INVESTIGATION OF DYNAMIC RESPONSE OF BRIDGES UNDER MOVING MASS

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Nowadays, vibration of structures under passing loads is important due to the development of fast vehicles (González, 2010). The effects of the moving load can be divided into two parts, including gravity effects of moving load and the inertia effects of vehicle.

Inertia effects of moving vehicle when relative mass of vehicle to structure is considerable, for high speed vehicles cannot be neglected and have a dominant effect in general response of system. These effects have wide application in different aspects of bridge dynamic problems, such as railway track system, deck design, vibration control and passenger's comfort. (Shadnam, 2001). Bridges are more important structures in this regard, because they routinely vibrate by operating loads. System of vehicle-bridge interaction has a dynamic nature and principles of structural dynamic govern it. Finite element method is applicable and the response of the system can be calculated by numerical methods. In this paper, Coupled system of bridge-vehicle interaction is modelled by using two approaches which is called accurate and approximation methods.

In the exact model, the inertial effects associated with the moving vehicle are considered at each time step, whereas in approximate model the inertial effects is considered to be placed in the middle of traveled path by the vehicle (Mirzaee et al., 2014).

As a result of change in the position of moving vehicle, the mass matrix similar to the force vector alters and should be updated at each time step with passing the vehicle over the bridge. Equation of motion of bridge under moving mass is as Eq. (1):

$$[M+Mv]\{\ddot{x}\}+[C]\{\dot{x}\}+[K]\{x\}=\{p(t)\} \tag{1}$$

In this equation, matrix [M] is the total mass of bridge, matrix [Mv] is the mass of vehicle which is different in exact and approximate models, matrix [C] is damping of bridge, matrix [K] is the stiffness of bridge, {p (t)} is the force vector, $\ddot{x}$ acceleration response of bridge , $\dot{x}$ speed is the speed response of bridge and x is the displacement response of bridge (Fryba, 1999).

A comparative study between the dynamic response of a simply supported single span bridge affected by a moving mass with constant speed is performed using exact and approximate models. The dynamic response of bridge using both models is calculated by a numerical method called central difference method. The speed effect of moving vehicle and mass ratio of vehicle to bridge is investigated over the bridge response.

By examining the response of bridge under moving vehicle it can be seen that in most cases the response of bridge using accurate model is slightly more than approximate model and accuracy of approximate model is greater than 99 percent. Table 1 shows the ratio of the maximum dynamic response to the maximum static response of bridge with 32 elements under both mentioned model in different speed ratio that approves aforementioned results.

Dynamic response of bridge under exact model have more precision compare to approximate model so by increasing the number of elements in bridge or increasing the weight of moving vehicle, the amount of error between two mentioned model is increased.

Table 1. The ratio of the maximum dynamic response to the maximum static response of bridge

Central difference method		
Speed ratio	Exact model of Moving mass	Approximate model of Moving mass
0.1	1.0963	1.0984
0.2	1.0838	1.0764
0.3	1.4276	1.4148
0.4	1.6305	1.6179
0.5	1.7209	1.7093
0.6	1.7445	1.7412
0.7	1.7288	1.7281
0.8	1.6826	1.6784
0.9	1.6227	1.6073
0.95	1.5949	1.5737

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