应用型人才培养实用教材
普通高等院校土木工程“十三五”规划教材

主　编◎李景林
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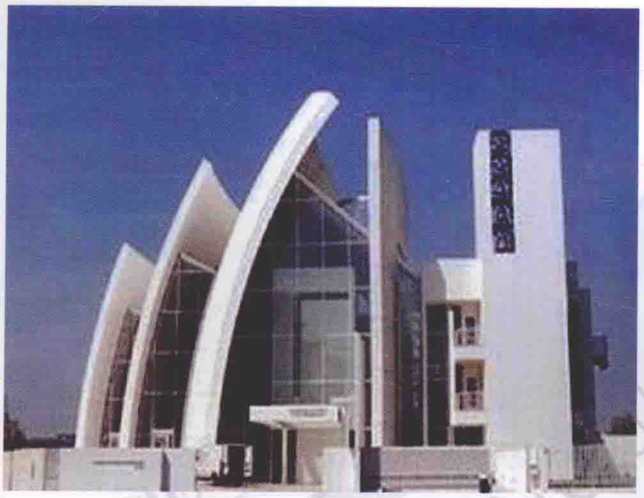
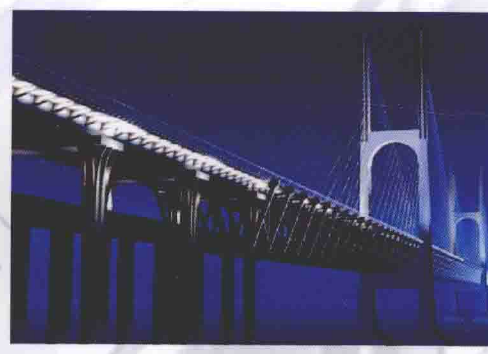
主　审◎谭丽华

建设工程专业英语

JIANSHE GONGCHENG ZHUANYE YINGYU





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前言

本书编写的目的在于响应国务院关于加快发展现代职业教育的决定。本书正是为培养应用技术型建设工程专业本科生而编写的。建设工程专业英语是应用技术型建设工程专业基础课程，开设此课程的目的是使大学生在完成基础英语学习后，由专业课教师讲授专业英语课程，进而培养学生阅读和翻译与建设工程专业相关英文文献和资料的能力，使学生能够用英文表述国内外前沿建设工程专业知识，实现应用技术能力和综合素质的提高。

本书较系统地介绍了建设工程所包含相关学科的基本内容，素材大多选自英文文献，内容新颖，反映了国内外学科发展的最新水平。本书在内容编排上力求重点突出，难度适中，可适用于不同英语水平的学生，满足多层次的教学目的和要求。全书共7章，每章含正文、生词与短语，以及与正文内容紧密相关的参考译文，其中有60%的正文配有参考译文；还包含附录。各学校可根据专业侧重点的不同和课程学时的差异为不同英语水平的学生选择相关内容进行讲解，其余部分可供教师指导学生选学或作为课外阅读材料。

参与本书编写的人员为：贵州民族大学人文科技学院李景林，长春科技学院胡一，西北民族大学陈成芹。

本书的具体编写分工如下：李景林，第1、5、6、7章和附录；胡一，第2章；陈成芹，第3、4章。本书由李景林担任主编。

贵州民族大学人文科技学院谭丽华教授担任本书主审，详细审阅了编写大纲和全部书稿，并提出了宝贵意见，在此表示感谢。

在本书编写过程中，编者参考了大量英文专业书籍、论文、研究报告，以及国内已出版的土木、建设工程专业英语教材，特向这些资料的作者表示诚挚的谢意。另外，感谢各主、参编院校的大力支持和帮助。

由于编者水平和能力有限，时间也较仓促，书中难免存在疏漏和不足之处，恳请读者批评指正。

编　者

2016年1月

目录

1 Building Materials

1.1 Commonly Used Building Materials

Materials for building must have certain physical properties to be structurally useful. Primarily, they must be able to carry a load or weight, without changing shape **permanently.** When a load is applied to a structure member, it will deform: that is a wire will **stretch** or a **beam** will **bend.** However, when the load is removed, the wire and the beam come back to the original positions. This material property is called **elasticity.** If a material were not elastic and a deformation were present in the structure after removal the load, repeated loading and unloading eventually would increase the **deformation** to the point where the structure would become useless. All Materials used in architectural structures, such as stone and **brick**, wood, steel, **aluminum**, **reinforced concrete**, and plastics, behave elastically within a certain defined range of **loading.** If the loading is increased above the range, two types of behavior can occur: brittle and plastic. In the former, the material will break suddenly. In the latter, the material begins to flow at a certain load (**yield strength**), ultimately leading to **fracture.** As examples, steel exhibits plastic behavior, and stone is **brittle.** The ultimate strength of a material is measured by the stress at which failure (fracture) occurs.

