CAE
Simulation #2

Dog-bone Specimen Fatigue

21900416
Gyeonheal An

1. Introduction

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 100 cycles) Apply the fatigue strength factor = 0.50 considering $C_f C_r C_s C_t$ values at the service condition.

2. Geometry Design (CATIA)

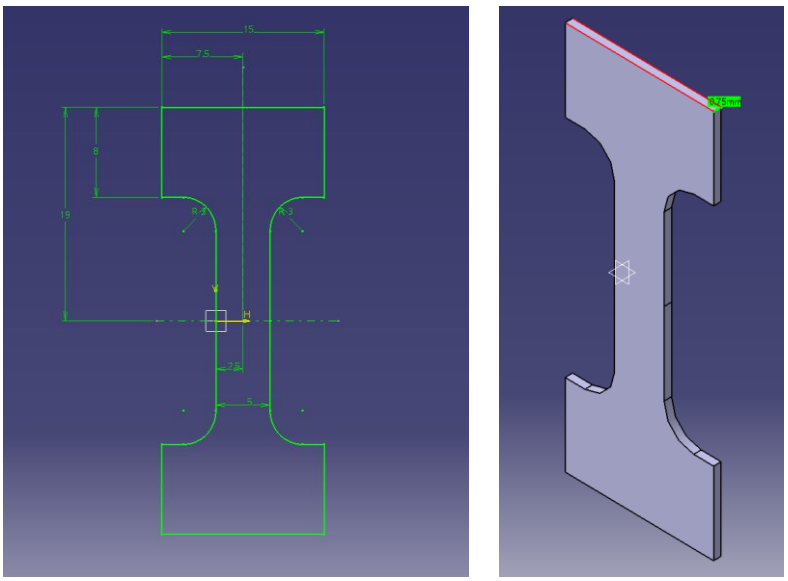
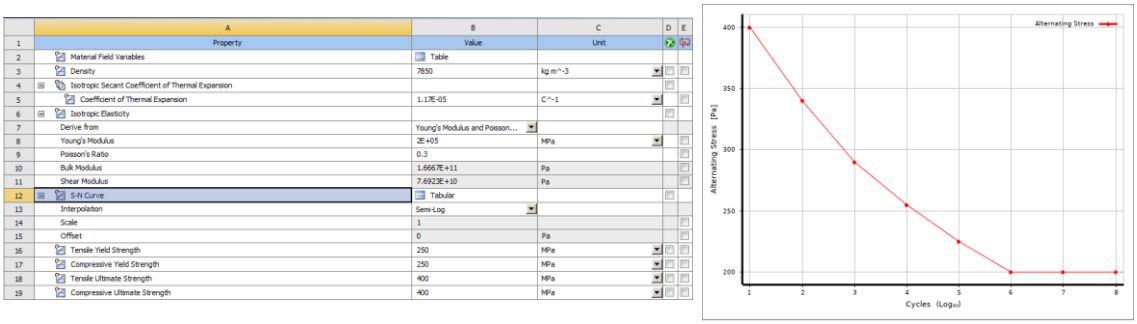


Figure 1. Dog-bone Geometry

3. Material (SS400)



	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	7850	kg m^-3		
4	Isotropic Secant Coefficient of Thermal Expansion				
5	Coefficient of Thermal Expansion	1.17E-05	C^-1		
6	Isotropic Elasticity				
7	Derive from	Young's Modulus and Poisson...			
8	Young's Modulus	2E+05	MPa		
9	Poisson's Ratio	0.3			
10	Bulk Modulus	1.6667E+11	Pa		
11	Shear Modulus	7.6923E+10	Pa		
12	S-N Curve	Tabular			
13	Interpolation	Semi-Log			
14	Scale	1			
15	Offset	0	Pa		
16	Tensile Yield Strength	250	MPa		
17	Compressive Yield Strength	250	MPa		
18	Tensile Ultimate Strength	400	MPa		
19	Compressive Ultimate Strength	400	MPa		

