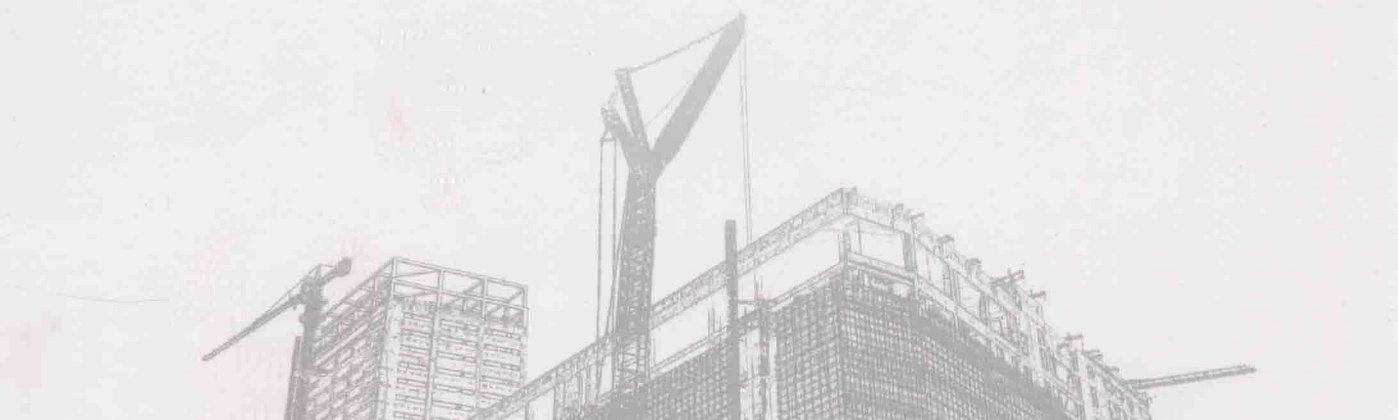
普通高等学校土木工程专业精编系列规划教材

English for Civil Engineering

土木工程专业英语

主编　王佐才　王顶堂
主审　任伟新



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主　编　王佐才　王顶堂
副主编　汪亦显　张广锋
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普通高等学校土木工程专业精编系列规划教材
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特别提示

教学实践表明,有效地利用数字化教学资源,对于学生学习能力以及问题意识的培养乃至怀疑精神的塑造具有重要意义。

通过对数字化教学资源的选取与利用,学生的学习从以教师主讲的单向指导的模式而成为一次建设性、发现性的学习,从被动学习而成为主动学习,由教师传播知识而到学生自己重新创造知识。这无疑是锻炼和提高学生的信息素养的大好机会,也是检验其学习能力、学习收获的最佳方式和途径之一。

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前言

随着全球经济一体化的发展,国际土木工程技术交流与合作日趋频繁。为了培养适应国际化环境下的土木工程专业人才,在高校的本科教学中开设“土木工程专业英语”课程就显得十分必要。“土木工程专业英语”是在大学英语之后结合土木工程专业知识以提高学生专业英语应用能力的一门学科。过去一般认为土木工程专业英语侧重读、写、译的能力,其实,听、说能力在国际化的环境下也显得尤为重要。

另外,为了贯彻落实《国家中长期教育改革和发展规划纲要》,提出了“卓越工程师教育培养计划”。为配合“卓越计划”的实施,我们联合武汉大学出版社,启动“高等学校土木工程专业卓越工程师教育培养计划教材建设项目”。本书就是根据卓越工程师计划的要求来编写的。其主要的特色表现在:(1)选材紧靠国外土木工程专业课教材。本教材中大多数课文均改编自现行美国高校土木工程专业课教材。通过对国外土木工程专业课教材的浓缩、改写,使得相关内容具有原汁原味的英语特色和很强的可读性;(2)由于所选教材的题材本身源于国外土木工程专业课的教材,其专业深度和难度非常适用于土木工程专业本科学生;(3)教材所有的编写教师均具有三年以上的海外留学经历,因此,教材的选材与编写均融入了各位教师的教学与海外学习的经验。

