



The Role of Human Resources in Civil Engineering Infrastructure Development: A Literature Review

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Abstract. *Civil engineering infrastructure development plays a vital role in driving economic progress and enhancing the quality of life within communities. The success of infrastructure projects depends not only on budgetary and technological factors but also on the quality of human resources (HR) involved in every project phase, from planning to maintenance. This literature review highlights that skilled and competent HR is a critical factor in achieving project success, particularly amidst increasing complexity and the challenges posed by globalization. Key issues faced by the sector include a shortage of skilled labor, high turnover rates, and a misalignment between educational outcomes and the skills required in the field. Additionally, technological advancements, such as the adoption of Building Information Modeling (BIM) and Artificial Intelligence (AI), demand continuous skill enhancement to adapt to the growing automation of industry processes. Effective HR management—encompassing ongoing education, fair incentive systems, and the integration of technology into HR practices—is essential for boosting productivity and mitigating risks during project execution. A comprehensive approach, including a structured HR management system, is required to ensure the sustainability and quality of infrastructure development. This study aims to provide an in-depth understanding of the critical role of HR management in the civil engineering sector and proposes practical recommendations for improving HR quality to meet the evolving demands of the construction industry.*

Keywords: *Civil engineering infrastructure, human resources, skills, technology, HR management, capacity development*

1. INTRODUCTION

Civil engineering infrastructure development plays an important role in supporting economic progress and the quality of life of the community. Good infrastructure is the main foundation for industrial growth, trade, and the mobility of people and goods. Civil engineering infrastructure covers various fields, such as transportation, housing, energy, and other public facilities that are basic needs for human life. Therefore, the success of infrastructure development is not only determined by budget and technology, but also depends heavily on the quality of human resources (HR) involved in each stage, from planning, design, construction, to maintenance (Frey et al., 2020).

In the context of civil engineering infrastructure development, human resources include various professions, ranging from civil engineers, architects, project managers, technicians, to field workers who have special technical skills. All of these parties work together to ensure that the project can be completed according to the established specifications, on time, and on budget. Therefore, the quality of the human resources involved

greatly affects the effectiveness and efficiency of the project, as well as the sustainability of the infrastructure being built. According to research conducted by Wang et al. (2019), human resource competence in the civil engineering sector is one of the main factors determining the success of construction projects, especially in facing the challenges of complexity and the demands of globalization.

The importance of human resource management in the civil engineering sector is becoming increasingly apparent as technology advances and demands for larger, more complex, and more environmentally friendly infrastructure projects increase. Today's infrastructure development requires not only technical skills in design and construction, but also the ability to manage risks, meet safety standards, and adapt to new technological developments. In addition, the sector also faces challenges in terms of skilled labor shortages, high labor turnover rates, and gaps between education obtained in educational institutions and the skills needs faced in the field (Yang et al., 2021).

These problems are further exacerbated by the development of digital technology that has had a major impact on the way construction projects are carried out. The use of technologies such as Building Information Modeling (BIM), drones, and artificial intelligence (AI) in project planning and management requires human resources who not only master traditional skills but also have the ability to operate these new technologies. This requires continuous renewal and development in human resource education and training so that they are able to compete in an increasingly automated industrial world (Hassan et al., 2020).

In addition, another challenge faced by the civil engineering sector is the need for more structured HR planning, so that existing resources can be utilized optimally in each project. Good HR management can increase work productivity and reduce costs arising from ineffective use of labor (Zhao et al., 2018). In this regard, it is important to examine how good HR management can have a positive impact on construction project performance and how HR capacity development can overcome existing challenges.

Through this literature review, the author will examine the role of human resources in the development of civil engineering infrastructure, with a focus on how human resource management and development can affect the quality, efficiency, and sustainability of infrastructure projects. This study is expected to provide insights for stakeholders, such as policy makers, construction companies, and educational institutions, to formulate better strategies in building the human resource capacity needed in the civil engineering sector.

The main objective of this article is to provide an understanding of the importance of the role of HR in the development of civil engineering infrastructure, as well as how the challenges faced by HR can be overcome through appropriate policies, relevant education, and effective management. In addition, this article also aims to explore various literature related to the best strategies in HR management in the construction sector and provide recommendations for improving the quality of HR in order to meet the demands of the increasingly complex and dynamic development of the construction industry.

