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How are AI driven programs used in civil engineering and will those fully take over this industry in the near future?

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Abstract:

The use of Artificial Intelligence driven programs in the field of civil engineering has revolutionized this industry when talking about efficiency and productivity, especially in the early stages of a construction project. There are areas that have shown an increasing trend when it comes to the areas or parts of construction projects that have started to be completed with the use of AI driven technologies. Some of those include management of risk assessments and uses in structural analysis. Human implications are most definitely the pillars of a successful project, but the recent development of Artificial Intelligence has aided the workers in this process. This research paper aims to explore the current developments and uses of AI driven programs in civil engineering and to compare it to the job of a civil engineer, the different specializations of civil engineers and what construction projects consist of. Using this data, the final goal is to decide whether Artificial Intelligence can take over this industry in the near future. This research will explore construction specific tools that use artificial intelligence such as BIM and generative AI tools such as ChatGPT or Bard.

Keywords: civil engineering, artificial intelligence, BIM, construction management

1. Introduction

Artificial Intelligence (AI) is a computational framework which creates human intelligence machines and applications to make decision making simple, rapid and effective. AI then uses this computational technology to apply it in different areas which include management, psychology, construction etc. (Kate et al., 2021). Civil engineering is a field of engineering that focuses on the planning, designing, construction and maintenance of the built environment, particularly infrastructure like roads, bridges or buildings. There are also plenty of specialisations of civil engineering, but the focus for this research was structural engineering, widely considered the more creative area of civil engineering and transportation engineering, widely considered the less creative. In structural analysis, Artificial Intelligence can be used to identify damages due to earthquakes (Munim et al., 2025) or to detect any structural anomalies before those lead to structural failure (Azanaw, 2024). In transportation engineering, AI contributes in areas such as traffic prediction and management or sustainable transportation solutions (Bharadiya, 2023). Regarding the skills required by a civil engineer, project management, communication and technical drawing are among the most crucial ones. In project management, AI has shown an increase in usage, particularly because it can analyze data much quicker than humans while also managing scheduling and decision making while also maintaining safety at the workplace (Molina-Recalde et al., 2024). However, both verbal and nonverbal communication is a skill that almost certainly relies on human interaction which means that AI can't have contributions regarding this particular area. Engineering students in general consider that developing communication skills is beneficial for their future career (Saleh et al., 2019) and that oral communication is mandatory for a professional engineer as instructions are given frequently, especially on the construction site or in meetings (Masduki & Zakaria, 2020). Of course if for instance written communication is taken into consideration, Artificial Intelligence can succeed, but verbal communication is more frequently used and it is used in more complex scenarios. Similarly, technical drawing skills are often associated with using paper which

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again does not require the use of AI tools. According to a research conducted by American Society for Engineering Education (ASEE), the researchers have agreed that free hand drawing and sketching using AI driven programs such as CAD should be introduced in the first year of college and the choice should be made by students (McGinnis & Andrew Assadollahi, 2022). In addition, technical drawing is considered to be an effective way of communicating ideas by highlighting the concepts that have to be touched during the planning stages of a construction project (Baralić & Bjekić, 2024). With the introduction of Computer Aided Devices, the vast majority of plans and sketches are made and edited on a computer. Despite this, freehand sketching can still be used for initial planning as it might be easier to manipulate. Regarding the progress of AI in civil engineering, this report will aim to highlight the changes in uses and contributions that occurred from 2021, the earliest year in which research papers related to this field were published and sources from 2025. Using this comparison, predictions related to the development of Artificial Intelligence in civil engineering will also be presented. On the other hand, one of the final aspects of this research is related to the different AI driven programs and tools. Firstly, Building Information Modelling (BIM) is a computer based program that is used to partially simulate the construction process by creating the structures and by analyzing the different information attributes (Honcharenko et al., 2021). According to a literature review conducted by two authors from the Liaoning Technical University, BIM can also improve communication, coordination and decision making and can also help employees better manage costs of the construction project by reducing budget overruns for example (Nsimbe & Di, 2024). Lastly, generative artificial intelligence such as ChatGPT or Bard have also revolutionized the construction industry, especially in the last 2 to 3 years. Contributions of those technologies include design optimization and material selection (Rane, 2023). Those contributions are present in most of the civil engineering fields, which include structural and transportation engineering, the main areas of interest for this research (Rane et al., 2024).

