时代教育·国外高校优秀教材精选

PEARSON

结构分析

影印版·原书第8版

(美) R.C.希伯勒 (R.C.HIBBELER) 编著

STRUCTURAL ANALYSIS

EIGHTH EDITION

机械工业出版社
CHINA MACHINE PRESS

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本书内容包括结构类型及荷载，静定结构分析，静定桁架分析，结构杆件中产生的内力，悬索和拱，静定结构的影响线，超静定梁的近似分析，挠度，用能量法求挠度，用力法分析超静定结构，位移法分析——转角位移方程，位移法分析——弯矩分配法，具有变截面杆件的梁和框架，用刚度法分析桁架，用刚度法分析梁，用刚度法分析平面框架。

本书可作为高等工科院校相关专业结构力学双语教学教材，也可供相关专业科研和技术人员参考。

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出版说明

随着我国加入WTO，国际间的竞争越来越激烈，而国际间的竞争实际上也就是人才的竞争、教育的竞争。为了加快培养具有国际竞争力的高水平技术人才，加快我国教育改革的步伐，国家教育部出台了一系列倡导高校开展双语教学、引进原版教材的政策。以此为契机，机械工业出版社推出了一系列国外影印版教材，其内容涉及高等学校公共基础课，以及机、电、信息领域的专业基础课和专业课。

引进国外优秀原版教材，在有条件的学校推动开展英语授课或双语教学，自然也引进了先进的教学思想和教学方法，这对提高我国自编教材的水平，加强学生的英语实际应用能力，使我国的高等教育尽快与国际接轨，必将起到积极的推动作用。

为了做好教材的引进工作，机械工业出版社特别成立了由著名专家组成的国外高校优秀教材审定委员会。这些专家对实施双语教学做了深入细致的调查研究，对引进原版教材提出许多建设性意见，并慎重地对每一本将要引进的原版教材一审再审，精选再精选，确认教材本身的质量水平，以及权威性和先进性，以期所引进的原版教材能适应我国学生的外语水平和学习特点。在引进工作中，审定委员会还结合我国高校教学课程体系的设置和要求，对原版教材的教学思想和方法的先进性、科学性严格把关，同时尽量考虑原版教材的系统性和经济性。

这套教材出版后，我们将根据各高校的双语教学计划，及时地将其推荐给各高校选用。希望高校师生在使用教材后及时反馈意见和建议，使我们更好地为教学改革服务。

机械工业出版社

高等教育分社

前言⊖

对于诸如桁架、梁、框架等结构，本书力求在结构力学的理论和实际应用上，提供给学生一个清晰、详细完整的解说；着重于对结构的建模和分析，并提供在工程实践中的具体应用。

多年来，工程师们利用矩阵来进行结构分析。虽然这些方法更为有效，但在这个学科中，学生们上的第一堂课，仍然应该是一些更为重要的古典方法。学生应用这些古典方法，将会对静力学、材料力学这些基础工程学科理解得更为深刻。当然，在各种技术不断出现并被明确有序地应用时，解题的技巧也将进一步提高。用古典方法解题，一个好处就是，能更好地了解荷载在结构中的传递，并对结构在荷载作用下的变形情况理解得更为完整。古典方法是一个检验计算机计算结果的好方法，比单纯依赖计算机打印输出更好。

1. 本版的更新

(1) **基本习题** 习题部分有选择性地直接安排在例题之后。例题给学生一个概念的简单运用，让他们在解答后面任何规定要做的习题之前，有一个提高解题技巧的机会。你可以把习题视作例题的扩展和延伸。这些习题在书后均给出了解法和答案。此外，基本习题教给了学生一些应对考试的好的学习方法，这对他们今后为获得职业工程师资格所必需的考试复习是很有用处的。

(2) **内容修订** 为增强理解，每一节课文内容都作了详细的回顾。本版包含的内容：第1章中综述了新的美国土木工程协会 ASCE/SEI 07-10 规程有关荷载的部分；关于如何绘制结构剪力图和弯矩图以及结构变形曲线的详尽说明；加重了具有变惯性矩结构的分量；增加了附录 B，包括对常规形状的结构采用通用的计算机软件进行结构分析的一些问题。

(3) **例题变换** 为了进一步阐明理论的实际应用，一些例题作了变动，并借助于插图、模型，以及对作用在真实结构上的荷载进行分析来实现，这些变动贯穿于全文。

(4) **附加照片** 掌握本课程的重要性是通过实际应用来体现的，许多贯穿于全文的新的或者更新的照片描述了这些实际应用。

(5) **习题更新** 本版中，近70%的习题是新的。在难易程度上保持平衡。除本作者外，这些习题还经过了其他三位合作者的检查和复核。

(6) **习题安排** 为了便于布置作业，习题是贯穿全书进程设置的。每一章都有明确的规定，包含一个专题解释、例题说明和一组作业。作业的难度是逐步提高的。

2. 标志性部分

(1) **照片** 为了阐明结构力学原理是怎样应用于现实世界的，书中用了许多照片。

(2) **疑难问题** 书中的大部分习题描绘出了实际中遇到的真实状态。希望这些习题既能引起学生对结构力学的兴趣，又能提高他们的技能，用适当的理论，从物理描述到模型或形象，来解决这些类似的疑难问题。本书的疑难问题与 SI 或 FPS 的部分对比大体均衡。有意扩充的疑难问题，可以测验学生应用理论