Figure 2. Material Settings

4. Experimental Condition

Used Material	SS400		
Mesh	0.5mm		
Pressure	25Mpa		
Solution	Total Deformation		
	Equivalent (Von-mises) Stress		
	Stress Tool	Safety Factor	
	Fatigue Tool	**Fatigue Strength Factor**	$K_f = 0.5$
		Loading Scale	1.0
		Analysis Type	Stress Life
		Loading Type	1. Fully Reversed, 2. Zero-based, 3. Ratio (-0.5 based) 4. History data
		Mean Stress Theory	Good-man Equivalent Von-mises

Table 1. Simulation Conditions

5. Result

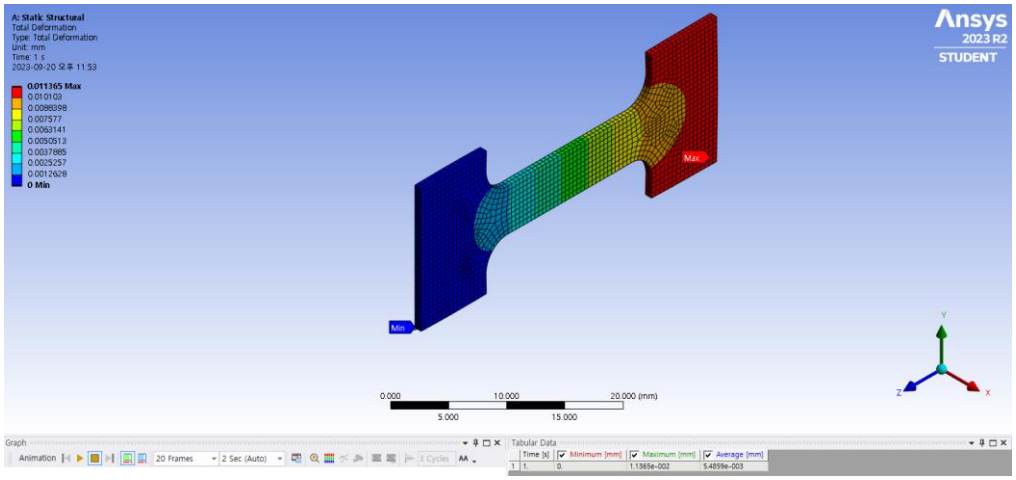


Figure 3. Total Deformation

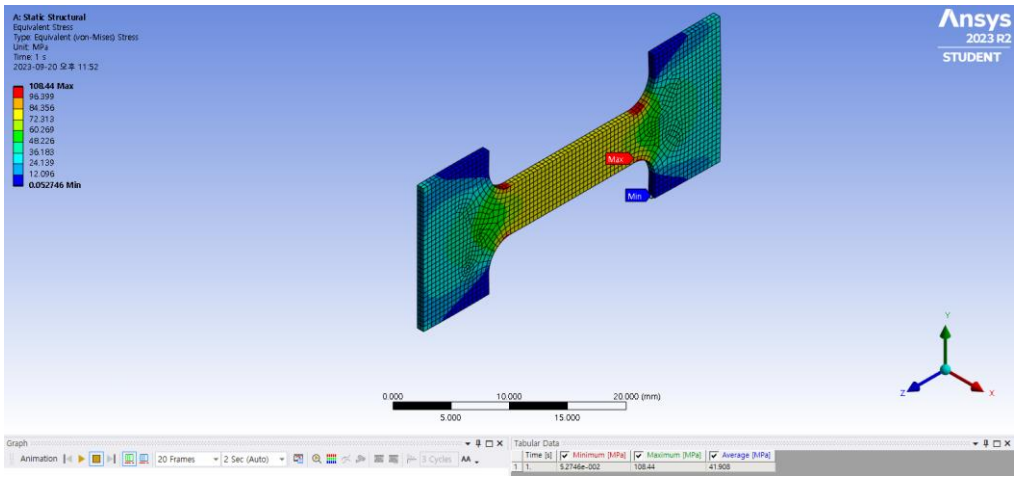


Figure 4. Equivalent Von-Mises Stress

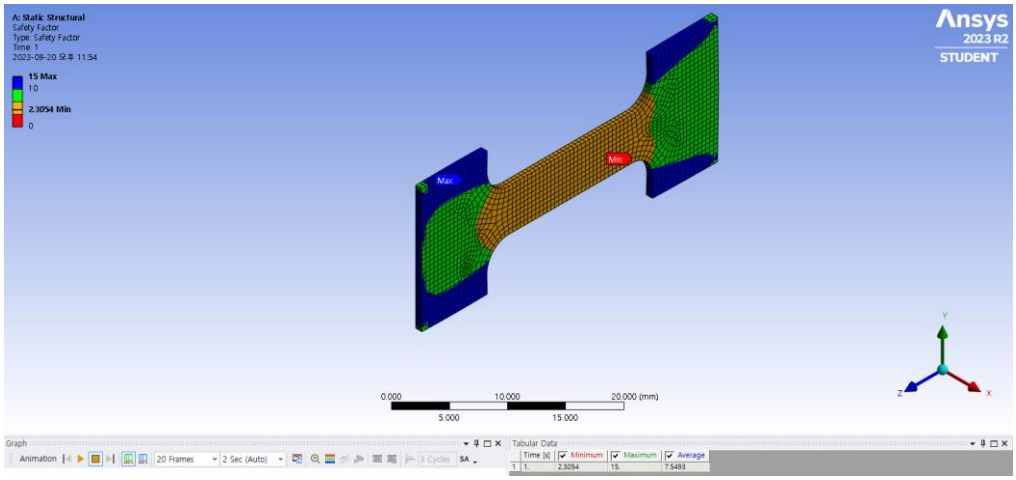


Figure 5. Safety Factor

6. Investigation on Fatigue Type (Goodman)

① Fully Reversed / Fatigue Safety Factor for 10^6 Cycles / 10^6 Cycles for Infinite Life

