Investigation of the shear buckling strength of the web panel with local corrosion

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1. Introduction A large number of seriously corroded bridges have been reported from the maintenance problem because their service periods of more than 50 years. Especially, For steel plate girder bridges, the web corrosion are easily found at near the support, because of the high humidity, depositions and rain water from the expansion joint. Thus, there is a need for evaluation procedures that examine accurate predictions of the structural performance and structural reliability of the corroded plate girder bridge to decide repair, rehabilitation and expected life-cycle costs. However, there is no appropriate evaluation method for their residual structural strength or structural performance. Therefore, numerical analyses were conducted to quantitatively evaluate the change in the shear buckling strength of the web panel with local corrosion according to corroded condition.

2. Corroded web and FE analysis model To eigenvalue and incremental nonlinear analyses for shear buckling analysis of the locally web panel, FE analysis were conducted using the finite element program MARC mentat2010 for A 2 web panel plate girder which has 800mm of height, 200mm of flange width, 16mm of flange thickness and 6mm of web thickness as shown in Fig. 1. The model is meshed using Four node shell element with 10mm mesh size. The material properties of the web panel were assumed as Young's Modulus of 206,000MPa, the nominal yield stress of 359MPa, and Poisson's ratio of 0.3. It was considered to be elastic-perfectly plastic, and the von Mises yield criterion was used for the material plasticity. The incremental load was applied at center span of the plate girder and both boundary condition of the support (A) were released to translate at the longitudinal direction and to rotate about transverse direction and a centre point at the lower flange (B) is prevented to translate at the longitudinal direction. Their corroded web height were changed as 100mm and 200mm and the web thickness of the corroded web was decreased as 1mm thickness unit. And three different imperfection of h_w /500 and hw/100 were considered for the web panel.

3. FE analysis result To validate the FE analysis model, The out-of-plane displacement of FE analysis model were compared with that of shear loading test specimen with same dimension. Figure 2 shows the out-of-plane displacement comparisons of the center web panel. For web panel with imperfection, the out-of-plane displacements were appeared to be directly appeared with increasing loads like test result and the tendency were shown to be similar to test results as shown in Fig. 2. Test result was evaluated about 110% of the FE analysis results. Figure 3 shows the out of plane displacement comparison for the shear loading test specimen. It shows the similar deformation shape which has a diagonal tension field band in the web to resist the shear load.

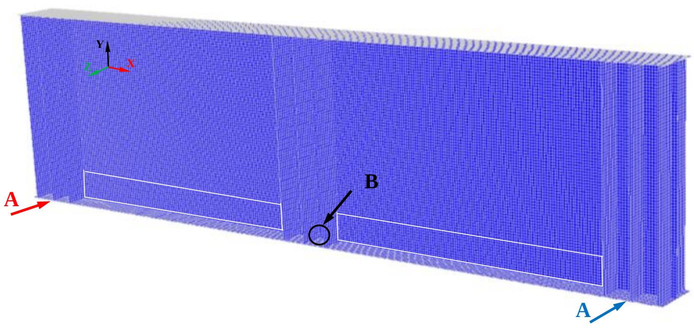


Fig.1 Boundary region and dimension of FE model (mm)

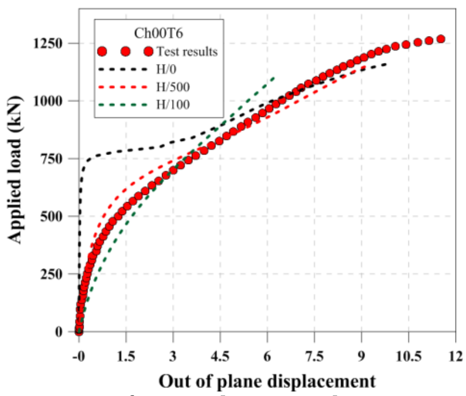
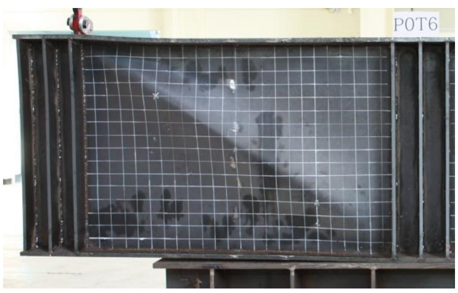
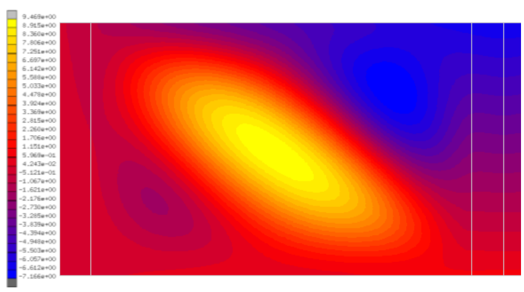