A second important property of a building material is its **stiffness.** This property is defined by the **elastic modulus**, which is the ratio of the stress (force per unit area), to the strain (deformation per unit length). The elastic modulus, therefore, is a measurement of the resistance of a material to deformation under load. For two materials of equal area under the same load, the one with the higher elastic modulus has the smaller deformation. Structural steel, which has an elastic modulus of 30 million pounds per square inch (lb/in^2), or $2100000kg/cm^2$ kilograms per square centimeter, is 3 times as stiff as aluminum, 10 times as stiff as concrete, and 15 times as stiff as wood.

1.1.1 Masonry

Masonry consists of natural materials, such as stone or manufactured products, such as brick and **concrete blocks.** Masonry has been used since ancient times; mud bricks were used in the city of Babylon for **secular** buildings, and stone was used for the great **temples** of the Nile Valley. The Great Pyramid in Egypt, standing 481ft (147m) high, is the most spectacular masonry construction. **Masonry units** originally were stacked without using any **bonding agent**, but all modern **masonry construction** uses a cement **mortar** as a bonding material. Modern structural materials include stone, brick of **burnt clay** or **slate**, and concrete blocks.

Masonry is essentially a compressive material: it cannot withstand a tensile force (a pull). The ultimate compressive strength of bonded masonry depends on the strength of the masonry unit and the mortar. The ultimate strength will vary from 1000 to 4000psi ($70\text{-}280kg/cm^2$), depending on the particular combination of masonry unit and mortar used.

1.1.2 Timber

Timber is one of the earliest construction materials and one of the few natural materials with good **tensile properties**. Hundreds of different species of wood are found throughout the world, and each species exhibits different physical characteristics. Only a few species are used structurally as **framing members** in building construction. In the United States, for instance, out of more than 600 species of wood, only 20 species are used structurally. These are generally the **conifers**, or softwoods, both because of their abundance and because of the ease with which their wood can be shaped. The species of timber more commonly used in the United States for construction are **Douglas fir**, Southern pine, **spruce**, and redwood. The ultimate tensile strength of these species varies from 5000psi to 8000psi ($350\text{-}560kg/cm^2$). Hardwoods are used primarily for **cabinetwork** and for interior finishes such as floors.

Because of the **cellular** nature of wood, it is stronger along the **grain** than across the grain. Wood is particularly strong in tension and compression parallel to the grain. And it has great bending strength. These properties make it ideally suit for columns and beams in structures. Wood is not effectively used as a tensile member in a tress, however, because the tensile strength of a **truss member** depends upon connections between members. It is difficult to devise connections which do not depend on the **shear** or tearing strength along the grain, although numerous metal connectors have been produced to utilize the tensile strength of timbers.

1.1.3 Steel

Steel is an outstanding structural material. It has a high strength on a pound-for-pound basis when compared to other materials, even though its volume-for-volume weight is more than 10 times that of wood. It has a high elastic modulus, which results in small deformations under load. It can be formed by rolling into various structural shapes such as I-beams, plates, and sheets; it also can be cast into complex shapes; and it is also produced in the form of **wire strands** and ropes for use as cables in suspension bridges and suspended roofs, as elevator ropes, and as wires for prestressed concrete. Steel elements can be joined together by various means, such as **bolting**, **riveting**, or **welding**. Carbon steels are subject to corrosion through **oxidation** and must be protected from contact with the atmosphere by painting them or embedding them in concrete. Above temperatures of about 700°F (371℃), steel loses its strength rapidly, and therefore it must be covered in a jacket of a fireproof material (usually concrete) to increase its fire resistance.

The addition of alloying elements, such as **silicon** or **manganese**, results in higher strength steels with tensile strength up to 250000psi (17500kg/cm^2). These steels are used where the size of a structural member becomes critical, as in the case of columns in a skyscraper.

