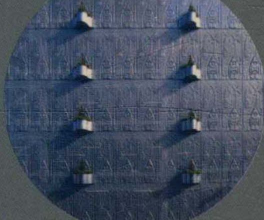
Architectural Material & Detail Structure

建筑材料与细部结构

（西）费尔南多 · 佩雷斯 编 常文心 译



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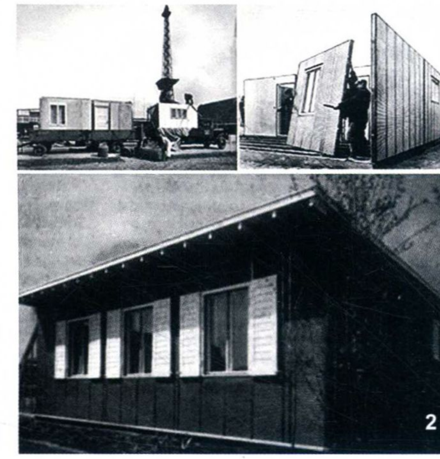
Preface 前言

ARCHITECTURE IN METAL

Towards a dialogue between industry and crafts

金属建筑

工业与工艺之间的对话



Associated to concepts of lightness, speed and industrialisation, the connection between steel and architectural production has strengthened and intensified since the second half of nineteenth century, allowing for the manufacturing in large quantities when necessary. The nature of steel construction has the capacity to accelerate construction processes, providing rapid response to growth or reconstruction of cities, in addition to its structural relation of optimisation of spatial usage of consolidated urban areas, steel structures have been involved major architectural productions in the last 150 years. (Image 1)

From the use of steel as linear elements, to its ability to work in tension; from conventional applications, to complex building solutions; steel structures extend the range of formal and spatial possibilities. Whether it be visible, or hidden, steel structure is able to free floor-spaces, provide for large spans and cantilevers, hanging or suspending various elements, and above all allow for great heights; consecrating the verticality as a typology indissolubly linked to modernity.

Today, only the need for fire protection limits the expressive possibilities and the role of steel in formal and spatial definition of architecture. The steel alone does not provide the necessary guarantees of stability in case of fire, and this requires the need for cladding and protective solutions, hence conditioning the expressive and visual possibilities offered by metal structures.

Steel has not only provided solutions for structural requirements, but when combined with other metal elements, has also been present in the building envelopes contributing to define the image of the architecture. While copper, bronze or zinc had always been used in roof coverings or finishing, there had been few examples of steel castings precast present on building façades in the turn of the nineteenth century into the twentieth. It is not until the second and third decades of the twentieth century when the first steel façade systems were patented[1], and early development of prefabricated houses were constructed with metal façades.

In 1926, Georg Muche, assisted by Richard Paulik, from the Walter Gropius Office, built the prototype of a house with a steel structure and modular wall panels clad with sheet steel. The early example of modular prefabricated system and façade panels, is expanded by Walter Gropius, firstly in the project of Stutgart Kleinhaus (1927) and later in residential designs for Hirsch Kupfer Copper Berlin. The prefabrication system of these houses were designed with façade panels, consisting of exterior-facing corrugated sheet copper cladding, and interior-facing corrugated sheet aluminium. It allowed for a spatially flexible house, expanding and contracting when needed, all produced in factories, delivered and moved by trucks. The truly innovative solution represents a turning point in the architectural innovation, so important for later developments. (Image 2)

Although were Buckminster Fuller with the Dymaixon houses in 1944, the Wichita House in 1947, and finally, Jean Prouvé with les Maisons Tropicales in 1949 who consolidate the use of aluminum in architectural, notably, Jean Prouvé was who developed more accurately the characteristics and requirements of the façade panel and profile elements that became the curtain wall. Example of this can be seen in the Maison du Peuple façade in Clinchy (1936-1939), or the aluminum extruded profiles and façade panels of the Fédération du applied Bâtiment (1953-1954) and in the housing of Mozart (1953-1954) square in Paris. (Image 3, Image 4)

Soon, the development and incorporation of different types of metals, such as titanium, bronze, copper, and zinc, gave way to numerous metallic coating systems and enclosure designs, which continue to be present today.

