"十三五"国家重点出版物出版规划项目

面向可持续发展的土建类工程教育丛书

# 土木工程
# 专业英语

鲁 正◎编

# CIVIL ENGINEERING SPECIALITY ENGLISH

机械工业出版社
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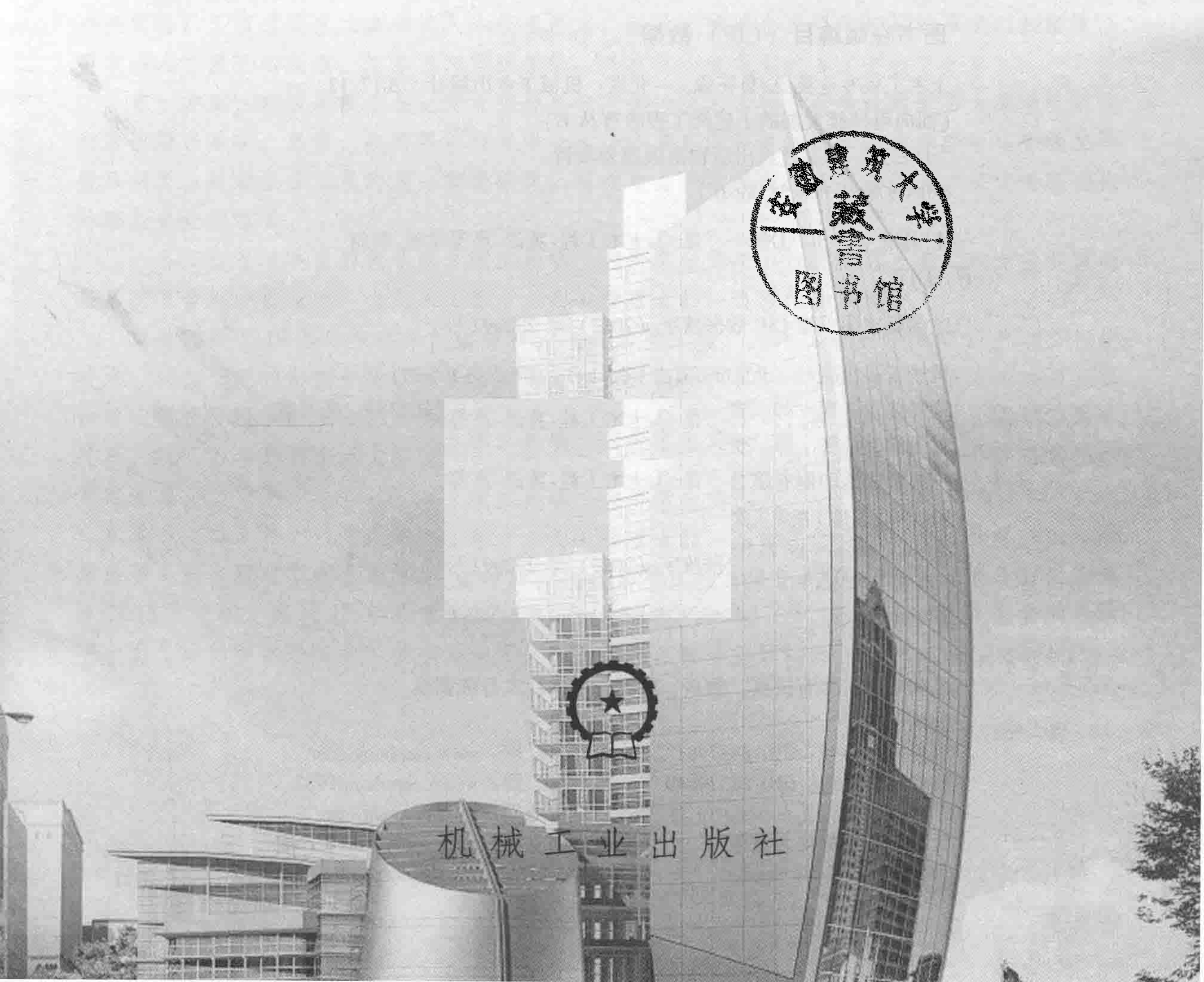

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本书的编写基于同济大学近十几年对土木工程专业英语课程的教学探索和大量的素材积累；全书涵盖土木工程各个领域的基本英语用法，有点有面；紧跟目前科研和工程热点，比如 BIM 技术、住宅工业化技术等；实用性很强，最后一章讲述了科技论文写作。全书分为 19 个单元，并将其归为 5 大部分，分别为结构工程、土木工程其他分支、土木工程新技术、项目管理和案例分析、专业英语写作。