⊖ “前言”、“目录”由重庆大学萧允徽教授翻译。——编辑注

的能力，使他们保持敏锐的思维。至于疑难问题所需要的单调乏味的计算，就由计算机来完成。

(3) **部分习题答案** 所选习题的答案附在书后，这些答案给出了非常细致说明和解答。所有题目经过检查和复核，确保清楚明了、答案准确。

(4) **例题** 所有例题都作了简明易懂的解说。

(5) **插图** 书中增添了双色插图，包括许多真实照片的图解说明，从而增强了与工程结构三维自然状态的联系。

(6) **检查** 本版经过严格精确的检查和校对。除作者审查了所有插图和校样外，弗吉尼亚理工学院的斯科特·亨德里克斯（Scott Hendricks），南佛罗里达大学的卡里姆·努赫拉（Karim Nohra）和劳雷尔技术服务处的库尔特·诺林（Kurt Norlin）复核了校样，最后一起复审了整个解题指南。

3. 教师参考资料

(1) 教师答疑手册。

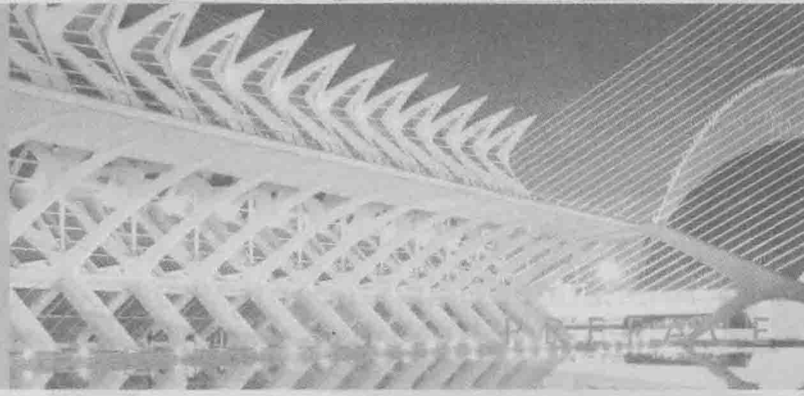
(2) 所有插图都已做成幻灯片和JPEG格式，可以从网上下载获取。

(3) 视频中把每个作业习题的解答步骤一步步地演示出来，使上课时间更有效地被利用来给学生讲授完整、清晰的解题方法。学生可以安排任何时间，由他们自己支配来观看。视频是灵活的资料，每个教师和学生都喜欢使用。作为有价值的参考资料，视频还可以帮助学生进行自我评估，他们可以暂停播放，检查自己的理解程度，可以一边观看，一边学习。在网上（www.pearsonhighered.com/hibbeler）进入视频，跟随本教材的链接学习。

4. 学生参考资料

包括配套网站手册、解题视频、解题全过程（加强许多概念之间的联系）、自我安排教学进程以及24/7捷径等。

Russel Charles Hibbeler



PREFACE

Structural Analysis, Eighth Edition in SI Units is developed for the effective study of the theory and application of structural analysis as it applies to trusses, beams, and frames. Emphasis is placed on developing the student's ability to both model and analyze a structure and to provide realistic applications encountered in professional practice.

Although technology has reduced the often lengthy calculations required when large or complicated structures are analyzed, it is Hibbeler's opinion that students taking a first course in this subject should also be well versed in the classical methods. Practice in applying these methods will develop a deeper understanding of the basic engineering sciences of statics and mechanics of materials.

This book goes beyond theory and steps into the information age by specially developing animations that breathe new life into classical concepts. Newly developed animations complement the video solutions as part of an enhanced visual learning kit that aids understanding. Anchored by the classic Hibbeler's methods of problem-solving, this is the definitive authority on structural theory gracing lecture halls today.