2. Methodology

The methodology employed for this paper consists of an exploratory desk research using the search engine Google Scholar. It was conducted during the period of 15.09.2025 - 1.12.2025, and consisted of a key-word and key-phrase approach: the following keywords “Civil Engineering", “Artificial Intelligence”, “Use of artificial intelligence in civil engineering in the year 2021”, “planning stage in civil engineering”, “The importance of technical drawing skills in civil engineering”, “most important skills of a civil engineer”, “Advancements of AI in civil engineering”, “Why do civil engineers use ai tools in their daily job?”, “building information modeling technology in civil engineering”, “Communication skills in civil engineering”, “Project management in civil engineering”, “application of AI tools in structural engineering”, “applications of ai in transportation engineering”, “uses of generative AI tools in civil engineering”. In order to offer relevance to the actuality of the subject studied, it was chosen to search and select sources published after and including 2019, but most sources selected were published after 2020. The primary results have shown a total of 363300 sources to be explored. Considering the criteria of Open Access journals and the relevance to the topic analyzed, a remaining 35 sources were selected for the second stage of the research. After engaging the sources with a thorough theme analysis, only 31 sources remained. The following sources were eliminated due to different incompatibilities, such as not being fully accessible: the articles “The role of artificial intelligence and digital technologies in dam engineering: Narrative review and outlook”, “Digital twins and artificial intelligence in transportation infrastructure: Classification, application, and future research directions”. The theme analysis demonstrated that the articles “Digital twin for civil engineering systems: An exploratory review for distributed sensing updating”, “BIM-enabled infrastructure asset management using information containers and semantic web” were incompatible with the research conducted, so in consequence they were removed from the source base. After analysing the 31 remaining sources, the main themes were revealed which helped develop the overview that aims at answering the following research questions: “how are AI driven programs used in civil engineering?” and “Will AI driven programs fully take over the industry of civil engineering in the near future?”. This article brings innovation to the field by exploring the complex context of the development of civil engineering in the era of technologization. The limitations of this research are the following: The dependency on secondary data that was collected by third-parties, The limitation of the academic search engine, the selection criteria which limited the research to open-access journals.

3. Literature Review

3.1 Applications of AI in civil engineering

Structural health monitoring has 3 main areas which are seismic damage identification, structural health monitoring and structural maintenance. Firstly, in earthquake damage testing, AI has performed significantly better than traditional methods of damage identification. For instance, 75% of the buildings were identified as seismically affected using conventional techniques and 92% from the same buildings were identified as damaged using Machine Learning which is a form of AI (Munim et al., 2025). In structural health monitoring, AI systems are used to monitor and assess the condition of infrastructures such as bridges and to even predict potential damages that might occur within the structure. Those systems enable early detection and interventions which helps reduce costs (Sargiotis, 2024). Lastly, structural maintenance is similar to structural health monitoring as the Artificial Intelligence usage is still used in the form of sensors. For example, for train tracks, sensors are placed along the tracks and those are used to identify potential degradations and allow for better timed interventions (Sargiotis, 2024). The main benefit of using AI in structural engineering is that damages can be identified more accurately and can also be predicted which can make interventions more efficient and maintain high safety.

To start with, sustainable development in civil engineering has become a priority for the majority of construction projects. With almost 25% of the total greenhouse gas emissions, the transportation industry, which is a specialized sector of civil engineering, plans to reduce those emissions by 50%. In addition, according to a research conducted by researchers from The University of Basque Country, one clear conclusion is that professionals should be trained to understand the importance of sustainable development in the civil engineering industry so that they will be influenced to always find ways of reducing environmental impact and to be more efficient (Álvarez et al., 2021). Regarding the contributions of AI in sustainable development, some areas include energy efficiency, identifying climate patterns and how to revolutionize architectural designs. Artificial intelligence has the ability to process and analyze extensive data from different sources which offers a wider perspective which results in better solutions being found in order to continuously develop the sustainability of the construction project (Rane, 2023).For example, AI tools can analyze historical patterns in energy consumptions and also forecast future needs to improve and make the new design more efficient (Molina-Recalde et al., 2024).

