第 1 章

绪论

Introduction

教学目标：

1. 了解各种建筑结构的材料和形式，熟悉建筑结构和混凝土结构的概念和分类；

2. 理解配筋的作用和要求，理解钢筋和混凝土共同工作的原因，了解混凝土结构的主要优点和缺点，了解混凝土结构的应用和发展概况；

3. 明确课程学习目标，了解课程学习内容，熟悉课程学习要求，了解课程学习中应注意的主要问题。

导读：

建筑结构是指组成工业与民用房屋建筑包括基础在内的承重骨架体系，为房屋建筑结构的简称。建筑结构设计是在满足安全、适用、耐久、经济和施工可行的要求下，按有关设计标准的规定对建筑结构进行总体布置、技术与经济分析、计算、构造和制图工作，并寻求优化的全过程。

作用是指能够引起结构产生内力和变形的各种因素，如荷载、地震、温度变化以及基础沉降等因素。楼盖是在房屋楼层间用以承受各种楼面作用的楼板、次梁和主梁等所组成的构件总称。板是建筑结构中直接承受楼面荷载的构件，具有较大平面尺寸，但厚度却相对较小，属于受弯构件，通过板将荷载传递到梁或墙或柱上。梁一般指承受垂直于其纵轴方向荷载的线型构件，属于受弯构件，是板与柱之间的支撑构件，承受板传来的荷载并传递到柱上。梁包括主梁和次梁，主梁是将楼盖荷载传递到柱、墙上的梁，次梁是将楼面荷载传递到主梁上的梁。柱和墙都是建筑结构中承受轴向压力的承重构件，柱是主要承受平行于其纵轴方向荷载的线型构件，截面尺寸小于高度；墙是主要承受平行于墙体方向荷载的竖向构件，并将荷载传到基础上；柱和墙都属于受压构件，有时也承受弯矩和剪力。基础是地面以下部分的结构构件，将柱和墙等传来的上部结构荷载传递给地基。

按照所用材料不同，建筑结构分为混凝土结构、砌体结构、钢结构和木结构。

混凝土是由胶凝材料（水泥或其他胶结料）、粗细骨料和水等拌和而成的先可塑后硬化的结构材料，需要时可另加掺合料或外加剂。混凝土产生于古罗马时期，现代混凝土的广泛应用开始于 19 世纪中期。混凝土结构是以混凝土为主要建筑材料的结构，主要包括素混凝土结构、钢筋混凝土结构和预应力混凝土结构等。随着生产的发展、理论研究以及施工技术的改进，混凝土结构逐步提升及完善，得到了迅速发展。

砌体结构是由块体(如砖、石或砌块)与砂浆或其他胶结料砌筑而成的结构,大量用于居住建筑和多层民用房屋(如办公楼、教学楼、商店、旅馆等)中,其中以砖砌体的应用最为广泛。砖、石、砂等材料具有就地取材、成本低等优点,结构的耐久性和耐腐蚀性也很好;缺点是材料强度较低、结构自重大、施工砌筑速度慢、现场作业量大等。

钢结构是以钢材为主组成的结构,钢材是结构用的型钢、钢板、钢管、带钢或薄壁型钢以及钢筋、钢丝和钢绞线等的总称。钢结构主要用于大跨度的建筑屋盖(如体育馆、剧院等)、吊车吨位很大或跨度很大的工业厂房骨架和吊车梁以及超高层建筑的房屋骨架等。钢结构的材料质量均匀、强度高,构件截面小、重量轻,可焊性好,制造工艺比较简单,便于工业化施工;缺点是钢材易锈蚀,耐火性较差,价格较贵。