The book contains these New and Enhanced Elements

1. **Animations help students visualize the invisible forces governing structures**
2. **24/7 video solution walkthroughs offer independent revision**
3. **Diversity of problems and probing analysis build critical thinking**
4. **Realistic diagrams and photos illustrate theories in practice**
5. **Comprehensive and concise organization pave the way for systematic study**
6. **Wide-ranging, time-prudent resources for instructors and students**

PREFACE

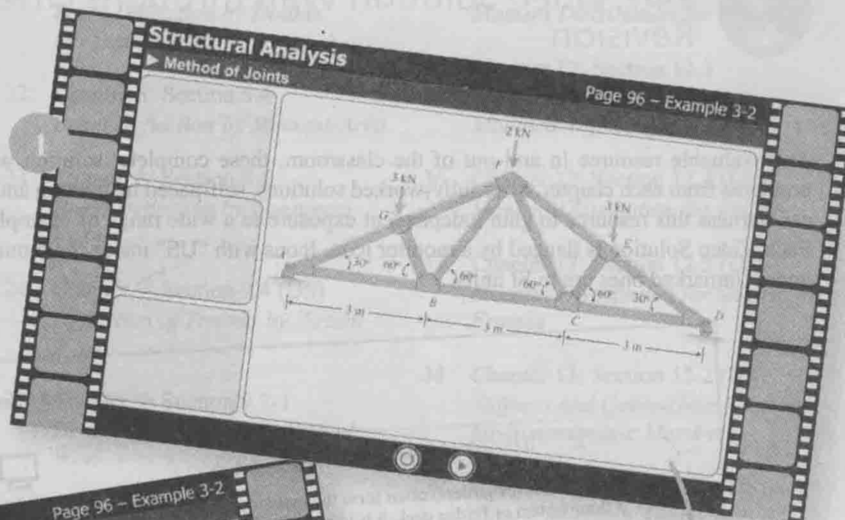
1 Animations Help Students Visualize the Invisible Forces Governing Structures

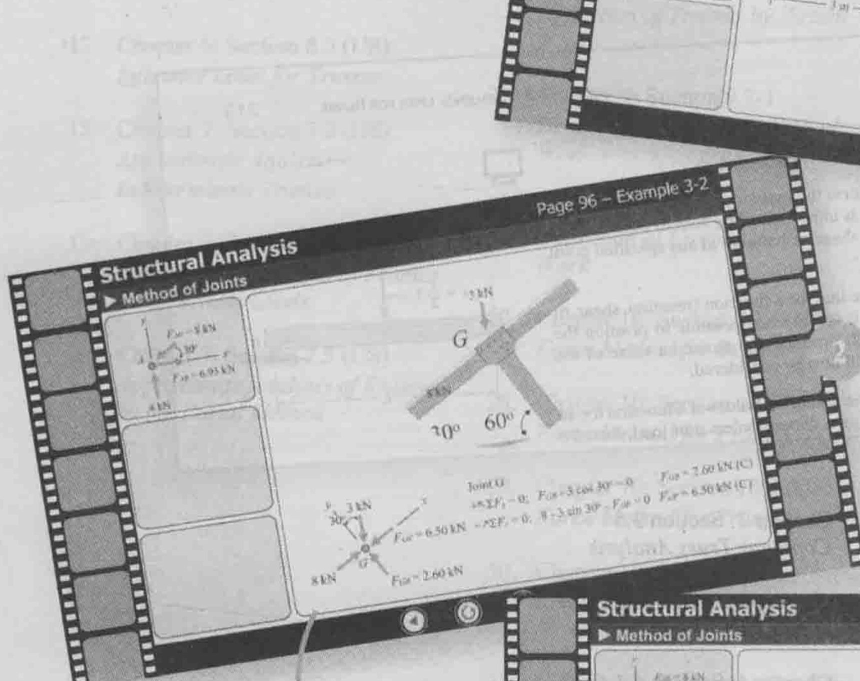
Animations available on the Companion Website

On the Companion Website, students have access to specially created animations. Conceptually designed by Dr. Tan Kiang Hwee, these animations cover concepts that were identified by him as important teaching concepts. Students can access the Companion Website with the Access Code provided. The animations help students visualize the relation between mathematical explanation and real structure, breaking down complicated sequences and building up fuller analysis. They lend a graphic component in tutorial and lecture, assisting lecturers in demonstrating the teaching of concepts with greater ease and clarity.

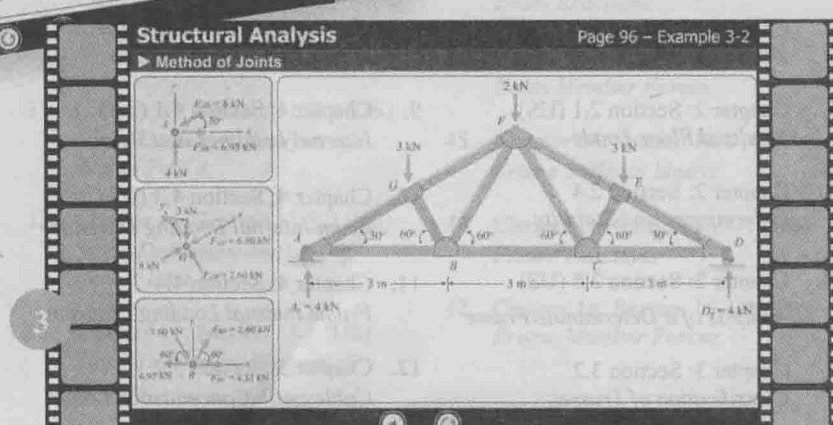
List of Animations

Lecturers can demonstrate the different methods of analysis step-by-step.