Project management is one of the most important skills and areas of civil engineering when talking about the different aspects it covers. Apart from human interaction which is a crucial component to success, AI has some contributions that aid the workers. Among these, the following are included: risk assessment management, cost estimation (Manzoor et al., 2021), quality control, labor productivity (Momade et al., 2021) and enhancing communication between stakeholders (Rane, 2023). Regarding how AI tools and programs carry out those processes, there are many similarities with the other areas of civil engineering. For instance, because of the excellent ability of AI to process and analyze data quickly and accurately, the workers can make better decisions based on the data and also do it more efficiently. This leaves more time to manage other stages such as the work on the construction site where human interaction leads (Rane, 2023). AI can also contribute to the management of human resources by providing insights regarding workforce trends, skill requirements and safety protocols. Furthermore, AI driven programs can also analyze historical project data which helps simulate and evaluate various scenarios and their effects on the construction process, which ensures a smooth development which helps optimize resources and most importantly, reduce costs (Rane et al., 2024).

Transportation infrastructure engineering consists of continuous improvements and processing of real time data as well as opinions from citizens. The main roles of Artificial intelligence in this field are to analyze data related to traffic, facilitate communication between engineers and planners and take into consideration the opinions of the participants in traffic (Rane et al., 2024). Furthermore, AI has pivotal roles in the architectural design and construction process (Rane, 2023). Firstly, AI has contributions in the transportation industry because it can access multiple types of information and those can be quickly analyzed. This pattern again repeats as with the other specializations of civil engineering presented. Moreover, AI has the ability to predict how the traffic will change if each of the solutions proposed are implemented which can generate detailed and precise reports (Iyer, 2021). On the other hand, artificial intelligence also contributes to sustainable and environmentally friendly transportation. Machine learning algorithms can help optimize energy consumption and can prioritize eco-friendly options of transportation by managing the logistics. Finally, AI can also be used in safety systems as it has the ability to detect risks much quicker than humans and can prevent accidents (Bharadiya, 2023).

Resulting from the keyword and theme analysis of two sources, one from 2021 and one from 2025, some clear conclusions can be drawn regarding how the contribution of AI in civil engineering has developed. To start with, in

the source from 2021, more ideas and innovations of different groups of people were presented. For example, the article presented how Lee and Eun have investigated methods for diagnosing damage in a body before and after a crash and those methods included using AI to aid them. Similarly, words such as “investigation” or “proposed” and phrases such as “may be implemented ” or “ proposed an alternative design” were used by the authors of the scientific article (Kate et al., 2021). Regarding the source from 2025, it first discusses the current uses of Article Intelligence in civil engineering from structural health monitoring to traffic management and optimization. Then, problems and solutions of using AI in civil engineering were explored. Some examples of problems identified include ethical and social issues which are related to job displacement or data quality issues. Some solutions linked with the issues include the implementation of regulations and preprocessing methodologies (Munim et al., 2025). Considering the content of the two scientific articles, it is safe to consider that the source from 2021 focuses on innovation in AI for civil engineering while the source from 2025 presents established information regarding the approach of technology driven programs in civil engineering while also discussing the problems and solutions regarding this issue.

Firstly, structural engineering is considered a more creative area of civil engineering due to its demand of strong problem solving skills and of constant improvement as the society receives new challenges (Dyke et al., 2024). When taking into consideration the applications of artificial intelligence in structural engineering, a very important one is the detection of structural anomalies before those can lead to failure of the body (Azanaw, 2024). Moreover, it can also be used for image analysis. For example, after a project is finished, images of the finished structure can be analyzed by the AI driven program and feedback related to the work being done can be given (Dyke et al., 2024). Lastly, AI tools can also aid in design optimization, meaning that the software browses ways of reducing costs and creating more efficient structures overall (Rane et al., 2024). On the other hand, transportation engineering is considered a less creative area of civil engineering due to the engineers having to comply with the requirements imposed by the government. Contributions of technology driven systems include analysis of demographics and traffic patterns to make predictions which helps find solutions to reduce traffic and facilitate transport for civilians (Rane, 2023). In addition, autonomous vehicles can be developed by such algorithms which can benefit drivers and also reduce risks of accidents. This will result in safer driving conditions and even reduce the pressure of participants in traffic (Rane et al., 2024). On the whole, some conclusions are that AI has very similar uses in both structural and transportation engineering as the ability of predictive analysis and making the processes more efficient. However, in transportation infrastructures, AI can contribute more in the planning and construction stage as it can offer alternative designs for roads for example while in structural engineering, the main role is to verify the structure regularly, but only after it has been designed.

