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Evaluation method of crack propagation life of CFRP bonded structures using urethane adhesives.

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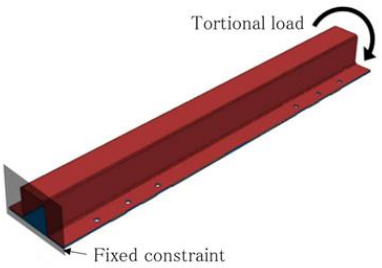
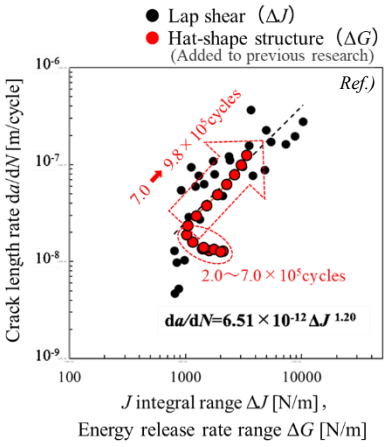
CFRP (Carbon Fiver Reinforced Plastic) is expected to be widely applied to automotive body structure because it has high specific strength and stiffness. Recent vehicle bodies commonly use hybrid constructions combining dissimilar materials, and CFRP is usually joined with adhesives. Because joints are the weakest regions in the structures, it is important to understand damage mechanisms and fatigue strength for structure design and evaluation. The JSAE Fatigue Reliability Committee developed the structure specimens which represent car body structure and performed fatigue tests by using these specimens. The test result showed that fatigue life of urethane adhesive is largely covered by crack growth and initial crack occurs early in the test. Therefore, this study focuses on assessing the fracture mechanical behavior by using experimental observation and finite-element analysis for hat-shaped tortional structure specimens.

Firstly, to clarify the aspect of crack propagation, the adhesive damage range of the structure specimen after its fatigue test was observed using osmotic fluid. In addition, finite element analysis was conducted to simulate the damage propagation. As a result, it was clarified that the adhesive crack initiated from the flange inside corner and propagated in the longitudinal direction and the width direction of the specimen and further propagated in the longitudinal direction after the damage spread in the whole width direction. It was also found that the crack growth rate increased with the crack growth.

It was shown in the previous study that the maximum principal strain can be a fatigue life evaluation parameter for urethane adhesives, and it was confirmed for I-shape bending structure specimens and lap shear specimens. Then, in this study, it was verified whether it can be applied also for the hat-shaped tortional structure specimens. The maximum principal strain was calculated by finite element analysis with applying non-linear stress-strain characteristic of adhesive. The result was aliened to previous study *(Ref)*, and it was confirmed that the maximum principal strain at the crack initiation point is useful for evaluating fatigue life for different shapes of structures.





However, the maximum principal strain is correlated with the crack initiation in common, and the crack growth characteristics are generally evaluated by the stress intensity factor range or the *J* integral value range. Then the reason for the fatigue life in which the crack growth is dominant can be evaluated by the maximum principal strain was studied. To clarify this subject, a unique method to estimate the crack growth resistance of structure specimens from the data measured during the test was examined and applied. Concretely, the number of durability cycles of crack passage and crack growth area were obtained from the strain transition during the test, and dissipated energy and energy release rate ΔG were calculated using these strain records and measured twist angle transition of structure specimen. As a result, the da/dN-ΔG relation of the hat-shaped torsional structure specimen was highly correlated with the da/dN-ΔJ relation of the lap shear specimen that was derived in the previous research at the higher crack growth rate. This result shows the possibility to evaluate the fatigue life of the hat-shaped torsional structure specimens by crack growth resistance obtained by lap shear specimens.

Finaly, it was clarified that the reason for the fatigue life of the bonded structure in which the crack growth is dominant could be evaluated by the maximum principal strain is that both show the similar crack growth characteristics.

Ref.) Fatigue life prediction method considering crack propagation in CFRP adhesive structure, 20245306, Transactions of the Society of Automotive Engineers of Japan, Vol.55, No.6, pp1165-1170