1.1.4 Aluminum

Aluminum is especially useful as a building material when lightweight, strength, and corrosion resistance are all important factors. Because pure aluminum is extremely soft and **ductile**, alloying elements, such as magnesium, silicon, zinc, and copper, must be added to it to impart the strength required for structural use. Structural aluminum alloys behave elastically. They have an elastic modulus 1/3 as great its steel and therefore deform 3 times as much as steel under the same load. The unit weight of an aluminum alloy is 1/3 that of steel, and therefore an aluminum member will be lighter than a steel member of comparable strength. The ultimate tensile strength of aluminum alloys ranges from 20000psi to 60000psi (1400-4200kg/cm^2).

Aluminum can be formed into a variety of shapes; it can be extruded to form I-beams, drawn to form wire and rods, and rolled to form foil and plates. Aluminum members can be put together in the same way as steel by riveting, bolting, and (to a lesser extent) by welding. Apart from its use for framing members in buildings and prefabricated housing, aluminum also finds extensive use for window frames and for the skin of the building in curtain-wall construction.

1.1.5 Concrete

Concrete is a mixture of water, sand and **gravel**, and **portland cement**. Crushed stone, manufactured lightweight stone, and seashells are often used in **lieu** of **mural** gravel. Portland cement, which is a mixture of materials containing **calcium** and clay, is heated in a **kiln** and then **pulverized**. Concrete derives its strength from the fact that pulverized portland cement, when mixed with water, hardens by a process called **hydration**. In an ideal mixture, concrete consists of about 3/4 sand and gravel (aggregate) by volume and 1/4 cement paste. The physical properties of concrete are highly sensitive to variations in the mixture of the components, so a particular combination of these ingredients must be custom-designed to achieve specified results in terms of strength or shrinkage. When concrete is poured into a mold or form, it contains free water, not required for hydration, which evaporates. As the concrete hardens, it releases this excess water over a period of time and shrinks. As a result of this shrinkage, fine cracks often develop. In order to minimize these shrinkage cracks, concrete must be hardened by keeping it **moist** for at least 5d. The strength of concrete increases in time because the hydration process continues for years; as a practical matter, the strength at 28d is considered standard.

Concrete deforms under load in an elastic manner. Although its elastic modulus is 1/10 that of steel, similar deformations will result since its strength is also about 1/10 that of steel. Concrete is basically a compressive material and has negligible tensile strength.

1.1.6 Reinforced concrete

Reinforced concrete has steel bars that are placed in a concrete member to carry tensile forces. These reinforcing bars, which range in diameter from 0.25in (0.64cm) to 2.25in (5.7cm), have wrinkles on the surfaces to ensure a bond with the concrete. Although reinforced concrete was developed in many countries, its discovery usually is attributed to Joseph Monnier, a French **gardener**, who used a wire network to reinforce concrete tubes in 1868. This process is workable because steel and concrete expand and contract equally when the temperature changes. If this were not the case, the bond between the steel and concrete would be broken by a change in temperature since the two materials would respond differently. Reinforced concrete can be molded into innumerable shapes, such as beams, columns, **slabs**, and **arches**, and is therefore easily adapted to a particular form of building. Reinforced concrete with ultimate tensile strength in excess of 10000psi (700kg/cm^2) is possible, although most commercial concrete is produced with strengths under 6000psi (420kg/cm^2).

1.1.7 Plastics

Plastics are rapidly becoming important construction materials because of the great variety, strength, durability, and lightness. A plastic is a synthetic material or **resin** which can be molded into any desired shape and which uses an organic substance as a binder. Organic plastics are divided into two general groups: thermosetting and thermoplastic. The thermosetting group becomes rigid through a chemical change that occurs when heat is applied; once set, these plastics cannot be remolded. The thermoplastic group remains soft at high temperatures and must be cooled before becoming rigid; this group is not used generally as a structural material. The ultimate strength of most plastic materials is from 7000 to 12000psi (490-840kg/cm^2), although **nylon** has a tensile strength up to 60900psi (4,200kg/cm^2).

