Analytical study on deterioration phenomena caused by water pressure effect on road bridge deck slab

Hiroshi YOKOYAMA
Civil Engineer
Kanazawa,JAPAN
yokoyama_hiroshi@kokudonet.co.jp

Mikio SEKIGUCHI
Civil Engineer
Tokyo Metropolitan Civil Engineering Technical Support, Development Center,Tokyo, Japan

Toshio HORIKAWA
Professor emeritus
Osaka Institute of Technology,Osaka,Japan

Hiroshi MASUYA
Professor
Kanazawa University,
Kanazawa, Japan
masuya@se.kanazawa-u.ac.jp

Summary

Deterioration phenomena of deck slab of road bridge include gravelization of upper edge concrete and horizontal cracks in deck slab. They are possibly caused not only with an influence of wheel load but also with a water pressure action by water penetration into the concrete. In this study, the authors applied a exact theory based on the three-dimensional elastic theory to the compression equation proposed by M.A.Biot and analyzed the problem that the water pressure influences the vicinity of the location of wheel load effects for an actual bridge deck. Results of the analysis revealed that large transverse shear stress, for which the water pressure influences the wheel load, occurred inside the deck slab. Therefore, it was shown that cracks were generated at the edge of on the water pressure area and it could progress.

Keywords: road bridge deck slab, gravelization, consolidation equation, transverse shear stress, horizontal crack

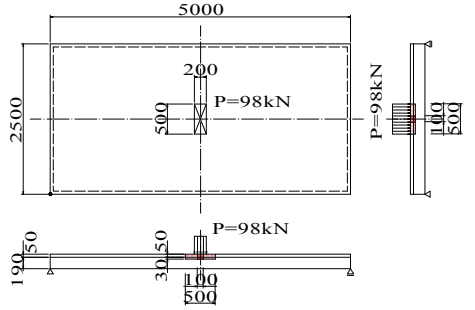


Fig. 1: Simple slab Computation model

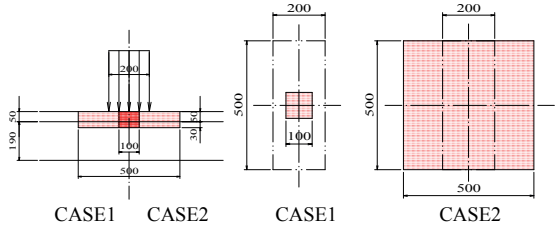


Fig.2: Model of water pressure effect

1. Introduction

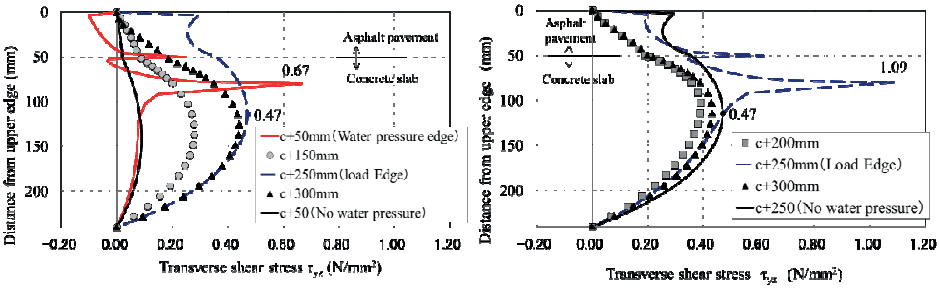
In this study, the authors assumed that water is involved with gravelization of concrete of a deck slab top surface and studied this influence analytically. In this study, gravelization expresses the phenomenon in which concrete becomes scattering like gravels. Installation of a water resistant layers is effective as a measure against harmful effects of water. Although the installation of water resistant layer is generally adopted for newly constructed bridges, there still are a number of bridges with no such layers installed. Moreover, there remains a risk that water penetrates into a concrete deck slab even for a new bridge depending on conditions, if water resistant layers of coating type are adopted. Because roller compaction in asphalt laying may cause damage to the water resistant layer. The authors have investigated the exact analysis of the deck slab problem based on the three-

https://doi.org/10.2749/222137813806521045

dimensional elastic theory until now. In this study, multi-layer theory consisting of displacement functions for the case of body force is derived. The water pressure problem caused by the water that penetrates into concrete is investigated by adding the multi-layer theory to the consolidation equation.

2. Computation model and specification

Fig.1 shows the simple slab and the continuous slab model with support girder at the span center employed as computation models. In this study, a calculation for the continuous slab for which a girder was placed on the center was also performed. A span in the bridge axis transverse direction was assumed as 2.5m and that in the bridge longitudinal direction was assumed as 5.0m, which is double of the above. The conditions of water pressure effects are as shown in Fig.2, and CASE1 and CASE2 in which water pressure was applied in some parts of the pavement and deck slab (upper cover of 30mm) were the subjects for the study. In this study, we also studied a model for which cracks were simulated and confirmed that there was a risk of crack progress by the water pressure effects on the cracked parts. Concerning the physical properties used for the calculation, the equivalent reduced modulus as Young's modulus of concrete slab was Ec=14.0kN/mm2. Here, ratio n=15 corresponding the crack state was considered. Young's modulus of asphalt pavement Ea=2.0kN/mm2 was used. Thus value was assumed for winter with consideration of temperature sensitivity.



(a) τ yz of CASE1 (b) τ yz of CASE2

Fig.3: Transverse shear stress by water pressure effect on simple slab

3. Calculations

Gravelization occurred in deteriorated deck slabs on the road bridges and the occurrence of horizontal cracks in the vicinity of the upper reinforcing steel bars are grasped as phenomena. However, their causes have not been identified. In this study, the authors developed a method that enables to discuss water pressure problems by the water which penetrated into the concrete slab by incorporating the multi-layer slab theory consisting of displacement functions into consolidation equation proposed by M. A. Biot. According to the calculation results, as shown in Fig.3, we have clarified that in the case that the load edge and water pressure effect edge which penetrates the concrete correspond, transverse shear stress occurring in the slab increases, and therefore there is a risk that cracks occur in the edge of the water pressure effect location. Furthermore, at the upper reinforcing steel location in the range of the water pressure effect that we focused on, cross sections of the concrete that resists transverse shearing are lost and therefore there is a risk it becomes the point where horizontal cracks may start. Most of the damages by material deterioration of concrete slabs have not been clarified and therefore more active studies about them will be needed in the future.