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A REVIEW ON EFFECT OF CORROSION ON REINFORCED CONCRETE BEAM

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Abstract
Corrosion significantly affects the structural integrity and durability of reinforced concrete beams, posing a substantial challenge in infrastructure maintenance and safety. This review delves into the intricate relationship between corrosion and reinforced concrete beams, examining its multifaceted effects on their mechanical properties, structural performance, and service life. The corrosion process initiates when steel reinforcement within concrete beams is exposed to environmental factors such as moisture, chloride ions, carbonation, or other aggressive agents. Over time, these agents penetrate the concrete cover, leading to the degradation of the passive film on the steel surface and subsequent rust formation. This corrosion-induced expansion exerts pressure on the surrounding concrete, causing cracking, spalling, and loss of bond between steel and concrete. Assessing the impact of corrosion on reinforced concrete beams involves evaluating various factors, including the corrosion rate, depth of corrosion penetration, and structural consequences. Advanced techniques such as electrochemical methods, non-destructive testing, and visual inspections are employed to quantify the extent of corrosion damage and assess the beam's condition.

The review consolidates studies exploring the mechanical behavior of corroded reinforced concrete beams under different loading conditions, including flexure, shear, and bond strength. Corrosion-induced reduction in steel cross-sectional area, loss of ductility, and stiffness alterations significantly compromise the structural performance and load-carrying capacity of beams, potentially leading to premature structural failure. Additionally, the review outlines preventive measures and rehabilitation strategies aimed at mitigating corrosion effects and enhancing the durability of reinforced concrete beams. These include protective coatings, cathodic protection systems, corrosion inhibitors, and proper concrete mix designs that increase resistance to corrosive agents. Furthermore, the environmental and economic implications of corrosion on reinforced concrete structures are discussed, emphasizing the imperative for proactive maintenance and effective rehabilitation techniques to extend the service life of infrastructure and minimize repair costs.

In conclusion, this comprehensive review underscores the detrimental impact of corrosion on reinforced concrete beams, emphasizing the need for continuous research, innovative technologies, and proactive maintenance practices to ensure the longevity and safety of structures in the face of corrosive challenges.

Keywords: Concrete, Reinforcement, Accelerated Corrosion, Shear.

I. Introduction
Because of its versatility, reinforced concrete (RC) is the most often used building material. Because the reinforcement is ingrained in the stone, both materials are able to endure this effort. Longer-lasting stress tolerance is produced by the combination of steel's tensile strength and concrete's compressive strength. Because regular stone cannot endure stress from vibration, wind, or other factors, it is not a good choice for many building projects. Worldwide, it is employed in many different technical applications, including buildings, bridges, dams, and, more recently, wind turbine tower foundation systems. Because it is so versatile, reinforced concrete finds application in a wide range of settings, including industrial, nuclear, maritime, and other atmospheric settings. Existing

structures may fail for several causes. This may cause the structure to function poorly under load due to excessive deformation, fracture, or insufficient ultimate strength.

The degradation of reinforced concrete beams due to corrosion poses a substantial threat to their integrity and causes structural damage. Corrosion of the steel reinforcement in concrete beams causes a number of negative outcomes, including:

- Loss of Structural Integrity: The steel reinforcement's cross-sectional area and load-bearing capability are reduced by corrosion. The capacity of the beam to sustain applied loads is compromised by this deterioration, creating structural weaknesses.
- Cracking and Spalling: As corrosion worsens, the concrete experiences expanding pressures that cause cracking and spalling. This weakens the concrete coating that protects the reinforcement, exposing it to more corrosive substances and accelerating the degradation.
- Bond Deterioration: The bond between the surrounding concrete and the steel reinforcement may deteriorate as a result of corrosion-related expansion. Decreased bond strength has an impact on stress transmission, which might have an impact on how well the beam performs under load.
- Reduction in Service Life: The anticipated service life of reinforced concrete beams is greatly shortened by the fast degradation brought on by corrosion. Without appropriate maintenance and repair, premature structural breakdowns become a concern.
- Mechanical Property Degradation: The beam's mechanical characteristics are changed by corroded reinforcing. The structural performance of the beam is eventually jeopardized as a result of decreased ductility, changes in stiffness, and loss of load-carrying capacity.

  To lessen these impacts, preventive actions and prompt maintenance are essential. To reduce the effect of corrosion on reinforced concrete beams, cathodic protection systems, protective coatings, corrosion inhibitors, and appropriate concrete mixes resistant to corrosive chemicals are used. Rehabilitation methods could also be required to prolong the service life of damaged beams and restore structural integrity.

