Stress Analysis on steel-concrete composite slab using angle shape shear connector

Nagoya University 〇Sung-Min CHOI and Kazuo TATEISHI

MES Co.,Ltd Daisuke UCHIDA, Koichi ASANO, and Kiyoshi KOBAYASHI

1. Introduction

Various types of steel-concrete composite slab have been proposed. Among them this paper picks up a steel-concrete composite slab using angle shape shear connector as shown in Fig.1, and investigated its local stress behavior through static test and FEA on large-scale plate specimen.

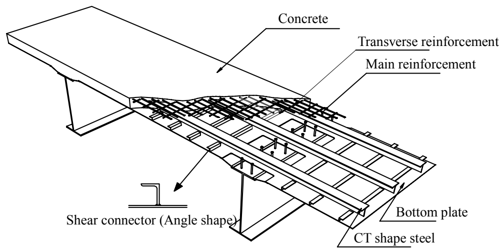


Fig. 1 Investigated composite slab

2. Test program and FE model

Test program Table 1 gives geometry dimensions of two specimens, and Fig. 2 illustrates configurations and dimensions of ST1 specimen. The bottom plate was 8mm in thickness. Hereafter, the angle shape shear connector is called as 'shear connector'. In actual composite slabs, the bond action is expected between steel and concrete. However, this study considers the no-bond condition between steel and concrete by the numerous repeated loads in long-term service life. Therefore, before casting the concrete, the remover was provided on the steel plate surface. The test specimens were simply supported, and the concentrated load was applied on loading plate located on the center of specimen. The loading plate was modeled as a 200×500mm^2 rectangle.

Table 1 Test specimens unit:mm

Specimen	Slab size	Slab thickness	Shear connector interval	CT-shape Steel interval
ST1	3,500×2100	200	500	600
ST2	〃	〃	833	〃

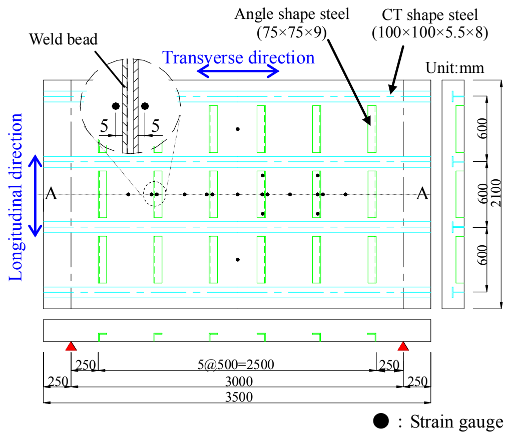
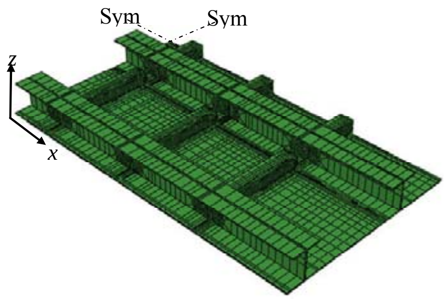
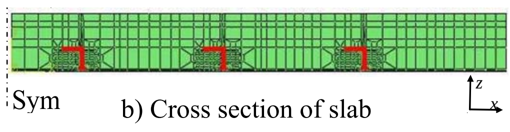


Fig. 2 Geometry dimensions of ST1

FE Model The finite element analysis was carried out on test specimens using ABAQUS/Explicit. Fig. 3 gives the FE model for ST1 specimen. One quarter model was created by solid element. The contact condition was applied to the interface between the steel and the concrete so that they could behave separately. Yield strength, Young's modulus and Poisson's ratio of the steel member are 302MPa, 2.06×10^{5}MPa and 0.3. Fig. 4 indicates the stress-strain curve of concrete material.



a) Model of steel members



b) Cross section of slab

Fig. 3 FE Model

3. Results of loading test and FEA

Local stress behavior on bottom plate Fig. 5 represents an example of the stress distributions on bottom plate in y-direction. The stresses were measured at 5mm away from weld toe. From the figure, stress differences between FEA and test results can be seen. This may be relevant to the existence of concrete crack around shear connectors. According to the test results, concrete cracks generated from the edge of shear connectors were observed. Moreover, the mesh configuration of concrete plane and the bond condition between steel and concrete are also possible reasons of the errors. However, below the load of 300kN, a relatively good agreement can be seen. Fig. 6 gives the stress distribution on bottom plate in x-direction along A-A line shown in Fig. 2 under the load of 300kN. On the inner surface of the bottom plate, stress is sharply fluctuated near welded joints of shear connectors,

Keywords Steel-concrete composite slab, Angle shape shear connector, Local bending deformation, Ultimate load

Department of Civil Engineering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan TEL 052-789-4514

and the symmetrical distribution can be seen on the outer surface. This is caused by the local bending deformation of the bottom plate. Even though there are some errors near shear connector, it can be found that the stress manners of FEA are almost same to that of test, and the stress values of FEA and test are in relatively good agreement below the load of 300kN. Considering that the single truck load is 100kN, this FE model can simulate the local stress behavior of steel members against the design wheel truck load.

