RC slab strengthened by grid type CFRP and polymer cement mortar

Worapatt RITTHICHAUY, Student Member, Gunma University
Yukikazu TSUJI, Fellow Member, Gunma University
Akira KOBAYASHI, Member, Nippon Steel Composite Co.,Ltd
Atsushi KAI, Member, Satobenec Co.,Ltd
Kouichi SATOH, Member, Nara Construction Co.,Ltd

Introduction

This paper presents the results of laboratory testing of RC slab strengthened by grid type carbon fiber reinforced polymer (hereafter grid CFRP). The study will be concentrated on strengthening effect between existing RC slab and strengthening materials which attached to RC slab by anchorage bolts and polymer cement mortar. From test result, it will show that in the case of a few number of bolts which used as bonding method in this test, quality of sprayed mortar and operation method have more important role than size or type of bolt in bonding strength. Moreover, position of diagonal shear reinforcement will affect on crack performance and horizontal shear cracking load.

Outlines of tests

Detail of specimen's size, reinforcing bar arrangement and applied load point are shown in Fig.1. All of tested specimens and the methods of strengthening are classified in Table 1. Properties of reinforcing bar and strengthening materials are shown in Table 2. The strengthening material is polyacrylonitrile (PAN) system grid CFRP which was attached to underneath of slab after first load test had finished. The method of grid CFRP attachment was performed by using of bolts or rivets that varied the size and number of bolts. Finally, specimen was sprayed by polymer cement mortar. Concrete used in this test was made by ordinary-strength Portland cement. After 1-day steam and 7-days moist curing operation was completed, specimen was loaded until lower reinforcing bar had tensile stress about 300 Mpa and flexural crack could be observed. The specimen was strengthened by grid CFRP and polymer cement mortar. The second loading test was performed until specimen's failure was occurred. Load, strains of main reinforcement and grid CFRP, mid-span deflection, crack performance and failure mode were measured.

Table 1 Classification of specimen

Specimen	Anchor bolt		Number of diagonal shear reinforcements	Mortar type
	Type	Numbers		
A-1	M-8	12	2	A
A-2	Rivet	24	-	A
A-3	M-8	12	-	A
A-4	M-12	12	-	A
B-1	M-8	12	-	B

Table 2 Properties of reinforcing materials

Type of materials	Yield Strength (MPa)	Tensile Strength (MPa)	Young's Modulus of Elasticity (MPa)
D10	381	526	1.89×10^5
D13	380	547	1.90×10^5
D6	375	516	1.90×10^5
CFRP	-	1527	1.72×10^5

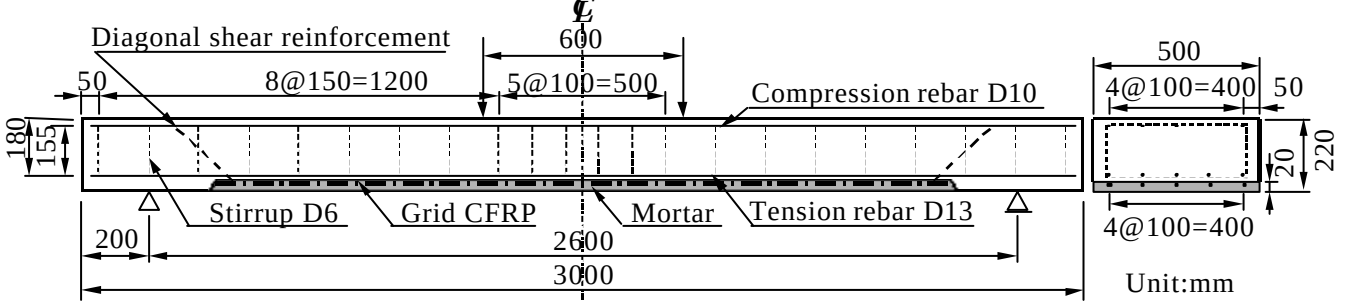

Fig.1 Detail of specimen

Keywords : Grid CFRP , Polymer cement mortar , Flexural crack , Horizontal shear crack
Tenjincho 1-5-1 , Kiryu-shi , Gunma 〒376-8515 Tel. 0277-30-1613 Fax. 0277-30-1601

Test results

Fig.2 shows some of flexural cracks that occurred from second load test obviously extended from first load test and reached in compression zone of specimen. At near applied load point in shear span, diagonal shear crack rose up from flexural crack to the point of applied load in crushing surface. Finally, failure of specimen was occurred.

