XXIV awarie budowlane
XXIV Konferencja Naukowo-Techniczna
Szczecin-Międzyzdroje, 26-29 maja 2009

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FATIGUE LIFE PROLONGING METHODS FOR WELDED FLANGE ATTACHMENT JOINT WITH A GAP

METODY PRZEDŁUŻANIA TRWAŁOŚCI ZMĘCZENIOWEJ SPAWANYCH POŁĄCZEŃ NAKŁADEK PASÓW ZE SZCZELINĄ

Abstract It was previously reported that fatigue strength of the lap joint with turn-round weldment behind the attachment does not satisfy even the lowest fatigue category H' of the Japanese Fatigue Design Recommendations for Highway Bridges. In this study, two types of fatigue strength improving methods a connection plate type and a coring type are proposed and investigated through finite element analysis and static loading tests. As a result, the Stress Concentration Reductive Effects of two types of improving method can be confirmed at the gap between attachments and core holes.

Streszczenie Wytrzymałość zmęczeniowa połączenia nakładek pasów ze spoiną zwrotną nie spełnia nawet najniższej kategorii zmęczeniowej H wg japońskich wytycznych dla mostów autostradowych. W pracy zaproponowano dwie metody polepszenia wytrzymałości zmęczeniowej: połączenia półkowego i rdzeniowego. Do analizy wykorzystano metodę elementów skończonych i testy obciążeń statycznych.

1. Introduction

It was previously reported1) that fatigue strength of the lap joint with turn-round weldment behind the attachment does not satisfy even the lowest fatigue catergory of Class H' of the Japanese Fatigue Design Recommendations for Highway Bridges2).

In this study, two types of fatigue strength improving methods the connection plate type and the coring type are proposed and investigated through finite element analysis and static loading tests.

2. Specimen

Photo 1 shows the plate girder specimen with welded lap joints and flange attachment joint with a gap. This specimen is the same as the specimens of previous study1). Lap type attachments are welded on to each edge of the bottom flange of a specimen of length 4m and depth 51cm.

