Strengthening of Steel I-girder Bridge with RC Slab by GFRP Elements
(ＧＦＲＰ部材によるＲＣ床版付き鋼 I桁橋の補強に関する研究)

Kyushu University..... Basem Abdullah
Kyushu University ....Shin-ichi HINO ,Toshiaki OHTA
Mitsubishi Heavy Industries Erection.... Hisao KATSUNO, Atsushi HAGIWARA

1-Introduction:

Using the GFRP to strengthen the bridges is not popular comparing with the use of the traditional construction materials such as steel and concrete. But due to the unique properties of the GFRP such as low specific gravities, high strength-to- weight ratio, durability and toughness particularly at low temperature, different studies have been started seeking for the ideal usage of the FRP in strengthening structures.

In this paper, an experimental study for strengthening steel I-girder Bridge with RC slab by GFRP elements is presented, also the results and the effectiveness of using the GFRP in rehabilitation such kind of bridges are discussed.

2- Experiment:

(1) Details of Experimental Models:

Four types of experimental models were examined under static and fatigue loads. An example of the models is shown in Fig.1, and their details are as follows:

Type A- Steel I-girder bridge model with RC slab not reinforced by FRP elements as shown in Fig.2

22 studs were used to connect the RC slab with the steel I-girders. The connection between the steel girders and the RC slab is a partial composite connection, which allows the connection horizontal movements, but it prevents any vertical movements in it.

Type B- Steel I-girder bridge model with RC slab reinforced by FRP elements:

The FRP unit was connected to the steel I-girders with 32 steel angles 16 in each side.

The gap between the FRP upper plate and the RC slab was filled with cement mortar. Plastic sheet was added between the mortar and the FRP upper plate to prevent the bonding.

Type C: This model is exactly the same like model B, the only difference that the plastic sheet, which prevents the bonding, is not available.

Type D: This model is like the previous model, but the gap between the slab and the FRP plate was filled with epoxy mortar.

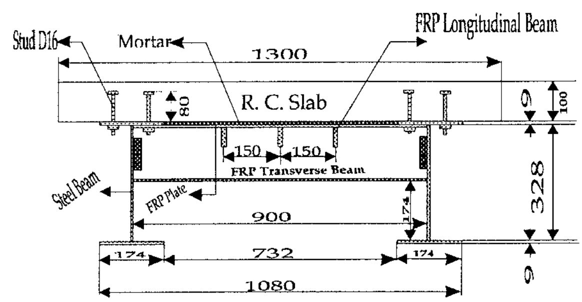

Fig.1 Bridge Model Details

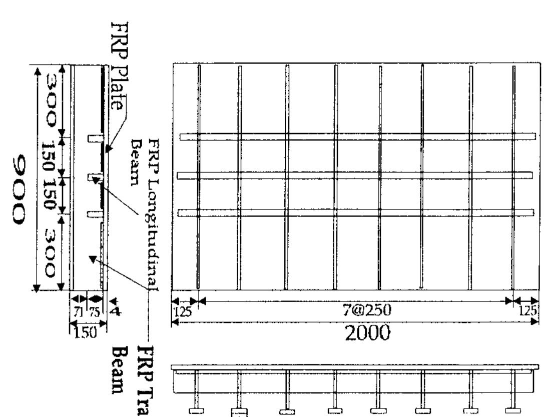

Figure 2: Fiber Reinforced Plastic Details

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

Model Name	Model Description			
	GFRP Elements	Bonding	Gap Material	Load case
Type A	X	X	X	Static/Fatigue
Type B	O	X	Nonshrankage Mortar	Static/Fatigue
Type C	O	O	Nonshrankage Mortar	Static/Fatigue
Type D	O	O	Epoxy Mortar	Static/Fatigue

(2)- Loading Procedure:
Model type A was loaded statically up to 26 tons, while dynamically was loaded for half a million times with a load range between 6-26 tons. Type B, C and D were loaded statically like model A, then the cracked models were reinforced with FRP, then loaded dynamically for half a million times like model A.

3- Results and Discussion:
(1) RC Slab: Strengthening the cracked slabs by FRP was very effective in reducing the slabs stress and deflection. Fig.3 shows the load-stress curves of the steel reinforcement in the slabs.
It is easily to recognize that the bonding in Type C delayed the mortar cracking, while the elastic properties of the epoxy mortar in Type D prevented the occurrence of the cracks.
(2) Steel Girder: Table 2 shows the reduction ratio of the stress and the deflection for Types B, C and D. Strengthening the steel girders in Types B,C and D by GFRP seems to be not too effective comparing with the effectiveness of the FRP in strengthening the RC slabs. But generally good reduction in stress and deflection were gained in the steel girders.

4- Conclusion:
The following conclusions are drawn from the experimental investigation on Strengthening steel I-girder bridges with RC slab by GFRP members:

1. Strengthening steel I-girder Bridge with cracked RC slab by GFRP members enhanced significantly the slab's capacity. Reducing the steel reinforcement stress approximately by 50% indicates the significant contribution of the GFR members in retrofitting the cracked bridge models.
2. Using the epoxy mortar in Type D enhances the bonding capability, which reflects positively on the strengthening procedure.

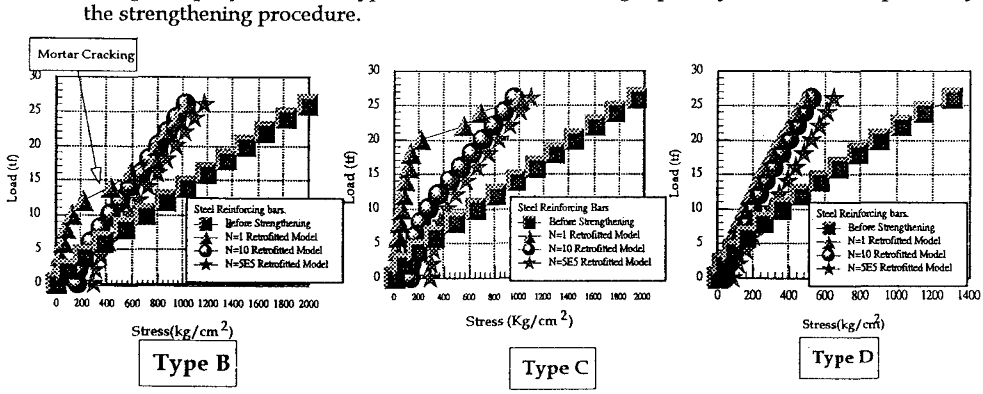

Fig.3 Load-Stress Curves of the steel reinforcement.

Table.2 Reduction Ratio of Stress and Deflection

Model Type	Reduction Ratio (%)						
	RC Slab		Steel I-Girder				
	Steel Reinforcement Stress	Deflection	Deflection	Upper Flange Stress		Lower Flange Stress	
				Outside	Inside	Outside	Inside
Type B	48.3	30.8	5.0	28.3	32.2	6.3	15.2
Type C	48.4	25.6	-13.5	-14.8	10.3	-1.0	10.3
Type D	62.4	35.7	1.8	46.0	69.6	8.2	17.3