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Review on AI-Based Durability Prediction of RCC Buildings with Floating Columns Using STAAD.Pro Analysis

Vishal Sahu, Sandeep Choudhary
Lakshmi Narain College of Technology (LNCT) in Bhopal

Abstract — Reinforced Cement Concrete (RCC) buildings with floating columns are increasingly adopted in modern urban construction to achieve architectural flexibility, open parking spaces, and large column-free areas. However, the discontinuity introduced by floating columns significantly alters the load transfer mechanism and may adversely affect the structural durability and long-term performance of buildings, particularly under seismic and environmental loading conditions. Recent advances in Artificial Intelligence (AI) provide an opportunity to predict the durability and service life of such complex structural systems more accurately than conventional empirical methods. This review paper presents a comprehensive analysis of AI-based durability prediction techniques for RCC buildings incorporating floating columns, with structural behavior evaluated using STAAD.Pro. The review summarizes the influence of floating column configurations on stress distribution, deflection, drift, and load-carrying capacity, while examining AI approaches such as Artificial Neural Networks (ANN), Machine Learning (ML), Deep Learning (DL), Support Vector Machines (SVM), Random Forest (RF), and ensemble models for predicting durability indicators including crack development, corrosion potential, service life, and structural degradation. The paper also discusses the integration of finite element analysis results obtained from STAAD.Pro with AI algorithms to improve prediction accuracy and facilitate intelligent structural health assessment. Furthermore, existing research gaps, challenges, and future opportunities in AI-assisted durability evaluation are highlighted. The review concludes that the combination of STAAD.Pro-based structural analysis and AI-driven predictive models offers a reliable and efficient framework for enhancing the safety, durability, maintenance planning, and sustainable design of RCC buildings with floating columns. This integrated approach supports data-driven decision-making and contributes to the development of resilient and smart infrastructure.

Keywords— STAAD Pro, Floating Column, RCC Framed Construction.

I. INTRODUCTION

Rapid urbanization and the increasing demand for aesthetically appealing and functionally efficient buildings have led to the widespread adoption of innovative structural configurations in reinforced cement concrete (RCC) construction. Among these, floating columns have become a popular architectural solution because they provide large column-free spaces for parking, commercial areas, auditoriums, and other open-floor requirements [1]. A floating column is a vertical structural member that does not extend continuously to the building foundation but instead transfers its load to a supporting beam or girder. Although this arrangement offers significant architectural flexibility, it creates discontinuities in the structural load path, resulting in increased stresses, beam deflections, and seismic vulnerability compared to conventional framed structures [2].

The presence of floating columns significantly influences the structural behavior of RCC buildings under gravity, wind, and earthquake loads. Since the load from the floating column is concentrated on transfer beams, these members experience higher bending moments, shear forces, and deflections. During seismic events, the irregularity introduced by floating columns may cause excessive storey drift, torsional effects, stress concentration, and even progressive structural failure if not properly designed. Therefore, detailed structural analysis and durability assessment are essential to ensure the long-term safety and serviceability of such buildings [3].

Durability is one of the most critical performance parameters in RCC structures because it determines the ability of a building to withstand environmental exposure, mechanical loading, and material degradation throughout its service life. Factors such as concrete quality, reinforcement corrosion, chloride penetration, carbonation, moisture ingress, cyclic loading, temperature variation, and structural irregularities directly affect the durability of RCC buildings [4]. Conventional durability assessment methods are generally based on empirical equations, laboratory testing, and visual inspections, which often require considerable time, cost, and engineering expertise while providing limited predictive capability for complex structural systems [5].

In structural engineering, numerical simulation plays a vital role in understanding the behavior of complex building systems. STAAD.Pro is one of the most widely used finite element analysis software packages for analyzing RCC structures under various loading conditions. It enables engineers to evaluate critical structural responses such as displacement, bending moment, shear force, axial force, storey drift, support reactions, and stress distribution. The analytical results generated from STAAD.Pro provide high-quality datasets that can be integrated with AI algorithms to develop reliable durability prediction models [6].

The integration of AI techniques with STAAD.Pro analysis represents a modern approach toward intelligent structural assessment. Structural parameters obtained from finite element simulations can be utilized as input features for AI models to estimate service life, predict crack propagation, assess reinforcement corrosion risk, evaluate structural degradation, and optimize maintenance planning. Such hybrid methodologies improve the reliability of durability predictions while supporting data-driven decision-making in the design, monitoring, and rehabilitation of RCC buildings [7].

