

A Review On Use of AI Tools to Design

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Abstract - The research examines how Artificial Intelligence (AI) functions in structural design through its assessment against conventional engineering tools which include STAAD.Pro and Microsoft Excel. The researchers used traditional methods to assess a multi-storey reinforced concrete structure which produced results for structural design. The Chatbase-developed AI-based chatbot received training in structural design principles to assist with beam grouping and basic member design tasks. The research team evaluated the two methods by comparing their results which they assessed for accuracy and time efficiency and design optimization. The research demonstrates that AI tools enable design work to be completed more quickly while delivering dependable first design recommendations which have a slight difference of 5-8 percent from standard design approaches. Engineers must use traditional engineering methods to confirm their findings from all investigations. The research demonstrates how AI functions as an essential resource for structural engineers.

Key Words : Artificial Intelligence, Structural Design, STAAD.Pro, Chatbase, Civil Engineering, Automation

1. INTRODUCTION

Engineers use structural engineering to safeguard building systems and infrastructure elements against potential safety risks and structural failures. Engineers use STAAD.Pro and Microsoft Excel software tools to conduct their structural analysis and design work. The tools deliver precise outputs yet demand extensive manual operations which take considerable time to complete.

Engineers now have access to new automated solutions which stem from Artificial Intelligence developments that help with their design work by streamlining repetitive tasks while boosting their design output. AI-based systems can analyze structural data, identify patterns, and provide preliminary design recommendations.

The research investigates how well AI performs in structural design compared to traditional design techniques.

• BACKGROUND OF STRUCTURAL ENGINEERING

Structural engineering represents a core discipline of civil engineering which focuses on evaluating, designing, and building various types of infrastructure including buildings and bridges and towers and additional infrastructure systems. The primary objective of structural engineering is to ensure that structures are safe, stable, and capable of withstanding various types of loads throughout their service life. The total load comprises dead loads which represent the weight of the structure itself, live loads which account for the weight of people and items in the building, environmental loads which include wind and earthquake effects, and all other types of dynamic forces.

Analytical methods together with empirical formulas functioned as the traditional design tools which structural engineers used to create their structural designs. Computer-based tools have become essential in structural engineering practice because technology has advanced. Structural engineers utilize STAAD.Pro and ETABS and SAP2000 as their primary tools for conducting structural analysis while Microsoft Excel functions as the standard software for performing design calculations.

Conventional tools deliver precise and dependable outcomes while requiring labor-intensive work to achieve those results. Engineers must interpret analysis outputs which they will use to perform calculations and execute design decisions based on their expertise. The process requires an extensive amount of time because of the need to handle extensive and complicated structural designs. The possibility of human mistakes rises because people have to repeat calculations and manage data throughout the process.

• BACKGROUND OF STRUCTURAL ENGINEERING

The development of structural engineering has undergone substantial changes during the last few decades because the field shifted from manual work to technology-based operations. Engineers performed structural design work by using hand calculation methods which required them to make basic engineering assumptions and apply their

professional judgment. Engineers developed secure structures by using their understanding of mechanics and material behavior principles. The method required excessive time and labor for execution while it included multiple chances for human mistakes to occur.

The field of structural engineering experienced its first major transformation with the arrival of computer technology. Engineers gained improved structural analysis capabilities through numerical methods which included the finite element method (FEM) as their analysis tool. FEM enables users to assess specific stress and strain and displacement behavior when they divide a structure into smaller components. The development brought substantial enhancements which increased the structural analysis system's reliability and operational capabilities.

The design process received additional support from modern structural engineering software which includes STAAD.Pro and ETABS and SAP2000. Engineers use these tools to build detailed 3D structural models which allow them to specify material properties and load conditions and examine structural performance during various loading situations. The software produces crucial outputs which include bending moments and shear forces and axial forces and deflections that structural engineers require for their work. Designers need human experts to evaluate output data and conduct design calculations which they must execute according to established design standards and procedures.

Structural engineering has seen a rise in technology use during the last few years because advanced systems increase both efficiency and production output. Artificial Intelligence (AI) has emerged as a promising solution in this context. The term AI defines machine abilities which enable systems to replicate human thought processes including learning and reasoning and making choices. AI systems can handle extensive data sets to find patterns which they use to build engineering decision-making models.

AI technologies create new possibilities for structural engineering to implement automated systems and achieve operational performance improvements. AI technologies help engineers to understand analysis outcomes while they create structural member groups based on their loading patterns and define initial design specifications. AI systems use machine learning and natural language processing techniques to acquire knowledge from structural data while they respond to user inquiries. Engineers can use design guidelines and calculation procedures to build AI-based chatbots which guide them through the initial design process.

