新世纪土木工程系列规划教材

土木工程专业英语

附赠光盘

陈瑛　邵永波　主编

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新世纪土木工程系列规划教材

SCIENCE ENGLISH FOR THE MAJOR IN CIVIL ENGINEERING

土木工程专业英语

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本教材是专门为高等学校土木工程专业建筑工程方向学生学习专业英语而编写的，本书通过集听、写、读于一体的综合训练模式，提高学生的专业英语水平。本书包括36篇文章的阅读、写作练习和随书光盘的20篇短文的听力练习共三大部分。内容涵盖了结构力学、土木工程材料、结构设计、钢筋混凝土基本结构、钢结构、多层及高层建筑结构抗震设计、砌体结构、组合结构、地基与基础、建筑施工组织与管理等方面英语文章阅读、词汇学习和科技论文写作指南。

本书适用于土木工程专业的本科生和研究生学习专业英语，也可作为土木工程领域的工程技术人员学习参考书。

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前　言

本教材是专门为高等院校土木工程专业建筑工程方向学生学习专业英语而编写的，提供了集听、写、读于一体的综合训练模式，以全面提高土木工程专业学生专业英语的阅读、写作能力和听力水平。

本教材阅读和写作部分共分10章，共36篇，涵盖了结构力学、土木工程材料、结构设计基本概念、钢筋混凝土基本构件、钢结构、多层及高层建筑结构抗震设计、砌体结构、组合结构、地基与基础、建筑施工组织与管理10个方面的基本概念和原理。每一课包括文章阅读、生词与词组注解及科技写作指南。写作部分分类讲解了土木工程期刊论文标题、摘要、前言、方法、结果和讨论部分的写法；提供了描述图表、尺寸、材料性质、比较、定义、分类、范围的典型例句，供学生仿写；总结了学生进行土木工程论文写作常犯的语法错误；最后归纳了描述结构设计所常用的句子，供学生写毕业论文时参考。

本教材听力部分（附光盘）以结构抗震为主题，包含20篇短文，介绍了结构抗震的基本概念。每篇短文均模拟英语课堂，学生可以边看边听，在学到专业知识的同时提高专业英语听力水平，为参加国际间学术交流等奠定良好的基础。

本书的第2章到第9章及听力部分覆盖了大学本科建筑结构专业课的全部知识要点，以《建筑结构荷载规范》(GB 5009—2001)、《混凝土结构设计规范》(GB 50010—2002)、《建筑结构抗震设计规范》(GB 50011—2001)、《砌体结构设计规范》(GB 50003—2001)、《钢结构设计规范》(GB 50017—2003)和《建筑地基基础设计规范》(GB 50007—2002)为编写依据，力求讲解系统、概念清晰、条理明确。本书既可以作为建筑学工程管理专业学习建筑结构课程的双语教材，也可作为广大从事建筑工程专业、工程管理专业工程技术人员撰写英语论文的有益参考书。

参加本书编写的有：山东大学陈瑛（第1～4章、第6～7章、第9章和写作部分）、烟台大学邵永波（第2.3节、第2.4节、第5章、第8.1节）、曲慧（第8.2节）、济南大学彭晓彤、青岛农业大学郭旻（写作部分）、山东交通学院汪明栋（第10章）、山东大学王薇（第1.1节）。美国Kent State University的Gregory A. Walker为听力部分进行了录音和编辑。本书由陈瑛、

邵永波任主编、Gregory A. Walker 任副主编。

本书在编写过程中借鉴了美国和其他英语国家的部分优秀教材，听力素材、写作部分的例句均摘自 Springgerlink、Elsevier Science Direct 网站的著名期刊，在此向相关作者致谢！

由于编者水平有限，书中难免有不足之处，恳请广大读者和同行、专家批评指正。

编者

Contents

Chapter 1 Structural Mechanics

1.1 Classification and Behavior of Structural Systems and Elements

1.1.1 Primary Structural Elements

Common rigid elements include beams, columns or *struts*, arches, flat plates, singly curved plates, and shells having a variety of different *curvatures*. Flexible elements include cables (straight and draped) and membranes (*planar*, singly curved, and doubly curved). In addition, there are a number of other types of structures that are derived from these elements (e. g., frames, trusses, *geodesic domes*, nets, etc.) (Figure 1.1).

