SHEAR CAPCITY OF CORRODED STEEL PLATE GIRDER WITH LOCAL STIFFENER DAMAGE

Yokohama National University Student Member ○Nauman KHURRAM
Yokohama National University Regular Member Hiroshi KATSUCHI
Tokyo Institute of Technology Regular Member Eiichi SASAKI
Yokohama National University Fellow Member Hitoshi YAMADA

1. INTRODUCTION

Corrosion is one of the aging phenomena that damages steel plate girder gradually with the passage of time. Tamakoshi et al. (2006) in his research report on local corrosion damages of highway bridges in Japan has illustrated that most of steel bridges corrode at the end, near the bearings that is primarily due to the leakage of water from the construction joints and rain water which gather near the bearing region. Photo 1 depicts the one of such damage case. Liu et al. (2011) investigated the shear capacity of the corroded plate girder by considering the different damage cases only in the interior web. However, Khurram et al. (2011) considered the stiffener damage in his study to evaluate its effect on bearing capacity. Since bearing stiffener are designed for both to resist the bearing load and to provide the anchorage to develop tension filed action to increase the post buckling strength of the plate girder. Thus, any particular damage level of bearing stiffener near the bearing may also affect the shear capacity that need to investigate. This study presents the effect of the local corrosion damage at the bearing stiffener on the shear capacity of plate girder.

Photo 1. Stiffener damage in corroded plate girder (Tamakoshi, 2006)

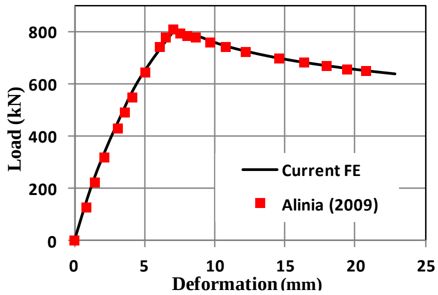

Fig. 1 Verification of FE model

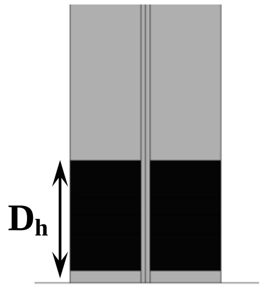

Fig. 2 Typical stiffener damage

2. FE MODEL CHARACTERISTICS

For the analytical study the plate girder model from the study of Alinia (2009) was taken and remodeled using a powerful four noded S4R shell element in a finite element computer package ABAQUS. After the convergence study, the geometry was divided into sufficient mesh numbers to trap the shear buckling with good accuracy of result. However, a very fine mesh of size 2.5x2.5mm was adopted in the stiffener damage zone. The detail dimensions and boundary conditions of the model are shown in fig 3.

2.1 Boundary conditions and material properties

The right and left supports are released to translate in direction 3 and to rotate about axis 1 and all other translations and rotations are restricted. At the center point only the translation in direction 3 is restrained. An imperfection value equal to $h_w/250$ was superimposed to the model geometry obtained through eignvalue buckling analysis, while no residual stresses are considered in the study. A mild steel with yield stress = 345Mpa, Poisson's ration υ =0.3 and elastic modulus E=210Gpa are used. The material is considered elastic perfectly plastics with no strain hardening. The thickness of the flange, stiffener and web are used as 9mm, 8mm and 4 mm, respectively. A mid span load was applied by using an elasto-plastic nonlinear modified ricks analysis procedure and vertical displacement was measured at the center point of the girder as shown in fig. 3. The verification of the load-deformations curve of current FE analysis is represented in fig. 1.

After the verification of the FE model the different damage thickness levels (residual thicknesses) are considered within the various damage heights *i.e.* 20, 40, 60, 80 and 100mm of the stiffener as shown in Fig. 2. The damage zone is considered from the bottom face of the weld near the weld seam.

Keywords: Steel plate girder, Corrosion damage, Shear capacity, Damage mode, initial imperfection
Contact address: Department of Civil Engineering, Yokohama National University, Yokohama, Hodogaya-ku, Tokiwadai, 240-8501, Japan, Tel: +81-45-339-4041