Mid-span deflection and stress The load-deflection curves at the center of specimen are given in Fig. 7. In the test, concrete fracture was observed near loading plate at 1051kN in ST1 and 1128kN in ST2 as shown in Fig. 8. The load-deflection curves represent that FEA and test results have good agreement. However, it is difficult to predict the maximum load from the load-deflection curve from FEA because the present FE model cannot simulate real concrete fracture as mentioned in the previous section. Fig. 9 indicates the load-stress curves at the center of specimen. The stresses were measured at the outer surface of bottom plate. Compared with load-deflection and load-stress curves of ST2, the deflection shows obvious increasing trend after the yield load of bottom plate. This may be due to the fact that the yield of bottom plate causes large deformation of slab. In case of ST1, yield load could not be estimated from test because the strain gauge was broken before reaching yield stress. On the other hand, FEA results mostly match well with test results in ST1 and ST2. The yield loads of ST1 and ST2 obtained from FEA are almost same level to the maximum loads in test, and in ST2 the yield load of FEA is estimated conservatively. Therefore, it is considered that the ultimate load of plate specimens can be evaluated by the yield load of bottom plate.

4. Conclusions

From static test and FEA on large-scale plate specimens, the stress behavior of composite slab using angle shape shear connectors was clarified. The validation and applicability of FE model were also confirmed by comparing with test results.

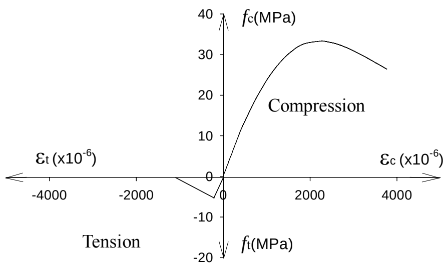


Fig. 4 Stress-strain curve for concrete

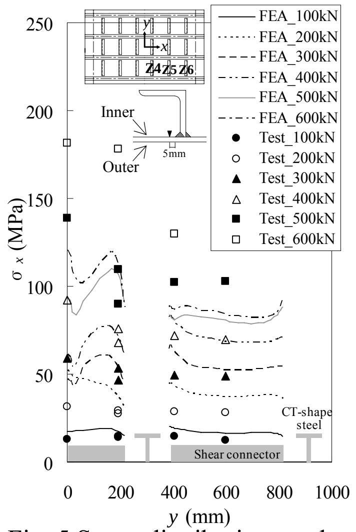


Fig. 5 Stress distributions on bottom plate in y-direction (ST1 near Z4)

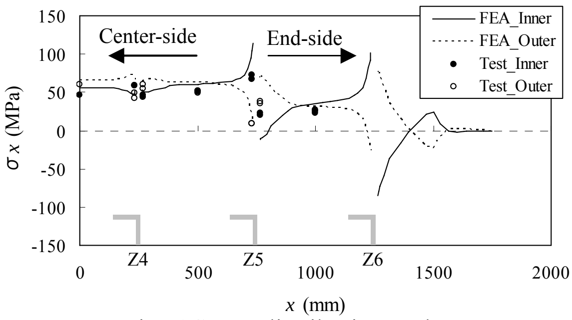


Fig. 6 Stress distribution on bottom plate in x-direction (ST1)

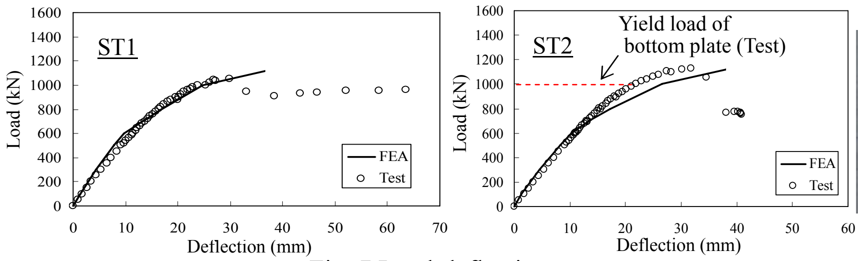


Fig. 7 Load-deflection curve


Fig. 8 Fracture near loading plate

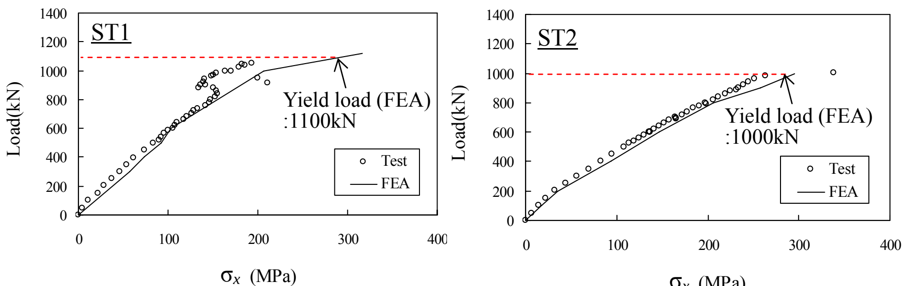


Fig. 9 Load-stress curve

Reference

崔ら，L 形鋼をずれ止めとして用いた合成床板の曲げ載荷試験，土木学会第65 回年次学術講演会，pp.575-576