With challenges such as optimisation of manufacturing and application, corrosive related durability issues, as well as the sealing of building envelopes, many systems and patents have been developed. Supported by steel's advantages like malleability; its ability to be folded, punched, or textured with finishes, and finally along with the development of digital fabrication methodologies, steel had increased the scope of architectural possibilities. Furthermore, these systems have radically transformed the construction procedures, and with them, the philosophy, concept and organisation of the construction site itself.

人们总是将金属与轻质、速度和工业化联系起来。由于大批量生产的可行性，钢材与建筑之间的联系 19 世纪下半叶变得更加紧密。钢结构的性质能加速建造流程，快速地对城市成长或重建做出反应。除了与城市区域的空间优化相联系之外，钢结构在过去的 150 年中与主要的建筑建造密不可分。（图 1）

从钢的直线特征到它的延展性，从传统应用到复杂的建筑方案，钢结构不断拓展自己的应用形式和空间潜能。无论是外露还是隐藏起来，钢结构都能解放楼面空间、实现大跨度和悬臂造型、悬挂各种元件；最重要的是，它能支承超高建筑，保证了现代化建筑典型特征——垂直性。

现在，只有防火需求能限制钢材在建筑形式和空间造型中的表现力。钢材本身并不能在火灾中提供必要的稳定性保证，需要添加一些覆层处理和保护措施，因此限制了金属结构的视觉表现力。

钢材不仅能为结构需求提供解决方案，当它与其他金属元素结合起来时，还能呈现在建筑表皮上，实现建筑的外观改造。铜、青铜和锌经常被应用在屋面覆盖层或立面上，然而，在 19 世纪末 20 世纪初，很少有钢铸件出现在建筑立面上。直到 20 世纪 20、30 年代，第一个钢立面系统才获得专利[1]，而一些预制住宅也开始采用金属立面构造。

1926 年，在理查德·波利克的协助下，乔治·蒙克（格罗皮乌斯工作室）利用钢结构和模块化钢覆层墙板建造了一座住宅原型。沃尔特·格罗皮乌斯进一步拓展了早期模块化预制系统和立面板材的应用，首先在斯图加特小住宅（1927）小试牛刀，随后将其应用在库伯住宅（柏林）的设计中。这些住宅的预制系统采用立面板材，由外饰面铜覆层波纹板和内饰面波纹铝板构成。该系统可实现灵活的住宅空间，根据需要随时扩张或收缩。所有结构都在工厂制造，由卡车运到现场。这个极富创意的策略代表着建筑创新的转折点，对后面的发展至关重要。（图 2）

虽然巴克敏斯特·富勒建造的黛米克森住宅（1944）和威奇托住宅（1947）以及让·普罗维打造的热带住宅（1949）都选择铝材作为建筑的外包围材料，但是让·普罗维的立面板材和型材构件显然更加精细，并最终形成了幕墙。这一应用还体现在民众之家（克林奇，1936–1939）的外墙、应用建筑联合会（1953–1954）的挤制铝型材和外墙板以及莫扎特住宅（巴黎，1953–1954）。（图 3、图 4）

很快，钛、青铜、铜、锌等不同类型金属的开发和结合开始让步于数不胜数的金属涂层系统和外壳设计，后者一直沿用至今。

在制造和应用优化、防腐性能以及建筑外壳密封性等挑战下，许多系统和专利进行了进一步开发。由于钢材具

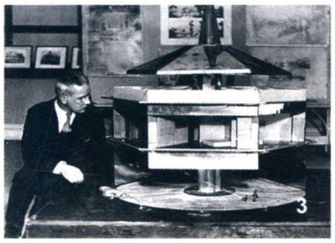


Image1 William LeBaron Jenney, Home Insurance Building. Chicago, 1895, the first building contructed with steel structure
Source: unknown

Image2 W. Gropius, Copper Houses. Berlin, 1931.
Source: Faber and Faber (http://www.faber.co.uk/)

Image3 Buckminster Fuller, Dymaixon House. 1944
Source: Bucky and the Dymaxion © Bettmann/Corbis via britannicacom.jpg