This review paper presents a comprehensive overview of AI-based durability prediction methods for RCC buildings incorporating floating columns using STAAD.Pro analysis. The paper discusses the structural behavior of floating-column buildings, durability-related challenges, finite element analysis techniques, AI algorithms used in structural engineering, and the integration of simulation data with intelligent predictive models. Furthermore, recent research developments, existing limitations, and future research directions are critically examined [8]. The review aims to provide researchers, structural engineers, and practitioners with a comprehensive understanding of emerging AI-assisted methodologies that can improve the durability, safety, resilience, and sustainability of RCC buildings with floating columns.

II. FLOATING COLUMN

A floating column is a vertical structural member that does not extend continuously from the foundation to the top of a building. Instead, it rests on a beam or transfer girder, which transfers its load to the supporting columns below. Floating columns are commonly used in modern RCC buildings to create large open spaces for parking, commercial areas, and architectural flexibility. However, this discontinuity in the load transfer path results in higher bending moments, shear forces, and deflections in the supporting beams, making the structure more susceptible to seismic effects. Therefore, careful structural analysis and design using advanced software such as STAAD.Pro are essential to ensure the safety, stability, and long-term durability of buildings incorporating floating columns [9].

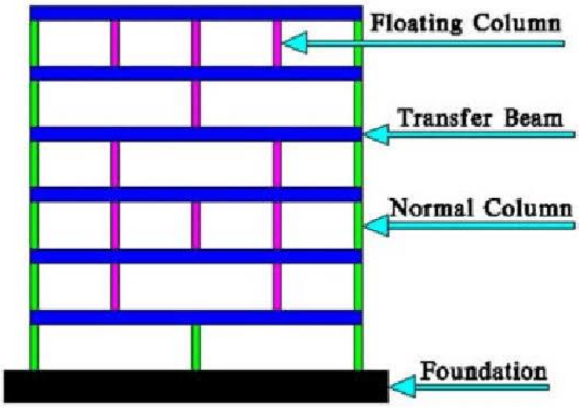

Fig.1. Floating column.

III. DURABILITY PREDICTION OF RCC BUILDINGS WITH FLOATING COLUMNS

Durability prediction is the process of estimating the ability of a reinforced cement concrete (RCC) building to maintain its structural integrity, safety, and serviceability throughout its intended design life while being exposed to various environmental and loading conditions. In RCC buildings with floating columns, durability assessment becomes more critical because the discontinuity in the structural load path creates stress concentrations and uneven force distribution. These effects may accelerate structural deterioration, particularly in transfer beams, supporting columns, beam-column joints, and foundation elements. Therefore, accurate durability prediction is essential for ensuring long-term structural performance, minimizing maintenance costs, and improving the overall reliability of the building [10].

Floating columns transfer their loads to transfer beams or girders rather than directly to the foundation. As a result, these supporting structural members experience higher bending moments, shear forces, deflections, and localized stresses than conventional RCC structures. Under repeated loading and environmental exposure, these stress concentrations can initiate micro-cracks in concrete, which gradually propagate over time [1,2]. The development of cracks facilitates the ingress of moisture, carbon dioxide, chlorides, and other aggressive agents into the concrete, leading to reinforcement corrosion, loss of bond strength, concrete spalling, and reduction in load-carrying capacity.

Several environmental factors influence the durability of RCC buildings with floating columns. Carbonation lowers the alkalinity of concrete, reducing the protective passive layer around steel reinforcement and increasing the risk of corrosion. Chloride penetration, especially in coastal or industrial environments, accelerates reinforcement corrosion and significantly shortens the service life of the structure [3]. Moisture ingress, freeze-thaw cycles in cold climates, sulphate attack, temperature variations, and chemical exposure further contribute to concrete deterioration. These mechanisms become more severe in regions experiencing high seismic activity, where repeated cyclic loading causes progressive crack development and structural degradation.

The durability of floating-column buildings also depends on material quality and construction practices [4-6]. The use of high-strength concrete, adequate reinforcement detailing, proper concrete cover, low water-cement ratio, supplementary cementitious materials, corrosion-resistant reinforcement, and effective curing techniques significantly enhances structural durability. Poor workmanship, inadequate compaction, insufficient concrete cover, improper reinforcement placement, and construction defects increase the likelihood of premature deterioration and reduce the expected service life of the building.

