International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

A Review on Progressive Collapse of the Bridge

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Abstract – *A bridge is a structure which usually built over the barrier sort of a water body, valley, or road. The most purpose of the bridge is to supply passage over these barriers. Bridge failure could also be a natural or human error that results in a progressive collapse that causes loss of life and property damage. Progressive collapse is understood as when a structure's key element fails, because of the failure of the key element entire structure gets collapsed. i.e local failure which ends up in global failure of the structure. The progressive collapse could also be accidental, due to a design error, low-grade materials, or Natural calamity (i.e earthquake, flood) or manmade crisis sort of an act of terrorism, War, or improper method of demolition there's tons of research has been done on building structures. But less responsive work has been done towards the bridges as compared to buildings. This paper is meant to review the concept of the progressive collapse of various varieties of bridges.*

Key Words**: Bridge, Progressive collapse, Seismic load.**

1. INTRODUCTION

India is a developing country. Transportation facilities and their related infrastructure development play a vital role in the progress of developing countries like India. Bridges are one of the foremost important engineering infrastructures utilized in transportation. Bridges are usually built over the barrier kind of water bodies like oceans, rivers, and lakes and valley or road. The most function of the bridge is to provide a guideway to counter these obstructions. The number of assorted loads engaged on the bridge like gravity loads, seismic loads, wind load, temperature load, braking load, moving loads. The primary intention of a design engineer is to upgrade the planning of a structural plan so that each structural member can sustain the code enumerated forces by relating with the adjoining members. Yet, a few structures,despite being meet member norm as set away in design blueprints, can't give satisfactory degrees of repetition to face up to an area loss, the loss that would induce the progressive collapse of the whole structural organization.

A structure undergoes progressive collapse when a primary structural element fails, leading to the failure of adjoining structural elements, which causes structural failure. It also defined as extent damage or collapse that's disproportionate to the magnitude of initiating event. Progressive collapse analyses are intended to work out the capacity of a structure either to resist an abnormal loading.

1.2. CAUSES OF PROGRESSIVE COLLAPSE

In the history of bridges, lots of bridges are collapsed due to various reasons. Mostly there are two main reasons which are Natural factors and manmade factors. Natural factors are Floods, Earthquakes, landslide, debris flow, hurricane, and typhoons, scouring these natural calamities are unavoidable which causes plenty of damage to the structure.

- **Natural Factors-**

1. **Flood-** Heavy precipitation usually results in flooding, which can induce phenomena like scour, erosion, river convergence, insufficient embedment depth, protection works-induced over fall or hydraulic jump, softened bedrock, sand mining, debris impact or abrasion on bridge foundations, etc. One or a mixture of those causes may result in dramatic reductions within the strength and stability of bridge key components and may even cause bridge failures.

Fig-1: - Bridge Collapse due to flooding at Mahad over Savitri River

2. **Scour-** Scour may be a phenomenon during which the extent of the riverbed becomes lower under the effect of water erosion, resulting in the exposure of bridge foundations. With a rise in scour depth, the lateral resistance of the soil supporting the inspiration is significantly reduced, thus increasing the lateral deflection of the

inspiration head. Furthermore, when the critical scour depth is reach, bending buckling of the inspiration may occur under the combined effect of a load of bridge superstructures and therefore the traffic load.

3. **Earthquake-** Earthquakes cause vertical and horizontal ground motions which will fail bridge substructures. The vertical ground motion causes significant fluctuating axial forces in bridge columns or piers, which can induce outward buckling or crushing of the columns or piers. Furthermore, the vertical ground motion may result in a significant addition of the bending moment towards the mid-span of the bridges, which may cause the bending failure of the bridge. Vertical ground motion and horizontal ground motion waves grant the shear failure of bridge columns or piers. Also, both the vertical and horizontal ground motions may cause the liquefaction of the soil at the bridge foundations, which may greatly reduce the load-carrying capacity of the foundations and even directly cause bridge collapse.

4. **Landslide-** The occurrence of a landslide is especially because of water saturation, earthquake, or eruption, and it's going to end in the downward and outward movement of slope-forming materials including rock, soil, artificial fill, or a mixture of those materials. These moving slope-forming materials, when hitting the bridge, will cause severe damage or maybe collapse of the bridge.

A human factor includes imperfect design and construction method, collision, vehicle overloading, fire, terrorist attack, lack of inspection and maintenance, etc., can also end in bridge collapses. These factors discussed within the following sections.

