

ERGONOMICS IN CONSTRUCTION: DESIGNING CONSTRUCTION SITES FOR EFFICIENCY AND SAFETY

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Abstract: *The ergonomic design of construction sites is an essential factor for improving the safety, efficiency and health of workers. This article explores the fundamental principles of ergonomics, emphasizing the importance of adapting the work environment to the physical and cognitive needs of workers, highlighting how adapting the work environment to human needs can reduce the risks of accidents and improve worker performance. Through relevant case studies, the article highlights the benefits of implementing ergonomics, demonstrating that it is not only a safety requirement, but also a determining factor of operational success.*

Key words: ergonomics, construction site, safety, environment, risks, worker performance

1. INTRODUCTION

In recent years, ergonomics has become an essential component in the design and operation of workspaces, and construction sites are no exception. The use of ergonomic principles on construction sites can lead to a reduction in the risk of accidents, an increase in the comfort and productivity of workers, and ultimately to the optimization of construction processes. However, in the Romanian context, the large-scale integration of these principles is still in a phase of development and adaptation, facing both opportunities and specific challenges.

In the construction industry, safety and efficiency have always been key priorities. However, despite technological advances and stricter regulatory standards, construction sites continue to be complex and demanding work environments, both physically and psychologically, for workers. In this context, the concept of ergonomics is gaining more and more ground as a fundamental solution for creating safer, more organized and more productive construction sites.

Ergonomics, defined as the science of adapting the workplace to human needs, offers a worker-centered approach. Not only does this help reduce the risk of injury and physical overload, but it also helps to improve overall comfort and performance on the jobsite. Moreover, the implementation of ergonomic principles proves to be a valuable investment, with tangible benefits for both employees and companies.

2. THE CURRENT STATE OF ERGONOMICS ON CONSTRUCTION SITES

Implementation of ergonomic workstations in Germany

A large infrastructure project in Germany has taken an innovative approach to improving working conditions by introducing mobile and adjustable workstations. These stations allowed workers to adapt their working position according to their height and comfort, thus reducing the risk of developing musculoskeletal problems. Another advantage was the integration of dedicated spaces for temporary tool storage, which eliminated the need for unnecessary movements. As a result, incidents related to excessive physical exertion decreased significantly, and the execution time of repetitive tasks was optimized. [1]

Use of exoskeletons in France

In France, a large construction site implemented the use of exoskeletons for workers involved in physically demanding activities. Exoskeletons, which are wearable devices that support areas of the body subjected to intense stress, have demonstrated a positive impact on workers' health, preventing back injuries and reducing muscle fatigue. On-site studies showed that workers who used the exoskeletons reported an increased level of comfort and were able to maintain high productivity throughout the day. Also, the duration of training required to use these devices was relatively short, which made them easy to adopt.

Digital Design on Construction Sites in the USA

In a major project in the USA, before construction began, a 3D digital simulation was used to design workflows and organize the space on site. This allowed the identification of the most efficient configurations for the location of equipment, material warehouses and travel routes. The simulation also included scenarios that assessed potential risks to workers and provided solutions to reduce them. The end result was a significant reduction in lost time and accidents, as well as an overall increase in work efficiency.

Space management on a construction site in Japan

An urban construction site in Japan faced the problem of extremely limited space, which required the use of an intelligent monitoring and organization system. This system used sensors and algorithms to analyze the movements of equipment and workers in real time. The data collected was used to plan optimal movements, avoiding blockages and collisions. In addition to increasing safety, this system has significantly improved team coordination, reducing the overall duration of the project.

3. THE CURRENT STATE OF ERGONOMICS ON CONSTRUCTION SITES IN ROMANIA

Awareness and acceptance of ergonomic principles

Over the past decade, discussions about workplace health and worker protection have led to a growing awareness of ergonomic benefits. EU-funded projects, training courses and awareness-raising campaigns have contributed to a better understanding of the importance of ergonomics. While large companies or pilot projects within organizations with available resources gradually implement ergonomic solutions, small or medium-sized companies encounter difficulties related to costs, organizational culture and specialized human resources.