本书可作为土木工程专业及相关专业的教材，也可供专业技术人员了解专业知识、提高英语水平时使用。

本书配有授课 PPT 和 Exercises 部分的参考答案等资源，免费提供给选用本书的授课教师，需要者请登录机械工业出版社教育服务网（www.cmpedu.com）注册下载。

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# 前言

随着“高铁外交”与中国“一带一路”倡议的实施，我国的土木工程在国际舞台上发挥着越来越重要的作用，涉外工程、科研项目越来越多，国际化趋势持续加速。国内土木工程领域的众多龙头公司已将开拓海外市场作为可持续发展的长期战略并取得了卓越成效。例如我国建筑行业的领军企业——中国建筑工程总公司（简称“中国建筑”），在2016年度新签海外合约额1264亿元，同比增长13%；实现海外营收796亿元，同比增长30%，首次突破百亿美元大关。中国交建、中国铁建、中国中车等国内著名的国际工程承包商在海外的订单额和营收也以每年20%左右的增速高速发展。

繁荣景象的延续需要后备力量的长久支持，土木工程专业英语的教学为国家“一带一路”倡议提供可靠人才保障。我国对外工程的长足发展不能仅依靠成本优势，更要凭借高端竞争优势，而企业竞争力的核心便是“人才”。目前，我国土木工程领域中既能熟练使用专业英语，又有过硬技术本领的人才极度匮乏。因此，紧追企业海外拓展的步伐，打破复合型双语人才匮乏的瓶颈，培养出与国际接轨、具有核心竞争力的人才是当务之急。

另一方面，我国高校毕业生就业形势异常严峻，土木工程专业英语的学习为毕业生的顺利就业增添筹码。目前，我国每年应届毕业生700多万人并逐年增加，众多毕业生为找工作费尽周折。随着企业工程的进一步国际化，精通专业英语的高质量复合型人才必定受到国内外著名企业的追捧。

土木工程专业英语的教学利于国家战略、利于学生发展，培养精通土木工程专业英语的高层次复合人才已成为广大土木工程专业相关管理者和一线教师的共识。

本书选择了19篇专业英语阅读材料，包括结构工程、土木工程其他分支、土木工程新技术、项目管理和案例分析以及专业英语写作等方面的内容。学生通过学习土木工程专业英语这门课程可以掌握英文科技专业书刊中各种句型的表达方式、语法、主要专业词汇及写作技巧，从而为今后阅读英文科技文献、撰写英文科技论文、从事涉外施工和涉外设计等工作奠定基础。

本书内容来源于同济大学土木工程学院结构工程与防灾研究所多年积累的教学讲义。讲义的第1版由蒋欢军和吕西林于2000年选编，第二版由周颖于2007年选编，第3版由鲁正于2015年选编。经过17年的教学实践和积累，最终在2017年12月，由鲁正选编形成本书。由于时间和水平关系，书中不妥之处在所难免，敬请批评指正。

