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Louisiana Transportation Research Center

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Monitoring System to Determine the Impact of Sugarcane Truckloads on Non-interstate Bridges

Introduction

The study aims to assess the strength, serviceability, and economic impact of overweight trucks that haul sugarcane on Louisiana bridges. Researchers identified the highway routes and bridges used to haul sugarcane and chose samples to analyze. Approximately 84 bridges were involved in this study. Four different scenarios of load configuration, based on the FHWA 3S3 truck configuration, including GVW=100,000 lb. with: 1) maximum tandem load of 48,000 lb., 2) maximum tridem load of 60,000 lb. 3) uniform distributed tandem and tridem loads, respectively, and 4) GVW=120,000 lb. with maximum tandem of 48,000 lb. and maximum tridem load of 60,000 lb. are examined. The 120,000 lb. GVW for sugarcane haulers is the highest level considered in this investigation.

The study evaluated the short term and long term behavior of bridges under the overweight vehicles. Researchers developed a load carrying capacity diagnostic system. The system was installed on the selected bridge to determine the structural responses and was used as a permanent structural health monitoring system. Possible solutions, which include reducing the load to the bridge or accepting more frequent rehabilitation of the bridges, were investigated. Bridge costs were generated for a gross vehicular weight (GVW) of 120,000 lb. and the load factors included in the method of design in the Load Resistance Factor Design (LRFD) specifications.

Objective

Increasing the maximum allowable sugarcane truckloads to 120,000 lb. on bridges will affect their safety, serviceability, and durability. While compromises can be made with respect to serviceability and durability in the interest of transportation efficiency, the fundamental safety of the existing bridge system must always be maintained. The objectives of this research are: (1) to investigate the strength and safety, (2) to monitor a bridge system based on current and future sugarcane overloads, and (3) to determine the economic impact of overweight trucks hauling sugarcane on Louisiana bridges.

Scope

The scope of this investigation was focused on the effects of sugarcane truckloads on distribution of forces and moments on slab-girder bridges. The investigation also focused on developing a long-term monitoring system to assess the impact of sugarcane truckloads on safety, serviceability, and durability of non-interstate bridges. The analysis concentrated on the effects of the following parameters: type of loading on the bridge and geometry of the bridge.

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Research Approach

The state bridge inventory was used to locate the bridges on state roads that are highly traveled by sugarcane trucks. Critical bridges for this study were those located on the roads most traveled by trucks carrying sugarcane. Research considered Louisiana State Highways and U.S. Numbered Roads. The review and selection processes were based on two factors: (1) the amount of sugarcane each parish produces and (2) the parish's geographic location.

The analysis used methodology based on LRFD and LFD design recommendations to evaluate the effect of heavy loads on the bridges from trucks transporting sugarcane products. The demand on the bridge girders due to the heavy truck loads was calculated based on bridge girder type, span type, and the bridge geometry. The effects of sugarcane truck loads on state bridges were determined by comparing the stresses in the girders, the vertical deflection of the girders, and the stress state of the deck. The American Association of State Highway and Transportation Officials (AASHTO) line girder analysis approach detailed analyses using finite element models, and Georgia Tech Strudl (GTSTRUDL) software was used to achieve the objectives of this study. Based on the results of the parametric study, one sample bridge was selected for the long term monitoring system installation.

The instrumentation plans were developed based on the results from the analyses of the parametric studies and the critical bridges used in this study. A bridge load carrying capacity diagnostic system was developed and installed on the bridge that was selected by LADOTD. Researchers performed the live load test to determine the stiffness, capacity, and rating of the bridge. The structural responses, namely strength and serviceability, were correlated with applied loads. The results of the combined analytical and field procedures were compared to the recommended design procedures stated in AASHTO specifications and the LADOTD Bridge Manual. The remaining life of the bridge was then evaluated.

Conclusions and Recommendations

The bridge costs were generated for sugarcane truck loads of GVW 120,000 lb. and 100,000 lb., including the load factors based on the method of design in the LRFD manual.

The bridges in this study were evaluated for safety and reliability under 3S3 trucks hauling sugar cane with two GVW of 120 and 100 kips in four different load cases, with the load lumped and uniformly distributed. The investigators used a probability-based method and conducted field experiments on a selected bridge to compare the theoretical results with the actual response of the bridge.

The sugarcane truck load with GVW 120,000 lb. with maximum tandem and tridem loads produced the largest moments and shear forces. Therefore, this load configuration controlled the strength, serviceability analyses, and evaluation of fatigue cost. The results from the bridge deck analyses indicated that the bridge deck was under a stable stress state, whether the stresses were in the tension zone or the compression zone. Moreover, the decks of bridges with spans larger than 30 ft. might experience cracks in the longitudinal direction under 3S3 trucks. Such cracks would require additional inspections and frequent maintenance.

Based on the results of this study, it is recommended that truck configuration 3S3 be used to haul sugar cane with GVW of 100,000 lb. uniformly distributed. This will result in the lowest fatigue cost on the network. It is not recommended that truck configuration 3S3 be used to haul sugarcane with GVW of 120,000 lb. This will result in high fatigue cost on the network, and could cause failure in bridge girders and bridge decks.