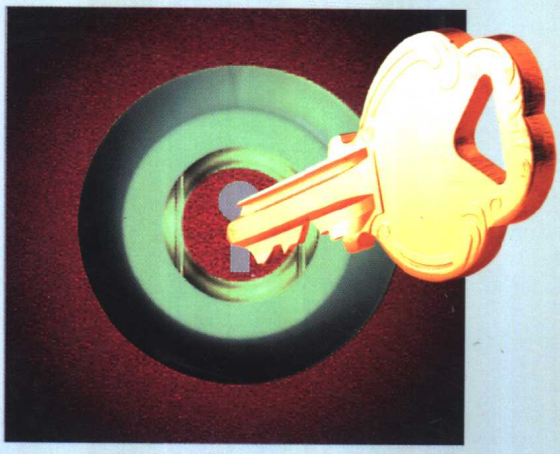
土木类

# 工程英语（教程）使用指南

## A Guide to *Civil Engineering English* (A Coursebook)

周开鑫　主编



人民交通出版社

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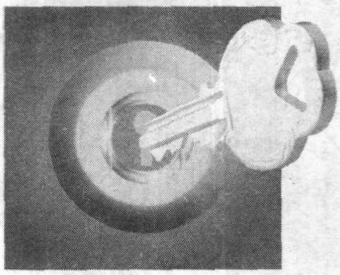

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## 内 容 提 要

本书是《土木类工程英语(教程)》的必要补充,内容包括(教程)全书练习的参考答案、102篇课文的参考译文和词汇短语总表,为使用者提供极大的方便。

本书可供我国高校道路工程、交通工程、桥梁工程、港航工程和管理工程专业的师生以及相关专业的工程技术和管理人员使用。

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# 编 者 的 话

本书是《土木类工程英语(教程)》必不可少的补充,因为它提供了该教程所有练习的答案、所有课文的参考译文和全书涉及的词汇总表,这些内容无疑可为师生的教和学带来极大的方便。

本书的编写耗时之多是难以数计的,其中遇到的困难也不少。加之我们的教学任务都很繁重,时间十分紧迫。因此,我们相信书中定有不少疏误和不足,诚恳希望同行专家和广大师生批评指正,以利进一步修改。

编 者

2002 年 4 月

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# I. 练 习 答 案
# (Key To The Exercises)

## Lesson 1

### Text A

**I.**

1. We must trace the history of road development.
2. In prehistoric times, tracks were first beaten in the ground by wild animals. Then people followed those winding trails, which provided an easy and quick way to get through thick forests. Later on, people began to improve the paths by filling holes with earth and laying logs across soft, boggy spots. Such was the beginning of road construction.
3. First, people packed their wares on animals. Then, they invented various kinds of sleds. Finally, after the wheel was invented, they built wagons.
4. It got its name from how it was built. When well-traveled routes were made sturdier rocks and stones, the path was raised above the surrounding land and it became a "high way".
5. The Romans bound their empire together with an extension system radiating in all directions from Rome. Some of these early roads were of elaborate construction. One of the examples is the Appian Way whose pavement was placed in three courses: a layer of small broken stones, a layer of small stones mixed with mortar and tamped firmly into place, and a wearing course of massive stone blocks, set and bedded in mortar. Even today, many modern highways follow the ancient Roman routes, some of which are still in existence.
6. Because most of the early settlements were located along bays or rivers and transportation was largely by water. Also, inland settlements were connected with the nearest wharf just by a clearing through the forest. Before the Revolutionary War, travel was mainly on foot or horseback, and roads were merely trails cleared to greater width.
7. During that period, a lot of turnpikes were built by companies seeking profits through toll collections, without much success. And many stagecoach lines and freight-hauling companies were organized in the same period.
8. The Tom Thumb, America's first steam locomotive constructed by Peter Cooper in 1830, brought about a rapid growth of the railroad, for this new invention, as a means of transportation over long distance, at once demonstrated its superiority over horse-drawn vehicles, and so it abruptly halted the extension of turnpikes in the United States.
9. At the beginning of the 20$^{th}$ century the automobile began to take over the road. This was followed by the improvement of the motor vehicle in the first two decades of the century, which in turn entailed a general demand for rural road improvement, especially for roads connecting outly-

ing farms with towns and railroad stations.

10. They were the completion of a network of all-weather rural roads and the provision of facilities of higher standards with greater capacity and load-carrying ability in urban areas.

