The performance of concrete bridge piers subjected to vehicular collisions in a circular reinforced structure

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ABSTRACT

Car crashes onto conduit piers have the potential to severely damage the prop up jetty and even cause the complete structure to cease altogether. The nation's ageing transportation infrastructure raises the possibility that many facilities do not meet modern design standards, making many conduits vulnerable to failure in the event of a severe loading episode. The purpose of this investigation is to examine how hardened concrete conduit piers behave structurally when struck by cars. In order to examine the reasons behind the shear and bending failures of conduit piers exposed to vehicle smash, a detailed analysis is carried out. This study examines a number of parameters, including stack cap height, vehicle shock velocity, pier diameter, sloping corrosion spacing, and multi-pier layout.

In order to obtain precise and comprehensive results, vehicle crashes are replicated and examined closely using. In order to obtain precise and comprehensive results, vehicle crashes are replicated and examined closely using the restricted element code LS-DYNA. This study is conducted using the vehicle models that are available to the National Crumple Scrutiny Centre and the National Haulage Investigative Centre, Inc. An impact drop hammer experiment is used to validate the material properties and gearshift used in the finite element modelling. The validity of the bridge pier smash models is confirmed by contrasting published study findings with vehicle damage and blast forces. Energy conservation is also necessary to guarantee stability in the impact simulation. According to a sensitivity analysis, the distribution of blow forces and disappointment modes are significantly impacted by pier factors. Largely taut piers have great struggle to shear forces, high bending moments, minimal lateral displacements, and strong bang forces. A performance-based scrutiny shows that bridge piers can be designed using dent ratios associated with particular damage states.

KEYWORDS

Performance-based design, Vehicle, Pier, Collision and Review.

INTRODUCTION

An acute loading event, like as a vehicle collision with a bridge pier, can happen relatively seldom over the course of a bridge's existence. However, it can cause notable structural damage to the support piers, warped caps, groundwork, and superstructure, and even lead to complete structural failure or wrinkling. Harik et al. (1990) looked into the reasons behind 79 bridge failures that happened in the US between 1951 and 1988. The analysis revealed that collisions involving trains, trucks, and ships were the main reasons for bridge failures. The study also revealed that there were more conflict-related bridge collapses—36—that resulted in full and partial collapses than failures brought on by natural events such floods, scour, wind, earthquakes, etc. A comparable investigation carried out by Wardhana & Hadipriono (2003) examined the reasons behind bridge collapses that occurred in the US from 1989 to 2000. This study demonstrated that the primary cause of bridge failures was hydraulic causes, such as scour and flood. Accidental collisions were the second most common cause of bridge failures, accounting for 11.73% of all 503 link failures. According to these research, car collisions, deteriorating materials, hydraulic damage, and overloading the structure are the main reasons why bridges fail. The subsequent car crashes against bridge piers have not caused the bridges to collapse structurally, but they have seriously damaged the bridge's components and disrupted traffic in large cities.

A tractor-trailer hauling 55 gallon sodium hypochlorite drums lost control and surrendered itself into the north support pier of the Road 26.5 overpass on August 15, 2007, at approximately three in the morning, while driving west on I-70 in Grand Junction, Colorado (Gallegos & McPhee 2007). After the collision, there were two confirmed deaths. Although there was no public concern associated with the chemicals being transported, they did need to be cleaned ecologically. The truck hit the bridge pier after tearing away 75 feet of guardrail. As seen in Figure 1.1, the impact force shredded the column at the bent cap connection. The following day, the bridge was reopened following the construction of a temporary support. The bridge support needed to be repaired for about $286,000.

METHODOLOGY

Objective of Project :

The following are the goals of this study: (1) carry out an extensive examination of the literature to understand the relationships and mechanisms involved in car crashes against bridge piers and how to investigate such incidents using finite element modelling; (2) simulate a stress event to ensure that the finite element technique and material models are operating properly; (3) simulate a bridge pier with a single column and maintain the precision of the car models are identified by contrasting diagnostic data with published findings; (4) a kindness analysis is carried out to identify the presence of pier diameter, hoopspacing, vehicle boom velocity, pile cap height, and multi-pier bents on the structural struggle and reaction of bridge piers.

Chapter 2 intends to start an extensive analysis of the literature on the subject of vehicle collisions with conduit piers and the modelling of such trials with the restricted ingredient code LS-DYNA. The analysis of the literature showed that car crashes are a significant risk to bridges and can result in significant damage to the structure, even though they are not the main cause of bridge collapses. El-Tawil (2004) states that the AASHTO's recommended counterpart static force design load significantly underestimates the dynamic shock force produced during a smash event. To have a better understanding of the design forces that are resisted by affected bridge piers, researchers are working on constructing finite element models to replicate vehicle impact events.

Chapter 3 intends to calculate the vehicle impact forces produced in rear-end collisions analytically. Based on the vehicle mass, impact velocity, and the amount of displacement brought about by the vehicle's crushing, the impact force of the vehicle is defined using the principle of conservation of energy. This crash force approach can also be used to provide a similar static force in piers during elastic deformations for design purposes.

