

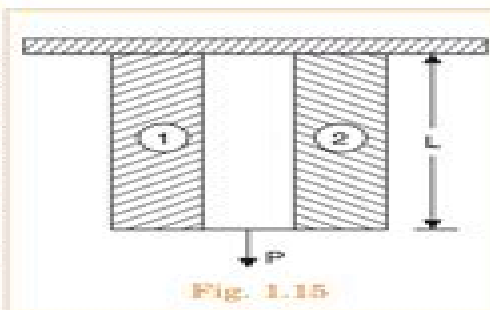
1.13. ANALYSIS OF BARS OF COMPOSITE SECTIONS

A bar, made up of two or more bars of equal lengths but of different materials rigidly fixed with each other and behaving as one unit for extension or compression when subjected to an axial tensile or compressive loads, is called a composite bar. For the composite bar the following two points are important :

1. The extension or compression in each bar is equal. Hence deformation per unit length *i.e.*, strain in each bar is equal.

2. The total external load on the composite bar is equal to the sum of the loads carried by each different material.

Fig. 1.15 shows a composite bar made up of two different materials.



Let P = Total load on the composite bar,

L = Length of composite bar and also length of bars of different materials,

A_1 = Area of cross-section of bar 1,

A_2 = Area of cross-section of bar 2,

E_1 = Young's Modulus of bar 1,

E_2 = Young's Modulus of bar 2,

P_1 = Load shared by bar 1,

P_2 = Load shared by bar 2,

σ_1 = Stress induced in bar 1, and

σ_2 = Stress induced in bar 2.

Now the total load on the composite bar is equal to the sum of the load carried by the two bars.

$$\therefore P = P_1 + P_2 \quad \dots(i)$$

$$\text{The stress in bar 1,} \quad = \frac{\text{Load carried by bar 1}}{\text{Area of cross-section of bar 1}}.$$

$$\therefore \sigma_1 = \frac{P_1}{A_1} \quad \text{or} \quad P_1 = \sigma_1 A_1 \quad \dots(ii)$$

$$\text{Similarly stress in bar 2,} \quad \sigma_2 = \frac{P_2}{A_2} \quad \text{or} \quad P_2 = \sigma_2 A_2 \quad \dots(iii)$$

Substituting the values of P_1 and P_2 in equation (i), we get

$$P = \sigma_1 A_1 + \sigma_2 A_2 \quad \dots(iv)$$

Since the ends of the two bars are rigidly connected, each bar will change in length by the same amount. Also the length of each bar is same and hence the ratio of change in length to the original length (*i.e.*, strain) will be same for each bar.

$$\text{But strain in bar 1,} \quad = \frac{\text{Stress in bar 1}}{\text{Young's modulus of bar 1}} = \frac{\sigma_1}{E_1}.$$

$$\text{Similarly strain in bar 2,} \quad = \frac{\sigma_2}{E_2}.$$

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Table of Contents Bansal Solution Manual

1. Understanding the eBook Bansal Solution Manual
 - The Rise of Digital Reading Bansal Solution Manual
 - Advantages of eBooks Over Traditional Books
2. Identifying Bansal Solution Manual
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Bansal Solution Manual
 - User-Friendly Interface
4. Exploring eBook Recommendations from Bansal Solution Manual
 - Personalized Recommendations
 - Bansal Solution Manual User Reviews and Ratings
 - Bansal Solution Manual and Bestseller Lists
5. Accessing Bansal Solution Manual Free and Paid eBooks

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- Bansal Solution Manual Budget-Friendly Options
- 6. Navigating Bansal Solution Manual eBook Formats
 - ePub, PDF, MOBI, and More
 - Bansal Solution Manual Compatibility with Devices
 - Bansal Solution Manual Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Bansal Solution Manual
 - Highlighting and Note-Taking Bansal Solution Manual
 - Interactive Elements Bansal Solution Manual
- 8. Staying Engaged with Bansal Solution Manual
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Bansal Solution Manual
- 9. Balancing eBooks and Physical Books Bansal Solution Manual
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Bansal Solution Manual
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Bansal Solution Manual
 - Setting Reading Goals Bansal Solution Manual
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Bansal Solution Manual
 - Fact-Checking eBook Content of Bansal Solution Manual
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development

- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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