**II.**

1. in existence 2. paved 3. superiority 4. aptly 5. made to low standards 6. in time 7. fallen into disuse 8. beaten tracks 9. trail 10. comparable 11. to

**III.**

1. load-carrying ability/capacity
2. all-weather road
3. hard-packed dirt
4. freight-hauling company
5. demand for road improvement
6. 到地平高度
7. 马拉车
8. 铺三层料的路面
9. 本世纪的前十年
10. 人口密度

**IV.**

1. Please tell me what it is (that) you want me to buy for you.
2. They cleared the trails to greater width, and turned them into roads for horse-drawn vehicles to ride on.
3. The Liberation Road is located on the north bank of the Yangtze River, with a total length of a few kilometers.
4. Excavate the well to a certain depth, and you will get clear and sweet drinking water.
5. Profiteers tend to take advantage of the chaotic market to gain fat profits.
6. When Mr. Green retired, his son took over the business from him.
7. He devoted most of his life to the cure of cancer.
8. In his speech, he focused his explanations on the essential characteristics and great significance of Deng Xiaoping Theory.
9. The 20th century saw the sufferings, struggles and rise of the Chinese people.
10. This accident was largely due to his negligence and carelessness.

## Text B

**I.**

1. Planning the route, testing the earth foundation while measuring the land, starting the construction work after the crew move in
2. Deciding the route; planning such details as the width of the highway, the number of driving lanes, the number and location of entrances and exits, and the strength of the road
3. The amount of traffic that is expected for the next 20 years.
4. Because they must learn how solid it is, how much moisture it contains, and how well it drains, etc. before deciding upon the preparation of the soil to provide a good, sturdy foundation.
5. It means "predetermine or specify with authority".
6. They begin to measure the lane to find out the amount of work to be done and the cost to be borne.
7. To clear the path for the roadbed by knocking over trees and tearing large rocks out of the ground

with bulldozers, to scoop up earth and rocks, and dump them into low spots with earth-moving machines, and to press down these filling materials tightly with power rollers so that the roadbed is gradually made a long-level band of hard-packed dirt

8. Because only proper drainage can prevent all sorts of damage to the highway.
9. Laying culverts across the roadbed in case of a strong flow of water, and raising the middle of the finished road a bit higher than the sides.
10. Because they have a solid foundation and they are surfaced with concrete or with bituminous materials.

# Lesson 2

## Text A

**I.**

1. Aerial photography can be used at technical conferences and public hearings. It is also very useful in seeking the most suitable topographic location for the highway.
2. They are: 1) finding the best topographic location, 2) locating sand and gravel deposits, borrow pits, and rock areas suitable for quarrying, 3) rating the soil-bearing capacities, 4) delineating the soil's Texture and estimating the depths of organic deposits, 5) classifying the bedrocks in terms of their physical types and their relative depths below the surface, etc.
3. The most up-to-date information about the current land use.
4. It can provide enough detailed information to enable elimination of all but a couple of possible bands and help narrow the choice of band routes.
5. It is to assemble one or more mosaic bands and to overlay them with topographic maps enlarged to the same scale and drawn on transparent material. Then, trial lines for each route can be sketched on the mosaics and profiles can be plotted directly from the contours of the overlay. When route profiles are found to indicate alignments that might satisfy the highway's design standards, they can be compared on a benefit-cost basis to help in the final selection.
6. It is to carry out auger-investigations at fixed intervals along the location line and then to do other detailed studies as indicated by the results obtained.
7. Air-photo interpretative methods cut down the amount of soil survey field work. Much of the routine augering and laboratory analysis may be eliminated if the air photos are used to delineate ground areas with similar physical characteristics.
8. The plans and specifications for a highway can be completed, and the construction contract can be made without actually placing a center-line peg in the ground. The final location line needn't be pegged until the contractor is about to begin construction. Therefore, the final location survey becomes a survey with location and construction combined.