Fig.2 Concept of nominal stress and maximum stress



(a) Failure mode of test specimen



(b) FE analysis with H/500

Fig.3 Out of plane displacement comparison

Keywords: shear buckling strength, web panel, corrosion, FE analysis, plate girder
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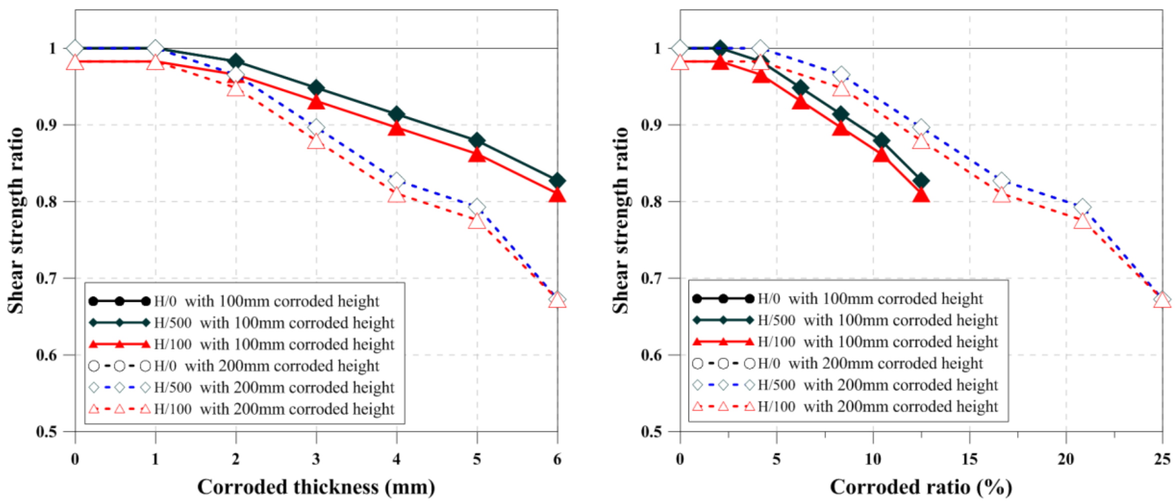
From the FE analysis results, shear buckling strengths of the web panel with local corrosion were summarized by varying the corroded web thickness and corroded volume in Table 1 and Fig. 4. From the Table 1, the shear buckling strengths of web panels with 100 corroded web height was steadily decreased to 81% of the uncorroded web panel. For web panels with 200 corroded web height, their shear buckling strengths were steadily decreased to 67% according to corroded thickness and volume ratio. In the H/100 cases, the shear buckling strengths were slightly decreased than the other imperfection cases.

Table 1 Shear buckling strengths of the web panels with local corrosion (kN)

Corroded height		Corroded thickness (mm)/ Volume(%)						
100 mm	Imperfection	0/0	1/2.08	2/4.17	3/6.25	4/8.33	5/10.42	6/12.50
	0	1160.0	1160.0	1140.0	1100.0	1060.1	1020.0	959.9
	H/500	1160.0	1160.0	1140.0	1100.0	1060.1	1020.0	959.9
	H/100	1140.0	1140.0	1120.0	1080.0	1039.9	1000.0	940.0
200 mm	Imperfection	0/0	1/4.17	2/8.33	3/12.50	4/16.67	5/20.83	6/25.00
	0	1160.0	1160.0	1119.9	1039.9	959.9	920.0	779.9
	H/500	1160.0	1160.0	1119.9	1039.9	959.9	920.0	779.9
	H/100	1140.0	1140.0	1100.0	1020.0	940.0	900.1	779.9



(a) Corroded thickness (b) Corroded volume

Fig.4 Relationship between shear buckling strength ratio and Corroded condition

4. Summary of findings In this study, the shear buckling strength of the web panel with local corrosion was numerically examined to quantitatively evaluate the change in the shear buckling strength according to corroded condition. From this numerical evolution for the shear buckling strength of the web panel, shear buckling strengths were decreased according to the corroded height and corroded volume. For corroded height of the web panel, the shear buckling strengths ratio were shown to be sharply decreased in the lower corroded height.

References

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