国外高等院校土建学科基础教材（中英文对照）

屋顶构造
ROOF CONSTRUCTION

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杨璐 柳美玉 译

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BASICS

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序

位于我们头顶的屋顶结构可以满足人类的一个基本需求——帮助我们抵抗雨雪风霜以及寒冷的侵袭。除此之外，屋顶结构还必须能够起到传递荷载和保持稳定性的作用：屋顶结构需要具有多种不同的功能。在人类历史发展的过程中，出现了多种不同形状和类型的屋顶结构，以通过不同的建造方法来满足屋顶结构的功能需要，而到今天，我们仍然在沿袭这些方法。

另外，屋顶结构也必须满足美观的要求。屋顶常被称作为建筑的“第五立面”。建筑作为人造景观，其平屋顶和坡屋顶的不同变化形式决定了建筑的主要特征，同时也为新的建筑设计提供了重要的素材。

本套丛书的出版主要针对的是初次接触其中某一主题或者学科的学生，希望该丛书能够起到一个普及教育和实例分析的作用。丛书的内容简单易懂，而且包括了相应的实例。丛书的每一册都对一些非常重要的概念进行了详细和深入的解释。丛书并不打算对广阔的专业知识进行一个纲要性的介绍，而是旨在为读者就某一主题进行入门介绍并让读者掌握一些必要的专业知识。

本书主要是针对最初接触相关知识的未来建筑师、结构工程师以及其他建筑专业人士而出版的。该册主要对不同的屋顶类型进行了介绍，并且阐述了不同的屋顶建造方法如何满足相应的结构功能要求以及各自的优缺点。本书对屋顶结构的各个要素和建筑层进行了清晰的说明，并对如何在设计阶段对各个因素进行考虑进行了指引；还对屋顶的结构形式、保温隔热层、防水层、覆层、面层以及排水系统的基本构件进行了介绍，目的在于让初学者熟悉和了解一些必要的专业术语，帮助他们在实际的设计和建造过程中进行更好地理解和区分。

编者：Bert Bielefeld

FOREWORD

The roof over our heads satisfies a fundamental human need – it protects us from rain, wind and cold. In addition to these technical requirements it must transfer loads and provide stability: a roof has a variety of functions to fulfil. Craft traditions have generated numerous roof shapes and typologies to address these tasks in a number of ways, which are still used today.

The roof must be aesthetically satisfying as well; it is often called the fifth façade. Variants on flat and pitched roof forms define the character of whole man-made landscapes, and also offer essential stylistic resources for new buildings.

The "Basics" series of books aims to provide instructive and practical explanations for students who are approaching a subject or discipline for the very first time. It presents content with easily comprehensible introductions and examples. The most important principles are systematically elaborated and treated in depth in each volume. Instead of compiling an extensive compendium of specialist knowledge, the series aims to provide an initial introduction to a subject and give readers the necessary expertise for skilled implementation.

The "Roof" volume is aimed at students who are encountering roofs for the first time as part of their training as architects, structural engineers, or other construction professionals. It explains roof types, how construction methods meet structural requirements, and their various advantages and disadvantages. The book gives a clear account of the individual structural elements and layers, and provides guidance on addressing them at the planning stage. It deals with the essential roof structure, insulation and waterproofing, coverings and surfaces, and the basic elements of drainage. The aim is to familiarize students with the necessary technical terms, so that they can translate general facts and differences into concrete design and construction.

Bert Bielefeld, Editor

INTRODUCTION

The roof is part of a building's outer skin, and fulfils a range of functions: first, it protects the space below it, open or closed, from the weather. Here the most important aspects are draining precipitation effectively, providing protection from sun and wind, and affording privacy.

Different structures can be used according to functional requirements or the design approach. The roofs described in this book demonstrate basic principles. They form a basis for new roof planning approaches, which are in a constant state of development.

Various forces act on the roof. They must be conducted to the ground directly, or via outside walls, columns or foundations.

