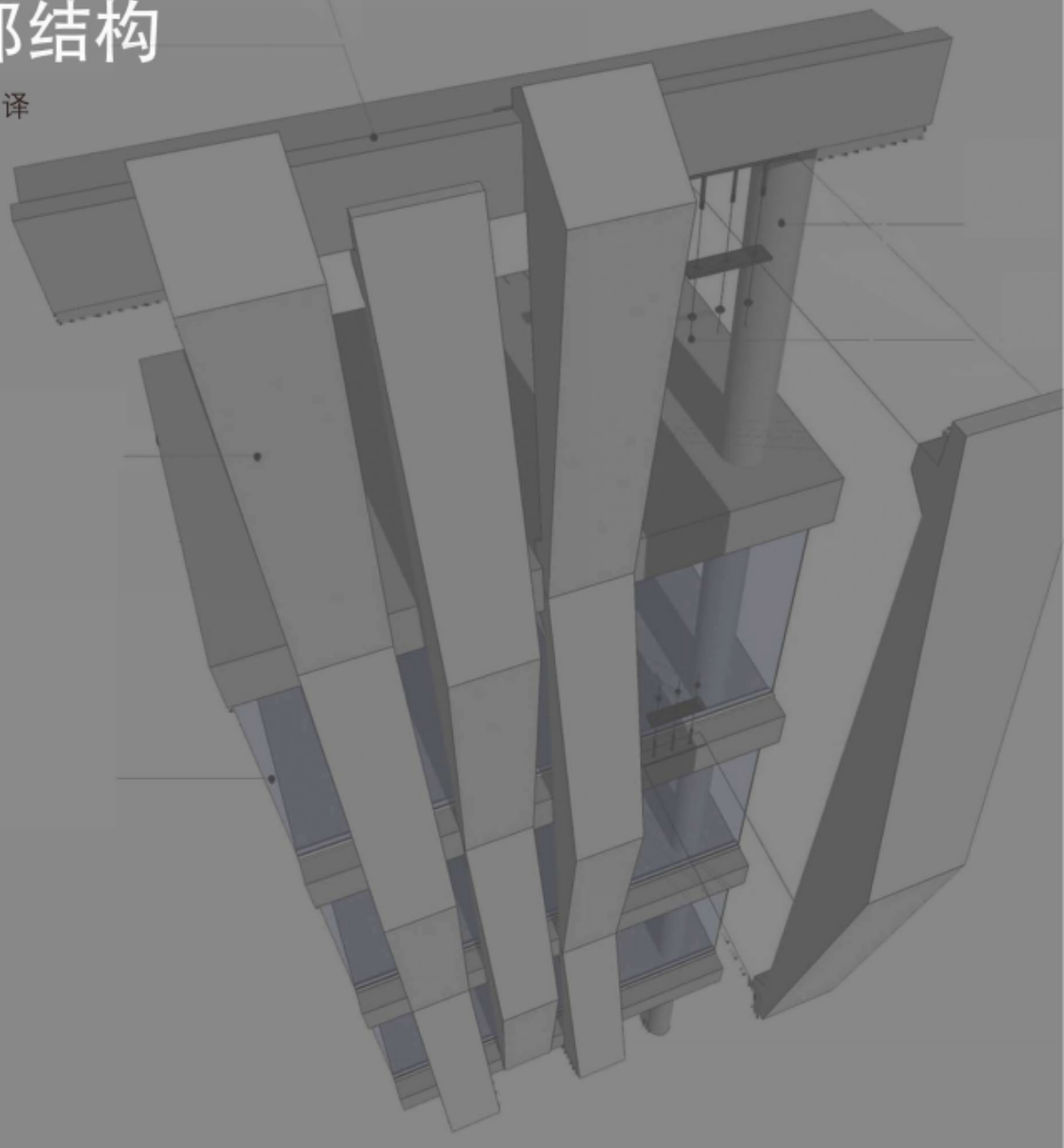
Architectural Material & Detail Structure

