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4

Theory of Structures  
Second Edition

# 结构理论

## 第2版

S. P. Timoshenko    D. H. Young

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# THEORY OF STRUCTURES

Second Edition

**S. P. TIMOSHENKO**

*Emeritus Professor of Engineering Mechanics  
Stanford University*

**D. H. YOUNG**

*Silas H. Palmer Professor of  
Civil Engineering  
Stanford University*



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S. P. Timoshenko D. H. Young

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# Theory of Structures

(Second Edition)

## 影 印 版 序

S. P. Timoshenko 教授和 D. H. Young 教授合作的“结构理论”(第2版),是 Timoshenko 教授 1926 年在原苏联列宁格勒出版的“结构理论”和 1945 年在美国 McGraw-Hill 出版的“结构理论”(第1版)的延续和发展。由于目前我国工科高等教育教材改革的需要,这本书由清华大学出版社再次影印出版。

在科技迅猛发展的大半个世纪里,一本高等教育的工科教科书在国际范围内得到活跃的教学界如此广泛的推崇和认可,这样的经典之作必有其奥妙之处。作为一名结构力学教师,我愿将如下体会与大家分享,以供参考。

这本书原来是为土木工程系写的关于结构分析的教科书,主要用作本科生和一年级研究生的教材。该书最大的优点在于:首先,它十分理解读者的状态,循循善诱、深入浅出。与有些书总是把简单问题复杂化的做法恰好相反,作者力图把一些十分复杂的问题用简单的方法描述清楚。作者在从力学的基本原理到各种结构分析方法的过渡上,在从结构分析方法到解决各种变化莫测的工程问题的过渡上,都写得非常自然。各章的安排似乎大多在讲不同的结构,实际上却有很清晰的理论系统。这不能不归结于作者丰富的教学经验和出色的表达艺术。因此,这本书也十分适合自学。其次,作者在 1926 年完成了这本书的编写框架,随着科技的发展,他不断地对原著进行修改、补充。以“结构理论”(第2版)为例:关于拱和框架的第 8、9 章几乎按弹性核的概念完全重写;由于结构和计算机的发展,增加了结构矩阵方法和结构动力学两章。Timoshenko 教授从来没有满足于已有的成果,从来不认为他的书已达到完美的境地,他一直在与时俱进。最后,特别应该指出的是:作者的写作十分严格,反映了作者严谨的治学精神。难怪人们说:在 Timoshenko

的书里很难找到错误。

可以说，Timoshenko 教授不仅是一位出色的结构工程学者，更是一位优秀的教师。循循善诱、不断进取、严谨治学是他的特点，也是我们在编写教材时应特别向他学习的地方。

刘西拉

于北京

# Preface

This second edition of "Theory of Structures," like the first, is intended primarily as a textbook for undergraduate and first-year graduate courses in structural analysis for civil engineers. To serve this purpose, every effort has been made to maintain a close connection between the methods that are developed for the analysis of various types of structures and the fundamental principles of mechanics on which they are based. It is only through a sound understanding of these principles that the engineer can successfully adapt his methods of analysis to the ever-changing problems that will confront him in this modern era.

The book may be roughly divided into two parts: the first part dealing with statically determinate structures, and the second part dealing with statically indeterminate structures. On this plan, the first four chapters deal successively with a review of statics (primarily graphic statics), statically determinate plane trusses, influence lines for beams and trusses, and statically determinate space trusses. Following this, Chapters 5 and 6 treat the fundamental theorems relating to elastic systems and their applications to the calculation of deflections of beams and trusses. In turn, there are chapters dealing with the analysis of statically indeterminate trusses, arches, and frames. The final chapters are devoted to an introduction to matrix methods in structural analysis, the analysis of stiffened suspension bridges, and an introduction to the dynamics of structures.

The first seven chapters in this second edition of "Theory of Structures" remain essentially the same as in the first edition. Chapters 8 and 9, dealing with arches and frames, have been completely rewritten. The present treatment of arches has been simplified by basing it on the theorem of least work and using the concept of elastic center. Several articles on the analysis of portal-type frames, using the elastic-center concept, have also been added. In rewriting the chapter on the uses of slope-deflection equations in the analysis of continuous beams and frames, we have extended the treatment to include systems with nonprismatic members and have included many examples of this kind.