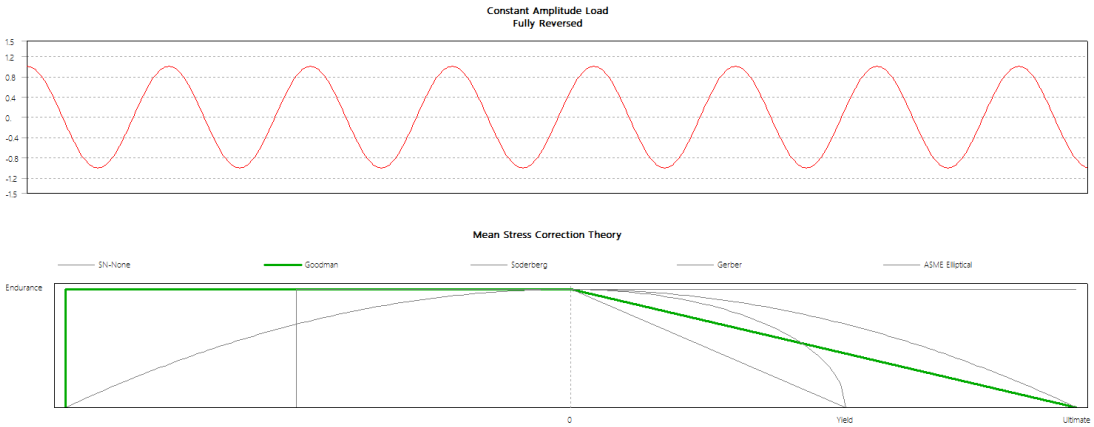


Figure 6-1. Fully Reversed Load Curve

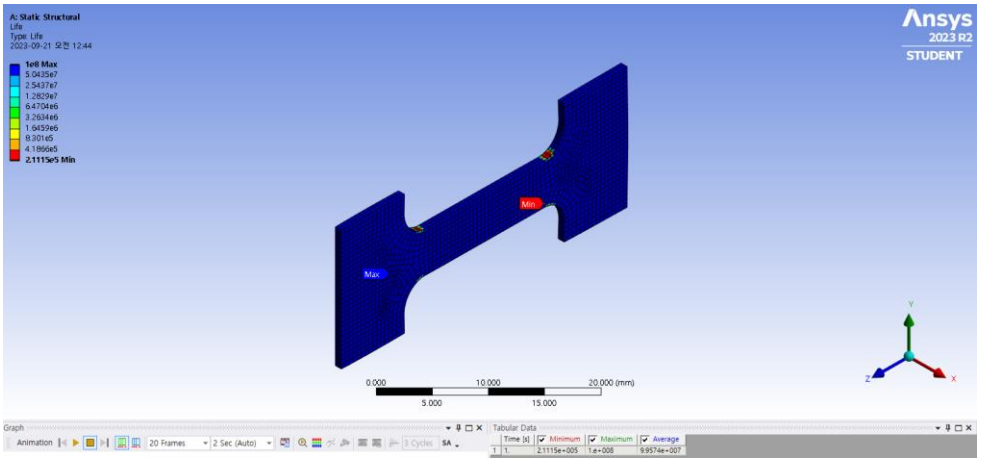


Figure 6-2. Life

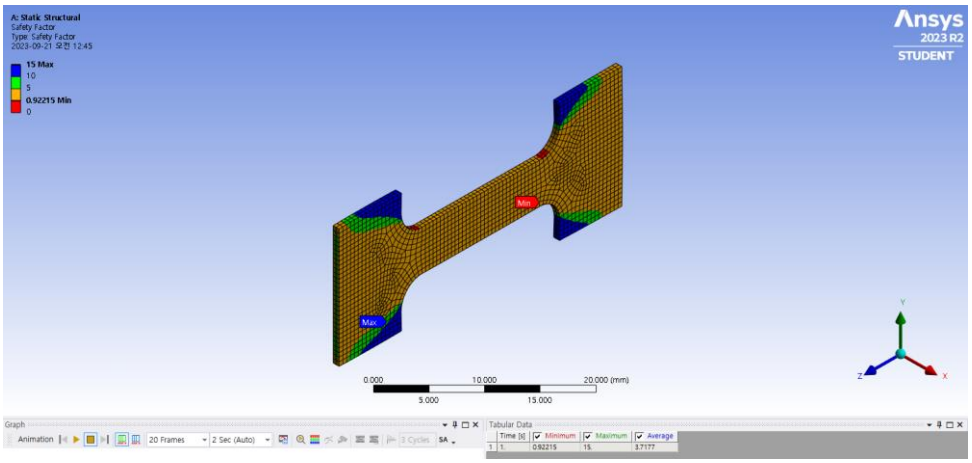


Figure 6-3. Safety Factor

② Zero-Based / Fatigue Safety Factor for 10^6 Cycles / 10^6 Cycles for Infinite Life