Words and Expressions

permanently *adv.* 永久地
stretch *v.* 伸展,张开,延伸 *n.* 伸展;张开 *adj.* 可伸缩的
beam *n.* 梁;横梁
bend *v.* 弯曲;屈服
elasticity *n.* 弹性;弹力
deformation *n.* 变形

brick *n.* 砖 *adj.* 砖似的 *vt.* 用砖围砌，用砖填补

aluminum *n.* 铝

concrete *n.* 混凝土

reinforced concrete 钢筋混凝土

loading *n.* 装载；加载

yield strength 屈服强度；屈变力；抗屈强度

fracture *n.* 破碎 *vi.* 破碎，破裂

brittle *adj.* 易碎的

stiffness *n.* 刚度；硬度

elastic modulus 弹性系数；弹性模量

masonry *n.* 石工；石工行业；石造建筑

concrete block 混凝土砖

secular *adj.* 世俗的；现世的；不朽的

temple *n.* 庙宇；寺院；神殿；

masonry unit 砌块

bonding agent 黏合剂，结合剂

masonry construction 砌筑结构；砖石结构

mortar *n.* 砂浆；灰浆

burnt clay 烧黏土

slate *n.* 板岩；石板；石片

timber *n.* 木材；木料

tensile property 抗拉强度

framing member 框架构件

conifer *n.* 针叶树；[植]松柏科植物

Douglas fir [林]花旗松；绿枞

spruce *n.* 云杉

cabinetwork *n.* 细木工；用具；细工家具

cellular *adj.* 多孔的；细胞的

grain *n.* 纹理；颗粒；谷物

truss member 桁架杆件

shear *n.* 切变；修剪

wire strand 钢丝索

bolt *n.* 螺钉；门闩

rivet *n.* 铆钉 *vt.* 用铆钉固定；敲进去

weld *n.* 焊接，焊缝 *vt.* 焊接

oxidation *n.* 氧化

silicon *n.* 硅

manganese *n.* 锰

ductile *adj.* 易延展的,柔软的

gravel *n.* 碎石

portland cement 波特兰水泥,硅酸盐水泥,普通水泥

lieu *n.* 代替

mural *adj.* 墙壁的 *n.* 壁画

calcium *n.* 钙

kiln *n.* (砖,石灰等的)窑;炉;干燥炉

pulverize *vt.* 粉碎;使成粉末;研磨

hydration *n.* 水合作用

moist *adj.* 潮湿的;湿润的

gardener *n.* 园丁;花匠;园艺家

slab *n.* 平板;厚的切片

arch *n.* 拱门;弓形

resin *n.* 树脂;松香

nylon *n.* 尼龙

【参考译文】

常用建筑材料

建筑材料必须具有一定的对结构有用的物理性质。首先,它们必须能够承担荷载或重量,且不改变形状。当一个荷载被施加到一个结构构件上时,构件会变形,这个内力将构件拉伸或使梁弯曲。然而,当荷载被卸除,构件和梁就会回到原来的位置。材料的这种性质称为弹性。如果材料没有弹性,在荷载移除后结构中的变形仍然存在,那么重复加载和卸载将最终使变形增加到结构不可用的程度。建筑结构用的材料,如石头、砖、木、钢、铝、钢筋混凝土、塑料,在一定荷载范围内表现出弹性。如果荷载增加超过了这个范围,可能会发生2种类型的行为:脆性破坏和塑性破坏。前者材料会突然断裂。后者在一定荷载(屈服强度)下材料开始屈服流动,最后导致破坏。例如,钢材呈现塑性,石材呈现脆性。材料的最终强度由发生破坏时的应力决定。

建筑材料的另一个重要特性是它的刚度。此属性由弹性模量定义,弹性模量是应力(单位面积的力)与应变(单位长度的变形)的比率。因此,弹性模量是一个材料在荷载作用下抵抗变形的能力的度量指标。在相同荷载作用下面积相同的两种材料,具有较高弹性模量的材料具有较小的变形。结构钢具有30 Mlb/in^2(或2 100 000 kg/cm^2)的弹性模量,是铝的弹性模量的3倍,混凝土弹性模量的10倍和木材的15倍。

1.1.1 砌　体

砌体由天然材料组成,如石材或人造制品、砖和混凝土砌块。自古以来,就一直在使用砌体。泥砖被用在巴比伦城市的非宗教建筑物中,石材被用在尼罗河流域的大寺庙中。埃及金字塔高481 ft(147 m),是最壮观的砌体结构。以前砌体单元仅是堆放,没有使用任何黏结剂,但所有现代的砌体建筑,施工时都使用水泥砂浆作为黏结材料。现代结构的砌体材料包括石头、烧结黏土砖或石板砖、混凝土砌块。

砌体实质上是一种受压材料,它不能承受拉力。黏结砌体的极限抗压强度取决于砌体单元和砂浆的强度,极限强度在1 000～4 000 psi(70～280 kg/cm^2)之间变化,极限强度取决于使用的砌体单元和砂浆的特定组合。