**II.**

1. public hearings
2. aerial photography
3. at fixed intervals
4. up-to-date information
5. sand and gravel deposits
6. frost heave

7. physical characteristics　　8. qualifying tests
9. visual aids　　10. cut-and-cover methods

**III.**

1. seek　2. satisfy　3. follows　4. regarding　5. assembled　6. overlaid　7. eliminate　8. aid　9. was　10. indicated　11. minimized　12. delineate

**IV.**

1. 新的航摄照片可提供有关目前土地使用情况的最新信息,这在公路定线研究的踏勘阶段尤其重要,特别是在城区。
2. 当线路纵断面得以确定,线路定线达到公路设计的标准时,即可根据利润—成本的分析比较,作出最后选择。
3. 航摄解释法可以减少野外的土质勘测工作,这项工作通常在最后的定线勘测中进行。
4. 同样,通过这些照片更容易确定适合的集料的来源,现场勘察和实验检测可减少到最小量。
5. 在这种情况下,最后的定位线可在承包人临近施工时才标桩,于是最后定线勘测就成了定线施工两相结合的勘测了。

**V.**

Aerial photography is another modern method of surveying. An aerial photograph distorts the scale at its edges in proportion to the distance the subject is from being in a direct vertical line with lens of the camera. For this reason, the photographs for an aerial survey are arranged to overlap so that the scale of one part joins the scale of the next. This arrangement is called a mosaic, after the pictures that are made from hundreds of bits of colored stone or glass.

## Text B

**I.**

1.T　2.F　3.F　4.T　5.F　6.F　7.F　8.T　9.T　10.F　11.T　12.F

# Lesson 3

## Text A

**I.**

1. They usually interpose transition or spiral curves between tangents and circular curves on the plan view.
2. The key to success is consistency. Sudden changes from flat to sharp curves, and placing circular curves of different radii end to end or having a short tangent between two curves with suitable transitions provided are all poor practices to be avoided, because they might cause accidents.
3. Because long, flat curves are pleasing in appearance and capable of decreasing the possibility of future obsolescence.
4. Superelevation and side friction.

5. When curved sections are superelevated, gradual change from one to the other must be provided for. To produce the desired superelevation, the center line of each individual roadway should be maintained at profile grade while the outer edge is raised and the inner edge lowered.
6. Because it is very hard for the passenger to achieve a position of equilibrium.
7. Easement curves, which result in a gradual change in radius from infinity on the tangent to that of the circular curve so that centrifugal force gradually develops as well.
8. Because they ensure both comfort and safety.
9. The decision should be made before the final location survey, because the addition of easement curve at the ends will change the location of the curve with relation to its tangents.
10. Factors such as the tendency for drivers to shy away from the pavement edge, the increased effective transverse vehicle width because the front and rear wheel don't track, the added width because of the slanted position of the front of the vehicle to the roadway centerline.

**II.**

1. advisable 2. assumed 3. provide for 4. provided 5. labeled 6. involve 7. attain 8. subject 9. hesitate 10. end to end 11. interpose 12. in terms of 13. free, free 14. allowing for 15. taken effect 16. making provision for 17. shying 18. preferable 19. exceed 20. proportional 21. consists 22. with relation to

**III.**

1. beginning of curve 曲线起点
2. circular curve to spiral 圆缓点
3. end of curve 曲线终点
4. point of curve 曲线起点
5. point of tangent 曲线终点
6. spiral to circular curve 缓圆点
7. spiral to tangent 缓直点
8. tangent to spiral 直缓点

**IV.**

土木工程项目除了需要进行地表测量外,还常常需要进行地质勘测。地质勘测包括确定施工现场地表下面的土壤和岩石的成分。土壤的性质,基岩的深度,以及有无断层和地下河流,都是一些地下因素,这些因素可帮助土木工程师确定构筑物基础的类型及大小,或者所能承受的构筑物的重量。在某些地区,这些因素可能是决定性的。例如,墨西哥城就建在近地表层无基岩的湖床上,而且还是位于一个地震区内。因此,建筑物的高度和重量就必须经过仔细的计算,以使其不超过这个地区所能承受的极限。

## Text B

**I.**

1.T 2.F 3.T 4.T 5.F 6.F 7.T 8.T 9.T 10.F

# Lesson 4

## Text A

**I.**

1. It's careful analyses of the volume, character and speed of traffic and of the characteristics of motor vehicles and their operators.

