The durability evaluation study for Welding

T.Nakamaru
NISSAN MOTOR CO., LTD.

Contents

1. Motivation

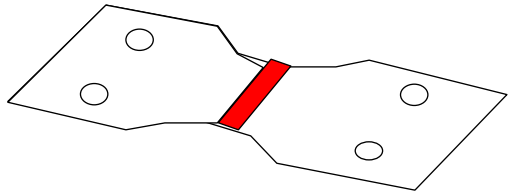
- Accuracy Verification of FEMFAT WELD Analysis at Welding seam
- Proposal of "*Extended Welding seam**" Analysis with a New Modeling method

* ***Extended Welding seam***: This welding measure is applied in Japan as often as about 30% of all welding parts. The purpose of this is to make welding start and end parts more stable, to ease sharp difference in stiffness distribution and to avoid large stress concentration.

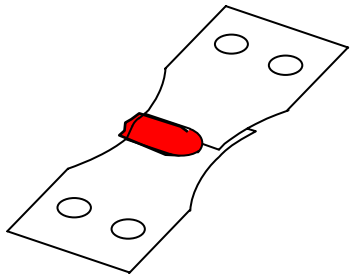
1. Motivation

Words definition

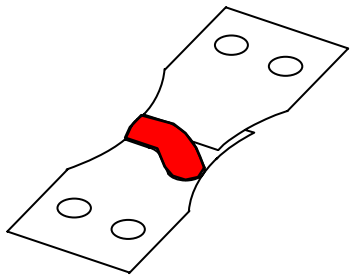
- Normal Welding seam



- End-free Welding seam



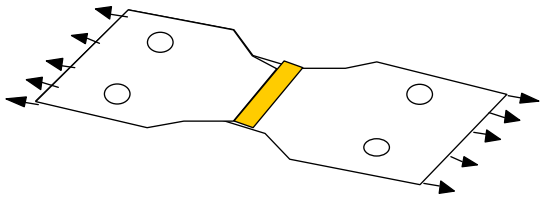