- **Human Factor-**

1. **Imperfect design and construction-** In many cases, errors stemming from imperfect design, willful use of inferior materials, or adoption of an inappropriate construction method, a false structural design which leads overstress in connections and members can cause bridge collapse within the construction phase. Also faulty material and inaccurate supervision affect the efficiency of the bridge which undergoes failure of the bridge.

2. **Collision-** Accidental collisions between vehicles and bridge superstructures and between vessels and bridge piers or columns are often unpredictable. During the collision, very large lateral forces are transmitting to the impacted bridge structures. This massive impact force, performing on a relatively small contact area, can cause very high local pressure and thus local damage to bridge components. Because the bridge consumes the dynamic collision energy, powerful inertial forces and vibrations developed. Collisions forces can cause severe damage to bridge components or maybe the collapse of the bridge.

3. **Terrorist attack-** Recent years have witnessed a variety of terrorist attacks against transportation systems worldwide. Important infrastructures considered as primary targets for attack due to their accessibility and potential impacts on human lives and economic activities. Terrorists frequently target key components of the bridge likewise piers and decks due to failure of these components causes bridge collapse.

4. **Lacks of Inspection and Maintenance-** Bridges in service are consistently subject to attack by the environment and live loads. As a result, bridges come in contact with degradation. When exceeding a particular intensity, can cause serious problems. The degradation is happened due to various factors including material properties and mechanical and environmental. Though the danger of bridge failures cannot be eliminated, a decent maintenance program including regular inspection and proper rehabilitation will prevent the deterioration process of bridges and help detect potential structural problems before they become serious disasters.

1.3. OBJECTIVES AND SCOPE

1) To study the different causes of progressive collapse of bridge.

2) To study the structural phenomena of progressive collapse.

2. LITERATURE REVIEW

Hartanto Wibowo, S.M. CSCE; Silvena S. Reshotkina; and David T. Lau, F. CSCE 2009 [1]Progressive Failure may be stated as a global hazard or collapse behavior of a large portion of the structure which happened due to failure of the small or relatively local part of the structure. Radical crash of bridges determined by characteristics of the earthquake such as intensity, Magnitude, and epicenter. In response to a structure to seismic waves, continuous vibration and shaking occur initial failure and repeated reversal stresses of cyclic inelastic actions cause degradation of rigidity, toughness, and ductility of bridge due to damage. He had analyzed the RC bridge by using ELS software which is set up on Applied Element Method. He observed that cracks are developed first at the connection between deck and pier and after developing the cracks deck fails due to joint failure. He stated that progressive destruction of structure can happen due to earthquake forces not only because of gravity loads and blast loads. The earthquake-resistant design must be scrutinized in the continuous collapse phenomenon.

Uwe STAROSSEK 2006 [2] states a clear variation among robustness along with crash prevention. About progressive collapse, non-robust structures are of precise matter and need specific consideration. the need for such consideration follows from an inspection of current design methods which are supported reliability concept. Because of fundamental difficulties and thanks to the amount and complexity of influencing factors that appear after failure initiation, a purely possibility based design of real structures seems impracticable. a practical design approach was therefore proposed during which the standard feasibility based design procedures, as described within the codes, are complemented by a further assessment and particular design measures concerning progressive collapse during which analyses are administered deterministically.

Forces should be determined supported the over strength of elements introduced for continuity and therefore the force transmission should be checked right down to the inspiration. Compartmentalization accomplished either by strengthening or by a discount of continuity at the compartment borders. In other words, the compartment borders must be ready to sustain either large forces or large displacements. Structures, compartmentalization is that the more suitable approach to stop progressive collapse—an incontrovertible fact that has gone nearly unnoticed within the structural engineering community. If this feature has been overlooked, one reason could be that the terms constancy, redundancy, along with robustness are intuitively equated, a tacit assumption that is justified at the best for particular sorts of structures.

Amir Seyedkhoei, Reza Akbari, Shahrokh Maalek 2019 [3] stated the procedure for progressive catastrophe of the pre-stressed concrete bridge. Its generation of other specifications for the disintegration of the various category of bridge-like regular, semi-regular, and irregular structures. progressive disruption of the pre-stressed bridge will appear like a domino-type under seismic loads. Punching shear shows under the seating sectors of the box girder. The use of a column begins introductory failure it is a part of the substructure possibility increases of progressive collapse but the prediction of the progressive collapse mechanism of the regular bridge much easier than the other bridge. height of the pier of the bridge also affects on the progressive collapse of different bridges. probability of failure of a tall pier is more than those short and medium piers. The ground slope also significantly influence on the collapse mechanism. It also observed that average values of impact force in medium height piers are less than tall piers.