本书由合肥工业大学王佐才、安徽建筑大学王顶堂担任主编,合肥工业大学汪亦显、张广锋担任副主编,安徽新华学院张劼担任参编。

具体编写分工如下:

合肥工业大学,王佐才(前言,第 1 章、第 3 章、第 6 章);

安徽建筑大学,王顶堂(第 8 章);

合肥工业大学,汪亦显(第 2 章、第 7 章);

合肥工业大学,张广锋(第 4 章);

安徽新华学院,张劼(第 5 章)。

合肥工业大学任伟新担任本书主审,并对本书的编写提出了许多宝贵的建议,特致谢意。在本书的编写过程中参考了有关书籍,并从中引用了部分内容,在此表示衷心感谢。由于编写时间仓促,书中不妥之处,敬请读者批评、指正。

编　者

2013 年 9 月

目录

Chapter 1 Introduction of Civil Engineering

Civil engineering is a technology that includes numerous other disciplines that produce useful facilities for human beings, including roads, dams, waste disposal and other facilities that are used in our daily life. Civil engineering is progressing at a fast pace as other technologies.

Civil engineering is considered as the first discipline of the various branches of engineering after military engineering, and includes the designing, planning, construction, and maintenance of the infrastructure. The works include roads, bridges, buildings, dams, canals, water supply and numerous other facilities that affect the life of human beings. Civil engineering is intimately associated with the private and public sectors, including the individual homeowners and international enterprises. It is one of the oldest engineering professions, and ancient engineering achievements due to civil engineering include the Pyramids of Egypt and road systems developed by the Romans.

Civil engineering plays a significant role in everyone's daily life, though one may not truly sense its importance in our daily routine. The function of civil engineering commences with the start of the day when we take a shower, since the water is delivered through a water supply system including a well designed network of pipes, water treatment plant and numerous other associated services. The network of roads on which we drive while proceeding to school or work, the huge structural bridges we come across and the tall buildings where we work, all have been designed and constructed by civil engineers. Even the benefits of electricity we use are available to us through the contribution of civil engineers who constructed the towers for the transmission lines. In fact, no sphere of life may be identified that does not include the contribution of civil engineering. Thus, the importance of civil engineering may be determined according to its usefulness in our daily life.

Civil engineering is a multiple science encompassing numerous sub-disciplines that are closely linked with each other. The various sub-disciplines of civil engineering are mentioned below.

Structural engineering: This discipline involves the design of structures that should be safe for the users, be economical, and accomplish the desired functions. The design and analysis should initially identify the loads that act on the structures, stresses that are created due to loads, and then design the structure to withstand these loads. It includes steel structures, buildings, tunnels, highways, dams, and bridges.

Geotechnical engineering: Geotechnical engineering deals with soils, rocks, foundations of buildings and bridges, highways, sewers and underground water systems. Technical information obtained from the sciences of geology, material testing, and hydraulics is applied in the design of foundations and structures to ensure safety and economy of construction.

Water resources engineering: This discipline of civil engineering concerns the management of quantity and quality of water in the underground and above ground water resources, such as rivers, lakes and streams. Geographical areas are analyzed to forecast the amount of water that will flow into and out of water source. Fields of hydrology, geology, and environmental science are included in this discipline of civil engineering.

Environmental engineering: It is related to the science of waste management of all types, purification of water, cleaning of contaminated areas, reduction of pollution, and industrial ecology. Technical data obtained from environmental engineering assists the policy makers in making decisions related to environmental issues.

Other disciplines: Other disciplines of civil engineering include coastal engineering, construction engineering, earthquake engineering, materials science, transportation engineering, and surveying.

Civil engineering utilizes technical information obtained from numerous other sciences, and with the advancement in all types of technologies, the civil engineering has also benefited tremendously. The future of civil engineering is expected to be revolutionized by the new technologies including design software, GPS, GIS and other latest technical expertise in varied fields. Technology will continue to make important changes in the application of civil engineering, including the rapid progress in the use of 3-D and 4-D design tools.

