CAE simulation 2

For the dog bone fatigue, find the safety factor and the number of repetitive loads before fatigue failure (Life) for the following four cases. For cases 1, 2, and 3, compare the analytical results with the Goodman theory. In this case, a new SS400 material is created and used for the analysis (E=200GPa, v=0.3, tensile strength 400MPa, yield strength 250MPa, endurance limit at laboratory condition Se=200MPa at 106 cycles) Apply the fatigue strength factor $= 0.50$ considering $C + C_f C_r C_s C_t$ values at the service condition.

With the given condition, coefficients for considering stress concentration in the fillet structure can be calculated as follows :

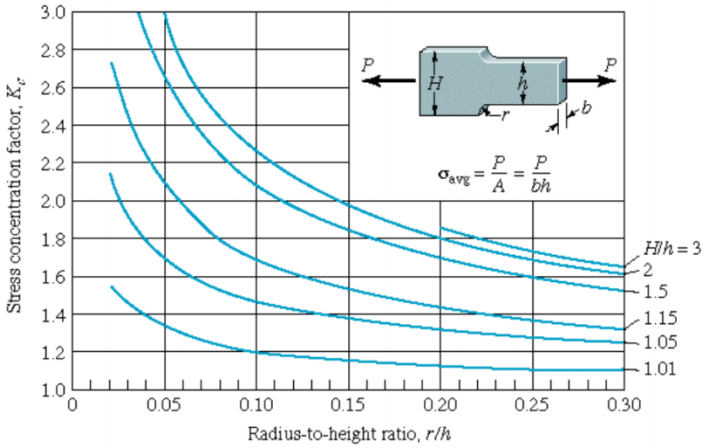


Figure 1. Stress concentration table of fillet structure

$$\frac{H}{\mathrm{h}} = \frac{15[mm]}{5\ [mm]} = 3.0, \qquad \frac{r}{\mathrm{h}} = \frac{3\ [mm]}{5\ [mm]} = 0.6\,, \quad K = 1.45$$

$$\sigma_{nom} = \frac{281.75\ [N]}{0.75 \times 5} = 75\ [MPa], \quad \sigma_{max} = K \times \sigma_{nom} = 108.75\ [MPa]$$

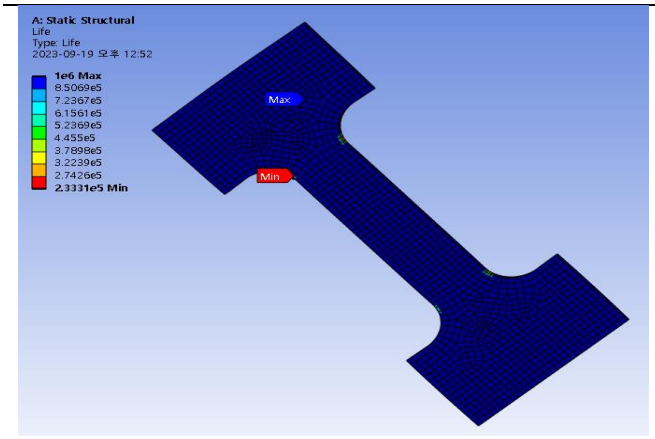
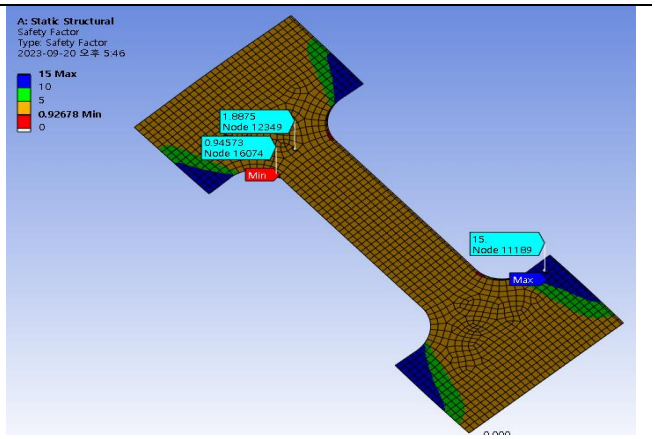
Since fatigue strength factor is set with 0.5, σ_e value at 10^6 cycles has to be calculated with $200\ [\mathrm{MPa}] \times 0.5 = 100\ [MPa]$.