建筑材料与细部结构

（西）何塞普·费尔南多 编 常文心 译

Concrete 混凝土



辽宁科学技术出版社

Architectural Material & Detail Structure

建筑材料与细部结构

（西）何塞普·费尔南多 编　常文心 译

Concrete 混凝土

辽宁科学技术出版社

图书在版编目（CIP）数据

建筑材料与细部结构 . 混凝土 / (西) 费尔南多编 ; 常文心译 . -- 沈阳 : 辽宁科学技术出版社 , 2016.3
ISBN 978-7-5381-9494-4

Ⅰ . ①建… Ⅱ . ①费… ②常… Ⅲ . ①混凝土 Ⅳ . ① TU5

中国版本图书馆 CIP 数据核字 (2015) 第 272623 号

出版发行：辽宁科学技术出版社
（地址：沈阳市和平区十一纬路 29 号　邮编：110003）
印 刷 者：利丰雅高印刷（深圳）有限公司
经 销 者：各地新华书店
幅面尺寸：245 mmx290 mm
印　　张：20
插　　页：4
字　　数：200 千字
出版时间：2016 年 3 月第 1 版
印刷时间：2016 年 3 月第 1 次印刷
责任编辑：于峰飞
封面设计：蒋俊敏 吴杨
版式设计：蒋俊敏 吴杨
责任校对：周　文

书号：ISBN 978-7-5381-9494-4
定价：368.00 元

联系电话：024-23284360
邮购热线：024-23284502
http://www.lnkj.com.cn

Preface

前言

CONCRETE, Monolithic vs Fragmentary

Josep Ferrando

混凝土, 整体与碎片

何塞普•费尔南多

Matter & Light

In the essence of the architectural project or the final built work resides an inherent duality: the place and the architect. The place always imposes itself, and architects adapt our method, gaze and, with it, a personal interpretation that will prevail during the process. This duality between the immovable state of reality – the context and the territory –, and our interpretation of it is combined in the project and, finally, is realised in the built work.

The architectural work, as a combination of matter and light. The volume (matter) in as far as the inanimate object: silent and still. And light (indefinite space), like a void defined by matter: alive, moving, dynamic.

In order to reach this symbiosis between matter and light, between the definition of space and the habitable space, the architect works in a place with a context, a place that imposes itself and that cannot be ignored and that must be addressed.

This architectural process is managed through many types of documents. A language is generated by the architect (personal and specific) from the place. It is the origin of a story that, in some cases, will arrive at its ultimate goal: to become spaces can be inhabited by people and can shelter new stories.

If the solid is not defined, there can be no habitable void. Without matter, there is no light, and therefore, no life. Nor architecture. Recognising a place and the process of adapting ourselves to it affords the architect the ability to provide it with life. It gives us the opportunity to bring matter to life through a correct interpretation of light.

Tectonic & Stereotomic

Construction materials owe their qualities to a specific technical procedure: tectonic (carpentry) or stereotomic (stonework, masonry). Therefore, the construction system that addresses the detail must be honest with the requirements of the material.

We can classify the materials into two groups according to the way it relate to each other. We work with aggregated materials (steel, wood, prefabricated ...) and mouldable materials (in situ concrete, cast steel, adobe ...). When it is about shaped or aggregated materials, is the joint's construction detail that defines the expression of the aggregation unit relative to the set. In the case of amorphous or malleable, detail expresses unwillingness to recognise the moment when two materials meet and that is why these are considered stereotomic or monolithic materials. We see in some examples the ability of architecture to generate ambiguity between the construction system used and its final appearance; always through the development of the constructive detail in the design process.

Concrete "in situ" & Precast Concrete

The difference between the reinforced concrete "in situ" and the use of precast concrete is that in the former case an amorphous material is set up in the construction site and in the second, one that is already shaped. One has the advantages of monolithic, while the other allows manipulation. The first takes advantage and accepts the imperfection of the construction site and the second benefits from the precision required by the design process.

In the case of precast concrete construction the weather conditions (temperature or humidity) do not affect its use in construction, but in the transport of its parts.

