国外高等院校土建学科基础教材（中英文对照）

木结构施工

TIMBER CONSTRUCTION

[德] 路德维希·史泰格 编著

李吉涛 李鹏 译

BASICS

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序

木材是人类最古老和最基本的建筑材料之一，直到如今，它仍然有很强的吸引力和实用性。在诸多文化氛围和气候条件下，建筑材料的选择，木材要优于砖材，在建材中具有重要地位。木材是一种生动的、轻质的、便于加工的材料，木材建造的房屋能够充分体现木材的这些特性。但是，木结构也有自己独特的区别于其他建筑材料的特性。所以，建筑师需要了解木材的特殊知识、木结构施工原则和规范，这样才能设计出合理使用木材的方案。

在本套“国外高等院校土建学科基础教材”（中英文对照）系列丛书中，除了《砌体结构》和《屋顶结构》外，本书将继续给学生介绍木建筑研究的基本内容。在建筑课程中，学生们面对的第一个设计通常是木结构房屋，对于学习建筑方法和原则，木材是非常理想的材料，并且容易实践。因此，作者首先介绍木材的特性，它既是一种天然的建筑材料，也可以加工成建材产品；然后介绍木结构常见的施工体系和它的特殊规程，这种木结构规程应用于木结构所有构件连接和节点，并且通过举例来详细说明。

本书能够让学生对木结构体系有大概了解，并深刻详细地区分了它们之间的不同之处。如果掌握了这些知识，就能够选择最合理的结构体系以满足我们的设计，并能够建设性地运用我们的建筑知识。

编者：Bert Bielefeld

FOREWORD

Wood is one of humankind's oldest and most elemental building materials, and has lost none of its appeal or validity. In many cultures and climates timber dominates over brick as the choice for house building. Wood is a living, light, simply worked material, and houses with a character all their own can be built from it. But timber construction has some particular characteristics that make it unlike other materials in construction. So architects need special knowledge about wood and the rules for timber construction, in order to develop quality designs that do justice to the material.

In addition to *Basics Masonry Construction* and *Basics Roof Construction*, the present volume in this series for students continues with the essentials for timber construction studies. The first designs in an architecture course are often for timber houses, as this material is ideal for learning construction methods and principles in a way that is close to practice. The author therefore begins by explaining the qualities of timber as a natural building material and the construction products developed from it, then moves on to the commonest timber construction systems and their specific rules. The construction rules learned in this way are then applied to all the connections and transitions for the building components, and are elaborated using examples.

The timber construction volume enables students to gain a general insight into individual timber construction systems, to understand them in detail and to distinguish them from each other. Armed with this knowledge, you can select the most sensible system for your design and apply your knowledge constructively.

Bert Bielefeld, Editor

INTRODUCTION

In a 1937 essay on training architects, Mies van der Rohe said: "Where does the structure of a house or building show with such clarity as in the timber structures of the ancients, where do we see the unity of material, construction and form so clearly? Here the wisdom of whole generations lies concealed. What a sense of material and what expressive power speaks from these buildings! What warmth they exude, and how beautiful they are! They sound like old songs." This statement by one of the 20th century's most important architects conveys both the fascination of timber construction and the challenge it presents.

The living material, the different kinds of timber, the large number of timber construction systems, the sophisticated stratification of the building components and the way they are jointed require a great deal of knowledge if this building material is to be used appropriately in student design work.

Unlike the monolithic massive construction procedures with which students are familiar, timber construction works by assembling members, following a fixed order, and working with a defined structural grid. In terms of planning, this means a more systematic approach is needed, and also a greater degree of detailing and drawing work. This book introduces students to timber construction in three stages. First, readers are familiarized with the material wood and its properties, then the most important construction systems and their characteristic joints, finally assembling components and fitting them together. Our presentation is based around simple, manageable building solutions that are suitable for identifying the key problems of any particular timber structure. Large-scale loadbearing systems, bridges or hall structures that are ideally suited to timber construction are not considered, but information on further reading is provided.

One particular difficulty in presenting timber construction should be mentioned, although it can also be seen as a great opportunity. Timber construction techniques can be said to be in a state of flux. To complement the existing traditional systems, the industry is introducing a large number of new materials and technologies to timber construction.

This book aims to structure this very broad field and provide an overview. This will involve first of all passing on established knowledge and tried-and-tested structures, but there will be at least an indication of new building materials and technical developments.

