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Demolition works on Occupational Health and Safety in Poland

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Abstract:
The study aims to investigate issues and factors related to applicable regulations and standards on safety during demolition works in Polish conditions. Demolition involves a number of factors and elements that outweigh potential threat prevention. A key issue to ensure safe and hygienic working conditions is conducting thorough risk assessments, having a comprehensive understanding of occupational health and safety regulations, and ensuring they are strictly followed. The paper provides scientists, engineers and workers with the fundamentals of occupational health and safety in demolition work in Poland. The study is also intended to initiate wide discussion and novel investigations in the field.

Keywords:
civil engineering, social and economic aspects, health and safety at work, demolition works

1. Introduction

The work in general, a component of human and social development, is an inherent factor of everyday life [1]. Many factors influence the choice of type of work and the fulfilment found. Each employee must acquire relevant skills and qualifications to safely perform the daily tasks and activities. One of the most vital branches of the economy, encompassing residential, industrial and civil engineering projects in the construction field. Construction of new buildings and structures requires appropriate site preparation for a newly erected structure or to expand the existing structure. In many cases, this action requires the removal of old infrastructure or existing buildings and structures from the site. This process is called demolition and involves dismantling and removing structures from the plot or building site. Demolition works are integral to the construction works [2].

Due to the specific nature of the work, demolition of buildings is considered a hazardous activity. Demolition is the opposite of construction, but it apparently looks like the easiest process. However, this misconception may lead to a possible misunderstanding of the challenges triggered during building demolition. Demolition is a high-risk activity. At every stage of the process, it should be organised and carried out in accordance with fundamental principles of safe and hygienic work. Every job carries a certain risk to operators. Even a simple sheet of paper may cut the skin in the course of office work. Demolition involves a higher number of factors and elements that potentially pose a threat. To ensure safe and hygienic working conditions, it is necessary to conduct a thorough risk assessment, acquire a comprehensive understanding of occupational health and safety regulations, and follow them.

The paper discusses issues and factors showing how applicable regulations and standards directly affect safety during building demolition in Polish conditions. The background of practice based on case studies seems appropriate for identifying the main safety hazards during demolition work. The authors are aware of the fact that the article does not cover all issues; each aspect may be separately considered a solitary investigation problem. The investigation does not distinguish between partial and total demolition. The paper may serve as a background for new investigations on occupational health and safety in demolition work in Poland.

2. Occupational Health and Safety in demolition works

2.1. Methods of demolition works

Demolition work is carried out by three basic methods: manual, mechanical and specialised. Manual demolition is conducted when the use of mechanical equipment is impossible due to existing limitations or requirements specified in the demolition plan. This applies to the following cases: the work is carried out close to structures at risk of damage, e.g. historic structures with large windows or in poor condition, the proximity of existing structures preventing the use of heavy construction equipment due to shock, vibration, and noise, harmful to people; the plans for the structure to be reused [3]. Manual methods are also commonly used as a supplement to mechanical demolition work. It should be noted that improper manual demolition work in urban environments generates significant vibrations that propagate to neighbouring buildings, potentially affecting occupant comfort and structural integrity [4].

Mechanical demolition is one of the most commonly used demolition methods. This method involves demolition equipment (heavy construction machinery), which guarantees high work efficiency, allowing for quick and safe building dismantling. This technology employs excavators with specialised attachments for chiselling and crushing, including jaws, shears, cranes, and loaders. These machines are advantageous, mobile, high-performing, and can operate on vertical and horizontal surfaces above their location. On the other

hand, this technology is bound to meet high requirements. The machines require adequate access to the object demolished, as well as a solid and relatively flat surface. The limiting means is the machine arm's working range [5]. Mechanical methods should be applied to remove all flat elements, beams and columns, steel and brick structures, cooling towers, walls, partitions, garages, workshops, depots, etc. [6]. Demolition robots are used as multi-functional, remotely controlled machines, designed to operate in severe conditions [7]. Special demolition methods include blasting, which involves demolishing buildings and structures with explosives. Demolition blasting covers an extensive and highly diverse range of applications [8]. They involve the following structural classes: foundations of buildings, machinery, and equipment, bridges, dense, tall, or large-scale reinforced concrete structures, ceramic and reinforced concrete chimneys, reinforced concrete towers, tanks, sedimentation tanks and other low-height reinforced concrete facilities, tall steel structures of variable design, etc. [9,10].

Each of the abovementioned methods of demolishing buildings poses certain hazards and risks to the workers. The construction industry is sensitive to occupational accidents [11]. According to Eurostat statistics [12], this field of activity is the most dangerous throughout European countries. The most common accidents on construction sites include: trips and falls (15%), accidents caused by falling objects or improper use of tools (13%), falls from height (11%), the case of being buried or pulled into a hole (3%). In addition, construction workers are exposed to injuries caused by vehicle traffic, contact with chemicals and the effects of variable and unfavourable weather conditions. Approximately 70% of construction accidents are caused by careless behaviour and misconducting occupational health and safety regulations. Occasionally, accidents are caused by negligence in the overall organisation of work on the construction site or the organisation of workstations, as well as by technical causes. Among the most common causes of employee misconduct, the following are predominant: the employee's incorrect action, insufficient focus on the task at hand, reaction to an unexpected event, ignorance of the hazard, inappropriate work pace, and the lack of experience [13]. Most accidents are attributed to human causes; this trend is likely to increase in proportion to the reliability and sophistication of hardware tools [14].