2. Because originally 15ft was enough for horse-drawn vehicles, but today, with the increase in motor-vehicles traffic and vehicle speeds, 24 ft is necessary for freeways and rural highways carrying high traffic volumes.
3. The shoulder is that portion of the roadway between the outer edge of the traffic lane and the inside edge of the ditch, gutter, curb, or slope. Divided highways may also have an inside shoulder between the inside lane and the median. The function of the shoulder is to provide a place for vehicles to park for different purposes so as to increase roadway capacity and decrease accident hazards.
4. It's the top layer of the travelway and shoulders. It is used to provide materials for maintenance blading and to protect the underlying materials from traffic.
5. For high-type pavements, the cross slope is often 1/8 in. per foot to 1/4 in. per foot. For cheaper pavements, it is greater. On paved shoulders, it may range from 3/8 in. to 1/2 in. per foot. For gravel and turf, the cross slope is even greater to effect satisfactory drainage.
6. Side slopes have been flattened in recent years to provide safer operation and less maintenance.
7. The steep side slope on fills and on gutter ditches may cause serious accidents, for if one wheel of a vehicle goes over the edge, the driver will lose control and overturn may result. With the flat slope, however, the car can often redirected back into the road or continue safely down the slope, and accidents are less likely to happen. Also, the steep slope erodes badly, thus creating serious maintenance problems, while the flat slope has less problems of this kind. Furthermore, the erosion of the steep slope is hard to control because it is difficult to grow plants or grasses on it. Besides, the steep slope usually looks ugly, far less pleasant than the flat slope.
8. The AASHO now demands flat slopes, especially on the roadway side of gutter ditches and at the top of the fill slopes. According to the standards for the Interstate System, it recommends that the side slope be just 4∶1 and never steeper than 2∶1, except in solid rock or other special soils.

**II.**

| | | | |
|---|---|---|---|
| 1. 横断面 | 2. 行车道 | 3. 高速公路车道 | 4. 路肩养护 |
| 5. 道路运行能力(量) | 6. 路中护栏 | 7. 高级路面 | 8. 截水沟 |
| 9. 散水沟 | 10. 填土 | 11. 填方边坡 | 12. 后坡,内坡 |

**III.**

1. offset 2. typical 3. originally 4. parking 5. oncoming 6. involved 7. except 8. regard 9. depends 10. ranging 11. place 12. ample

**IV.**

一般说来,路面(和路基)可分为两大类:柔性路面和刚性路面。作为美国普遍使用的术语,"刚性路面"指的是由普通水泥混凝土制作的路面磨耗层。人们认为由水泥做成的路面具有很大的抗弯强度,这种抗弯强度使之能用作梁架,并能跨越下面路基上发生的凹凸不平,因此称为"刚性"。同样,支撑砖砌或块体层的混凝土基座也可以说成是"刚性的"。

**V.**

Basically, road-building has improved in only two ways in the twentieth century. The first improvement involves the use of concrete for the wearing surface. The other is traffic engineering, the design of highways for high-speed, heavy-volume traffic, highways that are economical to build and safe for vehicles and their passengers. Traffic engineering has produced the modern express highways, or freeway, that has only limited access and maximum safety controls. The augular intersections common on older roads have been eliminated in favor of cloverleaf interchanges or others with even more complicated designs. Modern freeways usually have special lanes where traffic can either slow down before exiting or speed up on entering. Extreme curves or steep slopes are minimized so that the traffic can continue to move without slowing down. Since monotony has proved to be safety hazard, traffic engineering even includes the landscaping of the borders of the road.

When construction on a new highway begins, huge earthmoving machines called bulldozers level the ground along the designated route. The amount of earth to be moved, both in leveling and filling, has been previously calculated. Wherever possible, the amount in a cut where earth is being removed should be equal to the amount needed for a nearby fill. Moving earth from a distant point is extremely expensive, and economy is a critical aspect of an engineer's work.

After the earth had been moved and shaped according to the design of the road, other machines prepare the footing. The most important of these is probably a vibrating roller, which compacts the earth until it can bear the weight of the base course and wearing surface that will rest on it. In many cases, however, the soils must be stabilized by mixing some other material with it. This may be bitumen or a grout or concrete of some other substance. The new and complex science of soil mechanics classifies soils and relates those classifications to their load-bearing capacity in a number of different ways.

The base course, which is made of either crushed stone or layer of thinly-mixed concrete, comes next; the wearing surface, which may be a layer of asphalt or a series of reinforced concrete slabs, is then laid. Concrete surface must be laid in segments separated by joins to allow for expansion and contraction under differing weather conditions. One method of laying a reinforced concrete wearing surface is to put down the steel roads, usually in the form of a grill or mesh, after a certain proportion of the concrete has been poured. The top level must be poured within twenty minutes of the pouring of the bottom level to assure proper boding. Another method is to pour the entire thickness of concrete and then force the steel mesh down into it to a predetermined level.