Image4 J. Prouvé, Maisons Tropicales. Brazzaville, 1951
Source: lesmaisonstropicales.blogspot.com LMT 10_twoo houses in brazzaville 1951

图1 威廉•勒巴伦•詹尼，房屋保险大楼（芝加哥，1895），第一座钢结构建筑
来源：未知

图2 W•格罗皮乌斯，库伯住宅（柏林，1931）
来源：Faber and Faber (http://www.faber.co.uk/)

图3 巴克敏斯特•富勒，黛米克森住宅（1944）
来源：Bucky and the Dymaxion © Bettmann/Corbis via britannicacom.jpg

图4 J•普罗维，热带住宅（布拉柴维尔，1951）
来源：lesmaisonstropicales.blogspot.com LMT 10_twoo houses in brazzaville 1951

The possibility of reuse or disassembly, reversibility and transformation of spaces contribute to revitalise the idea of the building as a monument, to understand it as an organism in continuous evolution. The reconfigurable architectural space generates questions associated with spatial authorship, placing architects and their tools in a radically more open and dynamic position.

Yet at the same time, the construction processes of steel and metal architectures increasingly reinforce the systems of predesigned and prefabricated objects. Structures, partitions, and cladding are incorporated but are not produced on site, introducing new conditions and possibilities in the temporal and spatial organisation of the architectural work, issues that inevitably impact and affect major project decisions.

Nowadays, digital calculation and numerical control software systems make possible the realisation of almost all forms and surfaces with metallic elements. These advances optimise fabrication processes, and have facilitated the emergence of an even greater formal and expressive repertoire. However, they have also brought the construction of arbitrary shapes, absurd structures and banal use of the expressive possibilities.

Paradoxically, the obsession and fascination in the construction of increasingly complex shapes that these systems let conceive and resolve, has been what has most contributed to "increase in the gap between the space which can be represented, and space which can be effectively built"[2]. Hence, the increase of formal complexity, the greater the technology required for both design and fabrication of its components, thus placing these before the techniques and procedures of traditional manual labour and craft.

It is precisely in this tension, between the different phases of the spatial production, where the architectural design plays a crucial role. Architecture has the ability to influence and consolidate the space between industry and traditional crafts. The project can define and propose a method of materialisation, able to zoom and enhance technological capabilities, yet utilising existing traditional industrial resources, in the construction of the built environment. Therefore, enlivening the sense of cultural value, and the knowledge and expertise of its places where architectures operate.

One of the most important and urgent challenges for industrialisation is the urgent need to reduce consumption of non-renewable energy and emission of greenhouse gas. In this respect, metallic materials already offer significant advantages: 50% of new steel comes from of scrap metal smelting; almost all their products allow reuse, disassembly and transportation with low waste production. Nevertheless, the processes for obtaining raw materials for producing metal components still consume a lot of non-renewable energy, while also generating contaminating residues.

Therefore, through responsible use of the metals, a production that ensures long-term durability of the products, as well as the reuse and recycling at the end-of-life of the components, will certainly ensure the rapid development of metallic materials for construction, offering many new advantages and opportunities for the future built environment.

References
注释

【1】In 1929, it was patented the Fillod system for steel façades consisting of external and internal face in sheet metal panels fixed to a double tubular steel supporting structure spaced each other and filled with insulating material.

【2】AVELLANEDA, Jaume. "Revestimientos metálicos en fachadas y cubiertas". TECTONICA Nº32 (Mayo, 2010) p.4-17

【1】1929年，费尔罗德系统（Fillod system）获得了专利，该立面系统由内外层金属板固定在双层钢管支撑结构上构成，钢管的间隙填充了隔热材料。

【2】阿韦亚内达，若姆.《立面与屋顶的金属涂层》. TECTONICA Nº32（2010.5）p.4-17

Text by Fernando Pérez Blanco & Marta Pelegrín Rodríguez (MEDIOMUNDO Arquitectos) Translate by Chapman Kan (architect)
原文：费尔南多•佩雷斯•布兰可、玛尔塔•佩莱格林•罗德里格斯（MEDIOMUNDO建筑事务所）；英文翻译：查普曼•肯（建筑师）