Frames. The frame has rigid joints that are made between vertical and horizontal members. This joint rigidity imparts a measure of stability against lateral forces. In a framed system both beams and columns are bent or bowed as a consequence of the action of the load on the structure.

Trusses. Trusses are structural members made by assembling short and straight members into triangulated patterns. The resultant structure is rigid as a result of the exact way the individual line elements are positioned relative to one another. Some patterns (e. g., a pattern of squares rather than triangles) do not necessarily yield a structure that is rigid (unless joints are treated in the same way as in framed structures). A truss composed of discrete elements is bent in an overall way under the action of an applied transverse loading in much the same way that a beam is bent. Individual truss members, however, are not subjected to bending but are only either compressed or pulled upon.

Arches. An arch is a curved, line-forming structural member that spans between two points. The common image of an arch is that of a structure composed of separate wedge-shaped pieces that retain their position by mutual pressure induced by the load. The exact shape of the curve and the nature of the

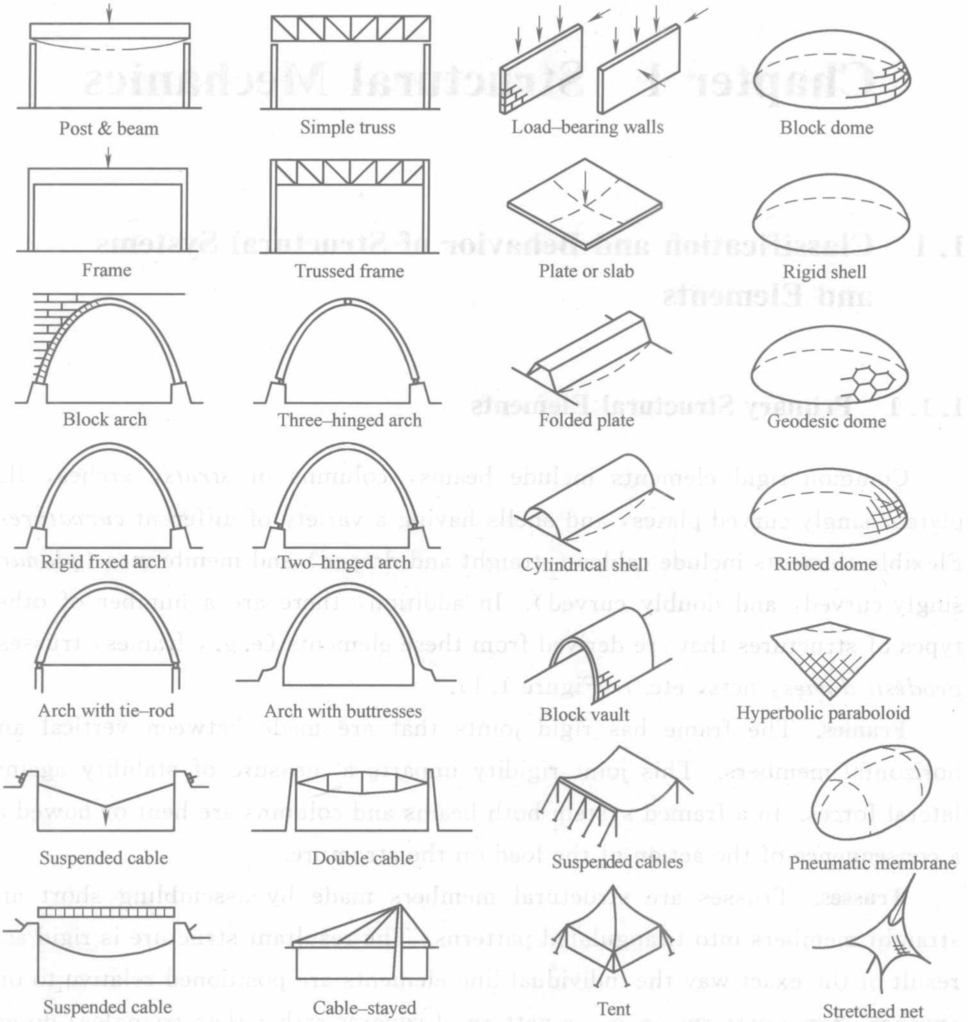


Figure 1.1 Structural elements

loading are critical determinants as to whether the resultant assembly is stable. When shapes are formed by simply stacking rigid block elements, the resultant structure is functional and stable only when the action of the load is to induce in-plane forces that cause the structure to compress uniformly. Structures of this type cannot carry loads that induce elongations or any pronounced type of bowing in the member (the blocks simply pull apart and failure occurs). The strength of a block structure is due exclusively to the positioning of individual elements, since blocks are typically either simply rested one on another or mortared together. The positioning is, in turn, dependent on the exact type of loading involved. The resultant structure is thus rigid only under very particular circumstances.

The rigid arch is frequently used in modern building. It is curved similarly to block arches but is made of one continuous piece of deformed rigid material. If rigid arches are properly shaped, they can carry a load to supports while being subject only to axial compression, and no bending occurs. The rigid arch is better able to carry variations in the design loading than its block counterpart made of individual pieces. Many types of rigid arches exist and are often characterized by their support conditions (fixed, two-hinged, three-hinged).

