Performance evaluation of the steel-concrete composite slab for the taxiway bridge that carries heavy aircraft

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Summary

At Narita international airport, a bridge is used in a part of new taxiway. The bridge style taxiways are rare in the world and the design method is not clearly established at present. Therefore, after the design of this bridge adopting the method for vehicle bridges, verification of the results by FEM was done. Furthermore, punching shear experiments in laboratory and loading tests on the bridge using real aircraft were executed. Through the series of experiments and studies, it was confirmed the bridge is safe enough to support heavy aircraft.

Keywords: Taxiway bridge; Composite structure; Punching shear strength; Loading experiments by real aircraft; Flexural cracks.

1. Introduction

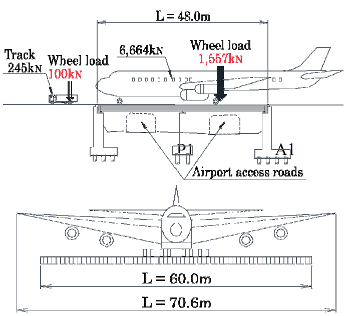

Fig. 1: Size of LA-0 and bridge

New taxiway is needed to ensure the clearance for the existing road and to support design load of LA-0 with 390kN per one tire. Steel- concrete composite deck slab bridge was adopted in the taxiway to make the girder height lower and ensure the fatigue durability. Although FEM analysis was done in addition to common designing of vehicle bridges, it was not entirely neglected unexpected behaviour by LA-0. This paper describes the evaluation of fatigue durability based on the punching shear experiments and the consideration of safety in regard to the concrete slab under LA-0 loading from results of loading tests by real aircraft. The sizes of LA-0 and the detail of the composite deck slab are shown in fig. 1 and 2.

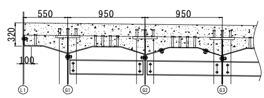

Fig. 2: Composite slab

2. Experiments of punching shear strengths and Loading tests by aircraft

2.1 Punching shear experiments

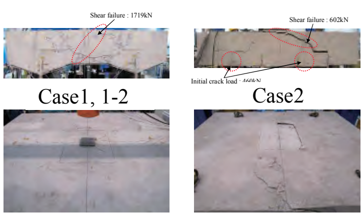

Fig. 3: Specimens for experiments

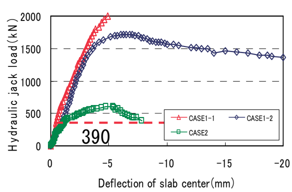

Fig. 4: Loads and deflections

Although the safety of the bridge was evaluated through numerical analysis, the possibilities of occurrences of unexpected behaviour were not eliminated completely. Moreover, it should be ensured that Matui's equation that was used for the evaluation of the fatigue performance of the bridge was appropriate because slab is thicker than slab of vehicle bridges. Hence, it was decided to execute full-scale experiments as shown in Fig. 3 and 4 to evaluate the punching shear strength and to identify the process to punching out fracture.

2.2 Loading tests by real aircraft

Fig. 5: Loading tests by aircraft

Although the design moment of concrete slab was calculated by method of vehicle bridges, it was necessary to investigate on applicability in case of LA-0. For this purpose, loading tests by real aircraft was planned to identify the stresses of the slab. Concrete Gauges were embedded in the area of around the centre of the span between A1 and P1. The positions where have high probability of taxiing of main gears of aircraft had been selected and the gauges were settled in the direction of slab depth. Boeing 777-300ER was used for the loading tests as shown in Fig. 5. The total weight was around 1754kN at the day of the tests.

3. Results and considerations

3.1 Evaluations on punching shear strengths

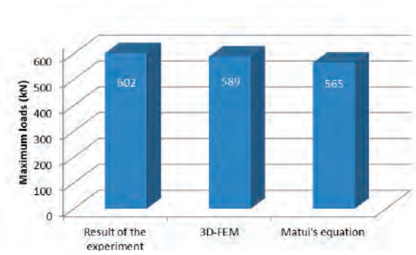

Fig. 6: Maximum loads

In regard to maximum loads, the result of case 2, 3D-FEM and the previous studies are shown in Fig. 6. It was verified that punching shear strength could be evaluated by method of road bridges on the safe side. About the fatigue durability, the dynamic model of punching shear of RC slab assuming that the slab becomes a beam was proposed and the equation of load-carrying capacity was proposed in previous studies. Based on this model and equation, allowable aircraft traffic is much enough towards forecasted traffic volume of 100 thousands per one year.

3.2 Stresses inside the concrete slab generated by real aircraft loading

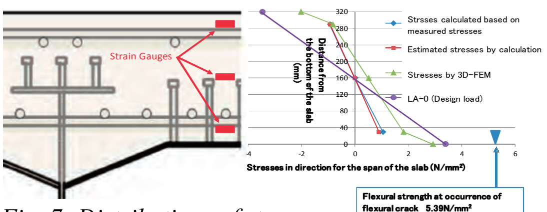

Fig. 7: Distributions of stresses

The distributions of stresses are shown in fig. 7 based on the load of 131kN per one tire and the properties of materials. It was identified that stresses from measured strains and calculation coincided and both neutral axes were located in almost same position. It is suggested that the method for calculating the bending moment of road bridges could be applicable to the slab designing for aircraft. Although the increase tendency of stresses at the surface and the bottom of the slab were appeared in FEM analysis, it was identified that the results had relatively good reproducibility. From these results, it was confirmed that no flexural cracks occurred by LA-0.

4. Conclusions

It is confirmed that the bridge has enough fatigue durability. And it is suggested that the calculation method of the bending moment of road bridges can be applicable to the calculation of bending moment for slab targeting aircraft. Furthermore, no flexural cracks in case of LA-0 loading are of importance for the composite deck bridge such as our case. Investigations on stresses due to temperature change inside the slab are executed presently. It is expected that more technical knowledge would be accumulated.