Maximize the use of class contact time.

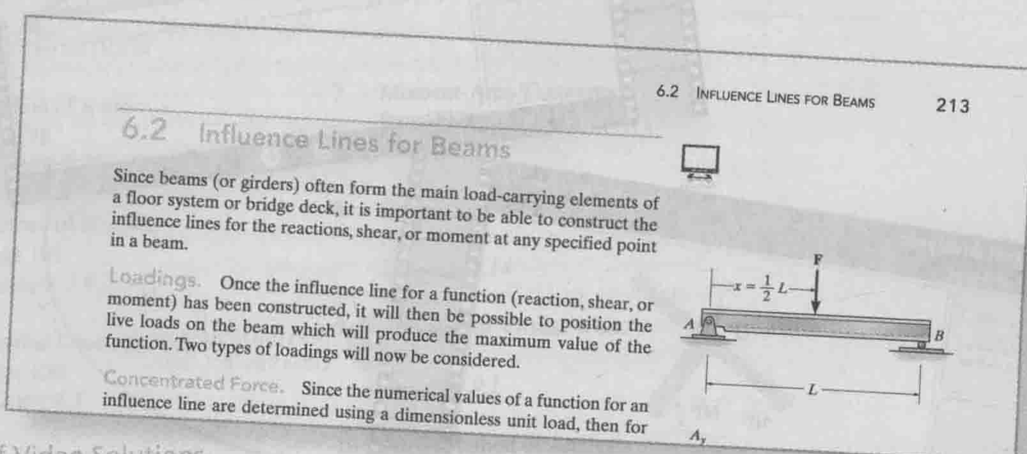


Students 'see' how the variables they apply in the mathematical equations affect the analysis of the structure.

2 24/7 Video Solution Walkthroughs Offer Independent Revision

Video Solutions

An invaluable resource in and out of the classroom, these complete, solution walkthroughs of representative homework problems from each chapter, offer fully-worked solutions, self-paced instruction and 24/7 accessibility. Lecturers and students can harness this resource to gain independent exposure to a wide range of examples applying formulae to actual structures. Each Video Solution is flagged by a monitor icon. Icons with "US" inside the monitor indicate that the videos are in imperial units. Unmarked ones are in SI units.


6.2 INFLUENCE LINES FOR BEAMS 213

6.2 Influence Lines for Beams

Since beams (or girders) often form the main load-carrying elements of a floor system or bridge deck, it is important to be able to construct the influence lines for the reactions, shear, or moment at any specified point in a beam.

Loadings. Once the influence line for a function (reaction, shear, or moment) has been constructed, it will then be possible to position the live loads on the beam which will produce the maximum value of the function. Two types of loadings will now be considered.

Concentrated Force. Since the numerical values of a function for an influence line are determined using a dimensionless unit load, then for

List of Video Solutions

1. Chapter 1: Section 1.3-1 (US)
   Floor Load
2. Chapter 1: Section 1.3-2 (US)
   Wind Load
3. Chapter 2: Section 2.1 (US)
   Idealized Floor Loads
4. Chapter 2: Section 2.4
   Determinacy and Stability
5. Chapter 2: Section 2.5 (US)
   Analysis of a Determinate Frame
6. Chapter 3: Section 3.2
   Classification of Trusses
7. Chapter 3: Section 3.5
   Coplanar Truss Analysis
8. Chapter 3: Section 3.8 (US)
   Space Truss Analysis
9. Chapter 4: Section 4.1 (US)
   Internal Loadings at a Point
10. Chapter 4: Section 4.3 (US)
    Beam Internal Loading Diagrams
11. Chapter 4: Section 4.4
    Frame Internal Loading Diagrams
12. Chapter 5: Section 5.2
    Cables with Concentrated Loads

