RELAXATION OF ARAMID FIBER ROPE IN REINFORCED CONCRETE BEAM

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1. INTRODUCTION

Continuous fiber rope (CFR) is considered as a method to replace prestressing steel because of its high strength, light weight and corrosive resistance. In order to clarify the efficient of CFR, there are many aspects need to take into account. One of them is relaxation of CFR, which is the main topic of this study.

In this paper, the relaxation of the aramid fiber rope is investigated. Through the experiments, the relaxation of aramid fiber rope was accessed.

2. EXPERIMENTAL PROCEDURES

2.1 Outline of the experiment

Two specimens (Length: 1500mm, Width: 150mm, Height: 150mm) were prepared for the relaxation tests. Grout was injected into the sheath of specimen No.1, while in the case of specimen No.2, grout was not injected. Outline of the specimen is shown in Fig.1

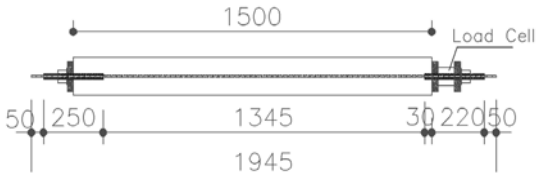

Fig.1 Test specimen

Three twisted aramid fiber rope was used in the experiment. The rope was tensioned up to 50% of its maximum tensile strength. The rope was inserted into the sheath inside a concrete beam and fixed using anchorage system of steel pipe, steel plate and screw.

At one end of the rope, a load cell was installed to measure the change of the tensile force. Also, changes of strain of reinforcing bar also were measured, using strain gauge attached in the middle of the steel bar.

Table 1 Properties of aramid fiber rope (Kawakami (2009))

Cross section	Young Modulus	Unit mass	Maximum Load	Tensile strength
11.5 (mm^2)	7500 (kg/mm^2)	16 (g/m)	27.8 (kN)	2414 (N/mm^2)

2.2 Materials

Concrete strength in experiment was 39.8 N/mm^2. Yield strength of steel bar was 406 N/mm^2. Grout strength injected into the sheath after 28 days cured was 62.3 N/mm^2.

2.3 Experiment execution

Fig. 2 shows the installation of hydraulic jack before execution of experiment. The hydro jack was operated to give tension to the aramid fiber rope. Since the maximum load of the aramid fiber rope is about 30kN, in order to keep experiment safe, tensile stressing was stopped at 15kN and fasten using the screw. Also, the tension of aramid fiber rope might be dropped down to 13kN. In that case, restressed up to 15kN, and hold the tension until stabilizing and fixing with screw afterward.

Fig. 2 Installation of hydraulic jack

Grout was injected after tensile process completed. The ultra-low viscosity grout using in this case will fill in narrow gaps between the rope and the sheath easily.

The experiment data, including changes of tensile force, strain of steel bar and temperature during the test was stored in the data logger in order to continue measure for about 6 months from the test date since the tension test was completed.

3. TEST RESULTS

Both concrete beam specimens had already been cured for about 4 months after concrete was casted. The maximum strain data at 20 micro obtained from measurement show that very small effect of creep and shrinkage affected during the test process. Therefore, the

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effects of creep and shrinkage on the relaxation process can be neglected.

Relaxation rate, which is the percentage of stress remained in the prestress aramid fiber rope compared to initial stress, is calculated from the test data.

As for specimen No.1, relaxation rate can be expressed as Eq. (1)

$$R_1 = \frac{P_1}{P_{0_1}} = \frac{12.43}{15.14} = 0.821 \quad (1)$$

As for specimen No.2, relaxation rate can also be expressed as Eq. (2)

$$R_2 = \frac{P_2}{P_{0_2}} = \frac{12.79}{15.01} = 0.852 \quad (2)$$

Fig.2 and Fig.3 show the observed relaxation during the experiment and their trend lines for specimen No.1 and specimen No.2, respectively.