## Text B

**I.**

1. T 2. T 3. T 4. F 5. F 6. T 7. T 8. F 9. T 10. F 11. T 12. F

# Lesson 5

## Text A

**I.**

1. It is cement used for concrete that resembles Portland stone in color. It's made from combinations of limestone, marl, or other calcareous materials and clay, shale or similar argillaceous

substances. These substances are first crushed and pulverized, then mixed in carefully determined proportions and burned to a clinker at about 2,800°F. Finally, the cooled clinker and a small amount of gypsum to control the rate of setting are intimately ground until almost all the individual particles are much finer than the No. 200 mesh sieve. When the finished product is got, it is often packaged in paper sacks holding 94 lb, representing a cubic foot loose measure.

2. There are five types. Type I or IA is used for general concrete construction when the special properties of the other four types are not required; Type II or IIA, for general concrete construction exposed to moderate sulfate action, or where moderate heat of hydration is required; Type III or III A, for high early strength; Type IV, for low heat of hydration; Type V, for high sulfate resistance.
3. They are shown in the specifications of various transportation agencies by reference to those prescribed by the AASHTO.
4. Each cement mill operates a complete testing laboratory, where samples of cements must pass a number of chemical and physical tests to see that they meet the specifications prescribed by the AASHTO in all respects.
5. Their aim is to determine whether the various strength-giving compounds appear in proper quantity and whether there are excessive amounts of certain undesirable substances.
6. They include tests for fineness, soundness, time of set, air content, and compressive strengths of mortars made with Ottawa sand.
7. Because they came into experimental use as recently as in 1970.
8. Yes, it grew fast. By 1976, about 15 million yards of geoTextiles were installed, and in 1980, the use of them was estimated to be 75 million years. In Europe, fabric use is now more than double that in the U.S. This rapid growth has brought a large number of manufacturers and a variety of products into the market. In the U.S. there are over two dozen sources, each of which has several products of different characteristics, and new lines are being constantly added. This makes it quite hard for the engineer to select the best product for any given use.
9. They serve a number of functions, such as filter, drainage, separation, reinforcement, armor, etc. to reinforce soil, or pavement and to provide drainage and erosion control for both highways and railroads.
10. They operate in combination, though one would normally predominate. For example, while a fabric put between the subgrade and the base course is to prevent mixing, it might also serve to drain water away from the subgrade, dissipate excess pore water pressures, and provide reinforcement to reduce tensile stresses in the bottom of the base course.

**II.**

1. relation of one thing to another in quantity, size, etc.
2. put, take, send in a ship
3. business, or place of business, of an agent
4. order the use of; lay down the course of action to be followed
5. one of the number taken to show what the rest is like
6. carry on/out

7. health, good condition, reliability
8. component part
9. of, used for, or based on, experiment
10. able to be used, that may be obtained

**III.**

1. tricalcium silicate 硅酸三钙
2. dicalcium silicate 硅酸二钙
3. tricalcium aluminate 铝酸三钙
4. tetrecalcium alumino ferrite 铁铝酸四钙
5. yard 码
6. inch 英寸
7. foot 英尺
8. degree of Fahrenheit 华氏度
9. type II air entraining 二号加气型水泥
10. number 200 200号

**IV.**

1. compressive strength test
2. drainage facilities
3. geoTextiles reinforcement
4. strength-giving compounds
5. well-equipped laboratory
6. tractive resistance
7. rate of economic growth
8. setting point
9. principal constituents
10. erosion control

**V.**

| | | | |
|---|---|---|---|
| 1. application | 2. combination | 3. variety | 4. exposure |
| 5. estimated | 6. frequency | 7. determined | 8. reinforced |
| 9. available | 10. specifically | 11. equipped | 12. prescriptive |
| 13. burning | 14. chemical | 15. manufacture | |