Precast concrete has many advantages for the architect and the project's execution:

Planning: it allows the architect to face up a

物质与光

建筑或建成设施的本质存在着固有的二元性：场所与建筑师。场所总是自己证明自己，而建筑师则不断适应我们的建筑方法，在建造过程中演绎出个人对建筑的解读。这种存在于不能移动的实体（环境和地域）与我们对其的解读之间的二元性在项目中相互融合，最终体现在建成的作品中。

建筑作品是物质与光的结合体。体块（物质）是静物，沉默静止；光（不确定的空间）则更像是物质所定义的空间，鲜活生动。

为了实现物质与光、空间与居住空间之间的共生，建筑师在置身于场景中的场所内工作，而场所则针对自身产生不可忽视的影响。

建造过程需要通过各种类型的文件进行管理，建筑师会针对场所的特点生成一套设计语言。有时候，故事的开始就决定了它的结局：经过处理的空间会成为人们的居住场所，在那里会衍生出全新的故事。

如果没有实体，就没有可居住的空间。如果没有物质，就没有光，也没有生命，更不用提建筑。认同一个场所并让自身适应它的过程就是建筑师赋予场所生命的过程。通过对光的正确解读，我们获得了把物质变成生命的机会。

构造与切割

建筑材料必须经过特殊的工艺处理才能体现出价值，即构造（主要针对木材）或切割（主要针对石材、砌体）。因此，注重细节的建造系统必须正确应对材料的处理要求。

我们可以根据建筑材料的相互关系将其分为两类：集料型材料（钢材、木材、预制材料）和可塑性材料（现浇混凝土、铸钢、砖坯）。在使用造型或集料型材料时，由节点构造细节来决定集合体的表现力。在使用无定形或可塑型材料时，细节会表现出两种材料的自然相斥，因此，它们又被称为切割材料或单体材料。在一些案例中，建筑的建造系统和最终外观能够通过设计过程中对建造细节的开发实现一种微妙的不确定感。

现浇混凝土与预制混凝土

现浇混凝土与预制混凝土的区别在于：前者是无定形材料，在施工现场进行塑形；后者是已经塑形完毕的预制材料。前者具有整体感，而后者有利于装配处理。前者能因地制宜，适应施工现场的缺陷；后者精密准确，可满足细节设计要求。

在预制混凝土施工中，天气条件（温度或适度）不会影响

project from its inception along with the craftsman-builder, optimising obstacles, reducing costs and avoiding contingencies.

Customisation: it allows customising the finished material textures and more complex mixtures. The use of architectural concrete provides versatility and flexibility in the design, also as regards sizes, shapes, colours, etc.

Time and cost control: it allows talking about prices and closed deadlines since the time of contract signing.

Optimising Performance: it decreases of the execution work's time, guarantees the safety during manufacture and installation, achieves reliability in all the phases of the project and minimises deviations from the project.

Absence of residues: precast concrete work does not provide residue in the construction site nor in its manufacture, since it can be reused as raw material without affecting the characteristics of the finished product.

Continuity & Discontinuity
Monolithic concrete expression "in situ" gives the appearance of a moulded object to the construction, that is, the arising of a work through extracting materials.

A key feature of the precast concrete is its discontinuity. Opposite to reinforced concrete "in situ", a prefabricated building will never be a single piece, and the resolution of its joints will determine the system behaviour.

Mould & Material
Whereas the construction system is based on industrial production, which considerably increases the quality of their physical and chemical characteristics: strength, surface finish, adhesion, corrosion resistance, etc.

It is a material manufactured by moulding and capable, without forgetting the characteristics of the raw material, to adopt any shape and thus to conform the pattern that will be repeated.

The surface finishes that can be achieved with precast concrete can be summarised as follows:
1. Smooth: surface finish of the mould directly.
2. Texturised: finishing of the panels by employing the negative moulds of the textures to be obtained. Choosing reliefs or finishes that prevent the formation of deposits of dirt is recommended.
3. Sand blasting: with this treatment it can be obtained a façade's surface finish on which can be appreciated from a fine sand finish up to a coarse one, depending on the degree of intensity of mechanical treatment, consisting on the sandblasting pressure over the panel's face side.
4. Arid relief: exposed arid finish, ranging from a few tenths of a millimetre to several millimetres, by the employment of a paper or primer that retards the setting of concrete.
5. Acid washing: this is achieved by applying a dilute acid or other products.
6. Polished: with this mechanical treatment panels with a completely smooth appearance can be obtained.