2.2. Health and safety requirements

Professional work is a crucial aspect of every adult's life, due to personal and company development. The work fulfils various functions: economic, i.e. value creation, social, manifested in social life and profitable, an income source for the individual [15]. Achieving a balance between work and personal life is significantly affected by the values and choices of individual workers [16]. Pursuant to Article 15 of the Labour Code [17], the employer is obliged to provide employees with safe and hygienic working conditions. A necessary condition for safe work performance is compliance with occupational health and safety regulations and principles. This fundamental obligation of an employee is defined in Article 211 of the Labour Code [17]. There is a group of particularly hazardous jobs where the risk of an accident is enormous, due to the specific nature of the work, the hazardous materials used and the local conditions. They include [5] particularly hazardous jobs in general occupational health and safety regulations, hazardous jobs in industry-specific occupational health and safety regulations, dangerous jobs in equipment and installation operating instructions and other jobs of increased risk or performed under difficult conditions, deemed particularly dangerous by the employer. Additionally, general occupational health and safety regulations [18] consider the following particularly hazardous jobs: construction, demolition, renovation, and assembly work conducted without breaks in tanks, channels, the interiors of technical equipment, and other hazardous confined spaces; work involving hazardous materials; and work at heights.

Ensuring safe and hygienic working conditions is a multi-stage process that requires knowledge of a range of occupational health and safety regulations and mandates [19]. Employees must be aware that their safety is not solely affected by the employer's actions; it is directly linked to their behaviour and knowledge of applicable regulations and requirements. Employees acquire such skills through training. Pursuant to Article 237 § 2 of the Labour Code [17], employers are obliged to provide occupational health and safety training to employees before allowing them to work and to conduct dedicated periodic training. Employers also have to complete occupational health and safety training and update their knowledge to the extent necessary to meet the requirements [20]. All types of work, including demolition work, pose hazards associated with their execution [21]. General construction work, including demolition of buildings, is considered particularly dangerous. An essential element of demolition is the work at height. The Regulation on General Occupational Health and Safety [18] states that work at height is defined as work performed on a surface at least 1.0 m above the floor or ground. Work at height is considered particularly hazardous; associated accidents often result in employee deaths or serious injuries. Therefore, while performing work at height, it is recommended that detailed occupational health and safety requirements are met [22]. To ensure an adequate level of safety, proper selection and use of collective fall protection equipment is required in construction and other sectors of the economy [23].

The construction sector is marked as the most accident-prone type of activity, with the most serious fatal accidents [24]. The level of safety during demolition work is also linked to the level of education and professional training of the workers participating in the demolition process. In civil engineering curricula, students acquire knowledge of building construction. In many cases, however, there are no contents dedicated to the principles of demolition. Such courses should be conducted by experienced instructors involved in the demolition process. Insufficient level of knowledge in the field is displayed by the results of construction qualification exams. Civil engineers are often unable to provide answers on topics related to the techniques and principles of safe demolition [25].

Demolition of a structure is the reverse of its construction, but in many cases, its outcomes are unpredictable. Failure to maintain workplace safety during demolition directly threatens the people and property within the work area. Ensuring proper protection throughout this process is a key condition for successfully completing the demolition work. In the evaluation of safety and health protection during construction projects, including demolitions, accident statistics play an important role, supplemented by demographic data on safety and health conditions produced by the behaviour of construction workers and their safety culture and climate. These data make it possible to assess and determine occupational safety levels, leading to the implementation of suitable preventive measures at each stage of the process. All construction activities, including demolition, correspond to high risk. This statement is supported by an analysis of accident causes, which stem from design, execution,

and operational errors resulting from non-compliance with health and safety regulations and principles. The performance of construction projects is closely linked with human behaviour. Accidents may be caused by behaviour not thoroughly identified, that fail to adhere to safe work regulations and principles [26]. The level of knowledge of occupational health and safety regulations is unsatisfactory. An action is anticipated to raise awareness of the scale and consequences of accidents, injuries and occupational diseases, as well as the scale and consequences of non-compliance with occupational health and safety regulations related to work in the construction industry, including demolition work [27].

Effective safety management in the construction process, including demolition projects, is linked to a properly prepared demolition schedule and the demolition work carried out on its basis. It is also necessary to ensure that relevant technical and organisational measures are targeted to minimise the risk of hazards during demolition work, including efficient communication and rapid evacuation in an emergency [28]. Health and safety in construction and demolition processes support the entire management system, which encompasses organisational structure, planning, responsibilities, policies, procedures, processes and resources required to develop, implement, review and maintain an appropriate level of occupational health and safety within the enterprise, during construction and demolition of a building. Occupational health and safety in the construction and demolition process should be regarded more broadly as the state of work conditions, work organisation and employee behaviour that ensures the required level of health and safety protection in the construction work environment at every stage of its execution. Ensuring health and safety is not just about monitoring the construction or demolition process; it is a process to be properly designed, organised, and implemented safely, in accordance with technical regulations and guidelines [29].

The duty of a construction manager is to create a working environment that provides employees with safe and hygienic conditions. This includes the mode and time of performing the assigned task as precisely as possible (Supreme Court ruling of February 1, 1968, I PRN 449/67). When issuing an order to possibly cause a threat to human health or life, the person issuing the order is obliged to verify that the person receiving the order has properly understood it, and that it has been carried out (Supreme Court ruling of October 25, 1968, II KR 148/68). The prohibition on the use of specific work methods is not sufficient unless it is assured that these prohibitions are respected by employees (Supreme Court ruling of December 3, 1963, II PR 558/63).

