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Effect of Corrosion on Flexure, Shear & Torsional Strength of Reinforced Concrete Beam- A Review

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ABSTRACT: Corrosion is known to compromise the structural integrity of concrete bridges, buildings, and other structures. This corrosion damage is both hazardous to the public and costly to the structure's owner. Corrosion is caused by chloride ions penetrating from the outside via diffusion or other penetration mechanisms, incorporation into the OPC concrete mixture, carbonation of the cement cover, or a combination of these mechanisms. Reinforcement corrosion is caused by carbonation of concrete or penetration of acidic gases into the concrete. Aside from these, there are a few other factors that affect reinforcement corrosion, some of which are related to concrete quality, such as the w/c ratio, cement content, impurities in the concrete ingredients, the presence of surface cracking, and others which are related to the external environment, such as moisture, bacterial attack, stray currents, and so on. Uncontaminated cover concrete acts as a physical barrier, preventing the steel surface from being exposed to the elements. It also creates a chemical environment that is highly alkaline, which protects steel from corrosion.

KEYWORDS: Flexure, Shear, Torsion, Reinforced Concrete beam, Corrosion.

I. INTRODUCTION

Because of its wide accessibility, reinforced concrete (RC) is the most widely used building material. Reinforced materials are embedded in concrete in such a way that they resist the applied forces along with the concrete. Concrete's compressive strength and steel's tensile strength combine to form a strong bond that can withstand these stresses over time. Plain concrete is not suitable for many construction projects because it cannot withstand the stresses caused by vibrations, wind, or other external forces. It's used in a variety of engineering applications around the world, including buildings, bridges, dams, and, most recently, as a foundation system for wind turbines. RC structures are exposed to a wide range of environmental exposures, including marine, industrial, nuclear, and other extreme environments, due to the wide variety of reinforced concrete applications.

Existing concrete structures may not perform as well as they should for a variety of reasons. Which results in poor structural performance under service loading, such as excessive deflections and cracking, or insufficient ultimate strength. Rehabilitation of damaged concrete structures to meet the more stringent limits on serviceability and ultimate strength of current codes, as well as strengthening existing concrete structures to carry higher permissible loads, appear to be a more effective alternative to demolishing and rebuilding in the current economic climate. Many RC structures experience unacceptable serviceability or safety losses much sooner than expected. A large number of concrete structures in corrosive environments have experienced severe premature deterioration. Many concrete structures constructed in recent decades are already showing signs of deterioration due to steel reinforcement corrosion. This premature deterioration is a concern for the structure's structural integrity and safety, and it must be addressed.

II. RELATED WORK

1. **Shrikant et al. (2019)** The effect of corrosion on the torsional, shear, and flexural strength of reinforced concrete beams is investigated. They used an accelerated corrosion technique in the lab to induce corrosion on reinforced concrete. Beam specimens are cast in M20 grade with ordinary Portland cement.

The UTM (universal testing machine) was used. The flexural and shear strengths, as well as load and deflection behaviour, are investigated. For torsional strength, a specially prepared setup was used. When compared to controlled beams, the ultimate load carrying capacity of beam specimens was reduced by 26.18 percent for 9 percent corrosion (i.e. 0 percent corrosion.). Corroded beams had a lower shear capacity and moment carrying capacity than controlled beam specimens. The crack width was smaller at lower levels of corrosion (0 to 6%), but it quickly increased after that (6 percent to 9 percent). Reinforcement corrosion caused bond behaviour to deteriorate.

