Development and application of Liquid-V-Dampers

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Summary

Nowadays dynamical problems in structural engineering arise more often because of the use of high strength materials and optimizations due to complex computer simulations. The tendency to more and more slender constructions can't be overlooked. These slender structures often reach the serviceability limit states, like excessive accelerations or displacements of floors and footbridges. There can also arise problems with the loading capacity, like the resonance effect, parametric resonance or wind induced vibrations. If these problems are not considered in static and dynamic calculations and no measures are taken against them, the worst case, a collapse of the structure, is possible. One of these effective measures against dynamical problems of constructions is the application of Liquid–V–Damper. These are tube constructions with V-shape in which a liquid with an initial deflection is moving towards the vibration of the structure. The damper must be tuned exactly to the properties of the structure according to tuning criterions presented in this paper. Due to the moving liquid in the exactly tuned dampers a great part of the kinetic energy which effects the construction is dissipated by the tuned liquid column dampers. Thus a minimization of the dynamically amplitudes of the construction as well as the resulting stresses can be achieved.

Keywords: dynamics; bridge constructions; vibrations; resonance; damping; Liquid–V–Damper; tuned liquid column damper

1. Description of the Liquid–V–Damper

The presented Liquid–V–Damper is a tube construction with V–shape, filled with a liquid that has an initial vertical deflection. The angle of the arms is 60° which presents the intermediate inclination of the diagonal trusses in frameworks. The cross section should be round due to hydro dynamical aspects. The Liquid–V–Dampers are mounted directly on the bridge construction in longitudinal direction. In figure 8 one can find the Liquid–V–Damper made of Plexiglas used in test series 2. The endings of the tubes can be left open or provided with closures, depending on the filling procedure as well as on the needed first frequency of the moving liquid.

2. Mechanical fundamentals

2.1 Equation of motion for the Liquid–V–Damper

Basic for the derivation of the equation of motion is the unsteady Bernoulli equation, defined in a generally moved reference system ([1], [2]).

$$\int_{1'}^{2'} \frac{\partial \vec{v}'}{\partial t} ds' + \frac{1}{2}\left(v_2'^2 - v_1'^2\right) = -g\left(z_2 - z_1\right) - \frac{1}{\rho}\left(p_2' - p_1'\right) - \int_{1'}^{2'} \left(\vec{a}_f \cdot \vec{e}_t'\right) ds' \quad (1)$$

In detail the terms in equation (1) describe from left to right the changing of velocity with time (unsteady term), the difference of the quadrate of the velocities, the difference in height, the

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