The Supreme Court, in its judgment of 5 December 1968, II PR 503/68, stated that proper organisation of the work process includes appropriate supervision, determining the method and time of performing the task assigned to the employee and ensuring proper condition of machines, devices and work tools [30].

2.3. Actions for safety and health protection

In the context of safety and health protection activities in demolition works, the following actions can be distinguished: local activities related to a given construction process, demolition of a building or a complex of buildings, national activities covering the territory of the country (the Republic of Poland) or several voivodeships and international activities covering the territory of several countries. The chapter includes regulations and institutional roles, but does not evaluate their effectiveness or the gaps between regulations. The authors are aware that the latter requires separate investigation.

2.3.1. Local activities

In the context of local activities, considering a single construction process involving demolition of a building, a complex of buildings or a construction object, the activities are regulated by the Construction Law [31]. This Act regulates activities involving the design, construction, maintenance, and demolition of buildings and defines the operational principles of public administration bodies in these areas [32]. According to Article 17 of the Construction Law [31], the collection participants in the construction process cover: the investor, the investor's inspector, the designer and the construction manager or work manager. Management of the construction or demolition process takes into account the safety and health protection principles of the regulations, which classify responsibility for the investor. The investor is responsible for: developing designs as needed upon request, assuming construction management by the construction manager and creating a safety and health protection plan, as indicated in Article 18 of the Construction Law [31]. The scope of responsibilities of the participants in the investment and construction process varies across countries; it requires the involvement of multiple entities [33].

The responsibilities of a construction manager, in accordance with Article 22 of the Construction Law [31], cover the organisation and management of the building construction due to design or building permit, technical and construction regulations, occupational health and safety regulations, coordinating the tasks to prevent from health and safety hazards, coordinating the activities to ensure health and safety regulations in the course of construction work [34]. Pursuant to Article 21a of the Construction Law [31], the construction manager is obliged to prepare or ensure the preparation of a health and safety plan before the start of demolition work, taking into account the specific nature of the building and the conditions for conducting construction work, specified in the demolition plan. Construction law requires the investor and construction manager to organise the construction process [35], including demolition work, corresponding to health and safety regulations. Execution of safety-related tasks in the course of the construction and demolition process is possible by means of work coordination and close cooperation of all participants of the construction process [36]. The construction manager is able to request changes to the design from the investor if they are justified by increasing the safety of the construction work or streamlining the demolition or construction process [32].

In many cases involving demolition of buildings or structures, a demolition permit is required and is issued by the architectural and construction authority. In most EU countries, including Germany, Poland, and France, the procedure depends on the building's scale or type. A demolition permit application, pursuant to Article 30b of the Construction Law [31], must be accompanied by the following: the consent of the building owner, a sketch of the building location, a specification of the scope and method of demolition work, ensuring how the safety of people and property will be ensured, permits, approvals, opinions and other documents required by separate laws and a demolition plan if required. From the perspective of ensuring health and safety, specification of the scope and method of demolition work, and the way to ensure the safety of people and property, is crucial from the health and safety viewpoint [5]. In many cases, these

abovementioned items are included in the demolition project. A building engineer with a building qualification is bound to prepare a demolition project. A building demolition project is required, in accordance with Article 31 of the Construction Law [31], if it concerns the following: buildings and structures higher than 8 meters, if their distance from the plot boundary is less than half their height; buildings and construction equipment listed in the register of historical monuments or under conservation protection.

The demolition project should be completed based on technical documentation and a detailed on-site inspection of the building to be demolished. Article 31 of the Construction Law [31] makes the owner or manager of a building obligatorily retain technical documentation for the time of the building operation. These entities are obliged to: maintain and store documentation, inspect the building and repair damage and deficiencies related to its maintenance [37]. In many cases, e.g. in older buildings, obstacles happen: technical documentation is unavailable, and documentation available to the investor is insufficient to properly determine the type of structure and its construction materials. This affects the duration of the demolition process and is linked to other factors: the frequency and severity of the factors specific to the given construction, company, and location [38]. In such cases, a detailed inspection of the building (site inspection), including excavation, is necessary to determine the correct type and grade of the structure to be demolished. In many cases, the site visit is limited to external inspection of the object to be demolished and a technical assessment. The conclusions drawn here may be related to significant errors. Furthermore, the construction and cladding of structural elements, or even reconstructions (often carried out without permission), make the assessment of the structural system complex, often leading to building failures [39]. The causes of building failures include unauthorised construction, reconstruction of structural elements without design documentation, and work performed by unqualified workers without proper supervision by specialists with appropriate building qualifications. Incorrect type and grade assessment of a building structure leads to a safety hazard during demolition.

Description and location of the building structures and utility networks is an essential element of a demolition project. This description should be comprehensive enough to avoid any doubts during demolition regarding the scope and purpose of the demolition and utility networks at the site. Incorrect or erroneous identification of existing utility networks at the design stage poses a direct safety risk. During demolition, the lack of information about utility networks (e.g. existing gas pipelines, power cables, pipelines, etc.) may bring damage to these networks, triggering a significant risk to the lives and health of humans and property [40]. A key element of a demolition project is the description of preparatory work to be completed before demolition, as well as the establishment of demolition stages. The scope of preparatory work, before demolition, includes securing the demolition site from unauthorised access [2]. Additionally, in large-scale structures, it may be necessary to carry out demolition work in stages. Logistical and staffing constraints of the demolition contractor may also indicate the need for demolition work in stages.