1.1.2 木　材

木材是使用最早的建筑材料之一,也是具有良好抗拉性能的建筑材料之一。数百种不同种类的木材在世界各地被发现,并且每一个树种都表现出不同的物理特性。在建筑施工中,只有少数几个树种被用作框架构件。例如,在美国,有超过600种的木材,只有20种在结构上使用。它们一般是针叶树或软木,因为它们数量丰富,而且柔软易成形。在美国木材品种中比较常用的是道格拉斯冷杉、云杉和红木及南方松。这些树种的极限抗拉强度为5 000～8 000 lb/in^2(350～560 kg/cm^2)。硬木主要用于细木家具和室内装饰,如地板。

由于木材多孔特性,它顺纹理方向的强度大于跨纹理方向的强度。木材顺纹的抗拉强度和抗压强度特别大,并且它有很大的抗弯强度。这些特性使它很适合作为结构中的柱和梁。木材作为桁架的抗拉构件是无效的,因为桁架构件的抗拉强度取决于构件间的节点。虽然生产出了很多利用木材抗拉强度的金属连接件,但是很难设计出顺纹方向的抗剪强度或抗拉强度关系不大的连接件。

1.1.3 钢

钢是一种优秀的结构材料。与其他材料相比,在相同重量条件下它有很高的强度,即使它等体积的重量是木材的10倍。它具有很高的弹性模量,这导致在荷载作用下的变形很小。它能轧制成很多结构形式,如I形梁、板、薄板,它也能铸成复杂的样式,它还能生产成绳索形式用作悬索桥和悬索屋顶的缆以及电梯吊索,还能用作预应力混凝土里的钢丝索。钢构件可以通过很多方式联结在一起,如螺栓连接、铆接和焊接。碳素钢易遭受氧化锈蚀,因此必须靠喷漆或嵌入混凝土中来避免与空气接触。当温度在700 ℉(371 ℃)以上,钢会迅速失去其强度,因此它必须被覆盖在一种防火材料(通常是混凝土)的内层来提高其耐火性能。

添加合金元素,如硅或锰,会得到抗拉强度高达250 klb/in^2(17.5 t/cm^2)的高强度钢。这些钢是用在结构尺寸的很关键构件,如摩天大楼的柱子。

1.1.4 铝

当轻质、高强和抗锈蚀都成为重要因素时,铝就成了一种特别有用的建筑材料。因为纯铝是极

其柔软和具有延展性的，所以必须增加镁、硅、锌、铜等合金元素，以满足结构使用所需的强度。结构铝合金表现出弹性，它们的弹性模量是钢的 1/3，因此在相同的荷载下，变形是钢的 3 倍。铝合金的单位重量是钢的 1/3。因此，铝合金构件的重量比同等强度的钢轻。铝合金的极限抗拉强度范围为 20 000～60 000 psi(1 400～4 200 kg/cm^2)。

铝可以形成各种形状；它可以初压制形成 I 形梁，拉制成线材和杆件，碾压成箔片和板。铝构件能和钢用同样的方法连接，如铆接、螺栓连接、低强度的焊接。除了用作建筑和预制房的框架外，铝也广泛用作窗框和结构幕墙。

1.1.5 混凝土

混凝土是水、砂、石料和硅酸盐水泥的混合物。碎石、人造轻质石和贝壳被常用来替代墙壁砾石。硅酸盐水泥是包含钙和黏土的混合物，在窑里加热，然后研磨成粉。混凝土通过硅酸盐水泥与水混合后的水合作用使其硬化获得强度。在理想的混合物里，混凝土由 3/4 体积的砂和石料与 1/4 体积的水泥浆组成。混凝土的物理特性对混合物成分的变化很敏感，为了获得规定的强度和收缩量，必须对这些组分的配比进行定制。将混凝土倾倒在模板里时，它包含自由水，不再需要水化作用的水会蒸发掉。随着混凝土的硬化，它在一定时期内释放出多余的水，并且收缩。由于收缩的作用，故细裂缝产生了。为了把收缩裂缝减到最少，混凝土硬化时必须至少保湿 5 天。混凝土强度随时间增长，因为水化过程会持续几年；实际上，28 天强度就被认为是标准强度。

混凝土在荷载作用下是弹性变形。虽然它的弹性模量是钢的 1/10，但是变形却一样，因为它的强度也只有钢的 1/10。混凝土本质上是一种抗压材料，它的抗拉强度可以忽略不计。