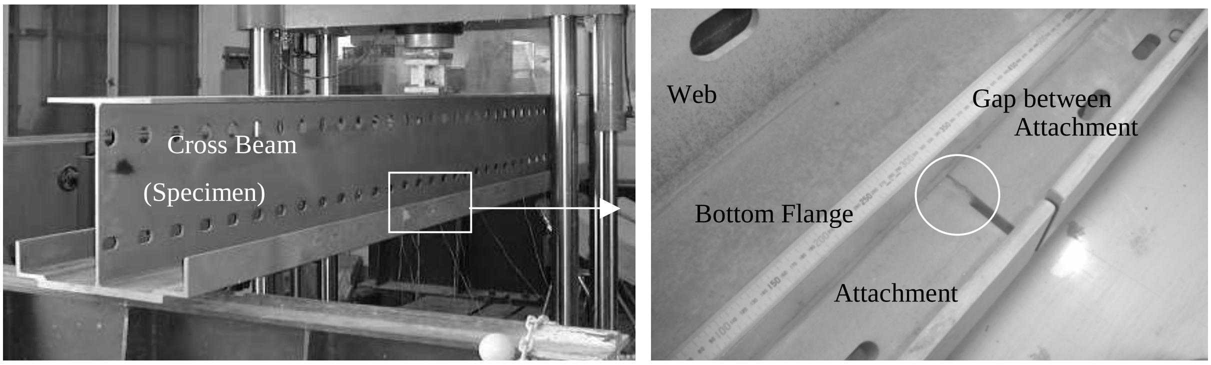


Photo 1. Cross beam specimen & flange attachment joint with a gap

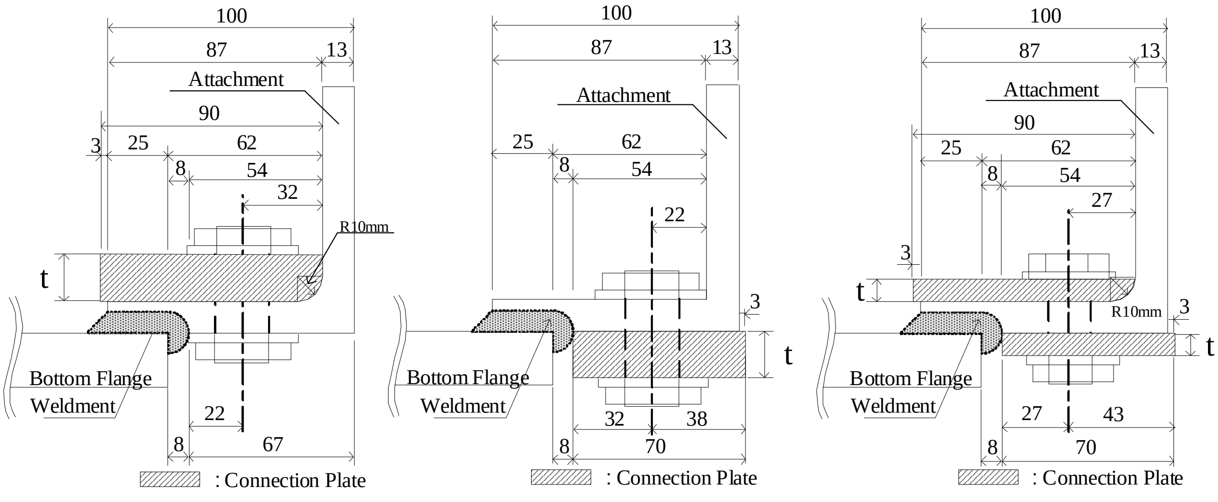
3. Reinforcing Method

As a fatigue strength improving method of the gap, we thought about two kinds of connection plate the type and the coring type.

3.1. Connection plate type

Fig. 1 shows the improving method of the connection plate type (in cross section). The connection plate type is expected to reduce the stress concentration at the gap by connecting attachments with a steel plate.

The reinforcing connection plate types were prepared, respectively for three cases: to install connection plates on the attachment 1) on both sides, 2) on the attachments upper side and 3) on the attachments lower side by changing the thickness or width of the connection plate of the connection board.



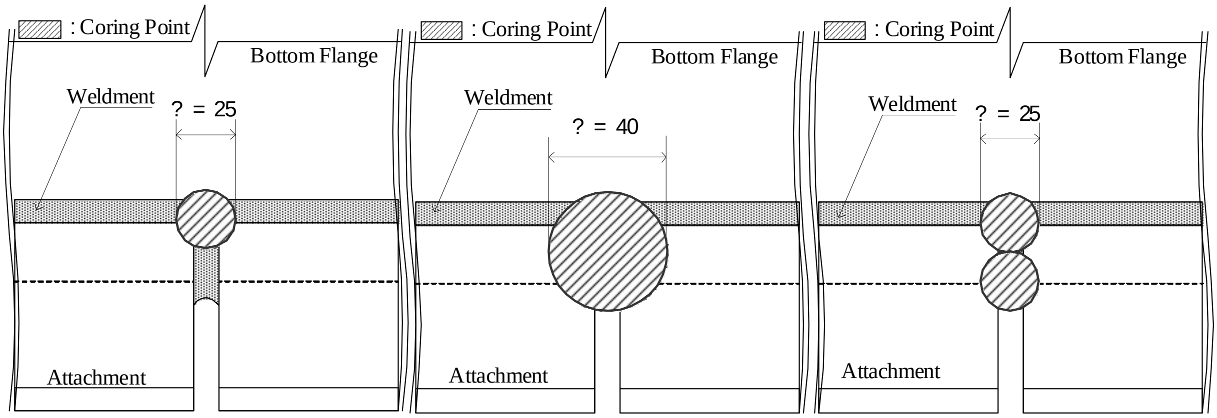
(a) Upper model (b) Lower model (c) Both sides model

Fig. 1. Connection plate type (cross section at gap between attachments)

3.2. Coring type

Fig. 2 shows an improving model by coring. The Coring type is expected to reduce the stress concentration at the gap by removing the turn-round weldment that is the source of crack initiation.

As for the improving model, we considered three types by changing the diameter and the position of coring (f25 model, f40 model and f25´2 model).



