



# Analysis of Centroid Location in Composite Structures

Prof. Sathe Pooja Ramchandra.<sup>1</sup>, Dnyaneshwar L. Bhavle<sup>2</sup>, Chaitanya I. Borade<sup>3</sup>, Mahesh B. Darade<sup>4</sup>,  
Kunal S. Dongare<sup>5</sup>, Rohan P. Dhokane<sup>6</sup>.

<sup>1</sup>Assistant Professor, Department of FE Engineering, Adsul's Technical Campus, Ahilyanagar, SPPU, India

<sup>2-6</sup>FE Students, Department of FE Engineering, Adsul's Technical Campus, Ahilyanagar, SPPU, India

[Poojasathe55@gmail.com](mailto:Poojasathe55@gmail.com),

## How to Cite this Article:

Bhavle, D. L., Borade, C. I., Darade, M. B., Dongare, K. S. & Dhokane, R. P. (2026). Analysis of Centroid Location in Composite Structures. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(05).  
<https://doi.org/10.55041/ijcope.v2i5.658>

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<https://doi.org/10.55041/ijcope.v2i5.658>

**Abstract**— Composite structures are widely used in modern engineering applications due to their high strength, lightweight properties, and design flexibility. The centroid of a composite structure plays a vital role in determining structural stability, load distribution, bending behavior, and balance characteristics. This research focuses on analyzing centroid locations in various composite geometrical sections such as T-sections, I-sections, channel sections, and built-up structures. Analytical and computational methods are used to determine centroid coordinates and study the effect of area distribution on centroid movement. The study highlights the importance of centroid analysis in structural and mechanical engineering applications.

**Keywords**— Centroid, Composite Structures, Structural Stability, Area Distribution, Mechanical Engineering, CAD Analysis, Structural Design.

## I. Introduction

Composite structures are formed by combining two or more geometrical sections into a single body. These structures are extensively used in:

- Building construction
- Bridge design
- Machine components
- Aerospace systems
- Automotive chassis
- Industrial equipment

The centroid represents the geometric center of the entire composite body. Proper centroid positioning ensures balanced load transfer and structural safety.

In composite structures, centroid location depends upon:

- Shape geometry
- Area distribution
- Material arrangement
- Structural symmetry

Incorrect centroid estimation may result in:

- Uneven stress distribution
- Structural instability



- Excessive vibration
- Failure of components

- $(x_i, y_i)$  = Coordinates of centroid of each section

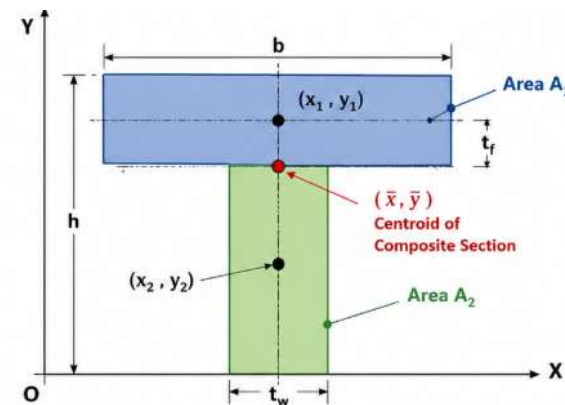
Therefore, centroid analysis is an important part of Mechanical Engineering and structural analysis.

## II.Objectives

1. To study centroid determination in composite structures.
2. To analyze centroid movement due to varying geometrical configurations.
3. To compare analytical and computational centroid calculations.
4. To understand the influence of centroid location on structural stability.
5. To evaluate engineering applications of centroid analysis.

## III.Theory of Centroid

For composite sections:



$$\bar{x} = \frac{A_1x_1 + A_2x_2 + \dots + A_nx_n}{A_1 + A_2 + \dots + A_n}$$

$$\bar{y} = \frac{A_1y_1 + A_2y_2 + \dots + A_ny_n}{A_1 + A_2 + \dots + A_n}$$

$$\bar{x} = \frac{\sum A_i x_i}{\sum A_i}, \quad \bar{y} = \frac{\sum A_i y_i}{\sum A_i}$$

Where:

- $(A_i)$  = Area of individual section

## IV.Composite Structures Considered

1. T-Section
2. I-Section
3. Channel Section
4. L-Section
5. Box Section
6. Built-up Structural Sections

## V.Methodology

1. Selection of composite geometries
2. Division into simpler geometrical sections
3. Area calculation of each component
4. Determination of individual centroid coordinates
5. Calculation of overall centroid
6. CAD-based verification using:
  - o AutoCAD
  - o Solid Works
  - o ANSYS

## VI.Example Numerical

Given:

A T-section consists of:

- Flange: 120 mm × 20 mm
- Web: 20 mm × 100 mm

### Step 1: Areas

Flange area:

$$A_1 = 120 \times 20 = 2400 \text{ mm}^2$$

Web area:

$$A_2 = 20 \times 100 = 2000 \text{ mm}^2$$

### Step 2: Centroid Locations

Flange centroid from bottom:

$$y_1 = 110 \text{ mm}$$

Web centroid from bottom:

$$y_2 = 50 \text{ , mm}$$



### Step 3: Composite Centroid

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$$

$$\bar{y} = \frac{(2400 \times 110) + (2000 \times 50)}{4400} = 82.73 \text{ mm}$$

Thus, the centroid lies 82.73 mm above the base.

## VII. Results and Discussion

The study shows:

- Symmetrical sections maintain central centroid alignment.
- Asymmetrical additions shift centroid toward larger areas.
- Built-up sections exhibit complex centroid movement.
- Composite structures require accurate centroid estimation for stability.

## VIII. Applications

### Structural Engineering

- Beam analysis
- Column design
- Bridge structures

### Mechanical Engineering

- Rotating machinery
- Machine balancing
- Flywheel systems

### Aerospace Engineering

- Aircraft stability
- Wing structure design

### Automotive Industry

- Chassis balancing
- Vehicle stability analysis

## IX. Advantages

1. Improves structural safety.
2. Enhances load balancing.
3. Reduces vibration.
4. Helps in lightweight design optimization.
5. Improves mechanical performance.

## X. Future Scope

- AI-based centroid prediction systems
- Real-time centroid monitoring
- Smart CAD-integrated structural optimization
- 3D computational centroid analysis
- Machine learning for irregular structure analysis

## XI. Conclusion

The centroid location of composite structures significantly affects structural performance and stability. Composite geometries exhibit varying centroid positions depending on area distribution and dimensional arrangement. Analytical and computational methods provide reliable centroid determination for engineering applications. Proper centroid analysis improves safety, balance, and efficiency in structural and mechanical systems.

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