Chapter 4 seeks to evaluate controls and materials for finite elements that can be utilised in vehicle impact simulations. Because there is a lack of experimental evidence relating automobile crashes with bridge piers, a drop hammer experiment was used to replicate a similar observed fact. Impact loads were applied to rectangular reinforced concrete beams with different longitudinal reinforcement ratios. The mid-span analytical results.

Design Standard sand Their Development

In order to ascertain the highest crest load produced during the crashes and closely examine the shock force distribution along the column's height, Buth et al. (2010) analysed car collisions with viaduct columns. Shear failure of the hit column is the main form of failure for bridges struck by cars; this often results in two 45-degree shear planes originating from the impact area. LS-DYNA was used to develop a finite aspect model that proposed the influence of a 36.3 Mg tractor-trailer and a 29.5 Mg single-unit truck on severe bridge columns. The single-unit truck simulation was utilised to determine that, at 1.524 metres above the ground, the impact forces concentrated the most along the column's height.

These results sparked worries that the forces produced during a car crash were not sufficiently taken into consideration in the design criteria. To estimate the realistic shock force that would result from a fully loaded tractor-trailer colliding with a bridge pier, a full-scale hurtle test was suggested. Two full-scale hurtle tests were performed by Buth et al. (2011) in order to determine the force produced when a rigid bridge pier is struck by a 36.3Mg tractor-trailer. In order to capture the highest impact force that might be produced during the collision, the column was made stiff. The impacting force measurements were in contrast to the smash force specified by the AASHTO LRFD for design, which is 1,779 kN practical at 1.219 m above ground in any direction perpendicular to the column.

Material Models Concrete

Material model 159 was used to represent the concrete material of the beam (Mohammed 2011). The Federal Highway Administration developed, assessed, and validated this continuous surface cap model to forecast the dynamic performance of concrete used in roadside safety structures exposed to car crashes (Murray et al. 2007). As a function of concrete density, compressive strength, and maximum aggregate size, the material model determined the necessary stiffness, hardening, softening, and rate effect parameters. An increase in the elements' strength with an increase in the strain rate is modelled using a viscoplastic formulation. The capacity of the model to maintain consistent fracture energy is independent of element size (LSTC2013). Tracking of damage to the current necessities occurs during pliable & weak spoil parameters. When stress is applied to an element in compression, ductile damage happens. When stress is functional to the component under tension, fragile damage results. The damage parameters are 0 for no damage and 1 for total damage.When strain-based energy requirements exceed a specific injury entry, damage is triggered. An element's stiffness and strength will both be equal to zero when one of the damage parameters gets close to 1. The real object that was modelled had a maximum aggregate size of 10 mm, an unrestricted compressive potency of 42 MPa, and a mass density of 2,274 kg/m3.

Analytical Results

The mid-span deflection and brunt forces from the studies were compared with the experimental data published by Fujikake et al. (2009). Figures 4.13–4.15 show the unoccupied S1616, S1322, and S2222 grin preliminary and diagnostic results, respectively. The typical difference between the experimental and systematic results for mid-span dislocation was 8.2%. All in all, the mid-span deflections are only a few millimetres off from the trial findings and light brightly.The maximal impact force difference between the experimental and analytical values was 10.8% on average. Overall, the peak shock forces exhibited a strong correlation with the experimental findings, suggesting a prudent performance from the finite element model. As the drop height grew, the post-peak shock forces sin time improved in accordance with the experimental findings. The plastic strain contours were used to observe the snap profile (Mohammed 2011). The crack patterns and the experimental findings agreed fairly well. Figures 4.16-4.18 show the crack profiles of the analytical and experimental data. It was determined that the finite element methods utilised on this work may be applied to creating car collision simulations with bridgepiers by validating the smile blow experiment. Under dynamic shock loading simulations, material models 24 and 159 can be utilised to represent the textile characteristics of concrete and steel corroboration, respectively. The interaction between two striking items is precisely captured using an autonomous surface-to-surface contact method. The Flanagan-Belytschko rigidity hourglass control reduces the amount of under-integrated solid parts that exhibit hourglassing.

CONCLUSION

Car crashes into bridge piers have the potential to severely harm bridge elements and ultimately result in the bridge's catastrophic failure. Car crashes can cause significant damage to nearby towns by closing important thoroughfares, requiring expensive repairs, and sometimes even taking lives. The design specifications provide for vehicle collision loading events by using an equivalent static load. Studies have shown that the design requirements significantly underestimate the forces produced during an impact event and recommend using a different approach to design. The previous paper describes several approaches for evaluating upward finite building block models that simulate accidents between vehicles and flyover piers.

Vehicle crashes with viaduct piers can provide a significant risk to the country's road and rail network, as demonstrated in Chapter 2. Researchers have not entirely explained the interface and design forces created by cars striking bridge piers. Many researchers use finite element programmes, like LS-DYNA, to examine car crashes with bridge piers because full-scale trials are expensive. According to one recent experiment, many bridge piers constructed before the modifications no longer meet design criteria, which resulted in adjustments to the design specifications. As demonstrated in Chapter 3, impact forces can be calculated using the conservation of energy method. The force necessary to move a pier a certain distance can be calculated using the work equation. The force exerted on a bridge pier as a result of an impact is significantly influenced by the mass of the vehicle and impact velocity.

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