- Extended Welding seam

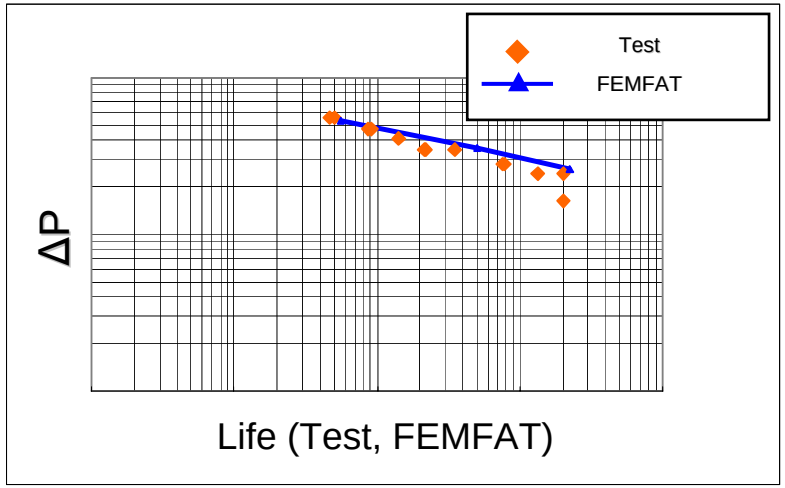


2. Accuracy verification of FEMFAT WELD with test specimen

Normal Welding Seam. Over lap Weld

<Tensile condition >

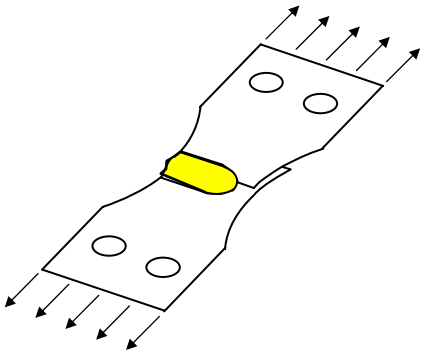




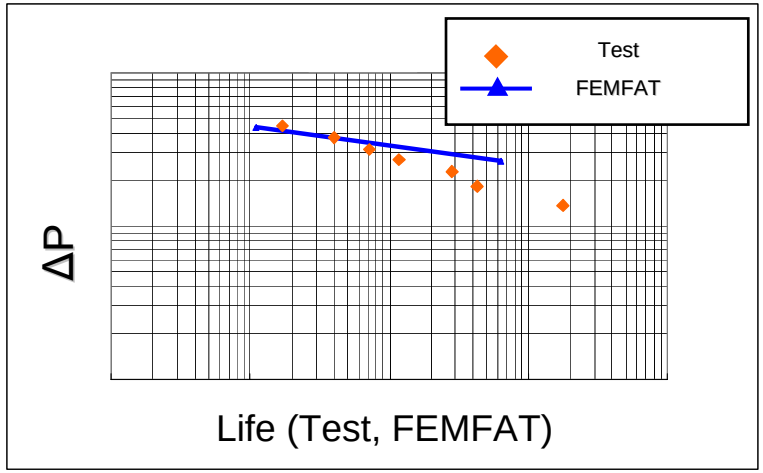
FEMFAT Accuracy Verification (ΔP-N curve)

2. Accuracy verification of FEMFAT WELD with test specimen

Test Specimen with End-free welding (ΔP-N curve)



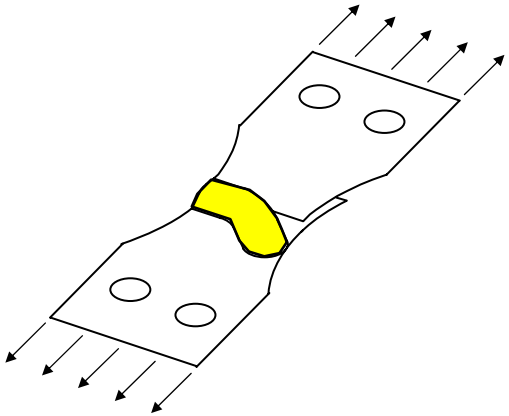
*root area

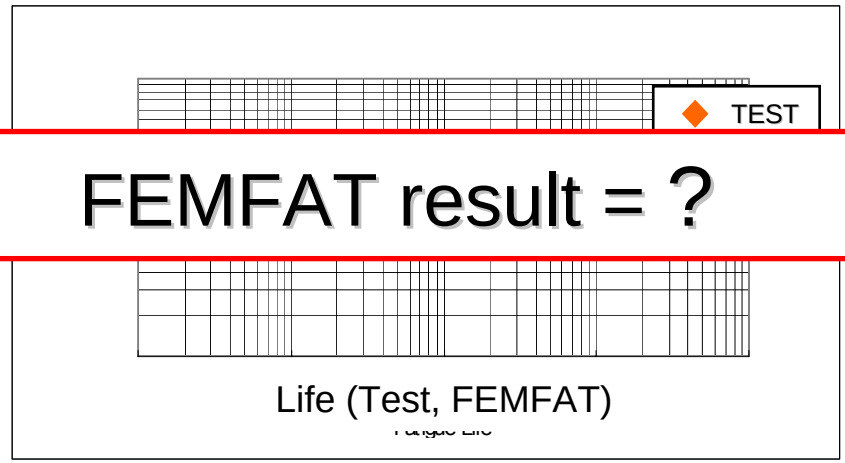


FEMFAT Accuracy Verification (ΔP-N curve)

2. Accuracy verification of FEMFAT WELD with test specimen

Test Specimen with Extended welding. (ΔP-N curve)

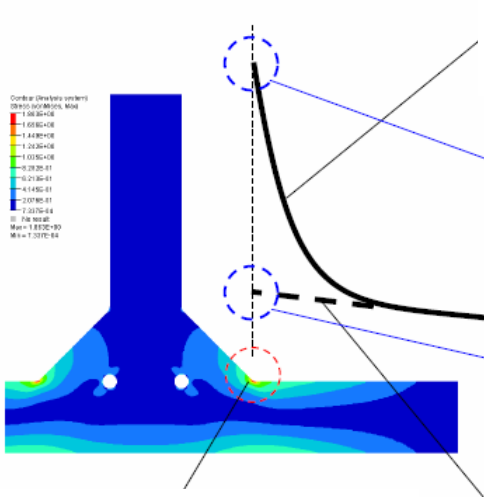




FEMFAT result = ?