Modern structural analysis software such as STAAD.Pro plays a significant role in durability prediction by accurately evaluating the structural response under various loading conditions. Using finite element analysis, STAAD.Pro computes important structural parameters including axial forces, bending moments, shear forces, stress distribution, displacement, support reactions, and storey drift. These analytical results help engineers identify highly stressed regions that are more susceptible to cracking and long-term deterioration. Such information forms the basis for durability assessment and preventive maintenance planning.

IV. PROBLEM IDENTIFICATION

The increasing use of floating columns in RCC buildings for architectural flexibility introduces structural irregularities that significantly affect load transfer, stress distribution, and overall durability. Conventional durability assessment methods often fail to accurately predict the long-term performance of such complex structures under varying environmental and loading conditions. Although STAAD.Pro effectively analyzes the structural behavior of floating-column buildings, it does not directly predict future deterioration or service life. Therefore, there is a need to integrate Artificial Intelligence (AI) with structural analysis to develop accurate, data-driven durability prediction models that can identify potential structural degradation, improve maintenance planning, and enhance the safety and sustainability of RCC buildings with floating columns [2-5].

V. LITERATURE REVIEW

Taffese and Sistonen (2017) reviewed the application of Machine Learning (ML) for durability and service-life assessment of reinforced concrete (RC) structures. The authors highlighted that conventional durability prediction models based on empirical equations often fail to capture the complex deterioration mechanisms caused by carbonation, chloride ingress, moisture, and environmental exposure. The study discussed the application of Artificial Neural Networks (ANN), Support Vector Machines (SVM), Decision Trees, and other ML techniques for predicting corrosion initiation, concrete degradation, and service life. The review concluded that ML models provide higher prediction accuracy and reduced computational effort compared with traditional analytical approaches. The authors also emphasized the need for integrating numerical simulation data with AI algorithms to improve long-term durability assessment of RC structures. This study forms a strong foundation for AI-based durability prediction of RCC buildings with floating columns.

Dadras Eslamlou and Huang (2022) presented a comprehensive review of Artificial Neural Network (ANN)-based surrogate models for structural health monitoring (SHM) of civil structures. The study examined the use of ANN models in predicting structural responses, crack formation, damage detection, and deterioration using numerical and sensor-based datasets. The authors reported that ANN models significantly reduce computational cost while maintaining prediction accuracy comparable to finite element simulations. The review further highlighted the growing integration of AI with digital monitoring systems for real-time structural assessment. The findings indicate that ANN-based surrogate models can effectively support durability prediction and health monitoring of RCC buildings with floating columns when combined with structural analysis software such as STAAD.Pro.

Haggag et al. (2025) proposed an interpretable machine learning framework for predicting the load-carrying capacity and failure modes of reinforced concrete columns subjected to seismic loading. Several machine learning algorithms were evaluated using experimental datasets, and the developed models achieved approximately 95% accuracy in predicting ultimate capacity and 90% accuracy in identifying failure modes. The study demonstrated that explainable AI techniques improve transparency while supporting engineering decision-making. The proposed methodology can be extended to RCC buildings with floating columns for predicting structural performance and identifying critical members vulnerable to deterioration and failure.

Jadhav et al. (2018) reviewed the seismic performance of multistorey RCC buildings with floating columns using STAAD.Pro. The study reported that floating columns introduce discontinuities in the structural load path, resulting in increased storey displacement, stress concentration, and seismic vulnerability. The authors compared buildings with and without floating columns and observed that structures incorporating floating columns exhibited larger lateral displacements and reduced seismic performance. The review recommended the use of additional lateral load-resisting systems, such as bracing or shear walls, to improve structural stability. This work highlights the importance of detailed structural analysis before evaluating the durability of floating-column buildings.

Ninu, Kaythry, and Sangeetha (2025) reviewed recent developments in Artificial Intelligence techniques for predicting the strength and durability of fiber-reinforced concrete. The authors summarized various AI models, including Artificial Neural Networks, Support Vector Machines, Random Forest, and ensemble learning algorithms, used for predicting compressive strength, durability indices, chloride resistance, and service life. The review concluded that AI-based prediction models consistently outperform conventional regression methods in terms of accuracy and computational efficiency. The study also emphasized the future integration of AI with finite element analysis and structural monitoring systems for intelligent infrastructure management. These findings are directly applicable to AI-based durability prediction of RCC buildings with floating columns analyzed using STAAD.Pro.

