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# A REVIEW ON ANALYSIS OF STEEL RC BEAM AND METAL MATRIX COMPOSITE RC BEAM

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## Abstract

In structure analysis, exclusively in uncertain structures, it becomes necessary to identify the material and geometric properties of the members. Reinforcement of concrete structures becomes critical due to excessive loading, construction errors and improper maintenance. This improves load bearing capacity, improves ductility and reduces losses due to deterioration. Present study is observing for new and innovative ways of reinforcing beams as some of the limitations required to overcome traditional methods of reinforcement were encountered. The technology of wrapping a reinforced concrete (RC) beam with composite materials has become popular and widely adopted in structural applications due to their superior properties.

***Keywords:*** *Structure Analysis; Reinforcement; Metal Matrix Composite.*

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## 1. Introduction

Reinforced concrete, or RCC, incorporates steel-bars, plates embedded within the substantial to enhance its strength. These materials enhance load-bearing capacity, which is why RCC is commonly employed in all types of construction. In fact, it is now the most commonly used construction material today.

The reinforced material is integrated into the concrete so that both materials work together to withstand the applied forces. The high strength (compressive) of concrete and the ductile strength of steel produce a durable bond capable of enduring these stresses for extended periods. Plain concrete is generally unsuitable for most construction projects since it struggles to endure the stresses caused by vibration, wind, or other forces.

In a framed structure, a beam is a horizontal structural element that carries the load from the slab to the columns positioned at its ends. If the structure is constructed from Reinforced Cement Concrete, it is referred to as an RCC beam..

## 2. Literature Review

Before initiating the present study, an extensive review of previous research related to vibration analysis, damage detection, flexural performance, and structural health monitoring of reinforced concrete beams was carried out. Relevant contributions reported in journals, conference proceedings, and technical publications are summarized below.

Alasadi et al. (2020) investigated the flexural response of over-reinforced concrete beams strengthened using Bolted Compression Steel Plates (BCSP). Their experimental program consisted of three strengthened beam specimens and one conventional reinforced concrete beam used for comparison. The beams were tested up to failure under laboratory conditions. The results demonstrated that the incorporation of BCSP significantly enhanced the flexural strength and improved the compression behavior of reinforced concrete beams.

Qu et al. (2020) examined the actual flexural capacity of two hollow beam components that had been in service for nearly twenty-four years. The beams were subjected to failure testing while important parameters such as crack propagation, strain distribution, and deflection behavior were carefully monitored. The study also assessed the influence of the concrete leveling layer on beam performance and compared measured results with analytical predictions.

Yang et al. (2020) performed an experimental investigation on reinforced concrete beams containing Recycled Coarse Aggregates (RCA). A total of twelve beam specimens were tested, including nine beams with different RCA replacement levels and three control specimens prepared with Natural Coarse Aggregates (NCA). The study provided valuable information regarding the influence of recycled aggregates on the structural behavior and load-carrying capacity of reinforced concrete beams.

Capozucca (2018) focused on evaluating the dynamic characteristics of both intact and damaged reinforced concrete beams subjected to different support conditions, namely hinged and free-free boundary conditions. Experimental studies were conducted on beams strengthened using Near Surface Mounted (NSM) Glass Fiber Reinforced Polymer (GFRP) reinforcement. One of the specimens was additionally reinforced with GFRP strips in the compression region to examine their effect on dynamic behavior.

Capozucca and Magagnini (2017) emphasized the significance of vibration-based techniques as reliable Non-Destructive Testing (NDT) methods for structural assessment. Their work highlighted the need for further investigation into the relationship between crack development, crack dimensions, and variations in dynamic properties of reinforced concrete elements. Frequency measurements obtained under different support conditions were analyzed to evaluate structural integrity.

Liu et al. (2017) investigated the influence of temperature variations on the modal properties of bridge structures. Various techniques, including statistical approaches, numerical simulations, and field monitoring methods, were reviewed and employed to establish correlations between environmental temperature changes and dynamic characteristics of bridges.

Toyota et al. (2017) studied the effect of prestressing force reduction on the vibration characteristics of prestressed concrete bridge beams. Motivated by reported failures of prestressing rods in Japanese expressway bridges, vibration tests were conducted on a model prestressed concrete beam. The research aimed to develop a practical and effective approach for evaluating the health condition of prestressed concrete bridge systems.

Kumar et al. (2016) examined the performance of different Fiber Reinforced Polymer (FRP) composites used for strengthening shear-deficient reinforced concrete beams. Their investigation showed that FRP materials provide an efficient strengthening technique due to their high strength-to-weight ratio, corrosion resistance, and ease of installation.

Taylor (2016) developed a finite element model capable of simulating both static and dynamic responses of reinforced concrete beams under different cracking conditions. The numerical model was validated through comparison with experimental data obtained from loading and unloading cycles. Good agreement was observed between simulated and experimental responses, including crack development and overall structural behavior.

