ABSTRACT

Every bridge has certain restriction for the vehicle load and length. When the limit exceeds, permit has to be sought from the competent authority to pass the vehicle through the bridge. Weigh bridges are installed at important sections of highways to restrict the overloaded vehicles to enter the bridge. Presently, weigh-in-motion system in use can estimate the axle loads. But it incurs high cost of installation and maintenance. Accuracy is also affected by the speed of the vehicle and unevenness of the pavement. For given structural configuration, construction materials and road surface condition, the physical parameters of vehicle also play a significant role in bridge dynamic behavior. Traditionally, the bridge design load is calculated by magnifying static live load with impact factor. Days are not far when complete moving load time history would be necessary to check the design of long span bridges. Recognizing the practical significance of the research on moving load identification, attempts have been made in this thesis to carry out theoretical and experimental study for the estimation of vehicle parameters from the bridge dynamic response.

In the present study, a conditional probability based approach known as "particle filtering technique" has been utilized to estimate the physical parameters of a passing vehicle from the measured dynamic response of the bridge. The particle filter technique requires a mathematical model of the system for the repeated generation of response samples, which is termed as "Forward Scheme". In the present work, a semi analytical method has been developed and interfaced with the particle filter method for generation of response samples. In the proposed semi-analytical method, the bridge has been modeled as Euler Bernouli beam with uniform cross sectional properties. Along with flexural vibration of bridge, the torsional motion of the bridge due to eccentric vehicle path has been considered in the study. Three vehicle models, viz, (i) Model-1: Quarter Car Model (ii) Model-2: Half Car Model with bending flexibility of the vehicle and (iii) Model-3 Full Car Model with bending and torsional flexibility of the vehicle has been incorporated in the semi-analytical formulation. The bridge deck surface roughness has been modelled as the realization of non-homogeneous process in spatial co-ordinates. The non homogeneity of pavement profile has been

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incorporated by superimposing variable mean surface over random unevenness. The present study considers two types of mean profile-(i) pre-cambered bridge surface which is often adopted to compensate excessive vertical deflection of the bridge under live load and (ii) approach road settlement as a construction defect.

A dynamic field test has been conducted on an existing bridge with controlled movement of a loaded truck at different speed. The test bridge has been modeled in Finite Element software SAP 2000 in order to update the bridge physical parameters using a combined Response surface and Genetic algorithm approach. The acceleration of bridge deck has been recorded at five locations, which have been utilized in particle filter technique to estimate test truck parameters.

Dynamic behavior of three different bridge-vehicle models has been studied using proposed semi-analytical method to examine the effect of different bridge vehicle parameters on the bridge response statistics and on the dynamic amplification factor. The effect of vehicle flexibility on the bridge dynamic response has been also investigated. Identification of vehicle parameters of three models has been presented with the help of simulated results. The interaction force between vehicle and bridge has been reconstructed using the identified parameters and the states of the system. Effects of measurement location, artificial noise level, vehicle speed and pavement roughness conditions on the accuracy of identified vehicle parameters have been studied.

Lastly, field test results have been utilized in particle filter method to estimate the parameters of the test truck. Different model options in Forward scheme of the particle filtering method have been studied with the help field data. The study reveals that vehicle flexibility has noticeable effect on the bridge dynamic response for long and slender vehicle body. The proposed semi-analytical method of bridge-vehicle interaction dynamics when combined with particle filter method has shown remarkable performance in terms of saving of computational time and improving the accuracy of the estimate of vehicle parameters.

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