Vocabulary and Expressions

infrastructure [ˈɪnfrəstrʌktʃə(r)] *n.* 基础设施，基础建设
intimately [ˈɪntɪmətli] *adv.* 熟悉地，亲密地
Pyramids of Egypt 埃及金字塔
sphere [sfɪə(r)] *n.* 球 *vt.* 形成球体，包围
encompassing *v.* (encompass 的现在分词)围绕，包围
geotechnical engineering 岩土工程
sewer [ˈsjuːə] *n.* 阴沟，污水管，下水道
hydraulics [haɪˈdrɔːlɪks] *n.* 水力学
water resources engineering 水利资源工程
geology [dʒiˈɒlədʒi] *n.* 地质学；(某地区的)地质情况
purification [ˌpjʊərɪfɪˈkeɪʃn] *n.* 洗净，提纯
coastal engineering 海岸工程学
GIS 地理信息系统

Explanations

[1] Technical information obtained from the sciences of geology, material testing, and hydraulics is applied in the design of foundations and structures to ensure safety and economy of construction.

将地质学、材料试验、水力学中的技术应用于基础和结构的设计中以确保其施工时的安全和经济性。

[2] Other disciplines: Other disciplines of civil engineering include coastal engineering, construction engineering, earthquake engineering, materials science, transportation engineering, and surveying.

土木工程学科也包含了其他学科的一些内容，如海岸工程、建设工程、地震工程、材料科学、交通工程以及测绘学。

Questions

1. What is civil engineering?
2. What kinds of works does civil engineering deal with?
3. What are sub-disciplines of civil engineering?
4. What is the future of civil engineering from the text?

Chapter 2　Structural Materials

2.1　Definition and Classification

More and more civil engineers came to know that understanding the knowledge of structural materials and their properties could help them to build innovation-type or modern landmark buildings. And, of all material classes, structural materials make a significant contribution to employment and GDP in the world. They represent a highly diverse and strongly multidisciplinary area, with links to numerous industrial sectors such as construction, energy infrastructure, military and water facility. As one of the basic and manufacturing industries, the structural material science and technology stimulates and leads to the development and progressing of construction industry.

Generally speaking, structural materials comprise a number of classes such as metals (eg. ferrous and non-ferrous), composites (eg. ceramic, metal and polymer matrix), construction materials (eg. glass, concrete, steel, ceramics, wood) and others (such as structural and refractory ceramics and polymers).

Whilst the range of materials may be diverse, many common technical challenges have been identified:

- Need for materials to withstand more aggressive environments (eg. extreme temperatures, stresses, impacts and weather conditions).
- Requirement to reduce environmental impact both in production, end use and recyclability.
- Need to understand complete materials "systems" (eg. coated components, sandwich structures, composites, joints).
- Need to improve the modeling of materials through the full life cycle (alloy design, production, process, manufacture and end use) including lifetime prediction.
- Requirement for better condition monitoring and node of structural materials and their manufacturing processes.
- Drive for lower cost through innovative production and processing methods.
- Need for technology transfer between materials sectors and the implementation of novel alternative uses for existing materials.

Obviously, the general public tends to hear of such advances only in the context of new style high-rise buildings, huge dams, or grand bridges, the materials industry makes continual improvements that affect many fields of endeavor. During the last few decades, new analytical tools for examining microstructures, new sensing devices for process control, and improved modeling capability have increased our knowledge bases and abilities to composite materials to specific civil engineering applications. The improved materials have led to enhanced performance of many constructions, often times with a reduction in costs.

As a civil engineer, we need to understand a series of related problems of construction materials. It is important, therefore, to be clear on what construction material defines and refers to as an application and relates to the range of application.

1. Definition

Construction materials are used for the construction and repair of structures. Many different purposes and operating conditions of buildings and structures account for the variety of demands placed on structure materials and for the great diversity of available materials. Two basic categories of structure materials are recognized: general-purpose materials, such as cement, concrete, and timber, used in the construction of various types of structures, and special-purpose materials, such as acoustic, insulating, and refractory materials. Depending on the degree of preparation before use, structure materials are conventionally classified as structure materials property, such as binders and aggregates, and structural components, which are prefabricated units and elements to be installed in buildings at the construction site, such as reinforced-concrete panels, toilet stalls, and door and window units.