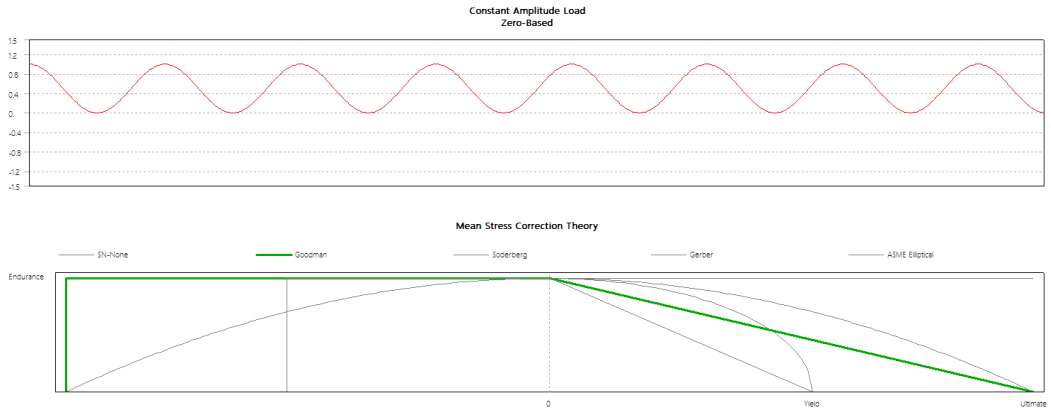


Figure 7-1. Zero-Based Load Curve

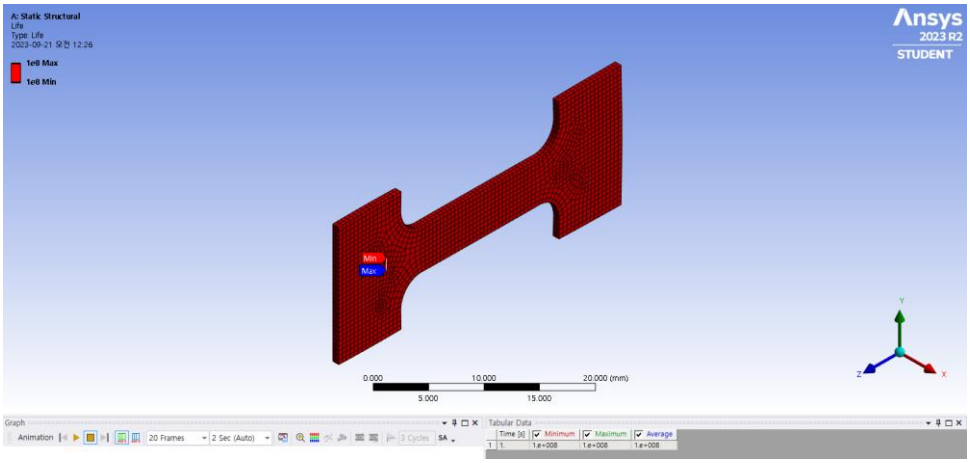


Figure 7-2. Life

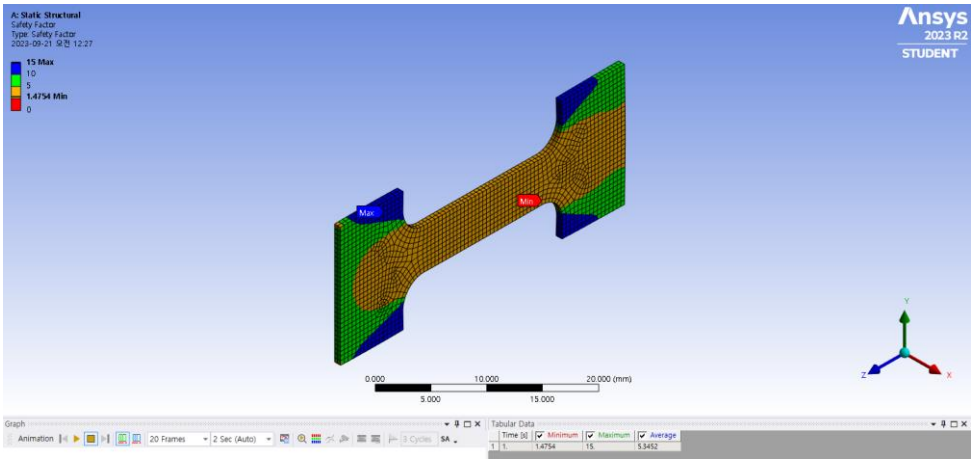


Figure 7-3. Safety Factor

③ Ratio / -0.5 Based / Fatigue Safety Factor for 10^6 Cycles / 10^6 Cycles for Infinite Life