2. **Nasih et al. (2019)** The behaviour of RC beams reinforced with FRP sheets (strips) of various configurations and NSM steel bars of various spacing that were subjected to combined torsion and bending moment actions was investigated and compared. Seven beams, each measuring 15 25 200 cm, were cast. One of the beams was not reinforced; three of them were reinforced with carbon fibre reinforced plastic, and the rest were reinforced with NSM steel bar. During the testing process, the angle of twist at torque intervals, first cracking torque, ultimate torque, and ultimate twist angle of conventional and strengthened beams are compared. The torsional performance of RC beams using carbon FRP and NSM steel bar improved significantly, according to the findings. In comparison to the NSM steel bar-strengthened test beams, the CFRP-wrapped test beams had a greater increase in the ultimate torsional moment.
3. **Imam et al. (2018)** The author has used all necessary information related to corrosion activity in this paper, encouraging researchers to come up with some useful results to improve the durability and service life of reinforced concrete structures. Several authors have used techniques such as the impressed current technique (normally in the range of 1 mA/cm² to 4 mA/cm²) to artificially induce corrosion in order to better correlate the results with the natural form of corrosion in structures. This paper focuses on the residual flexure and shear capacity of reinforced concrete sections subjected to corrosion, which can result in a 50%–60% reduction in strength. Based on data obtained from various experimental observations, several empirical relationships for the prediction of residual load capacity (flexure and shear) of reinforced-concrete members, as well as relationships for surface crack width (ranging from 0.05 mm to 15 mm) and weight/mass loss (average loss of 15%–30%), were established.
4. **Suresh et al. (2018):** Concrete durability is a critical design criterion that must be considered for any structure. Over the last two decades, reinforcement corrosion has been widely reported in the literature. It is one of the most common causes of concrete rebar corrosion, which occurs when chloride is present in the concrete, either as a result of the concrete ingredients or as a result of the surrounding chloride-bearing environment. Steel corrosion in concrete is a slow process. Because of the protective nature of concrete, initiation and progress take a long time. Accelerated corrosion techniques are used to determine the causes and extent of corrosion. The diffusion of chlorides has been identified as one of the primary causes of corrosion. This report discusses the mechanisms of reinforcement corrosion as well as the various corrosion tests that are used to monitor reinforcement corrosion. The methodology for determining the rate of corrosion is discussed. In this report, an attempt has been made to first describe commonly used accelerating reinforcement corrosion tests as well as the corrosion development of reinforcement bars in concrete using accelerated corrosion tests. The causes of reinforcement corrosion, including carbonation and chloride ingress, are also discussed.
5. **Thomas et al. (2017):** The combined action of bending and torsions occurs when the load acts away from the resultant force from the shear centre axis. The goal of this study is to look at how flexure and torsion interact when two beams are cast together. The test setup was designed specifically for combining torsion and bending. Crack pattern, load-deflection characteristics, and torque twist response of those specimens were taken for the study. The goal of this research is to investigate the combined flexural and torsional behaviour of RC beams in an experimental setting.
6. **Adheena et al.(2017):** The combined action of bending and torsions occurs when the load acts away from the resultant force from the shear centre axis. The goal of this study is to look at how flexure and torsion interact when two beams are cast together. The test setup was designed specifically for combining torsion and bending. Crack pattern, load-deflection characteristics, and torque twist response of those specimens

were taken for the study. The goal of this research is to investigate the combined flexural and torsional behaviour of RC beams in an experimental setting.