Li, Luo, and Niu (2025) presented a comprehensive review of data-intelligence-driven methods for durability prediction, damage diagnosis, and performance assessment of reinforced concrete structures. The authors discussed the application of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) for predicting concrete deterioration caused by carbonation, chloride penetration, corrosion, and fatigue. The review highlighted that AI models can efficiently process large datasets obtained from structural monitoring systems and finite element analysis to estimate service life and structural health with greater accuracy than traditional empirical methods. The study concluded that integrating AI with numerical simulation tools can significantly improve durability assessment and maintenance planning of RCC structures. The concepts discussed in this review are directly applicable to AI-based durability prediction of RCC buildings with floating columns using STAAD.Pro analysis.

Zhang and Kang (2025) reviewed various machine learning methods for predicting the durability of concrete materials. The authors compared algorithms including Artificial Neural Networks (ANN), Random Forest (RF), Support Vector Machines (SVM), Extreme Gradient Boosting (XGBoost), and Deep Learning models. Their review demonstrated that AI-based models consistently outperformed conventional statistical approaches in predicting compressive strength, permeability, chloride diffusion, carbonation depth, and service life. The paper emphasized that selecting appropriate input parameters and maintaining high-quality datasets are essential for achieving reliable predictions. The findings support the development of intelligent durability prediction frameworks for RCC buildings incorporating floating columns.

Zhou, Qiu, and Chen (2025) proposed a two-stage interpretable machine learning model for predicting the drift ratio limits of corroded reinforced concrete columns under seismic loading. The study employed the XGBoost algorithm along with SHAP (SHapley Additive Explanations) to improve prediction accuracy and model interpretability. Experimental data from 290 corroded RC columns were used for model development and validation. The results demonstrated that explainable machine learning can accurately estimate structural damage states and identify the most influential variables affecting structural deterioration. This methodology is highly relevant for predicting the durability and seismic performance of floating-column RCC buildings.

Laissy et al. (2024) investigated the combined effects of thermal loading and floating columns on reinforced concrete buildings using numerical analysis. The study revealed that floating columns create discontinuities in the load transfer mechanism, resulting in higher stress concentrations and structural deformation under thermal effects. The authors concluded that accurate finite element analysis is essential for evaluating the structural safety and long-term durability of floating-column buildings subjected to combined environmental and structural loading. The research demonstrates the importance of advanced analytical tools such as STAAD.Pro for assessing complex RCC building configurations.

Haggag, Ismail, and El-Dakhakhni (2025) developed interpretable machine learning models for predicting the load-carrying capacity and failure modes of reinforced concrete columns under seismic loading. Decision Trees and ensemble learning algorithms were trained using a database of cyclically tested RC columns. The developed models achieved approximately 95% accuracy in predicting ultimate load capacity and 90% accuracy in classifying failure modes. The study demonstrated that AI techniques can provide fast, reliable, and transparent predictions for structural engineering applications, reducing dependence on computationally intensive simulations. These findings support the integration of AI with STAAD.Pro for durability prediction and structural health assessment of RCC buildings with floating columns.

VI. CONCLUSION

This review paper highlights the significant potential of Artificial Intelligence (AI) in improving the durability prediction of Reinforced Cement Concrete (RCC) buildings with floating columns. Floating columns provide architectural flexibility and efficient space utilization; however, they introduce structural irregularities that increase stress concentration, beam deflection, and seismic vulnerability. These factors can accelerate structural deterioration and reduce the service life of buildings if not properly assessed. The review indicates that STAAD.Pro is an effective finite element analysis tool for evaluating the structural behavior of floating-column buildings under various loading conditions. Structural response parameters such as bending moments, shear forces, axial forces, storey drift, displacement, and stress distribution generated from STAAD.Pro can serve as valuable input data for AI models. Machine learning techniques, including Artificial Neural Networks (ANN), Support Vector Machines (SVM), Random Forest (RF), Decision Trees, Extreme Gradient Boosting (XGBoost), and Deep Learning (DL), have demonstrated high accuracy in predicting durability-related parameters such as crack propagation, reinforcement corrosion, structural degradation, and service life. Overall, the combination of STAAD.Pro-based structural analysis and AI-driven predictive models offers a promising framework for the long-term durability assessment of RCC buildings with floating columns.

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