Ergonomic solutions and technologies applied

Some construction sites in Romania have started to adopt solutions such as mobile stands or adjustable platforms, designed to minimize the physical effort and risks associated with fixed workstations. There are pilot initiatives where 3D simulations and space optimisation software have been used to define safe routes, appropriate storage areas and well-defined

workspaces. These tools help to anticipate movement flows and reduce collisions between equipment and workers. In addition to standard equipment, more and more adaptive solutions (e.g. vests, belts and even elements inspired by exoskeletal technology) are being sought to support employees in demanding tasks, reducing the risk of injuries associated with intense exertion. [2]

Although the Romanian literature on the implementation of ergonomics in construction is still in formation, some observations and pilot projects illustrate the potential of this approach as shown in Table 1:

Table 1. Evidence and observations from local studies and pilot projects

Analyzed aspect	Observations/Pilot projects
Adapting workstations	Projects in urban regions, especially at EU-funded companies, have implemented adjustable platforms, reducing physical fatigue and increasing efficiency in the execution of repetitive jobs.
Digital innovations	Some companies use 3D simulations to plan the location of equipment and the organization of the site, which leads to better movement of workers and minimizes accidents.
Training and education	Courses and workshops on ergonomics, promoted by specialized institutions and partnerships with technical universities, indicate an increase in interest in integrating this discipline into construction.
Integrated health and safety projects	Initiatives to integrate workplace health management systems, which also include ergonomic aspects, show that investments in the ergonomic profile reduce incidents and increase team morale.

These pilot projects, although relatively isolated, demonstrate that the implementation of ergonomic solutions can bring tangible results. More and more employers are recognizing that investing in a well-designed, ergonomically designed work environment translates into reduced long-term operational costs and a significant improvement in worker performance. [3]

4. CASE STUDY: THE "CONSTRUCT SAFE" PROJECT IN CLUJ-NAPOCA

Background and purpose

Context: The "Construct Safe" project was initiated by the company ConstructSafe SRL, which collaborated with ergonomics specialists and project engineers to build a modern office complex in Cluj-Napoca. In an industry often characterized by demanding working conditions and risks associated with intense physical activities, the direction adopted was to integrate ergonomic principles from the site planning stage.

Purpose:

- **Reduction of incidents:** To minimize the inconvenience caused by muscle fatigue and the risks of minor accidents.
- **Workflow optimization:** Streamline the processes of handling and moving equipment and materials.
- **Increase worker satisfaction:** Create a work environment adapted to the physical and psychological needs of the outfitters.

5. CHALLENGES AND DEVELOPMENT PROSPECTS

Challenges encountered

Upfront costs: Implementing modern ergonomic solutions requires investments that sometimes exceed the allocated budgets, especially at small and medium-sized firms.

Lack of specialist expertise: Although there is growing interest, expertise in the field of applied ergonomics in construction is not yet evenly spread. Collaborations with universities and research institutes are essential for the development of tailored local standards.

Resistance to change: The organizational culture on many construction sites remains traditional, and the shift in thinking towards prioritizing ergonomics may be met with reluctance from ordinary workers to use conventional working methods. [4]

Development prospects

European funding and partnerships: Structural funds and international cooperation programmes can facilitate access to technology and know-how, thus supporting the transition to more ergonomic construction sites.

Development of training infrastructure: Promoting specialised courses, seminars and training programmes on ergonomics can create a solid framework in which new design and organisation methods can be implemented on a large scale. [5]

Adoption of emerging technologies: As digital solutions and innovative tools become accessible, 3D simulations, augmented reality, and real-time monitoring are expected to transform the way construction sites are designed and operated, contributing to a continuous optimization of the work environment as shown in Table 2:

Table 2. Evidence and observations from local studies and pilot projects

Step	Actions	Purpose/Benefits
1. Preliminary assessment and risk analysis	- Evaluation of the project conditions (location, environment, type of works) - Identification of repetitive tasks and movements - Conducting ergonomic analysis with experts	Identifying critical points, prioritizing interventions and reducing the risk of injury
2. Interdisciplinary team formation	- Recruitment of specialists in ergonomics, engineering, architecture and project management - Establishing cross-domain collaboration for solution integration	Providing the necessary expertise for an integrated approach and effective implementation of ergonomic solutions
3. Ergonomic design and digital planning	- Elaboration of an ergonomic plan adapted to the specifics of the site - Using 3D simulation software to optimize space and workflows	Creating an optimized design that reduces risk and increases efficiency through detailed anticipation and planning
4. Implementation of ergonomic solutions	- Installation of adjustable and mobile workstations - Integration of modern equipment (e.g. exoskeletons) for weight handling - Reorganization of the workspace	Reducing physical exertion and accidents, optimizing travel and increasing the comfort and safety of workers
5. Training and involvement of workers	- Organizing specialized trainings on the use of ergonomic equipment and work techniques - Collecting and integrating feedback from workers	Raising awareness, accepting innovations and quickly adapting ergonomic solutions into practice