We distinguish between various structures and roof forms. A number of factors are involved in choosing a suitable roof. Appearance is probably the most important criterion. Then come the configuration and size of the plan view; construction costs and relevant building regulations play a crucial role.

The choice of structure and materials should be appropriate to the project in hand: elaborate prefabricated steel constructions are rarely used for private houses, and hand-finished on-site detailing is avoided for industrial buildings where possible.

Typically regional roof forms often emerge. Alpine regions usually have shallow-pitched roofs with very large overhangs, while houses with

\\Hint:
Roof pitch and roof shapes are often stipulated for building plots subject to a new master plan. If the plot is in a developed area and there is no master plan, "fitting in with the surroundings" is the correct approach to building regulations. The local building department will provide information about whether a particular site is subject to precise stipulations.

steeply pitched roofs set gable-on to the street › see chapter Roof types are more usual in northern European coastal regions. But buildings' functions have also produced typical roof shapes. For example, indoor tennis courts have vaulted barrel roofs that follow the flight of the ball, while normal events halls have flat roofs to facilitate flexible use.

Different roof types can be combined, but this often produces a complicated geometry of details. Simple structures are therefore preferable, to avoid leakage.

The main distinction in roof types is between pitched and flat roofs; generally speaking a roof is considered pitched if it inclines by more than 5°. These two roof forms are clearly distinct in structure and function, and will be considered separately in this book.

LOADS AND FORCES

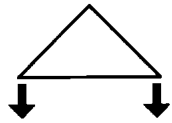
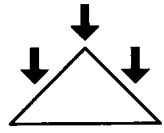
The statics of a building deal with its structural stability: the forces acting on it and their effects have to be calculated. Newton's law says: force = mass × acceleration. As a rule, forces cannot be identified directly, but only indirectly, by their effects. For example, if we observe the acceleration of a body, we will establish that one or more forces are at work. But in building, statics is the theory of the equilibrium of forces: the various parts of the buildings should be at rest. It is also essential to ensure that the internal forces are also in equilibrium, which means that each component part has to withstand load. Its ability to do this depends on its thickness or dimensions, and on the solidity and elasticity of the material.

If a load compresses a construction element, compressive forces are generated. If the forces affecting the element are pulling it apart, tensile forces are generated. If opposing forces affect an element at different points, the element tries to twist. The building industry applies the technical term momentum or torque to this torsion. The sum of the maximum forces that could be exerted identifies the overall forces that have to be directed into the construction below and absorbed by it.

The forces affecting a building or a construction element are also defined according to their direction. A distinction is made between longitudinal forces and lateral forces.

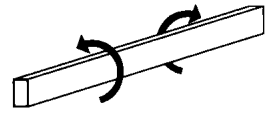
Various forces act on buildings. They must be identified at the planning stage and plans must be made for transferring them into the

Table 1:
Loads

Type of load		Duration	Main direction	Determination
Dead load		Permanent	Vertical	Calculated according to the quantity and specific weights of the structural elements (in KN/m²)
Imposed load		Variable	Vertical	Can be taken from table values as a mean values for certain uses (in KN/m²)
Snow and ice load		Variable	Vertical	Can be taken from table values according to the roof pitch and snow-loaded areas
Wind load		Variable	Variable	Can be taken from table values according to the roof pitch and wind-loaded areas

compression force

tensile force



moment

ground. Loads can act horizontally, in longitudinal and transverse directions, and vertically. Identifying the individual loads forms the basis for dimensioning the roof construction. Planners must first decide which materials to use, so that the building's self-weight can be determined. The dead load is a permanent load. It acts vertically downwards. Imposed loads are the next factor. These can be movable objects, such as furniture, or people. But it is not necessary to list every object individually and take it into account when dimensioning the structure. Mean values are available for different types, e.g. dwellings, factories and warehouses. Individual specifications are required only in exceptional cases. If a structural element is not planned to be generally accessible, a diagonal roof section, for example, it is still necessary to ensure that a person could walk on it for maintenance purposes, or during the assembly process. This is known as a point load. As a rule, imposed loads act vertically downwards, like a dead load.

