CAE report 1

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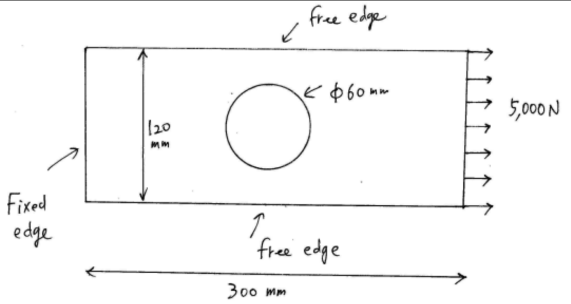
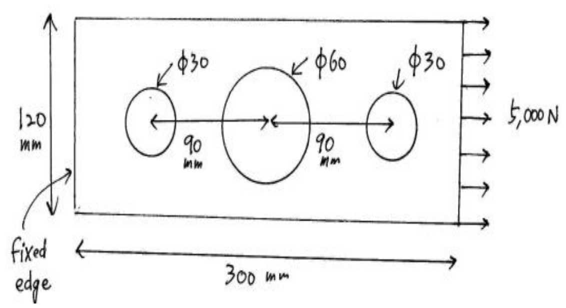
1. Introduction

In this report, the process and results of using the ANSYS simulation tool to determine how much normal stress occurs when a concentrated load is applied to one side of a fillet shape (with a hole in the rectangular parallelepiped shape) is introduced. Also, the process of applying the same cross-sectional force to fillet structures of different shapes, comparing how the results change, and comparing them with theoretical values are introduced.



structure 1



structure 2

2. Simulation

2.1. Theoretical value

First, since both structures have holes, stress concentration occurs. Therefore, if there is no hole, the following theoretical stress value is calculated, but larger stress occurs due to stress concentration around the hole.

$$\sigma_{theoretical} = \frac{F}{A} = \frac{5.0\ [kN]}{30.0\ [mm] \times 60.0\ [mm]} = 1.39\ [MPa]$$

Also, theoretical analysis for the stress concentration has to be conducted.

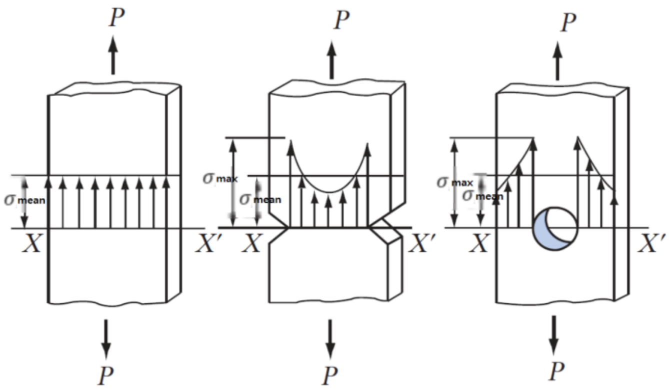


Figure 2.1.1. Stress concentration

Stress concentration factor (K), average stress are defined as follows.

$$K = \frac{\sigma_{max}}{\sigma_{avg}}\ ,\ \ \sigma_{avg} = \frac{P}{(w - d_{hole}) \times thickness} = \frac{5\ [kN]}{(120 - 60)\ [mm] \times 30\ [mm]} = 2.78[MPa]$$

According to the **figure 2.1.2. stress concentration table**, stree concentration factor of structure 1 is about 2.25.

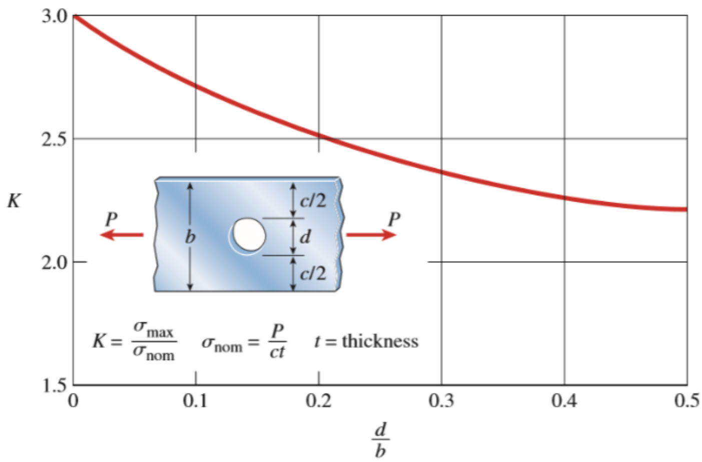


Figure 2.1.2. Stress concentration table

Accordingly, theoretical maximal stress in the part where stress concentration occurs of structure 1 can be calculated as follows.

