DEVELOPMENT OF A NEW CONNECTION METHOD BETWEEN PRECAST CONCRETE BARRIER AND RC SLAB FOR EXPRESSWAY

o Saitama University, Graduate Student, Member of JSCE, Thinh Quang Nguyen
Saitama University, Fellow of JSCE, Professor, Mutsuyoshi Hiroshi
Saitama University, Member of JSCE, Professor, Maki Takeshi
Metropolitan Expressway Co.Ltd, Yousuke Ishihara

Abstract: Nowadays, usage of precast concrete components on construction is becoming popular for good quality of concrete and short construction period. The purpose of this study is to develop a method to connect precast concrete barrier and reinforced concrete (RC) slab of the expressway which will be extended to satisfy the increase of vehicles. In this study, seven specimens were made considering some parameters such as length of loop joint, diameter of bars, type of connections of anchorage and thickness of the barrier. Static loading tests were conducted, and the failure mode, load-displacement curve and cracking behavior of these specimens were compared. Based on the experiment results, the best connection method between concrete barrier and RC slab which satisfies the design requirements was proposed.

Keywords**:** *precast concrete barrier, reinforced concrete slab, non-shrink grout, loop joint, interface, static load*

1. INTRODUCTION

In recent decades, hybrid elements are widely applied in bridge structures. However, the performance of the precast structures is influenced significantly by in-site cast connection joints. Besides, the connection between precast barrier and RC slab is very important to resist the lateral load due to traffic accidents. Therefore, a perfect design of the joint should have detailings as simple as possible. This joint, moreover, must be also designed to reduce material and labor force. According to Rammi (2017), application of loop joint on the connection can satisfy almost the foregoing; therefore, an experimental study on the type of connection is carried out.

2. EXPERIMENTAL PROGRAM

The experimental investigations included testing of seven specimens with precast concrete barriers and RC slab (**Table 1.**). The barriers were produced in the factory, and it had been connected with the RC slab by loop joint in the experimental room. Because of great advantages, Hawileh (2010) suggested that, non-shrink grout will be used to fill up the recesses and cores of the connection in the experiments (**Fig.1**).

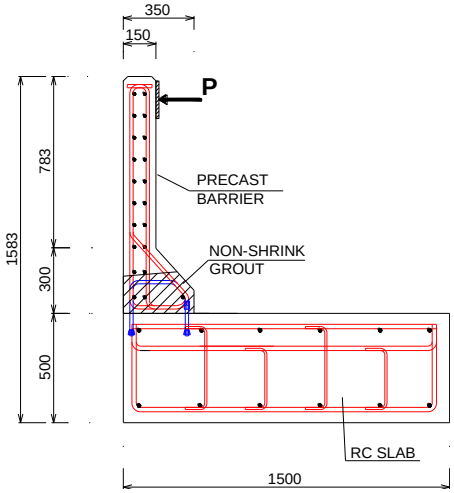

Fig. 1. Dimension of test specimen

The aim of the tests is to make clearly load carrying capacity as well as mode of failure of the structure having different parameters under static load. The thickness of the precast barrier (w), the length of loop joint (l_{dh}), the diameter of the loop bars (d_b) and the length of anchorage in the slab (l_{ach}) are changed through the experiments (**Fig.2**). Besides, the geometry of the later specimens will be modified based on the foregoing experiments to improve the load capacity as well as to change the mode failure.

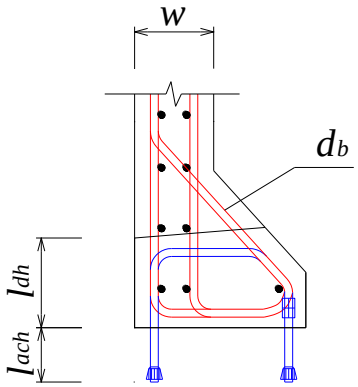

Fig. 2. Details of loop joint

The horizontal load was applied to the top of the specimens (**Fig.1**). Loading of the specimens was applied step by step up to failure. For every load step, strains of loop reinforcements and concrete were measured by strain gauges. Moreover, deflection of walls, joints and basement as well as strains at the interfaces between new and old concrete were taken into the account of the study. The crack appearances and state failure were also observed and marked during the experiments.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The force-displacement curves determined at the top of the barrier were presented in **Fig.3**, meanwhile, the **Table 1** showed a maximum load of each specimen.