**编　者**

# 目 录

前言

## Part 1 Introduction to Structural Engineering

## Part 2 Introduction to Other Branches of Civil Engineering

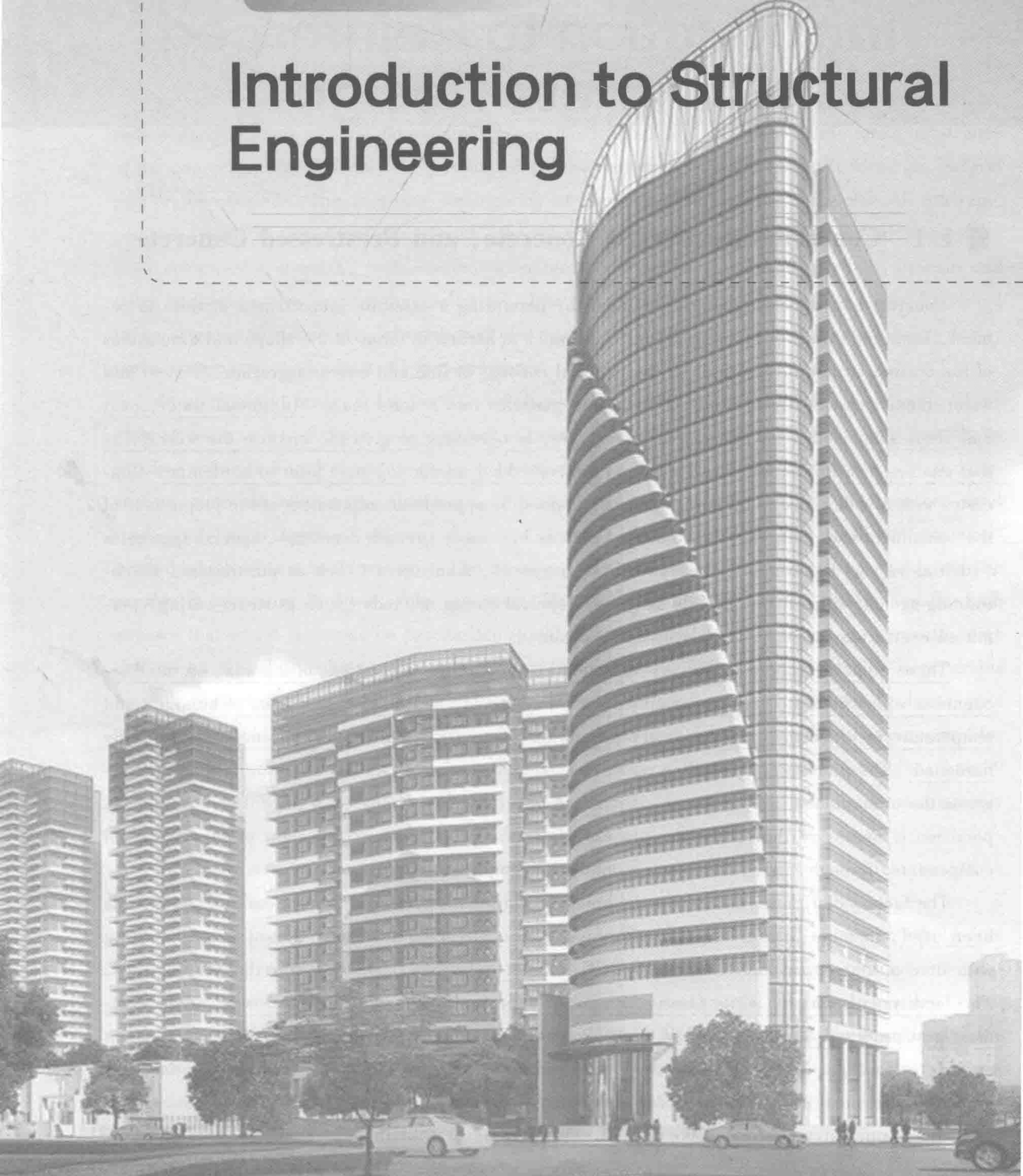
## Part 3 New Technology in Civil Engineering

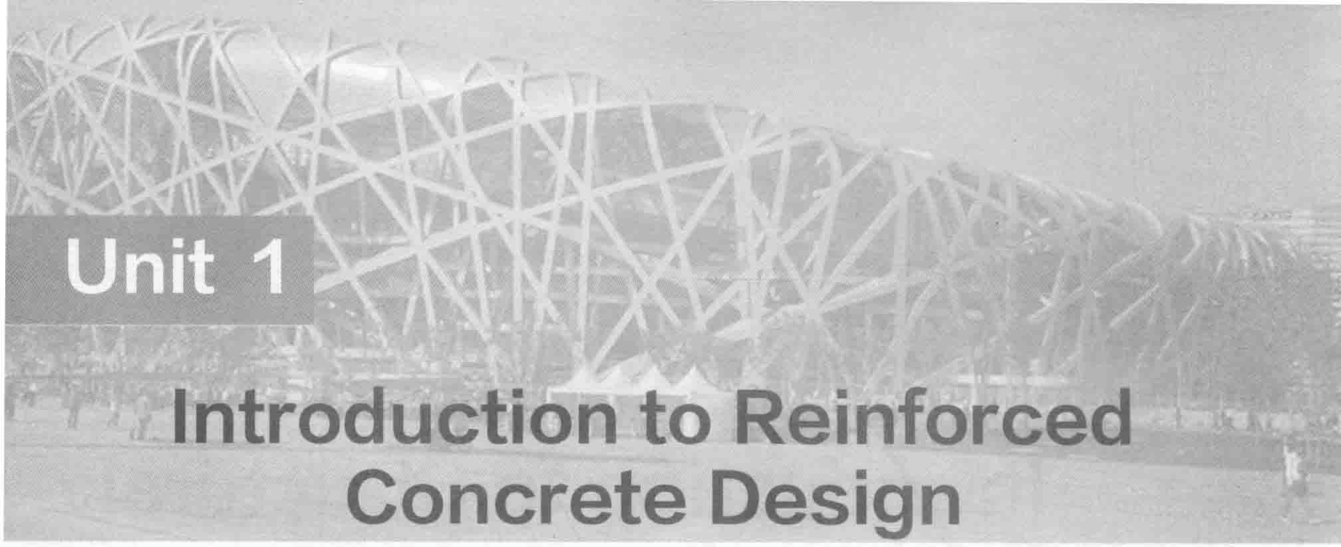
## Part 4 Project Management and Case Study