Joint & Monolithic
In the section "Tectonic & Stereotomic" it points to the concept of ambiguity in architecture relative to that the eyes can see. Ambiguity cannot get confused with being dishonest or inconsistent with the construction systems and materials we use. The concept of ambiguity responds to the possibility for an architect to get a result – connected to the concept of the building and the expected atmosphere to be transmitted – through work and development of the constructive detail and the conformation of the materials going beyond its characteristics by definition.

The classical played with the effect of perspective and a single material. Today we have the opportunity, thanks to industrialisation, to refine the details of the union between different materials and pieces.

In the precast concrete exists the problem – or not – of the joints. Far from thinking that initially with it the sense of monolithic is rejected, it should unite their efforts, as we said, the study of the details of joints that generates the union of pieces or patterns. By studying the shadows produced by the textures on a surface we can hide and therefore perceive a single volume or, on the contrary, accentuate and even modify. The possibilities are endless. In this book a few examples of buildings with precast concrete façades that meet any of the abovementioned characteristics are collected.

施工效果，但是会影响混凝土零件的运输。

从建筑师和项目实施的角度来说，预制混凝土具有以下优势：
规划：它能让建筑师与施工人员共同直面设计规划，从而优化障碍、减少成本、避免意外事件。

定制：它能定制饰面材料的纹理和更复杂的混合质地。建筑混凝土的应用让设计更丰富、更灵活，使其在尺寸、造型和色彩上具有多样性。

时间与成本控制：它能控制成本和施工时间，保证合同的执行。

优化性能：它能缩短执行工作的时间，保证制造和安装的安全性，实现项目在各个阶段的可行性，并减少项目的偏差和失误。

无残留物：预制混凝土在施工现场不会留下任何残留物，因为它可以作为原材料被反复使用，不会影响最终成品的特性。

连续性与非连续性
单体混凝土通过"现场浇注"的方式赋予建筑物成型的外观，即通过提取材料来创造作品。

预制混凝土的主要特征在于它的非连续性。与钢筋混凝土的现场浇注相反，预制建筑绝不会是一个单一的体块，它的连接方式将决定整个建筑系统的性能与造型。

模具与材料
建筑系统的基础是工业生产，工业生产的进步大幅提升了材料的物理和化学特性，例如，强度、表面装饰、附着力、抗腐蚀性等。

在保持原材料的特性下，由模具制造出来的材料可以被塑造成各种形状，从而组成可以反复出现的图案。

预制混凝土材料可以实现以下几种表面装饰：
1. 光滑表面：直接通过模具获得。
2. 纹理表面：通过应用带有纹理的阴模获得板材饰面。建议选择不易积灰的浮雕或装饰。
3. 喷砂：喷砂处理能够让建筑立面获得细砂至粗砂的饰面效果，其效果取决于机械加工的强度，即喷砂压力作用于板材的强度。
4. 干纹浮雕：外露的干纹装饰，其宽度在零点几毫米至几毫米之间，通过在表面上使用纸或底漆来延缓混凝土的凝固获得。
5. 酸洗表面：通过应用稀酸或其他产品获得。
6. 抛光表面：通过极细处理板来实现彻底光滑的外观。

连接体与单体
在上文的"构造与切割"一节中，我指出建筑的不确定感与人们鉴赏它的方式有关。不确定感并不是不真实或建造系统与所选材料的不一致。不确定感所对应的是建筑师通过建造细节和材料构造所获得的结果的可能性，它与建筑的设计理念和建筑师所期望表现的氛围有关，超越了可定义的特征。

传统建筑通过透视和单一材料来实现不同的效果。今天，得益于工业化的进步，我们可以进一步改良不同材料与组件之间的组合效果。

预制混凝土存在着连接的问题。单独预制混凝土组件不具备整体感，但是对连接细节的研究能够组合成整体或图案。我们可以通过研究表面纹理的阴影来隐藏连接点，从而获得单一的整体；也可以反其道而为之，突出连接甚至对其进行修饰。设计有无限可能。本书中以混凝土作为主要材料的建筑案例将向读者展示上面提到的各种特征与应用。

Contents 目录

Contents 目录

Overview

Basic Information of Concrete

概述 混凝土简介

Concrete is a composite material composed mainly of water, aggregate and cement. Often, additives and reinforcements are included in the mixture to achieve the desired physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that is easily molded into shape. Over time, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with many uses.