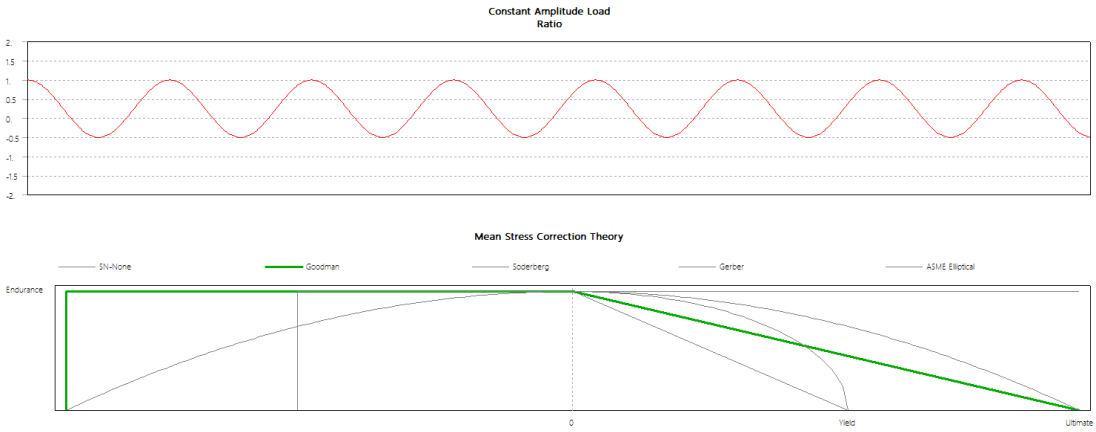


Figure 8-1. Ratio Load Curve

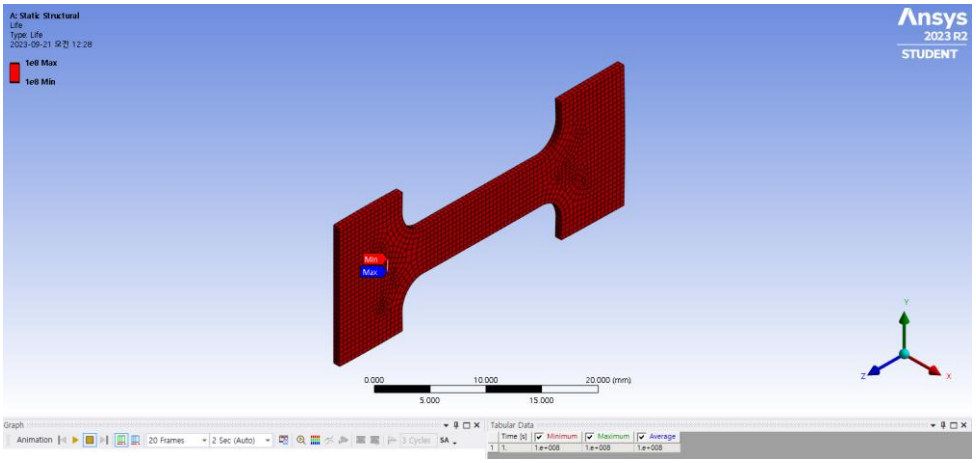


Figure 8-2. Life

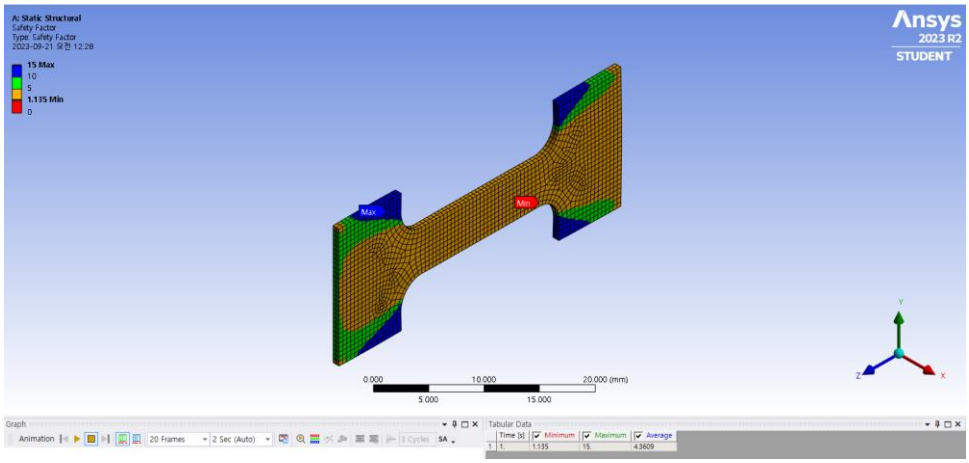


Figure 8-3. Safety Factor

④ History Data / SAE Bracket History / 10^9 Cycles for Infinite Life / 100 Blocks