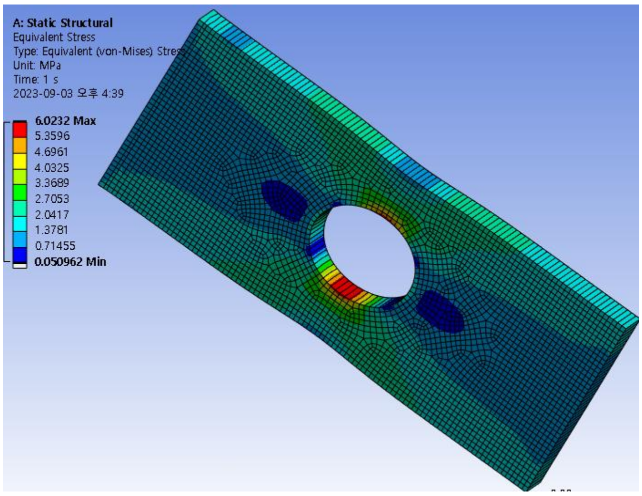
$$\sigma_{max} = K \times \sigma_{avg} = 6.22\ [MPa]$$

In a beam structure, deformation according to the elongation stress can be calculated as follows.

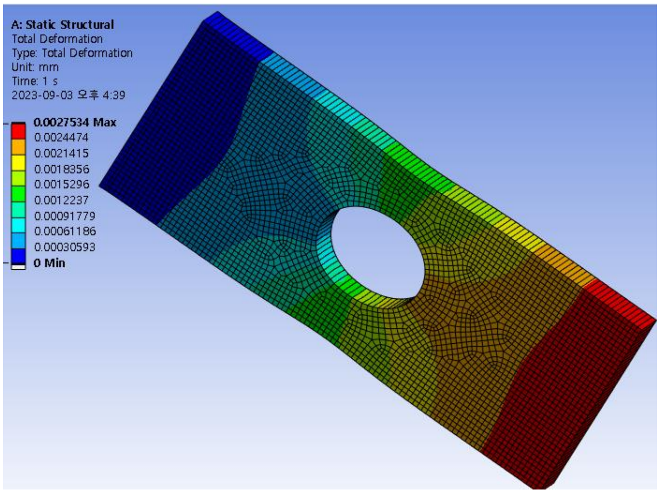
$$\delta = \frac{FL}{EA} = \frac{5[kN] \times 300[mm]}{2 \times 10^5\ [MPa] \times (30\ [mm] \times 120[mm])} = 0.0021\ [mm]$$

Simulation results for the structure 1 and 2 are introduced in **2.2. structure 1** and **2.3. structure 2**. In the simulation, material was set with structural steel and the size of each mesh element is set with $3.0\ [mm]$. And since the thickness part is hardly affected by stress, the edge elements were set so that the mesh enters only one line at a time to reduce unnecessary calculations.

2.2. simulation result : structure 1



Maximum stress



Total deformation

In the part of maximum stress of structure 1, each result about minumum, maximum, average value is as follows :