Feng Miao, Michel Ghosen 2017 [4] Current protocols for the continuous failure of buildings aren't applicable to progressive failure of bridge. Difference between the topology, load transfer mechanism, and structural configuration of buildings is different from bridges for permanent as well as transitory loadings. In that case, there are huge problems that occur in the appraisal of applied loads and the capability of the system to lower the dynamic collapse. Probabilistic expression which shows the continuous crash of the bridge as follows P(C) = P (C/D) P (D/H) P. The term P (C/D) mostly utilized to evaluate robustness. They have analyzed box girder steel bridge and steel truss bridge. They concluded that the box girder bridge affected fatigue fracture at the mid-span of a box girder and the steel truss is lose the load-carrying capability of the primary strut. These scenarios selected due to these bridges usually designed as a non-redundant, fracture-critical composition which are expected that to collapse under their weight if there any member get failed.

Lu Deng, Wei Wang, Yang Yu 2015 [5] They have done plenty of work on understanding behavior also as a collapse mechanism of various sorts of bridges although frequent challenging matters go on. Because the combined effects of the many various factors make the bridge failure structure absolutely convoluted that comes very difficult to spot the leading circumstances that precipitate failure. It's difficult to perform field investigation because of safety and price. Two things namely natural along with human factors provoke the catastrophe of the bridge. The most breakdown forms of the bridge are sort of a weak reference to support, decking breakdown, and shear loss cause bearing dysfunction, shear loss of pier, and progressive collapse because of irregular forces resulting from the loss of support.

Uwe Starossek 2007 [6] states dynamic breakdown can be delivered by an alternate instrument. Coming up next are the various kinds of breakdown depend on capability the dynamic reaction, power function, material properties, over quality, and malleability of the material. Six sorts of breakdowns are enrolled, for example, Pancake type and Zipper type, as well as domino type. Segment type, Instability type, and blended sort. The more elevated level of thought can be shaped by the flapjack type and domino type breakdown instrument which are known as effect class or redistribution class. Zipper type breakdown for the most part caused because of tremors. The hypothetical and unique conditions can vary for various kinds of breakdown systems. In the event that flapjack breakdown can be examined in a deterministic manner, the zipper-type might be viewed as dependent on likelihood. It additionally gives clues by crack component of breakdown.

Audumber Wani1, Dr. R. S. Talikoti 2[7] A hypothetical cable-stayed bridge with concrete box deck has been modeled and analyzed for the gravity loads and subjected to different cable loss scenarios in the software SAP2000 V17. They compared models of cable loss and without cable loss based on parameters like deflection and forces in the cables. After losing of a cable healthy bridge goes under the major deflection in one span. It also affects the uneven distribution of force in the cable which leads to progressive collapse. They concluded as per the typology of progressive collapse zipper-type progressive collapse happened by the forming of hinges.

Abolhassan Astaneh-Asla 2018[8] He represents the summary of how the progressive collapse of the bridge I-35W steel deck bridge has occurred, condition of the bridge before collapse. He studied the inspection report of the Minnesota Department of Transportation, owner and maintainer of the bridge. He also studied the photograph which has been taken in the past. The fatigue and cracks are developed in the primary member of the bridge or a connection of the main truss which caused progressive collapse due to the absence of a secondary load path. He studied the blueprints of the bridge and the same bridge is modeled and analyzed with the same condition in SAP 2000 software. He concluded that the gusset plate of the main truss was under design. This happened due to improper design and lack of maintenance of the bridge.

3. CONCLUSION

A bridge is a crucial link in transportation and communication in the country. The approach of analysis of the bridge has developed speedily and equally with the computer-aided programs. For above papers, the progressive collapse has occurred due to different reasons. Earthquake is one of the most important factors of the progressive collapse of the bridge it's not limited to only gravity loads and blast loads. It also seems that existing guidelines of progressive collapse of the building are not suitable for the bridges because of the different load transfer mechanism, topology, and its structural configuration. Plenty of work has been done in the progressive collapse building structures but response towards bridge infrastructure is quiet less therefore there is a need for separate progressive collapse guidelines for the bridges. This helps the structural engineers for the more comprehensive seismic design approach. While designing the bridge one should avoid the human error by checking the design and requirement criteria of the bridge design also proper inspection and maintenance of the bridge is needed to avoid further consequences.

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BIOGRAPHIES

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