6. Monitoring and evaluation of performance	- Establishing performance indicators (minor accidents, execution time, worker satisfaction) - Conducting regular audits and monitoring results	Assessing the impact of the implemented solutions and identifying opportunities for improvement in the short and long term
7. Review and continuous improvement	- Review processes and adjust procedures based on feedback - Documenting good practices for standardization	Continuous adaptation to the needs of workers and technological developments, ensuring a constant optimization of the working environment
8. Integration into current and future practice	- Extending ergonomic methodologies to other projects - Collaboration with research institutions and adoption of emerging technologies	Strengthening a modern and sustainable working environment with a positive long-term impact on safety and efficiency on the construction site

In the construction sector, operational efficiency and worker safety are essential pillars for the success of any project. As the industry evolves, innovative solutions are increasingly being found to optimize working conditions and reduce the risk of injury. One of these solutions, which is becoming increasingly important, is the integration of ergonomic equipment on construction sites. [6]

Ergonomics is not just about individual comfort, but is a strategic approach that allows the work environment to be adapted to the real needs of the human mechanism. By using ergonomic equipment, excessive physical exertion and pressure on workers' body structures can be reduced, thus preventing injuries and increasing productivity. At the same time, ergonomic solutions contribute to the creation of healthier work environments, in which employees feel supported and motivated to perform at an optimal level. [7]

In the current context, many projects in Romania have started to adopt such innovative measures, highlighting the need to modernize construction sites. Design and construction management teams are increasingly working closely with ergonomics specialists to implement solutions that target both worker comfort and safety.

This change not only reduces the number of accidents and minor incidents, but also contributes to a better organization of workflows and an optimized use of resources. Below, the table presented details various types of ergonomic equipment used on construction sites. Each piece of equipment is described in terms of technical characteristics and benefits offered, from wearable devices that support correct posture, to tools with special handles designed to reduce physical effort.

The purpose of this practical guide is to provide respondents, whether they are project managers or workplace safety managers, with the necessary information to understand and implement the most appropriate ergonomic solutions within their projects. [8]

By adopting these modern technologies, construction sites become not only safer and more efficient working environments, but also spaces that contribute to the overall well-being of the personnel involved. T

his integrated approach is an important step towards a sustainable development model oriented towards human added value as shown in Table 3:

Table 3. Types of ergonomic equipment

Type of equipment	Description		Benefits
Wearable exoskeletons	Wearable support devices that, integrating mechanical structures and lightweight materials, help maintain correct posture during weight handling.		It reduces fatigue, prevents back pain and the risk of musculoskeletal injuries.
Adjustable workstations	Height and angle adjustable mobile platforms and stands, designed to adapt to different tasks and heights of workers.		It minimizes incorrect postures, increases comfort and reduces repetitive physical strain.
Tools and tools with ergonomic handles	Specially designed tools with non-slip handles, contoured to provide a natural grip, reducing strain on the wrists and arms.		It reduces fatigue and the risk of injury, ensuring more precise and comfortable handling.
Trolleys and modular transport systems	Mobile equipment for transporting materials, created with a design that allows ease of handling and optimal arrangement to reduce physical effort.		Improves travel efficiency, decreases the risk of injuries when handling equipment and materials.
Adapted personal protective equipment	PPE (helmet, gloves, boots) with ergonomic and adjustable design, created specifically for construction tasks involving high physical exertion.		It provides increased protection and increases the comfort of workers throughout the working day.
Lifting systems with ergonomic controls	Cranes, lifting platforms and other material handling equipment equipped with intuitive and ergonomically adjustable control panels.		It reduces operator effort, improves handling accuracy and decreases the risk of injury.

6. CONCLUSIONS

In Romania, the concept of ergonomic construction sites is still in full development. Despite some pilot initiatives and an increase in interest from innovative companies, the widespread implementation of ergonomic principles remains a challenge, due to economic factors, the complete lack of expertise and the resistance to change of some traditional structures.

However, the trend is towards adapting modern international methodologies, and collaborations with training institutions and European funding open new horizons for a deeper and more systematic integration of ergonomics in construction.

This promising development could not only significantly reduce accidents and improve working conditions, but will also bring major operational benefits, transforming construction sites into a working environment adapted to the real needs of workers. Further research, the exchange of best practices and the adoption of modern technologies will be the fundamental steps to promote an organizational culture open to innovation and security.

In addition, it is worth mentioning that an integrated approach, combining ergonomic aspects with sustainability and energy efficiency management, can lead to a new standard of excellence in the construction industry in Romania and beyond. This approach could serve as a reference model for other industries, demonstrating that investing in the health and comfort of employees is, in the end, an investment in the economic and social future.

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