

Study on fracture mode of spot weld joint using continuum damage mechanics model

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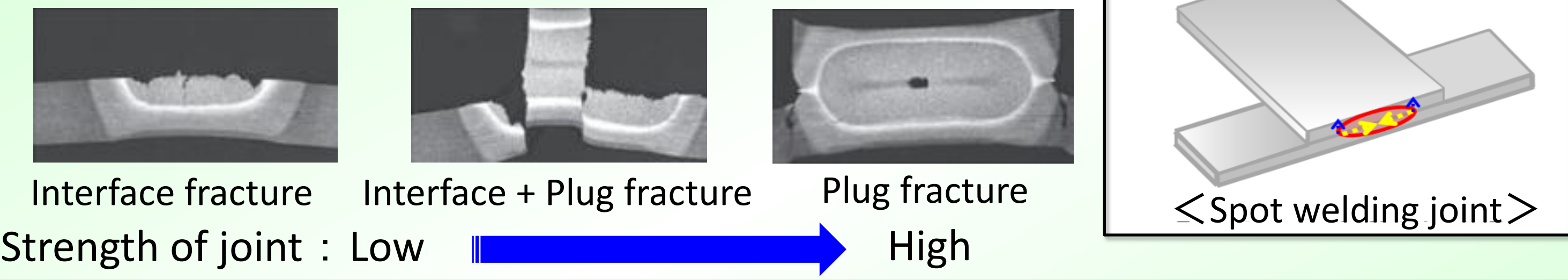
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Background, Objectives of this study

Problems of spot welding joint

Strength of spot weld joint may decrease on high tensile steel depending on the fracture mode

Fracture mode of spot weld joint



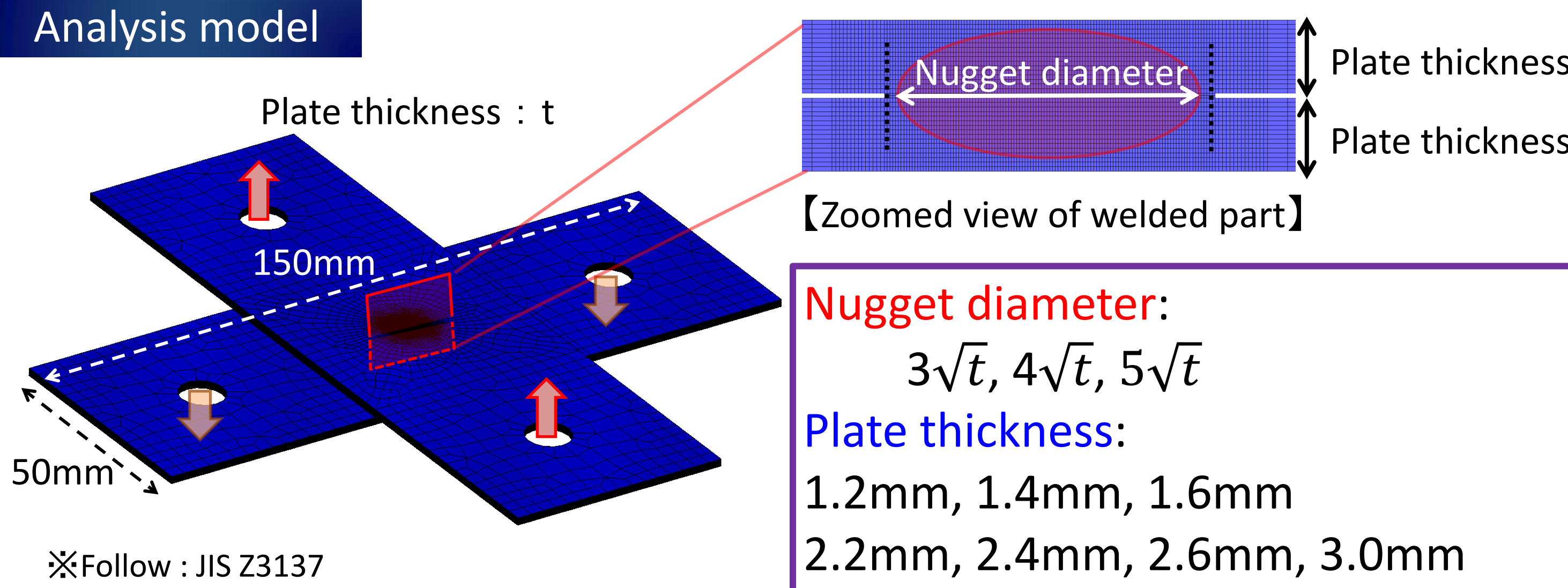
Prediction of fracture mode is important to investigate the mechanism of changing fracture mode

Objectives

- Proposal of analysis method to simulate ductile fracture
- Prediction of the fracture mode of the spot weld joints