The description of the scope and method of demolition work [41] is a key element of a demolition project, along with information on the impact zone of the planned demolition. These contents should clearly indicate the method of work and the sequence of work, to ensure that the work is carried out safely according to occupational health and safety regulations [42]. Correct and accurate documentation corresponds with the proper determination of the type of structure to be demolished. Information on the impact zone, based on the location of the buildings to be demolished and the planned demolition method, indicates the impact zone of the planned demolition and potential restrictions in the neighbourhood of the demolition work. Furthermore, the planning process of construction work, including demolition work, close restricted areas, makes it necessary to verify if a protective zone has been established around the restricted area, next, to determine the scope of restrictions applicable to this protective zone [43]. Another element that should be included in a demolition plan is a display of measures aimed at reducing the potential negative impact of vibration emissions on surrounding buildings and the surrounding area resulting from the planned demolition. To reduce vibration emissions during demolition, it is recommended to primarily use crushing equipment, e.g. vibration-reducing demolition hammers, to cut the largest possible section of the structure to facilitate transportation and fragmentation outside the demolition area, and to conduct demolition work in the close vicinity of other structures by manual techniques.

Due to legal requirements for greenery and forest patch protection [44,45], a demolition project should also include a study of the terrain and vegetation layout and information on any protected species whose habitats are located within the area affected by the planned demolition works. In special cases, dendrological inventory is conducted to cover species identification, tree trunk circumference, and crown range growing near the planned demolition works, and the results are plotted on a design map. This content includes information on the demolition works location planned demolition works location, say near the trees and shrubs exceeding 25 square metres. In cases where the existing vegetation and trees interfere with the ongoing works, appropriate permits for their removal are required. Article 83f of the Nature Conservation Act [46] lists exceptions to the requirement for a permit for the removal of trees or shrubs. A key to ensuring safety during demolition work is proper development of the rules how of ensuinge the safety of people and property during demolition work [47]. The method of ensuring the safety of people and property during demolition work should be consistent with the Regulation of the Minister of Infrastructure on occupational health and safety during construction work [48] and the Regulation of the Minister of Labour and Social Policy on general occupational health and safety regulations [18]. Before any demolition work begins, a Safe Work Instruction must be developed for construction works, based on the Safety and Health Protection Plan. The Safety and Health Protection Plan addresses risks to the health and life of employees and provides appropriate protective measures and procedures. It must be tailored to the specific nature of the job site, the type of work performed and applicable occupational health and safety regulations [49]. The responsible persons for preparing a Safe Work Instruction are the construction manager or the employer. The purpose of the instruction is to prevent hazards associated with construction work [50].

During the demolition of buildings and structures, waste is generated. Under the Waste Act [51], information on waste generated and the methods of waste management must be developed and submitted to the relevant authority. The demolition project is bound to include information on waste management, to cover a summary of waste quantities. Germany and France often have more stringent "pre-demolition auditing" and waste-separation requirements. Waste should be classified in

accordance with the Regulation of the Minister of Climate on the Waste Catalogue [52]. Each waste material requires an individual approach – it should first be dismantled, then safely transported, next, processed or stored. Important steps in this process include: proper waste classification (determining its type, quality and quantity), transferring recyclable waste to relevant entities, and transferring non-processable waste to a landfill after prior segregation [53]. Hazardous waste, like asbestos, requires an asbestos inventory before any demolition work. Certified companies with specialised equipment and trained personnel can only carry out to dedicated landfills and their transport is closely monitored. During demolition work, it is possible to discover waste that could not be identified during the on-site inspection. If such a situation occurs, the designer and the relevant authorities should be informed by correcting the information on waste management during the demolition process. This procedure is intended to ensure that an appropriate level of environmental safety is maintained and regulated by the waste law [54].

In addition to a summary of the type and quantity of predicted waste, generated by demolition work, waste management data should include: the advice, how to prevent or reduce waste generation and its negative impact on the environment, outline on further waste management methods, including waste collection, transport, recovery, and disposal, indication of the location and method of storage and the type of waste being stored, information on the disposal of hazardous materials, the expected completion date of the waste-generating work. The quantities of specific types of construction waste are primarily affected by: the type of climate zone, building culture, availability of raw materials, architecture, construction trends, designer, contractor, investor, and the influence of the investor in the context of renovation frequency to keep pace with evolving construction trends [55]. The developed demolition plan forms the basis for demolition work. The scope of additional documentation required for demolition employing the blasting method is specified in the regulation on the demolition of buildings involving the explosive method [56]. Blasting is performed by authorised personnel based on blasting documentation, if the building does not require a demolition permit or notification, based on the blasting certificate. This certificate is bound to include technical data necessary for blasting work, including the location and construction of individual explosive charges, their size and the mode of connection within the blasting network. This action is prepared as required for the entire building, its individual parts, or its components. After the blasting course is completed, these materials are considered the as-built documentation [54].