## Part 5 Scientific English Writing Skills

# Part 1

# Introduction to Structural Engineering





# Unit 1

# Introduction to Reinforced Concrete Design

## 1.1 Concrete, Reinforced Concrete, and Prestressed Concrete

Concrete is a stonelike material obtained by permitting a carefully proportioned mixture of cement, sand and gravel or other aggregate, and water to harden in forms of the shape and dimensions of the desired structure. The bulk of the material consists of fine and coarse aggregate. Cement and water interact chemically to bind the aggregate particles into a solid mass. Additional water, over and above that needed for this chemical reaction, is necessary to give the mixture the workability that enables it to fill the forms and surround the embedded reinforcing steel prior to hardening.[1] Concretes with a wide range of properties can be obtained by appropriate adjustment of the proportions of the constituent materials. Special cements (such as high early strength cements), special aggregates (such as various lightweight or heavyweight aggregates), admixtures (such as plasticizers, air-entraining agents, silica fume, and fly ash), and special curing methods (such as steam-curing) permit an even wider variety of properties to be obtained.

These properties depend to a very substantial degree on the proportions of the mix, on the thoroughness with which the various constituents are intermixed, and on the conditions of humidity and temperature in which the mix is maintained from the moment it is placed in the forms until it is fully hardened.[2] The process of controlling conditions after placement is known as *curing*. To protect against the unintentional production of substandard concrete, a high degree of skillful control and supervision is necessary throughout the process, from the proportioning by weight of the individual components, through mixing and placing, until the completion of curing.

The factors that make concrete a universal building material are so pronounced that it has been used, in more primitive kinds and ways than at present, for thousands of years, starting with lime mortars from 12000 to 6000 BCE in Crete, Cyprus, Greece, and the Middle East. The facility with which, while plastic, it can be deposited and made to fill forms or molds of almost any practical shape is one of these factors.[3] Its high fire and weather resistance is an evident advantage. Most of the constituent materials, with the exception of cement and additives, are usually available at low cost locally or at small distances from the construction site. Its compressive strength, like that of natural stones, is high, which makes it suitable for members primarily subject to compression, such as columns and arches. On the other hand, again as in natural stones, it is a relatively brittle material whose tensile strength is small compared with its compressive strength. This prevents its economical use in structural members that are subject to tension either entirely (such as in tie-rods) or over part of their cross sections (such as in beams or other flexural members).

To offset this limitation, it was found possible, in the second half of the nineteenth century, to use steel with its high tensile strength to reinforce concrete, chiefly in those places where its low tensile strength would limit the carrying capacity of the member. The reinforcement, usually round steel rods with appropriate surface deformations to provide interlocking, is placed in the forms in advance of the concrete. When completely surrounded by the hardened concrete mass, it forms an integral part of the member. The resulting combination of two materials, known as reinforced concrete, combines many of the advantages of each: the relatively low cost, good weather and fire resistance, good compressive strength, and excellent formability of concrete and the high tensile strength and much greater ductility and toughness of steel. It is this combination that allows the almost unlimited range of uses and possibilities of reinforced concrete in the construction of buildings, bridges, dams, tanks, reservoirs, and a host of other structures.

In more recent times, it has been found possible to produce steels, at relatively low cost, whose yield strength is 3 to 4 times and more that of ordinary reinforcing steels. Likewise, it is possible to produce concrete 4 to 5 times as strong in compression as the more ordinary concretes. These high-strength materials offer many advantages, including smaller member cross sections, reduced dead load, and longer spans. However, there are limits to the strengths of the constituent materials beyond which certain problems arise. To be sure, the strength of such a member would increase roughly in proportion to those of the materials. However, the high strains that result from the high stresses that would otherwise be permissible would lead to large deformations and consequently large deflections of such members under ordinary loading conditions. Equally important, the large strains in such high-strength reinforcing steel would induce large cracks in the surrounding low tensile strength concrete, cracks that not only would be unsightly but also could significantly reduce the durability of the structure. This limits the useful yield strength of high-strength reinforcing steel to 80 ksi (1ksi=6.895MPa) according to many codes and specifications; 60ksi steel is most commonly used.

A special way has been found, however, to use steels and concretes of very high strength in combination. This type of construction is known as prestressed concrete. The steel, in the form of wires, strands, or bars, is embedded in the concrete under high tension that is held in equilibrium by compressive stresses in the concrete after hardening.[4] Because of this precompression, the concrete in a flexural member will crack on the tension side at a much larger load than when not so precompressed. Prestressing greatly reduces both the deflections and the tensile cracks at ordinary loads in such structures, and thereby enables these high-strength materials to be used effectively. Prestressed concrete has extended, to a very significant extent, the range of spans of structural concrete and the types of structures for which it is suited.