13. Chapter 5: Section 5.5 (US)
Three-Hinged Arch Analysis

14. Chapter 6: Section 6.2
Influence Lines for Beams

15. Chapter 6: Section 6.3 (US)
Influence Lines by Müller-Breslau Principle

16. Chapter 6: Section 6.4
Influence Lines for Floor Girders

17. Chapter 6: Section 6.5 (US)
Influence Lines for Trusses

18. Chapter 7: Section 7.2 (US)
Approximate Analysis – Indeterminate Trusses

19. Chapter 7: Section 7.3 (US)
Approximate Analysis of Frames with Vertical Loads

20. Chapter 7: Section 7.5 (US)
Approximate Analysis of Frames by the Portal Method

21. Chapter 8: Section 8.3
Beam Deflection by Double Integration

22. Chapter 8: Section 8.4
Beam Deflection by Moment-Area

23. Chapter 8: Section 8.5
Beam Deflection by Conjugate Beam

24. Chapter 9: Section 9.4 (US)
Deflection of Trusses by Virtual Work

25. Chapter 9: Section 9.7-1
Deflection of Beams by Virtual Work

26. Chapter 9: Section 9.7-2 (US)
Deflection of Frames by Virtual Work

27. Chapter 10: Section 10.4 (US)
Force Method for Beams

28. Chapter 10: Section 10.5
Force Method for Frames

29. Chapter 10: Section 10.6 (US)
Force Method for Trusses

30. Chapter 10: Section 10.7
Force Method for Composite Structures

31. Chapter 11: Section 11.3-1 (US)
Slope-Deflection Analysis of Beams Part 1

32. Chapter 11: Section 11.3-2 (US)
Slope-Deflection Analysis of Beams Part 2

33. Chapter 11: Section 11.4 (US)
Slope-Deflection Analysis of Frames

34. Chapter 12: Section 12.2 (US)
Moment Distribution for Beams

35. Chapter 12: Section 12.3
Moment Distribution Using Modified Stiffnesses

36. Chapter 12: Section 12.4 (US)
Moment Distribution for Frames

37. Chapter 12: Section 12.5 (US)
Moment Distribution for Sidesway Frames

38. Chapter 13: Section 13.2 (US)
Stiffness and Carry-Over Factors for Nonprismatic Members

39. Chapter 13: Section 13.3 (US)
Slope-Deflection Analysis of Nonprismatic Beams

40. Chapter 14: Section 14.5
Truss Stiffness Matrix

41. Chapter 14: Section 14.6
Truss Reactions

42. Chapter 14: Section 14.8 (US)
Trusses with Thermal Changes

43. Chapter 15: Section 15.4-1
Beam Reactions

44. Chapter 15: Section 15.4-2
Beam Member Forces

45. Chapter 16: Section 16.3 (US)
Frame Stiffness Matrix

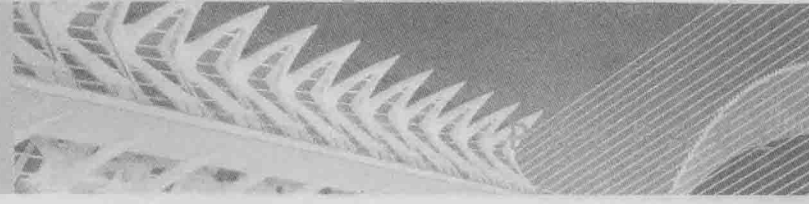
46. Chapter 16: Section 16.4-1 (US)
Frame Reactions

47. Chapter 16: Section 16.4-2 (US)
Frame Member Forces

Independent replays of the voiceover videos reinforces students' understanding

Reduces lecturers' time spent in repetitive explanation of concepts

Flexible resource for student self-evaluation



3 Diversity of Problems and Probing Analysis Build Critical Thinking

24 CHAPTER 1 TYPES OF STRUCTURES AND LOADS

1 **EXAMPLE 1.4**

The unheated storage facility shown in Fig. 1–14 is located on flat open terrain in southern Illinois, where the specified ground snow load is 0.72 kN/m². Determine the design snow load on the roof which has a slope of 4%.

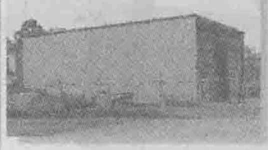


Fig. 1–14

SOLUTION

Since the roof slope is < 5%, we will use Eq. 1–5. Here, $C_e = 0.8$ due to the open area, $C_t = 1.2$ and $I_s = 0.8$. Thus,

$$p_f = 0.7C_eC_tI_sp_g$$
$$= 0.7(0.8)(1.2)(0.8)(0.72\ \text{kN/m}^2) = 0.39\ \text{kN/m}^2$$