有延展性，可折叠、可穿孔、可制作纹理表面，随着数字制造的发展，钢材为建筑带来了更多的可能。此外，这些系统从根本上改变了建造流程以及建造法则、概念和施工场地的组织方式。

再利用性、可拆卸性、可逆性和空间改造为建筑概念注入了新的活力，使建筑变成了不断进化的有机体。可重组的建筑空间衍生了与空间原创权相关的问题，把建筑师和他们的设计工具放在了更开放、更活跃的位置。

同时，金属建筑的建造流程逐步强化了预设计和预制组件系统。结构、隔断和覆层被合为一体，但是并不在现场制造，在建筑工作的时间和空间组织中引入了新的条件和可能，不可避免地影响了重要的项目决定。

如今，数字计算和数值控制软件系统让金属元件几乎可以实现任何造型和表面设计。这些发展优化了制造流程，有助于打造更大、更具表现力的建筑。但是，它们也带来了随意的形状、荒谬的结构和表现力的滥用。

在通过这些系统所实现的日渐复杂的造型中，困扰与魅力并存，它们已经成为解决"空间表现力和建造效率之间的差距"[2]的最大障碍。因此，造型越复杂，对预制组件的设计和制造技术的要求越高，它们的地位就会超越传统手工劳动和工艺的技术和流程。

恰恰是在这种空间制造的不同阶段之间所形成的张力中，建筑设计扮演了决定性的角色。建筑有能力影响和联合工业和传统工艺之间的空间。项目能明确提出一种物化方案，从而提升技术能力，但是在建筑环境中仍然使用传统工业资源。在这一过程中，建筑所在地的文化价值和知识技术都能得到活化。

工业化进程所面临的最重要、最紧急的挑战之一就是减少不可再生能源的消耗和温室气体的排放。在这方面，金属材料已经呈现出极大的优势：50%的新钢材来自于废金属冶炼，几乎所有钢产品都能实现再利用，拆卸和转化，减少了废料的产生。虽然如此，金属原材料的获取过程仍然需要消耗大量不可再生能源，并且会产生污染残留物。

因此，负责的使用金属、生产经久耐用的产品以及回收利用旧组件都能保证金属材料在建造过程中的快速发展，为未来的建筑环境带来更多的优势与机遇。

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Overview

概述

1. Definition

A metal (from Greek "μέταλλον" – métallon, "mine, quarry, metal"[1][2]) is a solid material (an element, compound, or alloy) that is typically hard, opaque, shiny, and features good electrical and thermal conductivity. Metals are generally malleable – that is, they can be hammered or pressed permanently out of shape without breaking or cracking – as well as fusible (able to be fused or melted) and ductile (able to be drawn out into a thin wire).[3] 91 of the 118 elements in the periodic table are metals.

Metals in general have high electrical conductivity, high thermal conductivity, and high density. Typically they are malleable and ductile, deforming under stress without cleaving.[4] In terms of optical properties, metals are shiny and lustrous. Sheets of metal beyond a few micrometres in thickness appear opaque, but gold leaf transmits green light.

1. 定义

金属（在希腊语中写作μέταλλον，意为"矿产、开采、金属"[1][2]）是一种具有光泽、坚硬、不透明、容易导电、导热的物质。金属一般具有可锻性，可锤炼压延成永久的造型，并且不会破裂、断裂。金属还具有可熔性（能够熔化、熔解）和延展性（能够被拉成细丝）。[3]在元素周期表的118种元素中，91种元素都是金属。（见表1）

金属通常都具有良好的导电性、导热性和较大的密度，可锻造、可延展，在压力下能够变形且不破裂。[4]从光学特性来讲，金属具有光泽。厚度在几微米以下的金属板仍是不透明的，但是金箔能传送绿光。

2. Categories

Base Metal

In chemistry, the term base metal is used informally to refer to a metal that oxidises or corrodes relatively easily, and reacts variably with dilute hydrochloric acid (HCl) to form hydrogen. Examples include iron, nickel, lead and zinc. Copper is considered a base metal as it oxidises relatively easily, although it does not react with HCl. It is commonly used in opposition to noble metal.