Due to the specific nature of the work, the demolition process must be carefully planned and organised. Demolition preparation has to involve the structure and its surroundings. During the demolition of buildings, exceptional situations arise, and their consequences are difficult to predict due to a lack of sufficient database on construction type and technical conditions [25]. Any design inconsistencies or deficiencies that constitute significant flaws may trigger structural failure; they should be detected to ensure an adequate level of safety during demolition work.

2.3.2. National activities

In terms of national activities covering the territory of the Republic of Poland, there are government institutions, associations and workgroups involved in implementing occupational health and safety programs [57]. The Ministry of Family, Labour and Social Policy designates the following institutions responsible for occupational health and safety: National Labour Inspectorate, Chief Sanitary Inspectorate, State Mining Authority, National Atomic Energy Agency, Office of Technical Inspection, Central Institute for Labour Protection – National Research Institute and Institute of Occupational Medicine in Łódź.

The National Labour Inspectorate [58], as a government body, enforces labour law, including occupational health and safety, through effective and targeted inspections and preventive measures. These activities aim to reduce accident risks and ensure compliance with labour law. This manifests the legislature's recognition of the need to maximise protection of the most important values: the lives and health of workers [59]. The National Labour Inspectorate's responsibilities stem from a number of normative acts. The most important responsibilities are defined in Article 10 of the Act on the National Labour Inspectorate [60].

The State Sanitary Inspectorate reports to the minister responsible for health, headed by the Chief Sanitary Inspector [61]. As a central government office, the Chief Sanitary Inspectorate oversees and develops activities aimed at promoting the well-being and public health of citizens, as well as tasks related to minimising the impact of events that adversely affect citizens' lives. The current sanitary-epidemiological system in Poland has been shaped throughout the years [62]. The Chief Sanitary Inspectorate operates under the Act on the State Sanitary Inspectorate [63]. Based on information and materials submitted by state sanitary inspectors at provincial, district and border levels, the Chief Sanitary Inspectorate prepares the National Sanitary Status [64].

The State Mining Authority [65] provides services to the President of the State Mining Authority. The President of the State Mining Authority and the directors of the district mining offices supervise and control the operations of mining plants, particularly in the following areas: occupational health and safety, fire safety, mine rescue, management of mineral deposits during extraction, environmental protection and deposit management, damage prevention, construction and decommissioning of mining plants, including land reclamation after mining operations.

The National Atomic Energy Agency [66] (NAEA) performs tasks related to ensuring nuclear safety and radiological protection in the country. The President of the NAEA, the central government authority responsible for nuclear safety and radiological protection, submits annual reports (the Annual Report of the President of the NAEA [67]) to the Prime Minister on its activities and assessments of the country's radiological safety and protection status.

The Office of Technical Inspection (UDT [68]) is a state legal institution operating in the field of technical equipment safety, based on the Technical Inspection Act [69]. The mission of the UDT is defined as "We support development. We care for safety." The UDT also conducts training, thus supporting efforts to improve the professional qualifications of manufacturers and users in the safe operation of technical equipment. A construction site is a place where a wide range of construction machinery, equipment, and vehicles are used, both subject to technical inspection and under the supervision of other services to ensure safety on construction sites. Regulations and safety assessments on construction sites often overlap, assigning responsibility for a given area of operation, type of equipment, or field of work to specific entities [70].

The Central Institute for Labour Protection – National Research Institute [71] is dedicated to shaping working conditions in accordance with human psychophysical capabilities. The Institute's activities include conducting scientific research and developing new technical and organisational solutions of labour protection, occupational health and safety and ergonomics.

The Institute of Occupational Medicine in Łódź [72] covers activities related to the broad worker health protection, public health and environmental health. It provides services in testing the toxic properties of medical devices and chemicals, molecular testing, individual and environmental dosimetry, labyrinth examination, radon concentration measurements, and expertise and consulting in the fields of occupational physiology, ergonomics, and biological testing.

Activities promoting safety and health protection in construction are implemented by individual government institutions at the national level, and by associations and agreements. In 2010, the Agreement for Safety in Construction was stated in Poland. The goal of cooperation between signatory companies and companies associated with the Agreement for Safety in Construction [73] is to implement safety standards, including the introduction of systemic health and safety solutions and educational and training activities. The Agreement for Safety in Construction has developed a package of standards for safe work on construction sites, as a result of experience and many years of construction practice of the companies, thus it can be considered a deposit of knowledge.

2.3.3. International activities

At the international level, several organisations operate in the field of occupational health and safety, including the International Labour Organisation [74] and the European Agency for Safety and Health at Work [75].

The International Labour Organisation [74], founded in 1919 as a tripartite organisation, here representatives of workers, businesses, and individual governments work together to promote social justice and better living conditions worldwide.

The European Agency for Safety and Health at Work [75] has defined its objectives by identifying three strategic lines of action, which encompass the following:

1. Providing evidence and knowledge on current, new and emerging risks, concerning their impact on safety and health and their prevention,
2. Promoting and facilitating the development of tools and resources to more effectively prevent occupational health and safety risks,
3. Conducting outreach and networking activities to enable the Agency and its stakeholders to foster a positive culture of risk prevention in the workplace.

Efforts at the local, national, and international levels to ultimately improve safety and health protection must be coordinated and complementary.