2. Accuracy verification of FEMFAT WELD with test specimen

Notch Factor Database used in FEMFAT WELD



Stress concentration area (toe)

Actual stress distribution

Actual Max stress

Ratio = Stress concentration ratio

Hot spot stress
----stress at shell element

Nominal stress distribution
Shell stress distribution

Notch Factor Database (FEMFAT)

- Normal Welding seam : ○ (available)
- End-free Welding : ○ (available)
- Extended Weld : X (n.a.)

3. Introduction of New Modeling Method for welding seam fatigue analysis

< Approach for Welding Part Analysis >

- Determine the Evaluation criteria of fatigue analysis and Proper Modeling method
- Establish Experimental S-N curve Database Based on the Evaluation Criteria

Calculate Stresses by FEM Analysis with Specially-modeled Weld ⟷ Fatigue Life Prediction by Experimental S-N curve Database

Unique evaluation criteria is necessary which is independent of factors (crack mode, load direction and etc.)

3. Introduction of New Modeling Method for welding seam fatigue analysis

Selection of suitable Evaluation Criteria for Application

Table. Rating table due to applicability

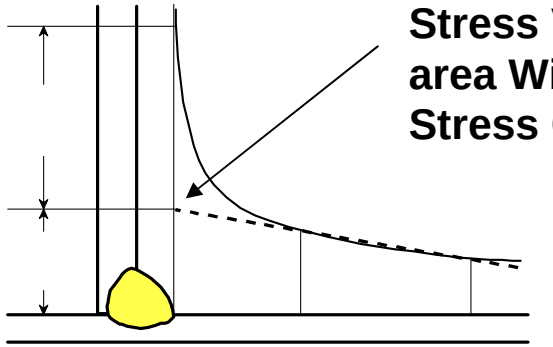
Criteria / Concerns	Toe area	Root area	Routine Work
Nominal stress	×	×	○
Hot spot stress	○	△	○
Local stress	○	△	×
Stress intensity	○	○	×

Rating

○… 1

△… 2

×… 3



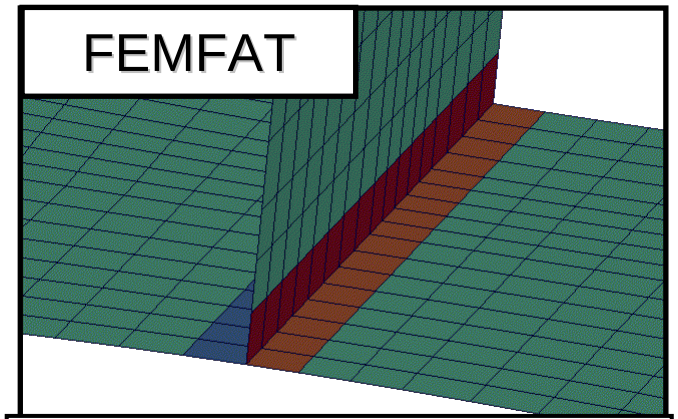
Hot-Spot Stress is suitable for Practical Application.

Fig. Concept of Hot-Spot Stress σhs

3. Introduction of New Modeling Method for welding seam fatigue analysis

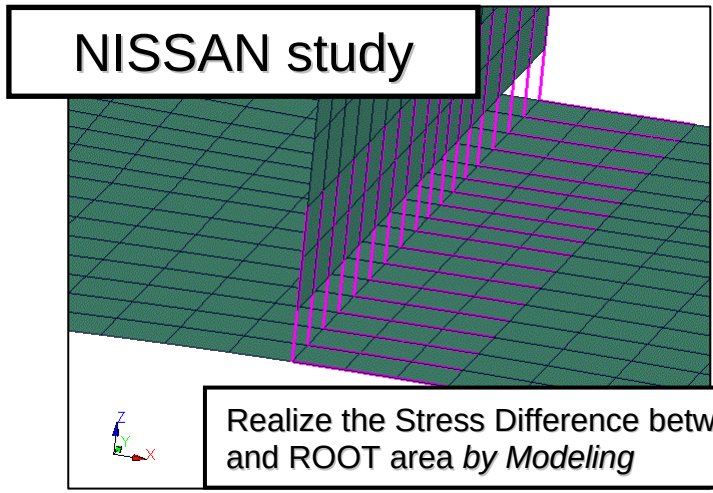
Difference in Welding Part modeling method (Between FEMFAT and NISSAN)