In alchemy, a base metal was a common and inexpensive metal, as opposed to precious metals, mainly gold and silver. A longtime goal of the alchemists was the transmutation of base metals into precious metals.

In numismatics, coins in the past derived their value primarily from the precious metal content. Most modern currencies are fiat currency, allowing the coins to be made of base metal.

Ferrous Metal

The term "ferrous" is derived from the Latin word meaning "containing iron". This can include pure iron, such as wrought iron, or an alloy such as steel. Ferrous metals are often magnetic, but not exclusively.

Precious Metal

A precious metal is a rare metallic chemical element of high economic value.

Chemically, the precious metals are less reactive than most elements, have high luster and high electrical conductivity. Gold, silver, platinum and palladium each have an ISO 4217 currency code. The best-known precious metals are gold and silver. While both have industrial uses, they are better known for their uses in art, jewelry, and coinage. Other precious metals include the platinum group metals: ruthenium, rhodium, palladium, osmium, iridium, and platinum, of which platinum is the most widely traded.

3. Metal's Application in Architectural Facade

Sheet metals have a wide application and various types, including aluminium sheet, aluminium-plastic sheet, colour plate, copper plate, stainless steel plate, etc. There are many advantages of sheet metal: metal is highly recyclable and environment-friendly; sheet metal is easy to be processed preciously, which shortens construction time and reduces labour cost; with various types, rich colours and good ductility, sheet metal can express complex geometric shapes, textures and patterns; sheet metal is weather resistance and can meet most buildings' requirements in durability. Different metals bring different visual effects: smooth aluminium sheet and stainless steel sheet show the beauty of modern technology; copper plate achieves the combination between the present and history; corrugated plate brings rich details; raw steel plate is easily marked by nature and shows influences of time; titanium plate expresses a magic feeling...(See Figure 1 to Figure 4)

2.分类

基本金属

在化学中，基本金属指相对容易氧化或腐蚀、与稀盐酸能发生反应产生氢的金属，例如铁、镍、铅、锌。尽管铜不与稀盐酸发生反应，但由于它相对容易氧化，也属于基本金属。基本金属的概念主要与贵重金属相对。

在炼金术中，基本金属指普通且价格较低的金属，与金、银等贵重金属相对。炼金术士的终生目标就是把基本金属变成贵重金属。

在钱币学中，过去硬币的价值主要取决于其中贵重金属的含量。现代货币基本为法定货币，硬币也大多由基本金属制成。

含铁金属

"含铁"的英文"ferrous"来自于拉丁文。含铁金属包括纯铁（如锻铁）和铁合金（如钢）。含铁金属通常都具有磁性，但是也有例外。

贵重金属

贵重金属是稀有而具有很高经济价值的金属化学元素。

在化学中，贵重金属比大多数元素更具惰性、更有光泽、更易导电。金、银、铂、钯都具有ISO 4217（国际标准化组织）货币代码。最著名的贵重金属是金和银。虽然二者在工业中也有应用，它们更以其在艺术品、珠宝和钱币中的应用而闻名。其他贵重金属包括铂族金属：钌、铑、钯、锇、铱、铂，其中铂是最常见的一种。

3.金属在建筑饰面中的应用

金属板材的应用广泛，种类很多，包括铝板、铝塑板、彩钢板、铜板、不锈钢板等。金属板材有很多优点：回收率高，是名副其实的环保材料；金属板材易于加工，精度高，可以缩短工期，降低人工成本；金属板材形式众多，色彩丰富，易于延展成型，能够表现出各种复杂的立体造型、纹理及质感；金属板材还具有良好的耐候性、耐久性，能够适应大部分建筑耐久性的要求。各种金属板材的使用会带来不同的视觉效果:平滑的铝板、不锈钢板能体现现代技术及工艺美；铜板能达到现代感与历史感的结合；波纹板则给建筑带来更丰富的细部；自然未处理的钢板更容易留下自然的印记，显示出时间对建筑的影响；钛板带给人一种亦幻亦真的绝妙体验……（见图1~图4）