(a) f = 25mm (b) f = 40mm (c) f = 25mm x 2

Fig. 2 Coring type (plan near the gap between attachments)

4. Analytical Method

Fig. 3 shows the analytical model, a three-dimensional 1/4 model with a symmetrical condition. This specimen was modelled using Solid elements. Boundary condition and loading condition reproduced the condition of the loading test (see Fig.4). Young's modulus is 200GPa. Poisson's ratio is 0.3.

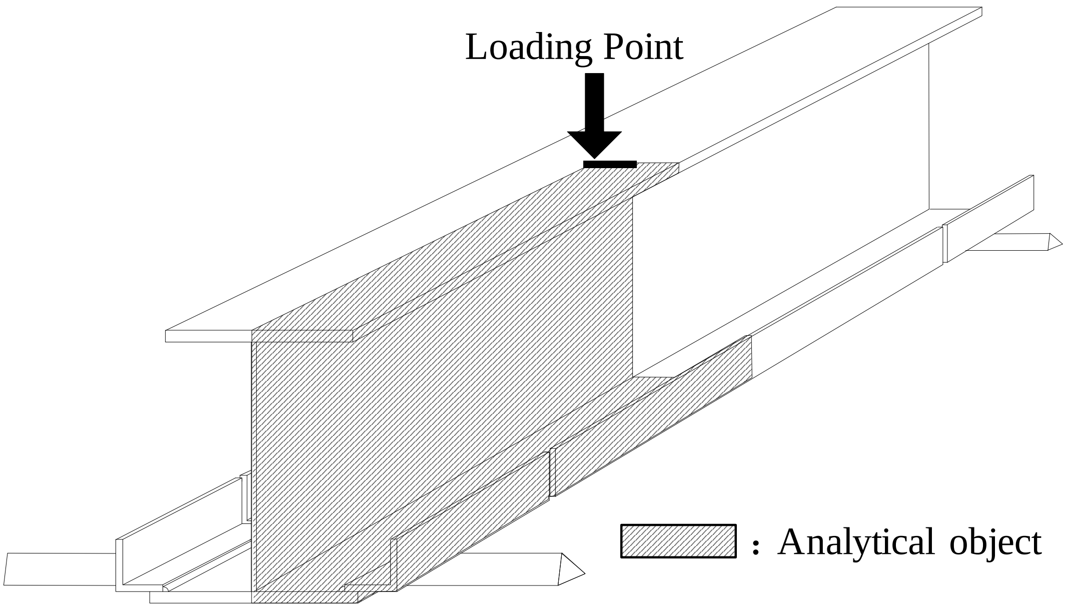


Fig. 3. Analytical model

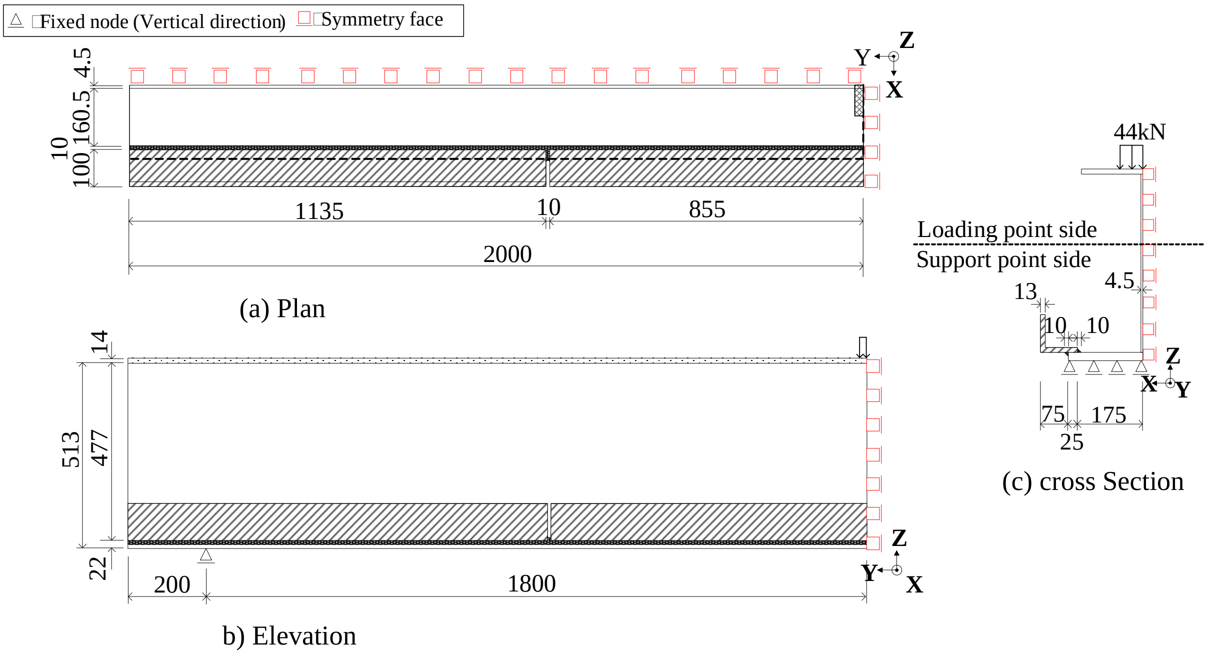


Fig. 4. Boundary Condition and Loading Condition

5. Analytical Results

5.1. Connection plate type

Fig. 5 shows the relation between plate thickness and maximum stress value. Reinforcement on both sides is most effective connection plate type, and the upper connection plate type is more effective than the lower connection plate type. In the upper and lower connection type, the effect of decreasing the stress is almost constant when plate thickness of connection plate is 19 mm.

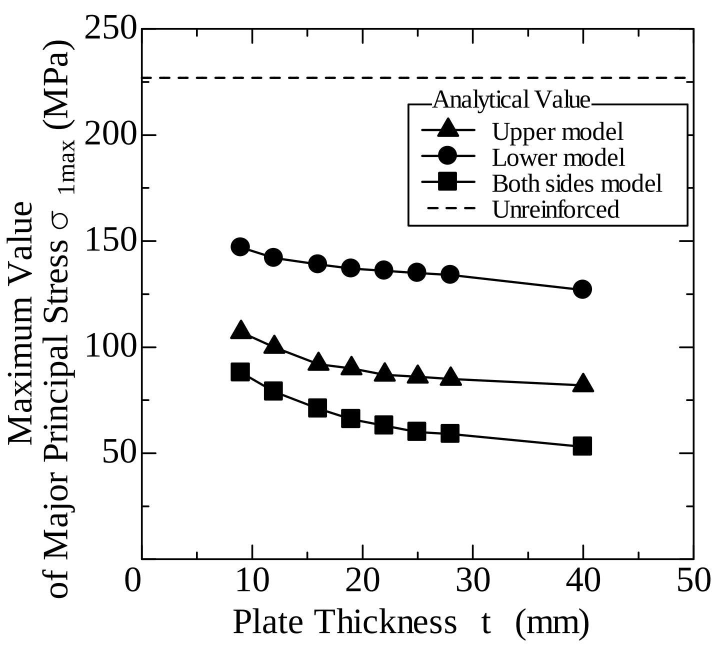


Fig. 5 Relation between plate thickness and maximum stress value

5.2. Connection plate type

Fig. 6 shows analytical results of major principal stress distribution of both unreinforced and coring types. In the unreinforced type, a maximum value of major principal stress of 227 MPa is observed at the end of the turn-round weldment. In the improvement coring type of f40 mm to remove the turn-round weldment, a maximum value of major principal stress of 102 MPa is observed at the edge of a coring circular hole, and reduced to lower than half (45%) as compared with its state before improvement. In the coring type of f25 mm´2pieces, a maximum value of major principal stress of 129 MPa is observed at the edge of a coring circular hole, and reduced about 57% compared to the unreinforced type. In the coring type of f25 mm to remove only part of the turn-round weldment, the major principal stress is almost the same as that in the unreinforced type though it becomes 57 MPa in the edge of a coring circular hole. Thus, it is predicted that the magnitude of the major principal stress would be almost the same as that in the coring type of φ 25mm´2 pieces when the remaining turn-round weldment was broken.