AI provides organizations with a major benefit because it enables employees to complete repetitive work in a shorter time frame. The design procedure requires several steps which include data interpretation work and manual calculation tasks that take substantial time to complete. AI systems can perform these tasks through automation which enables them to produce instant results that

enhance operational productivity. AI systems improve operational efficiency through automated processes while they decrease human errors by adhering to set procedures. AI systems possess specific boundaries that require careful assessment before implementation. AI systems produce precise results when they operate with high-quality training data but they fail to predict structural behavior because their training data does not include essential information. Structural design requires engineers to make calculations while they apply their expertise to develop practical solutions which meet design standards. AI systems do not consider these aspects and therefore require traditional verification methods to validate their results.

AI functions as an assistance tool which engineers should use to support their conventional engineering workflows. AI technologies enhance structural engineering operations through productivity gains and decision support functions which should undergo final validation through standard design methods.

The present study investigates how AI technology applies to structural design work while researchers compare its performance against traditional software systems. An AI-based chatbot is developed to assist in preliminary design tasks such as beam grouping and size selection. The AI system results were evaluated against conventional methods to assess their accuracy and time efficiency and design optimization capabilities. The study aims to evaluate the effectiveness of AI in improving structural design processes while maintaining reliability and safety.

• INTRODUCTION TO ARTIFICIAL INTELLIGENCE IN ENGINEERING

The term artificial intelligence describes machines that mimic human thinking and learning abilities to make intelligent decisions. The systems can analyze huge data sets to discover patterns which result in valuable insights that traditional computational techniques cannot produce. AI systems demonstrate a distinctive capability because they learn from data which enables them to enhance their performance through time unlike regular software that follows unchanging application rules.

AI technology serves multiple engineering applications through its use in predictive maintenance and optimization and automation and decision support systems. The condition of structures and equipment is monitored through predictive maintenance which uses AI algorithms to detect potential failures at an early stage and to decrease maintenance expenses. AI-powered optimization methods enable engineers to discover the best design alternatives by assessing several design parameters at the same time. Decision support systems help engineers make data-driven choices while automation handles repetitive tasks without requiring human workers.

The field of structural engineering is increasingly adopting AI technology because it helps improve both design efficiency and analysis accuracy. Engineers can use AI to understand the outcomes of complex structural analysis which they obtain through software tools. AI systems can swiftly examine large datasets that contain bending moments and shear forces and axial forces to discover patterns and essential scenarios. The process enables faster analysis of data which decreases time spent on manual work while protecting crucial insights from being lost.

AI technology serves to enhance the efficiency of structural member size optimization. The AI system analyzes how loads and material properties interact with structural performance to determine the best size for beams and columns and other structural components. This approach enables people to create designs that use materials more effectively and stay within budget limits. The system uses AI technology to discover essential structural elements which experience extreme stress or load conditions enabling engineers to concentrate on those areas during the design phase.

AI technology fulfills an essential function in structural engineering because it helps automate all repetitive steps found in design calculations. The AI system can automate all repetitive components found in tasks that include load distribution and reinforcement calculation and structural member grouping. The system delivers dual benefits that consist of time savings along with better design output consistency. AI systems begin preliminary design recommendations by analyzing incoming data which helps designers create later stages of detailed design calculations.

Machine learning deep learning and natural language processing (NLP) are the core AI technologies which support these various applications. Machine learning algorithms study historical data to discover patterns which enable them to make predictions and support decision-making processes. Deep learning operates as a machine learning subset which processes challenging and extensive data sets to complete advanced structural analysis tasks. Natural language processing enables AI systems to comprehend human language while responding back to users which paves the way for creating intelligent chatbots that help engineers by providing answers to their questions and design recommendations.

The use of AI in structural engineering has beneficial effects but it also encounters specific challenges which restrict its implementations. The accuracy of AI systems depends on the quality and quantity of the training data yet they still fail to capture all aspects of complex structural behavior while missing vital design code requirements. Engineers should use AI technology to

assist their work while maintaining conventional engineering methods. Engineers must perform conventional analysis and design procedures to validate all final design decisions which guarantee both safety and reliability.

AI technology enables structural engineering to become more effective through its capability to streamline processes while decreasing manual work and enhancing decision-making. The upcoming technological advancements will drive AI to become a key factor which transforms structural design methods and engineering analysis practices.