## 1.2 Structural Forms

The figures that follow show some of the principal structural forms of reinforced concrete. Pertinent design methods for many of them are discussed later in this volume.

Floor support systems for buildings include the monolithic slab-and-beam floor shown in Fig. 1-1, the one-way joist system of Fig. 1-2, and the flat plate floor, without beams or girders, shown in Fig. 1-3. The flat slab floor of Fig. 1-4, frequently used for more heavily loaded buildings such as warehouses, is similar to the flat plate floor, but makes use of increased slab thickness in the vicinity of the columns, as well as flared column tops, to reduce stresses and increase strength in the support region. The choice among these and other systems for floors and roofs depends upon functional requirements, loads, spans, and permissible member depths, as well as on cost and esthetic factors.

**Fig. 1-1 One-way reinforced concrete floor slab with monolithic supporting beams** (Portland Cement Association).

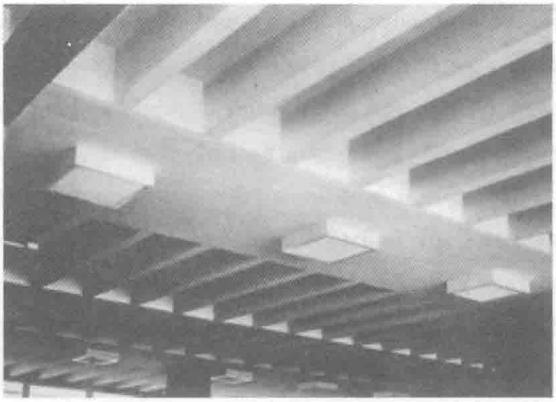


**Fig. 1-2 One-way joist floor system, with closely spaced ribs supported by monolithic concrete beams; transverse ribs provide for lateral distribution of localized loads** (Portland Cement Association).

**Fig. 1-3 Flat plate floor slab, carried directly by columns without beams or girders** (Portland Cement Association).

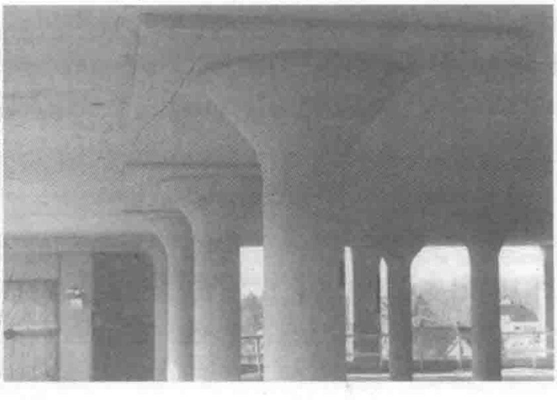


**Fig. 1-4 Flat slab floor, without beams but with slab thickness increased at the columns and with flared column tops to provide for local stress concentration of forces.**

Where long clear spans are required for roofs, concrete shells permit use of extremely thin surfaces, often thinner, relatively, than an eggshell. The folded plate roof of Fig. 1-5 is simple to form because it is composed of flat surfaces; such roofs have been employed for spans of 200 ft (1ft = 0.3048m) and more. The cylindrical shell of Fig. 1-6 is also relatively easy to form because it has only a single curvature; it is similar to the folded plate in its structural behavior and range of spans and loads. Shells of this type were once quite popular in the United Staler and remain popular in other parts of the world.

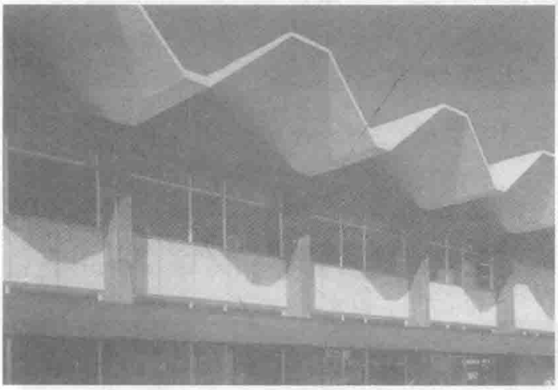


**Fig. 1-5 Folded plate roof of 125 ft span, in addition to carrying ordinary roof loads, carries the second floor as well from a system of cable hangers; the ground floor is kept free of columns.**