## Text B

**I.**

1. It refers to substances containing bitumen.
2. It's hydrocarbon material, gaseous, liquid, semisolid, or solid, all soluble in carbon disulfide.
3. only those hydrocarbon materials, both natural and man-made, which are cementitious in character, either intrinsically or derivatively.
4. You can get asphalts either from nature or from the refining of petroleum.
5. It is used directly in paving, and it must be used hot, because it has a normal penetration between 40 and 300.
6. Native asphalt is also called natural asphalt. It occurs in nature. It may be of the lake, rock, or vein variety, and may be essentially pure bitumen or contain a large amount of mineral matter. It may be either hard or soft to a certain extent.
7. It's manufactured. It is got from the refining of petroleum.
8. In the case of the former, the solvent is naphtha and dissolved asphalt is relatively hard while in the case of the latter, the solvent is kerosene and the dissolved asphalt is relatively soft.
9. in which asphalt is the continuous phase with water dispersed in it, liquid asphaltic materials.
10. Asphalt concrete is plant mix of closely graded mineral aggregate and asphalt, designed and controlled to produce a mixture of high quality with good stability and durability. It may be produced as base, binder, or surface courses.

# Lesson 6

## Text A

**I.**

1. Concrete is a stone-like 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.
2. Additional water, over and above that needed for the chemical reaction, is necessary to give the mixture the workability that enables it to fill the forms prior to hardening.
3. Concretes in a wide range of strength properties can be obtained by appropriate adjustment of the proportions of the constituent materials.
4. Special cements, aggregates and curing methods can permit a wider variety of properties to be obtained.
5. The 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.
6. Curing is the process of controlling 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.
7. 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.
8. There are many factors. The facility is one of them. Concrete can be deposited and made to fill forms or molds of almost any practical shape with the facility.
9. High fire and weather resistance are its advantages. Most of its constituent materials, with the possible exception of cement, are usually available at low cost locally or at small distances from the construction site. In addition, its compressive strength is high, which makes it suitable for members primarily subject to compression, such as columns and arches.
10. Yes. Plain concrete is a relatively brittle material. Its tensile strength is small compared with its compressive strength. Hence it is used only for footings and concrete slabs laid on the ground, and for massive structures such as retaining walls.

**II.**

1. bulk 2. deposit 3. pronounced 4. proportion 5. dimension 6. compression 7. substantial 8. brittle 9. constituent 10. properties

**III.**

1. fine and coarse aggregate
2. high-early-strength cement
3. steam curing
4. tensile strength
5. concrete slab
6. compression (compressive) strength

7. concrete aggregate　　8. reinforced concrete slab

**IV.**

1. He earns a large amount over and above his salary.
2. Once the cargo is unloaded, it will be subject to the usual customs procedures.
3. The drawings of young children usually lack proportion; they make arms and legs look like sticks.
4. I suppose that each one of us is, to a substantial degree, a prisoner of our experience.
5. Cement and water interact chemically to bind the aggregate particles into a solid mass.

**V.**

当水泥、集料(砂、砂砾、碎石)和水以适量的比例混合并硬化,便得到像石头一样的块体、这就是混凝土。混凝土稠浆中的水和水泥发生化学反应(水合作用),稠浆硬化后使集料凝固。在混凝土干燥前,只要温度适宜,且水泥未水化完,水合作用就会继续下去。为了加快水化作用,新浇注的混凝土应保持湿润状态并保持一定的温度,直到混凝土达到设计要求。

## Text B

**I.**

1. In the second half of the nineteenth century
2. Usually round steel rods with appropriate surface deformations to provide interlocking.
3. It combines many of the advantages of concrete and steel: 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.
4. The stress in the lowest-grade reinforcing steel under the normal working loads is of the order of 140 MPa. Taking the modulus of elasticity of steel as 200 GPa, this amounts to an elastic strain of $7 \times 10^{-4}$, which is more than the ultimate tensile strain of concrete. Cracks are thus produced in the concrete by the mere process of the reinforcing steel being stressed under the normal working loads.
5. When the cracks are kept very small and are bridged by tension steel, they have no adverse effect on the safety or durability of the structure.
6. It depends on the width of the cracks being kept below a permissible minimum, because if the cracks are kept very small and are bridged by tension steel they have no adverse effect on the safety or durability of the structure.
7. The safety of reinforced concrete structure has become a more serious problem in recent years because the use of higher steel stresses also increases the strain of the concrete.
8. Because cracks would not only be unsightly but would expose the steel bars to corrosion by moisture and other chemical action.

# Lesson 7

## Text A

**I.**

1. An interchange is a grade separation in which vehicles moving in one direction of flow may trans-