木结构是以木材为主制作的结构,由于受自然条件的限制,我国木材相当缺乏,仅在山区、林区和农村地区使用。

按照组成建筑主体结构的受力体系的不同,建筑结构可分为框架结构、剪力墙结构、框架-剪力墙结构、筒体结构、混合结构、大跨结构(排架结构、网架结构、悬索结构、壳体结构、膜结构)等。高层建筑的混凝土结构可采用框架、剪力墙、框架-剪力墙和筒体等结构体系。框架结构是由梁和柱以刚接或铰接形式连接成承重体系的房屋建筑结构。剪力墙结构是指纵横向的主要承重结构用钢筋混凝土墙板来代替框架结构中的柱,形成一种有效抵抗水平作用的结构体系,又能起到对空间的分割作用,其墙身平面内的抗侧移刚度很大,抵抗变形的能力强,建筑物上大部分水平作用(风荷载和水平地震力)或水平剪力被分配到剪力墙上,这也是剪力墙名称的由来。框架-剪力墙结构也称框剪结构,是在框架结构中的适当部位布置一定数量的钢筋混凝土剪力墙,能构成灵活自由的使用空间,满足不同建筑功能的要求,足够的剪力墙有相当大的侧向刚度,承担大部分水平荷载,框架则主要承担竖向荷载。筒体结构是由竖向悬臂的筒体组成能承受竖向、水平作用的高层建筑结构,筒体分剪力墙围成的薄壁筒和由密柱框架围成的框筒等。框架筒体结构是由中央薄壁筒与外围的一般框架组成的高层建筑结构。筒中筒结构是由若干并列筒体组成的高层建筑结构。

任务 1-1:观察并判断学校教学楼的建筑结构类型。

Task 1-1: Observe and judge the building structure type of the school teaching building.

核心词汇:

混凝土结构	concrete structure	木结构	wood structure
柱	column	纤维混凝土	fiber concrete
素混凝土结构	plain concrete structure	钢管混凝土结构	concrete-filled steel tube structure
共同工作	work together		
钢筋混凝土结构	reinforced concrete structure	智能混凝土	intelligent concrete
温度线膨胀系数	thermal linear expansion coefficient	钢筋	reinforcement
		土木工程	civil engineering
预应力混凝土结构	prestressed concrete structure	梁	beam
耐火性	fire resistance	建筑工程	architectural engineering
砌体结构	masonry structure	板	slab
轻质混凝土	light-weight concrete	设计规范	design code
钢结构	steel structure	基础	foundation
高强高性能混凝土	high strength and high performance concrete	高层建筑	high-rise building
		图集	atlas

1.1　混凝土结构的概念和分类

Concept and classification of concrete structures

任务 1-2：判断图 1-1 中的建筑各属于哪种建筑结构。

Task 1-2：Determine which building structure the buildings in Fig. 1-1 belong to.

(a)　(b)　(c)

图 1-1　不同结构材料的建筑

(a) 北京某施工中的建筑；(b) 北京某正在浇筑混凝土的建筑；(c) 清华大学图书馆

Figure 1-1　Buildings with different structural materials

(a) A building under construction in Beijing; (b) A building undergoing concrete pouring in Beijing; (c) Tsinghua University library

混凝土结构是指以混凝土为主要材料，并根据需要在其中合理配置钢筋、型钢、钢管及纤维，作为主要承重材料的结构，主要有素混凝土结构、钢筋混凝土结构、预应力混凝土结构、钢骨混凝土结构、钢管混凝土结构、纤维混凝土结构等，其中应用最广泛的是钢筋混凝土结构。

Concrete structure refers to the structure with concrete as the main material according to the need of the rational allocation of steel bar, section steel, steel tube and fiber as the main load-bearing material structure. There are mainly plain concrete structures, reinforced concrete structures, prestressed concrete structures, steel-reinforced concrete structures, concrete-filled steel tube structures, fiber-reinforced concrete structures, etc., among which reinforced concrete structures are the most widely used.

素混凝土结构是指无筋或不配置受力钢筋的混凝土结构，其承载力低，性质脆，使用很有限，常用于路面、受压的基础、柱墩和一些非承重结构。钢筋混凝土结构指配有受力钢筋、钢筋网或钢筋骨架的混凝土结构，是目前应用最广泛的结构形式。承重的主要构件是用钢筋混凝土建造的，钢筋承受拉力或压力，混凝土承受压力，具有坚固、耐久、防火性能好、比钢结构节省钢材和成本低等优点。

Plain concrete structure refers to the concrete structure without reinforcement or stressed reinforcement. It has low bearing capacity, brittle nature and limited use. It is often used for pavements, pressed foundations, piers and some non-load-bearing structures. Reinforced concrete structure refers to the concrete structure equipped with stressed steel bars, steel nets or steel skeletons, and is currently the most widely used structural form. The main load-bearing members are constructed of reinforced concrete.