Apply to the analysis of cross tension test on spot weld

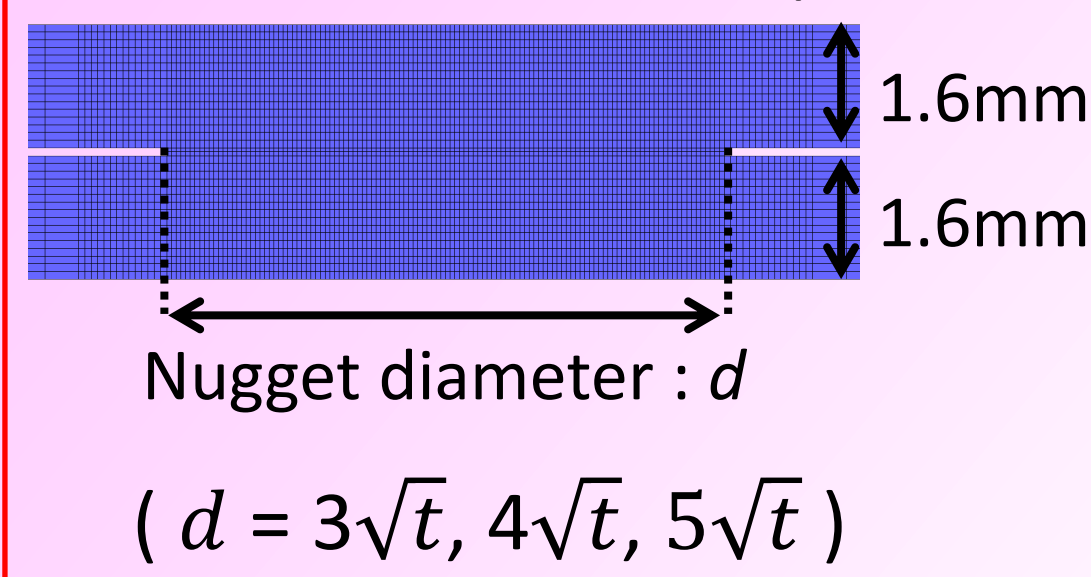
Analysis model



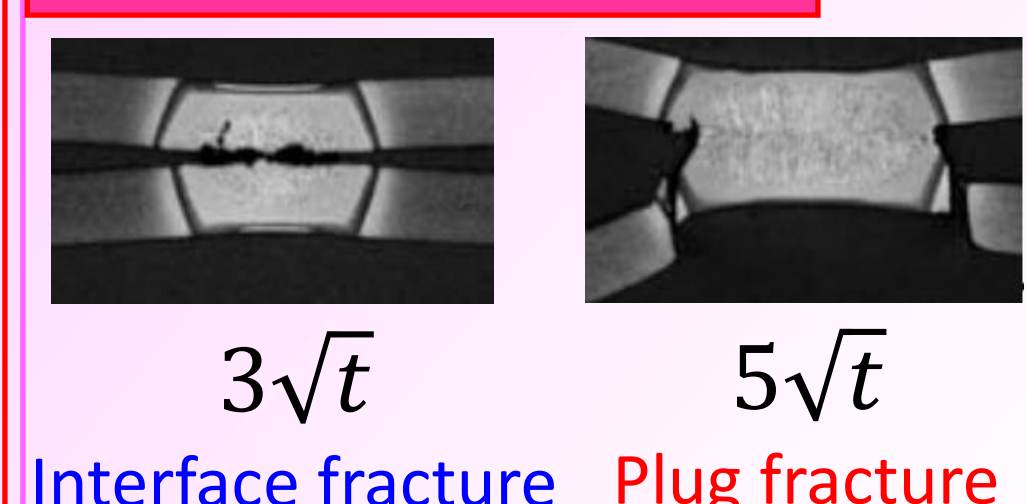
Influence of nugget diameter on fracture mode