Since the first appearance of this book (1945), two new aspects of structural analysis have become very important, namely, the use of matrix methods of formulating problems and the analysis of structures under dynamic loading. These are both very extensive subjects, and a number of complete books on each are now available. Chapters 10 and 12 here are intended only as introductions to these topics, but we hope that they will encourage the reader to continue his studies in these directions.

In the preparation of the first edition of this book, the senior author's Russian book "Theory of Structures" (Leningrad, 1926) was extensively used. Acknowledgment is also due to Otto Mohr's "Abhandlugen aus dem Gebiete der technischen Mechanik" and to H. Müller-Breslau's "Die graphische Statik der Baukonstruktionen." The authors also wish to give special thanks to Mr. P. Rabcevic of New York City for the use of a number of examples and problems appearing in Chapters 8 and 9 and to Miss Rose Marie Stampfel and Miss Martha Lee Young for their careful typing of the new portions of the manuscript.

*S. P. Timoshenko*

*D. H. Young*



# 内 容 提 要

<b>第 1 章</b>	<b>平面静力学单元</b> .....	1
1.1	一个平面中同时发生的力 .....	1
1.2	三力平衡 .....	5
1.3	平衡方程 .....	10
1.4	内力 .....	14
1.5	索多边形 .....	19
1.6	索多边形的应用 .....	24
1.7	分布力作用下的索曲线 .....	29
1.8	柔性悬索 .....	33
1.9	画弯矩图 .....	39
1.10	虚位移原理 .....	45
<b>第 2 章</b>	<b>静定平面桁架</b> .....	52
2.1	简单桁架 .....	52
2.2	反力 .....	57
2.3	结点法 .....	62
2.4	Maxwell 图 .....	65
2.5	截面法 .....	70
2.6	组合桁架 .....	77
2.7	平面桁架的一般理论 .....	85
2.8	复杂桁架: Henneberg 方法 .....	92
2.9	虚位移方法 .....	98
<b>第 3 章</b>	<b>影响线</b> .....	105
3.1	移动荷载和影响线 .....	105
3.2	梁反力的影响线 .....	112
3.3	剪力影响线 .....	119
3.4	弯矩影响线 .....	127

3.5	带次梁的主梁 .....	134
3.6	三绞拱肋的影响线 .....	140
3.7	简单桁架的影响线 .....	147
3.8	组合桁架的影响线 .....	154
<b>第 4 章</b>	<b>静定空间结构 .....</b>	<b>161</b>
4.1	空间中同时发生的力 .....	161
4.2	简单空间桁架: 结点法 .....	169
4.3	空间一刚体的静定约束 .....	176
4.4	组合空间桁架: 截面法 .....	183
4.5	静定空间桁架的一般理论 .....	188
4.6	复杂空间桁架分析 .....	195
4.7	Henneberg 方法 .....	205
<b>第 5 章</b>	<b>与弹性系统有关的一般理论 .....</b>	<b>215</b>
5.1	拉、扭、弯中的应变能 .....	215
5.2	叠加原理 .....	219
5.3	应变能的一般形式 .....	223
5.4	Castigliano 第一定理 .....	229
5.5	Castigliano 第二定理 .....	234
5.6	最小功原理 .....	241
5.7	互等定理 .....	247
<b>第 6 章</b>	<b>铰结桁架的位移 .....</b>	<b>257</b>
6.1	Castigliano 定理的应用 .....	257
6.2	计算位移的 Maxwell-Mohr 方法 .....	263
6.3	桁架位移图解法 .....	267
6.4	虚拟荷载法 .....	276
6.5	变更的虚拟荷载法 .....	285
<b>第 7 章</b>	<b>静不定桁架 .....</b>	<b>294</b>
7.1	一般考虑 .....	294
7.2	带一个冗余杆件的桁架 .....	297
7.3	带多个冗余杆件的桁架 .....	303