Walls and Plates. Walls and flat plates are rigid surface-forming structures. A load-bearing wall can typically carry both vertical loads and lateral loads (wind, earthquake) along its length. Resistance to out-of-plane forces in block walls is marginal. A flat plate is typically used horizontally and carries loads by bending to its supports. Plate structures are normally made of reinforced concrete or steel.

Horizontal plates can also be made by assembling patterns of short, rigid line elements. Three-dimensional triangulation schemes are used to impart stiffness to the resultant assembly.

Long, narrow rigid plates can also be joined along their long edges and used to span horizontally in beam-like fashion. These structures, called folded plates, have the potential for spanning fairly large distances.

Cylindrical Shells and Vaults. Cylindrical barrel shells and vaults are examples of singly curved-plate structure. A barrel shell spans longitudinally such that the curve is *perpendicular* to the direction of the span. When fairly long, a barrel shell behaves much like a beam with a curved cross-section. Barrel shells are invariably made of rigid materials (e. g. , reinforced concrete or steel). A vault, by contrast, is a singly curved structure that spans transversely. A vault can be conceived of as basically a continuous arch.

Spherical Shells and Domes. A wide variety of doubly curved surface structures are in use. These include structures that are portions of spheres and those that form *warped surface* (e. g, the *hyperbolic paraboloid*). The number of shapes possible is actually boundless. Probably the most common doubly curved structure is the spherical shell. It is convenient to think of this structure as a rotated arch. This analogy, however, is actually misleading with respect to how the structure actually carries loads because of the fact that loadings include *circumferential forces* in spherical shells which do not exist in arches. Domed structures can be made of stacked blocks or a continuous rigid material (reinforced concrete). Shells and domes are very efficient structures capable of spanning large distances using a minimum of material.

Cables. Cables are flexible structural elements. The shape they *assume* under a loading depends on the nature and magnitude of the load. When a cable is simply pulled on at either end, it assumes a straight shape. This type of cable is often called a tie-rod. When a cable is used to span between two points and carry an external point load or series of point loads, it deforms into a shape made up of a series of straight-line segments. When a continuous load is carried, the cable deforms into a continuously curving shape. The self-weight of the cable itself produces such a *catenary* curve. *Suspension cables* and cable-stayed structures can be used to span large distances.