混凝土是一种主要由水、骨料和水泥混合而成的复合材料。通常，混合物种会包含添加剂和强化剂，以实现饰面材料的理想物理性能。这些原料混合起来，形成容易塑形的流体团。随着时间的流逝，水泥形成坚硬的基质，将其他原料胶合起来，形成具有多种用途、经久耐用的石样材料。

1

1. History of Concrete

Concrete additives have been used since 6500BC by the Nabataea traders or Bedouins who occupied and controlled a series of oases and developed a small empire in the regions of southern Syria and northern Jordan. They later discovered the advantages of hydraulic lime – that is, cement that hardens underwater – and by 700 BC, they were building kilns to supply mortar for the construction of rubble-wall houses, concrete floors, and underground waterproof cisterns. The cisterns were kept secret and were one of the reasons the Nabataea were able to thrive in the desert. In both Roman and Egyptian times it was re-discovered that adding volcanic ash to the mix allowed it to set underwater. Similarly, the Romans knew that adding horse hair made concrete less liable to crack while it hardened, and adding blood made it more frost-resistant.

Concrete is one of the most durable building materials. It provides superior fire resistance compared with wooden construction and gains strength over time. Structures made of concrete can have a long service life. Concrete is used more than any other manmade material in the world.

Famous concrete structures include the Hoover Dam, the Panama Canal and the Roman Pantheon. The earliest large-scale users of concrete technology were the ancient Romans, and concrete was widely used in the Roman Empire. The Colosseum in Rome was built largely of concrete, and the concrete dome of the Pantheon is the world's largest unreinforced concrete dome.

After the Roman Empire collapsed, use of concrete became rare until the technology was re-pioneered in the mid-18th century. Today, concrete is the most widely used man-made material (measured by tonnage).

2. Applications in Architectural Field

Concrete is the oldest and the most widely used synthetic building material, currently produced at a rate of over five

1. 混凝土的历史

混凝土添加剂早在公元前6500年就已经被纳巴泰商人或贝都因人所使用，他们占领并控制了许多绿洲，在南叙利亚和北约旦地区建立了一个小王国。后来，他们发现了水硬石灰（即在水中变硬的水泥）的优点，公元前700年前后，他们建造了窑炉来制作灰浆，用于建造碎石墙住宅、混凝土地面以及地下防水蓄水池。这些秘密的蓄水池是纳巴泰人在沙漠中兴旺的原因之一。在罗马和埃及时代，人们发现在混凝土中添加火山灰能使其在水下凝固。同样的，罗马人知道添加马毛能让混凝土在变硬的过程中不易裂开，而添加血能让混凝土更抗霜。混凝土是最耐久的建筑材料之一。与木材结构相比，它具有卓越的防火性能，并且能随着时间而变得更加坚固。混凝土结构拥有很长的使用寿命，是应用最广泛的人造材料。

胡佛水坝、巴拿马运河以及罗马万神殿都是著名的混凝土建造物。最早大规模使用混凝土技术的是罗马人，混凝土在罗马帝国有着广泛的应用。罗马斗兽场主要由混凝土建造而成，而万神殿的混凝土圆顶则是世界上最大的无钢筋混凝土圆顶。

在罗马帝国陷落之后，混凝土的使用率变得很低。直至18世纪中期，新技术的发展实现了混凝土的复兴。现在，混凝土是应用最为广泛的人造材料（以吨数计量）。

2. 建筑领域中的应用

混凝土是最古老、应用最广的合成建筑材料，当前每年

billion cubic yards per year and reportedly the second most consumed substance after water. It is easily taken for granted as the surface of everyday elements of infrastructure such as streets and sidewalks. It is also strongly associated with utilitarian structures such as parking garages and power plants, along with a variety of cheaply built and often poorly designed public and commercial buildings of the mid-twentieth century.