Since $p_g = 0.72\ \text{kN/m}^2 < 0.96\ \text{kN/m}^2$, then also

$$p_f = Ip_g = 0.8(0.72\ \text{kN/m}^2) = 0.58\ \text{kN/m}^2$$

By comparison, choose

$$p_f = 0.58\ \text{kN/m}^2 \quad \textit{Ans.}$$

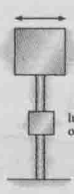


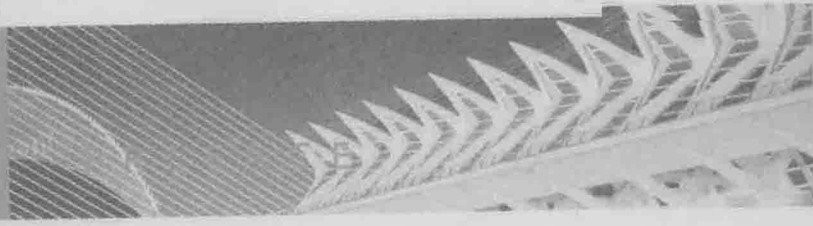
Fig. 1–15

Earthquake Loads. Earthquakes produce loadings on a structure through its interaction with the ground and its response characteristics. These loadings result from the structure's distortion caused by the ground's motion and the lateral resistance of the structure. Their magnitude depends on the amount and type of ground accelerations and the mass and stiffness of the structure. In order to provide some insight as to the nature of earthquake loads, consider the simple structural model shown in Fig. 1–15. This model may represent a single-story building, where the top block is the "lumped" mass of the roof, and the middle block is the lumped stiffness of all the building's columns. During an earthquake the ground vibrates both horizontally and vertically. The horizontal accelerations create shear forces in the column that put the block in sequential motion with the ground. If the column is *stiff* and the block has a *small* mass, the period of vibration of the block will be *short* and the block will accelerate with the same motion as the ground and undergo only slight relative displacements. For an actual structure which is designed to have large amounts of bracing and stiff connections this can be beneficial, since less stress is developed in the members. On the other hand, if the column in Fig 1–15 is very flexible and the block has a large mass, then earthquake-induced motion will cause small accelerations of the block and large relative displacements.

In practice the effects of a structure's acceleration, velocity, and displacement can be determined and represented as an *earthquake*

◀ Example Problems

Students are able to exercise their problem-solving skills through these problems which have a range of possible solutions. Concluding notes have also been incorporated in the examples enabling the student to extend the analysis of the example with detailed solutions.

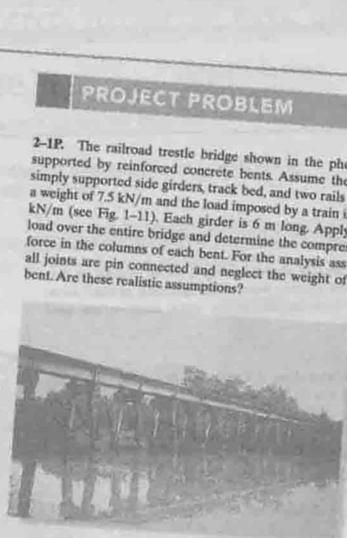


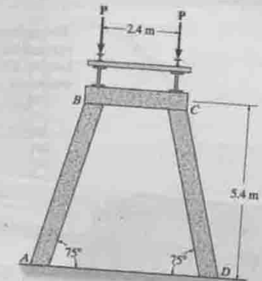
Project Problems ▶

Project Problems that involve real structural systems are included at the end of selected chapters. They provide the student with insight as to how loads are determined and transmitted through the structure.

PROJECT PROBLEM

2–1P. The railroad trestle bridge shown in the photo is supported by reinforced concrete bents. Assume the two simply supported side girders, track bed, and two rails have a weight of 7.5 kN/m and the load imposed by a train is 100 kN/m (see Fig. 1–11). Each girder is 6 m long. Apply the load over the entire bridge and determine the compressive force in the columns of each bent. For the analysis assume all joints are pin connected and neglect the weight of the bent. Are these realistic assumptions?



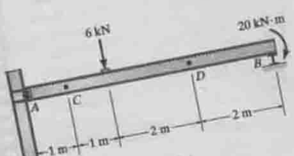


Project Prob. 2–1P

146 CHAPTER 4 INTERNAL LOADINGS DEVELOPED IN STRUCTURAL MEMBERS

PROBLEMS

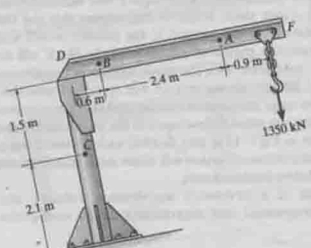
4–1. Determine the internal normal force, shear force, and bending moment in the beam at points *C* and *D*. Assume the support at *A* is a pin and *B* is a roller.



Prob. 4–1

4–2. Determine the internal normal force, shear force, and bending moment in the beam at points *C* and *D*. Assume

4–3. The boom *DF* of the jib crane and the column *DE* have a uniform weight of 750 N/m. If the hoist and load weigh 1350 N, determine the internal normal force, shear force, and bending moment in the crane at points *A*, *B*, and *C*.