Following the Goodman theory, safety factor can be calculated with the following equation.

$$\frac{\sigma_a}{\sigma_e} + \frac{\sigma_m}{\sigma_{ut}} = \frac{1}{N}$$

1. Fully reversed

- Apply 10^6 cycles for infinite life

Life	Safety factor
	

Ansys simulation result about fully reversed fatigue factor indicates that with 2.3331e5 cycles, the safety factor in the part with 'min' marked is lower than 1 (0.94573). To get the theoretical value in this case, σ_a is set with $108.75\,[MPa]$, which is considered with stress concentration. Furthermore, σ_e value is set with $100\,[MPa]$ at 10^6 cycles , since the fatigue strength factor is 0.5.

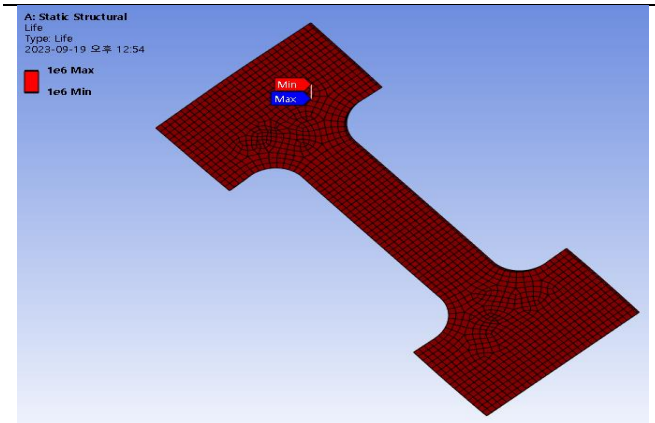
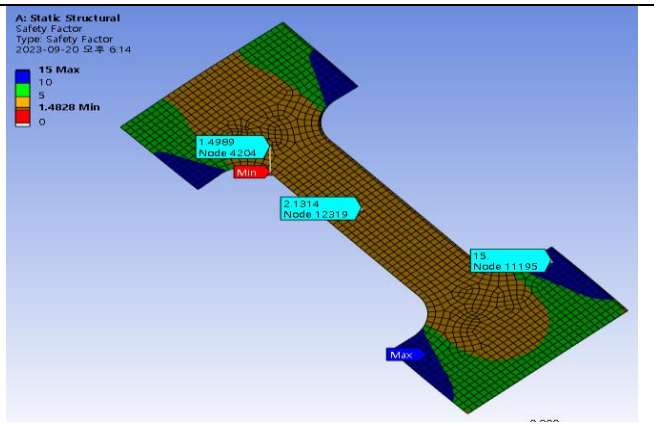
Safety factor in fully reversed case can be calculated as follows :

$$\frac{\sigma_a}{\sigma_e}+\frac{\sigma_m}{\sigma_{ut}}=\frac{108.75\,[\mathrm{MPa}]}{100\,[MPa]}+\frac{0\,[MPa]}{400\,[MPa]}=\frac{1}{N}$$

$$N=0.92$$

2. Zero-based

- Apply 10^6 cycles for infinite life

Life	Safety factor
	

Ansys simulation result about zero based fatigue factor indicates that with 1e6 cycles, the safety factor in the part with 'min' marked is 1.48. To get the theoretical value in this case, σ_a is set with $54.375\,[MPa]$, which is considered with stress concentration. Furthermore, σ_e value is set with $100\,[MPa]$ at 10^6 cycles , since the fatigue strength factor is 0.5.

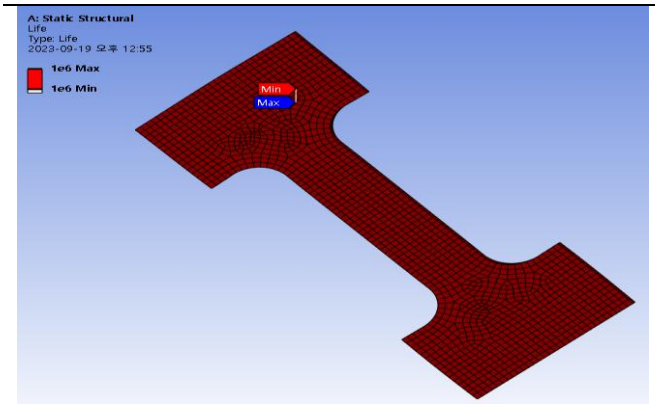
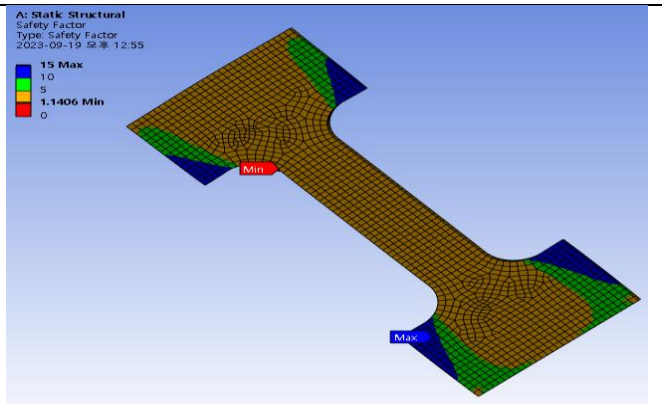
Safety factor in zero-based fatigue case can be calculated as follows :