3.2 Building Information Modelling and generative AI in civil engineering

Building Information Modelling is the most famous approach regarding 3D model based processes that can organize the entire construction process. The purpose of BIM is to partially simulate the stages of a construction project by creating the necessary layers which include structures and information about how tasks should be performed and delegated (Honcharenko et al., 2021). This research report will discuss the general advantages and roles of BIM in the construction industry and then the focus will be on the impact on cost management and how this technology aids in urban planning. Firstly, the use of BIM in civil engineering has led to efficiency in construction workflows. The program provides the workers with the project information which allows all of the parties to be updated regarding the progress of the work. Also it is easy to update the program so that it is up to date. This leads to less cases of poor communication and data loss. Building Information Modelling can also analyze the effects of the construction works on the environment after it has been simulated. This can have a significant impact on sustainability and environmental compliance. For example, the algorithm can make or support decisions related to using environmentally friendly materials or reducing energy consumption (Purwanto & Satriawansyah, 2025). Secondly, BIM technology can be effectively utilized in urban planning as it can show the different stages when planning a territory. This is possible because three different layers of spatial data are created and presented. The first layer is a scheme of the transportation links, the second layer is the scheme of engineering support of the territory and the third layer is the architectural and planning solution of the territory. This layout helps employees from the construction industry to identify and examine the current situation and it aids in decision making about what areas could be developed without any risks of traffic congestion or structural failures (Honcharenko et al., 2021). Lastly, cost overrun is considered one of the most impactful risks in construction projects. This is why the BIM tool is widely used in this area. Because of the design options it presents, it is much easier to determine the costs accurately at every stage of construction and cost evaluation is facilitated (Sepasgozar et al., 2022). A case study conducted by authors from the Liaoning Technical University on

the Mombasa Port Area Development Project explores respondents' view on the accuracy of BIM in cost estimations. The results show that 14% of respondents believe that BIM enhances cost precision at a very high extent while 26% and 30% of respondents believe that BIM enhances cost precision at a high extent and moderate extent respectively (Nsimbe & Di, 2024). From those statistics, it can be concluded that Building Information Modelling has a crucial role in cost estimation and from the view of more than 50% of the people surveyed, it does this very accurately. Despite the wide use of this computer program, one issue with BIM is that it requires extensive and continuous training due to its demanding nature. There is also a need for specialist trainers as the training process needs to be adequate or else the applications of BIM are limited (Purwanto & Satriawansyah, 2025).

Generative AI tools have shown an increasing trend of usage in the field of civil engineering. While not designed and programmed to contribute in the construction industry, those softwares have optimized the processes in civil engineering, even though it has traditionally relied on manual labor and human expertise (Rane, 2023). To start with, generative AI such as ChatGPT or Bard, which are commonly used, have diverse applications in construction engineering. Those include structural and transportation engineering (Rane, 2023) or construction management and urban planning (Rane et al., 2024). Apart from the specific uses of AI in those areas, there are some common contributions that apply to all those disciplines and that are based on the main abilities of Artificial Intelligence. Firstly, generative AI has the skill of predictive analytics. By the use of sensors and by data analysis, those online tools can access data from previous construction projects and can make comparisons to the current project. Similarly, using available information, estimates of costs or effects of the weather on the construction process can be forecasted. Another example of this practice is in transportation systems where the AI tools use data for sensors to predict traffic patterns and can brainstorm solutions to improve the current situation. In addition, Artificial Intelligence can manage risks and safety especially in the execution phase. The algorithms can simulate the entire stage and can generate a list of risks and safety precautions. This improves the overall security of construction workers and also allows the employees to focus on more important tasks, especially those related to communication or last minute changes. Moreover, sensors powered by AI can be installed which enables real time monitoring in case of unexpected changes or malfunctions in the overall plan . Lastly, quality control is another discipline that has a crucial role in the completion of construction projects. In this case, those generative tools can process data from architectural plans to inspection reports and can compare it to the actual building. Furthermore, AI can facilitate discussion between project managers and other stakeholders so this ensures clearer communication so there is a lower chance of mistakes. Those two factors contribute to the overall quality (Rane, 2023). In spite of aiding workers in time consuming duties, Chat GPT or Bard have some disadvantages. Because data is being received by the software program, the humans do not have direct control over what is happening with it which affects data privacy and cybersecurity (Rane et al., 2024). Also, even though cost reduction is another main reason for using AI tools in civil engineering, the initial costs of installing and also training the workers to use the tools is high (Rane, 2023).