Analysis model and result

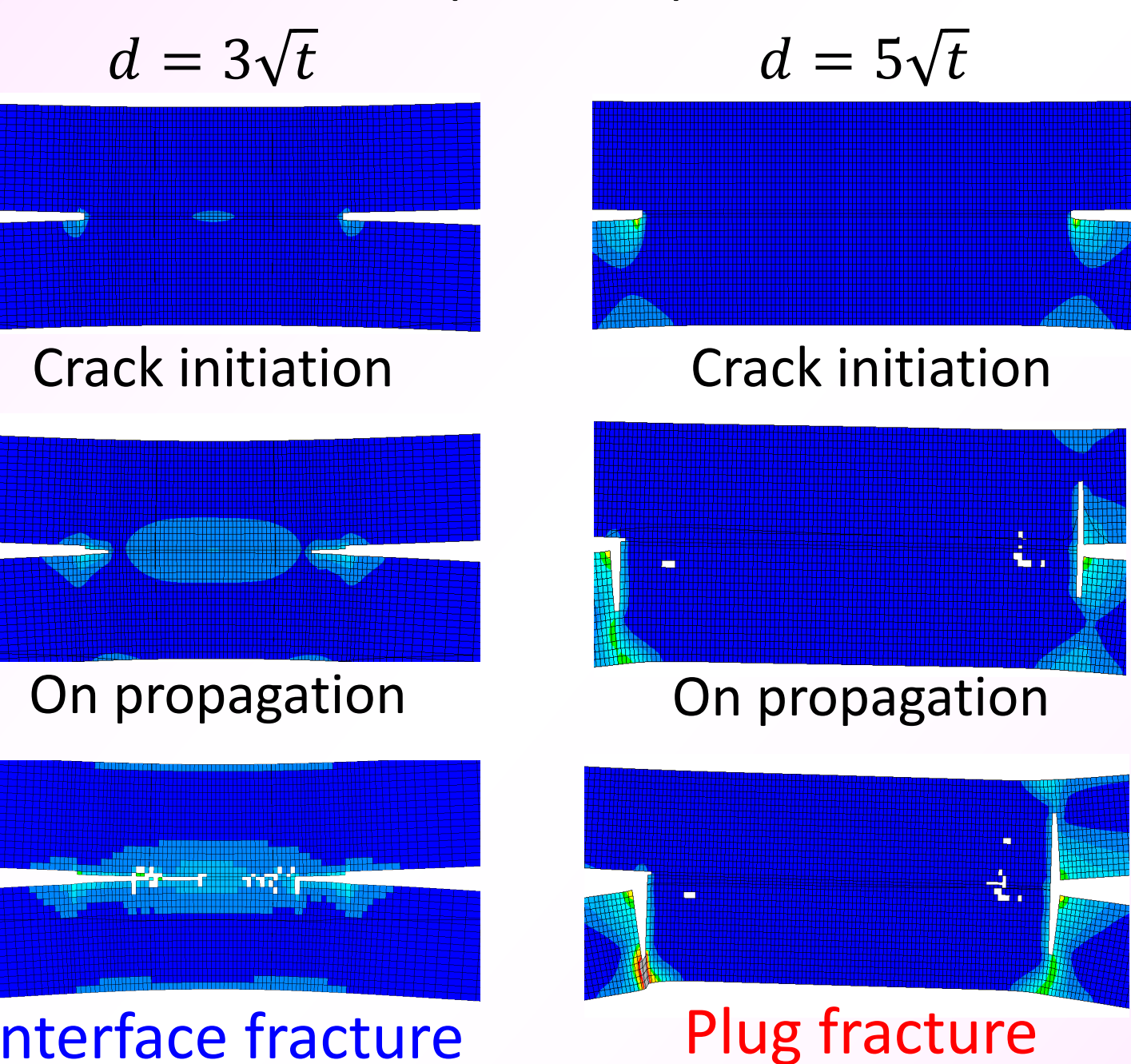
【Zoomed view of welded part】



Result of experiment

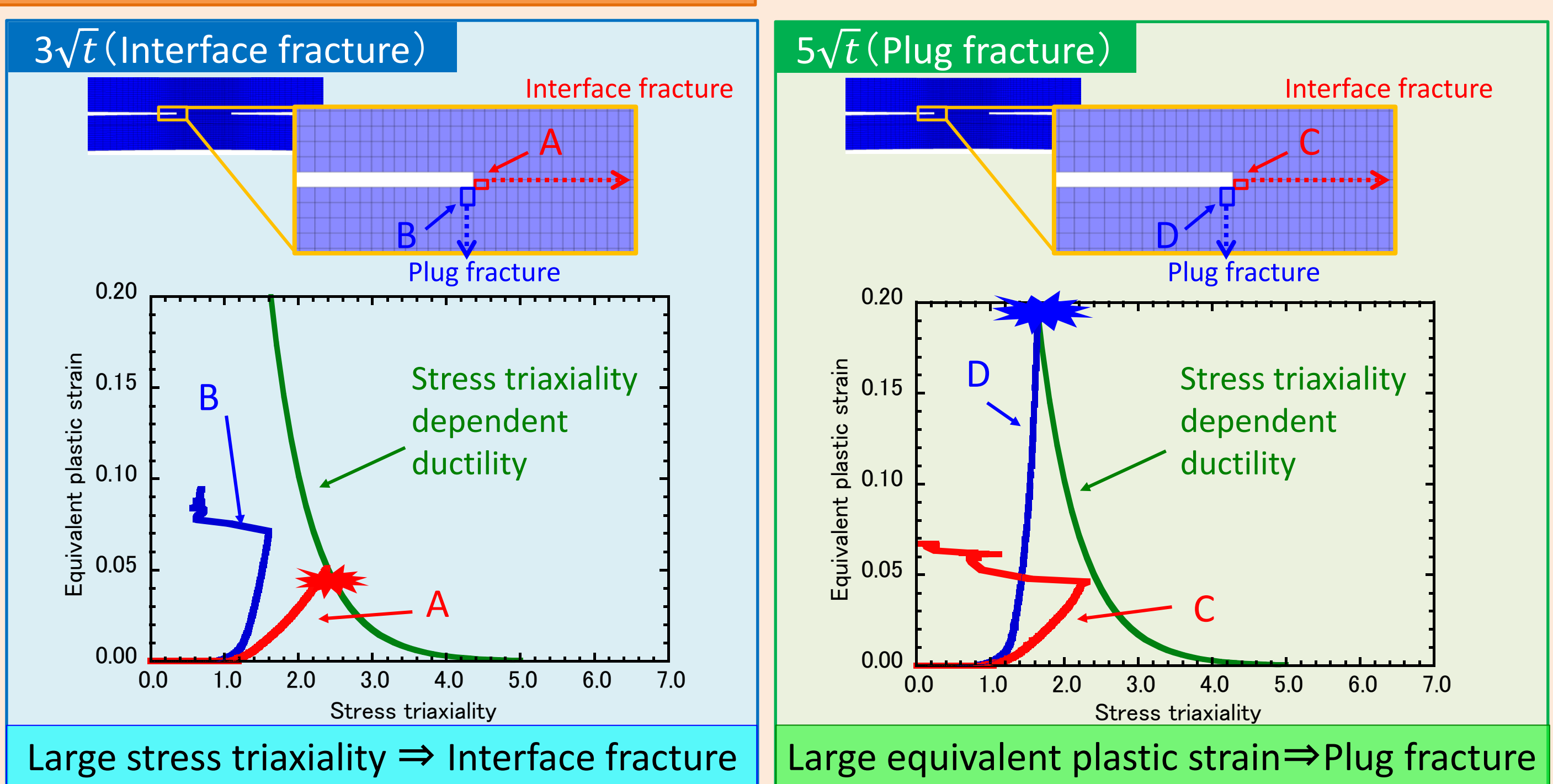