Bae et al. (2016) carried out experimental studies on slender beam specimens subjected to four-point loading using a 2000 kN actuator. A total of twenty-one specimens were evaluated. The obtained results were compared with previous studies on steel fiber reinforced concrete and ultra-high-strength concrete. The researchers concluded that triangular compression stress block models and strain-softening tension stress block models provide accurate predictions of ultimate flexural behavior.

Poulikakos et al. (2016) presented the findings of a Swiss inter-laboratory research program involving two-point bending (2PB) and four-point bending (4PB) tests. The study focused on evaluating the complex modulus and fatigue behavior of pavement materials extracted from aged field sections. Experimental results demonstrated the applicability of these testing methods for characterizing long-term pavement performance.

Chaitanya and Krishna (2014) experimentally investigated the load-deflection behavior of reinforced concrete beam specimens tested as vertical cantilever beams. The specimens were prepared using M20 grade concrete made with Ordinary Portland Cement (OPC). Their study highlighted the importance of flexural strength as an indicator of concrete's resistance to bending failure.

Capozucca et al. (2014) conducted an experimental investigation to assess vibration characteristics of reinforced concrete beams subjected to increasing levels of cracking. Three beam specimens were tested using both static loading and free vibration techniques. The study examined the influence of crack development on natural frequency variations and demonstrated the usefulness of vibration-based assessment methods.

Abdelkrim et al. (2014) explored the effects of crack depth and crack location on the modal properties of cantilever beams. Their results revealed that as the crack location moved away from the fixed support, natural frequencies and high-frequency vibration amplitudes increased, whereas low-frequency vibration amplitudes showed a decreasing trend.

Ahmed (2014) developed a finite element model for reinforced concrete beams subjected to impact-induced vibrations. Numerous analyses were conducted by varying parameters such as damping characteristics, stiffness recovery factors, damage parameters, displacement relationships, and friction coefficients. The study identified the most suitable modeling approach for accurately representing beam behavior under impact loading.

Kaveh and Behnam (2013) proposed an optimal design methodology for multi-story three-dimensional reinforced concrete structures using advanced metaheuristic optimization techniques, namely Charged System

Search (CSS) and Enhanced Charged System Search (ECSS). Structural design was performed according to ACI 318-05 requirements, while loading conditions followed ASCE 7-05 provisions. The analysis considered members subjected to combined axial forces and biaxial bending moments.

Vasudevan et al. (2013) investigated the behavior of reinforced concrete beams through both experimental testing and nonlinear finite element analysis using ANSYS software. Six beam specimens were analyzed using discrete reinforcement modeling techniques. Load-deflection relationships, stress distributions, strain profiles, and deformed shapes obtained from finite element analysis were compared with experimental observations.

Aziz et al. (2013) experimentally studied the influence of different curing methods on the flexural performance of High-Performance Slurry Infiltrated Fiber Reinforced Concrete (SIFCON) beams. The investigation revealed that both curing conditions and steel fiber content significantly affect beam strength and deflection characteristics.

Yang et al. (2012) reported experimental findings on reinforced concrete beams strengthened with a Polyethylene (PE) fiber reinforced Strain-Hardening Cementitious Composite (SHCC) layer placed in the tension zone. The effects of SHCC layer thickness and the use of expansive SHCC materials on cracking behavior and flexural performance were thoroughly evaluated.

Srinivas et al. (2012) carried out an experimental study to investigate the influence of damage on the vibration characteristics of reinforced concrete beams. Forced vibration testing was performed using an electrodynamic shaker under both sweep sine and random excitation conditions. Changes in natural frequencies and vibration responses were analyzed for different levels of structural damage.

Rezaee and Hassannejad (2011) introduced a novel method for free vibration analysis of cracked cantilever beams. The study considered the opening and closing behavior of cracks during vibration and modeled the crack as a fatigue-induced defect. Local stiffness variations at the crack location were represented as nonlinear amplitude-dependent functions, resulting in continuously changing frequencies and mode shapes throughout the vibration cycle.

Della and Shu (2005) presented an analytical solution for the free vibration behavior of composite beams containing two overlapping delaminations. The damaged beam was modeled as seven interconnected Euler-Bernoulli beam segments separated by delaminated regions. Continuity and equilibrium requirements were satisfied at all interfaces, allowing accurate determination of vibration characteristics without the need for numerical approximations.

## 3. Conclusion

Over the past few years, repairing damaged reinforced concrete structures has gained significant importance in civil engineering and is now commonly applied across various projects. In today’s era, reinforcing the structure is of paramount importance to prevent escalating risks stemming from its continued deterioration. Thus, the health of the structure must be given due importance, as its fitness directly influences its long-term performance. Damage to reinforced structures often stems from various issues, some arising over their lifespan, such as inadequate reinforcement, excessive deflection, substandard concrete, corrosion of steel bars, or insufficient structural capacity. Thus, resistance to fatigue and vibration are crucial characteristics of every engineering material.

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