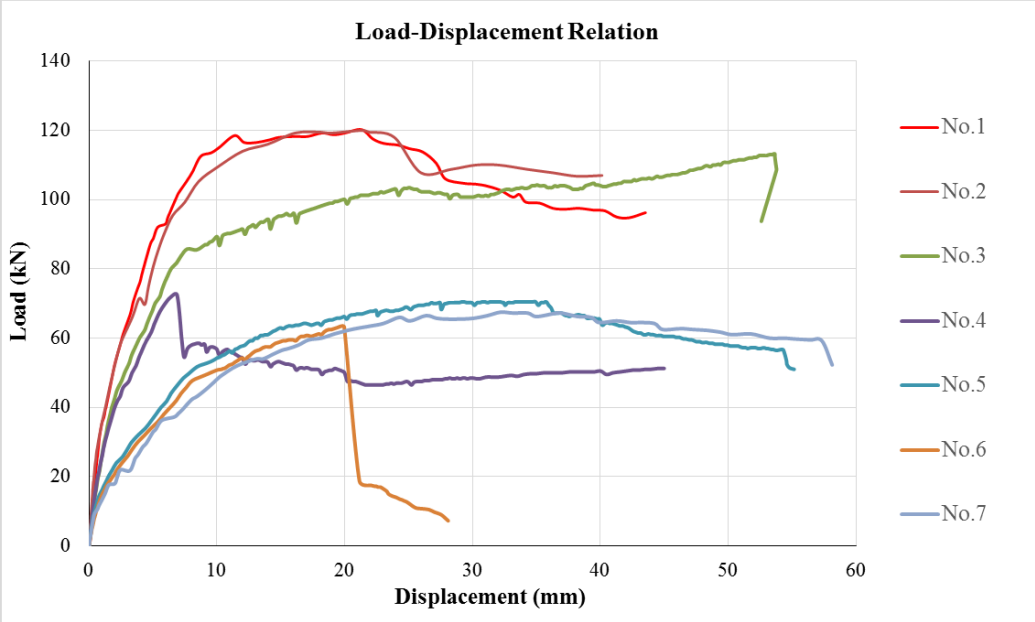

Fig. 3. Load-Displacement relation

Table 1. Geometrical values of specimens

No.	w (mm)	l_{dh} (mm)	d_b (mm)	l_{ach} (mm)	Max. Load (kN)
1	250	260	16	>10d_b	120.25
2	250	170	16	>10d_b	120
3	200	260	13	>10d_b	113.25
4	200	170	13	6db	72.5
5	150	170	13	>10d_b	70.5
6	150	170	13	6d_b	63.5
7	150	170	13	8d_b	67.5

According to the results of No.1 and 2, the loop length decreased from 260mm to 170mm; however, the maximum loads, force-displacement curves as well as cracking behavior of both the specimens are similar. Moreover, both of the precast barriers failed due to shear and moment instead of failure at the connection joint. Because of dissimilarity of the length of the anchorage, No.3 and No.4 not only had a significant difference in the behavior but also on ultimate load, 113.25kN and 72.5kN respectively. The mode failure of No.3 was the same as No.1 and No.2 meanwhile that of No.4 was anchorage failure (joint failure). According to Ryu (2007), the lap length had a considerable effect on the ultimate behavior of a loop connection; however, because of distinction of the structure geometry, there was no reduction on the ultimate strength of the experiments by decreasing the lap length from 260mm to 170mm.

Although decreasing thickness of the barrier, the mode failure of No.5 and No.6 were similar with that of No.3 and No.4, respectively. From **Fig.3**, it can be seen that the anchorage length mainly influenced the behavior of the specimens. Therefore, based on the results of No.6 which had l_{ach} equal to 6d_b, the anchorage length on No.7 was increased (l_{ach}=8d_b). As a result, the behavior of the specimen was similar to that of No.5 through the test. Moreover, most of the cracks appeared on the surface of the barrier, and this specimen was failed due to moment and shear instead of joint failure like No.6.

All of these models didn't failed at the interface between the precast specimens and new non-shrink grout. The strains at the interfaces were very small at the ultimate load, 1.35mm on No.7 for instance. By visual observation, there were just a few cracks appeared on the surface of the in-site cast grout during the experiments. Consequently, it can be concluded that the grout satisfied strength requirements of the connection joint in the structure.

4. CONCLUSION

The following conclusions were drawn from this study:

1. With the geometry of the specimen, the length of the loop joint should be 170mm instead of 260mm for a loop bar diameter of 13mm.
2. The length of anchorage (l_{ach}) should be minimum 8 times larger than the loop bar diameter.
3. The last experiment on this study satisfies the design requirement; therefore it should be applied in reality.

This study investigates the connection between precast concrete barrier and RC slab. Therefore, further research will inspect connection between the barriers.

REFERENCES

Hawileh, R.A., Rahman, A., Tabatabai, H.: Nonlinear finite element analysis and modeling of a precast hybrid beam-column connection subjected to cyclic loads, J. Applied Mathematical Modelling 34 (2010), pp. 2562-2583.

Ramni, V., Farzad, H., Hafez, T.: Development of a new connection for precast concrete walls subjected to cyclic loading, J. Earthq Eng & Eng Vib (2017) 16, pp. 97-117.

Ryu, H. K., Young-Jin, K., Sung-Pil, C.: Experimental study on static and fatigue strength of loop joints, J. Engineering Structure 29 (2007), pp. 145-162.