【Distribution of equivalent plastic strain】



These results are in agreement with result of the past experiment

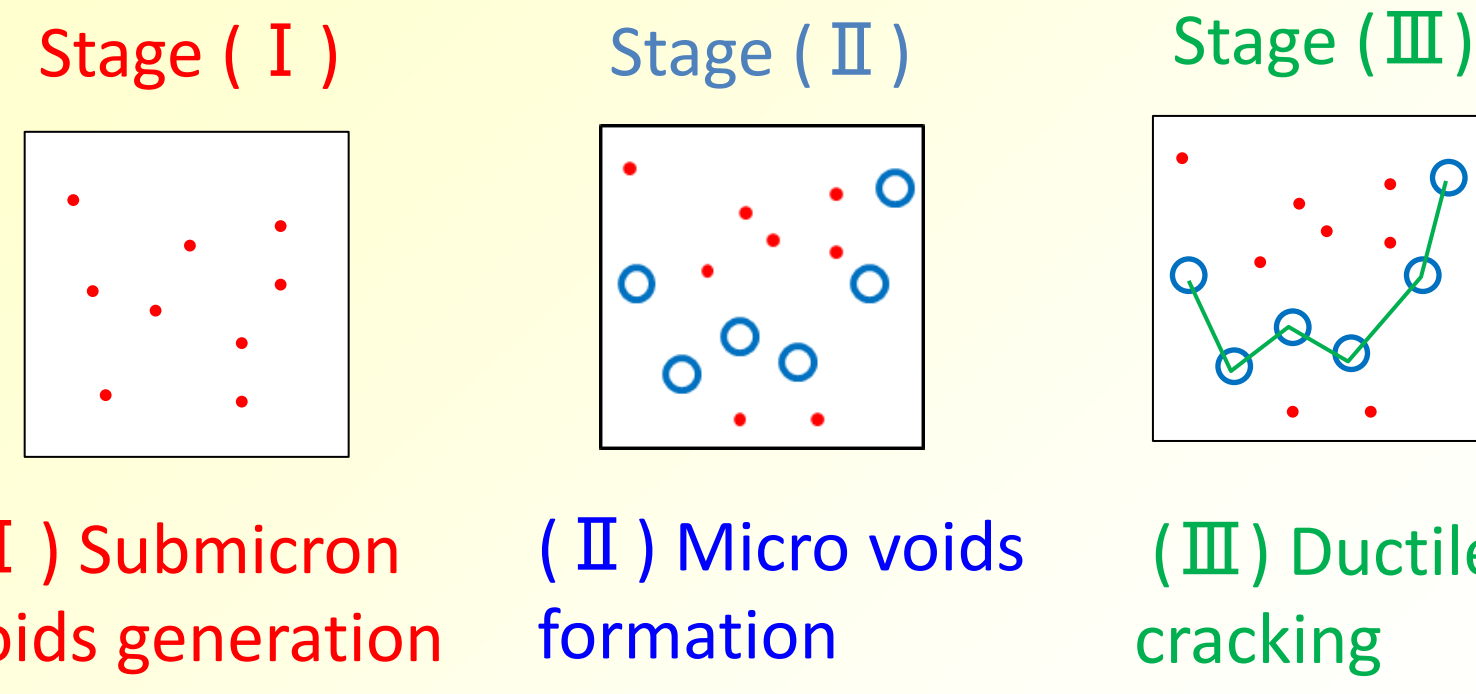
