STATIC AND IMPACT BEHAIVIOR OF RC BEAM REINFORCED BY CARBON FIBER AND SIMULATION

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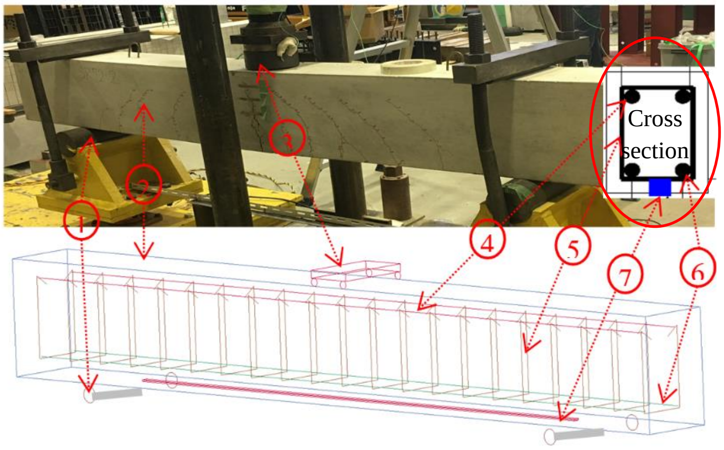
1. INTRODUCTION

Recently, static loading tests on reinforced concrete (RC) beam maintained by carbon fiber have been performed successfully. Generally, the strands of carbon fiber are effective for the reinforcement to static ultimate bending capacity of RC beams and it has a sufficient strength. Based on extremely reasonable results in experiment, finite element method (FEM) enabled to more exactly identify with mechanical behavior and particularly the adequate contact conditions. For this reason, the use of LS-DYNA_971 to simulate the actual response of such structure is one of the most appropriately computational approaches.

2. OUTLINE OF EXPERIMENTS

Upper part of Fig.1 shows the experiment of static bending strength of RC beams reinforced by carbon fiber. The test was carried out with various specimens. SN (Static, Normal) specimen is not reinforced with carbon fiber strands, SR (Static, Reinforcement) specimen is reinforced with carbon fiber strands. The number of the carbon fiber strands was divided into two types (SR-48, SR-72). The position of reinforcement with a length of 1500 mm was formed on the lower surface of the beam, and the carbon strands were bonded by epoxy resin to the slits. Average compressive strength of concrete was 35.81N/mm^2. The span length was set to (200×300×2200) mm, the position of load is put in the middle of beam.



1: Supports, 2: Concrete, 3: Load cell, 4: Top bending bar, 5: Shear reinforced bar, 6: Bottom bending bar, 7: Carbon fiber

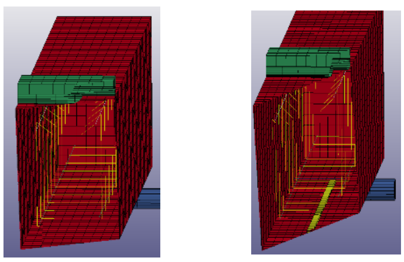
Fig.1 Experiment of RC beam and numerical model

3. NUMERICAL MODELING

The numerical models in this study are idealized to as the same geometrical dimensions as experimental models of SN, SR-48 and SR-72. Therefore, all considered components (e.g., concrete, main reinforcement bars, supports, load cell and carbon fiber) were simulated as under part of Fig.1.

Table 1. Mechanical properties of materials

Type	Mass density RO [kg/m^3]	Young's modulus E [N/m^2]	Poisson's ratio PR	Yield stress SIGY [N/mm^2]
Concrete	2.35E-09	-	0.167	-
D10-D13 bars	7.86E-09	2.00E+05	0.300	295
D19 bars	7.86E-09	2.00E+05	0.300	245
Carbon fiber	1.91E-09	2.45E+05	0.200	-



a. SN model b. SR48–SR72 model

Fig.2 The center cross section of models

Figure 2 presents numerical model of SN, SR while Table 1 summarizes the main parameters for numerical simulation. The elements of models is divided into two parts: beam elements (reinforcement bars), and solid elements (concrete, supports, load cell and carbon fiber). Thank to this, the SN model comprises of 23882 nodes, 1302 beam elements and 18648 solid elements; The SR models consist of 24126 nodes, 1302 beam elements, and 18708 solid elements.

