:** *Prilikom izvođenja građevinskih radova, najveći broj povreda sa teškim ili smrtnim ishodom rezultat je pada sa visine. U radu su prikazani građevinski radovi na visini, mere, sredstva i oprema za ličnu zaštitu radnika koja se koristi prilikom izvođenja ovih radova a čijom primenom je omogućen bezbedan rad. Takođe su prikazane privremene i pomoćne konstrukcije koje se koriste prilikom izvođenja radova na visini.*

**Ključne reči:** građevinarstvo, rad na visini, zaštita na radu, zaštitna sredstva i oprema