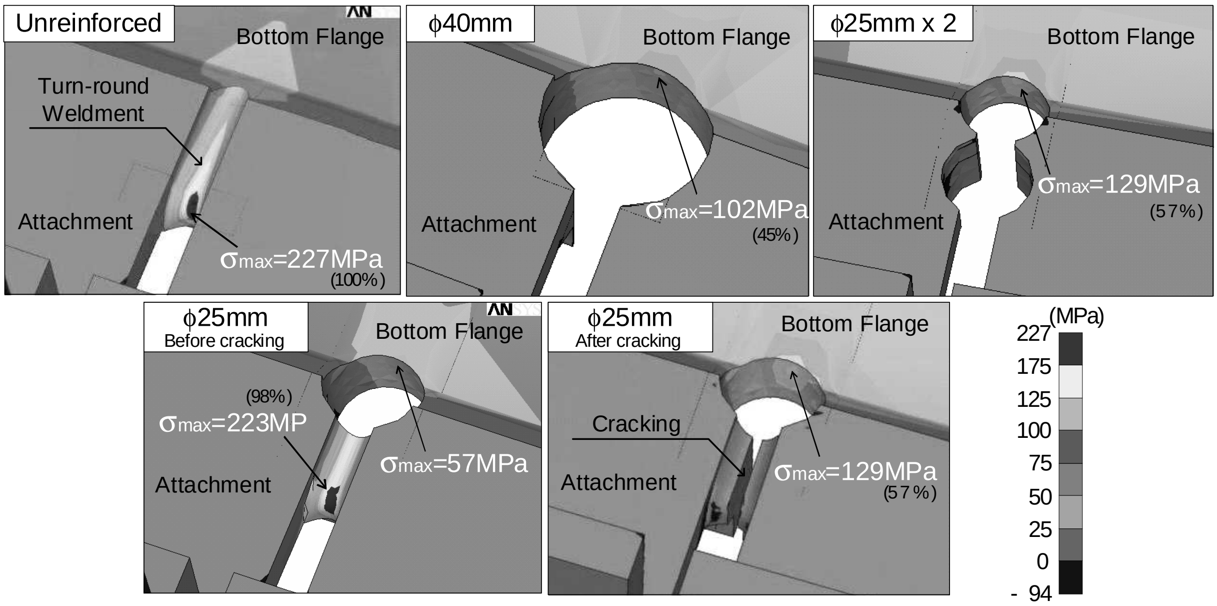


Fig. 6. Major principal stress distribution of both no reinforcement and coring type