Table 2.2.1. Simulation result of structure 1

Results	
Minimum	5.0962e-002 MPa
Maximum	6.0232 MPa
Average	1.5638 MPa

Stress values

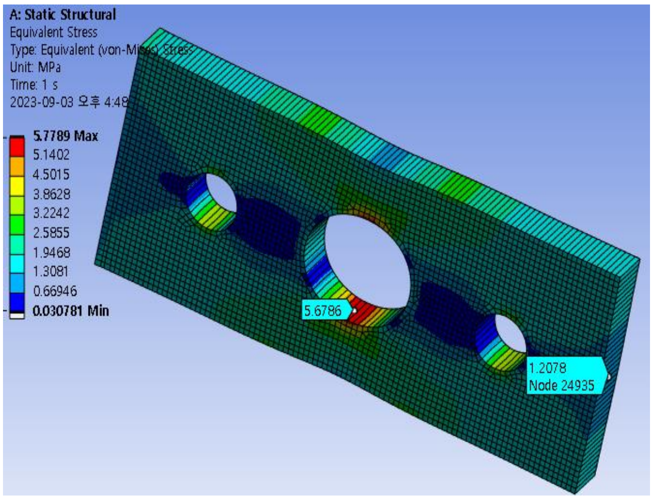
Results	
Minimum	0. mm
Maximum	2.7534e-003 mm
Average	1.377e-003 mm

Deformation values

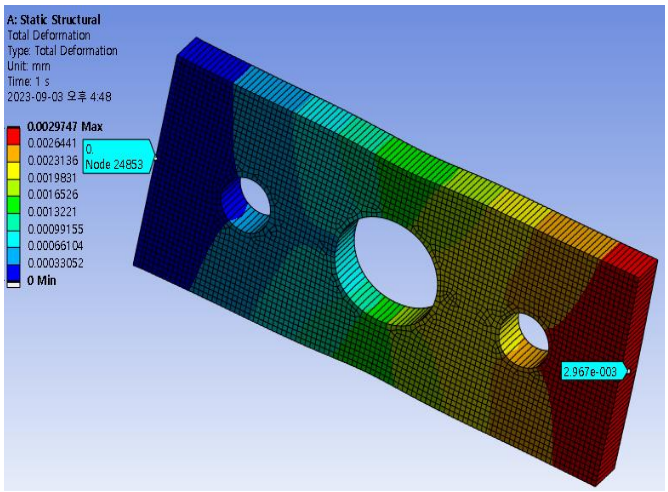
According to the simulation result, stress concentration factor is calculated as,

$$K = \frac{\sigma_{max}}{\sigma_{avg}} = 2.16\ [-]$$

2.3. simulation result : structure 2



Maximum stress



Total deformation

In the part of maximum stress of structure 2, each result about minumum, maximum, average value is as follows :

Table 2.3.1. Simulation result of structure 2

Results	
Minimum	3.0781e-002 MPa
Maximum	5.7789 MPa
Average	1.6287 MPa

Stress values

Results	
Minimum	0. mm
Maximum	2.9747e-003 mm
Average	1.4628e-003 mm

Deformation values

According to the simulation result, stress concentration factor is calculated as,

$$K = \frac{\sigma_{max}}{\sigma_{avg}} = 2.07\ [-]$$

3. Discussion and analysis

As can be seen in the result part, structure 2 has less maximum stress and the deformation value compared to the structure 1. Since structure 2 has 2 more holes with half diameter of original hole, stress concentration is alleviated in the middle hole as can be seen in the result. When a new structure is simulated with 3

$60\ [mm]$ holes in a same base square shape, the maximum stress value was about $6.98\ [MPa]$ which is higher than that of structure 1. As a conclusion for the analysis of simulation result, two more holes with half diameter in the structure 2 those are not exist in the structure 1 got a effect for alleviation of structure concentration.

From an analytical point of view, it is desirable to select a model that can detect damage relatively quickly by selecting a structure with a low safety factor. The safety factor is defined as follows :

$$safety\ factor = \frac{\sigma_{ultimate}}{\sigma_{max}}$$

When comparing the two shapes, the maximum stress generated due to concentrated load is larger in structure 1. Therefore, the safety factor is relatively lower and it would be better to use it from an analytical perspective.

From a process perspective, it is important to select a shape that has low cost and a relatively high safety factor. Assuming a casting process that manufactures with a mold rather than a hole process for a square shape, the material cost for structure 2 is relatively low. Additionally, because the maximum stress value is less for the same force with stress distribution with multiple holes, structure 2 has a relatively higher safety factor compared to structure 1. Therefore, from a process perspective, it is desirable to select structure 2.