CFRP repair for connections in steel structure

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Introduction and background

Is well known that corrosion is one of the main problem steel bolted joints have due to it leads to degradation. The usual reinforcement method for such cases is using splice plates. However, to install such reinforcement, heavy machinery for the reparation method is needed, making it a complicated task. Also, by opening holes for the new splice plate's bolts, leads to a reduction on the cross section of the member on reparation, compromising its integrity as well.

To make the reparation method on such members an easier task, using CFRP was proposed due to its light weight, high strength and anti-corrosive characteristics, eliminating the need of heavy machinery, also this method doesn't compromise the member's integrity as well, and its workability makes it an efficient reparation method. **Image 1** shows the standard reinforcement method used by NEXCO to reinforce steel bolted joints using CFRP. Showing us a taper length with a proportion of 1 to 10, a determinate fixing length of 200mm and for every Carbon Fiber Sheet used there must be a slide length of 25mm for each sheet.

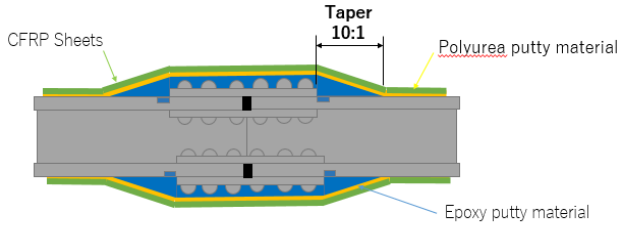


Image 1. – Standard method to reinforce steel joints with CFRP

Objectives and research flow

This research focus on CFRP repair and reinforcement for connections in steel structures. There were conducted bending tests on different experimental cases of steel girder beams with corrosion near
the splice plates with the objective of confirming the repair effect by CFRP, the influence of the taper length and the position of the high elasticity putty.

In this research, the target steel members are bolted connections with corrosion damage near the splice plate and the taper length. All the specimens used in this research were fabricated under the specifications of NEXCO Construction Manual.

Healthy specimen. The first step of this research was to obtain the behavior of a healthy specimen (neither corrosion nor reduced cross-section) under bending forces.

Specimen damaged by corrosion. After this, the next step was focus on obtain data using a damaged specimen by corrosion, in the same way as the previous one, compressive forces on steel members were applied.

CFRP reinforced specimen. Finally, on the last specimen, obtain data for a damaged specimen but reinforced with 9 layers of CFRP Sheets, applied as the current manual related to the CFRP bonding standard indicates. In order to try recovering a healthy state.

On this last specimen, there was not enough area to attach the CFRP sheets as planned, because of the fact that the length of CFRP sheets and the length of the loading range was limited.

Therefore, to supplement this research, using the finite element software, an analysis was conducted in which the last specimen has attached not 9 layers but 18 layers in order to see the real CFRP repair effect.

Experiment results and conclusions

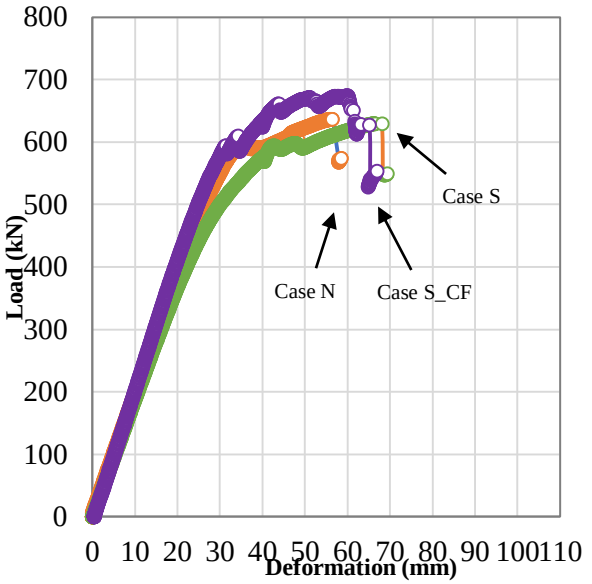
After conducting the bending experiments, principally we obtain the next results on this research:

About the bearing load capacity:

- We can appreciate that the maximum load reached for a healthy specimen before slipping is obtained over the 650 kN point. Therefore, from

this range we can conclude the results of the following two specimens.

- As for the damaged specimen by corrosion, it barely obtained its maximum load on the range of 630 kN. Making clear the effect that a specimen suffers when having its cross section reduced and corroded by corrosion.
- As for the CFRP reinforced experiment the maximum load was reached at a point near 680 kN surpassing the maximum load of the healthy specimen.



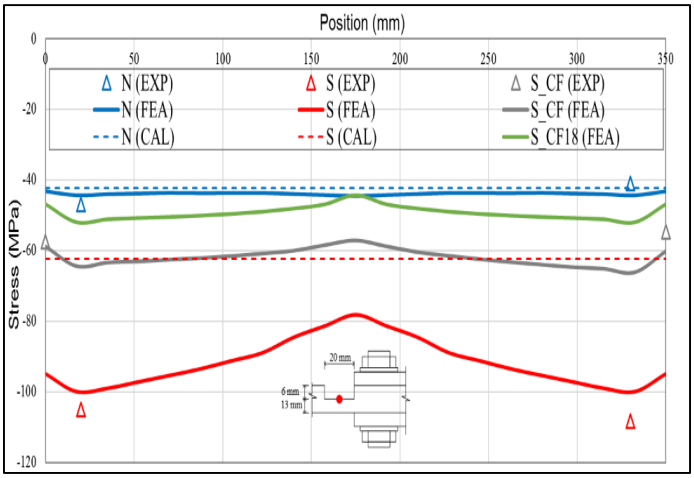
Graph 1.-Load-Deformation Relation
Healthy specimen (orange), Specimen damaged by corrosion(green), CFRP reinforced specimen(purple).

Graph 1 shows the comparison between the maximum load on each experiment in this research.

About the Stress Reduction:

Since one of the objectives of this research is confirm the stress reduction, in a representative way the stress distribution was measured on a cross sectional direction across the girder beam on each experimental case.

We can appreciate the obtained results for the stress distribution on the next graph., which also include the results obtained on the finite element analysis conducted on this research.



Graph 2.- Reduced cross section stress distribution upper part

As we can appreciate on the graph, the reinforced with 9 layers of CFRP sheets specimen gray line is not even close to the healthy specimen blue line we can conclude that the stress of a healthy specimen was not recovered with this amount of layers of CFRP.
However, we can appreciate that after conducting an analysis with 18 layers on the last specimen.
We can see that the 18 layers CFRP sheet reinforced specimen green line of stress is very close to the healthy specimen blue line, therefore from this fact we can confirm that the stress of a healthy specimen was very close to being recovered.

In general, since characteristics such as the load-displacement curve, the maximum load, the fracture behavior and the stress distribution can be obtained and compared, based on these results, we can conclude that the FEA can be considered as valid to determine the validity of the repair effect of CFRP on steel structure.

References

1.-K.Morihisa, REINFORCEMENT OF CORODED CONTINUOUS STEEL STRUCTURES USING CARBON FIBER SHEETS, 2017.3 (in Japanese)

2.-NEXCO Construction Manual for Maintenance with Carbon Fiber Sheets, Nippon Expressway Research Institute Company Limited, 2013.10 (in Japanese)