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The suitable material models used for each component of the RC beam are considered based on their characteristics and existing data obtained from material tests and relevant research results. Therefore, concrete damage rel3 model is so called Mat_72 used for the concrete; Mat 3, plastic kinematic model, is defined for the bars, and the carbon fiber strand is considered to a model of the isotropic elastic (Mat 1).

The precise reproduction of the contact behaviors between components might be a significant, so contact automatic surface to surface is set up between specimens and supports, as well as specimens and load cell. The penalty method is used to simply and efficiently reproduce friction for the contacts as mentioned above. The coefficients of friction were considered for each type of contact involving in the used material and contacting surface properties through sensitive analyses.

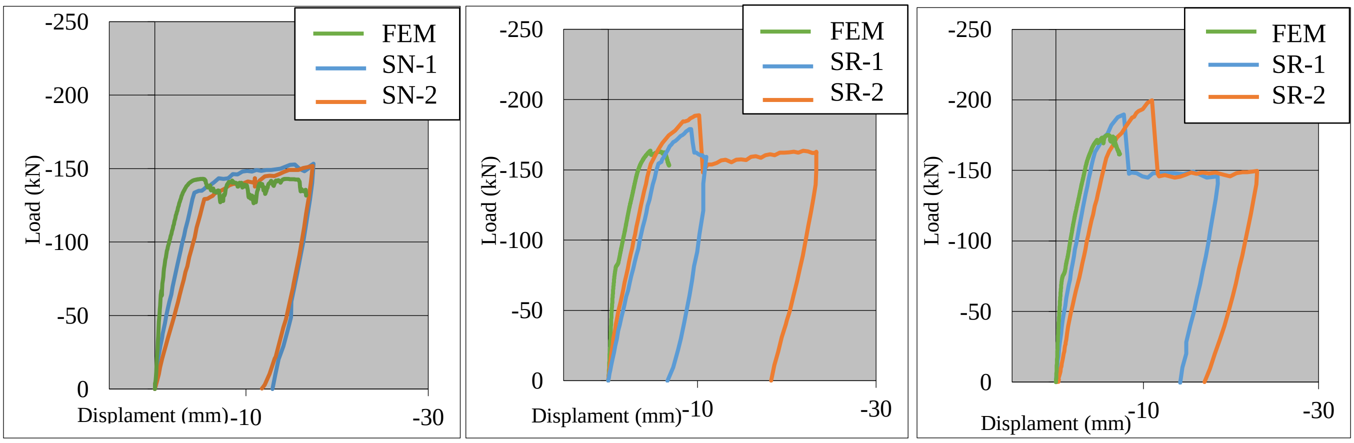
4. RESULTS AND DISCUSSIONS

Figure 3 illustrates a comparison between load and displacement from experiment and simulation, it could be said that all of cases are quite good agreement. In the SN specimen which was not reinforced with carbon fiber strands (Fig. 3a), the yield load of experiment is almost the same that of the analysis, nearly 134 kN. While, the maximum load is calculated is around 140 kN that tend to be insignificantly lower than the number of experiment; however, the displacement increase continuously to the number of test in the ultimate state.

On the other hand, the yield load value results definitely the same between experiment and simulation of SR48 and SR72 model, accounting for 160 kN and 163 kN respectively. When comparing the maximum load, this value shows deviation of about 30 kN and 20 kN for SR48 and SR72 model respectively. The various levels of maximum load between numerical model and test seem to be caused by difference in the setup and bond method of carbon fiber strands.

Regarding the relationship between load and displacement in the ultimate state (Fig.3b–3c), it can be seen that the maximum load of SR48 and SR72 model decrease remarkably after peaking at 188 kN and 199 kN respectively. In addition, the displacement of these models rises sharply from 10 mm to 20 mm. While, the fluctuation of FEM presents an obvious opposite trend, and the strength of this model achieves reasonable result even entering into the ultimate state.

The main reason why the ultimate state has the different between FEM and SR models, it can be said that many of reinforced specimens in experiment finally ended due to peeling of the carbon fiber in the final state. However, this phenomenon do not happen when surveying numerical model.



a. SN model b. SR48 model c. SR72 model

Fig.3 Load – Displacement relation

5. CONCLUSION

This research concerning static loading tests on RC beam maintained by carbon fiber contributed some technical ideas to numerical computation of response on static ultimate bending capacity of RC beams. It is also shown that the numerical simulation and the real experiment showed a mostly good fit in yield load, maximum load and displacement.

To utilize advantages of simulation more, further investigations of s impact behavior on RC beam maintained by carbon fiber are now planning.

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