3.3 Skills of a civil engineer

Management skills are undoubtedly pivotal in the successful development of construction projects. Some areas that are covered by managers are task delegation, human resource management and planning and directing of staff members (Gómez et al., 2021). Construction managers have an important role mainly at the start of the process as in the execution phase they only make verifications. One trait of a director is leadership. Most civil engineering projects employ large numbers of workers which are not cooperating at times. The duty of the director is to delegate tasks based on the performance of each worker so that everyone receives work that is in accordance with their level of experience. Apart from this, motivating employees is a n important aspect as the fastest the project is completed, the lower the costs and there is more time for verifying and making changes. Another ability to take into account is the actual planning. Having engineering knowledge and being able to design the whole construction process by presenting deadlines, cost estimations and managing resources is crucial. If there is good organisation from the start, the clarity of the stages of production increases so the assignments are better understood by the team. This further reduces the chances of mistakes so the costs remain constant (Ghorbani, 2023). Construction projects carry high amounts of stress due to their importance in society and mass use by other individuals. But all this stress can be avoided if the management department is able to maintain a healthy relationship with the delegates and to connect with them on an emotional level.

Communication is another pillar of civil engineering success. Whether it is verbal, non-verbal, written or displayed, it ensures that the activity is going smoothly and every worker understands their role. Oral communication is one of the most used methods as it is used everyday at the workplace. From team discussions to phone calls, it is the main source of information especially during the execution phase, but also in the planning stage as most of the employees want reassurance regarding their work. Written communication is considered the easiest to use, but as important as the oral one. Because of the large numbers of stakeholders in every construction project, this technique can be more effective and it makes sure that everybody gets and understands the message (Masduki & Zakaria, 2020). Because most communication is oral, many mistakes and misunderstandings can occur. This is where non-verbal communication comes into place. The lack of expressivity such as eye contact, tone, posture etc. is a main barrier of effective communication. Those small gestures can indicate how important is the message being transmitted, how significant is the task explained and can even capture the attention of the listener which leads to better understanding (Salleh & Hanid, 2022). On the other hand, according to a study conducted by students from the Faculty of Engineering and Faculty of Communication from Jakarta, most of the students were satisfied with the communication training they received (Saleh et al., 2019). It is encouraging that communication is a promoted skill in the civil engineering field, but because it is based on human interaction, continuous practice is mandatory to achieve accuracy.

Technical drawing or engineering drawing is an effective way to conceptualize, coordinate and communicate their thoughts and visions regarding projects they are working on. This engineering tool is widely used because it presents the spatial relations and visualization of the actual body. Its importance also lies beneath perception as drawing and then observing makes the person doing it better understand if the initial ideas are solid in practice or if those need more thought (Baralić & Bjekić, 2024). In addition, Computer Aided Devices are also taught in university along with freehand sketching. Despite this, technical drawing is taught first in the module as students are expected to first be able to express their ideas in paper and then use the CAD program to transfer the design for future use (McGinnis & Andrew Assadollahi, 2022). According to a survey conducted by professors from the American Society for Engineering Education, most of the students benefited from the exercises of technical drawing in university and that it has helped them better understand how a CAD program operates (McGinnis & Andrew Assadollahi, 2022). The benefits of paper sketching are visible and can definitely improve the quality of the construction works. Furthermore, those skills are taught in university, even though CAD or similar programs exist.

4. Results & Analysis

Following the secondary research conducted and the analysis and interpretation of existing studies, the following subjects can be discussed.

There was a clear difference between how AI in civil engineering was perceived in 2021 compared to 2025. If in 2021, innovation and new ideas were tested and proposed, in 2025 not only artificial intelligence had clear uses, but also its problems were discussed. In such a short time, the applications have become clearer and have been inserted in the daily job of civil engineers. From this point of view, if AI can progress at a similar rate, it can further revolutionize the construction industry. However, because of this rapid development, issues and threats such as more complex staff training or data security. Many years will pass before this situation will stabilize so considering this, the future of the field is still unknown.