The steel bars bear tensile force or compressive force, and the concrete bears compression. It has the advantages of firmness, durability, good fire resistance, saving steel materials and lower cost than steel structures.

预应力混凝土结构指配置受力的预应力钢筋,通过张拉预应力钢筋或其他方法建立预加应力的混凝土结构。钢骨混凝土结构是配置型钢或用钢板焊成钢骨架的混凝土结构,承载力大,延性好,刚度大,抗震性能好,但耗钢量较多,可在高层、大跨或抗震要求较高的工程中采用。钢管混凝土结构是把混凝土灌入钢管中并捣实以加大钢管混凝土的强度和刚度,主要用于以轴心受压、偏心受压构件为主的高层建筑结构。钢管混凝土的构件连接较复杂,维护费用大。纤维混凝土结构是在混凝土中掺入钢纤维、合成纤维等纤维材料构成的结构,具有抗拉强度高、抗裂性能好、抗渗性能强、抗磨损和抗冲击等优点。纤维混凝土使混凝土的性能获得飞跃发展,混凝土的拉压强度比从 1/10 提高到 1/2,并且具有早期强度高和收缩、徐变小的特性。纤维混凝土主要应用于建筑楼面、高速公路路面、机场跑道、停车场以及储液池等。

Prestressed concrete structure refers to the concrete structure configuring of load bearing prestressed steel bars, and the prestressing is established by tensioning the prestressed steel bars or other methods. The steel-reinforced concrete structure is the concrete structure with steel frame welded by steel or steel plate. It has large bearing capacity, good ductility, high rigidity and good seismic performance, but it consumes more steel. It can be used in high-rise, large-span or projects with high seismic requirements. The concrete-filled steel tube structure is to pour concrete into the steel tube and to increase the strength and rigidity of the concrete-filled steel tube. It is mainly used for high-rise building structures with axial compression and eccentric compression members. The splice of concrete-filled steel tube members is complex and the maintenance cost is high. Fiber-reinforced concrete structure is the structure composed of concrete mixed with fiber materials such as steel fiber and synthetic fiber. It has the advantages of high tensile strength, good crack resistance, strong impermeability, abrasion resistance and impact resistance. Fiber concrete has made a leap development in the properties of concrete. The tensile-compression strength ratio of concrete has been increased from 1/10 to 1/2, and it has the characteristics of high early strength, small shrinkage and small creep. Fiber concrete is mainly used in building floors, highway pavements, airport runways, car parks and liquid storage tanks etc.


拓展知识 1-1

1.2 混凝土结构的特点
Characteristics of concrete structures

1.2.1 配筋的作用与要求
Role and requirements of reinforcement

混凝土材料最显著的特点是抗压强度高,抗拉强度低。普通混凝土的抗拉强度一般是

其抗压强度的 1/17～1/8，高强混凝土的抗拉强度一般是其抗压强度的 1/24～1/20。大部分钢筋混凝土结构构件要承受弯矩等作用，在截面上产生拉应力，如果拉应力全部由素混凝土承担，当截面受拉边缘的拉应力达到混凝土的抗拉强度时，构件就会突然发生脆性断裂破坏，破坏前无明显预兆，属于脆性破坏，构件的承载能力将会非常低，在很小的弯矩作用下构件就会破坏。因此，不配置钢筋的素混凝土无法应用于截面具有拉应力的结构构件中。

The most notable features of concrete materials are high compressive strength and low tensile strength. The tensile strength of ordinary concrete is generally 1/17-1/8 of the compressive strength, and the tensile strength of high-strength concrete is generally 1/24-1/20 of the compressive strength. Most of the reinforced concrete structural members have to bear the action of bending moment, etc., and tensile stress is generated at the section. If the tensile stress is all borne by plain concrete, when the tensile stress on the tension side of the section reaches the tensile strength of the concrete, the member will undergo suddenly brittle failure. There is no obvious advance warning before failure occurs. It belongs to brittle failure. The bearing capacity of the member will be very small. The member will be damaged under the action of a small bending moment. Therefore, plain concrete without reinforcement cannot be applied to structural members with tensile stress on the cross section.