Industrialization and the expansion of modern construction have led to an increased share of prefabricated structural components in the total production volume of structure materials. The greater output of structure materials in the form of almost totally prefabricated items makes it possible to increase labor productivity, decrease costs, and accelerate construction work.

2. Classification

Construction materials may be divided into 11 basic groups according to process and functional criteria.

(1) Natural masonry materials

Natural masonry materials include rocks that have been mechanically processed, such as facing slabs, stone for blocks, crushed stone, gravel, and quarry stone. The introduction of advanced methods of extracting and processing stone, such as diamond sawing and heat treatment, substantially reduces labor requirements and costs in the preparation of masonry materials and increases the application of such materials in construction.

(2) Timber and wood products

Timber and wood products are structure materials derived mainly from the mechanical process of wood, including round timber, lumber and semifinished products, parquet, and veneers. Lumber and semifinished products are used in modern construction on a wide scale for various carpentry products, built-in building equipment, and such strip products as baseboards, handrails, and overlays. Laminated-wood products hold promise for future use.

(3) Ceramic materials and products

Ceramic materials and products are prepared by shaping, drying, and firing raw material containing clay. Such materials are used in diverse areas of construction because of their greater variety of types, high strength, and durability. They are used for walls (brick and ceramic blocks) and sanitary fixtures and as exterior and interior facings for buildings (ceramic tiles). A porous aggregate for lightweight concretes called keramzit is also included in this category.

(4) **Inorganic binders**

Inorganic binders are primarily powdered materials, such as various kinds of cements, gypsum plaster, and lime, that form a plastic paste when mixed with water and then harden. Some of the most important inorganic binders are port land cement and its varieties.

(5) **Concretes and mortars**

Concretes and mortars are artificial masonry materials with a wide range of physico-mechanical and chemical properties, obtained from a mixture of binders, water, and aggregates. The principal type of concrete is cement concrete. Modern construction also uses products made of silica concrete. Lightweight concretes are ideal for large, precast structural components and units. Reinforced concrete—a combination of concrete with steel reinforcement—is used to increase the flexural strength and tensile strength of structural elements. Concretes and mortars are used directly at building sites (cast-in-situ concrete) and also in the factory preparation of structural units (precast reinforced concrete). Asbestos cement products and structural components, obtained from a cement slurry and reinforced with asbestos fiber, are also included in this category.

(6) **Metals**

Rolled steel is the principal metal used in construction. Steel is used for the reinforcement in reinforced concrete, for building frameworks, bridge spans, pipes, and heating apparatus, and as a roofing material (roofing steel). Aluminum alloys are also used as structural and finishing materials.

(7) **Heat-insulating materials**

Heat-insulating materials are used for insulation in the enclosing structures of buildings, in industrial equipment, and in pipes. The materials in this group are available in a large variety of compositions and structures. They include mineral wool and mineral-wool products, cellular concretes, asbestos materials, foam glass, expanded perlite and vermiculite, fiberboard, reedboard, and fibrolite (rigid insulation made from a mixture of wood-wool in portland cement). The use of heat-insulating structure materials in enclosing structures permits substantial weight reductions in such structures and reductions in the overall expenditure of materials and in the energy required to maintain temperatures in buildings and structures. Some heat-insulating materials are also used as acoustic materials.

(8) **Glass**

Glass, used chiefly for transparent enclosures, is produced in the form of ordinary sheet glass, glass for special purposes, including reinforced, tempered, and heat-insulating glass, and glass products, such as glass bricks, rolled glass sections, and glass facing tiles. The use of glass for the exterior facing of buildings, for example, sheet glass with a pigment on one side, holds promise for the future.