This common and apparently mundane material also, however, makes possible structures of extraordinary beauty and creativity. Concrete has been the indispensable medium for numerous architects and engineers attracted by its sculptural and expressive possibilities, and indeed, reinforced concrete is arguably the quintessential material of the Modern Movement in architecture. Its strength and versatility have allowed unprecedented experimentation with forms, surfaces, and structural frames, yielding numerous beloved landmarks ranging from Frank Lloyd Wright's Falling water, with its audacious cantilevered balconies, to Australia's highly evocative Sydney Opera House.

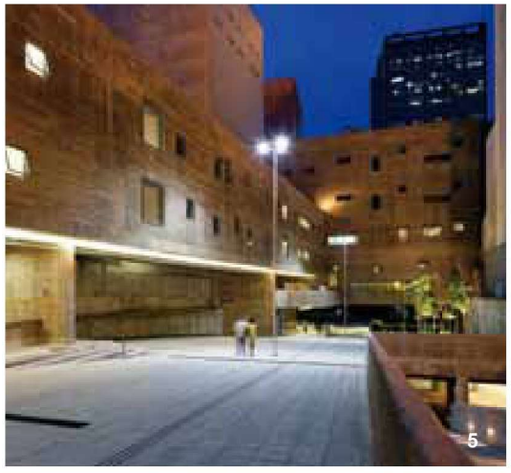
的生产量在38亿立方米以上，是仅次于水的第二大消耗物质。街道、人行道等大量日常基础设施的表面都是混凝土构成的。停车场、发电厂等市政设施以及20世纪中期所建造的大量廉价的公共建筑和商业建筑也大多采用混凝土作为主要材料。

然而，这种常见且看起来平淡无奇的材料能够打造出具有非凡的美丽和创意的结构。无数建筑师和工程师被混凝土的雕塑潜能和表现力所吸引，将其看成一种不可或缺的介质。事实上，钢筋混凝土可能是现代建筑运动中的典型材料。它的强度和广泛用途让建筑师在造型、表面和结构框架上进行了前所未有的实验。从弗兰克·劳埃德·赖特的流水别墅到悉尼歌剧院，混凝土成就了无数深受人们喜爱的地标性建筑。


2


3


4


5

Chapter 1

Cast-in-place Concrete

第一章 现浇混凝土

Cast-in-place concrete walls are made with ready-mix concrete placed into removable forms erected on site. Historically, this has been one of the most common forms of building basement walls. The same techniques used below grade can be repeated with above-grade walls to form the ground floor and upper levels of homes.

现浇混凝土墙由预拌混凝土浇注现场在可拆除模板中而成。这曾是建造建筑地下室墙壁最常见的形式之一。地下所用的技术同样可以应用在地上空间的墙壁，如一楼或住宅的上层墙壁等。

1.1 Components, Including Insulation

(See Figure 1.1 to Figure 1.4)

Cast-in-place (CIP) concrete systems are relatively straightforward. Steps required include the placement of temporary forms and placing fresh concrete and steel reinforcement. Although it is possible to batch concrete on site, ready mixed concrete is widely available and is usually delivered by a ready mix supplier.

Although uninsulated walls were common in the past, changing energy code requirements are more or less eliminating walls without insulation in most climates. This is the case with all types of systems, including concrete, wood, and steel. Energy is simply too important in terms of its cost and environmental impact. Concrete's thermal mass helps moderate temperature swings, but cannot provide the improved energy performance mandated by codes unless the wall system contains insulation. In the past, therefore, insulation may have been an optional component of a cast-in-place system, but it is increasingly included in contemporary construction.

The most common formwork materials for casting concrete in place are steel, aluminum, and wood. Many wood systems are custom manufactured and may be used only once or a few times. Steel and aluminum forming systems, on the other hand, are designed for multiple reuses, saving on costs. Metal panel forms are usually two to three feet wide and come in various heights to match the wall. Most common are eight and nine foot tall panels.

1.2 Installation, Connections, Finishes

Casting concrete in place involves a few distinct steps: placing formwork, placing reinforcement, and pouring concrete. Builders usually place forms at the corners first and then fill in between the corners. This helps with proper alignment of forms and, therefore, walls. Reinforcement bars ("rebar" for short) can be erected before either form face as a cage or after one side of the formwork is installed. Once both form faces are tied together and braced, concrete is placed in the forms via truck chute, bucket, or pump. Forms should always be filled at an appropriate rate based on formwork manufacturer recommendations to prevent problems. Although blowouts are uncommon with metal and wood forms, misalignment could potentially occur.