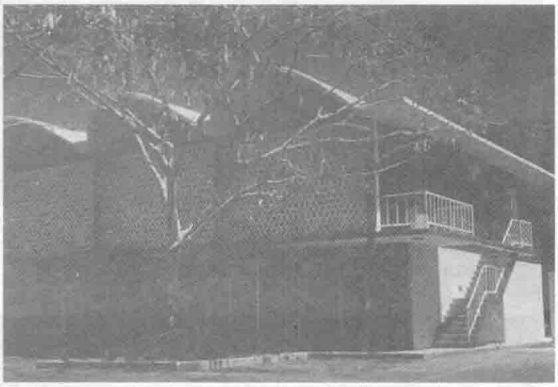


**Fig. 1-6 Cylindrical shell roof providing column-free interior space.**

Doubly curved shell surfaces may be generated by simple mathematical curves such as circular arcs, parabolas, and hyperbolas, or they may be composed of complex combinations of shapes. The hyperbolic paraboloid shape, defined by a concave downward parabola moving along a concave upward parabolic path, has been widely used, It has the interesting property that the doubly curved surface contains two systems of straight-line generators, permitting straight-form lumber to be used. The complex dome of Fig. 1-7, which provides shelter for performing arts events, consists essentially of a circular dome but includes monolithic upwardly curved edge surfaces to provide stiffening and strengthening in that critical region.

Bridge design has provided the opportunity for some of the most challenging and creative applications of structural engineering. The award-winning Napoleon Bonaparte Broward Bridge, shown in Fig. 1-8, is a six-lane, cable-stayed structure that spans St. John's River at Dame Point, Jacksonville, Florida. Its 1300 ft center span is the second longest of its type in the western hemisphere. Fig. 1-9 shows the Bennett Bay Centennial Bridge, a four-span continuous, segmentally cast-in-place box girder structure. Special attention was given to esthetics in this award-winning design. The spectacular Natchez Trace Parkway Bridge in Fig. 1-10, a two-span arch structure using hollow precast concrete elements, carries a two-lane highway 155 ft above the valley floor. This structure has won many honors, including awards from the American Society of Civil Engineers and the National Endowment for the Arts.

**Fig. 1-7 Spherical shell in Lausanne, Switzerland. Upwardly curved edges provide stiffening for the central dome.**

**Fig. 1-8 Napoleon Bonaparte Broward Bridge, with a 1300 ft center span at Dame Point, Jacksonville. Florida** (HNTB Corporation, Kansas City, Missouri).

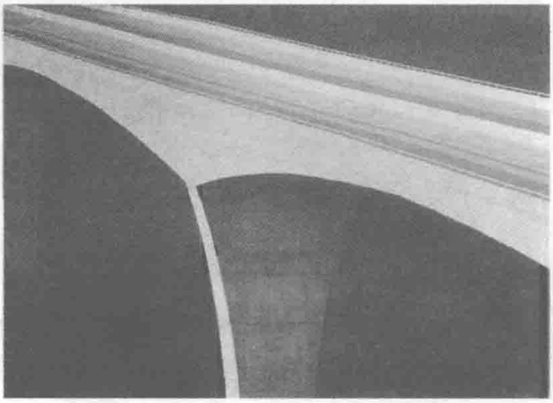


**Fig. 1-9 Bennett Bay Centennial Bridge, Coeur d' Alene, Idaho, a four-span continuous concrete box girder structure of length 1730 ft** (HNTB Corporation, Kansas City, Missouri).

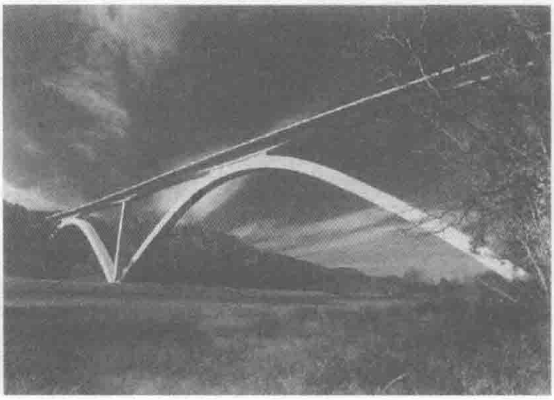


**Fig. 1-10 Natchez Trace Parkway Bridge near Franklin, Tennessee, an award-winning two-span concrete arch structure rising 155 ft above the valley floor.**

Cylindrical concrete tanks are widely used for storage of water or in waste purification plants. The design shown in Fig. 1-11 is proof that a sanitary engineering facility can be esthetically pleasing as well as functional. Cylindrical tanks are often pre-stressed circumferentially to maintain compression in the concrete and eliminate the cracking that would otherwise result from internal pressures.

Concrete structures may be designed to provide a wide array of surface textures colors, and structural forms. Fig. 1-12 shows a precast concrete building containing both color changed and architectural finishes.