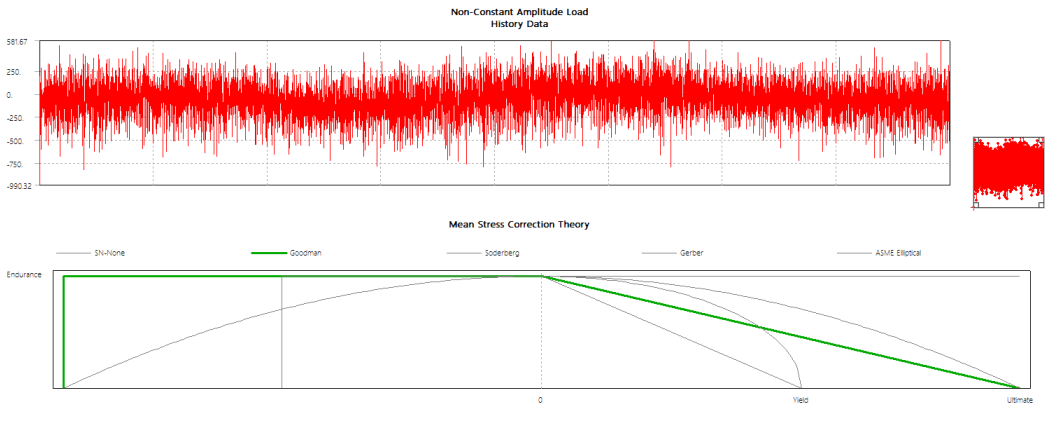


Figure 9-1. History Data Load Curve

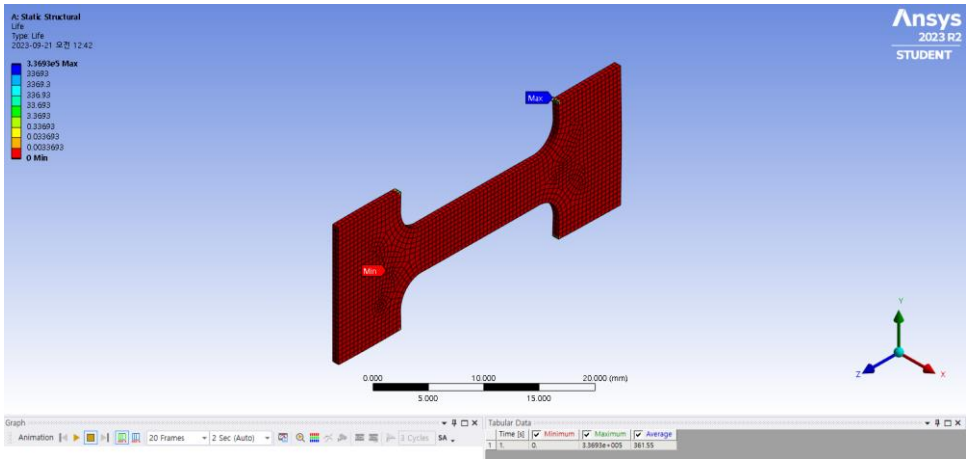


Figure 9-2. Life

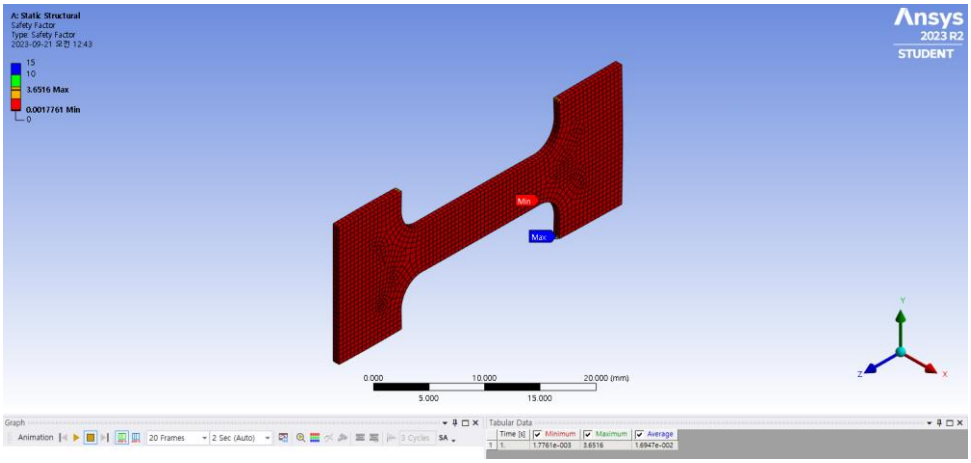


Figure 9-3. Safety Factor

7. Theroical Result (Goodman)

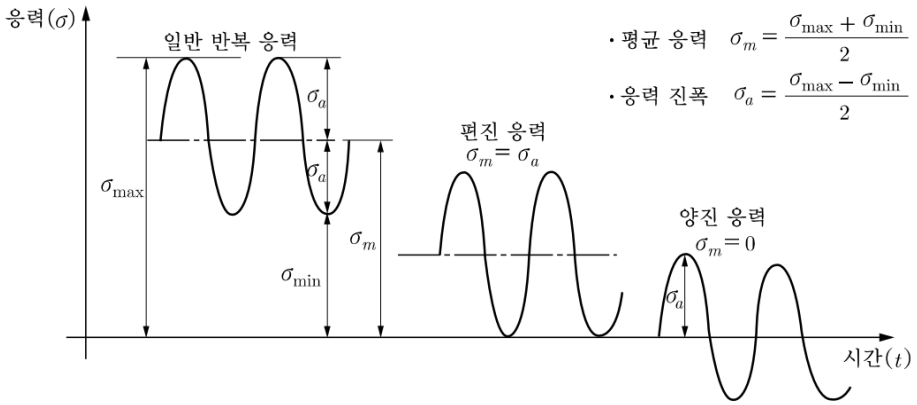


Figure 10.1 Various Load Curve

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

$$\sigma_e = C_f C_r C_s C_t \left(\frac{1}{K_f}\right)\sigma_e' = 0.5 \times 0.5 \times \sigma_{ut} = 100\ [Mpa]$$

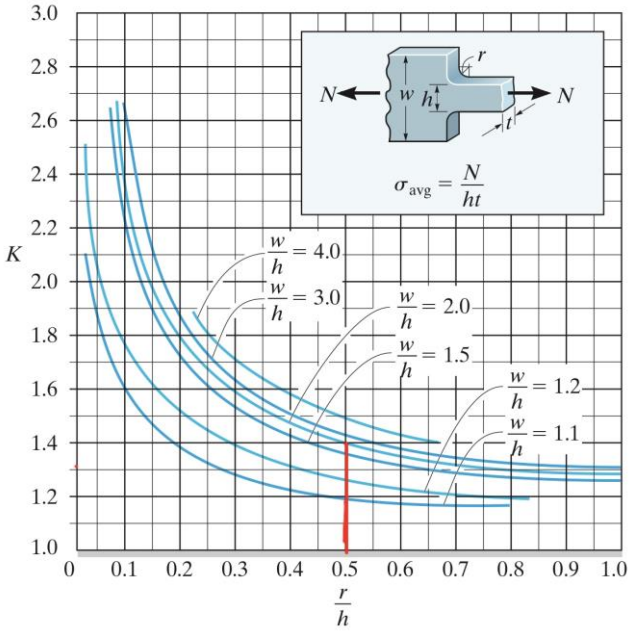


Figure 10-1. Stress Concentration Factor Curve

$$\frac{w}{h} = 3.0, \qquad \frac{r}{h} = 0.6, \quad K = 1.38$$

$$\sigma_{avg} = \frac{\sigma \times A'}{A} = \frac{25 \times 10^6 \times 0.75 \times 15 \times 10^{-6}}{0.75 \times 5 \times 10^{-6}} = 75[Mpa]$$

$$\sigma_{max} = K \times \sigma_{avg} = 103.5\ [Mpa]$$

1. Fully Reversed