***Membranes*, Tents, and Nets.** A membrane is a thin, flexible sheet. A common *tent* is made of membrane surfaces. Both simple and complex forms can be created using membranes. For surfaces of double curvature, such as a spherical surface, however, the actual surface would have to be made as an assembly of much smaller segments, since most membranes are typically available only in flat sheets. A further implication of using a flexible membrane to create the surface is that it either has to be suspended with the *convex side* pointing downward or, if used with the convex side, pointing upward, supplemented by some mechanism to its shape. *Pneumatic*, or air-inflated structures are of the latter type. The shape of the membrane is maintained by the internal air pressure inside the structure. Another mechanism is to apply external *jacking* forces that stretch the membrane into the desired shape. Various stressed-skin structures are of this general type. The need to pretension the skin, however, imposes various limitations on the shape that can be formed. Spherical surfaces, for example, are very difficult to pretension by external jacking forces, while others, such as the hyperbolic paraboloid, can be handled with comparative ease.

Nets are three-dimensional surfaces made up of a series of crossed cables. Nets are very analogous to membrane skins. By allowing the mesh opening to vary as needed, a wide variety of surface shapes can be formed. An advantage of using crossed cables is that the positioning of the cables *mitigates* fluttering due to wind suctions and pressures. In addition, tension forces are typically induced into the cables by jacking devices, so that the whole surface is turned into a type of stretched skin. This also gives the roof stability and resistance to flutter.

1.1.2 Basic Issues in the Analysis and Design of Structures

1. Fundamental Structural Phenomena

Structure components could break apart or deform badly. The forces causing overturning or collapse come from the specific environment (e.g., wind, earthquakes, occupancies) or from the self-weight of the form itself. These same applied loadings produce internal force in a structure that stress the material used and may cause it to fail or deform. There are several fundamental ways in which failure can occur.

A first set of concerns deals with the overall stability of a work. As a whole unit, a structure might overturn, slide, or twist about its base, particularly when subjected to horizontally acting wind or earthquake forces. Structures that are relatively tall and/or have small bases are particularly prone to overturning effects. Forces induced by earthquakes tend to cause overturning or sliding actions, but they are dependent in magnitude on the weight of the structure because of the inertial character of earthquake forces. Overturning or twisting needs not be caused only by horizontally acting forces. A work might simply be out of balance under its own self-weight and overturning. The use of wide, rigid foundations helps prevent overturning, as does the use of special foundation elements such as *piles* capable of carrying tension forces.

A second set of concerns deals with internal, or relational stability. If the parts of a structure are not properly arranged in space or interconnected appropriately, an entire assembly can collapse internally. Collapses of this type invariably involve large relative movements within the structure itself. Assemblies may be internally stable under one loading condition and unstable under another. Horizontally acting wind or earthquake forces, in particular, cause collapses of this kind. There are several basic mechanisms—walls, frame action, cross bracing—for making an assembly internally stable.

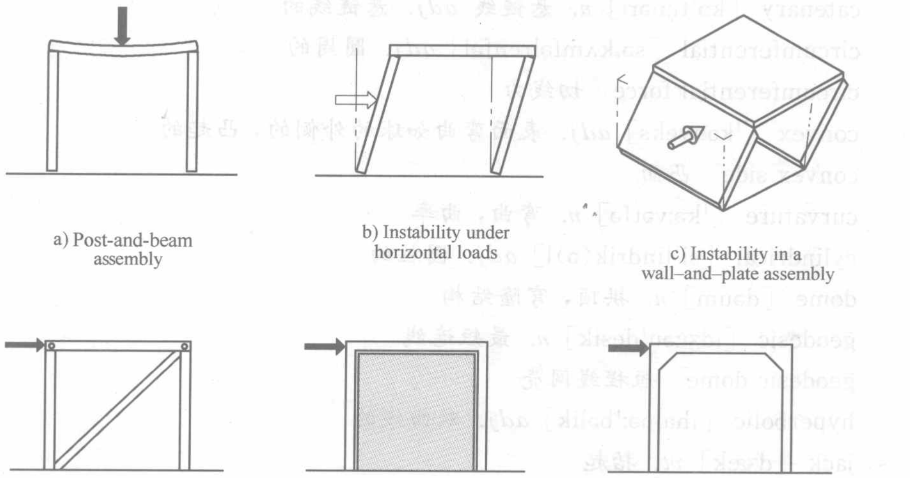
A third set of concerns deals with the strength and stiffness of constituent elements. There are many structural issues that revolve around the strength of component parts of a structure. These failures, which may or may not lead to total collapse, may be caused by excessive tension, compression, bending, shear, torsional, bearing forces, or deformations that are developed internally in the structure as a consequence of the applied loadings. Associated with each force state are internal stresses that actually exist within the fabric of the material itself. By carefully designing components in response to the force state present, the actual stresses developed in the components can be controlled to safe levels.

