A Study on the Bond Performance of ϕ5 mm CFRP Tendons According to Surface Treatment

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Abstract. Need is for diversified material tests and member tests of CFRP tendons to develop NSM (Near Surface Mounted) strengthening using CFRP. To that goal, research should be preliminary conducted on the bond characteristics between the CFRP tendon and the filler. Accordingly, this study performed bond test on ϕ5 mm CFRP tendons of which surface were treated by grinding or coated with sand coating, screwed-sand coating, and aluminum-oxide coating to improve the bond characteristics. The experimental results showed that the surface treatment of the tendon increases the bond strength by about 3 times on the average compared to the non-coated tendon and, that there is practically no difference in the bond strength according to the type of coating. The reason for such result could be verified through the failure mode of the specimens. That is, the bond strength between the CFRP tendon and the resin used to fix the sand coating and oxide coating appeared to be smaller than the bond strength between the surface treatment and the filler. Therefore, surface treatment shall be imperatively executed for the CFRP tendon to improve its bond performance. Further research should focus on the improvement of the bond performance between the CFRP tendon and the resin to achieve that purpose.

Introduction

All over the world, countries are today facing a steep increase of maintenance costs following the degradation of social overhead capitals. Colossal budgets are allotted and invested every year to cope with this problem. Moreover, the incessant maintenance works are also affecting the industrial activity and result in tremendous costs for the users [1].

Most of the tendons used for the maintenance of degraded facilities are made of steel. The bridges or coastal structures strengthened by steel tendons experience loss of their load bearing capacity due to environmental factors like the corrosion induced by salt attack and require frequent maintenance. Various researches are now actively conducted for the development of tendons using fiber reinforced plastic exhibiting the advantages of being non-corrosive like glass or carbon in order to solve the corrosion problem of steel.

Korea is today focusing on the CFRP tendon to replace the steel tendon. Compared to the conventional steel tendon, the CFRP tendon offers advantageously high strength, light weight, non-corrosiveness, insulation and low conductibility, design flexibility and high durability. Owing to such properties, research targets the development and practical use of the strengthening technique of degraded structures exploiting the NSM technique and the CFRP tendon.

To that goal, need is for diversified material tests and member tests of CFRP tendons. Furthermore, studies shall imperatively be conducted on the development of dedicated jacking systems, design methods, anchoring devices, bond characteristics with the filler and design of the anchor sleeve.

This study examines the bond performance between the CFRP tendon and the filler as shown in Fig. 1, and investigates experimentally the improvement of the anchor performance according to the surface treatment of the CFRP tendon. The corresponding results will provide precious data necessary for the practical use of the strengthening technique using CFRP.

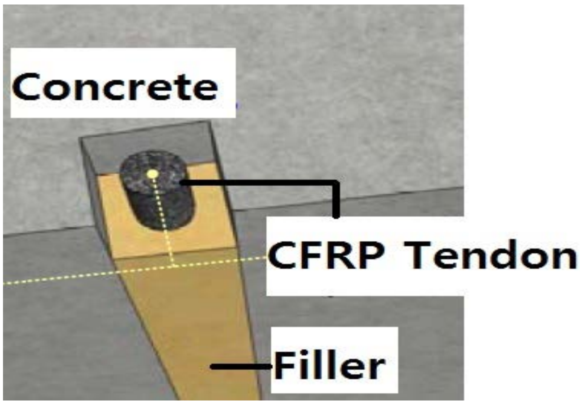

Fig. 1 Conceptual drawing of strengthening using CFRP.

Basic properties of CFRP Tendon

The CFRP tendon is fabricated by pultrusion and its basic properties are listed in Table 1. Its cross-section is round and its surface is smooth without cover. The diameter is 5 mm with a tensile strength of 3500 MPa and elastic modulus of 190 GPa.

Table 1. Basic properties of CFRP tendon.

Cross-sectional shape	Diameter	Area	Tensile strength	Elastic modulus	Surface aspect
Round	5 mm	19.63 mm^2	3500 MPa	190 GPa	

Testing Method and Fabrication of Specimens

The test variable is chosen to be the surface treatment of the CFRP tendon in order to examine the bond performance with respect to the surface treatment. A reference specimen without surface treatment is adopted with its surface subject to grinding. The considered types of surface treatment are: oxide-coating, sand-coating, and screwing-and-sand-coating. Three bond test specimens were fabricated for each type of treatment.

As compared to the conventional steel tendon, there is currently a lack in the design specification for the CFRP tendon. Accordingly, the specimens in this study were fabricated with reference to the bond test method proposed by Jung et al. [2]. The bonded part, that is the jacked end, has a bond section of 50 mm corresponding to 10 times the diameter using a carbon steel pipe for pressure service of KS standards 32A with outer diameter of 42.7 mm and inner diameter of 32.9 mm. The anchored part, that is the fixed end, is anchored by bond-type anchor through spreading of its sectional bond area as proposed by Jung et al. [3]. The main body at the center of the CFRP tendon is fabricated to have a length 40 times the diameter of the tendon with respect to the test method suggested by CSA [4] and ACI Committee 440 [5]. The filler is a non-shrinkage mortar wit compressive strength higher than 50 MPa and is poured to fill the steel pipe.

Planning of Test

Loading was applied using a UTM with capacity of 980 kN at velocity of 1.27 mm/min as proposed by ACI [5]. Strain gages were attached at the center of the specimens to examine the strain of the CFRP tendon. The displacement was measured as shown in Fig. 2 by reflecting the recommendations of ACI [5]. The details of the bonded part of completed specimens are shown in Fig. 3.