1.1.6 钢筋混凝土

钢筋混凝土靠置于混凝土中的钢筋承担拉力。这些钢筋直径为 0.25～2.25 in(0.64～5.7 cm)，表面有刻痕以确保黏结住混凝土。虽然钢筋混凝土在很多国家有所发展，但是它的发现要归功于一个法国园艺师 Joseph Monnier。他在 1868 年用一个钢筋网加强混凝土筒。这个操作是可行的。因为当温度变化时，钢筋和混凝土同等地膨胀和收缩。如果不是这样的话，温度改变时钢筋和混凝土之间的黏结将因为这两种材料的反应不同而被破坏。钢筋混凝土可被浇筑成各种形状，如梁、柱、板和拱。因此，它适用于建筑的特殊形式。虽然大部分商品混凝土强度在 6 000 lb/in^2(420 kg/cm^2)，但是钢筋混凝土的极限抗拉强度可能超过 10 000 lb/in^2(700 kg/cm^2)。

1.1.7 塑　料

塑料因其种类多、强度高、耐久性好和轻质而迅速成为重要的建筑材料。塑料是一种合成材料或树脂，可以被塑造成任何想要的形状，并使用有机物质作为黏合剂。有机塑料一般分为热固性塑料和热塑性塑料两类。热固性塑料在加热时通过化学变化而变得坚硬；一旦成型，这类塑料不能被重塑。热塑性塑料在高温下保持柔软，在变得坚硬之前必须冷却，这种塑料一般不作为结构材料使用。虽然尼龙的拉伸强度高达 60 900 lb/in^2(4 200 kg/cm^2)，但大多数塑料材料的极限强度是 7 000～12 000 lb/in^2(490～840 kg/cm^2)。

1.2 Concrete as a Structural Material

In an article published by the *Scientific American* in April 1964, S. Brunauer and L. E. Copland, two **eminent** scientists in the field of cement and concrete, wrote:

The most widely used construction material is concrete, commonly made by mixing portland cement with sand, crushed rock, and water. Last year in the U. S. 63 million tons of portland cement were converted into 500 million tons of concrete, 5 times the consumption by weight of steel. In many countries the ratio of concrete consumption to steel consumption exceeds ten to one. The total world consumption of concrete last year is estimated at three billion tons or one ton for every living human being. Man consumes no material except water in such tremendous quantities.

Today, the rate at which concrete is used is much higher than it was 40 years ago. It is estimated that the present consumption of concrete in the world is of the order of 11 billion metric tones every year.

Concrete is neither as strong nor as tough as steel, so why is it the most widely used engineering material? There are at least 3 primary reasons.

First, concrete possesses excellent **resistance to water.** Unlike wood and ordinary steel, the ability of concrete to withstand the action of water without serious **deterioration** makes it an ideal material for building structures to control, store, and transport water. In fact, some of the earliest known applications of the material consisted of **aqueducts** and **waterfront retaining walls** constructed by the Romans. The use of plain concrete for dams, **canal linings**, and **pavements** is now a common sight almost everywhere in the world.

For example, Itaipu Dam in Brazil, this spectacular 12600 MW **hydroelectric** project at Itaipu, estimated cost \$ 18.5 billion, includes a 180m high hollow-gravity concrete dam at the Parana River on the Brazil-Paraguay border. By 1982 twelve types of concrete, totaling 12.5 million m^3, had been used in the construction of the dam, **piers** of diversion structure, and the precast beams, slabs, and other structural elements for the power plant.

The designed **compressive strengths** of concrete ranged from as low as 14 MPa at 1 year for mass concrete for the dam to as high as 35 MPa at 28 days for **precast concrete members.** All **coarse aggregate** and about 70% of the **fine aggregate** was obtained by crushing **basalt rock** available at the site. The coarse aggregates were separately **stockpiled** into gradations of 150mm, 75mm, 38mm, and19mm maximum size. A combination of several aggregates containing different size fractions was necessary to reduce the **void content** of the mass concrete was limited to as low as $108kg/m^3$, and the **adiabatic** temperature rise to 19℃ at 28 days. Furthermore, to prevent thermal cracking, it was specified that the temperature of freshly cooled concrete would be limited to 7℃ by precooling the constituent materials.