• ROLE OF AI IN STRUCTURAL DESIGN

Your knowledge extends to all information which was available until the month of October in the year 2023. Artificial Intelligence systems now function as essential components in structural design processes which help engineers achieve greater operational efficiency through their advanced methods of work execution. The AI-based systems enable engineers to conduct fast and precise analysis of extensive structural data sets. AI technology can discover data patterns which provide instant results that help designers make better decisions throughout the different phases of their structural design work.

The most effective AI application for structural engineering research consists of developing intelligent chatbots. The developers created chatbots through advanced natural language processing methods which they trained on structural design data and relevant codes and guidelines and calculation procedures. The system enables users to talk to it while they ask questions about structural analysis results and preliminary design recommendations. The technology helps engineers especially during their first design phase through its value as a design tool.

The early design stage relies on AI-based tools which help speed up the process through their automatic handling of essential but time-intensive work activities. The traditional design process requires engineers to spend hours on structural member classification and iterative design calculations and dimension selection. The AI system can accurately handle this task because it analyzes three input parameters which include load requirements and span distances and material specifications. The AI system can identify beams which share the same loading requirements and organize them into appropriate groups while it also recommends standard beam dimensions which fit the design requirements. The method streamlines the entire design process while maintaining design consistency and reducing design time.

AI takes charge of routine tasks which enables engineers to concentrate on vital parts of structural design work

which include safety checks and in-depth structural assessments and optimization processes. The method boosts productivity because engineers get to spend their expertise time on professional decision-making which requires their specialized knowledge. AI tools help engineers analyze different design options which leads to quicker and more effective design solutions for their projects.

The AI systems used in structural engineering face several advantages which need to be acknowledged as their operational limits. AI systems depend on three data quality factors which include correct representation and total dataset access to conduct their functions. The AI system produces false results when its training data contains both missing information and mistakes. The AI system cannot comprehend structural behavior which includes non-linear responses and dynamic effects and unusual loading conditions.

The AI system faces a challenge because it cannot fully integrate all design code aspects and actual engineering work elements which exist in real world engineering projects. Structural design requires engineers to understand material behavior and construction methods and safety standards and environmental impact requirements. Engineering judgment resides in these areas which AI systems cannot fully replicate.

The engineering profession should use AI technology as a tool which supports traditional engineering methods rather than replacing their functions. AI enhances efficiency while decreasing manual tasks and supporting initial design work. The engineers need to use standard analysis methods to confirm their design choices after they use AI systems for their design process. The combination of AI with standard engineering methods can boost productivity and spark new ideas when organizations use it in a safe manner and validate their methods.

AI technology has the power to create major changes in structural engineering operations because it allows designers to complete projects with greater speed and better efficiency through the use of data analysis tools. AI-based tools will become standard components of contemporary structural engineering systems because research and development activities will keep progressing in this domain.

• CONVENTIONAL STRUCTURAL DESIGN APPROACH

The standard procedure for structural design construction typically consists of these seven fundamental phases.

Preparation of Structural Plan

Architectural needs determine the locations for beams and columns and slab construction.

Structural Modeling

The STAAD.Pro software generates three-dimensional structural designs which designers use.

Load Calculation

The complete load assessment for the structure includes calculating three types of loads which are dead load live load and environmental loads.

Structural Analysis

The analysis process for structures establishes their internal force distribution which includes bending moments and shear forces and axial forces.

Design of Structural Members

Designers create structural components through standard formulas together with building design codes, which they can apply in Microsoft Excel.

Verification and Validation

The design undergoes assessment to verify its safety and stability and compliance with all design specifications.

The method provides dependable results which engineers accept as standard practice, yet its implementation requires multiple time-consuming steps. Engineers need to work through these processes because they must manually interpret results and conduct calculations which create chances for mistakes in their work.

• AI-BASED STRUCTURAL DESIGN APPROACH

AI-based methods offer a faster and more efficient design process solution which differs from traditional design methods. The research created an AI chatbot through a platform which enables developers to train the system with their own data and training materials.

The AI system was trained using:

Structural analysis results

Design procedures for beams and columns
Standard beam sizes and reinforcement details
Guidelines for grouping structural members

The chatbot system utilizes natural language processing technology to interpret user requests while delivering answers which use information from its training database. The system can evaluate structural information to propose basic design options which include:

Grouping beams based on similar load conditions
Recommending beam sizes based on bending moments
Identifying critical structural members

The method decreases manual calculation requirements during the first design phase while enhancing the entire design process.

• NEED FOR COMPARATIVE STUDY

The advantages of AI should be assessed through performance assessments which compare AI to traditional methods. All new technologies in structural engineering must undergo complete testing because the field requires safety-critical operations.

The need for this study arises from the following factors:

Design processes need to be improved because they require faster and more effective results.