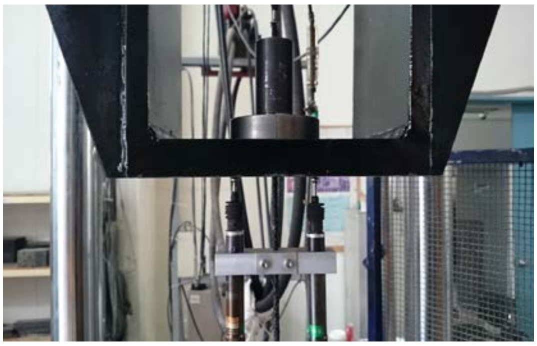

Fig. 2 Measurement of displacement and view of test setup.

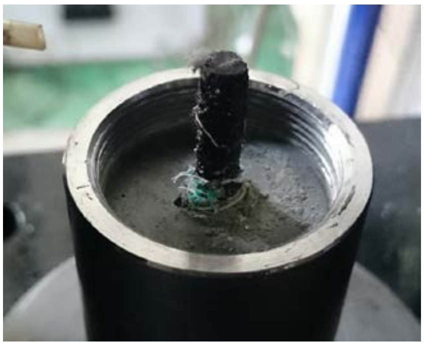

Fig. 3 Bonded part of specimen.

Analysis of Experimental Results

As shown in Fig. 4, all the specimens failed through slip failure. Such failure mode enabled to verified that slip failure occurred due to the low bond force with the resin in the specimens that were surface treated.

Table 2 arranges the bond test results. The average bond strength of the grinded specimen is 6.7 MPa and becomes respectively 19.5, 20.6, and 19.1 MPa for the oxide-coated, sand-coated, and screwed and sand-coated specimens. This indicates that the average bond strength of the surface treated specimens is approximately 3 times larger than the non-treated one with a constant value of about 20 MPa. The reason for such results can be found in the fact that the bond strength between the CFRP tendon and the resin used to fix the coating is smaller than the bond strength between the surface treatment and the filler.

This means that surface treatment of the CFRP tendon is indispensable for improving the bond performance. Further research should focus on the improvement of the bond performance between the CFRP tendon and the resin.

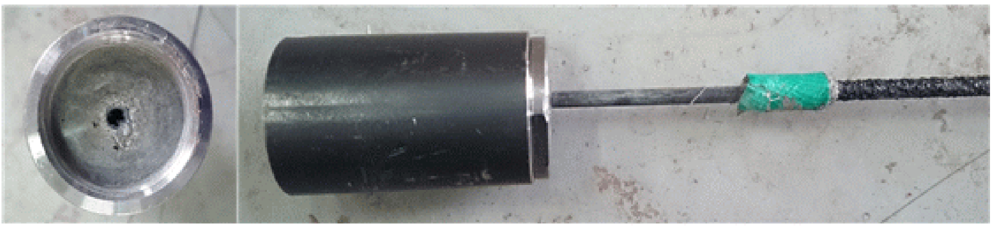

Fig. 4 Failure mode.

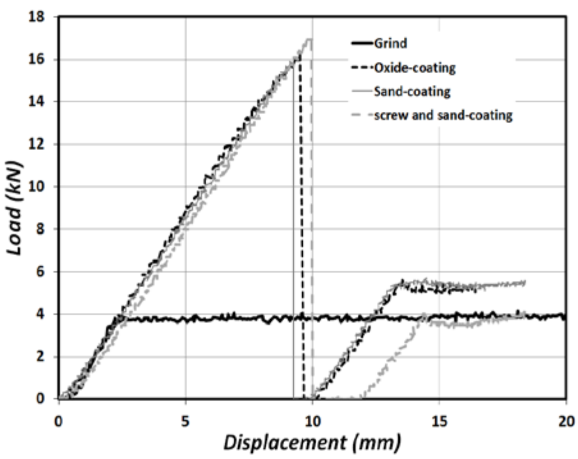

Fig. 5 Load-displacement curves.

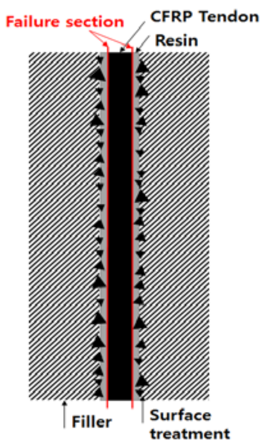

Fig. 6 Failed section.

Table 2. Summary of test results.

Surface treatment	Aspect of treated tendon	Average peak load [kN]	Bond strength [MPa]
Grinding		5.2	6.7
Oxide-coating		15.3	19.5
Sand-coating		16.2	20.6
Screw and sand-coating		15.0	19.1

Conclusions

This study examined the bond performance of the CFRP tendon according to the type of surface treatment for application in the near surface mounted strengthening. The following conclusions can be drawn.

1. The average bond strength increased by 3 times in case of coating compared to the absence of coating.

2. The bond strength took constant value of about 20 MPa in case of coating. The reason could be attributed to the larger bond strength between the CFRP tendon and the resin used to fix the coating is smaller than the bond strength between the surface treatment and the filler.

3. Surface treatment of the CFRP tendon is indispensable for improving the bond performance. Further research should focus on the improvement of the bond performance between the CFRP tendon and the resin.

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