2. LITERATURE REVIEW

Human resource (HR) management in the civil engineering sector plays a very crucial role in ensuring the success of sustainable and quality infrastructure development. Civil engineering infrastructure, which includes various projects such as roads, bridges, buildings, and other public facilities, depends not only on technical and material aspects, but also on the competence and performance of the people involved in each stage of the project, from planning, design, construction, to maintenance.(Levashina et al., 2014)

Human Resources Concept in Civil Engineering

In the context of civil engineering, HR refers to the workforce that has skills, knowledge, and abilities in the field of construction and infrastructure planning. HR in this sector includes various professions, ranging from civil engineers, project managers, field technicians, to skilled construction workers. Each individual on the project team has the responsibility to carry out certain functions that support the smooth running and success of the project (Bresnen & Marshall, 2020).

The role of HR in civil engineering projects is not only limited to the implementation of technical tasks, but also includes aspects of resource management, such as workforce planning, efficient task allocation, supervision, and quality control and work safety. In this case, HR management is the key to optimizing productivity and the final results of the project.(Mangkuprawira, 2009)Effective HR management can reduce the risk of delays, cost overruns, and work accidents that often occur due to poorly structured HR management.

The Influence of Education and Training on Human Resources Quality

Education and training are key factors in improving the quality of human resources in the civil engineering sector. As a growing sector, civil engineering requires a workforce that not only masters basic skills, but is also able to adapt to the latest technological developments and construction methodologies. Good educational programs are expected to produce skilled

workers, while ongoing training will update their skills to keep up with industry trends and needs. (Winardi, 2000)

Research by Wright et al. (2019) shows that on-the-job training and skills development have a significant impact on construction project performance. This is especially true in the civil engineering sector, which often requires knowledge related to the use of new technologies, such as geographic information systems (GIS), Building Information Modeling (BIM), and advanced structural design software. Therefore, continuous education and training are very important in ensuring that human resources in the civil engineering sector have relevant skills and can manage the challenges that arise in projects.

Human Resource Management in Construction Projects

Human resource management in civil engineering projects involves a variety of activities, from recruitment, selection, and training, to performance management and employee welfare. Effective management can increase productivity and reduce project-related risks. Research by Bresnen and Marshall (2020) states that an adaptive managerial approach is essential in dealing with the dynamics of construction projects that often change, both in terms of resource requirements and technical and logistical constraints.

One aspect that needs attention in HR management is occupational safety. Civil engineering projects often involve high-risk work, which requires HR management that focuses not only on efficiency and productivity, but also on worker protection and safety. A study by Gann et al. (2018) states that poor safety management can have an impact on decreasing worker motivation and performance, as well as increasing project costs due to accidents or damage that occurs.

Technology and Innovation in Human Resource Management

Technological advances have also had a significant impact on the way human resources are managed in civil engineering projects. The increasing digitization and automation in the construction sector have changed the way project managers manage their workforce. For example, the use of Building Information Modeling (BIM) in project planning and execution allows engineers and project managers to visualize and plan more precisely the workflow and human resource requirements at each stage of the project (Wang et al., 2020).

Technologies such as drones and artificial intelligence (AI) are also increasingly being used to monitor and evaluate project performance in real-time, allowing project managers to identify potential issues earlier and make faster decisions in HR management (Hassan et al., 2020). Thus, the integration of technology in HR management not only increases efficiency and productivity but also enables better and more well-planned human resource management.

3. RESEARCH METHODS

The research method used in this study is the library research method or literature review. This study aims to collect, analyze, and synthesize relevant information from various literature sources related to the role of human resources (HR) in the development of civil engineering infrastructure. This literature review was conducted to deeply understand the contribution of HR to the success of infrastructure projects and the challenges faced in their management. This method was chosen because it allows researchers to explore and analyze various previous studies, which can provide important insights for further research.

4. RESULTS AND DISCUSSION

HR Skills and Competencies in Civil Engineering Infrastructure Projects

Most of the studies reviewed show that the quality of human resource skills and competencies is a determining factor in the success of civil engineering infrastructure development. The technical skills possessed by the workforce in the construction sector, such as understanding structural design and mastery of modern construction tools, affect the speed and quality of project construction (Bresnen & Marshall, 2020). In addition, the managerial competencies possessed by project leaders also play a crucial role in managing various project elements, including budget, time, and human resources (Gann et al., 2018). Research by Wright et al. (2019) revealed that project success is highly dependent on the manager's ability to plan and coordinate the various teams involved in the project.