Those two specializations are similar as both contribute to civil development, but have different approaches. When looking at the comparison between how Artificial Intelligence contributes in those two industries, the main difference is that those algorithms can only verify, maintain and optimize in structural engineering, while it can also generate alternative designs and aid in the planning stage in transportation engineering. This contrast is due to the more creative nature of structural engineering. If in transportation infrastructures, architects are restricted to government instructions, in structural engineering in buildings such as in bridges or apartment buildings, the architect is less limited. And because there is more human interaction involved between the architect and engineer as there is more creativity involved, it becomes much easier for the human to understand and replicate the vision described. Taking this into account, the stages which employ originality and communication of ideas can't be substituted by AI as of now and the near future.

With similar applications and capabilities, those two tools have made the construction processes more efficient, more cost effective and safer. Despite BIM being primarily used due to its ability to simulate construction stages and monitor

the entire project, generative AI also contributes in analyzing and processing data and managing quality and offering alternative solutions. With the rising popularity of these technologies, problems related to social aspects have appeared, the main one being the loss of jobs due to the reduced employees needed, but also the increase of training costs to update the workforce. The most probable scenario will be that engineers will embrace the new computer systems implemented, but will also figure out solutions to the problems that the introduction of Artificial Intelligence have brought.

Lastly, from the skills presented, the only one that can be potentially taken over by AI is project management. The ability of Artificial Intelligence to analyze and organize data and to manage the resources from humans to relevant documents is unmatched. In the case of communication, the software can facilitate written or visual communication, but as it was previously stated, the most important method is oral communication which involves human interaction and expression of emotions which the AI will not be able to replicate in the near future. When it comes to technical drawing, the use of pen and paper for designs is again impossible to achieve by AI as of now. In spite of CAD existing, the study presented showed that freehand sketching is the root of communicating the intention and even understanding how those online programs work.

5. Conclusion

The introduction of AI and its rapid evolution in civil engineering has shaped this domain mainly in the areas of making more environmentally friendly designs, reducing cost by minimizing faults and managing safety more appropriately. When considering the hypothesis being tested and the research questions being addressed, it is safe to state that AI will not take over the civil engineering industry in the near future. Out of the 4 subjects being discussed, only one discussion partially agrees that AI has the potential to overtake this engineering area. This is mainly due to many stages of production requiring human interaction and expressing emotions. On the same note, the fast paced progresses of Artificial Intelligence has also come with many challenges and concerns which further cement that an idea of a total domination of civil engineering is not achievable in the near future.

Without a doubt, AI will continue to aid civil engineers in their job and will continue to develop to further improve the entire construction sector. For the moment and the near future, the nature of the field prevents the complete management of all the duties and functions required for the infrastructural advancement of the society.

References

1. Almaz, A. F., El-Agouz, E. A. E. A., Abdelfatah, M. T., & Mohamed, I. R. (2024). The future role of Artificial Intelligence (AI) design's integration into architectural and interior design education is to improve efficiency, sustainability, and creativity. *Civil Engineering and Architecture*, 12(3), 1749-1772. DOI: 10.13189/cea.2024.120336
2. Álvarez, I., Etxeberria, P., Alberdi, E., Pérez-Acebo, H., Eguia, I., & García, M. J. (2021). Sustainable civil engineering: Incorporating sustainable development goals in higher education curricula. *Sustainability*, 13(16), 8967. https://doi.org/10.3390/su13168967
3. Azanaw, G. M. (2024). Revolutionizing Structural Engineering: A Review of Digital Twins, BIM, and AI Applications. *Indian Journal of Structure Engineering (IJSE)*, 4(2), 1-8. DOI: 10.54105/ijse.B1321.04021124
4. Baralić, J., & Bjekić, D. (2024). Technical Drawing in Engineering Education: Tool for Engineers' Communication, Design and Ability Development. In *10th International Scientific Conference Technics, Informatics and Education-TIE 2024*. Faculty of Technical Sciences Čačak, University of Kragujevac. http://dx.doi.org/10.46793/TIE24.301B
5. Bharadiya, J. P. (2023). Artificial intelligence in transportation systems a critical review. *American Journal of Computing and Engineering*, 6(1), 35-45. Available at: https://d1wqtxts1xzle7.cloudfront.net/123707099/1610-libre.pdf?1752175563=&response-content-disposition=inline%3B+filename%3DArtificial_Intelligence_in_Transportatio.pdf&Expires=1786560273&Sign