FEMFAT



Realize the Stress Difference between TOE and ROOT area *by Notch Factor*

NISSAN study



Realize the Stress Difference between TOE and ROOT area *by Modeling*

< Method of Stress Difference Description between ROOT area and TOE area >

FEMFAT: By Notch Factor

NISSAN : By Modeling

3. Introduction of New Modeling Method for welding seam fatigue analysis

Detailed Model for Accuracy Verification for Normal welding

The models below are used to calculate Hot-Spot Stress accurately

Fig. Fine section FE model

4. Accuracy verification and modeling of New Method with test specimen

4-1. Normal welding seam

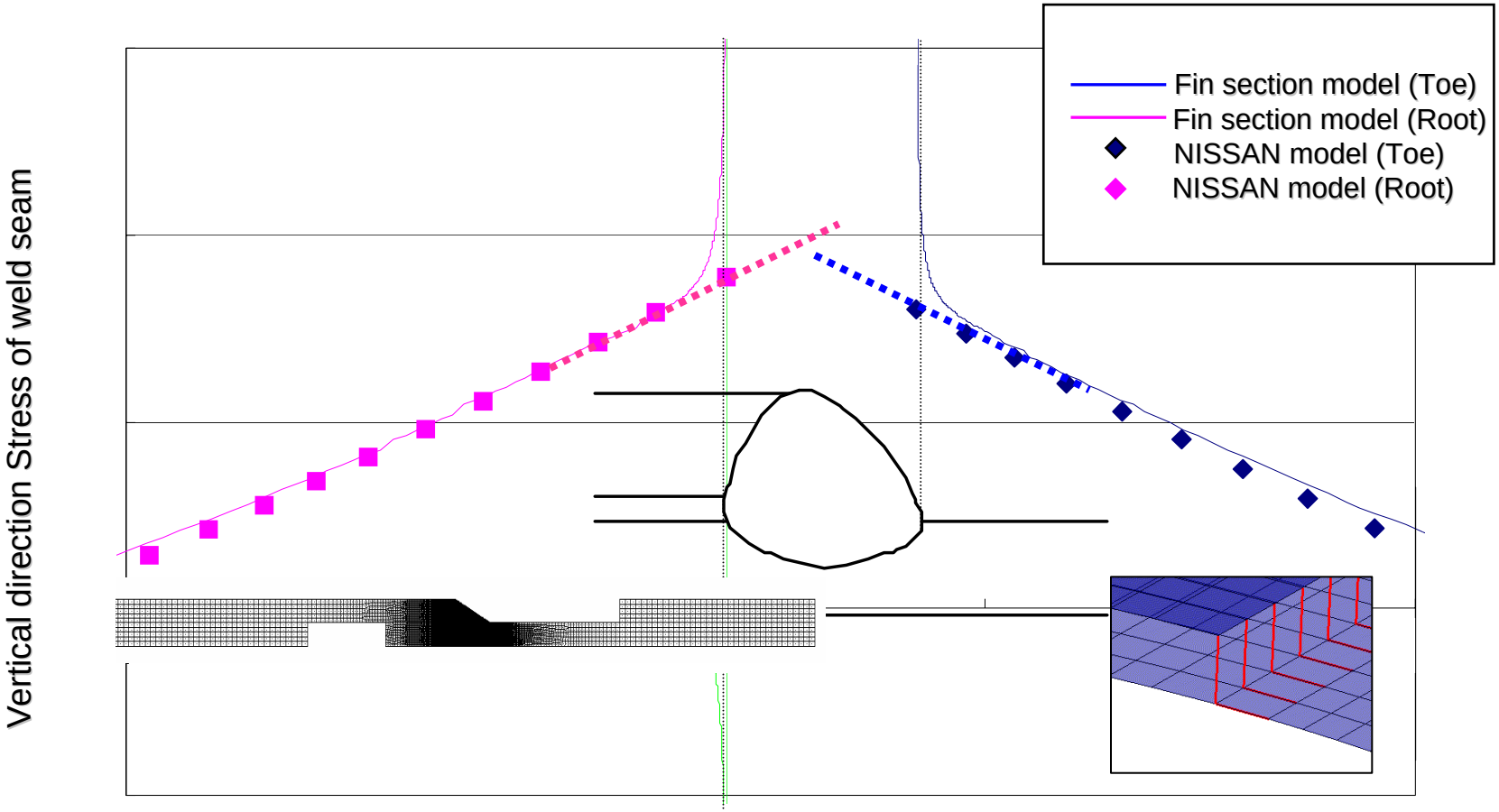
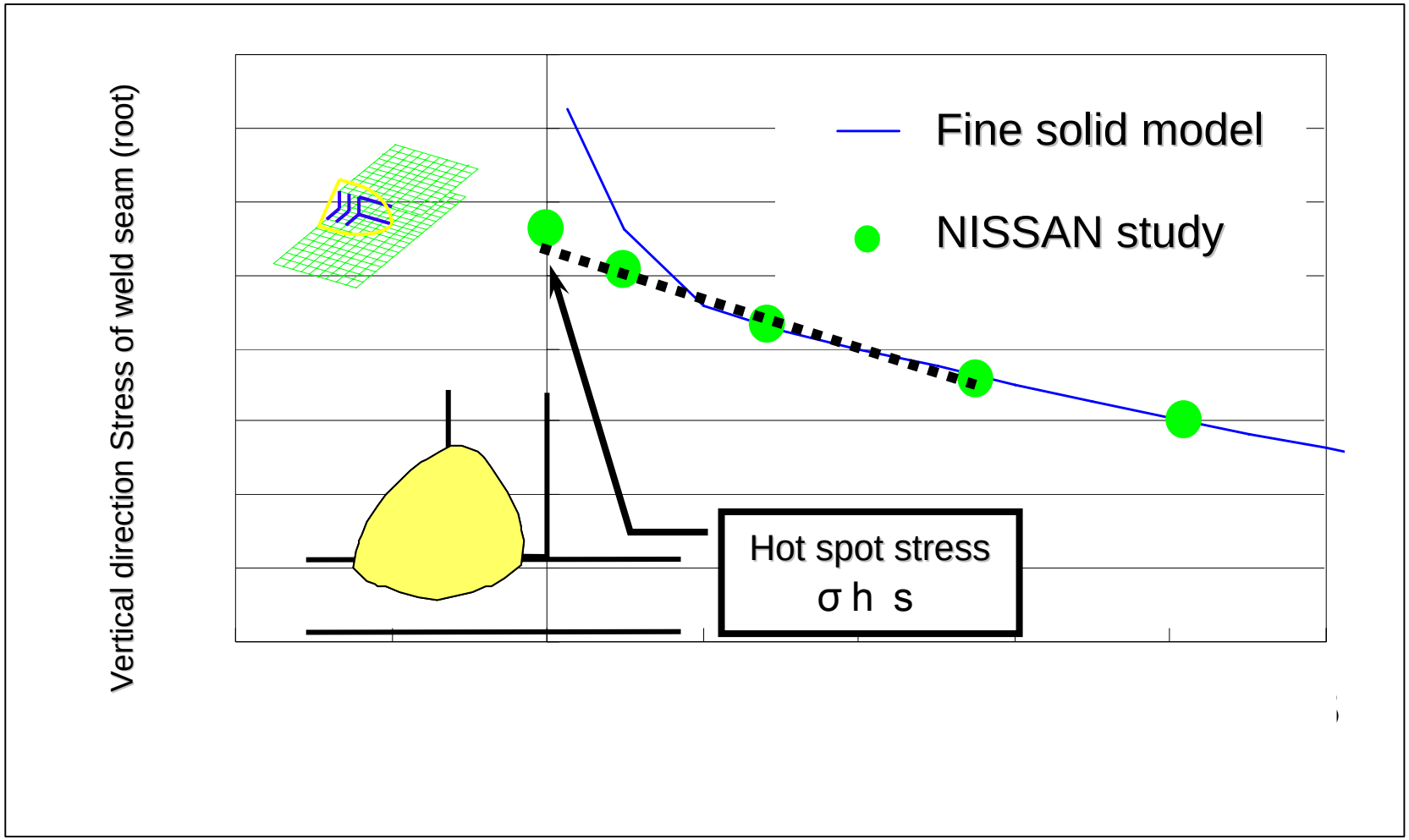


Fig. FE Stress (Over lap Weld)