2. Structural Stability

A fundamental consideration in designing a structure is that of assuring its stability under any type of possible loading condition. All structures undergo some shape changes under load. In a stable structure the deformations induced by the load are typically small, and internal forces are generated in the structure by the action of the load tend to restore the structure to its original shape after the load has been removed. In an unstable structure, the deformations induced by a load are typically massive and often tend to continue increasing as long as the load is applied. An unstable structure does not generate internal forces that tend to restore the structure to its original configuration. Unstable structures quite often collapse completely and instantaneously as a load is applied to them. It is the fundamental responsibility of the structural designer to assure that a proposed structure does indeed form a stable configuration.

Stability is a crucial issue in the design of structures that are assemblies of discrete elements. For example, the *post-and-beam* structure illustrated in Figure 1.2a is apparently stable. Any horizontal force, however, tends to cause deformations of the type indicated in Figure 1.2b. Clearly, the structure has no capacity to resist horizontal load, nor does it have any mechanism that tends to restore it to its initial shape after the horizontal load is removed. The large changes in angle that occur between members characterize an unstable structure that is beginning to collapse. This particular structure will collapse almost instantaneously under load. Consequently, this particular pattern of members is referred to as a collapse mechanism.

There are really only a few fundamental ways of converting a self-standing structure of the general type shown in Figure 1.2a-c from an unstable to a stable configuration. These are illustrated in Figure 1.2d. The first is to add a diagonal member to the structure. The structure cannot now undergo the *parallelogram* indicated in Figure 1.2b without a dramatic release in the length of the diagonal member (this would not occur if the diagonal were adequately sized to take the



d) Three basic methods of assemblies: diagonal bracing, shear plane and rigid ioints

Figure 1.2 Structural stability

forces involved). Another method used to assure stability is through shear walls. These are rigid planar surface elements that inherently resist shape changes of the type illustrated. A reinforced concrete or masonry wall can be used as a shear wall. Either a full or a partial wall can be used (the required extent of a partial wall depends on the magnitudes of the forces involved). A final method used to achieve stability is through stopping the large angular changes between members that are associated with collapse by assuring that the nature of the connections between members is such that their angular relationship remains a constant value under any loading. This is done by making a rigid joint between members. This is a very common form of joint.

There are, of course, variants on these basic methods of assuring stability. Still most structures composed of discrete elements rely on one or the other of these basic approaches for stability. More than one approach can be used in a structure (e. g., a structure having both rigid joints and a diagonal), but a measure of redundancy is obviously involved.

Words and Expressions

assume [ə'sjuːm] *vt.* 呈现

catenary [kəˈtiːnəri] *n.* 悬链线 *adj.* 悬链线的
circumferential [səˌkʌmfəˈrenʃəl] *adj.* 圆周的
circumferential force 切线力
convex [ˈkɔnveks] *adj.* 表面弯曲如球的外侧的，凸起的
convex side 凸面
curvature [ˈkəːvətʃə] *n.* 弯曲，曲率
cylindrical [siˈlindrik(ə)l] *adj.* 圆柱的
dome [dəum] *n.* 拱顶，穹隆结构
geodesic [ˌdʒiːəuˈdesik] *n.* 最短连线
geodesic dome 短程线网壳
hyperbolic [ˌhaipəːˈbɔlik] *adj.* 双曲线的
jack [dʒæk] *vt.* 抬起
membrane [ˈmembrein] *n.* 膜，隔膜
mitigate [ˈmitigeit] *v.* 减轻
paraboloid [pəˈræbəlɔid] *n.* [数] 抛物面
parallelogram [ˌpærəˈleləgræm] *n.* [数] 平行四边形
perpendicular [ˌpəːpənˈdikjulə] *adj.* 垂直的，正交的 *n.* 垂线
pile [pail] *n.* 桩
planar [ˈpleinə] *adj.* 平面的
pneumatic [nju(ː)ˈmætik] *adj.* 装满空气的
post-and-beam 梁柱结构
suspension [səsˈpenʃən] *n.* 吊，悬浮
suspension cable 悬缆，吊索
strut [strʌt] *n.* 支柱，压杆
warp [wɔːp] *n.* 弯曲，歪曲
warped surface 扭曲面

