2-3. Investigation on Fatigue Types

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.

- It was set according to the conditions given.

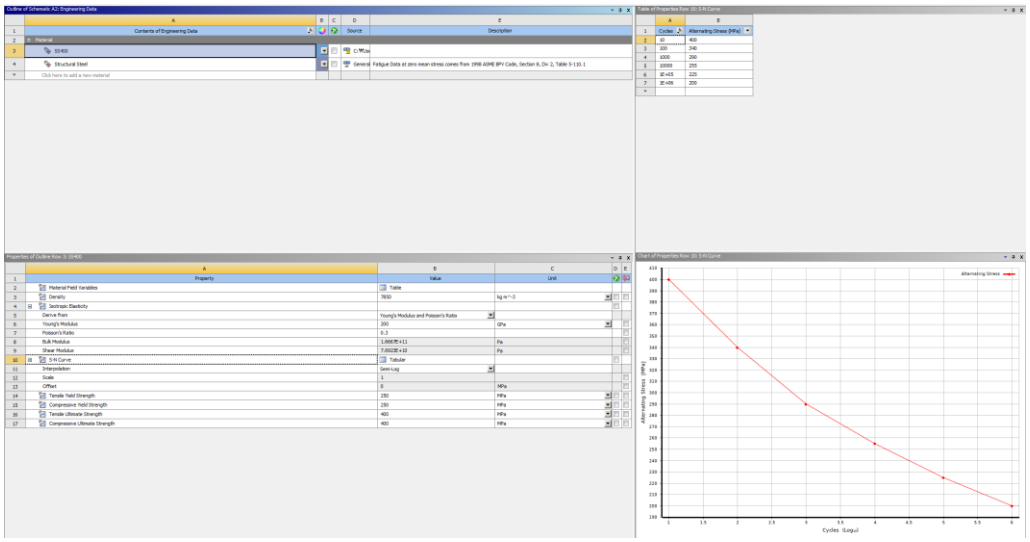


Figure 1. Material setting

- Figure 2 was used to obtain the stress.

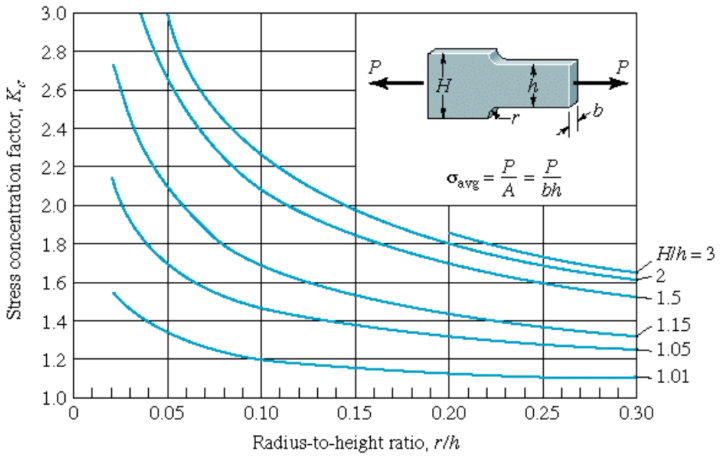


Figure 2. Stress Concentrations of Plate with Fillet

$$\sigma_{avg} = \frac{F}{A} = \frac{PA'}{bh} = \frac{(25 \times 10^6)(0.75 \times 15 \times 10^{-6})}{0.75 \times 10^{-6} \times 5} = 75\text{MPa}$$

$$\frac{H}{h} = \frac{15}{5} = 3, \qquad \frac{r}{h} = \frac{3}{5} = 0.6 \;\rightarrow\; K_c = 1.45$$

We can calculate maximum stress using following equation.