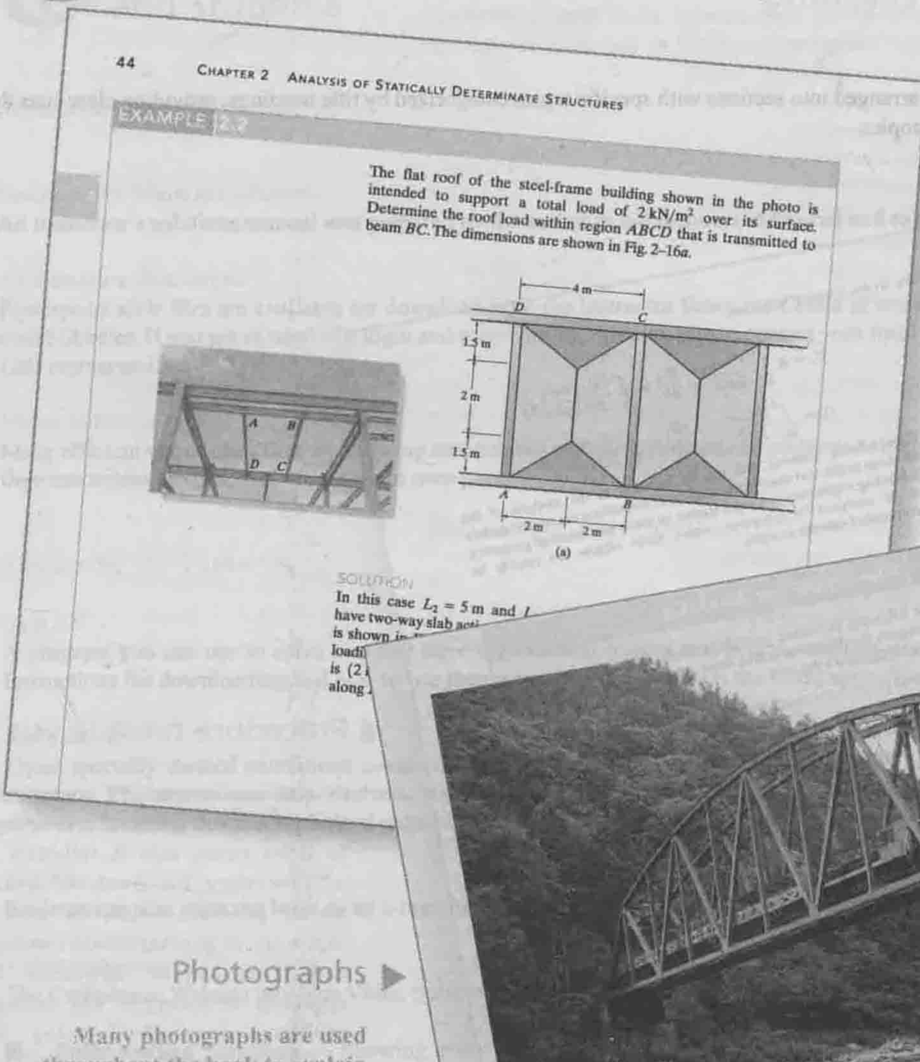
Prob. 4–3

***4–4.** Determine the internal normal force, shear force, and bending moment at point *D*. Take $w = 150$ N/m.

◀ Problems

These problems depict realistic situations encountered in practice. They are developed to test student's ability to apply the concepts. A wider range of questions is given for student's practice and application. Lecturers have more questions to select, modify and add as new questions to their resources.

4 Realistic Diagrams and Photos Illustrate Theories in Practice



44 CHAPTER 2 ANALYSIS OF STATICALLY DETERMINATE STRUCTURES

EXAMPLE 2.2

The flat roof of the steel-frame building shown in the photo is intended to support a total load of 2 kN/m² over its surface. Determine the roof load within region *ABCD* that is transmitted to beam *BC*. The dimensions are shown in Fig. 2–16*a*.

SOLUTION

In this case $L_2 = 5$ m and *L*
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is shown in
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along

Illustrations

Throughout the book, an increase in two-color art has been added, including many photorealistic illustrations that provide a strong connection to the 3-D nature of engineering.