如果在构件受拉区边缘设置钢筋，当受拉区混凝土开裂后，混凝土上的拉应力可以转移到钢筋上，钢筋可以继续承受受拉区的拉应力。当荷载继续增加，钢筋达到屈服阶段，虽然荷载不能继续增加，但构件可以继续变形，具有足够的变形能力。受压区的混凝土受到的压应力和变形继续增加，当受压区混凝土边缘压应力达到混凝土轴心抗压强度时，混凝土被压碎而导致构件破坏。与素混凝土梁相比，混凝土的抗压强度和钢筋的抗拉强度都得到充分利用，钢筋混凝土梁的破坏荷载和承载能力大大提高，破坏前构件有明显的裂缝和变形，有显著的预兆，属于延性破坏，在实际工程中可以最大限度地减少财产损失和人员伤亡。

If steel bars are installed at the edge of the tension zone of the member, after the cracking of the concrete in the tension zone, the tensile stress on the concrete can be transferred to the steel bars, and the steel bars can continue to bear the tensile stress in the tension area. When the load continues to increase and the steel bars reach the yielding stage, although the load cannot continue to increase, the member can continue to deform and has sufficient deflection capability. The compressive stress and deformation of the concrete in the compression zone continue to increase. When the edge compressive stress of the concrete in the compression zone reaches the axial compressive strength of the concrete, the concrete fails by crushing and the member fails. Compared with plain concrete beams, both the compressive strength of concrete and the tensile strength of steel bars have been fully utilized. The failure load and bearing capacity of reinforced concrete beams have been greatly improved. There are obvious cracks and deformations in the members before failure occurs, which has significant advance warning. It belongs to ductile failure, which can minimize property losses and casualties in actual projects.

除了在受弯构件的受拉区配置钢筋，在结构构件中可能出现拉应力的位置都应该配置

钢筋,如在梁中配置箍筋提高构件的抗剪承载力,配置钢筋网来防止出现温度裂缝或收缩裂缝等。还可以在构件的受压区配置受压钢筋,提高构件的承载力和延性,如采用双筋截面和在柱受压区配置钢筋等。

In addition to the arrangement of reinforcement in the tension zone of flexural members, steel bars should be arranged where tensile stress may occur in structural members. For example, stirrups are arranged in beams to increase the shear capacity of the members, and steel meshes are arranged to prevent temperature cracks or shrinkage cracks, etc. The compression reinforcement can also be configured in the compression zone of the member to improve the bearing capacity and ductility of the member, such as the use of doubly reinforced section and the configuration of steel bars in the compression zone of the column, etc.

因此,钢筋混凝土结构构件充分利用混凝土和钢材两种材料的力学特点,在荷载作用下,混凝土和钢筋共同作用,发挥各自的优点。

Therefore, reinforced concrete structural members make full use of the mechanical characteristics of the two materials of concrete and steel. Under the action of load, concrete and steel bars work together to play their respective advantages.

1.2.2 钢筋和混凝土共同工作的原因
Reasons why steel and concrete work together

在混凝土中加筋的主要目的是抵抗结构构件中产生的拉应力,为什么一般把钢筋作为加筋材料?

The main purpose of reinforcement in concrete is to resist the tensile stress generated in structural members. Why are steel bars usually used as reinforcement materials?

(1) 钢筋和混凝土之间存在很好的黏结力。混凝土结硬后,能与钢筋牢固地黏结在一起,相互传递内力。在荷载作用下,可以保证两者协调变形、共同受力、整体工作,两者的接触面不会出现滑移、开裂等现象,这是钢筋和混凝土两种性质不同的材料共同工作的基础。

(1) There is a good bond between steel and concrete. After the concrete is hardened, it can be firmly bonded with the steel and transfer internal forces to each other. Under the action of load, it can ensure that the coordinated deformation, joint force and overall work of the two. The contact surface of the two will not appear slip or crack, etc. This is the basis for the joint work of reinforcement and concrete with different properties.