Factors of difference of fracture mode



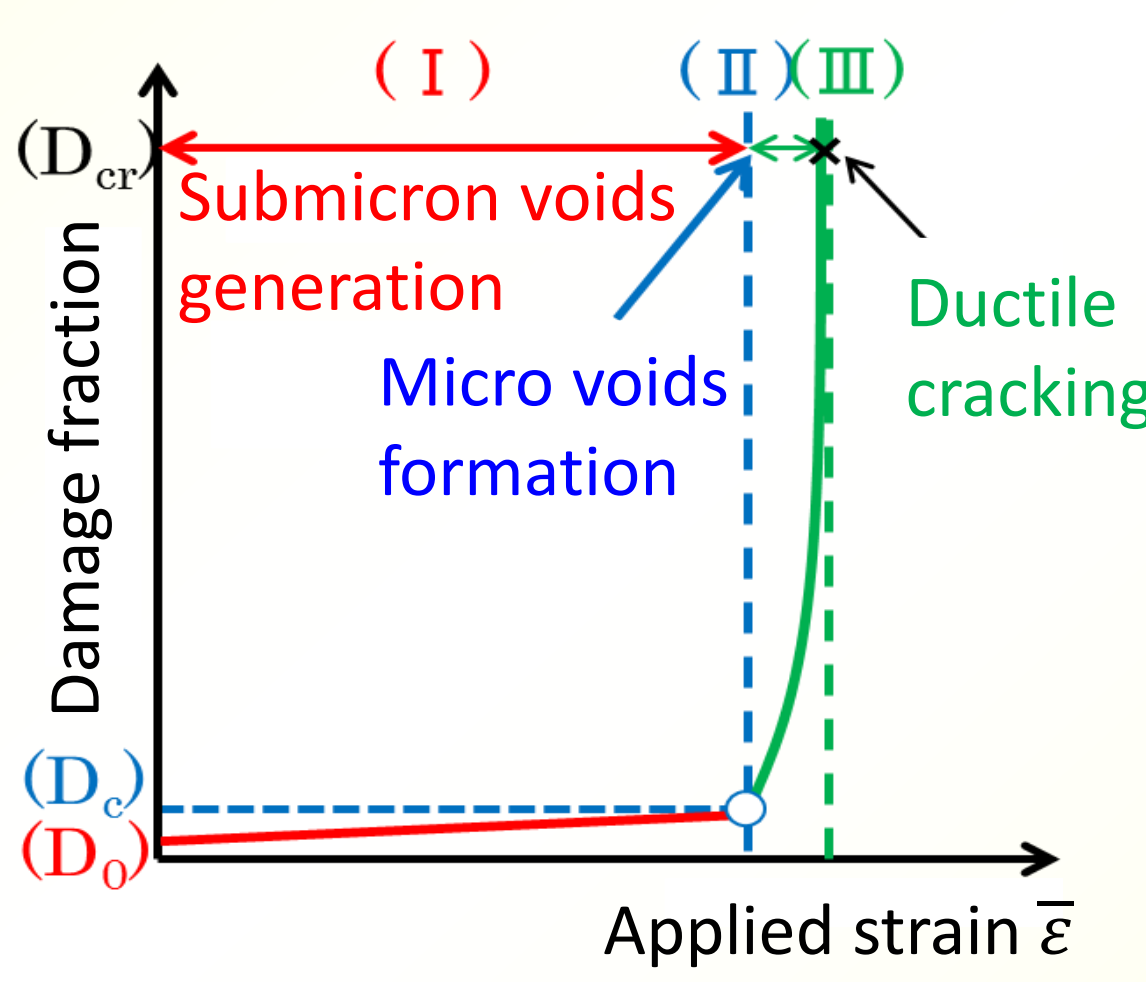
Change of fracture mode due to nugget diameter can be predicted