2.4. Principles of safety management

The trend of ensuring safe living conditions, especially safe working conditions, emerged in Poland in the late 1980s. These activities were given the term safety management [76]. Safety management is a method of managing occupational risk. In a construction work environment, there is always a risk of exposure to harmful, burdensome or dangerous factors, regardless of the type, form, scope, or nature of the work performed. The nature of the hazards stems from the industry's specific mode of operation; the safety and health of construction workers require a systematic approach to managing both the enterprise and work crews [77]. Recently, new technologies have been used to manage occupational safety in the construction industry, including unmanned aerial vehicles (UAVs). Drones can be used, for example, to monitor employee compliance with occupational health and safety regulations and to assess the technical condition of machinery and equipment used on construction sites [78].

Shaping a management system requires implementing numerous processes. Developing a management system can be driven by the pressure of current problems within the enterprise, its strategic intentions and future challenges stemming from a dynamic environment. Significant accumulation of current problems and dysfunctions within the organisation, along with the associated threats, favours adopting a diagnostic approach to organisational design [79]. At every stage, a company needs to continually adopt its management system. Each of the areas identified in the management system also requires adaptation to the needs of both external and internal environments. None of them is bound to contradict the other elements of the management system. Values and goals, which are listed among areas of the management system, also have to match the criteria of the organisation and its environment [80].

In many cases, investors expect or even impose on contractors the completion of construction work, including demolition, within deadlines (time periods) that are disproportionate to the scope of the general construction work entrusted. Imposing demolition work within a shorter timeframe than the one relevant to the proper construction process often triggers contractors to perform these works in violation of safety requirements or even in violation of occupational health and safety requirements and regulations, with the only primary goal to meet contractual deadlines.

3. Key safety principles

3.1. Training for construction workers

Every worker should receive appropriate safety training, including health and safety regulations, the use of tools and machinery, and emergency and accident procedures. Workers should also be trained in first aid and in administering it in the event of an accident. Employee health and safety training is a key factor in reducing or eliminating workplace accidents and occupational illnesses. Failure to realise the need for qualification improvement yields negative consequences, as health and safety training is often considered obligatory [81].

3.2. Regular inspections of the technical condition of equipment and tools

Equipment and tools used on construction sites must be regularly inspected for their technical condition and safety. Defective and inoperable equipment and tools should be removed to avoid potential breakdowns and accidents that pose a safety risk. Persons operating given pieces of equipment or machinery must familiarise themselves with the relevant occupational health and safety instructions, which should apply to the specific, relevantly equipped operating station due to a given machine or other technical device installed in the same location [82].

3.3. Use of appropriate personal protective equipment

Every employee should be equipped with appropriate personal protective equipment to the extent necessary for the

proper and safe performance of work at a given workstation. Basic personal protective equipment includes:

- Head protection by the use of safety helmets and hard hats. Hard hats and safety helmets protect the head against small objects falling from heights. Safety helmets are typically used with other personal protective equipment [83], protecting from hazardous factors.
- Face and eye protection should be provided by wearing glasses, if necessary, masks, goggles or face shields, essential for work where the eyes are exposed to harmful effects of dust, spatter, sparks or irritating substances. Demolition work often involves manual welding processes, e.g. cutting or sawing steel components. Proper eye and face protection is essential for this type of work [84].
- Hearing protection is required for work that exceeds permissible noise levels. Noise is classified as a physical work environment factor. In this case, earmuffs and earplugs are used. While earplugs are located in the external auditory canal or at the entrance to the external auditory canal, it is important to use them correctly [85].
- Hand and arm protection, including gloves and protectors, is appropriate for a number of working modes. Hand protection should be applied in professional work involving a high risk of hand injuries [86] or at the risk of skin contact with hazardous substances, e.g. chemicals.
- Protecting legs and feet from possible injuries and damage during work. Here, wearing safety footwear is appropriate, e.g., shoes of the appropriate resistance class – waterproof, with reinforced toes and thick soles, protectors for individual parts of the legs – they are required when in contact with moisture, mud, extreme temperatures or sharp objects [87].
- Body protection by wearing workwear designed to protect against contact with chemicals, water, mud or excessively high/low temperatures. With regards to the type of work, this may include overalls, jackets, trousers and body protection. Proper workplace safety also requires equipping employees with appropriate workwear and using reflective materials [88].

A wide range of fall protection equipment is required while working at heights, including roof edges, scaffolding, etc. Basic fall protection equipment includes: safety harnesses, ropes, harnesses, shock-absorbing devices and self-locking devices. The practice of using personal fall protection equipment indicates that one key configuration element of a fall protection system is proper equipment anchoring [89]. Personal protective equipment for demolition works requires essential hard hats, safety glasses, high-visibility vests, safety boots and hearing protection, designed to protect against falling debris, dust, noise, and other structural hazards.

3.4. Collective protective equipment

Minimising the risk of construction accidents is achieved by providing collective protective equipment. Relevantly to § 6, paragraphs 1 and 2 of the Regulation of the Minister of Infrastructure on occupational health and safety during construction works [18], collective protective equipment has to be employed to protect workstations at height against falls from height, particularly, railings referred to in § 15, paragraph 2, protective nets, and safety nets. The use of personal protective equipment, e.g., safety harnesses, is allowable in cases where collective protective equipment cannot be applied. Additionally, the provisions of the Regulation of the Minister of Economy, Labour and Social Policy amending the regulation on minimum requirements for occupational health and safety regarding the use of machinery by employees during work impose an obligation to ensure priority use (§ 8a, paragraph 1, point 2 of the Regulation) of collective protective equipment (including permanently installed protective railings) over personal protective equipment. Safety railings are typically made of materials such as wood and steel; they cannot be made of tapes or ropes [90].

