A Comprehensive Review on Safety of Bridge Structures

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Abstract: *Bridges are acknowledged as the most crucial components of any network of transportation infrastructure, and their inability to function severely impairs the performance of the entire network. For a very long time, decision-making authorities have placed a high importance on the security and integrity of the infrastructure. Improved mechanical properties of materials used in bridge construction have become more popular in recent years. This study paper discusses safety precautions made during bridge building as well as the effects of seismic behavior on bridges.*

Keywords: *Bridges, reinforced concrete, fiber reinforced polymers, and seismic behavior*

I.INTRODUCTION

Bridges are acknowledged as the most crucial components of any trans- port infrastructure network, and their inability to function severely impairs the performance of the entire network. In earthquake-prone areas, there are a large number of deteriorating big bridges that are still in use. A systematic mathematical approach must be used to assess bridge safety, functionality, and service life in order to advance a trustworthy solution. Aged reinforced concrete (RC) bridges are vulnerable to a variety of environmental stresses, such as corrosion and carbonation brought on by chloride.
For a very long time, decision-making authorities have placed a high importance on the security and integrity of the infrastructure. Deterioration and hazardous events have resulted in structural collapse that has caused not only deaths but also direct and indirect economic losses, posing a serious threat to society's well-being (Al-Nasar& Al-Zwainy, 2022). Structure-based damage diagnosis has long been carried out in a qualitative approach using changes in the structure's dynamic response (ivanovi et al., 2005).This damage detection strategy's roots as an engineering problem can be found in the era when tap testing for fault diagnosis became popular, for instance on railroad wheels. The structural condition of offshore platforms and later the health of aeronautical structures sparked a lot of interest in the 1980s, which helped this topic gain traction in the research community.
Improved mechanical properties of materials used in bridge construction have become more popular in recent years. Engineers may now create lighter, more streamlined, and aesthetically pleasing structures (Abbas et al., 2017; ivanovi et al., 2005; Zou et al., 2021). The vibration caused by human-induced stresses is now generally acknowledged to be more of a serviceability issue than a safety (i.e. strength-related) issue. Bridge durability is a problem everywhere due to steel corrosion. In addition to impairing structural performance, it also shortens the lifespan of bridges. The maintenance, repair, and/or replacement of corrosion-damaged components results in significant economic costs every year.This leads structural engineers to look at other ways to stop steel corrosion via new building materials. Fiber reinforced polymers (FRP), one of the various alternatives put forth, have emerged as a promising choice due to their benefits including corrosion resistance, light weight, high mechanical strengths, etc. In some situations, FRP materials are an excellent replacement for steel in bridge construction (Zou et al., 2021).

FRP materials do, however, have certain drawbacks of their own, such as high starting costs (OBrien et al., 2015), a low elastic modulus (Bassett, 2015), and a lack of ductility. As a result, many of the existing FRP structural applications are mixed with concrete to create FRP-concrete hybrid sections, which are more structurally effective than steel or concrete buildings and less expensive than pure FRP structures [4]. FRP sheets/laminates for strengthening, FRP bars/grids for reinforcement, and tailored FRP parts for novel structural systems are examples of FRP materials used in bridge structures (Bassett, 2015; OBrien et al., 2015; Zou et al., 2021).

II. BRIDGE MANAGEMENT

Evaluation of the safety of bridge structures is a crucial component of bridge management. A bridge is safe when it has more capacity to resist load than is being applied, to put it simply. A bridge can be deemed safe when there is an acceptable low likelihood that the load will exceed the capacity. There has been a lot of research done on how to assess the uncertainties in a bridge's load-carrying capability. Depending on elements like the structural material, the level of craftsmanship used during construction, the age of the structure, the environment, and the history of loading, the load-carrying capacity may be diminished by various forms of deterioration.Non-destructive and/or destructive tests can be performed to obtain more particular site-specific information on these deterioration mechanisms to reduce uncertainty and related conservatism in order to perform a more accurate estimate of the load-carrying capability (Akbari &Maalek, 2018). These inspection findings can be added to time-dependent reliability-based assessments to provide the most recent deterioration rates for a given structure.These in turn can be used to plan maintenance and repairs and to precisely anticipate the structure's capacity. This article focuses on traffic loads on bridges, one of the major sources of uncertainty. Numerous statistical and probabilistic approaches have been used using various data sets to solve the issue, but no clear "winner" has emerged

III. LITERATURE REVIEW

In order to determine whether the backfill soil has a positive or negative impact on IAB seismic responses, a parametric study that was carried out within the framework of (Mitoulis, 2020) looked at the following factors: (a) the length of the IAB; (b) the stiffness of the bridge; (c) the type and height of the abutment; (d) the backfill soil; and (e) the PGA. The results regarding periods showed that the backfill soil mass has a more significant role in defining the dynamic response of the bridge the shorter the bridge is in length.The influence of the backfill soil mass is less significant in longer IABs, whilst the stiffness and capacity for energy dissipation of the fill take over to dominate the seismic response. If the backfill soil is ignored during the seismic study, the period of the bridge would be underestimated in short-span IABs and overstated in long-span IABs.