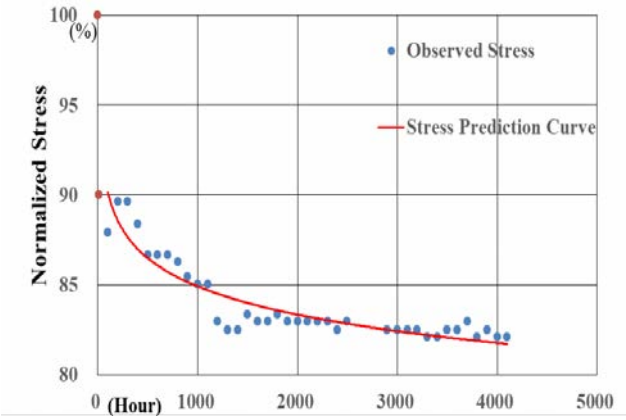

Fig.2 Relaxation of specimen No.1

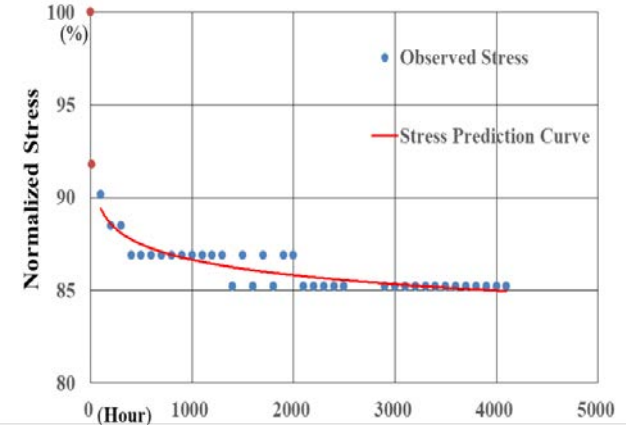

Fig.3 Relaxation of specimen No.2

The graphs show that the relaxation of aramid rope reached stable state in 2 weeks after the test. In the first 2 weeks, relaxation decreased 10.8 - 13.1%, whereas in the stable state, relaxation only decreased 7.07% - 1.67%.

However, when the test was finished, difference of relaxation rate between two specimens was only 3.2% (0.5kN). The difference only came from the grout injection, therefore, it can be said that the effect of grout can be neglected.

Fig.4 and Fig.5 show the prediction of relaxation of aramid fiber rope in 100 years (approximately 1 million hours) for both cases of specimen No.1 and specimen No.2. The equation of prediction line for each specimen are shown in the graphs.

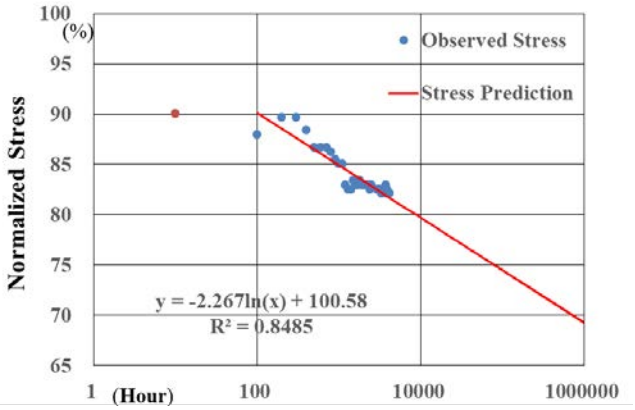

Fig.4 Prediction for Specimen No.1

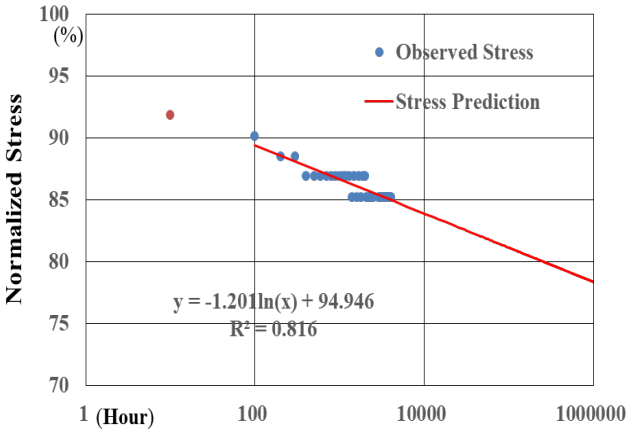

Fig.5 Prediction for Specimen No.2

4. CONCLUSIONS

The following conclusions are obtained from this study.

(1) Relaxation of aramid fiber rope using in concrete beam reached the stable state at about 2 weeks after aramid fiber rope was tensioned.

(2) In total, relaxation rate was in the range of about 15% - 18% (result obtained from equation (1) and (2)).

(3) The difference between stress values of the two specimens was small (0.5kN), therefore no need to consider about the effect of grout injected.

(4) As for prediction, the relaxation in both specimens will decrease for about 25% in a period of 100 years.

REFERENCES

Kawakami, K.: Tensile properties of continuous fiber rope, 4th International Conference on Construction Materials: Performance, Innovation and Structural implications, August 2009.