II. Literature

1. Adheena Thomas, Afia S Hameed(2017) et.al When the stress is focused away from the shear axis, bending and torsion combine to produce this effect. The purpose of this study is to look at how two castings behave when bent and twisted together. This testing apparatus is intended especially for use in conjunction with bending and torsion. The fracture structure, load-deflection characteristics, and torsional torsion response of these structures were identified for the purposes of this investigation. Examining the combined and torsional behavior of reinforced concrete beams is the goal of this research.

2. Chhabirani Tudu(2012) et.al In order to fulfill the system's needs for strength related to bending and shearing, fiber-reinforced polymers, or FRPs, are frequently employed as exterior reinforcements. However, there hasn't been any research done on the empowerment of members who are suffering. It is best to prevent torsion fracture, which is a prevalent kind of damage, particularly in areas prone to earthquakes. This study used experiments to examine the behavior and performance of glass fiber reinforced polymer (GFRP) fabric reinforced beams under composite and torsion.

3. Suresh Bhalgamiya, Govind Tivadi, Mehul Jethva(2018) et.al Every structure's endurance is a crucial design consideration that has to be assessed. Over the past 20 years, rebar corrosion has been extensively documented in the literature. When the metal is kept in the rock and exposed to either chlorides from the mixed rock or chlorides coming from an environment that contains chlorides, this is frequently one of the primary issues. The deterioration of steel in concrete happens gradually. It will take a long time to start up and succeed because of the difficulty of building. The fast approach is used to measure corrosion's cause and extent.

4. Needa Marwan Lingga(2016) et.al There have been reports of reinforced concrete (RC) constructions failing prematurely in corrosive settings. A significant number of recently constructed concrete structures have already aged owing to steel reinforcement corrosion. The structure's integrity and safety are compromised by this early degradation. Regarding the reinforcing characteristics of current reinforced concrete (RC) constructions, several alternatives exist.

5.Mohammad Rashidi, Hana Takhtfiroozeh (2016) et.al In the construction of buildings and bridges, a lot of structures are susceptible to large torques that have an impact on the design. This research offers a straightforward technique to gauge a reinforced concrete structural element's torsional strength. The experiment's goal is to comprehend how longitudinal and transverse reinforcement affect torsional strength. The identical length and concrete mix design were tested on four test wires.

6. A. Aryanto & Y. Shinohara(2012) et.al One of the key elements in determining how well reinforced concrete (RC) resists earthquake stresses is contract strength. The behavior of stressed reinforced concrete members—including joint position, fracture propagation, crack spacing, and tensile hardness—at varying degrees of steel corrosion is examined in this work. In a corrosion simulation environment, seven cylindrical samples with a cover rod diameter of 2.8 and a rod diameter of 19 mm were constructed and evaluated. Corrosion-related dimension loss ranges from 0% to 4%. Bond stress rises at corrosion levels as low as 1%, which results in a drop in mean spacing. The tensile strength of the concrete is weakened by fractures surrounding the corroded steel bars, which causes the mean spacing to drop at greater corrosion levels. To determine the average spacing of components subjected to stress corrosion, a straightforward analytical formula is provided.

7. Naga Chaitanya , Vamsi Krishna(2014) et.al Generally speaking, reinforced concrete beams are made to be sufficiently weak to exhibit properties like resistance to tensile moments. Steel corrosion is a common source of deterioration to concrete structures in coastal environments, hence compromising the service life and durability of these structures. Concrete strength has a direct impact on structural stability. Concrete's tensile strength, or its capacity to withstand flexural failure, is measured by its flexural strength. This study's primary goal is to assess the corroded beams' strength using regular Portland cement. The accelerated approach was used to test the beam for corrosion. Utilizing Applied Corrosion inspection tools, gauge corrosion. M20 class concrete from OPC was used to prepare the beam construction. For loading purposes, cracks in the particular material were tested as vertical lines, and the behavior of the load deflection was investigated.

8. Khaldoun N. Rahal(2011) et.al A straightforward technique is shown to forecast the ultimate strength and damage of beams made of reinforced concrete subjected to pure torsion. This approach is a development of the recently created technique for determining membrane element strength only from shear forces; it may also be used for beams that are subjected to axial loads, bending moments, and mixed shear forces.

9. Akshatha Shetty, Katta Venkataramana and K. S. Babu Narayan(2014) et. One of the main factors impacting a structure's longevity is corrosion. It is not possible to alter or disregard the structure's corrosion impact. It is necessary to look at various corrosion rates in order to comprehend how well the structure functions. Consequently, this study was carried out to investigate the acceleration behavior of NBS (National Bureau of Standards) beam specimens made of concrete matrices containing Portland Pozzolana Cement (PPC) and Ordinary Portland Cement (OPC) at various corrosion levels. 2.5% with a 2.5% latency to 10%. Samples from the control beam are used to compare the findings. It was found that as corrosion developed, the bond tension dropped. A decrease in the ability to bear loads can also be brought on by corrosion.