$$\frac{\sigma_a}{\sigma_e}+\frac{\sigma_m}{\sigma_{ut}}=\frac{54.375\,[\mathrm{M}Pa]}{100\,[MPa]}+\frac{54.375\,[MPa]}{400\,[MPa]}=\frac{1}{N}$$

$$N=1.47$$

3. Ratio-based

- Apply 10^6 cycles for infinite life

Life	Safety factor
	

Ansys simulation result about ratio based fatigue factor indicates that with 1e6 cycles, the safety factor in the part with 'min' marked is 1.14. To get the theoretical value in this case, σ_a is set with $81.56\,[MPa]$, which is considered with stress concentration. Furthermore, σ_e value is set with $100\,[MPa]$ at 10^6 cycles , since the fatigue strength factor is 0.5.

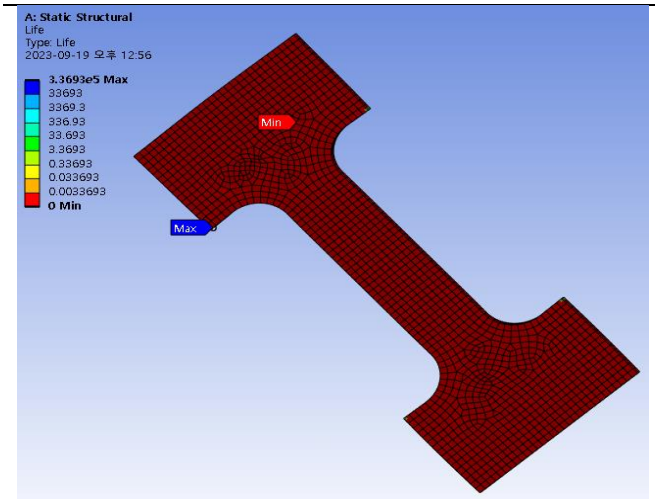
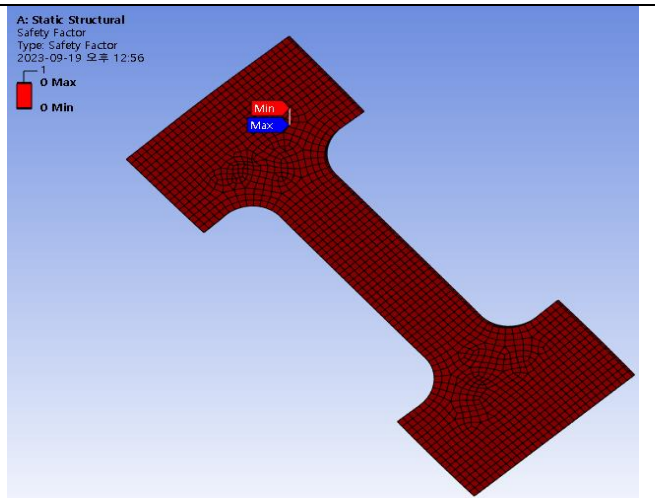
Safety factor in fatigue with ratio-based case can be calculated as follows :

$$\frac{\sigma_a}{\sigma_e}+\frac{\sigma_m}{\sigma_{ut}}=\frac{81.56\,[\mathrm{M}Pa]}{100\,[MPa]}+\frac{27.1862\,[MPa]}{400\,[MPa]}=\frac{1}{N}$$

$$N=1.13$$

4. History data : Apply SAE Bracket History

- Apply 10^9 blocks for infinite life

Life	Safety factor
	

Ansys simulation result about historical data-based fatigue factor indicates that safety factors of every part is about zero even though the cycle is not up to 1,000,000 cycles.