4. Accuracy verification and modeling of New Method with test specimen

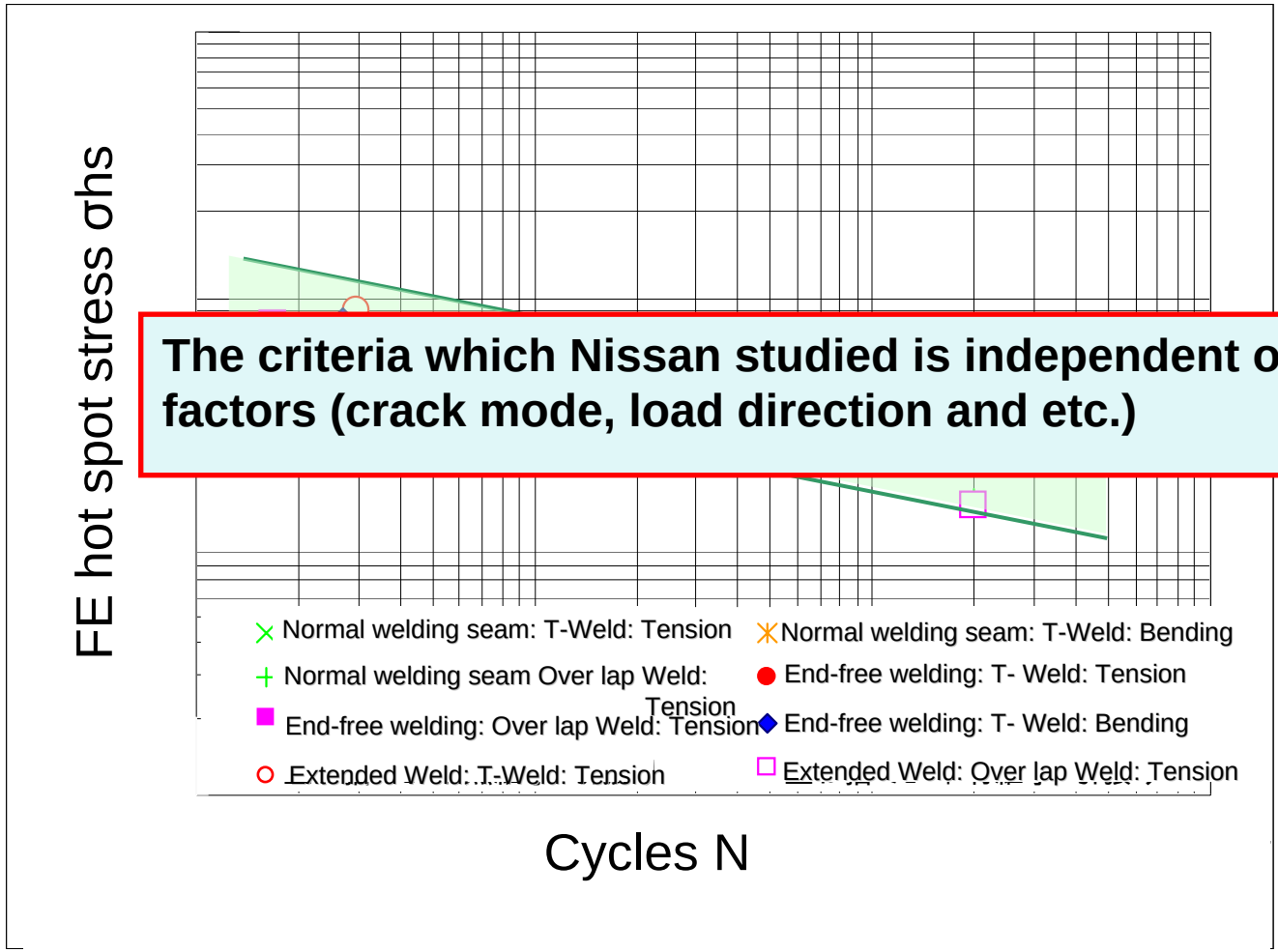
4-2. End-free welding seam and Extended welding seam