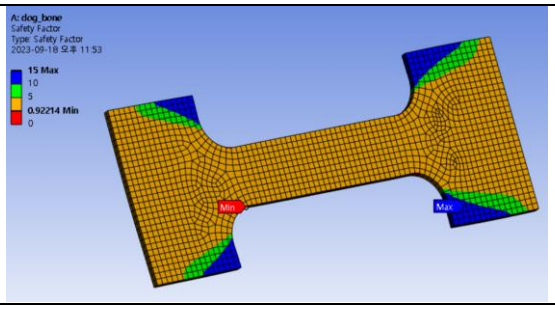
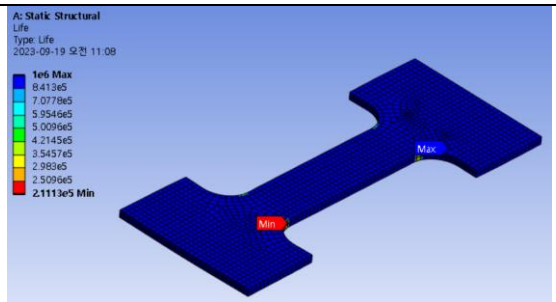
$$\sigma_{max} = K_c \times \sigma_{avg} = 1.45 \times 75MPa = 108.75MPa$$

1. Fully Reversed Apply 10^6 cycles for infinite life

(1) Fatigue safety factor for 10^6 cycles

(2) Life: Cycles

(3) Compare results with Goodman's theory

Safety factor	Life
	

It was designed based on the conditions given using ANSYS. After the design, fatigue analysis was conducted. In the case of the above model, the safety rate is 0.922, and the effective life is 21113 times. That is, after 21113 cycles, damage starts to occur from the part marked Min. Use Goodman's story to compare the values. Next is the goodman's story equation.

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

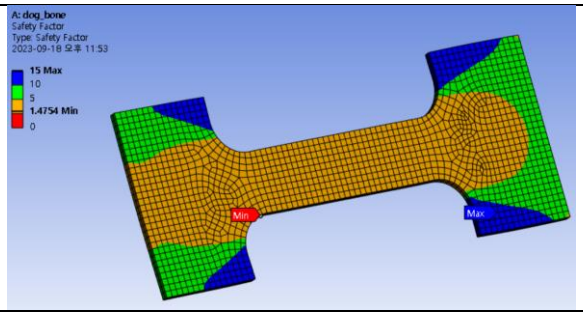
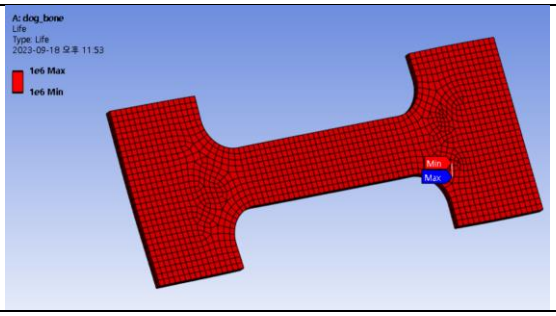
Since type is Fully Reversed, the average stress is zero. Using the given condition, the fatigue strength factor = 0.5, so we can calculate this value. $\sigma_e = 100\text{MPa}$. In addition, since $\sigma_{max} = 108.75MPa$, $\sigma_{min} = 0MPa$, alternating stress $\sigma_a = 54.22\text{MPa}$. Therefore, $\frac{\sigma_a}{\sigma_e} = \frac{108.75}{100} + \frac{0}{400} = \frac{1}{N}$ → N = 0.9195. Comparing the theoretical value with the ANSYS value, the result value was similar.

2. Zero-based Apply 10^6 cycles for infinite life

(1) Fatigue safety factor for 10^6 cycles

(2) Life: Cycles

(3) Compare results with Goodman's theory

Safety factor	Life
	

It was designed based on the conditions given using ANSYS. After the design, fatigue analysis was conducted. In the case of the above model, the safety rate is 1.4754, and the effective life is 10^6 times. However, since the model came out in red in life, we can see that the material is being damaged by fatigue. Use Goodman's theory to compare the values. Next is the goodman's story equation.