Proposal of analysis method

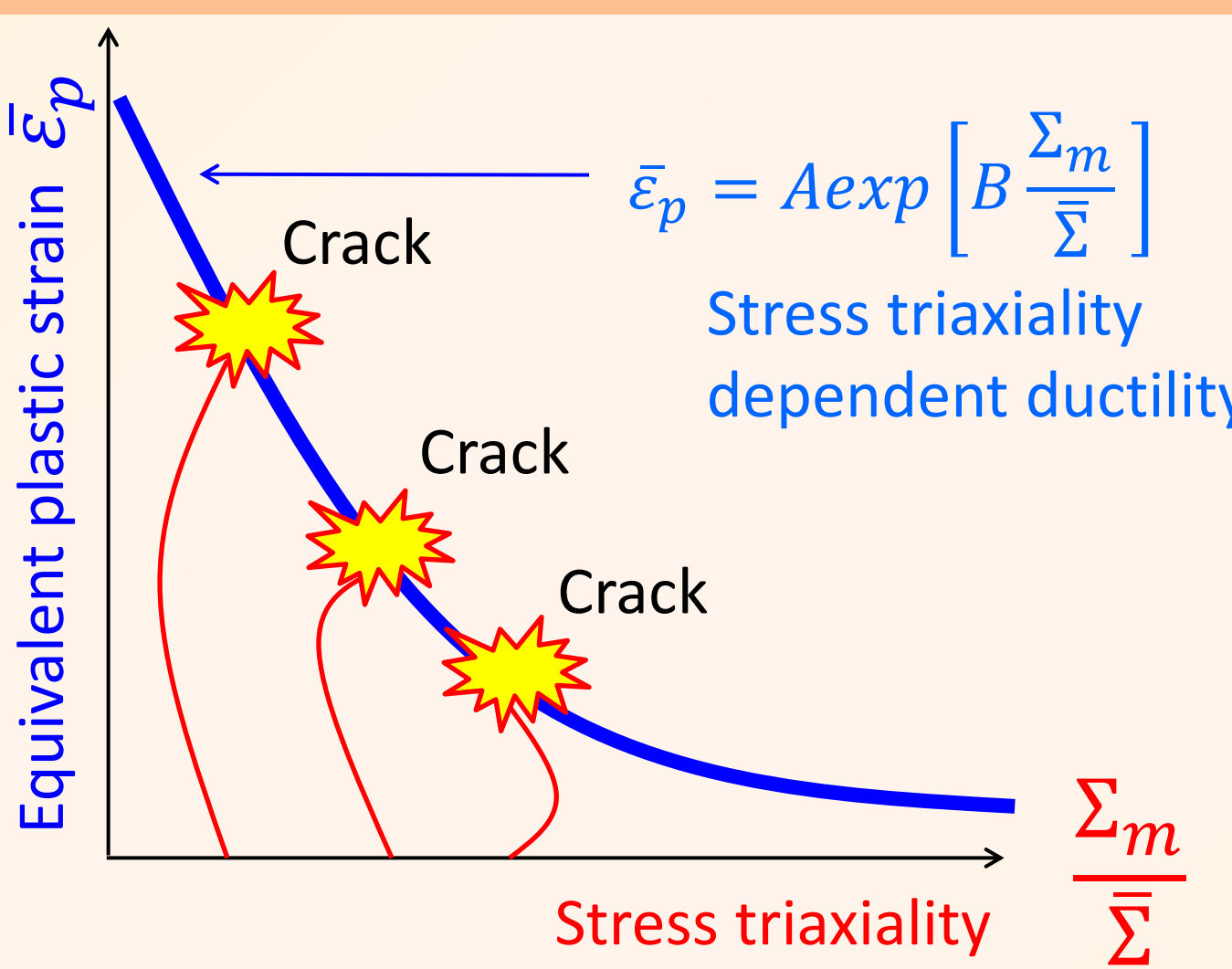
Progress of damage



Damage model based on the observed damage process
Reference : M.Ohata, T.Fukuhara, F.Mitsumori, Damage Model for Predicting the Effect of Steel Properties on Ductile Crack Growth Resistance, International Journal of Damage Mechanics, Vol. 19(2010), pp.441-459



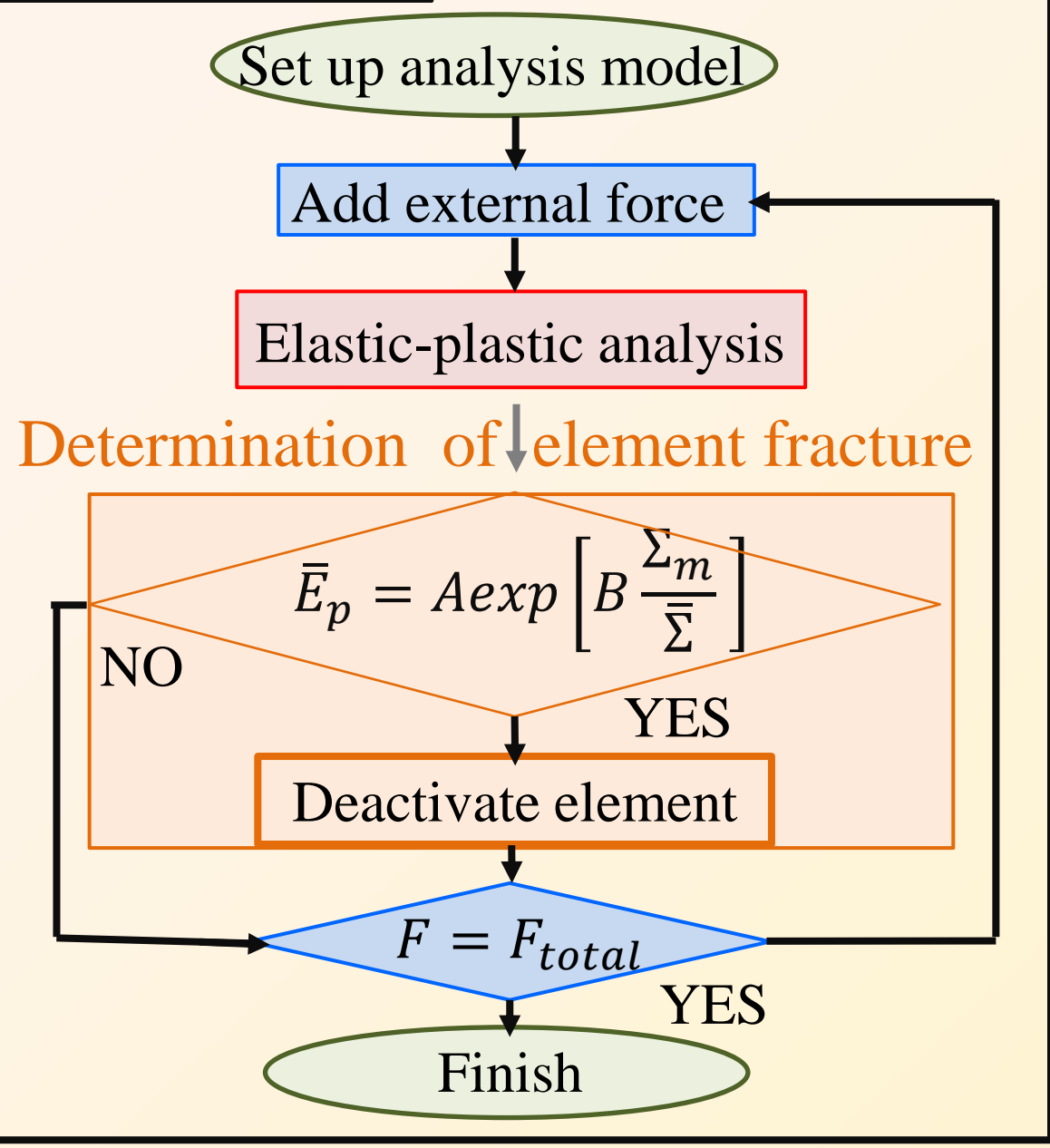
Simplified crack propagation analysis method