7.4	静不定桁架的装配和热应力 .....	310
7.5	静不定桁架的影响线 .....	316
7.6	静不定空间结构 .....	325
<b>第 8 章</b>	<b>拱与框架 .....</b>	<b>332</b>
8.1	序言 .....	332
8.2	对称二铰拱 .....	335
8.3	对称无铰拱 .....	341
8.4	冗余杆件的数值计算 .....	351
8.5	拱中心线的索线 .....	358
8.6	不对称拱 .....	371
8.7	无铰框架 .....	381
8.8	带铰的框架 .....	390
8.9	温度变化和支座沉降的影响 .....	394
8.10	环 .....	398
<b>第 9 章</b>	<b>连续梁与框架 .....</b>	<b>402</b>
9.1	斜率-挠度方程 .....	402
9.2	固端梁 .....	408
9.3	连续梁 .....	412
9.4	变截面梁 .....	421
9.5	变截面连续梁 .....	431
9.6	带等截面杆的简单框架 .....	441
9.7	带等截面杆的连续框架 .....	451
9.8	弯矩分配法 .....	460
9.9	建筑物框架分析 .....	469
9.10	带加筋肋的框架 .....	475
<b>第 10 章</b>	<b>结构分析的矩阵方法 .....</b>	<b>480</b>
10.1	力法和位移法 .....	480
10.2	矩阵代数的单元 .....	484
10.3	矩阵方法在平面桁架中的应用 .....	491
10.4	连续梁的矩阵分析 .....	500

10.5	拱与框架的矩阵处理 .....	510
10.6	连续梁的矩阵分析 .....	516
<b>第 11 章</b>	<b>悬索桥 .....</b>	<b>523</b>
11.1	抛物线索曲线 .....	523
11.2	不考虑索刚度的悬索桥的挠度 .....	525
11.3	考虑索刚度的悬索桥的基本方程 .....	533
11.4	刚桁架分析 .....	538
11.5	挠度计算中三角级数的应用 .....	543
11.6	带简支刚桁架的三跨悬索桥 .....	547
11.7	带连续刚桁架的三跨悬索桥 .....	549
11.8	变截面刚桁架 .....	556
<b>第 12 章</b>	<b>结构动力学 .....</b>	<b>562</b>
12.1	单自由度的自由振动 .....	562
12.2	Rayleigh 法 .....	568
12.3	稳态强迫振动 .....	575
12.4	一个干扰力的通用情况 .....	581
12.5	数值积分 .....	588
12.6	图形积分 .....	594
12.7	轨道静动应力 .....	601
12.8	等截面梁的横向振动 .....	608
12.9	桥梁的振动 .....	613
12.10	地震作用下的结构 .....	617
姓名索引 .....		625
专业词汇索引 .....		627

# Contents

*Preface*      *xiii*

## **chapter 1   ELEMENTS OF PLANE STATICS      1**

1.1	CONCURRENT FORCES IN A PLANE	1
1.2	THREE FORCES IN EQUILIBRIUM	5
1.3	EQUATIONS OF EQUILIBRIUM	10
1.4	INTERNAL FORCES	14
1.5	FUNICULAR POLYGON	19
1.6	APPLICATIONS OF THE FUNICULAR POLYGON	24
1.7	FUNICULAR CURVES FOR DISTRIBUTED FORCE	29
1.8	FLEXIBLE SUSPENSION CABLES	33
1.9	GRAPHICAL CONSTRUCTION OF BENDING-MOMENT DIAGRAMS	39
1.10	PRINCIPLE OF VIRTUAL DISPLACEMENTS	45

## **chapter 2   STATICALLY DETERMINATE PLANE TRUSSES      52**

2.1	SIMPLE TRUSSES	52
2.2	REACTIONS	57
2.3	METHOD OF JOINTS	62
2.4	MAXWELL DIAGRAMS	65
2.5	METHOD OF SECTIONS	70
2.6	COMPOUND TRUSSES	77
2.7	GENERAL THEORY OF PLANE TRUSSES	85
2.8	COMPLEX TRUSSES: HENNEBERG'S METHOD	92
2.9	METHOD OF VIRTUAL DISPLACEMENTS	98