ature=I-0MiRJ1NqA7aQvRAw13~~uxijU0bjZ14V9VXOSRbfTk1y4AqzxknqPoxX6Kg120jlBAbZQYfwok5IywYcmghq2mNaEnhkR6OLoNaRJohkA4VO3hK7iJa9qBC0sMkvMC~fOQH-BrdihnaeVMCCRkoGTgvoW56k~o8ZEsJII7e4aBEMPbzkzmRs3DbRtWtrfSYp~zwsnYIUueOVjcNI4PA3s9qfB5eusGzoWdGfoE4FDcz-tgCPw5eBUKPWL0QbMD48WMr4D0bOK0cp5SUHNkT1k34ROwnldhWQ0PvnttAY22SuHcMWbGj-BD2m-KWfVZcwoIm5kigyU6OEQCvrYhw__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA

6. Dyke, S. J., Liu, X., Zhang, X., & Iturburu, L. (2024). Empowering Engineers by Leveraging AI in Structural Engineering and Monitoring. *Procedia Structural Integrity*, 64, 21-28. https://doi.org/10.1016/j.prostr.2024.09.203
7. Ghorbani, A. (2023). A review of successful construction project managers' competencies and leadership profile. *Journal of Rehabilitation in Civil Engineering*, 11(1), 76-95. https://doi.org/10.22075/JRCE.2022.24638.1560
8. Gómez, M. Á., Herrera, R. F., Atencio, E., & Munoz-La Rivera, F. C. (2021). Key Management Skills for Integral Civil Engineering Education. *Int. J. Eng. Pedagog.*, 11(1), 64-77. https://doi.org/10.3991/ijep.v11i1.15259
9. Honcharenko, T., Terentyev, O., Malykhina, O., Druzhynina, I., & Gorbatyuk, I. (2021). BIM-concept for design of engineering networks at the stage of urban planning. *International Journal on Advanced Science, Engineering and Information Technology*, 11(5), 1728-1735. https://doi.org/10.18517/ijaseit.11.5.13687
10. Huang, Y., Shi, Q., Zuo, J., Pena-Mora, F., & Chen, J. (2021). Research Status and Challenges of Data-Driven Construction Project Management in the Big Data Context. *Advances in Civil Engineering*, 2021(1), 6674980. https://doi.org/10.1155/2021/6674980
11. Imran, C. A. B., Shakir, M. K., & Qureshi, M. A. B. (2022). Applications of Artificial Intelligence in Enhancing Construction Safety and Productivity. *The Asian Bulletin of Big Data Management*, 2(1), 63-74. https://doi.org/10.62019/2tv5mv35
12. Iyer, L. S. (2021). AI enabled applications towards intelligent transportation. *Transportation Engineering*, 5, 100083. https://doi.org/10.1016/j.treng.2021.100083
13. Kate, S., Swami, V., Doiphode, S., & Singh, V. (2021, July). Advanced Applications of Artificial Intelligent Systems in Civil Engineering: A Review. In *IOP Conference Series: Earth and Environmental Science* (Vol. 822, No. 1, p. 012009). IOP Publishing. DOI 10.1088/1755-1315/822/1/012009
14. Khaleel, M., Ahmed, A. A., & Alsharif, A. (2023). Artificial intelligence in engineering. *Brilliance: Research of Artificial Intelligence*, 3(1), 32-42. https://doi.org/10.47709/brilliance.v3i1.2170
15. Manzoor, B., Othman, I., Durdyev, S., Ismail, S., & Wahab, M. H. (2021). Influence of Artificial Intelligence in Civil Engineering toward Sustainable Development—A Systematic Literature Review. *Applied System Innovation*, 4(3), 52. https://doi.org/10.3390/asi4030052
16. Masduki, M., & Zakaria, N. (2020). Fulfilling the demand for workplace communication skills in the civil engineering industry. *Pertanika Journal of Social Sciences & Humanities*, 28(4), 3069-3087. https://doi.org/10.47836/pjssh.28.4.32
17. McGinnis, R. E., & Andrew Assadollahi, P. E. (2022, July). WIP: The Importance of Freehand Sketching and Technical Drawing. In *2022 First-Year Engineering Experience*. DOI: 10.18260/1-2--42259
18. Molina-Recalde, M., Molina-Recalde, N., & Molina-Granja, F. (2024, December). Ai and Its Application in Civil Engineering, a Vision of Trends. In *Proceedings of International Conference on Engineering, Science and Technology* (p. 36). Available at: https://www.istes.org/storage/01JGPTYP8X57JRQZ3W9KSSY5J1.pdf, page 36
19. Momade, M. H., Durdyev, S., Estrella, D., & Ismail, S. (2021). Systematic review of application of artificial intelligence tools in architectural, engineering and construction. *Frontiers in Engineering and Built Environment*, 1(2), 203-216. https://doi.org/10.1108/FEBE-07-2021-0036