Hot spot stress (σhs) verification of End-free welding



4-3. Verification σhs-N curve of All test models

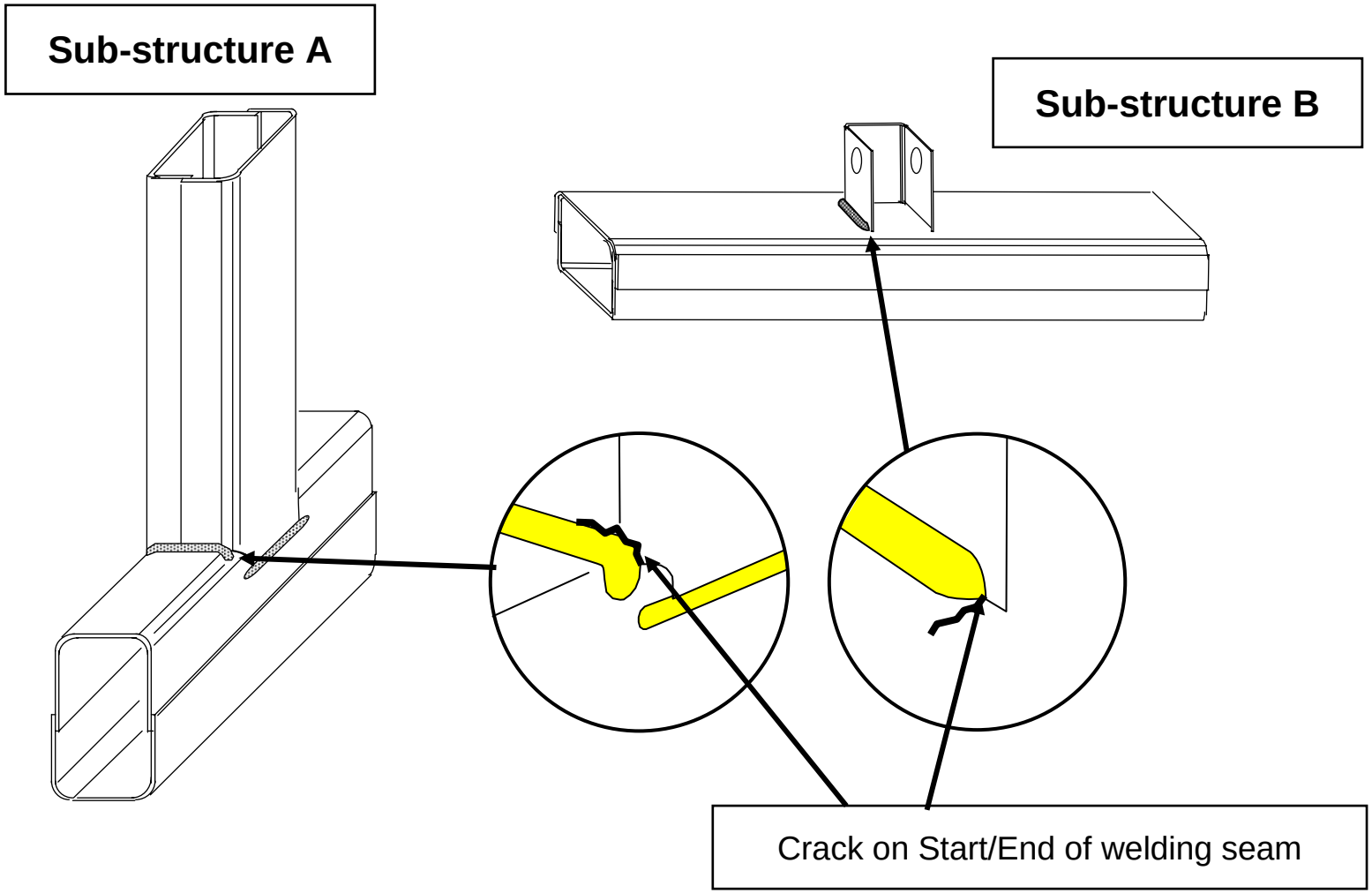
All test model σhs - N curve



The criteria which Nissan studied is independent of factors (crack mode, load direction and etc.)