(2) 钢筋与混凝土的温度线膨胀系数接近。钢筋的温度线膨胀系数为 $1.2\times10^{-5}/℃$,混凝土的温度线膨胀系数为$(1.0\sim1.5)\times10^{-5}/℃$,温度变化时,钢筋与混凝土的黏结力不会因温度变化引起两者较大的相对变形而导致破坏。

(2) The thermal linear expansion coefficient of reinforcement and concrete is close. The thermal linear expansion coefficient of reinforcement is $1.2\times10^{-5}/℃$, and the thermal linear expansion coefficient of concrete is $(1.0\text{-}1.5)\times10^{-5}/℃$. When the temperature changes, the bond force between steel and concrete will not be damaged due to the large relative deformation of reinforcement and concrete caused by temperature

changes.

(3) 钢筋外的混凝土保护层包裹住钢筋，可以防止钢筋锈蚀，保证结构的耐久性；能提高钢筋的耐火性能，在遭受火灾时不致因钢筋很快软化而导致结构整体破坏。

(3) The concrete protective layer outside reinforcement wraps reinforcement to prevent steel corrosion and ensure the durability of the structure; it can improve the fire resistance of reinforcement, and will not cause overall collapse of structure due to the rapid softening of reinforcement in the event of a fire.

另外，钢筋的弹性模量是混凝土的 6～10 倍，在相同变形下钢筋能承担更大的应力，有利于钢筋强度的充分利用。钢筋在生产、施工、经济方面有比较显著的优势。

In addition, the elastic modulus of reinforcement is 6-10 times that of concrete, and reinforcement can bear greater stress under the same deformation, which is conducive to the full utilization of the reinforcement strength. The reinforcement has obvious advantages in production, construction and economy.

1.2.3　钢筋混凝土结构的特点
Characteristics of reinforced concrete structures

1. 钢筋混凝土结构的主要优点
Main advantages of reinforced concrete structures

钢筋混凝土结构在土木工程的各个领域得到广泛的应用，主要是因为其具有以下优点：

Reinforced concrete structures are widely used in various fields of civil engineering, mainly because of the following advantages:

(1) 取材容易。混凝土所用砂、石等原材料来源广泛，易于就地取材，造价相对低廉，还可以利用建筑垃圾、工业固体废料如矿渣、粉煤灰等来制作人工骨料或胶凝材料，改善混凝土的性能，制造再生骨料混凝土。既可以废物利用，变废为宝，又有利于环境保护，实现建筑业的可持续发展。钢材的生产、加工比较简单，是用途广泛、价格相对低廉的材料。

(1) Easy to obtain materials. The raw materials such as sand and stone used in concrete have a wide range of sources, are easy to use local materials, and are relatively inexpensive. Construction waste, industrial solid wastes such as slag, fly ash, etc. can also be used to make artificial aggregates or cementitious materials to improve the performance of concrete and manufacture recycled aggregate concrete. It can not only use waste, turn waste into treasure, but also be beneficial to environmental protection and realize the sustainable development of the construction industry. The production and processing of steel are relatively simple, and it is a material with a wide range of uses and relatively low prices.

(2) 合理用材。充分发挥钢筋和混凝土材料的力学性能，发挥各自的优势，两种材料的结合不需要特别的措施，解决了钢材容易失稳等方面的问题，结构具有较高的承载力，和钢结构相比可以降低造价。

(2) Reasonable use of materials. Give full play to the mechanical properties and respective advantages of reinforcement and concrete materials. The combination of two

materials requires no special measures and solves the problem of easy instability of steel. The structure has higher bearing capacity, which can reduce the cost compared with steel structure.

(3) 可模性好。混凝土拌合物具有流动性、可塑性,可以利用模板将混凝土浇筑成各种形状和尺寸的构件或结构,以满足工程需要。

(3) Good mouldability. The concrete mixture has fluidity and plasticity, and concrete can be placed into various shapes and sizes of members or structures through using formwork to meet engineering needs.