## **chapter 3   INFLUENCE LINES      105**

3.1	MOVING LOADS AND INFLUENCE LINES	105
3.2	INFLUENCE LINES FOR BEAM REACTIONS	112

3.3	INFLUENCE LINES FOR SHEARING FORCE	119
3.4	INFLUENCE LINES FOR BENDING MOMENT	127
3.5	GIRDERS WITH FLOOR BEAMS	134
3.6	INFLUENCE LINES FOR THREE-HINGED ARCH RIBS	140
3.7	INFLUENCE LINES FOR SIMPLE TRUSSES	147
3.8	INFLUENCE LINES FOR COMPOUND TRUSSES	154

#### **chapter 4    STATICALLY DETERMINATE SPACE STRUCTURES    161**

4.1	CONCURRENT FORCES IN SPACE	161
4.2	SIMPLE SPACE TRUSSES: METHOD OF JOINTS	169
4.3	STATICALLY DETERMINATE CONSTRAINT OF A RIGID BODY IN SPACE	176
4.4	COMPOUND SPACE TRUSSES: METHOD OF SECTIONS	183
4.5	GENERAL THEORY OF STATICALLY DETERMINATE SPACE TRUSSES	188
4.6	ANALYSIS OF COMPLEX SPACE TRUSSES	195
4.7	HENNEBERG'S METHOD	205

#### **chapter 5    GENERAL THEOREMS RELATING TO ELASTIC SYSTEMS    215**

5.1	STRAIN ENERGY IN TENSION, TORSION, AND BENDING	215
5.2	PRINCIPLE OF SUPERPOSITION	219
5.3	STRAIN ENERGY IN GENERALIZED FORM	223
5.4	CASTIGLIANO'S FIRST THEOREM	229
5.5	CASTIGLIANO'S SECOND THEOREM	234
5.6	THEOREM OF LEAST WORK	241
5.7	THE RECIPROCAL THEOREM	247

#### **chapter 6    DEFLECTION OF PIN-JOINTED TRUSSES    257**

6.1	APPLICATIONS OF CASTIGLIANO'S THEOREM	257
6.2	MAXWELL-MOHR METHOD OF CALCULATING DEFLECTIONS	263
6.3	GRAPHICAL DETERMINATION OF TRUSS DEFLECTIONS	267
6.4	METHOD OF FICTITIOUS LOADS	276
6.5	ALTERNATIVE METHOD OF FICTITIOUS LOADS	285

#### **chapter 7    STATICALLY INDETERMINATE PIN-JOINTED TRUSSES    294**

7.1	GENERAL CONSIDERATIONS	294
7.2	TRUSSES WITH ONE REDUNDANT ELEMENT	297

7.3	TRUSSES WITH SEVERAL REDUNDANT MEMBERS	303
7.4	ASSEMBLY AND THERMAL STRESSES IN STATICALLY INDETERMINATE TRUSSES	310
7.5	INFLUENCE LINES FOR STATICALLY INDETERMINATE TRUSSES	316
7.6	STATICALLY INDETERMINATE SPACE STRUCTURES	325

## **chapter 8 ARCHES AND FRAMES 332**

8.1	INTRODUCTION	332
8.2	SYMMETRICAL TWO-HINGED ARCHES	335
8.3	SYMMETRICAL HINGELESS ARCHES	341
8.4	NUMERICAL CALCULATION OF REDUNDANT ELEMENTS	351
8.5	FUNICULAR CURVE AS THE CENTER LINE OF AN ARCH	358
8.6	UNSYMMETRICAL ARCHES	371
8.7	FRAMES WITHOUT HINGES	381
8.8	FRAMES WITH HINGES	390
8.9	EFFECTS OF TEMPERATURE CHANGES AND SUPPORT SETTLEMENT	394
8.10	RINGS	398