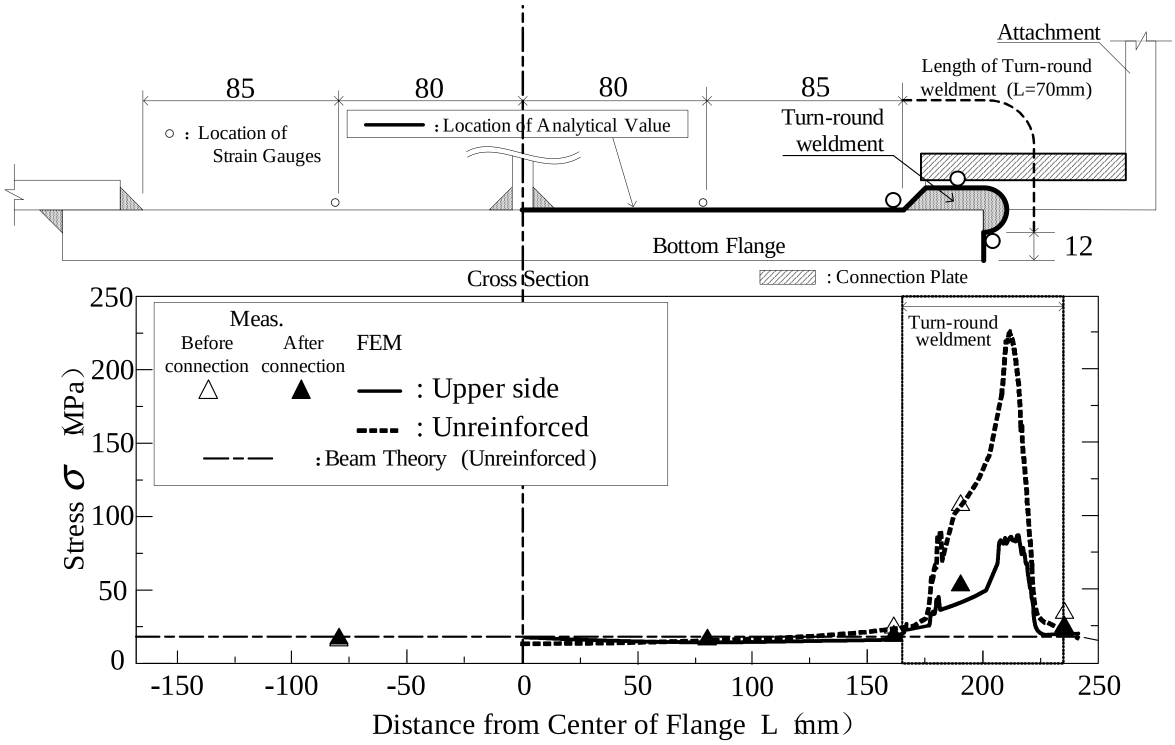
6. Experimental Method

Static loading tests are conducted in order to grasp if the stress distributions at the gap between the attachments is reinforced by connection plate and coring. The loading condition is 3-point bending, as shown in Photo. 1. The load is set to 176kN (18tf) the same as in the previous study.

