CS-42

Experimental Study on Strengthening of Damaged Steel I-girder Bridge with RC Slab by GFRP Members

Kyushu University Student Member Basem Abdullah
Kyushu University Member Shin-ichi Hino, Toshiaki OHTA
Mitsubishi Heavy Industries Erection Member Hisao KATSUNO, Atsushi Hagiwara

1.Introduction:

Several rehabilitative methods, which strengthen flexural concrete members by adding tensile reinforcement, have been developed. These include the application of bonded steel or CFRP sheets to the tensile face of the member. Using the steel sheet employs material, which is as susceptible to corrosion as the original reinforcement. While using the CFRP sheet rises highly the rehabilitation expenses.

An application of strengthening steel I-girder bridge with RC slab by GFRP members provides an efficient, non-corrosive and economical alternative to other rehabilitative methods.

This paper describes the experimental and the analytical results of an investigation into a strengthening system of steel I-girder bridge with RC slab using GFRP members.

2. Experimental Study:

(1) Experimental specimens: four types of experimental specimens were prepared, GFRP members reinforced three of them. Fig.1 shows an example of the specimens. The details of the specimens are as follows:

Type 1: This specimen consists of two steel I-girders and RC slab, which is modeled as non-retrofitted structure. The RC slab and the Steel I-girders connected to each other by shear connectors (studs), which dipped inside the concrete slab.

Types 2,3 and 4: All these types consist of two steel I-girders, RC slab and GFRP members. These specimens represent retrofitted structures. The differences between these three specimens are in the bonding method between the RC slab and the GFRP upper plate. In specimen Type 2, the gap between the RC slab and the GFRP upper plate was filled with non-shrinkage cement mortar, then plastic cover was placed between the mortar and the GFRP upper plate to prevent bonding.

The gap was filled with non-shrinkage cement mortar and epoxy mortar in specimen types 3 and 4 respectively.

Table (1) shows the general properties of the experimental Specimens.

(2) Loading procedure: Specimen Type 1 was loaded statically up to 26 tons, then fatigue loading (6-26) tons was applied for half a million times. Specimen types 2,3 and 4 were loaded statically like Type 1, then the cracked specimens were strengthened by GFRP members (Fig.2). Finally the retrofitted specimens were loaded dynamically (fatigue) with load range between (6-26) tons for half a million times.

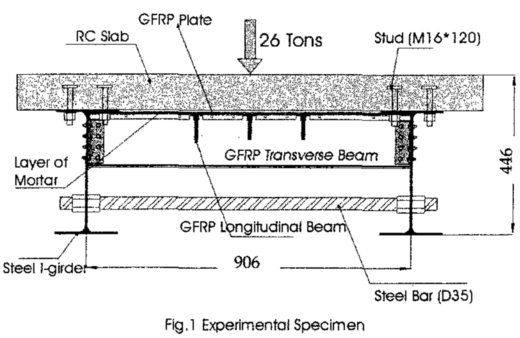

Fig.1 Experimental Specimen

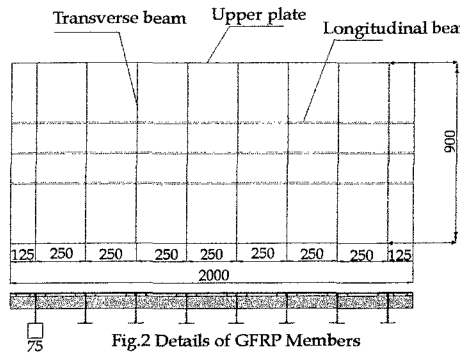

Fig.2 Details of GFRP Members

Table.1 General Properties of the Experimental Specimens. X= not available, O= available

Specimen Type	Specimen Description			
	GFRP Strengthening	Bonding	Gap Material	Load case
Type 1	X	X	X	Static/Fatigue
Type 2	O	X	Non-shrinkage Mortar	Static/Fatigue
Type 3	O	O	Non-shrinkage Mortar	Static/Fatigue
Type 4	O	O	Epoxy Mortar	Static/Fatigue

3. Experimental Results

Strengthening the Steel I-girder Bridge with RC slab by GFRP members enhanced the capabilities of the RC slab and the Steel I-girders. Fig.3 shows the load-stress curves of main steel reinforcement in the RC slab before and after strengthening by GFRP members. Table 2 shows the effectiveness of the GFRP strengthening process by introducing the reduction ratio of the stresses and the deflections of types 2,3 and 4.