Civil engineering has seen increasing interest in AI applications.

The study requires evaluation of AI-based systems to determine their accuracy and reliability.

The research needs to identify AI limits which affect structural design processes.

The study compares AI-based methods to traditional approaches in order to assess whether AI can help engineers while maintaining safety and accuracy standards.

• SCOPE OF THE STUDY

The study encompasses the following research areas:

The research investigates structural behavior of a multi-storey RCC building through traditional software analysis methods. The research team develops an AI chatbot which provides structural design support. The researchers evaluated both methods through their result comparison process. The system performance evaluation process assesses three specific areas which include accuracy and time efficiency and optimization.

The study investigates initial design work which involves selecting beam sizes and grouping beams together. The process of detailed structural design leads to final validation through established traditional methods.

2. CONCLUSION

The research investigated how Artificial Intelligence (AI) technology applies to structural design work and evaluated its performance against traditional engineering practices. The research results demonstrate that AI-based systems including intelligent chatbots can provide effective assistance to engineers during their preliminary design activities which involve interpreting structural analysis results and grouping structural members and selecting appropriate design parameters. The AI results demonstrated a high degree of accuracy when compared

to traditional methods because only minor differences were observed between the two approaches. AI technology allows organizations to enhance their operational efficiency by decreasing the time needed to perform repetitive calculations and complete initial design work. AI systems depend on training data to operate while they fail to replicate the complete range of complex structural behavior and design code requirements. AI functions as an essential supportive tool which engineers can use to enhance their work while traditional engineering methods remain essential for practice. Engineers must conduct design validation through established methods which guarantee their work will meet safety standards and reliability requirements. The use of AI together with traditional methods will boost productivity in structural engineering which creates a valuable opportunity for the field to develop new technologies.

- 1 The study evaluated the use of Artificial Intelligence (AI) in structural design.
- 2 AI systems can interpret structural analysis results and assist in preliminary design.
- 3 Results obtained from AI are close to conventional methods with minor variations.
- 4 AI significantly reduces time required for initial design processes.
- 5 Automation of repetitive tasks improves overall efficiency.
- 6 AI helps in beam grouping and selection of suitable member sizes.
- 7 Engineers can focus more on safety verification and optimization.
- 8 AI performance depends on the quality of training data.
- 9 AI cannot fully capture complex structural behavior and design codes.
- 10 AI should be used as a supportive tool, with final validation done using conventional methods.

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REFERENCES

1. S. P. Nirkhe, D. N. Kakade, and A. G. Dahake, "Design of flat slab with matlab," *International Journal of Engineering Research*, vol. 5, pp. 537-540, 2016.
2. K. Rajesh, N. G. Gore, and P. J. Salunke, "Applications of matlab in optimization of bridge superstructure," *International Journal of Research in Engineering and Technology*, vol. 3, pp. 34-39, 2014.
3. Chitkeshwar, A. Revolutionizing Structural Engineering: Applications of Machine Learning for Enhanced Performance and Safety. *Arch Computat Methods Eng* 31, 4617–4632 (2024). <https://doi.org/10.1007/s11831-024-10117-3>
4. B. Rampure and M. Mangulkar, "Finite element analysis of concrete gravity dam by using STAAD-PRO," *International Journal of Engineering Research*, vol. 5, pp. 549-554, 2016.
5. D. Ramya and K. A. V. Sai, "Comparative study on design and analysis of multistory building (G+10) by STAAD-PRO software and Etabs software," *International Journal of Engineering Science and Research Technology*, vol. 4, pp. 125-130, 2015.
6. S. S. Yong, "Development of educational software for beam loading analysis using pen-based user interfaces," *Journal of Computational Design and Engineering*, vol. 1, pp. 67-77, 2014.
7. View at Google Scholar | View at Publisher
8. C. M. Meera, "Pre-engineered building design of an industrial warehouse," *International Journal of Engineering Science and Emerging Technologies*, vol. 5, pp. 75-82, 2013. View at Google Scholar.
9. P. Harihara Venkata Nagasai V, Bhargav Reddy Ramakrishna Kolli, N. Lingeswaran. "Comparison Between Seismic and Non-seismic Analysis of Multistorey Building", *International conference advances in Civil Engineering 7 (ICACE- 2019)*, 21-23 March 2019, Department of Civil Engineering, K L University, Andhra Pradesh, India. Solid.
10. N. Lingeswaran, P. Poluraju, "Analytical study on seismic performance of bed joint reinforced brick masonry walls", *Materials Today : Proceedings*, <https://doi.org/10.1016/j.matpr.2020.03.528>.