The forms shown in Fig. 1-1 to Fig. 1-12 hardly constitute a complete inventory but are illustrative of the shapes appropriate to the properties of reinforced or prestressed concrete. They illustrate the adaptability of the material to a great variety of one-dimensional (beams, girders, columns), two-dimensional (slabs, arches, rigid frames), and three-dimensional (shells, tanks) structures and structural components. This variability allows the shape of the structure to be adapted to its function in an economical manner, and furnishes the architect and design engineer with a wide variety of possibilities for esthetically satisfying structural solutions.

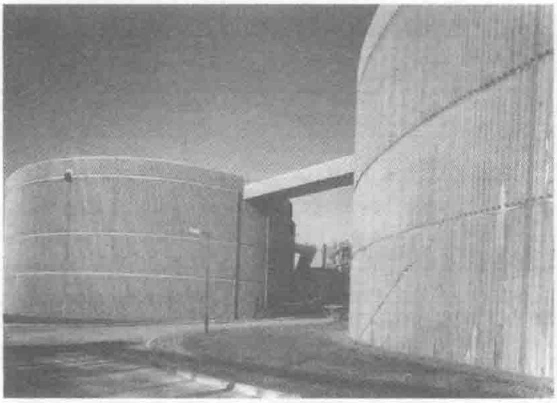


**Fig. 1-11 Circular concrete tanks used as a part of the wastewater purification facility at Howden, England** (Northumbrian Water Authority with Luder and Jones, Architects).

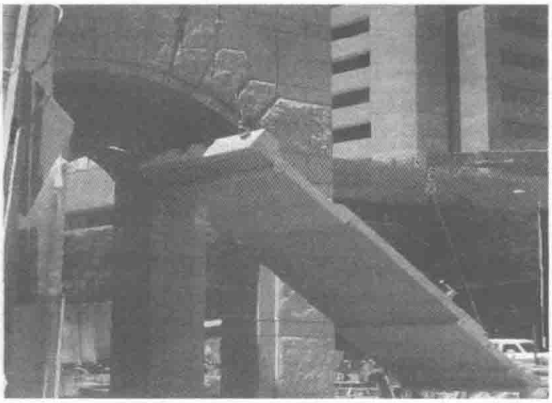


**Fig. 1-12 Concrete structures can be produced in a wide range of colors, finishes, and architectural detailing** (Courtesy of Rocky Mountain Prestress Corp).

## 1.3 Loads

Loads that act on structures can be divided into three broad categories: dead loads, live loads, and environmental loads.

Dead loads are those that are constant in magnitude and fixed in location throughout the lifetime of the structure. Usually the major part of the dead load is the weight of the structure itself. This can be calculated with good accuracy from the design configuration, dimensions of the structure, and density of the material. For buildings, floor fill, finish floors, and plastered ceilings are usually included as dead loads, and an allowance is made for suspended loads such as piping and lighting fixtures. For bridges, dead loads may include wearing surfaces, sidewalks, and curbs, and an allowance is made for piping and other suspended loads.

*Source*: From *Minimum Design Loads for Buildings and Other Structures*. Used by permission of the American Society of Civil Engineers.

Live loads consist chiefly of occupancy loads in buildings and traffic loads on bridges. They may be either fully or partially in place or not present at all, and may also change in location. Their magnitude and distribution at any given time are uncertain, and even their maximum intensities throughout the lifetime of the structure are not known with precision. The minimum live loads for which the floors and roof of a building should be designed are usually specified in the building code that governs at the site of construction. Representative values of minimum live loads to be used in a wide variety of buildings are found in *Minimum Design Loads for Buildings and Other Structures*, a portion of which is reprinted in Table 1-1. The table gives uniformly distributed live loads for various types of occupancies; these include impact provisions where necessary. These loads are expected maxima and considerably exceed average values.