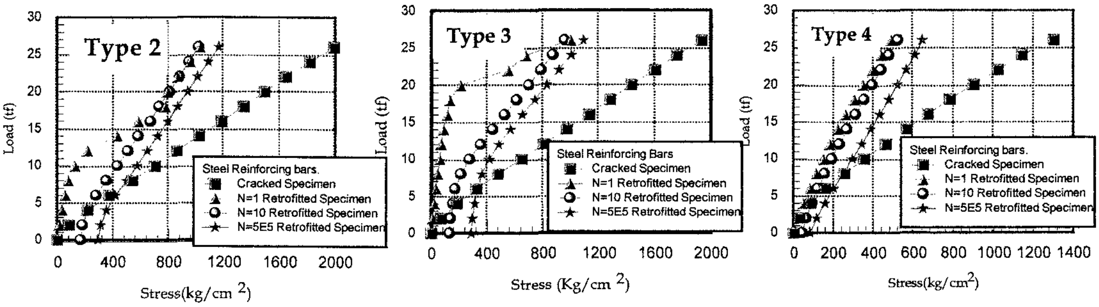

Fig.3 Load-Stress Curves of the steel reinforcement.

Table.2 Reduction Ratio of Stress and Deflection.

Specimen Type	Reduction (%)						
	RC Slab		Steel I-Girder				
	Steel Reinforcement Stress	Deflection	Deflection	Upper Flange Stress		Lower Flange Stress	
				Outside	Inside	Outside	Inside
Type 2	48.3	30.8	5.0	28.3	32.2	6.3	15.2
Type 3	48.4	25.6	-13.5	-14.8	10.3	-1.0	10.3
Type 4	62.4	35.7	1.75	46.0	69.6	8.2	17.3

4. Analytical Study: These specimens were analyzed using advanced FEM software (LUSAS 12). The analytical study completed for the specimens before and after the strengthening (cracked specimen, retrofitted specimen). Fig.4 shows the mesh of the analytical model, and Fig.5 shows the load-stress curves of the slab steel reinforcement for Type 2, which indicates a good agreement between the experimental and the analytical results.

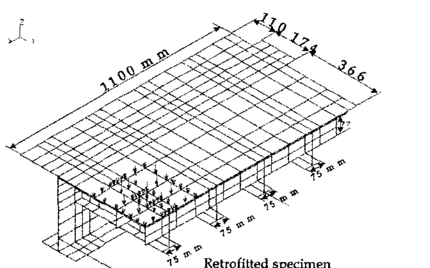

Fig.4 FEM mesh of the analytical model

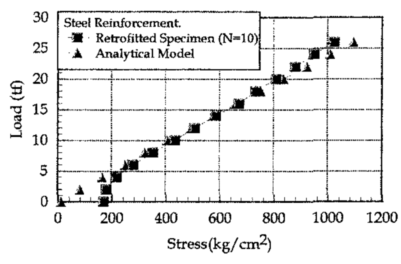

Fig.5 load-stress curve for the slab main reinforcement

5.Conclusions: The following conclusions are drawn from the experimental and analytical studies;

1) Strengthening the specimen types 2,3 and 4 by GFRP members had good effects not only in reducing the stresses and the displacements of the RC slab, but also had noticeable effects on the functionality of the steel I-girders.
2) Comparing the stress and the displacement reduction ratios of the specimen types 2 and 3 show that the bonding of the cement mortar in type 3 was a major factor in reducing the stress and the displacement of the RC slab up to the cracking of the mortar.
3) Type 4 showed the best loading capacity, as the properties of the epoxy mortar prevented the generation of cracks, allowing perfect bonding capabilities between the epoxy mortar, the GFRP upper plate and the RC slab.
4) The analytical results were in good agreement with the experimental results.