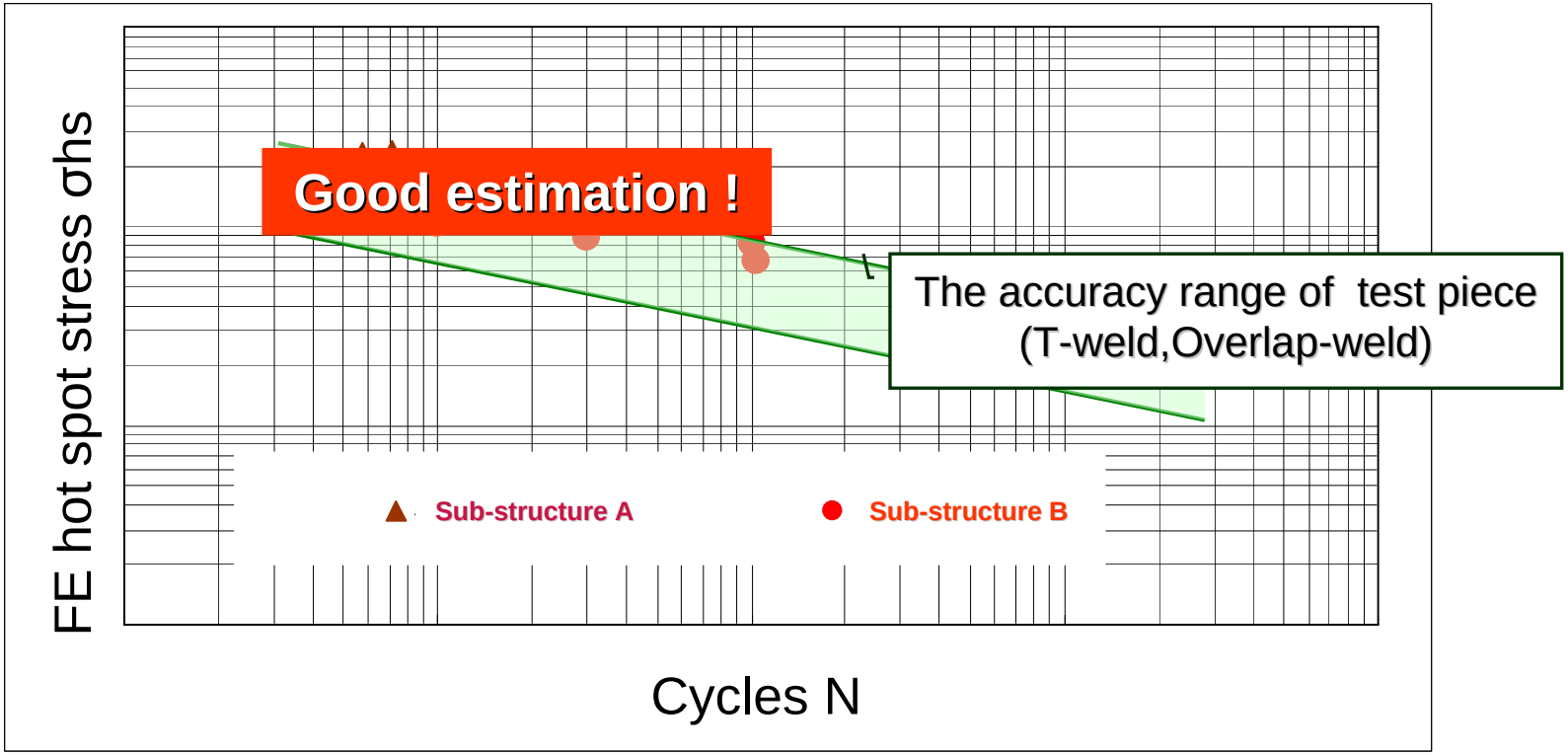
4-3. Verification σhs-N curve of Sub-structure models

Sub-structure models



4-3. Verification σhs-N curve of Sub-structure models

All test model σhs - N curve included the result of sub-strucure model



5. Summary

We concluded Pros (+) and Cons(-) of FEMFAT and NISSAN method for Fatigue life prediction at welding seams as follows:

- FEMFAT Method:
  (**+**) Easy modeling.

  (**-**) Lack of Database for Extended Welding which is commonly used.
  ==> Database enhancement is expected for Extended-Weld.

- NISSAN Method:
  (**+**) NISSAN Method is effective for Extended Welding, as well as normal and end-free Welding seam.

  (**-**) Time and effort consuming for modeling.
  The usage of external tool like FEMFAT is necessary for practical routine work.