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主　論　文　の　要　旨

論文題目　BEHAVIOUR OF CURVED STEEL BRIDGE RAILINGS SUBJECTED TO VEHICLE COLLISION
（曲線自動車用橋梁防護柵の挙動に関する研究）

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論　文　内　容　の　要　旨

The current Japanese specifications for the railing design prescribe four requirement standards for the railings following as: (1) to prevent vehicles from leaving the road; (2) to protect occupants; (3) to guide vehicles back to the line of the road; and (4) to prevent penetration of the railing. A wide variety of curved steel railing types has been used along curved bridges in Japan and overseas. Some researchers and engineers have suspected that the curved railings are more disadvantageous than straight one when they are subjected to the same collision conditions.

In 2004, two improvement functions of a requirement of a landscape-friendly appearance and to take account of flow in the road user’s view from bridges were mentioned into the Japanese specifications for railing design. Those improvements have led to change a concept of the railing design. After the year of 2004, the form of railing beams and posts shall be designed to become smaller and slender.

An impact angle in the impact collision is formed from the direction of the truck and the course of the railing. This angle has a bearing on the performances of railing and the behaviours of the truck. The maximum amount of impact angle specified in the Japanese specifications is of 15^o. Certainly, the present study finds that in some actual cases of concave-curved bridges together with human problems the impact angle may be larger than the angle of 15^o. Accordingly, the performances of concave-curved railing under the collisions6 of such larger impact angles should be investigated.

The current Japanese specifications for the railing design have referred only to the design of straight railings. According to above statements of the study, the purpose of this research is to contribute to:

(1) Qualify the suspicion of the researchers and engineers about advantageous situation between the curved and straight railings when they are subjected to the same vehicular collision conditions.

(2) Develop two new-type concave-curved steel bridge railings. Those railings meet improvement functions in the Japanese specifications issued in 2004. The form of new-type railing posts are designed to become smaller and slender.
(3) Investigate the performances of the concave-curved steel bridge railings under the collision of the greater impact angles. Those angles are larger than 15^o that is specified in the current Japanese specifications for the railing design.
(4) Investigate the performances of the convex-curved railing under the impact of the heavy truck. According to the concave or convex curvature of the curved bridges, a corresponding curved railing is applied. This research creates the numerical simulation to study the collision performances for such kind of curved railing.
(5) From the results of study, recommendations and remarks for the curved steel bridge railing in the design and analysis are made.

A full-scale test is the ideal methodology for this study, but this test involves a considerable cost and effort. Nowadays computer software used in combination with supercomputer is powerful enough to simulate the collision problems with a full set of properties and boundary conditions. The numerical results can converge with results from experimental tests. Numerical analysis, therefore, is the effective method used for the present study of the performances of curved steel bridge railings under the impact of a heavy truck. The present research adopts the successful experiences and assuming properties in the representation of the impact collision models from existing studies that were performed by our laboratory.

The study consists of six chapters. Chapter 1 explains about the rational, statements, and objectives of the research and the general introduction for the field of impact collision.

Chapter 2 reports the result of the verification of numerical collision simulation. The full-scale test for the collision performances of a straight steel railing that was carried out by Japan Public Works Research Institute is studied by the finite element models. From this study, assumed properties of model, mesh size of element, strain rate effect, type of connection between beam and beam and so on are adopted into the present study of the collision performances of curved steel bridge railings.

The performances of the concave-curved steel bridge railings subjected to the truck collision load are reported in Chapter 3. The railings have an H-shape cross section, and were designed before 2004. The concave-curved railings are improved from a corresponding straight one. The study deals with the concave-curved railings with a curve radius of 100 m, 150 m, 280 m and 460 m.

Chapter 4 reports a development of two new types of concave-curved steel bridge railings. Their posts have a slender form, and meet improvement functions. The performances of new posts are examined by experimental static and collided loads. The numerical simulations are developed to study the collision performances of posts, and are verified by using experimental results. Those verified simulations are adopted to create impact collision simulations of new-type concave-curved steel bridge railings subjected to the truck collision.

To verify the suspicion of engineers and researchers, the behaviours of concave-curved steel bridge railings are compared with those of corresponding straight one in the same collision conditions. As with above discussions, the greater impact angles may occur on some cases of the concave-curved railing. Thus, the performances of those railings under the collision of the large impact angles are examined.

The performances of a convex-curved steel bridge railing subjected to heavy truck collision are presented in Chapter 5. The convex-curved railing investigated in this chapter names M-type which is one of railing types presented in Chapter 4. The convex-curved railing has radius of 100 m and the grade of A.

Summary and conclusions of the present study and recommendations and remarks for the design of curved steel bridge railing are presented in Chapter 6.

The finite element models of impact collision between the railings and the heavy truck are created by using the LS-DYNA 3D software. The study problems are determined with an executing by supercomputer installed at Information Technology Center of Nagoya University, which has a peak speed of 60 TFLOPS.