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

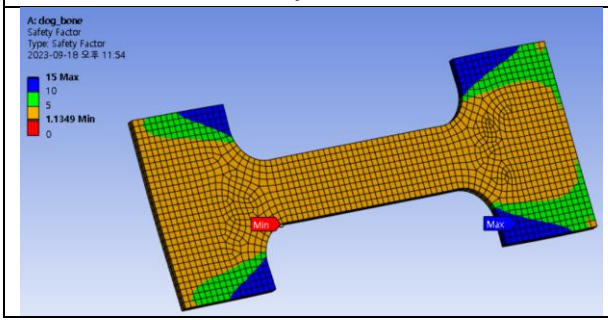
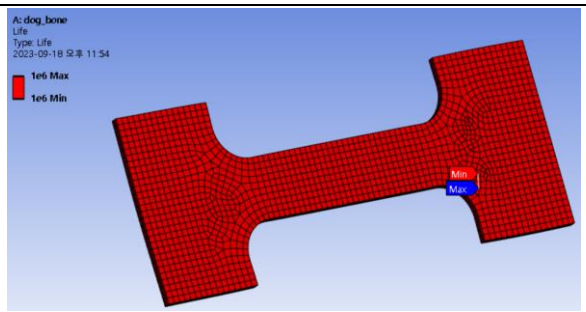
Since type is zero-based, average stress and alternating stress coexist. Using the given condition, the fatigue strength factor = 0.5, so we can calculate this value. $\sigma_e = 100\text{MPa}$. In addition, since $\sigma_{max} = 108.33MPa$, $\sigma_{min} = 0MPa$, alternating stress $\sigma_a = 54.375\text{MPa}$, and average stress $\sigma_m =$ 54.375. Therefore, $\frac{\sigma_a}{\sigma_e} + \frac{\sigma_m}{\sigma_{ut}} = \frac{54.375}{100} + \frac{54.375}{400} = \frac{1}{N}$ → N = 1.4712. Comparing the theoretical value with the ANSYS value, the result value was similar.

3. R=-0.5 Apply 10^6 cycles for infinite life

(1) Fatigue safety factor for 10^6 cycles

(2) Life: Cycles

(3) Comparison with Goodman's theory

Safety factor	Life
	

It was designed based on the conditions given using ANSYS. After the design, fatigue analysis was conducted. For the above model, the safety rate is 1.1349, and the effective life is 10^6 times. However, since the model came out in red in life, we can see that the material is being damaged by fatigue. Use Goodman's story to compare the values. Next is the goodman's story equation.

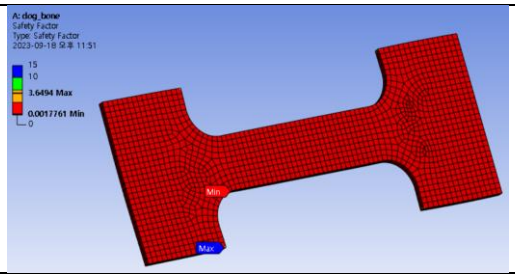
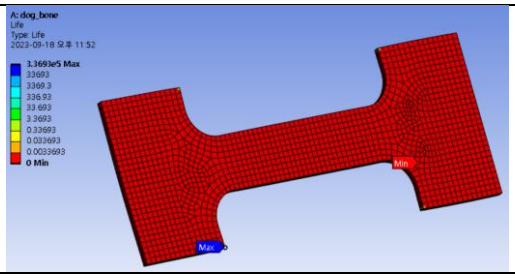
$$\frac{\sigma_a}{\sigma_e} + \frac{\sigma_m}{\sigma_{ut}} = \frac{1}{N}$$

Since type is ratio = - 0.5, average stress and alternating stress coexist. Using the given condition, the fatigue strength factor = 0.5, so we can calculate this value. $\sigma_e = 100\text{MPa}$. In addition, since $\sigma_{max} = 108.75MPa$, $\sigma_{min} = -54.375MPa$, alternating stress $\sigma_a = 81.5625\text{MPa}$, and average stress $\sigma_m = 27.1875$. Therefore, $\frac{\sigma_a}{\sigma_e} + \frac{\sigma_m}{\sigma_{ut}} = \frac{81.5625}{100} + \frac{27.1875}{400} = \frac{1}{N}$ → N = 1.13174. Comparing the theoretical value with the ANSYS value, the result value was similar.

4. History data: Apply SAE Bracket History Apply 10^9 blocks for infinite life

(1) Fatigue safety factor for 100 blocks load history

(2) Life: Block

Safety factor	Life
	

Safety factor, Life were obtained through History data using the given conditions. The safety factor was found to be 0.0017761, a significantly smaller value than other types. In terms of life, it can be seen that it came out high from the inner corner including the Max part, and overall, it can be seen that the life of the model is short as 0 block.