Questions

1. What are the differences between the rigid arch and the block arch?
2. Why can a folded plate span a larger distance than a flat plate?
3. How to creat a tension surface for a membrane structure?
4. How to design a stable structure?

Writing Study (1)

The Structure and Format of a Journal-Style Scientific Paper

Most journal-style scientific papers (SP) are subdivided into the following sections: Title, Authors and Affiliation, Abstract, Introduction, Methods, Results, Discussion, Acknowledgments, and References.

The main purpose of the Introduction is to provide the rationale for the paper, moving from general discussion of the topic to the particular question or hypothesis being investigated. A secondary purpose is to attract interest in the topic—and hence readers.

The Methods section describes, in various degrees of detail, methodology, materials, and procedures.

In the Results section, the findings are described, accompanied by variable amounts of commentary.

The Discussion section offers an increasingly generalized account of what has been learned in the study. This is usually done through a series of "points", at least some of which refer back to statements made in the Introduction.

As a result of these different purposes, the four sections have taken on different linguistic characteristics, and are summarized in Table 1. The first line of the table shows, for instance, that the present tense is common in the Introduction and Discussion, but uncommon in Methods and Results.

Table 1 Frequencies of selected items in SP sections

	Introduction	Methods	Results	Discussion
Present tense	high	low	low	high
Past tense	mid	high	high	mid
Passive voice	low	high	variable	variable
Citations/references	high	low	variable	high
Commentary	high	low	variable	high

1.2 Determinate and Indeterminate Structures

1.2.1 Statically Determinate Structures

Structures are said to be *statically determinate* when the forces and reactions produced by a given loading can be calculated using only the equations of equilibrium. The simply supported beam shown in Figure 1.3 is statically determinate. We can solve for the three unknown reactions using the equations of equilibrium and then calculate the internal forces such as bending moment, shear force, and axial force at any given location along the length of the beam.

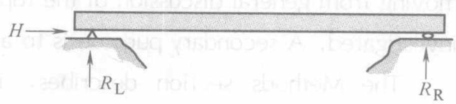


Figure 1.3 Statically determinate structure

1.2.2 Statically Indeterminate Structures

The structure shown in Figure 1.4 is *statically indeterminate*. There are four unknown reactions, F_{Ax}, F_{Ay}, M_A, F_{By}. However, there are only three independent equilibrium equations, $\sum F_x = 0$, $\sum F_y = 0$, $\sum M = 0$; the number of unknow is larger than the number of equations.

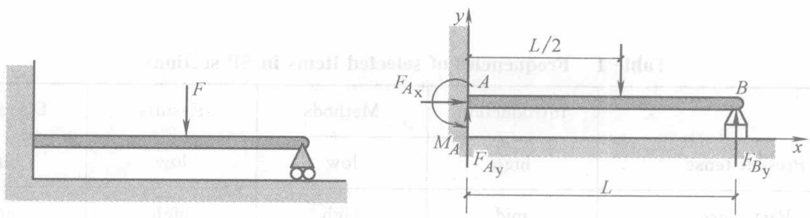


Figure 1.4 Statically indeterminate structure

1.2.3 Force Method

The force method (also called the flexibility method) is used to calculate internal forces and reactions in statically indeterminate structures due to loads and imposed deformations.

The steps in the force method are listed as follows:

(1) Determine the *degree of statical indeterminacy* of the structure.