(4) 施工优势。对施工场地环境要求比较低,一般情况下,可以在任何需要的地方施工,对环境的破坏相对较小。施工工艺简单、成熟,施工机具和熟练工人容易获得,施工质量比较稳定。

(4) Construction advantages. The environmental requirements of the construction site are relatively low. Under normal circumstances, construction can be carried out wherever needed, and the damage to the environment is relatively small. The construction process is simple and mature, construction equipment and skilled workers are easy to obtain, and the construction quality is relatively stable.

(5) 整体性好。现浇式或现浇整体式混凝土结构整体性好,具有抗震、抵抗振动和爆破冲击波、防辐射等多种用途。混凝土结构的刚度比较大,有利于变形控制。

(5) Good integrity. The cast-in-place or cast-in-place monolithic concrete structure has good integrity and has resistance to earthquake, vibration, blasting shock waves and radiation, etc. The rigidity of concrete structure is relatively large, which is conducive to deformation control.

(6) 耐火性好。受到火灾等高温作用时,因混凝土传热性能比较差,钢筋外有足够厚度的混凝土保护层时不会像钢结构那样很快升温达到屈服强度而丧失承载力,从而提高结构的耐火极限。厚度为 30mm 的混凝土保护层可耐火 2h,比裸露的木结构和钢结构耐火性好。

(6) Good fire resistance. When subjected to high temperatures such as fire, the heat transfer performance of concrete is relatively poor, and there is concrete protective layer of sufficient thickness outside reinforcement, which will not heat up as quickly as steel structure and reach the yield strength, lose the bearing capacity, thereby increase the fire resistance limit of the structure. The concrete protective layer with the thickness of 30mm can resist fire for 2 hours, which is better than bare wood structure and steel structure.

(7) 耐久性好。混凝土本身具有很好的化学稳定性,一般环境下,混凝土本身的性能不会退化,随着时间的增长,混凝土的强度还会有所增长,后期维护费用低。钢筋因混凝土保护层的存在而不易锈蚀。混凝土呈碱性,钢筋包裹在混凝土中,钢筋表面形成一层致密的氧化膜,能避免或延缓钢筋腐蚀,具有良好的耐久性,维修费用很低。

(7) Good durability. The concrete itself has good chemical stability. In general environment, the performance of concrete itself will not be degraded. With the increase of time, the strength of concrete will increase, and the maintenance costs in the later stage

will be low. The reinforcement is not easy to rust due to the existence of the concrete protective layer. The concrete is alkaline, the steel bars are wrapped in the concrete, and a dense oxide film is formed on the surface of reinforcement, which can avoid or delay the corrosion of reinforcement. It has good durability, maintenance costs are very low.

另外，钢筋混凝土结构比钢结构等其他结构形式造价相对便宜，性价比好。经过长时间的发展和工程应用，设计理论比较成熟可靠，结构安全性有保障。

In addition, the costs of reinforced concrete structures are relatively cheaper than steel structures and other structural forms, and the performance price ratio is good. After a long period of development and engineering application, the design theory is relatively mature and reliable, and the structural safety is guaranteed.

2. 钢筋混凝土结构的主要缺点

Main disadvantages of reinforced concrete structures

(1) 自重大。混凝土材料的重度较大，约为 25kN/m^3，比砌体和木材的重度都大，结构构件的截面尺寸比钢结构的大，因此结构的自重大。其自重远远超过相同跨度或高度的钢结构，不利于高层建筑结构、大跨度结构和结构抗震。目前正在大力研究与发展轻质、高强、高性能混凝土及预应力混凝土以减轻自重。

(1) Large self-weight. The weight of concrete material is relatively large, about 25kN/m^3, which is greater than that of masonry and wood. The cross-sectional dimensions of structural members are larger than that of steel structures. Therefore, the self-weight of the structure is far more than that of the steel structure with the same span or height. It is not conducive to high-rise building structures, large-span structures and structural seismic resistance. At present, it is vigorously researching and developing lightweight, high-strength, high-performance concrete and prestressed concrete to reduce its own weight.

