V-148 Tensile Strength of Aramid FRP Subjected to Various Adverse Environments

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1.Introduction

Durability of concrete structures reinforced by tension-resisting bars like Aramid FRP significantly depends on the ability of the reinforcing material to withstand attacks from various chemical agents under some adverse environments throughout the life of the structure. The adverse environments mainly involve alkaline condition within concrete, acid rain, chlorine-ion-prevailing condition due to the use of thawing agents and marine condition.

This paper reports the evaluation of tensile strength of AFRP flat bar subjected to experimental conditions which simulate the aforementioned adverse environments.

2.Experimental Procedures Simulating the Adverse Environments

An experiment was conducted to subject the AFRP to various surrounding conditions with the presence of chemical agents found in the adverse environments. The procedure of the experiment generally involves exposing specimens to designated chemical solutions through designated period of time. Details of the testing procedures are summarized in Table-1.

As shown in the table, there are 9 groups of AFRP flat bars (1.5x20mm) in which the *A* group is treated as the control specimen group experienced no chemical exposure. The remaining 8 groups can be categorized into 5 main tests simulating various adverse environments, i.e., the test for resistance to alkaline, to acidity, to chlorine ion, to sea water and to salt water respectively.

Test	Specimen group	Number of spc.	Length (cm)	Chemical agents	Procedures
Control spc.	A	10	120	-	-
Alkaline resistance	B	6	120	NaOH (0.4 %)	[3] 500 hr.
	C	6	120		[3] 1000 hr.
Acidity resistance	D	6	120	H_2SO_4 (1 %)	[3] 500 hr.
	E	6	120		[3] 1000 hr.
Chlorine ion resistance	F	6	120	$CaCl_2$ (10 %)	[3] 500 hr.
	G	6	120		[3] 1000 hr.
Sea water resistance	H	6	120	[1] mixed solution	[4] 20 cycles
Salt water resistance	I	6	60	[2] NaCl (5 %)	[4,5] 20 cycles

1 : The mixed solution of NaCl 24.5g, $MgCl_2 \cdot 6H_2O$ 11.1g Na_2SO_4 4.1g, $CaCl_2$ 1.2g and KCl 0.7g in 1000ml.
2 : P.H. 6.7-7.2.
3 : Time duration of submersion in the solution.
4 : 1 cycle consists of 24 hr submersion and 24 hr.drying.
5 : The solution was applied by means of spraying.

Table-1: ***Summary of all the test specimens and testing procedures.***

3.Drying of Specimens

It was desirable to dry all the specimens which were in wet condition after being exposed to the chemical solutions. There are some suggestions that AFRP yields inconsistent tensile strength under wet condition. Therefore, the drying of specimens before tensile strength testing will eliminate such inconsistency and, presumably, the test results will be more reliable.

The procedure to dry the wet specimens is putting the specimens in control environment in which temperature was kept at 25°C and relative humidity at 30%. The initial weight of wet specimens were recorded and weight reduction of all specimens were monitored during the drying period. It took about 20 days until there was no apparent change of weight and the specimens were assumed to be in dry state.

Table-2 summarizes the averaged final weight changes of all the specimen groups.

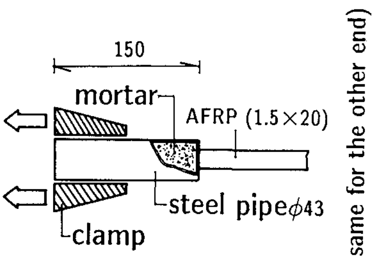

Fig.1: ***Set up for tensile strength test.***

Table-2: ***The final weight change of dried specimens from the initial weight at wet condition.***

Specimen group	Initial weight (g)	* Weight change (g)
B	40.598	-0.461
C	41.139	-0.642
D	47.591	-4.087
E	50.609	-5.954
F	40.469	-0.419
G	40.703	-0.537
H	40.498	-0.429
I	21.967	-0.266

* After being dried for about 20 days

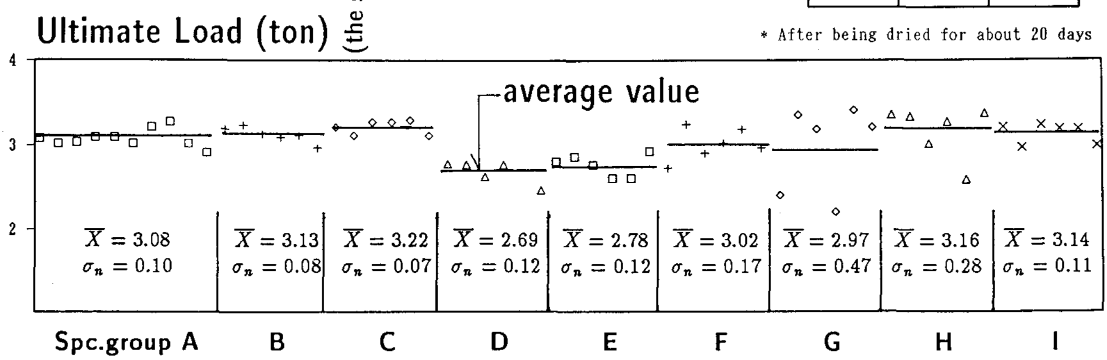

Fig.2: ***Results of the tensile strength test for all specimen groups ($\overline{X}$:the average ultimate load within the group, σ_n:the standard deviation).***

4.Tensile Strength Testing

The dried AFRP flat bars were tested for their tensile strength using testing set up which was assured to have acceptable consistency. The important point of the testing set up is how to hold both ends of a specimen to the standard tension testing machine. Fig.1 shows the set up which consists of the AFRP flat bar being embedded in expansive mortar confided in a steel pipe. The steel pipe is then gripped by the clamp of the tension testing machine prior to starting of the test for each specimen.

All the specimens were pulled until they ruptured at their ultimate strength. The order of each test for a specimen was random to exclude any bias of the test results.

Fig.2 summarizes and shows the results of the test for all of the specimen groups. From the figure, one can see that the average ultimate load of the control group *A* is 3.08 ton which is very close to the assured strength of 3.1 ton. This, to some extent, confirms the reliability of the utilized tension testing set up.

It can be seen from the figure that there is no apparent drop of tensile strength of all the groups in referring to the strength of the control group *A*. However, for group *D* and *E* which were exposed to 1% H_2SO_4 solution, there is about 10% drop in the tensile strength.

5.Discussion

It can be concluded that the tensile strength of AFRP is not significantly affected by the chemical agents prevailing in the adverse environments, namely the alkaline condition, the chlorine-ion-prevailing condition and the marine condition. However, the drop in tensile strength of AFRP exposed to the diluted sulfuric acid somehow can not be said to be negligible. The strength drop of AFRP was also found by Okamoto et al.[1]. It is to be emphasized here that the test result is just the indication that there is a need to investigate in more details the question of durability of concrete members reinforced by AFRP under acid rain environment.

Acknowledgment

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REFERENCE

[1] Okamoto, T. :Characteristics of Braided Aramid, Proceedings of the Japan Concrete Institute, Vol.10, No.2, 1988, pp.659-664.