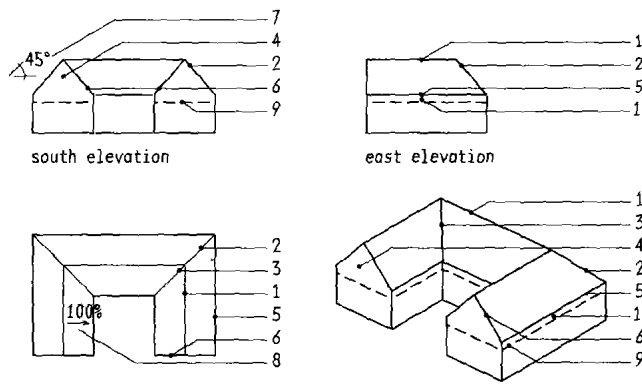
Wind, snow and ice loads act on the roof from the outside. Snow and ice exert pressure on the roof because of their weight, and so also create vertical forces, but wind can act both horizontally and vertically. These forces are identified as wind suction and wind pressure. Wind suction acts as a lifting force. Structural elements that are so loaded must be appropriately protected against being blown away.

\\Tip:
Individual national standards provide load compilation tables. The individual weights of materials and structural elements and assumptions about imposed, snow and wind loads can be taken from these. The most important standards are listed in the appendix to this book.

BASICS

By far the most roofs for detached dwellings are pitched. Pitched roofs are exceptionally well suited to draining precipitation off buildings. The loadbearing structure is usually of wood and is made by hand, although steel and concrete are also possible. The triangular cross sections under the roof surfaces absorb horizontal wind forces well and conduct them into the structure.

The highest point of the roof is known as the ridge, and the lower edges as the eaves. The diagonal link on the wall of the house, at the gable, forms the verge. › see Fig. 2 When two roof surfaces intersect, the intersection line pointing outwards is known as the arris and the internal line as the valley. It the roof is set on a wall that rises higher than the topmost ceiling in the house, this wall is called a jamb wall. The roof pitch is defined by the angle between the roof surface and the horizontal. This dimension is always given as the inside angle and is measured in degrees. For gutters and waterproofing elements the term slope is used. This is usually given as a percentage.



1 ridge 3 valley 5 eaves 7 roof pitch 9 ceiling
2 arris 4 gable 6 verge 8 slope 10 jamb wall

ROOF TYPES

The different roof forms have names that define the nature of the roof and gable pitch.

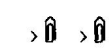
Monopitch roof

A single inclined area is called a monopitch roof. This form produces walls of different height at the ridge and eaves, so is particularly suitable if a building is intended to face in a particular direction, e.g. towards the garden (for dwellings) or towards the street (for prominent public buildings).

Gable roof

Two juxtaposed inclined planes form a gable roof. This and the monopitch roof are the simplest pitched roof forms.

Mansard roof



A mansard roof has two juxtaposed roof planes of different pitches, and is now less commonly used. It was intended to give more headroom if the roof space were to be used.

If the end wall under the pitched roof areas is upright, it forms a gable. If this area faces a street or square, the building can is said to stand gable-on to the street. The opposite, eaves-on, is less common.

Hipped roof

If the roof slopes on all four sides it is known as a hipped roof.

Pavilion roof

A pavilion roof has all its roof planes pitched, with outside walls of equal length. The roof planes meet at a single point.

Half-hipped roof

If a roof has a gable and a pitched roof plane on the end wall, it is known as a half-hip.

Barrel roof

Roofs can be built with cylindrical vaulting, as a barrel roof. Roofs that are curved on all sides are domes.

Shed roof

Shed roofs have small monopitch roofs or gable roofs aligned like the teeth of a saw; the steeper plane is usually glazed. Fully glazed versions are common. They are often used to light large spaces such as production halls.