I-187 Fatigue Performance of Single Spliced Bolted Joint

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INTRODUCTION : For field joints of deck plates in bridge deck systems, double spliced bolted joints are currently used. Therefore, additional pavement thickness due to the presence of upper splice on deck is required. Furthermore, because of the projection of bolt head, the pavement cracks occur easily unless adding some extra pavement thicknesses. Hence, by using single spliced joint with special types of bolts which are flat-head or round-head bolts in panel connections as shown in Fig.1, the reduction of pavement cost becomes feasible.

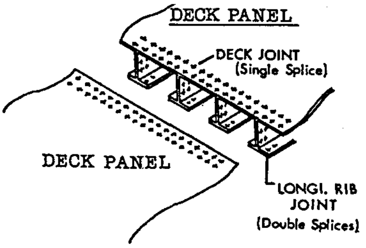

Fig.1 Panel Connection

In contrast to double spliced joints, single spliced joints are simple to fabricate and erect but are usually avoided because of concern with the inherent eccentricity that result in out-of-plane bending. The bending deformation cause larger stress to occur at the discontinuities of the joint. The bending stress combines with the normal stress and result in high local stress that reduce the fatigue strength. On current specifications of single spliced bolted joint, there are different statements about this eccentricity problem. For example, the ECCS demands that the effect of stresses arising from joint eccentricity, secondary bending stress should be calculated and taken into account. However, the AASHTO prohibits axially loaded joints which induce out-of-plane bending in connected material. Therefore, to study the reduction of fatigue strength due to eccentricity and how to take into account this reduction by using restraint factor according to structural restraint effect is necessary.

EXPERIMENT PROCEDURE : Four types of joints for deck specimens adopted are :(1)torque shear bolts with round head, (2)bearing bolts with flat head, (3)In order to reduce secondary stress due to eccentricity, combination of (1) or (2) with adhesive materials (acrylic type) was applied, and (4)thick splice (20mm) lap joints. The clamping forces of 50 kgf-m are introuduced to all joints. Furthermore, joint specimens of types (1),(2) and (3) are tested under axial tensile force to check the differences of fatigue strength between deck specimens and joint specimens, and to investigate basic fatigue behaviors. The mechanical properties of the adhesive used are shown in Table 1. Fig.2 illustrates configurations and dimensions of specimens.

Table 1. Mechanical properties of Adhesive Material

chemical type	shear strength	bond strength	specific weight
acrylic	448 kgf/cm^2	395 kgf/cm^2	1.0

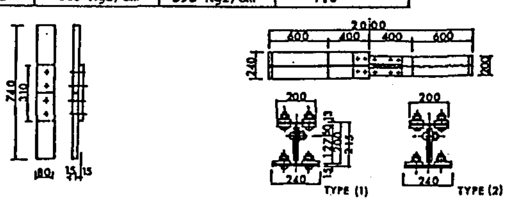

Fig.2 Specimen

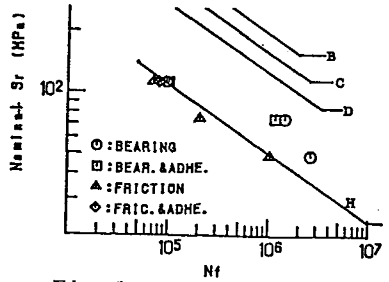

Fig.3 S-N Curve of Joint Specimen

FATIGUE BEHAVIORS : Fig.3 shows the fatigue strength of joint specimens on basis of nominal gross stress range. No major slips occurred during the fatigue test. The JSSC Fatigue Design Category B Curve for double spliced joint and Curve H which is the lowest design curve in JSSC are shown as well to give a comparison. The figure indicates that the fatigue strength of joint specimen based on nominal stress range is significantly low, almost equal to the lowest Curve H. The critical point under repeaded loading condition is not at the main plates but at the middle of splices due to large relative displacement between the splice and main plate.

The bending test results are shown in Fig.4. the fatigue strength of deck specimens based on nominal stress range is fairly high, comparing with the results of joint specimens shown in Fig.3, due to structural restraints are provided so that secondary bending stress are reduced. Besides, this figure indicates a significant increase of fatigue strength by combining adhesives with single spliced bolted joint. These phenomena can be explained as changing of load transfer mechanism and exhibition of structural restraint effect in deck specimens against secondary bending. Hence, the fatigue strength of deck specimen in bending test is much higher than that of joint specimen in tension test under same stress range. Therefore, if single spliced joints are adopted on deck specimen, the restraint effect should be considered in more detail. Evaluating single spliced joint fatigue strength of deck specimen by using joint specimen is not suitable.

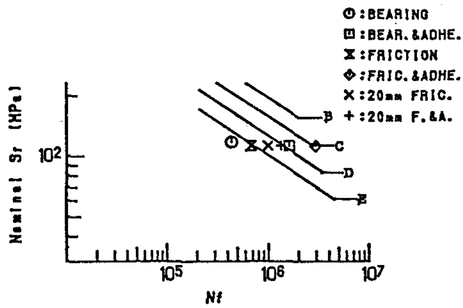

Fig.4 S-N Curve of Deck Specimen

Considering the restraint effect as stated above, Eq.1 is suggested for evaluating the local stress in cross section at the faying surface when subjected to an eccentric axial load, which a restraint factor defined as ratio of measured stress and calculated stress is taken into account.

$$\sigma_l = \sigma_t + \lambda \cdot \frac{P \cdot e}{I} \cdot y \qquad \cdots\cdots (1)$$

Where: σ_l :local stress at faying surface
σ_t :nominal stress (=P/A)
λ :restraint factor , P :loading
I :moment of inertia of the splice
e : eccentricity $(t_1+t_2)/2$

Test results show the mean values of restraint factor are 0.69 for joint specimens and 0.39 for deck specimens. Hence, it is proposed that the restraint factor for joint specimens is 0.7 and for deck specimen is 0.4. However, in more general cases, restraint factors depend on joint geometry need more study.

Fig.5 indicates the fatigue strength of single spliced joint of joint specimens and deck specimens on basis of local stress range at the faying surface of splice that are calculated by Eq.1. This figure indicates that in case stress ranges are arranged for local stress range, the JSSC Fatigue Design Category B can be applied to the fatigue strength of single spliced joint.

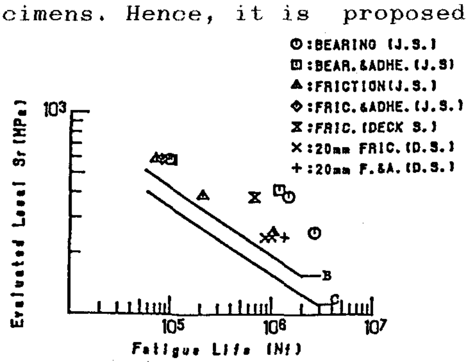

Fig.5 S-N Curve by using Eq.1

Considering the influence by using thick splice (20mm) in bending test, the secondary stress can be reduced due to increasing of section nodulus. However, Fig.4 & 5 indicate that no significant splice effect shows. Explanitions of these phenomena need more study.