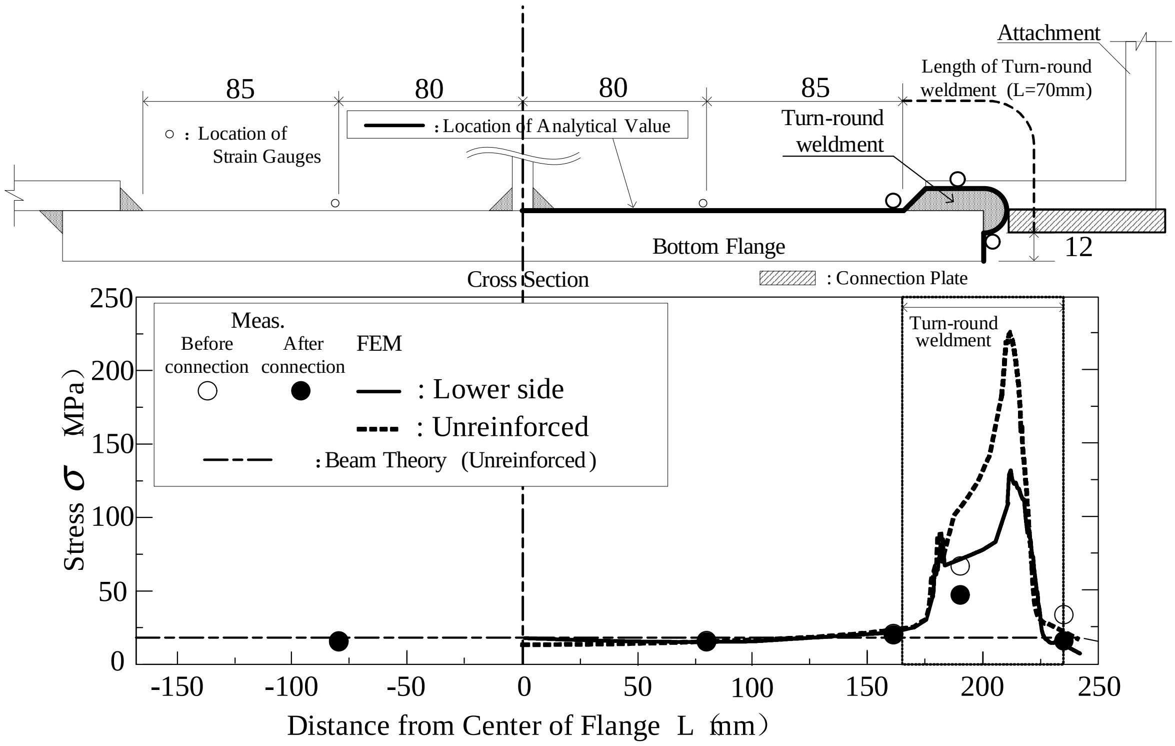
7. Static Loading Test Results

7.1. Effect of improving by connection plate type

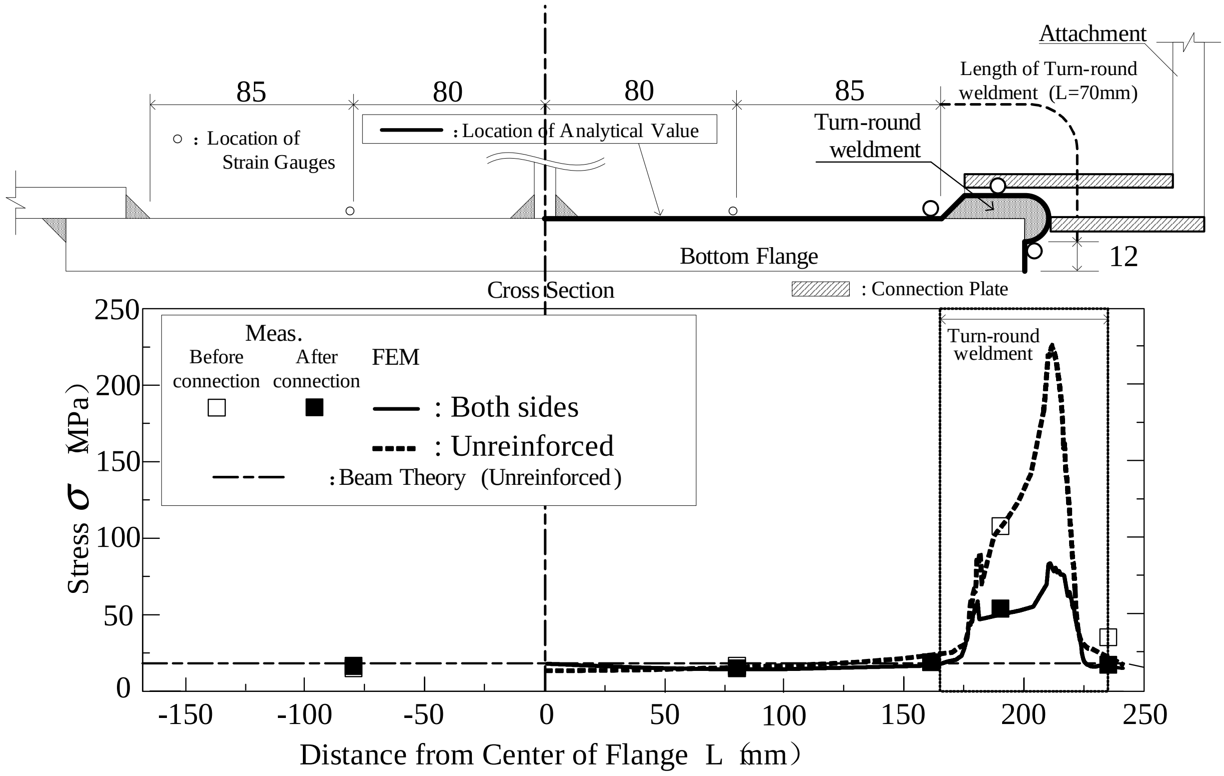
Fig. 7 shows the transverse stress distributions of connection plate types, and shows the location of strain gauges, as well as measured and analytical results. In Fig.9, measured stresses are close to the calculated value, and the magnitude of stress on the turn-round weldment is the largest both in terms of measured and analytical values. The maximum measured stress on the turn-round weldment before improvement can be reduced about 50% by reinforcing to connect the upper side or both sides, while they are reduced about 30% by reinforcing to connect the lower side.