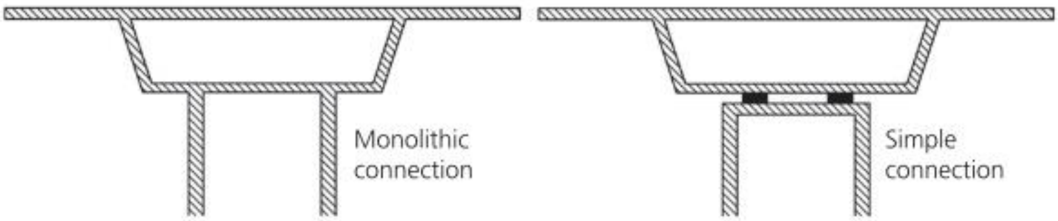

Figure 1 Seismic Behaviour of Irregular Bridges

There has been a thorough assessment of all experimental work on corroded RC parts, including (1) beams in flexure, (2) beams in shear, (3) columns under pure axial compressive pressure, (4) circular columns in flexure, and (5) rectangular columns in flexure (Kashani et al., 2019). The experimental data from each of the aforementioned groups were used to conduct regression analysis to investigate the detrimental effects of corrosion on the ductility and loss of flexural, shear, and axial capacity of the corroded RC components.Finally, cutting-edge numerical models that are currently published in the literature were used to compare the observed outcomes of the earlier experimental research with the projected values.
The present state of practice for the evaluation and load rating of existing bridges in Canada, the USA, the UK, Denmark, and Switzerland is reviewed in (Wiewski et al., 2012). As part of a probabilistic framework for evaluating the safety of existing bridge structures, it also covers recent research that established cutting-edge methods for incorporating diagnostic load and material testing, proof load testing, site-specific load data, and the impact of redundancy. The advantages of including these principles in bridge evaluation codes have been proved by years of research at the national, European, and international levels, as well as by practical implementations of these concepts on particular projects.
(Papies, 2017)proposes a situated cognition framework for developing social psychology interventions to close the intention-behavior gap, and it uses examples from the aggressiveness, environmental behavior, stereotyping, and health behavior domains to explain the approach. The fact that intentions frequently do not convert into behavior, or the so-called intention-behavior gap, is a persistent issue in behavior modification. The argument made here is that this occurs when environmental stimuli set off situated conceptualizations, such as routines, urges, hedonistic objectives, or stereotypical associations, which can then automatically direct behavior.Behavior change treatments can try to alter situational cues through cueing interventions like priming, nudging, upstream policy interventions, or reminders of social norms in order to be effective in altering such automatic effects. Alternative behavior modification strategies include training interventions like behavioural inhibition training, mindfulness training, or implementation intentions that aim to alter the underlying contextual conceptualizations.
(Akbari & Maalek, 2018)gives a current, state-of-the-art review of how irregular bridges behave when subjected to seismic stimulation. Even though the regularity of bridge structures may be characterized by a number of factors and definitions, the majority of the published literature referring to the term "irregular bridge" focuses on a particular type of straight reinforced concrete (RC) bridge with uneven pier heights as the primary cause of irregularity along the bridge length. Over the past 20 years, there have been reported multiple subsequent as well as paused study works on the subject. The development of displacement-based design technique and a deeper understanding of higher modes effects, which reflects the suitability of various analytical methods for irregular bridges, are two notable developments under ongoing progress in this sector.
Due to their close connection to structural stiffness and the spatial information they contain, modal-based Damage Sensitive Features (DSFs) have traditionally been the focus of damage diagnosis techniques in bridges. Their transition to practical applications, however, has not been without difficulties and drawbacks, primarily due to: (1) environmental and operational variations; (2) ineffective application of machine learning algorithms for damage detection; and (3) a general over-reliance on modal-based DSFs alone. The development of modal-based DSFs is thoroughly reviewed in this work,

along with a summary of the difficulties they have to overcome. The following section of (Moughty& Casas, 2017) aims to address the issues raised by the problems by presenting published innovations and fresh literature-based solutions.

Table 1 Damage Detection Levels(Moughty & Casas, 2017)

Levels	Labels	Description
1	Detection	detection of structural deterioration
2	Localization Assessment	localization of damage discovered
3	Prediction	Evaluation of the degree of the damage
4	Description	an estimate of the service life left.

An extensive amount of research has been conducted in recent decades to increase assurance of structural condition and safety due to aging road and rail infrastructure. Many bridges are currently being subjected to traffic loading situations that were not considered when they were being designed. Because of the constant rise in operational condition loads, structural fatigue is now a challenge for the entire country's infrastructure as opposed to just a single structure.
Different stiffnesses of the bridge's supporting components, like its piers, could be a significant cause of irregularity. According to the aforementioned definition, several investigations have been conducted and a significant number of articles and reports have been published regarding bridges that exhibit considerable irregularity along their whole length. A particular class of multi-span reinforced concrete bridges with regular and irregular configurations and varying degrees of irregularity has been the subject of the majority of earlier research. In fact, during the past 20 years, this kind of bridge has played a significant part in the development of new ideas in seismic research and bridge design

V.CONCLUSION

The most important parts of any network of road facilities are without a doubt the bridges, and when one fails, the performance of the entire network is significantly hampered. The dependability and security of the infrastructure have long been given top priority by the decision-making authority. Recent years have seen a rise in the usage of materials with improved mechanical qualities for building bridges. The safety measures taken when building bridges and the consequences of seismic behavior on bridges are both covered in this study article.

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