Collective protective equipment for demolition works includes guardrails, scaffolding, toe boards, mesh panels, secure netting, temporary fencing to establish exclusion zones, dust-control systems, etc. These means are critical for securing the work area and preventing accidents.

3.5. Proper construction site organisation and planning work

A key element in ensuring the safety of a construction site is proper site organisation and planning for demolition work. The site should be fenced, provided with electricity and water connections, equipped with roads and walkways, and equipped with secure hygiene and sanitation facilities. Minimising the risk of construction accidents also requires designation and precise marking of hazardous areas where threats to human life and health occur [91]. The application of modern, available tools, e.g. BIM models, simplifies risk analysis. The creation of scenarios is possible for the duration of demolition work, allowing for the selection of the fastest solution while simultaneously reducing costs and optimising resources [92].

3.6. Safe material storage and construction waste disposal

Construction materials should be stored safely and in accordance with regulations to avoid accidents related to falling or shifting. Various types of demolition materials are generated during the demolition process. Their storage process should also take into account the hazardous nature of these materials. Systematic measures are bound to be implemented to obtain high-quality, recyclable materials, requiring selective demolition of buildings and separating them into individual materials [93]. Properly organised waste storage, away from work areas, and regular waste removal is intended to reduce the risk of injury and ensure cleanliness and order on the construction site.

3.7. Regular cleaning and maintenance of the construction site

Regular cleaning of the work area and maintenance of the demolition site directly prevent accidents related to slips, falls, or trips. Proper cleaning ensures communication on escape routes, which have to be kept clear in the event of an emergency and prevents accidents. An effective way of accident prevention is identifying the misses and their causes [94].

3.8. Compliance with safety regulations for work in inclement weather

Demolition works, part of the construction process, should be performed with particular caution in selected weather conditions, such as snow, rain, or strong winds. Working outdoors in winter exposes workers to low ambient temperatures, windy conditions, and wet clothing, which can result in hypothermia, frostbite, chilblains, trench foot, dehydration, and upper respiratory tract infections. Climatic factors are direct causes of many disasters. Thus, climatic conditions and their changes should be taken into account during construction work [95].

3.9. Regular inspections of building technical condition, monitoring, and structure control

Technical condition inspections of buildings should be conducted regularly to detect any irregularities or hazards and to take appropriate preventative measures to avoid undesirable risks. During demolition work, structural elements should be continuously monitored and inspected, especially when major load-bearing elements are removed. Ensuring that the structure of a given building is dismantled correctly and in the correct order minimises the risk of uncontrolled damage and ensures the safety of workers. Demolition in dense urban areas is particularly dangerous. In this case, monitoring of buildings located in the immediate vicinity of the demolition work should be conducted [96].

4. Safety requirements on construction or demolition sites

To plan and organise demolition work on construction sites in safe conditions, extensive engineering knowledge is essential, including standards and legal regulations. In the event of a hazard, employees are obliged to behave in accordance with their occupational health and safety training appropriate to their role on the construction site; they are required to use personal protective equipment, e.g. helmets, protective gloves, etc.

Pursuant to Article 207 § 3 of the Labour Code [17], a person managing employees is obliged to be acquainted with labour protection regulations, including occupational health and safety regulations and principles, to the extent necessary to perform the duties. The responsibilities of a work manager are outlined in Article 212 of the Labour Code [17], they include: organizing workstations in accordance with occupational health and safety regulations and principles, ensuring proper functioning of personal protective equipment and its use for its intended purpose, organizing, preparing, and conducting work, taking into account protection of employees against occupational accidents, occupational diseases and the illnesses related to the working environment, enforcing employee compliance with occupational health and safety regulations and principles.

The Supreme Court's judgment of 19 February 2013 (ref. IV KK 216/12) indicates that a person entrusted with managing the work of others is naturally obliged to constantly ensure that the work of their subordinates is carried out in accordance with occupational health and safety regulations and principles. Furthermore, issuing a ban on specific working methods is insufficient if it does not ensure that the prohibitions are respected by employees (Supreme Court judgment of 3 December 1963, ref. II PR 558/63). It requires subsequent verification of the subordinates' compatibility with the recommendations.

Additionally, those responsible for occupational health and safety are obliged to protect the health and lives of employees, ensuring safe and hygienic working conditions and exploring the achievements of science and technology. The persons responsible for occupational health and safety are intended to: organise work in a manner that ensures safe and hygienic working conditions, ensure compliance with occupational health and safety regulations and principles on the construction site, issue instructions to restore any violations in this regard and monitor the implementation of these instructions. The organisational obligations of the persons responsible for occupational health and safety are far-reaching: safe and hygienic working conditions must be created, and the work must be organised in a way that ensures these conditions are actually achieved. Due to Article 220 § 1 of the Penal Code [97], a person responsible for occupational health and safety who fails to fulfil the obligations and exposes an employee to direct danger of loss of life is directed to imprisonment.