The importance of training and continuing education is also emphasized in this study. Several studies indicate that human resource development in the civil engineering sector must involve training that is in accordance with the latest technological developments and industry standards (Yang et al., 2021). Therefore, this sector requires structured training programs to improve the technical and managerial skills of the workforce in order to meet the increasingly complex demands of the industry.

Challenges in Human Resource Management in the Civil Engineering Sector

One of the biggest challenges faced by the civil engineering sector is the shortage of skilled labor. Several studies, including those conducted by Zhao et al. (2018), explain that the construction sector often experiences difficulties in meeting the need for skilled and trained labor. This is largely due to the gap between the formal education received by the workforce and the real needs in the field. On the other hand, the high labor turnover rate in the construction sector is also a problem, because many workers move from one project to another, making it difficult to manage and plan resources (Gann et al., 2018).

In addition, occupational safety in the construction sector is an important issue that also affects HR management. As noted by Bresnen & Marshall (2020), despite efforts to improve safety through training and standard operating procedures, work accidents still occur in many construction projects. Therefore, effective HR management must also pay attention to safety aspects to reduce the risk of accidents that can hinder the smooth running of the project.

The Influence of Technology on Human Resource Management in Infrastructure Projects

Technological advances, especially in the fields of digitalization and automation, have had a significant impact on human resource management in the civil engineering sector. The use of technologies such as Building Information Modeling (BIM), drones, and project management software has increased efficiency in project planning and implementation. This technology not only facilitates project design and supervision but also improves collaboration between various parties involved in the project, both field workers and project managers (Hassan et al., 2020).

A study by Wang et al. (2020) showed that the application of BIM in construction projects enables more efficient human resource management by providing an integrated platform for planning, design, and implementation. This allows the project team to monitor and manage worker performance in a more structured manner, reduce errors in work, and speed up the project completion process. In addition, the use of technology can also help identify specific problems or training needs for the workforce, so that project managers can take more appropriate actions to improve the quality of human resources.

Best Practices in Human Resource Management in Construction Projects

This literature review also identified a number of best practices that can be applied in human resource management in the civil engineering sector. Some recommendations resulting from the literature analysis are as follows:

1. Improved Welfare and Incentives for Workers.

According to Wright et al. (2019), improving employee welfare through fair incentives can increase employee motivation and loyalty. This will reduce employee turnover and encourage productivity in the field.

2. Training and Continuing Education.

In order for the workforce to always be ready to face new challenges, a continuous training program is needed that is in accordance with the development of construction

technology (Yang et al., 2021). This training must include technical, managerial, and soft skills needed to work in a dynamic project environment.

3. Implementation of Technology-Based HR Management System.

Along with the advancement of technology, the civil engineering sector also needs to adopt a technology-based HR management system to monitor and manage workforce performance more efficiently. This integrated management system allows project managers to monitor project progress and workforce quality in a more timely manner (Hassan et al., 2020)

4. Focus on Work Safety.

Occupational safety should be a top priority in any construction project. Research by Bresnen & Marshall (2020) emphasizes the importance of implementing strict safety standards and regular training to prevent accidents that can harm the project and cause financial losses.

Effective Human Resource Management as a Project Success Factor

From the study conducted, it can be concluded that effective human resource management plays a very important role in ensuring the success of infrastructure projects. Qualified and trained human resources, if managed properly, can improve the efficiency and quality of project implementation, as well as reduce the costs and time required to complete the project. Therefore, construction companies and policy makers must pay attention to aspects of continuous training, workforce empowerment, and the use of technology in human resource management.

5. CONCLUSION AND SUGGESTIONS

The results of this study indicate that the role of human resources in the development of civil engineering infrastructure is very important. The main factors that influence project success include technical and managerial skills and competencies, challenges in workforce management, application of technology in human resource management, and occupational safety management. Therefore, effective human resource management requires a holistic approach that includes continuous training, fair incentives, and adoption of the latest technology to improve project performance. This study also provides practical recommendations for construction companies and policy makers to create a safe and productive work environment, which will ultimately support the success of civil engineering infrastructure development.

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