For single-family residential construction, wall thicknesses can range from four to 24 inches. Uninsulated walls are typically six or eight inches thick. Walls with insulation are generally thicker when they contain an internal layer of insulation: either the inner or outer wall layer has to serve a structural function. Cast-in-place walls are generally thicker than frame walls (wood or steel).

Reinforcement in both directions maintains the wall strength. Vertically, bars are usually placed at one to four feet on centre, and tied to dowels in the footing or basement slab for structural integrity. Horizontally, bars are typically placed at about four foot spacings in residential applications. Additional bars are placed at corners and around openings (doors,

1.1 构成组件，包括隔热层（见图1.1~图1.4）

现浇混凝土系统相对简单，制作步骤包括临时模板的摆放、新鲜混凝土的浇注以及钢筋加固。尽管可以在现场分批处理混凝土，大多数项目仍选用通过预拌供货商所提供的预拌混凝土。

尽管过去无隔热层的墙壁占主流，变化的能源标准正逐渐使没有隔热层的墙壁退出历史舞台。各种类型的系统都是一样的，如混凝土、木材、钢材等。从成本和环境影响来讲，能源至关重要。混凝土的热容量有助于缓和温度波动，但是不能提供良好的能源绩效，因此不许在墙面系统上安装隔热层。过去，隔热层是现浇混凝土系统的任选成分；现在，越来越多的建造结构都包含了隔热层。

最常见的现浇混凝土模板材料是钢、铝和木材。许多木材系统都是特别定制的，只能使用单次或数次。钢模板系统和铝模板系统则可以反复利用，节约了成本。金属板模板通常2~3英寸（约5.1~7.6厘米）宽，高度与墙壁的高度相匹配，大多数为8~9英尺（约20.3~22.9厘米）高。

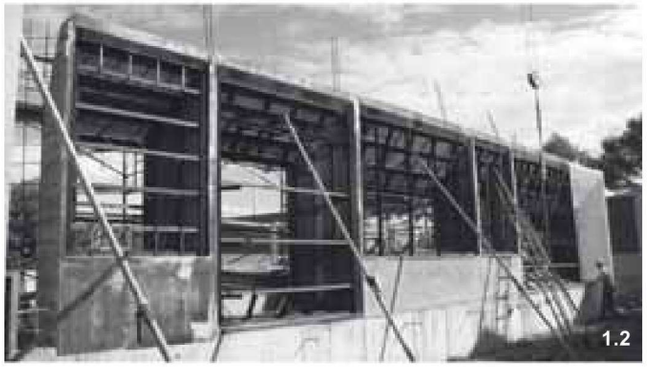
1.2 隔热层、连接件、饰面

现场浇注混凝土包含一系列独立的步骤：摆放模板、放置钢筋、浇注混凝土。施工人员通常先将模板放在拐角，然后在拐角之间进行填充。这有助于保持模板的同轴度，从而建造更精准的墙壁。钢筋可以在模板面前方作为笼子造型架起，也可以在模板一侧安装之后进行安装。当模架的两面固定起来支撑牢固之后，就可以通过货车斜槽、桶或泵进行浇注。为了避免产生问题，一定要根据模板制造商的推荐规范进行匀速浇注。尽管金属模板和木模板很难爆裂，错位等情况也可能发生。

对于独户住宅的建造，墙壁的厚度可以在4~24英寸（约10~60厘米）之间。无隔热层的墙壁通常是15厘米或20厘米厚。带有隔热层的墙壁通常更厚，它们在内部加入了隔热层，由内层或外层墙壁担当结构功能。现浇混凝土墙通常比框架墙（木框或钢框）要厚。

双向钢筋加固能维持墙壁的强度。纵向钢筋通常放置在中心1~4英尺（约30~120厘米）处，系在底脚或底板的木钉上来保持结构完整性。在住宅建筑中，横向钢筋通常间隔4英尺（约120厘米）。额外的钢筋被配置在转角和门窗开口四周，有助于防止开裂，增加强度。

1.1



1.2

1.3

1.4