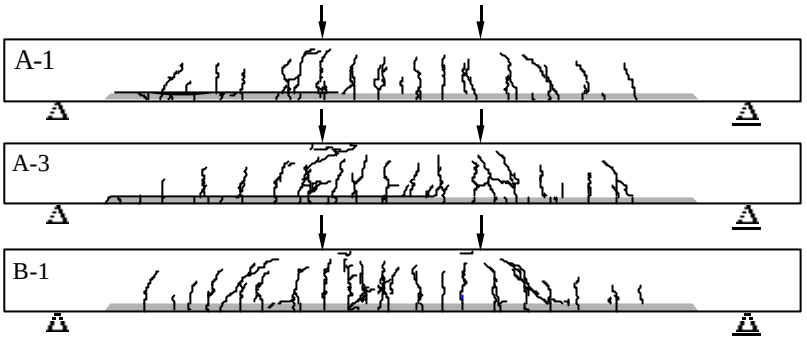

Fig.2 Crack performance of specimens

From Fig.2 and Fig.3, using of diagonal shear reinforcement in A-1, which horizontal shear crack also occurred, is rarely made good results in strengthening. The main reason is position of this shear reinforcement is too close to the outer edge of mortar, but in mostly, diagonal shear crack formed at near applied load point in shear span.

A remarkable point is in A-1, A-2 and A-3 specimen which horizontal shear crack occurred, these specimens could be loaded up to failure approximately 4%, 8% and 8% from horizontal shear cracking load could be recorded, respectively. Therefore, we can imply that these specimens fail by the failure of bonding of RC slab and strengthening materials. In contrast, A-4 and B-1 specimens did not have such crack mentioned before, rupture of strengthening material was caused to failure of specimens. From Fig.3, in comparison of maximum load of A-4 and B-1 specimens, B-1 has maximum load more than A-4 about 8%. Even though, the total cross sectional area of anchor bolts used in A-4 is 125% higher than B-1, but perfectly bonded strength of interface that can be achieved by neatly operation and better quality of mortar used in B-1 specimen. In other word, the quality of mortar is also affect on strengthening because B-type mortar, which used in B-1 is more viscous than A-type mortar which used in A-4.

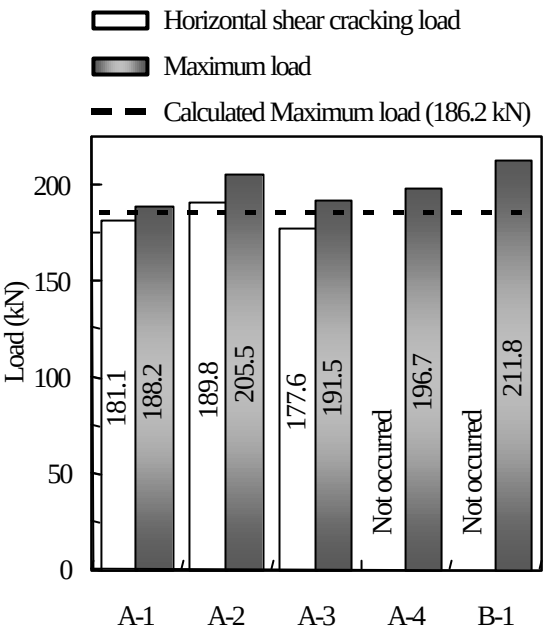

Fig.3 Horizontal shear cracking load and maximum load

Fig.4 shows the comparison of grid CFRP's measured tensile strain in moment span to the computed value of all specimens. It is shown that the results matched well together. Therefore, using of small number of anchor bolts to attached grid CFRP to existing RC slab, we can receive the expecting performance if quality of material such as sprayed mortar and quality of construction can be controlled.

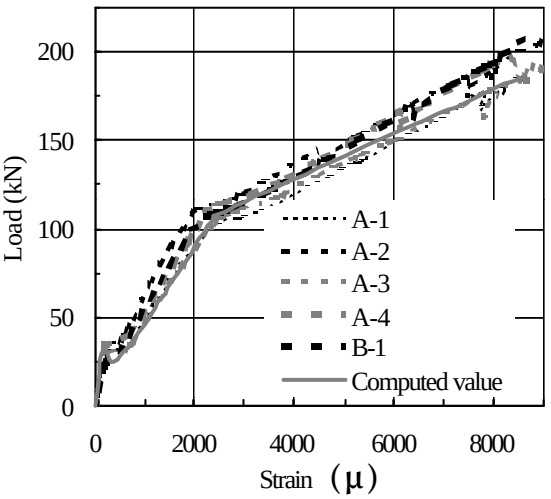

Fig.4 Grid CFRP's Tensile strain at central span

Conclusions

In case of a few of anchor bolts used for attaching grid CFRP to existing RC slab or beam, size or type of bolt will have small effect on strengthening. But quality of mortar and construction method such as curing operation and scattering of sprayed mortar have more important role. Position of shear diagonal reinforcement can also increase the strengthening effect if it is placed in the inner side of shear span.