$$\frac{\sigma_a}{\sigma_e}+\frac{\sigma_m}{\sigma_{ut}}=\frac{103.5}{100}+\frac{0}{400}=1.035$$

$$Safety\ factor=0.966$$

2. Zero-Based

$$\frac{\sigma_a}{\sigma_e}+\frac{\sigma_m}{\sigma_{ut}}=\frac{103.5/2}{100}+\frac{103.5/2}{400}=0.647$$

$$Safety\ factor=1.546$$

3. Ratio-Based

$$R=\frac{\sigma_{min}}{\sigma_{max}}=-0.5$$

$$\sigma_{min}=-0.5\times 103.5\times 10^6=-51.75\ [Mpa]$$

$$\sigma_m=\frac{\sigma_{max}+\sigma_{min}}{2}=\frac{103.5-51.75}{2}=25.875\ [Mpa]$$

$$\sigma_a=103.5-25.875=77.625\ [Mpa]$$

$$\frac{\sigma_a}{\sigma_e}+\frac{\sigma_m}{\sigma_{ut}}=\frac{77.625}{100}+\frac{25.875}{400}=0.841$$

$$Safety\ factor=1.189$$

8. Comparison of Theory and Simulation Values

SF	Simulation (Ansys)	Theory
Fully Reversed	0.92215	0.966
Zero Based	1.4754	1.546
Ratio Based	1.135	1.189
History Data	1.7761E-3	X

Table 2. Results of Ansys and Theory