7. **Rashidi et al. (2016):** Many structural elements in the construction of buildings and bridges are subjected to significant torsional moments, which have an impact on the design. This study presents a simple experiment for determining the torsional strength of reinforced concrete beams, which is one of these structural elements. The role of transverse and longitudinal reinforcement on torsion strength would be the focus of these experiments. Four beam test samples with the same length and concrete mix design were tested. Because the goal of this experiment is to determine the effect of reinforcement type on torsion strength of concrete beams, bars of various types have been used in each beam. The ductility factor was found to increase as the percentage reinforcement from the test results increased. It should also be noted that transverse or longitudinal bars alone will not increase the torsional strength of RC beams; however, both are required for good torsional behaviour in reinforced concrete beams.
8. **Needa et al. 2016):** In corrosive environments, a large number of reinforced concrete (RC) structures have experienced severe premature deterioration. Due to corrosion of steel reinforcement, many concrete structures built in the last few decades are already showing signs of deterioration. This early deterioration can compromise the structure's structural integrity and safety. There are several options for retrofitting existing reinforced concrete (RC) structures' structural members. In this study, the fundamentals of corrosion and the accelerated corrosion technique are discussed in depth. This paper refers to the fundamentals of corrosion, such as causes of corrosion, corrosion processes, corrosion effects, and corrosion retrofitting techniques, among others. The steel in RC beams was assumed to be completely corroded, resulting in the greatest loss of steel cross-section and strength.
9. **Ahmed et al. (2016):** The effect of corrosion damage to stirrups on the shear strength and behaviour of reinforced concrete beams was investigated experimentally. A total of fourteen full-scale reinforced concrete beams were built and tested up to failure under four-point bending. 200 mm wide, 350 mm deep, and 2800 mm long were the dimensions of the test beams. Prior to structural testing, the reinforcing stirrups of nine of the beams were subjected to accelerated corrosion. The corrosion damage level, stirrup spacing, and shear span to depth ratio were the test variables. The beams were put through their paces with a shear span to depth ratio of 2 or 1 to represent short or deep members, respectively. In comparison to the uncorroded control specimens, the corroded beams showed a decrease in stiffness and shear strength. As the corrosion level rises and the stirrup spacing and shear span to depth ratio decrease, this degradation appears to accelerate.
10. **Akshatha et al. (2014):** Corrosion is one of the major factors affecting structure durability. The effects of corrosion on structures cannot be ignored or replaced. The rate at which different corrosion levels occur must be studied in order to understand the performance of structures. As a result, the current study was undertaken to investigate the behaviour of NBS (National Bureau of Standard) beam specimens made up of Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC) concrete matrix when subjected to accelerated corrosion at 2.5 percent intervals for different corrosion levels ranging from 2.5 percent to 10%. The results are compared to those obtained with the control beam specimen. It has been observed that as corrosion levels rise, the bond stress value decreases. Corrosion also causes a reduction in load carrying capacity.
11. **Naga Chaitanya et al. (2014):** Under-reinforced reinforced concrete beams are designed to provide ductile behaviour, such as the tensile moment of resistance. Reinforcement corrosion is an obvious cause of concrete structure deterioration in coastal environments, affecting the durability and service life of reinforced concrete structures. Concrete strength has a significant impact on structural stability. Flexural strength is a measurement of concrete's tensile strength, or resistance to bending failure. The main goal of this research is to investigate the strength of corroded beams using Ordinary Portland Cement in an experimental setting. The beam was corroded experimentally using the accelerated corrosion technique. Applied Corrosion Monitoring Instrument was used to measure the corrosion. For OPC, beam specimens are made from M20 grade concrete. The load deflection behaviour of beam specimens cast as vertical cantilever beams is studied in a specially prepared loading setup.

12. **Naveen et al. (2013):** The effectiveness of epoxy-bonded GFRP fabrics as external transverse reinforced to reinforced concrete beams with flanged cross sections (T-beam) subjected to torsion is evaluated in this study. Torsional results from strengthened beams were compared to experimental results from control beams that did not have FRP applied. All of the GFRP-strengthened beams show a significant improvement in torsional behaviour, according to the study. The experimentally obtained results are compared to A. Deifalla and A. Ghobarah's analytical model and found to be in good agreement.
13. **Jeremy Lewis (2012):** This paper investigates the use of polypropylene or basalt fibres to improve the structural performance of corrosion-damaged concrete. The use of polypropylene fibres in the concrete mix improves the tested concrete beams' moment capacity and ductility. Corroded beams are shown to have a higher toughness value and retain more ductility when polypropylene fibres are added. The results for basalt fibre in this area were mixed, with some beams exhibiting increased ductility and others exhibiting decreased ductility.

III. CONCLUSION

By studying above research papers it is observed that

- Corrosion beams may have a lower moment carrying capacity and shear capacity than controlled beam specimens.
- When compared to the control beam, the bending moment may be reduced.
- In comparison to the control beam, shear capacity may be reduced.
- In a three-point bending test, the maximum load carrying capacity may be lower than in a control beam.
- When compared to control beam corrosion, maximum torque may be reduced.

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