(9) **Organic binders and waterproof materials**

Organic binders and waterproof materials include bitumens and pitches, as well as asphalt concrete, ruberoid, tar paper, and other materials that use bitumens or pitches as a base. Polymer binders used to obtain polymer concretes are also included in this category. Sealing materials in the form of mastic and elastic packing, for example, Gernit (a porous gasket made from a foam polymer with a hard protective coating), Izol (a sealing mastic), and Po-roizol (a porous, elastic, rubber strip or gasket made from worn-out tires), and waterproof polymer films are produced to meet the needs of prefabricated housing construction.

(10) Polymer structure materials

Polymer structure materials constitute a large group of materials that use synthetic polymers as a base. They are noted for excellent mechanical and decorative properties and water and chemical resistance, and they are easy to handle. They are used mainly for floor coverings (linoleum, rubber linoleum, vinyl tiles), structural and finishing materials (laminated paper plastics, glass-reinforced fiber plastics, chipboard, decorative coatings), heat-and sound-insulating materials (foam and honeycomb plastics), and strip construction products.

(11) Varnishes and paints

Varnishes and paints are finishing materials that use organic and inorganic binders as a base and form decorative and protective coatings on the surfaces of structures. Synthetic paint and varnish materials and water-emulsion paints with polymer binders are widely used.

3. Standards and Improvements

The quality of construction materials is characterized by the grade rating. The grade rating is the basic performance characteristic of the materials, for example, the strength, specific weight, or frost resistance, or a combination of several characteristics. The methods of testing structure materials and the technical requirements placed on such materials are established by standards and specifications.

The cost of structure materials in modern construction accounts for approximately 60 percent of the total construction costs. Thus, further improvement in the efficiency of construction depends to a considerable degree on more extensive use of new, primarily lighter structure materials, such as lightweight concretes, polymer materials, and metal structures that use light alloys, on increased production of special structure materials, such as rapid-hardening cements and efficient heat-insulating materials, and on the use of better-quality traditional structure materials.

Important potential factors in lowering construction costs are the increased use of local structure materials, for example, blocks made from such lightweight rocks as tuff and coquina, and industrial wastes, such as metallurgical slags, ash from steam power plants, and woodworking waste materials. An important trend in the improvement of structure materials is the development of efficient finishing materials that improve the architecture and appearance of buildings and structures.

Nowadays, China is undergoing an unprecedented process of urbanization in terms of scale and range, with new strides constantly made in the modernization drive. With China urban construction, we need to develop new construction materials to support future growth needs. According to the empirical data, the steel and concrete remain as major materials in manufacturing and constructing for bridges, buildings, dams. And also, asphalt is a long-lasting material for roads construction. Therefore, we should focus on the characteristics of structural materials and develop new technology in the stage of construction. This chapter describes several recent examples of the use of improved structural materials and discusses opportunities for future development.

Vocabulary and Expressions

gravel [ˈgræv(ə)l] *n.* 碎石，砂砾 *vt.* 用碎石铺；使船搁浅在沙滩上

parquet [ˈpɑːkeɪ; pɑːrˈkeɪ] *n.* 镶木地板 *vt.* 铺镶木地板于；用镶木制；铺

sanitary fixture 卫生设备;卫生器具;卫生设施,卫生配件
flexural [ˈflekʃərəl] *adj.* 弯曲的;曲折的
acoustic material 声学材料
metallurgical slag 冶金炉渣
natural masonry materials 自然的砌体材料
timber and wood products 木材和木制品
ceramic materials and products 陶瓷材料及制品
inorganic binders 无机黏结剂
concretes and mortars 混凝土和砂浆
heat-insulating materials 热绝缘材料
organic binders and waterproof materials 有机黏合剂和防水材料
polymer structure materials 聚合物的结构材料
varnishes and paints 清漆和油漆

Explanations

[1] Generally speaking, structural materials comprise a number of classes such as metals (eg. ferrous and non-ferrous), composites (eg. ceramic, metal and polymer matrix), construction materials (eg. glass, concrete, steel, ceramics, wood) and others (such as structural and refractory ceramics and polymers).