Fracture is evaluated from only stress triaxiality and equivalent plastic strain

Ductile fracture is predicted by performing elastic-plastic analysis

Analysis flow



Influence of plate thickness on fracture mode

Analysis model and result

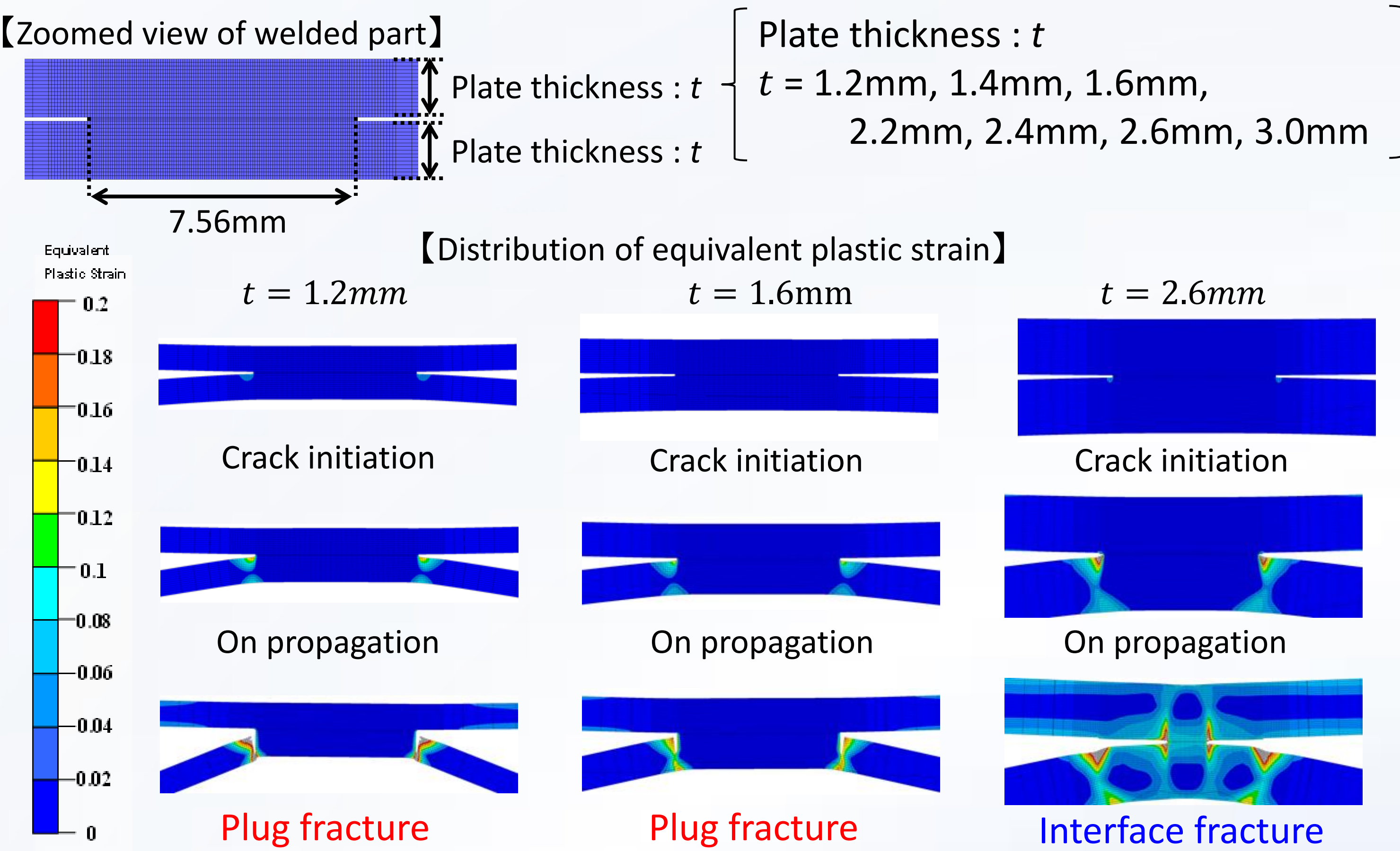
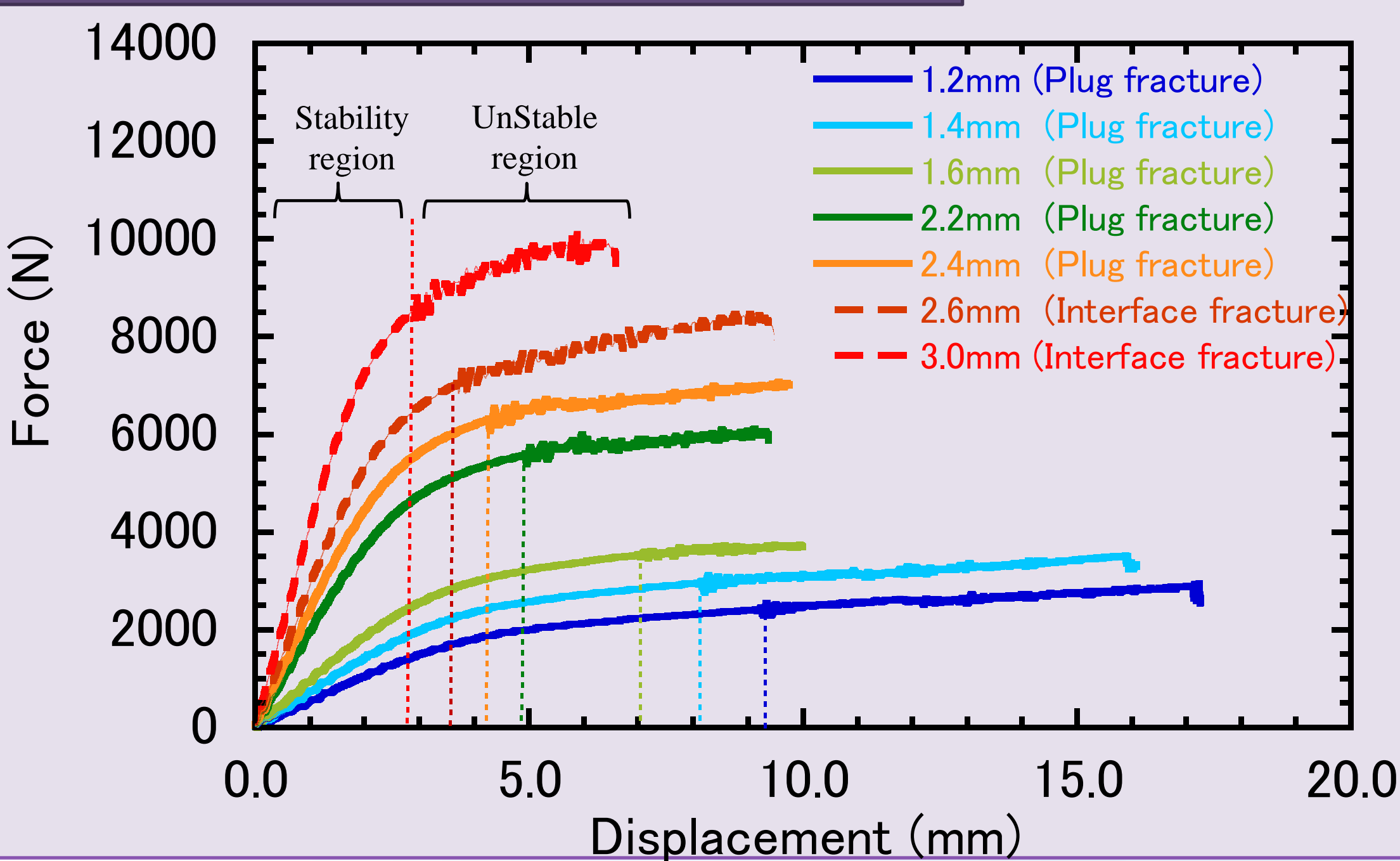


Plate thickness : thin ⇒ Plug fracture, Plate thickness : thick ⇒ Interface fracture

Load-displacement curve in several plates thickness



Change of fracture mode due to plate thickness can be predicted

Conclusions

In this study, a simplified ductile fracture evaluation method based on continuum damage mechanics was proposed. And the proposed method was applied to cross tension test on spot weld joints to investigate fracture modes. The following results were obtained.

- 1) It was shown that the fracture mode of the cross tension test on spot welding can be predicted by using the proposed method.
- 2) It is found that size of nugget diameter affect fracture mode, in the case of small nugget diameter, fracture mode is interface fracture, and in the case of large nugget diameter, fracture mode is plug fracture.
- 3) Through the comparison of the fracture behavior, it was found that crack propagates into the nugget due to large stress triaxiality in the case of interface fracture. On the other hand, crack propagates along the outer periphery of the weld nugget due to the large equivalent plastic strain in case of plug fracture.