(a) Upper side model



(b) Lower side model



(c) Both sides model

Fig. 7. Transverse stress distributions of connection plate types

7.2. Effect of improving by connection plate type

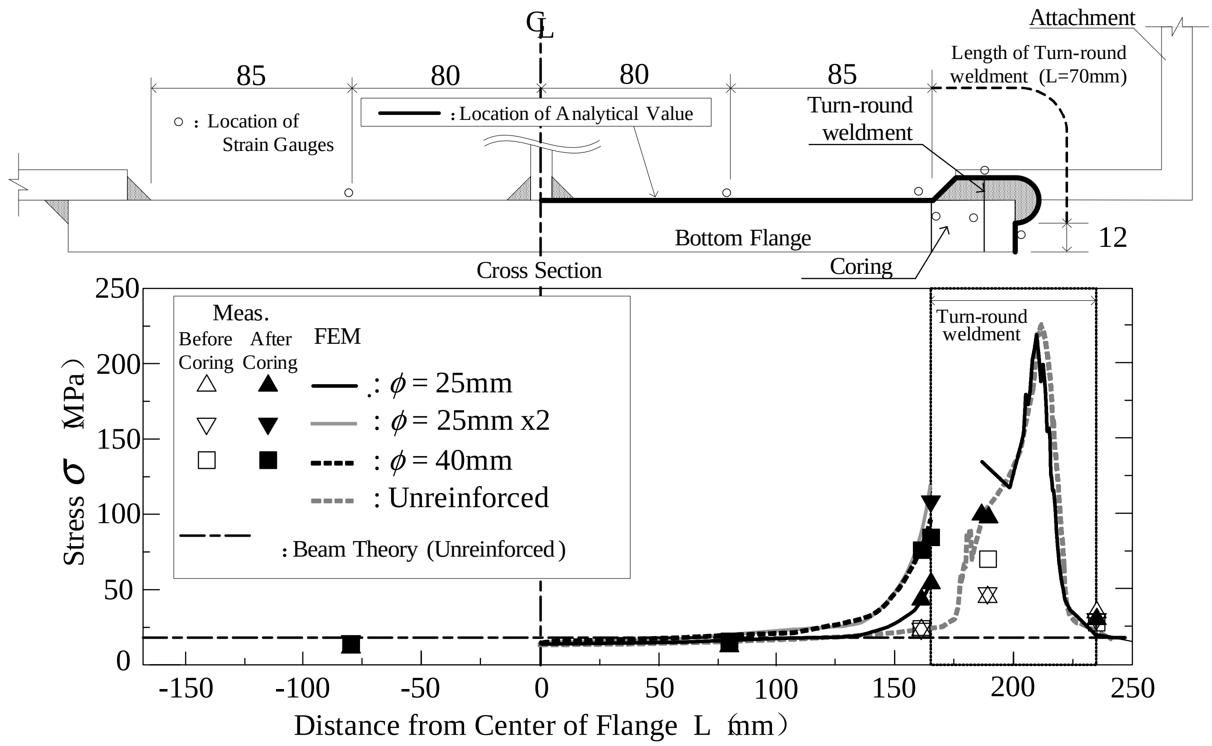


Fig. 8. Transverse stress distributions of coring type

Fig. 8 shows transverse stress distributions of coring types. In Fig.8, measured stresses are close to the calculated values. The coring type improvement can remove the turn-round weldment at the gap between the attachments with moderate stress concentration at the edge of a coring circular hole.

8. Conclusions

The principal results obtained through this study are as follows:

It has been confirmed through static loading testing that the connection plate type improvement can reduce the stress concentration at the gap between the attachments to less than 50% of the maximum stress before improvement.

The coring type improvement can remove the turn-round weldment at the gap between the attachments with moderate stress concentration at the edge of a coring circular hole.

9. References

1. M. Sakano, K. Matsumoto, S. Yajima, and K. Sakashita, " Fatigue behaviour of steel floor beams with weld lap joints in a composite slab railway truss bridge", Proceedings of the Second International Conference on Bridge Maintenance, Safety, Management and Cost, IABMAS '04, 579–580, Kyoto(2004).
2. Japan Road Association. "Fatigue design recommendations for highway bridges" (2002, in Japanese).