一般来说,结构材料分为以下几种:金属材料(如铁金属和有色金属)、复合材料(如陶瓷、金属和聚合物基体)、施工材料(如玻璃、混凝土、钢、陶瓷、木材)和其他材料(如具有耐火特性的陶瓷和聚合物)。

[2] Varnishes and paints are finishing materials that use organic and inorganic binders as a base and form decorative and protective coatings on the surfaces of structures.

清漆和油漆是使用了有机和无机黏合剂的涂饰材料,它们作为一种装饰层和保护层涂抹在结构的表面上。

[3] Important potential factors in lowering construction costs are the increased use of local structure materials, for example, blocks made from such lightweight rocks as tuff and coquina, and industrial wastes, such as metallurgical slags, ash from steam power plants, and woodworking waste materials.

增加以下这些当地现有的结构材料的使用是降低建造成本的重要因素,例如,利用凝灰岩、贝壳灰岩等轻质岩制作成的砖块,工业废料,如冶金矿渣、发电厂废灰及木厂废料。

Questions

1. What technical challenges are structural materials facing with?
2. What basic groups could construction materials be divided into, according to process and functional criteria?
3. What are the characteristics of heat-insulating materials?
4. What aspects could polymer structure materials be used mainly for?
5. What is the importance of developing new construction materials?

2.2 Concrete

Concrete is widely used in building and civil engineering structures, due to its low cost, flexibility, durability, and high strength. It also has high resistance to fire. Concrete is a non-linear, non-elastic and brittle material. It is strong in compression and very weak in tension. It behaves non-linearly at all times. Because it has essential zero strength in tension, it is almost always used as reinforced concrete, a composite material. It is a mixture of sand, aggregate, cement and water. It is placed in a mould, or a form, as a liquid, and then it sets (goes off), due to a chemical reaction between the water and cement. The hardening of the concrete is called curing. The reaction is exothermic (gives off heat).

Concrete increases in strength continually from the day it is cast. Assuming it is not cast under water or in constantly 100% relative humidity, it shrinks over time as it dries out, and it deforms over time due to a phenomenon called creep as presented in Fig. 2-1. Its strength depends highly on how it is mixed, poured, cast, compacted, cured (kept wet while setting), and whether or not any admixtures are used in the mix. Fig. 2-2 shows a concrete compressive strength test. Concrete can be cast into any shape that a form can be made for. Its color, quality, and finish depend upon the complexity of the structure, the material used for the form, and the skill of the worker.

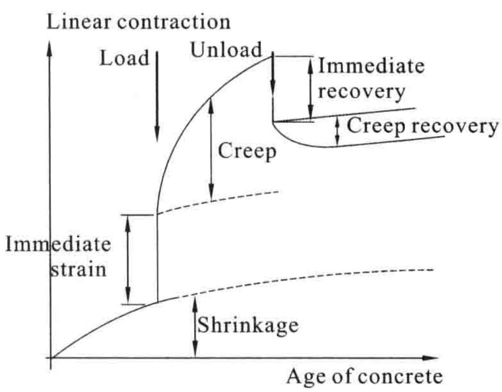

Fig. 2-1 The creep curve after application of the load

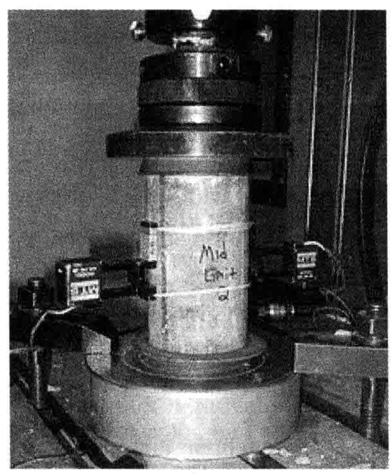

Fig. 2-2 Compression testing for concrete

The elastic modulus of concrete can vary widely and depends on the concrete mix, age, and quality, as well as on the type and duration of loading applied to it. It is usually taken as approximately 25 GPa for long-term loads once it has attained its full strength (usually considered to be at 28 days after casting). It is taken as approximately 38 GPa for very short-term loading, such as footfalls.