20. Munim, A., Waqar, I., Faisal, I., & Ahmed, J. (2025). Use of AI in Civil engineering, its problems and solutions. *Intersect: The Stanford Journal of Science, Technology, and Society*, 18(2). Available at: https://ojs.stanford.edu/ojs/index.php/intersect/article/view/3377/1806

21. Nsimbe, A., & Di, J. (2024). The impact of building information modeling technology on cost Management of Civil Engineering Projects: A case study of the Mombasa port area development project. *Buildings*, 14(4), 1175. https://doi.org/10.3390/buildings14041175

22. Purwanto, S., & Satriawansyah, T. (2025). Integration of building information modelling (BIM) in civil engineering project: a literature review. *Indonesia Journal of Engineering and Education Technology (IJEET)*, 3(1), 319-328. https://doi.org/10.61991/ijeet.v2i2.56

23. Rane, N. (2023). Role of ChatGPT and similar generative artificial intelligence (AI) in construction industry. Available at SSRN 4598258. http://dx.doi.org/10.2139/ssrn.4598258

24. Rane, N., Choudhary, S., & Rane, J. (2024). Transforming the civil engineering sector with generative artificial intelligence, such as ChatGPT or Bard. Available at SSRN 4681718. http://dx.doi.org/10.2139/ssrn.4681718

25. Saleh, R., Widiasanti, I., & Hermawan, H. (2019, December). Development of communication competency for civil engineering students. In *Journal of Physics: Conference Series* (Vol. 1402, No. 2, p. 022024). IOP Publishing. DOI 10.1088/1742-6596/1402/2/022024

26. Salleh, H., & Hanid, M. (2022). Nonverbal Communication in the Construction Industry: A literature review. *Journal Of Project Management Practice (JPMP)*, 2(2), 39-52. https://doi.org/10.22452/jpmp.vol2no2.3

27. Sargiotis, D. (2024). Advancing civil engineering with AI and machine learning: from structural health to sustainable development. Available at SSRN 4883999. https://dx.doi.org/10.2139/ssrn.4883999

28. Sargiotis, D. (2024). Transforming civil engineering with AI and machine learning: innovations, applications, and future directions. *Applications, and Future Directions* (November 15, 2024). https://dx.doi.org/10.2139/ssrn.5021723

29. Sepasgozar, S. M., Costin, A. M., Karimi, R., Shirowzhan, S., Abbasian, E., & Li, J. (2022). BIM and digital tools for state-of-the-art construction cost management. *Buildings*, 12(4), 396. https://doi.org/10.3390/buildings12040396

30. Srivastava, A., Jawaid, S., Singh, R., Gehlot, A., Akram, S. V., Priyadarshi, N., & Khan, B. (2022). Imperative role of technology intervention and implementation for automation in the construction industry. *Advances in Civil Engineering*, 2022(1), 6716987. https://doi.org/10.1155/2022/6716987

31. Zhang, W. H., Lu, D. G., Qin, J., Thöns, S., & Faber, M. H. (2021). Value of information analysis in civil and infrastructure engineering: a review. *Journal of Infrastructure Preservation and Resilience*, 2(1), 16. https://doi.org/10.1186/s43065-021-00027-0