Structural elements exposed to **moisture**, such as piles, foundations, footings, floors, beams, columns, roofs, exterior walls, and pipes, are frequently built with reinforced and **prestressed concrete**. Reinforced concrete is a concrete usually containing steel bars, which is designed on the assumption that the two materials act together in resisting tensile forces. With prestressed concrete by tensioning the **steel tendons**, a precompression is introduced such that the tensile stresses during service are **counteracted** to prestressed structural elements. The **durability** of concrete to aggressive water is responsible for the fact that its use has been extended to severe industrial and natural environments.

The largest circular precast concrete structure ever built for the transportation of water is part of the Central Arizona Project — A $ 1.2 billion U.S. Bureau of **Reclamation** development, which provides water from the Colorado Diver for agricultural, industrial, and municipal use in Arizona, including the metropolitan areas of Phoenix and Tucson. The system contains 1560 pipe sections, each 6.7m long, 7.5m outside diameter (equivalent to the height of a two-story building), 6.4 m inside diameter, and weighing up to 225t.

Since 1971, twenty concrete **platform** requiring about 1.3 million cubic meters of concrete have been installed in the British and Norwegian sectors of the North Sea. Statfjord B, the largest concrete platform, built in 1981, has a base area of $18000m^2$, 24 oil storage cells and the **deck** frame, and 42 drilling **slots** on the deck. The structure was built and assembled at a dry **dock** in Stavanger; then the entire assembly, weighing about 40,000 t, was towed to the site of the oil well, where it was **submerged** to a water depth of about 145m. The prestressed and heavily reinforced concrete elements of the structure exposed to the corrosive action of seawater and are designed to withstand 31m high waves. Therefore, the selection and proportioning of materials for the concrete mixture was governed primarily by consideration of the speed of construction by slip-forming and durability of hardened concrete to the hostile environment. A free-flowing concrete mixture (220mm slump), containing $380kg/m^3$ of finely ground portland cement, 20mm of maximum-size coarse aggregate, a 0.42 water-cement ratio, and a superplasticizing **admixture** was found satisfactory for the job.

The second reason for the widespread use of concrete is the ease with which structural concrete elements can be formed into a variety of shapes and sizes. This is because freshly made concrete is of a **plastic consistency**, which enables the material to flow into **prefabricated** formwork. After a number of hours when the concrete has solidified and hardened to a strong mass, the formwork can be removed for reuse.

The third reason for the popularity of concrete with engineers is that it is usually the cheapest and most readily available material on the job. The principal components for making concrete, namely aggregate, water, and portland cement are relatively inexpensive and are commonly available in most parts of the world. Depending on the components' transportation cost, in certain geographical locations the price of concrete may be as high as U. S. \$75 to \$100 per m^3, at other it may be as low as U. S. \$60 to \$70 per cubic meter.

Some of the considerations that favor the use of concrete over steel as the construction material of choice are as follows:

(1) Maintenance

Concrete does not corrode, needs no surface treatment, and its strength increases with time; therefore, concrete structures require much less maintenance. Steel structures, in addition, **are susceptible to** rather heavy corrosion in **offshore** environments, require costly surface treatment and other methods of protection, and entail considerable maintenance and repair costs.

(2) Fire resistance

The fire resistance of concrete is perhaps the most important single aspect of offshore safety and, at the same time, the area in which the advantages of concrete are most evident. Since an adequate concrete cover on reinforcement or tendons is required for structural integrity in reinforced and prestressed concrete structures, the protection against failure due to excessive heat is provide at the same time.

(3) Fatigue resistance

The **fatigue strength** of steel structure is greatly influenced by local stress fields in welded joints, corrosion pitting, and sudden changes in **geometry**, such as from thin web to thick frame connections. In most codes of practice, the allowable concrete stresses are limited to about 50 percent of the ultimate strength; thus the fatigue strength of concrete is generally not a problem.

Words and Expressions

eminent *adj*. 著名的;卓越的

resistance to water 耐水性

deterioration *n*. 恶化;降低;退化

aqueduct *n*. 渡槽;沟渠

waterfront *n*. 水边;滨水地区

retaining wall 挡土墙,壅壁;护岸

canal lining 渠道衬砌

pavement *n*. 人行道; 路面

hydroelectric *adj*. 水力发电的

pier *n*. 桥墩;码头,直码头

compressive strength 抗压强度;压缩强度

precast *adj*. 预制的 *vt*. 预制;预浇制

concrete member 混凝土构件

coarse aggregate 粗集料;粗骨料