PERSPECTIVES OF THE GREEN'S FUNCTIONS USING FOR ESTIMATION OF BRIDGES STATE

Poliarus O. V., Dr. Sci. professor
Kharkiv National Automobile and Highway University
poliarus.kharkiv@gmail.com

The technical state of all bridge structures should be periodically monitored. As a rule, in practice the status of bridges is estimated according to accepted methods based on measurements of individual parameters. One of the important indicators that is determined in the research process is the ratio of the dynamic deflection of the lower surface of the bridge to the static one, which is called dynamic amplification factor (DAF). The research methodology requires the blocking cars traffic on the bridge, the arrival of a heavy truck on this bridge, determination of the bridge surface static deflection, the jump of the truck from a low obstacle and determination of the dynamic deflection. The ranges of DAF inherent for various types of workable bridge structures were obtained during the exploitation of these bridges.

From the standpoint of the theory, a jump of the truck from the obstacle is a pulse effect for a bridge. The reaction of the dynamic system to the impulse action is called the impulse (or pulse) response of the system $h(t)$. It describes the dependence of the deflection of the point on the bridge surface from time. As a rule, $h(t)$ is a periodic fading function of time, which in general depends on the position of the point of the surface, in which the measurement of the deflection is carried out. This means that the impulse response is a function of not only time, but also the spatial coordinates of the surface x, y and it is written as $h(x, y, \tau)$. In addition, the type of impulse response will also depend on the point of applying impulse action on the upper surface of the bridge, which is described by coordinates l, r. Consequently, the impulse response of the bridge structure can be written as $h(x, y, l, r, t)$.

It should be noted that the concept of impulse response is introduced for linear dynamic systems. The estimation of the linearity of a bridge requires many measurements, and in some cases it may turn out to be that for some points of impulse action and deflection measurement the bridge is a linear system, and for others it is nonlinear one. In such situations, the concept of impulse response can't be applied.

Let's assume that the bridge is a linear dynamic system. Since it has a length in space, then it should be called a distributed system. If the origin of coordinates of the bridge upper surface is at the point $\vec{\rho}_0$, then the impulse action that is applied at the point $\vec{\rho}$ at the time τ_0, can be written as

$$H(\vec{\rho}, t) = \delta(\vec{\rho}_0 - \vec{\rho}) \cdot \delta(t - \tau_0), \tag{1}$$

where the first factor in (1) is a spatial delta function, and the second factor is the temporal one.

For a linear distributed bridge structure as a system after applying impulse action at a time t_0, we get a deflection as a function of time and spatial coordinates:

$$s(x, y, t) = \int_{t_0}^{t} G(x, y, t, \vec{\rho}, \tau) P(\vec{\rho}, \tau) d\vec{\rho} d\tau, \quad (2)$$

where $\int_{t_0}^{t} G(x, y, t, \vec{\rho}, \tau)$ - Green's function, which characterizes the spatial-temporal response of the linear system to the impulse action [1]; $P(\vec{\rho}, \tau)$ - weight of the vehicle on the bridge at the point $\vec{\rho}$ in time τ.

Consequently, with using of the known Green's function of the bridge structure and the known load on the bridge $P(\vec{\rho}, \tau)$, one can determine the deflection of lower surface of the bridge at any point. The deflection of the entire surface can be calculated on the basis of distance measurements [2] and then by methods developed in [3], one can estimate the load on the bridge at different points in different moments of time, i. e. the traffic movement monitoring along the bridge can be carried out.

In the presence of n vehicles on the bridge at points $\vec{\rho}_i$ and in time τ_i, the formula (2) is transformed into a form:

$$s(x, y, t) = \int_{t_0}^{t} G(x, y, t, \vec{\rho}, \tau) \sum_{i=1}^{n} P(\vec{\rho}, \tau) d\vec{\rho}_i d\tau_i \quad (3)$$

with the condition of linearity of the bridge.

The Green's function described here can be a passport characteristic of each bridge structure. Its periodic monitoring will detect any changes of Green's function. Calculations made by formulas (2), (3) provide the possibility for estimating the deflection of a bridge at any point of the lower surface, which is the basis for diagnosing the bridge and predicting its state for a certain period.

References

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