The fundamental legal regulations regarding health and safety in general construction and demolition work include [98]:

- The Constitution of the Republic of Poland [99]. The importance the legislator attaches to these issues is clearly demonstrated by the provision contained in Article 66, Section 1 of the Constitution [99]. Workers have the right to be given safe and hygienic working conditions. It is also stated that the manner of realising this right and the employer's obligations in this regard are to be specified in statutory provisions [100].
- The Labour Code [17], within its Section X, separates a group of regulations related to occupational health and safety. It specifically addresses the basic obligations of employers, the rights and obligations of employees, and issues related to buildings and workspaces, as well as machinery and technical equipment. Additionally, it regulates issues related to preventive health care, workplace accidents, occupational diseases, personal protective equipment, and work clothing and footwear.
- The Construction Law [31], which covers design, construction, maintenance and demolition of buildings and specifies the principles of operation of public administration bodies in these areas.
- Regulation of the Minister of Infrastructure of 6 February 2003 on occupational health and safety during construction works [101], which specifies requirements for work at heights, earthworks, welding, demolition and construction work performed with the use of explosives, etc.
- Regulation of the Minister of Infrastructure of 23 June 2003 on safety and health protection, safety and health protection plan [102], which specifies: the scope and form of information on safety and health protection and the detailed scope of types of construction works posing a risk to human safety and health, the detailed scope and form of the safety and health protection plan.

Even the most detailed and effective legal orders and prohibitions do not reduce or minimise risks during general construction work, including demolition, unless they are implemented and enforced by the employer and followed by employees [103]. Hazardous factors may cause accidents at work, while harmful and burdensome factors may bring occupational diseases. Preventive measures to ensure work safety on a construction site include: proper preparation and organisation of the construction site; training and preparation of workers for their tasks; equipping the construction site with safe machinery, equipment, and tools; and preparing individual workstations according to occupational health and safety requirements [104].

5. Asbestos and hazardous materials

Directive 2009/148/EC on protection of workers from the risks related to exposure to asbestos imposes strict standards. The situation in Poland displays slow progress in achieving the goals set out in the Program for Disposal of Asbestos for the years 2009–2032 [107]. Any general construction work that involves the risk of contact with asbestos-containing products is classified as hazardous work to possibility cause health problems. The work related to the removal of asbestos-containing products should be carried out in a way that prevents the emission of

asbestos into the environment or limits its dusting. Improper demolition work is associated with potential health problems for workers [108,109].

The primary document aborting the use of asbestos-containing products is the Act on the Prohibition of the Use of Asbestos-Containing Products [110]. Detailed rules for handling and removing asbestos-containing materials are set out in regulations [111,112]. The implementation of tasks related to the demolition of buildings containing hazardous materials, including asbestos, requires the use of detailed procedures in order to ensure that the removed hazardous material has no negative impact on the environment and on people at direct contact with these materials [113-115].

6. Conclusions

A demolition project must be properly prepared and planned in terms of logistics, equipment, technical, and personnel. Logistics planning encompasses site organisation, providing appropriate equipment and securing the area. While developing a logistics management plan for a construction project, it is important to remember that it encompasses several complex processes characterised by significant labour intensity and variable execution conditions [105]. Demolition, like construction, is a process of constant variation during demolition or construction execution. As the work carries on, the impact area, scope, and front of the demolition work change. At every stage of the work, the employees face variation within their workstations. The ability to understand the processes occurring during structure demolition works improves safety during construction. However, some hazards cannot be avoided. Even a highly organised workplace or a meticulously developed health and safety plan cannot completely prevent accidents at the construction site. Therefore, every person at the construction site should properly react in a threat event to health or life, and be able to provide first aid. High employee turnover, as the employees change jobs after training and acquiring basic skills, is problematic for businesses. However, Chojnicki and Jarosiewicz indicated: "creating safe working conditions and motivating people to act safely is not only fulfilling a legal obligation, but also an investment that pays off [106]". It is the process of investing in a smart employee who reliably and safely performs assigned tasks. Every employee brings a unique background and personality. The degree of basic knowledge of occupational health and safety presents challenges in this process. Nevertheless, irrelevant behaviour cannot be tolerated; the supervisors should be informed of any violations of occupational health and safety regulations and requirements. Responsible employees work together to ensure their own safety and respond to inappropriate behaviour by other team members.

Enhancing the workers' experience through occupational health and safety training is the most effective way to improve safety and prevent accidents and hazards. There is also a need to increase the number of occupational health and safety training courses. Legal changes are required in this regard to ensure that the frequency of occupational health and safety training meets the current needs of employees performing hazardous work. Increasing the employee competencies through occupational health and safety training is the most effective way to prevent hazards and improve safety. While educated employees realise that the most important factor on a construction or demolition site is the safety of themselves and other co-workers, it is a key factor in ensuring the level of safety during work.

Selected workers, especially young people, believe they are immortal. They may be given advice that the workplace, especially the demolition area, is not a place where you can easily reload a saved data file. Furthermore, ignorance and a lack of adherence to occupational health and safety regulations and requirements (in many cases driven by simple laziness) increase the level of risk, which, in the case of demolition work, is already classified as very high. Therefore, compliance with applicable occupational health and safety regulations and standards is a key element in ensuring the safety of demolition work. Changes to building regulations and occupational health and safety training regulations are also necessary to align them with the current reality and the requirements of demolition work.

The present investigation is intended to trigger momentum for further investigations and discussion on demolition works in the light of occupational health and safety. The results encourage the authors to conduct broad investigations into demolition robots and BIM-based demolition planning, which are highly relevant to modern occupational health and safety in demolition. Future research will likely address the distinction between partial and total demolition. Partial and total demolition involve highly variable risk profiles, planning requirements, and occupational health and safety considerations, especially regarding the stability of remaining structural elements.

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