(2) 易开裂。混凝土材料的抗拉强度低，容易出现裂缝，普通钢筋混凝土结构在正常使用阶段往往是带裂缝工作的，如果裂缝宽度符合规范要求，就不会影响混凝土结构的正常使用。当裂缝数量较多、宽度较宽时，会给人带来不安全感。在工作条件较差的环境，影响结构的耐久性和适用性，不适用于对防渗、防漏要求较高的结构。对一些不允许出现裂缝或对裂缝宽度有严格控制的结构，采用预应力混凝土结构是解决混凝土开裂的有效途径之一，但要满足这些要求就需要提高工程造价。在混凝土中掺入适量纤维也能够提高混凝土的抗拉强度，增强混凝土的抗裂能力。

(2) Easy to crack. The tensile strength of concrete materials is low and cracks are easy to appear. Ordinary reinforced concrete structures often work with cracks in the normal service stage. If the crack width meets the specification requirements, it will not affect the normal use of concrete structures. When the number of cracks is large and the width is wide, people will feel a sense of insecurity. In an environment with poor working conditions, it affects the durability and applicability of the structure, and is not suitable for structures with high requirements for watertight and leakage. For some structures that do not allow cracks or have strict control of crack width, the use of prestressed concrete

structures is one of the effective ways to solve the cracking of the concrete, but to meet these requirements, it is necessary to increase the project cost. Adding proper amount of fiber into concrete can also improve the tensile strength of concrete and enhance crack resistance of concrete.

(3) 施工复杂。混凝土结构的施工具有工序多、工期长、受季节及天气影响大等缺点。钢筋混凝土结构的建造需要经过支模板、绑钢筋、浇筑、养护、拆模等多道施工工序,工期长,湿作业多,施工质量和进度易受季节、气候等环境条件的影响。混凝土结构损伤修复比较困难,特别是某些隐蔽工程。采用早强混凝土、泵送混凝土、自密实混凝土等高性能混凝土,施工采用大模板、滑模、飞模、爬模等先进模板技术,可以大大提高混凝土工程的施工效率。

(3) The construction is complex. The construction of concrete structures has many shortcomings, such as many procedures, long construction period, and great influence by seasons and weather, etc. The construction of reinforced concrete structures requires multiple construction processes such as supporting formwork, binding steel bars, pouring, curing, and demoulding. The construction period is long and there are many wet operations. The construction quality and progress are easily affected by environmental conditions such as seasons and climate. It is difficult to repair the damage of concrete structure, especially for some concealed projects. The concrete adopts high-performance concrete such as early-strength concrete, pumped concrete, self-compacting concrete, and advanced formwork technologies such as large formwork, sliding formwork, flying formwork and climbing formwork, which can greatly improve the construction efficiency of concrete projects.

(4) 承载能力有限。与钢材相比,混凝土的强度还是比较低的,用作高层建筑的底部结构时,往往需要比较大的构件尺寸,占用比较大的建筑空间。通常采用高强混凝土、钢骨混凝土或钢管混凝土等混合结构来解决这一问题。

(4) Limited carrying capacity. Compared with steel, the strength of concrete is relatively low. When used as the bottom structure of the high-rise building, it often requires relatively large member sizes and occupies relatively large building space. It is usually solved by mixed structures such as high-strength concrete, steel-reinforced concrete or concrete-filled steel tube.

(5) 补强修复困难。混凝土一旦破坏,其修复、加固以及补强比较困难。采用植筋、粘贴钢板、粘贴碳纤维布、外包钢等加固技术,能够较好地对发生损坏的混凝土结构或构件进行修复。

(5) Difficulty in reinforcement and repair. Once the concrete is damaged, it is difficult to repair, strengthen and reinforce it. Reinforcement techniques such as planting steel bars, pasting steel plates, pasting carbon fiber cloth and wrapping steel outside can better repair damaged concrete structures or members.

随着科学技术的不断发展,以上缺点正逐渐被克服。

With the continuous development of science and technology, the above shortcomings are gradually being overcome.