**Table 1-1 Minimum uniformly distributed live loads**

| Occupancy or Use | Live Load/psf① | Occupancy or Use | Live Load/psf① |
|---|---|---|---|
| Apartments (see residential) | | Dining room and restaurants | 100 |
| Access floor systems | | Dwelling(see residential) | |
| Office use | | Fire escapes | 100 |
| Computer use | 100 | On single-family dwellings only | 40 |
| Armories and drill rooms | 150 | Garages (passenger cars only) | 40 |
| Assembly areas and theaters | | Trucks and buses② | |
| Fixed seats (listened to floor) | 60 | Grandstands (see stadium and arena bleachers) | |
| Lobbies | 100 | Gymnasiums, main floors and balconies③ | 100 |
| Movable seats | 100 | Hospitals | |
| Platforms (assembly) | 100 | Operating rooms, laboratories | 60 |
| Stage floors | 150 | Patient rooms | 40 |
| Balconies(exterior) | 100 | Corridors above first floor | 80 |
| On one and two-family residences | 60 | Hotels (see residential) | |
| only, and not exceeding 100ft$^2$ | | Libraries | |
| Bowling alleys, poolrooms, and similar | | Reading rooms | 60 |
| recreational areas | | Stack rooms④ | 150 |
| Catwalks for maintenance access | 40 | Corridors above first floor | 80 |
| Corridors | | Manufacturing | |
| First floor | 100 | Light | 125 |
| Other floors, same as occupancy | | Heavy | 250 |
| served except as indicated | | Marquees and canopies | 75 |
| Dance halls and ballrooms | 100 | Office buildings | |
| Decks (patio and roof) | | File and computer rooms shall be designed for | |
| Same as area served, or for the | | heavier loads based on anticipated occupancy | |
| type of occupancy accommodated | | Lobbies and first-floor corridors | 100 |
| Offices | 50 | Schools | |
| Corridors above first floor | 80 | Classrooms | 40 |
| Penal institutions | | Corridors above first floor | 80 |
| Cell blocks | 40 | First-floor corridors | 100 |
| Corridors | 100 | Sidewalks, vehicular driveways, and yards | 250 |
| Residential | | subject to trucking | |
| Dwellings (one and two-family) | | Stadiums and arenas | |
| Uninhabitable attics without storage | 10 | Bleachers | 100 |
| Uninhabitable attics with storage | 20 | Fixed seats (fastened to floor) | 60 |
| Habitable attics and sleeping areas | 30 | Stairs and exit ways | 100 |

(Continued)

| Occupancy or Use | Live Load/psf① | Occupancy or Use | Live Load/psf① |
|---|---|---|---|
| All other areas except stairs and balconies | 40 | One and two-family residences only | 40 |
| Hotels and multifamily houses | | Storage areas above ceilings | 20 |
| Private rooms and corridors serving them | 40 | Storage warehouses (shall be designed for heavier loads if required for anticipated storage) | |
| Public rooms and corridors serving them | 100 | | |
| Reviewing stands, grandstands, and bleachers⑤ | | Light | 125 |
| Roofs | | Heavy | 250 |
| Ordinary flat, pitched, and curved roofs | 20 | Stores | |
| Roofs used for promenade purposes | 60 | Retail | |
| Roofs used for roof gardens or assembly purpose | 100 | First floor | 100 |
| Roofs used for other special purposes.⑥ | | Upper floors | 73 |
| Awnings and canopies | 5 | Wholesale, all floors | 125 |
| Fabric construction supported by a lightweight rigid skeleton structure⑦ | | Walkways and elevated platforms (other than exitways) | 60 |
| All other constructions | 20 | Yards and terraces, pedestrians | 100 |

① Pounds per square foot, 1psf = 47.88Pa.

② Garages accommodating trucks and buses shall be designed in accordance with an approved method that contains provisions for truck and bus loadings.

③ In addition to the vertical live loads, the design shall include horizontal swaying forces applied to each row of seats as follows: 24 lb㊀ per linear ft of seat applied in the direction parallel to each row of seats and 10 lb per linear ft of seat applied in the direction perpendicular to each row of seats. The parallel and perpendicular horizontal swaying forces need not be applied simultaneously.

④ The loading applies to stack room floors that support nonmobile, double-faced library bookstacks subject to the following limitations: (a) the nominal bookstack unit height shall not exceed 90 in.㊁; (b) the nominal shelf depth shall not exceed 12 in. for each face; and (c) parallel rows of double-faced bookstacks shall be separated by aisles not less than 36 in. wide.

⑤ Other uniform loads in accordance with an approved method that contains provisions for truck loadings shall also be considered where appropriate.

⑥ Roofs used for other special purposes shall be designed for appropriate loads as approved by the authority having jurisdiction.

⑦ Nonreducible。

In addition to these uniformly distributed loads, it is recommended that, as an alternative to the uniform load, floors be designed to support safely certain concentrated loads if these produce a greater stress. For example, office floors are to be designed to carry a load of 2000lb distributed over an area 2.5ft square ($6.25\text{ft}^2$), to allow for the weight of a safe or other heavy equipments, and stair treads must safely support a 300lb load applied on the center of the tread. Certain reductions are often permitted in live loads for members supporting large areas, on the premise that it is not likely that the entire area would be fully loaded at one time.

Tabulated live loads cannot always be used. The type of occupancy should be considered and the probable loads computed as accurately as possible. Warehouses for heavy storage may be designed for loads as high as 500psf or more; unusually heavy operations in manufacturing buildings may require an increase in the 250psf value specified in Table 1-1; special provisions must be made

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㊀ 1lb：磅，1lb = 4.45N。

㊁ in：英寸，1in = 2.54cm。