Hole plate_Test2

Prompt >>

[Task 1] Using the contents of {experimental_introduction}, {experimental_goals}, {model shape} and {parameters}, carry out the following tasks

1. Explain what you're trying to do
   (1) Overview
   (2) Purpose and Objective
   (3) Plan for Implementation
2. For each response variable, we estimate the importance ranking of the sensitivity of the design variable and explain the engineering basis for that estimation using equations and etc..
   (Example: a > b ...)

[Model Information]
{experimental_introduction} = "Perform a structural analysis on a planar plate with a hole"
{experimental_goals} = "examine the correlation between the design variables and response variables and estimate the sensitivity of each design variable."
{model shape} = Front views of the hole plate
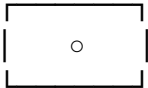
{parameters} =

1. design variable
   length: 250mm - 300mm
   width: 100mm - 110mm
   diameter: 20mm - 90mm
   thickness = 5mm ※fixed variable
2. response variable
   max stress, max displacement
3. constraints
   the entire left side = fixed
   the entire right side = vertical tensile stress 1,000N

Answer >>

1. Explanation of the Experimental Plan

(1) Overview
This experiment involves performing a structural analysis on a planar plate with a hole. The objective is to evaluate how different design variables (length, width, and hole diameter) influence the response variables (maximum stress and maximum displacement) under a fixed boundary condition and tensile loading.

(2) Purpose and Objective
The primary goal of this study is to:

- Examine the correlation between design variables and response variables.
- Estimate the sensitivity ranking of each design variable's influence on the response variables.
- Understand the underlying engineering principles affecting stress and displacement in the plate.

By analyzing these relationships, we aim to determine which design variable has the most significant impact on the mechanical performance of the plate.

(3) Plan for Implementation
1. **Define the Model**
- A rectangular plate with a central hole.
- Dimensions vary within the given parameter range.
- Fixed left boundary and tensile stress applied on the right.
2. **Perform Finite Element Analysis (FEA) Simulations**
- Use simulation software to calculate max stress and max displacement for different design variable settings.
- Maintain a fixed thickness of 5mm.
3. **Analyze Sensitivity of Design Variables**
- Rank design variables based on their influence on max stress and max displacement.
- Use engineering principles and equations to justify the rankings.

2. Sensitivity Analysis of Design Variables

(A) Sensitivity Analysis for Max Stress

Max stress in a plate with a hole is determined by stress concentration principles, particularly using the stress concentration factor (Kt):

$$\sigma_{max} = K_t \cdot \sigma_{applied}$$

where:

- σapplied is the applied tensile stress (1,000N).
- Kt is the stress concentration factor, which depends on the hole diameter (d) and plate width (W):

An empirical approximation for Kt in an infinite plate is:

$$K_t = 1 + 2\frac{d}{W}$$

For a finite plate, empirical formulas suggest:

$$K_t = 3 - 3.14\frac{d}{W} + 3.66(\frac{W}{d})^2$$

Variable Importance Ranking for Max Stress

1. **Hole diameter (d):** Directly increases stress concentration, making it the most critical factor.
2. **Width (W):** Reduces stress concentration, but its effect is weaker than diameter.
3. **Length (L):** Has minimal influence on max stress unless it significantly changes the global stiffness.

Thus, d>W>L in terms of importance for max stress.

(B) Sensitivity Analysis for Max Displacement

The max displacement (δ) in a plate subjected to tensile loading follows:

$$\delta = \frac{\sigma_{applied}L}{E} \cdot \frac{Wt}{1}$$

where:

- E is Young's modulus (assumed constant).
- t is thickness (fixed at 5mm).
- L, W, and d influence stiffness.

Since displacement is inversely proportional to width W, increasing width reduces deformation. Hole diameter (d) also affects the local stiffness, but its impact is smaller compared to width.

Variable Importance Ranking for Max Displacement

1. **Width (W):** Dominates stiffness, reducing displacement.
2. **Hole diameter (d):** Reduces local stiffness but has a secondary effect.
3. **Length (L):** Increases total elongation, but since stress is uniform, the impact is smaller than width.

Thus W>d>L in terms of importance for max displacement.

Final Sensitivity Ranking Summary

- **Max Stress:** d>W>L
- **Max Displacement:** W>d>L

This ranking will be validated through numerical simulations using FEA tools.