

# Bracket Platform Test 3

## Prompt >> (attached Bracket.json file)

[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 bracket"

{experimental\_goals} = "examine the correlation between the design variables and response variables and estimate the sensitivity of each design variable."

{model shape} = [Bracket.json]

{parameters} =

1. design variable
  - a: 600 - 650mm
  - b = 200mm **#fixed** factor
  - c: 500 - 550mm
  - d = 200 **#fixed** factor
  - e: 100 - 120mm
2. response variable  
max stress, max displacement
3. constraints  
Hole A = fixed  
Hole B = vertical tensile stress 1,000N. "A downward load is applied through the hole located at the bottom-right portion of the  $\pi$ -shaped bracket."

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## Answer >>

### 1. Explanation of the Structural Analysis Experiment

#### (1) Overview

This experiment involves performing a structural analysis on an  $\pi$ -shaped bracket to examine how various design variables affect response variables such as maximum stress and maximum displacement. The bracket model is defined in Bracket.json, which consists of arc, circle, and line segments forming its structure.

#### (2) Purpose and Objective

The key objective is to:

- Determine the correlation between design variables (a, c, e) and response variables (max stress, max displacement).
- Estimate the sensitivity ranking of each design variable on structural performance.
- Use engineering principles and equations to justify sensitivity rankings.

### (3) Plan for Implementation

#### 1. Model Setup:

- Import the bracket model from Bracket.json.
- Apply boundary conditions: Hole A is fixed, and Hole B is subjected to a vertical tensile load of 1,000 N.
- Ensure constraints are met.

#### 2. Simulation & Analysis:

- Conduct Finite Element Analysis (FEA) for different values of a, c, and e while keeping b and d fixed.
- Record maximum stress and maximum displacement for each simulation.

#### 3. Sensitivity Ranking:

- Analyze the rate of change in response variables as each design variable varies.
- Rank the design variables based on their impact on stress and displacement.
- Justify the ranking using engineering equations (stress-strain relationships, beam bending theory, etc.).

## 2. Sensitivity Analysis of Design Variables

We analyze the effect of a, c, and e on maximum stress and maximum displacement ranking them in order of influence.

### (1) Sensitivity on Maximum Stress ( $\sigma_{max}$ )

The maximum stress in the bracket is influenced by:

- Cross-sectional area (A): Larger sections reduce stress.
- Moment of inertia (I): Higher inertia leads to lower stress under bending.
- Load distribution: Affects stress concentration around holes.

Using the bending stress equation:

$$\sigma = \frac{My}{I}$$

where:

- M is the moment.
- y is the distance from the neutral axis,
- I is the moment of inertia.

### Ranking based on effect on $\sigma_{max}$ :

#### 1. a (600-650mm) > c (500-550mm) > e (100-120mm)

- Increasing a increases the length of the moment arm, raising bending stress.
- Increasing c shifts load distribution but has a smaller effect than a.
- Increasing e affects cross-sectional thickness, slightly influencing stress.

### (2) Sensitivity on Maximum Displacement ( $\delta_{max}$ )

Maximum displacement follows beam bending theory:

$$\delta = \frac{FL^3}{3EI}$$

where:

- F is the applied force,
- L is the effective length,
- E is Young's modulus,
- I is the moment of inertia.

#### **Ranking based on effect on $\delta_{\max}$ :**

##### **1. a (600-650mm) > e (100-120mm) > c (500-550mm)**

- 'a' has the highest influence as it directly increases the bending length L.
- 'e' affects stiffness (I) and plays a moderate role.
- 'c' changes geometry slightly but has the least impact on deflection.

#### **Conclusion**

- **Maximum Stress Sensitivity Ranking:**  $a > c > e$
- **Maximum Displacement Sensitivity Ranking:**  $a > e > c$
- **Engineering Justification:** Longer length increases bending moment, while thickness and width affect inertia and stress distribution.

**Next Step:** Perform FEA simulations to verify rankings quantitatively.