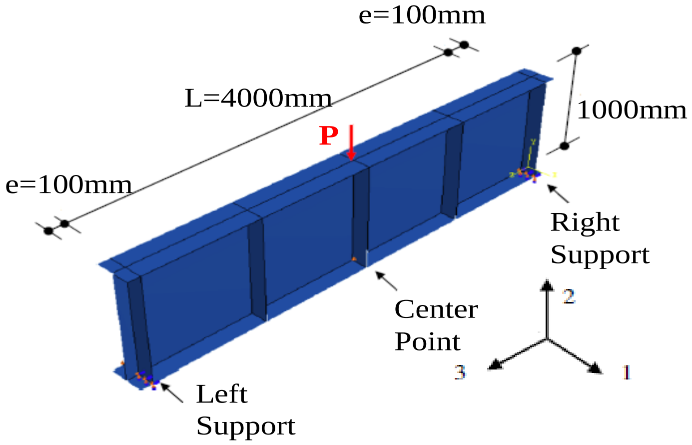

Fig. 3 Detail dimensions and boundary condition of FE model

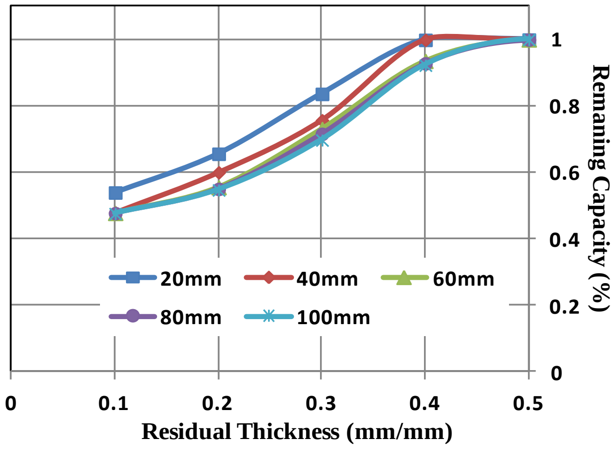

Fig. 4 Remaining capacity Vs residual thickness for various damage heights

3. RESULTS ANS DISCUSSION

All the results are plotted in term of the remaining capacity verses residual thickness of the bearing stiffener corresponding to different damage heights as illustrated in Fig. 4. The anlytical results depicts that 50% reduction of the bearing stiffner does not affect the shear capacity of plate girder and still sufficient anchorage is availble to develop the post bucking strenght. Fig 4 also shows that ulitimate shear capacity reduce gradually and almost in linear trend with reduction of residual thickness (less than 0.5) for all damage heights cases considered in the study. Table 1 depicts that resiual thickness equal to the 0.4 does not reduce the peak load significantly but it reduce the post bukling strength remarkabley. Thus, a small reduction of around 8% in ultimate shear capcity was observed for the maximum damage height of 100mm with residual thickness equal to 0.4. However, for the cases where residual thickness is less than 0.3, the reduction in both the ultimate and post buckling shear capacity become significant. Fig 4 also reveals almost same strength reduction trend for all the damage heights greater than 60mm which indicates that residual thickness less than 0.4 for a damage heights is quite critical for the shear strength and in these case local buckling within the stiffner damage zone shift the damage mode from shear to bearing before developing the full post buckling strength. A typical buckling within the stiffener damage zone is shown in fig. 5

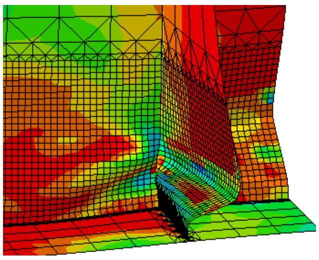

Fig. 5 Local buckling in the damge stiffener

Table 1. Remaining shear capacity

Damage Height		Residual Thickness (t/t_0)					
D_h (mm)	D_h/d (%)	1	0.5	0.4	0.3	0.2	0.1
20	20	1	1	0.999	0.837	0.657	0.540
40	40	1	1	0.999	0.757	0.601	0.480
60	60	1	1	0.936	0.731	0.556	0.478
80	80	1	1	0.928	0.716	0.551	0.478
100	100	1	1	0.923	0.698	0.548	0.477

4. CONCLUSIONS

The study revealed that local corrosion damage at the bearing stiffener with residual thickness less than 0.5 (50%) may shift the shear failure mode to the bearing or local buckling at bearing stiffener which also reduces the critical shear buckling load and post buckling strength without developing the tension field action in the web.

REFERENCES

Alinia, M. M., Shakiba, M., and Habashi, H.: Shear Failure Characteristic of Steel Plate girders, Thin Walled Structures, 47, 2009, pp. 1498-1506.
Liu, C., Miyashita, T., and Nagai, M.: Analytical study on Shear Capacity of Steel I-Girder with Local Corrosions nearby Girder Ends, Journal of Structural Engineering, JSCE, 57-A, 2011, pp. 715-723.
Khurram, N., Sasaki, E., Kihira, H, Katsuchi, H., and Yamada, H.: Effect of Bearing Stiffener Damage on Ultimate Bearing Strength of The Corroded Plate Girder, Proceedings of 13th International Summer Symposium, JSCE, 2011, pp 39-43
Tamakoshi, T., Nakasu, K., Ishio, M., Takeda, T., and Suizu, N.: Research on Local Corrosion of Highway Steel Bridges. Report No. 294, National Institute of Land and Infra Structure Management, Ministry of Land, Infrastructure and Transport, JAPAN, 2006.