Photographs

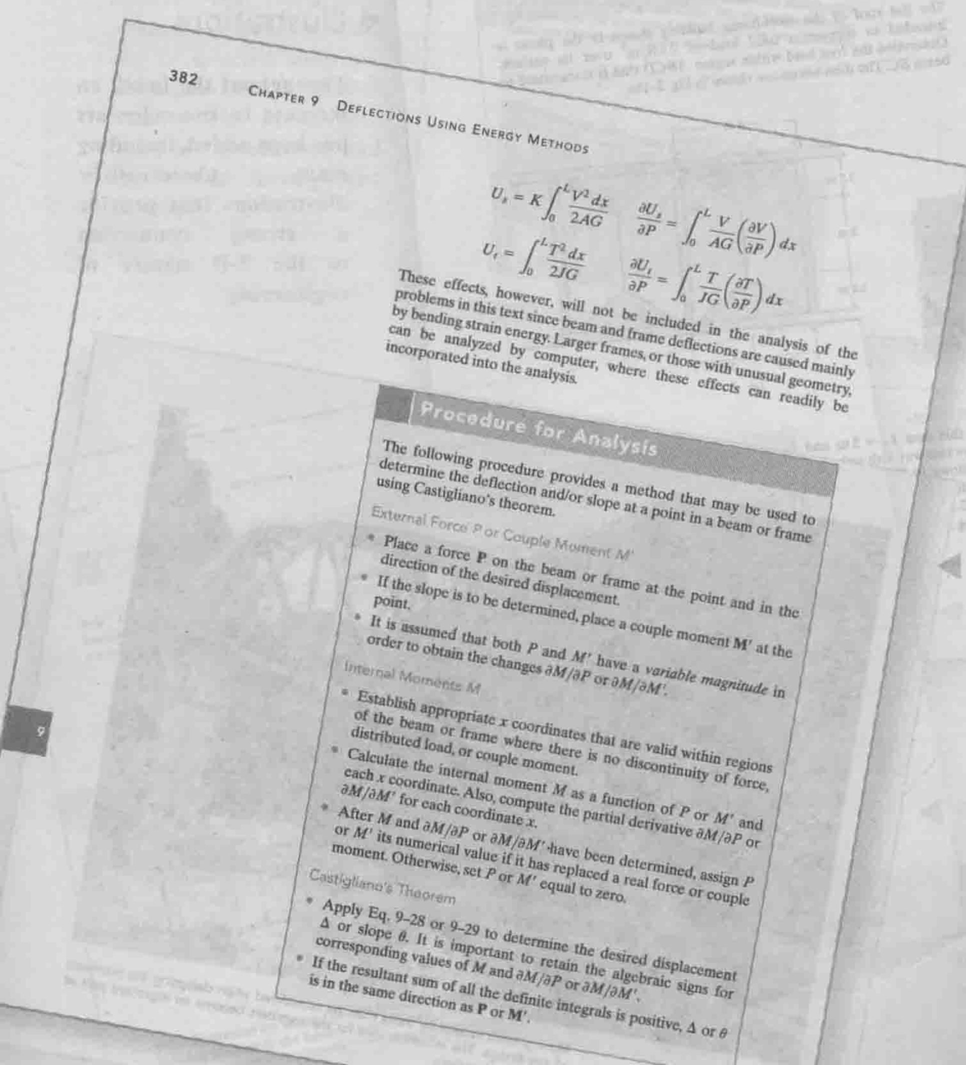
Many photographs are used throughout the book to explain how the principles of structural analysis apply to real-world situations. New photos have been added to the eighth edition.

Moving loads caused by trains must be considered when designing the members of this bridge. The influence lines for the members become an important part of the structural analysis.

5 Comprehensive and Concise Organization Pave the Way for Systematic Learning

Framework

The contents of each chapter are arranged into sections with specific topics categorized by title headings, providing clear cues that allows students to progressively follow topics.



382 CHAPTER 9 DEFLECTIONS USING ENERGY METHODS

$$U_s = K\int_0^L \frac{V^2\,dx}{2AG} \qquad \frac{\partial U_s}{\partial P} = \int_0^L \frac{V}{AG}\left(\frac{\partial V}{\partial P}\right)dx$$

$$U_t = \int_0^L \frac{T^2\,dx}{2JG} \qquad \frac{\partial U_t}{\partial P} = \int_0^L \frac{T}{JG}\left(\frac{\partial T}{\partial P}\right)dx$$

These effects, however, will not be included in the analysis of the problems in this text since beam and frame deflections are caused mainly by bending strain energy. Larger frames, or those with unusual geometry, can be analyzed by computer, where these effects can readily be incorporated into the analysis.

Procedure for Analysis

The following procedure provides a method that may be used to determine the deflection and/or slope at a point in a beam or frame using Castigliano's theorem.

External Force **P** or Couple Moment **M'**

- Place a force **P** on the beam or frame at the point and in the direction of the desired displacement.
- If the slope is to be determined, place a couple moment **M'** at the point.
- It is assumed that both P and M' have a *variable magnitude* in order to obtain the changes $\partial M/\partial P$ or $\partial M/\partial M'$.

Internal Moments M

- Establish appropriate x coordinates that are valid within regions of the beam or frame where there is no discontinuity of force, distributed load, or couple moment.
- Calculate the internal moment M as a function of P or M' and each x coordinate. Also, compute the partial derivative $\partial M/\partial P$ or $\partial M/\partial M'$ for each coordinate x.
- After M and $\partial M/\partial P$ or $\partial M/\partial M'$ have been determined, assign P or M' its numerical value if it has replaced a real force or couple moment. Otherwise, set P or M' equal to zero.

Castigliano's Theorem

- Apply Eq. 9–28 or 9–29 to determine the desired displacement Δ or slope θ. It is important to retain the algebraic signs for corresponding values of M and $\partial M/\partial P$ or $\partial M/\partial M'$.
- If the resultant sum of all the definite integrals is positive, Δ or θ is in the same direction as **P** or **M'**.

Procedure for Analysis

Discussions relevant to a particular theory are succinct, yet thorough. In most cases, this is followed by a "Procedure for Analysis" guide, which provides students with a summary of the important concepts and a systematic approach for applying the concepts. The example problems are solved using this outlined method in order to clarify its numerical application. Problems are given at the end of each chapter and are arranged to cover the material in sequential order; moreover, for any topic they are arranged in order of increasing difficulty.