A SIMPLE LOW CYCLE FATIGUE ASSESSMENT OF WELDED JOINT BY LOCAL STRAIN APPROACH AND TEST VERIFICATION

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1. INTRODUCTION

Low cycle fatigue failure of steel structure arose in 1995 Hyogo-ken Nanbu earthquake. Most of the observed cracks initiated from the welded joint. Therefore, low cycle fatigue research on welded joint has important significance to the seismic design and damage assessment of structure components. However, limited numbers of studies have been carried out on the low cycle fatigue in civil structures. In this paper, endeavor was exerted to develop a new local strain based method for low cycle fatigue assessment for welded joint in engineering application.

2. FINITE ELEMENT MODELING

T shaped welded joint is introduced to the numerical analysis. Main plate thicknesses are 12mm, 24mm and 36mm while transverse plate thickness remains 12mm. Fig.1 shows the geometry configuration when main plate thickness is 12mm. The fillet weld leg lengths are 6mm, 8mm and 10mm. For all specimens, the ratio of support distance to main plate thickness remains constant.

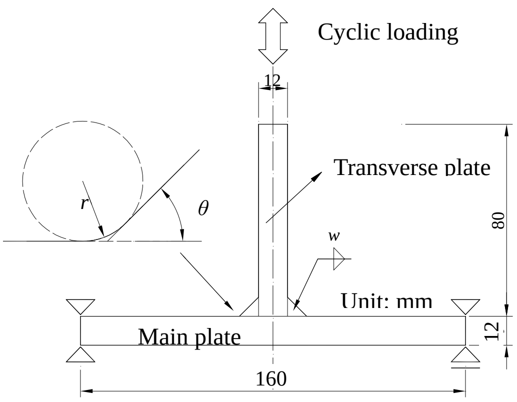

Fig. 1 Geometry configuration (t=12mm)

Several 2D models are created and analyzed by MSC/ Marc under plain strain condition. FE models are shown in Fig. 2. For coarse model, the weld toe radius r is set to zero and mesh size of 1mm×1mm is used near weld toe. But for fine model, very fine mesh is employed to model weld toe profile. According to measurement results, four different radiuses, which are 0.2mm, 0.5mm, 1mm and 2mm, were modeled. The flank angle θ remains 45^{o}. Cyclic loading is applied to the transverse plate end.

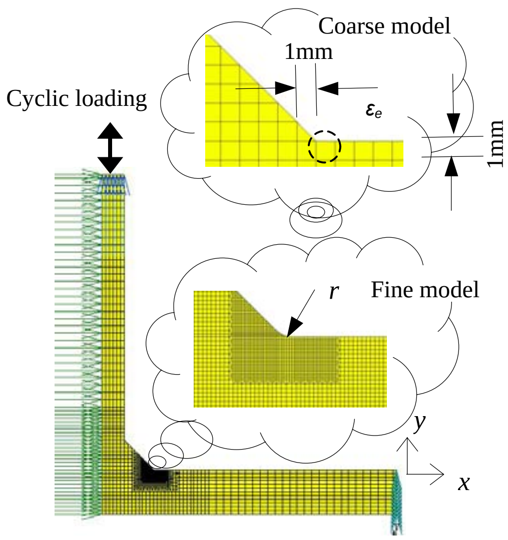

Fig. 2 FE models

Bilinear constitutive model is used. Yield strength, Young's modulus and Poisson's ratio are 407MPa, 2.0×10^{5}MPa and 0.3 respectively. The strain-hardening ratio, which is the ratio between post-yield tangent and initial elastic tangent, is assumed as 1/100 and von Mises yield criteria with kinematic hardening rule is adopted. Several random amplitude blocks were generated by random function and they were applied to specimens as displacement controlled loading.

3. NUMERICAL ANALYSIS RESULTS

For coarse model, strain of element ε_e near weld toe is calculated.

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For fine models, the maximum strain ε_r of weld toe is acquired. They are processed by rain flow counting method and correlated the relationship between them. Numerical results show that the influences of thickness and weld leg length are negligible, whereas the effect of radius is influential (Tateishi 2006). Owing to the space limit, only the results relating to weld toe radius was graphed in Fig. 3. Abscissa represents the strain range of coarse model, whereas ordinate indicates the strain range of fine models. The results are based on the welded joint that main plate thickness is 24mm and weld leg length is 8mm. By quadratic regression, functions were obtained when radiuses are 0.2mm, 0.5mm, 1.0mm and 2.0mm respectively and they were tabulated in Table1.

Table 1 Functions for strain range relationship

Function	$\Delta\varepsilon_r / \Delta\varepsilon_e = a\Delta\varepsilon_e + b$	
Weld toe radius (*mm*)	a	b
0.2	-44.6	11.4
0.5	-17.9	6.1
1.0	-9.2	4.2
2.0	-3.5	2.7

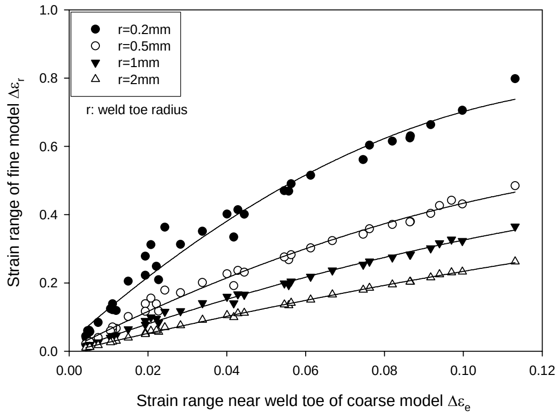

Fig. 3 Strain range with respect to radius

4. LOW CYCLE FATIGUE TEST

Constant amplitude and random loading tests were conducted to welded joints for verification of proposed approach (Hanji 2006, Tateishi 2006). Only coarse model was created and then element strains were acquired. They were converted to local strain range by function in Table 1. Then equivalent strain amplitudes versus number of cycles to crack initiation were plotted in Fig. 4. In the graph, marks represents test results whereas lines are fatigue strength curved obtained by former researches (Hanji 2006). It can be found that dots of test results are near the strength curve of deposited metal. This is consistent with the observed phenomenon of crack initiation, which initiated from weld deposit. We also noticed that results of random loading are above constant amplitude loading. This owes to the firstly observed crack initiation lengths of specimens. They were already several millimeters for random test whereas calibrated to 0.5mm for constant loading. It shows that the proposed method is applicable to low cycle fatigue assessment.

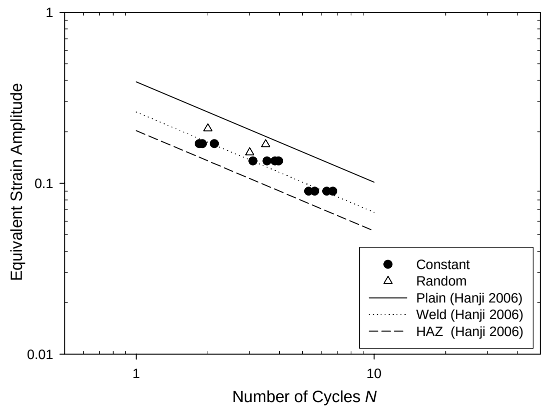

Fig. 4 Relationship between strain amplitude and crack initiation life

5. CONCLUSIONS

A simplified low cycle fatigue assessment method was proposed and applied to constant amplitude and random loading tests. It shows that the method is applicable and easy to use for low cycle fatigue assessment.

REFERENCE

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