10. Ahmed K El-Sayed, Raja R Hussain, Ahmed B Shuraim(2016) et.al Experimental research was done to determine how corrosion-related stirrup damage affected the shear strength and functionality of concrete panels. Using the four-point bending method, a total of fourteen reinforced

concrete blocks were created and tested until they failed. The measurements are 200 mm in width, 350 mm in depth, and 2800 mm in length. Nine beams received extra force to hasten corrosion prior to evaluating the samples. The corrosion damage, difference in difference, and difference in ratio to depth are the distinct parameters. A factor of two or one is used to evaluate beams (such as short or deep members). According to test results, corroded beams' hardness and shear strength were lower than those of untreated samples. Stirrup spacing, corrosion level, and other factors tend to rise with this deterioration.
11. Shamsad Ahmad(2009) et.al The deterioration of steel in concrete happens gradually. Even in extremely corrosive environments, steel corrosion takes a long time to start and proceed because of the protection provided by concrete. It is challenging to quickly ascertain the relevance of steel corrosion to enable studies to assess (i) bond loss and the diminished capacity of reinforced members to corrode, and (ii) the impact of mineral depletion. steel corrosion, (iii) coated or alloyed steel's resistance to steel corrosion, and (iv) the efficacy of electrochemical corrosion prevention techniques. For this reason, scientists have accelerated the metals' absorption in rocks using a variety of approaches. Based on the most recent data from the literature, we will attempt to provide an explanation of the existing techniques for accelerating metal rods in both small and large samples in this article.
12.Ashutosh S.Trivedi, R.P.Sharma, Sarvesh K Jain, S.S.Bhadauria, Abhishek Tiwari(2017) et.al This article looks at how the corrosion process, temperature, permeability, moisture content, and other variables affect the corrosion of steel reinforcement in concrete.
13. P. R. Wankhede et.al The effects of flying fire debris on property have been studied and assessed through experimental research in order to assess M25 cement surface admixtures. As the percentage of rock water to cement increases, the sag loss of solids varies.

III. Conclusion
It is evident from the aforementioned study findings that the corroded beam's bending moment and shear capacities could be lower than those of the control beam construction.
• In accordance with the control beams, the bending moment will be decreased.
• In comparison to the control beam, the shear capacity will be decreased.
• In the three-point bending test, the bearing's maximum capacity will be lower than that of the control beam.
• In comparison to the regulated voltage, the maximum power will be lower.

References
[1]. Thomas, A. and Hameed, A. S. (2017), “An Experimental Study On Combined Flexural And Torsional Behaviour Of RC Beams”, International Research Journal of Engineering and Technology, 4(5), May 2017
[2]. Csikos, A. And Hegedus, I. (1998), “Torsion of reinforced concrete beam”, 2nd int. Phd.symposium in civil engineering 1998 Budapest
[3]. Tudu, C. (2012), “Study Of Torsional Behaviour Of Rectangular Reinforced Concrete Beams Wrapped With GFRP”, Department of Civil Engineering National Institute of Technology Rourkela Odisha, India, May 2012
[4]. Rashidi, M. and Takhtfiroozeh, H.(2016), ” The Evaluation of Torsional Strength in Reinforced Concrete Beam”, Mechanics, Materials Science & Engineering, December 2016
[5]. Aryanto, A. & Shinohara, Y.(2012), “Bond Behavior between Steel and Concrete in Low Level Corrosion of Reinforcing Steel

[6]. Chaitanya, N. and Krishna, N.(2014), "An Experimental Study of Flexural Strength of Reinforced Concrete Beam Due To Corrosion", IOSR Journal of Mechanical and Civil Engineering, 11(4), 98-109
[7]. Rahal, K. N.(2011)" Torsional strength of reinforced concrete beams", Canadian Journal of Civil Engineering, Vol. 27
[8]. Shetty, A., Venkataramana, K. and Narayan, K. S. (2014), " Effect of corrosion on flexural bond strength", J. Electrochem. Sci. Eng., 4(3) (2014), 123-134
[9]. El-Sayed, A. K., Hussain, R. R. and Shuraim, A. B.(2016) "Effect of stirrup corrosion on the shear strength of reinforced concrete short beams", Journal of Civil Engineering and Management, 22(4), 491–499
[10]. Ahmad, S.(2009) "Techniques for inducing accelerated corrosion of steel in concrete", The Arabian Journal for Science and Engineering, 34(3C)
[11]. Ashutosh Gupta(2014)"Monitoring of Reinforced Concrete under accelerated corrosion" Material Science and Engineering, Volume 8.
[12]. P. R. Wankhede, V. A. Fulari, Effect of Fly ASH on Properties of Concrete. IJETAE (2014) vol. 4, 284-289.