Concrete has very favorable properties in fire—it is not adversely affected by fire until it reaches very high temperature. It also has very high mass, so it is good for providing sound insulation and heat retention (leading to lower energy requirements for the heating of concrete buildings). This is offset by the fact that producing and transporting concrete is very energy intensive.

1. Properties of Concrete

(1) Elasticity

The modulus of elasticity of concrete is a function of the modulus of elasticity of the aggregates and the cement matrix and their relative proportions. It can be seen from Fig. 2-3 that the modulus of elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels. The elastic modulus of the hardened paste may be in the order of 10 ~ 30 GPa and aggregates about 45 to 85 GPa. The concrete composite is then in the range of 30 to 50 GPa.

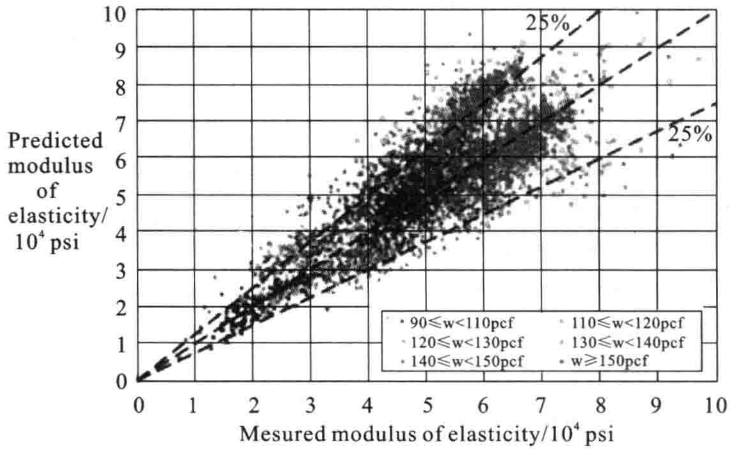

Fig. 2-3 Modulus of elasticity of concrete

(2) Expansion and shrinkage

Concrete has a very low coefficient of thermal expansion. However, if no provision is made for expansion, very large forces can be created, causing cracks in parts of the structure are not capable of withstanding the force or the repeated cycles of expansion and contraction. The coefficient of thermal expansion of Portland cement concrete is 0.000008 to 0.000012 (per degree Celsius) (8 to 12 microstrains/℃) (8 ~ 12 1/mK).

As concrete matures, it continues to shrink, due to the ongoing reaction is taking place in the material, although the rate of shrinkage falls relatively quickly and keeps reducing over time (for all practical purposes, concrete is usually considered to not shrink due to hydration any further after 30 years). From Fig. 2-4, one can clearly see the volume reduction caused by chemical shrinkage and autogenous shrinkage. The relative shrinkage and expansion of concrete and brickwork require careful accommodation when the two forms of construction interface.

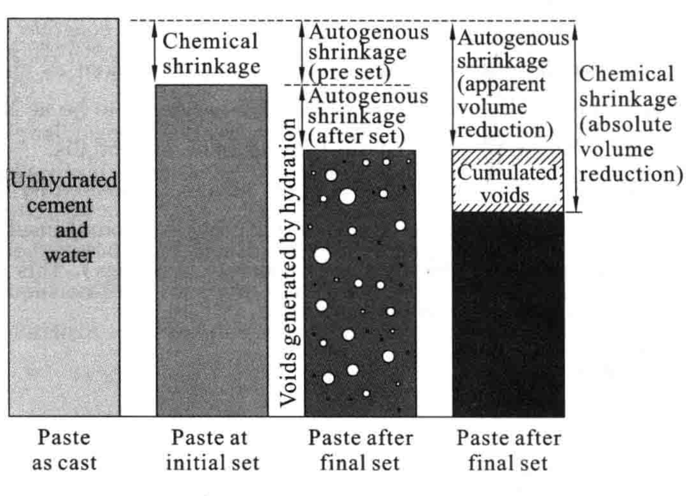

Fig. 2-4 Shrinkage cracks occur when chemical shrinkage and autogenous shrinkage volume changes of fresh concrete