## **chapter 9 CONTINUOUS BEAMS AND FRAMES 402**

9.1	SLOPE-DEFLECTION EQUATIONS	402
9.2	BEAMS WITH FIXED ENDS	408
9.3	CONTINUOUS BEAMS	412
9.4	BEAMS OF VARIABLE CROSS SECTION	421
9.5	CONTINUOUS BEAMS OF VARIABLE CROSS SECTION	431
9.6	SIMPLE FRAMES WITH PRISMATIC MEMBERS	441
9.7	CONTINUOUS FRAMES WITH PRISMATIC MEMBERS	451
9.8	MOMENT-DISTRIBUTION METHOD	460
9.9	ANALYSIS OF BUILDING FRAMES	469
9.10	FRAMES WITH NONPRISMATIC MEMBERS	475

## **chapter 10 MATRIX METHODS IN STRUCTURAL ANALYSIS 480**

10.1	FORCE AND DEFORMATION METHODS	480
10.2	ELEMENTS OF MATRIX ALGEBRA	484
10.3	APPLICATION OF MATRIX METHODS TO PLANE TRUSSES	491
10.4	MATRIX ANALYSIS OF CONTINUOUS BEAMS	500
10.5	MATRIX TREATMENT OF ARCHES AND FRAMES	510
10.6	MATRIX ANALYSIS OF CONTINUOUS FRAMES	516

**chapter 11 SUSPENSION BRIDGES 523**

- 11.1 PARABOLIC FUNICULAR CURVE 523
- 11.2 DEFLECTIONS OF UNSTIFFENED SUSPENSION BRIDGES 525
- 11.3 FUNDAMENTAL EQUATIONS FOR STIFFENED  
SUSPENSION BRIDGES 533
- 11.4 ANALYSIS OF STIFFENING TRUSSES 538
- 11.5 APPLICATION OF TRIGONOMETRIC SERIES IN  
CALCULATING DEFLECTIONS 543
- 11.6 THREE-SPAN SUSPENSION BRIDGES WITH SIMPLY SUPPORTED  
STIFFENING TRUSSES 547
- 11.7 THREE-SPAN SUSPENSION BRIDGE WITH CONTINUOUS  
STIFFENING TRUSS 549
- 11.8 STIFFENING TRUSS OF VARIABLE CROSS SECTION 556

**chapter 12 STRUCTURAL DYNAMICS 562**

- 12.1 FREE VIBRATIONS: ONE DEGREE OF FREEDOM 562
- 12.2 RAYLEIGH'S METHOD 568
- 12.3 FORCED VIBRATIONS: STEADY STATE 575
- 12.4 GENERAL CASE OF A DISTURBING FORCE 581
- 12.5 NUMERICAL INTEGRATION 588
- 12.6 GRAPHICAL INTEGRATION 594
- 12.7 STATICAL AND DYNAMIC STRESSES IN RAILS 601
- 12.8 LATERAL VIBRATIONS OF PRISMATIC BEAMS 608
- 12.9 VIBRATION OF BRIDGES 613
- 12.10 STRUCTURES SUBJECTED TO EARTHQUAKES 617

*Name index* 625  
*Subject index* 627



## Chapter 1

# Elements of plane statics

### 1.1 CONCURRENT FORCES IN A PLANE

The *theory of structures* is based to a large extent upon the principles of statics with which the reader is assumed to be familiar. However, we shall review here some parts of statics that are most useful in the analysis of engineering structures. We begin with the principle of the parallelogram of forces as follows: Two forces  $P_1$  and  $P_2$ , as represented by the vectors  $\overline{OA}$  and  $\overline{OB}$  in Fig. 1.1a, are equivalent in action to a single resultant force  $R$  obtained as the diagonal  $\overline{OC}$  of the parallelogram formed on the given vectors as shown. The same resultant force can be obtained also from the triangle of forces shown in Fig. 1.1b. This follows from the fact that the triangle  $ABC$  in Fig. 1.1b is identical with the triangle  $OAC$  in Fig. 1.1a.

If several forces in a plane act at a single point  $O$  (Fig. 1.2a), they can always be reduced to one resultant force which also acts through that point. This resultant force can be found by successive applications of the parallelogram of