WOOD

Several hundred varieties of wood are used on a large scale all over the world. They all look different and have their own particular properties. Many of them are used for finishing, and in furniture manufacture. Relatively little coniferous timber is used in wooden buildings, so beginners do not have to be timber experts in order to build with timber. The important thing is to understand its anatomical structure, and to know about the fundamental physical properties of this material.

Growth

When using wood, it is important to be aware that a piece of timber, a beam or plank is part of a vegetable organism, a tree, and that its growth and quality are influenced by its surroundings. No one piece of wood is identical to another. Its properties depend in the first place on the kind of tree, and in the second on its position within the trunk.

Cells

The trunk consists of longitudinal tubiform cells, which are responsible for transporting nutrients as the tree grows. The cell walls enclosing the tubiform cavity are made up of cellulose and lignin (filler substance). The structure of the cell walls and the cell framework determine the strength of the wood. Unlike building materials such as non-reinforced concrete or masonry blocks, wood has a directional structure, corresponding to the path taken by nutrients from the trunk to the branches.

Cell growth takes place around the centre of the trunk, called the pith cavity, the oldest part of the trunk. It takes place in the form of annual growth phases, generally lasting from April to September in temperate zones, and creates annual rings.

\\Hint:
The loadbearing properties of a timber construction component are fundamentally determined by the loading across the direction of the fibre, the grain, or parallel to it. Plans must therefore contain information about the installation direction. In sections, the hatching makes it clear whether the timber is cut across or parallel to the grain.

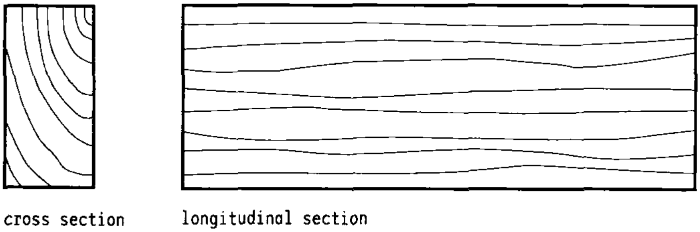


Fig. [illegible]
[illegible] crossways and parallel

Early wood, late wood

Within these rings, the softer early wood is formed in the spring from large-pored cells, and the more solid late wood with thick-walled cells follows in the autumn. The proportion of late wood essentially determines the strength of the timber.

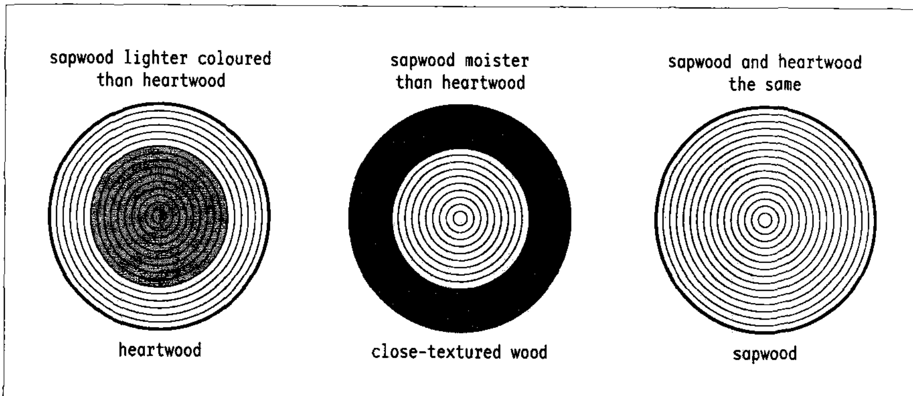
Sapwood, heart

This growth process can be read very simply by looking at the cross section of the trunk. According to the type of wood, the outer area, the sapwood, is more or less clearly distinct from the older, inner section, the heartwood. The heartwood has no supply role to fulfil, and is thus drier than the sap-bearing parts. Differences between heartwood and sapwood make it possible to divide timber types into:

- Heartwood trees
- Close-textured trees
- Sapwood trees

Heartwood trees have a dark core and light sapwood. They are considered to be particularly weather-resistant. They include oak, larch, pine and walnut. Close-textured trees show no colour difference between sapwood and heartwood, simply differences in moisture content. Both are equally light-coloured; the heart is dry, the sapwood moist. This applies to spruce, fir, beech and maple, for example.

Sapwood trees, on the other hand, show no difference in either colour or moisture content. They include birch, alder and poplar.



Timber moisture

Almost all physical properties of wood are influenced by moisture content. Its weight depends on this, its resistance to fire and pests, its load-bearing capacity and above all, its dimensional stability and consistency.

Shrinking, swelling

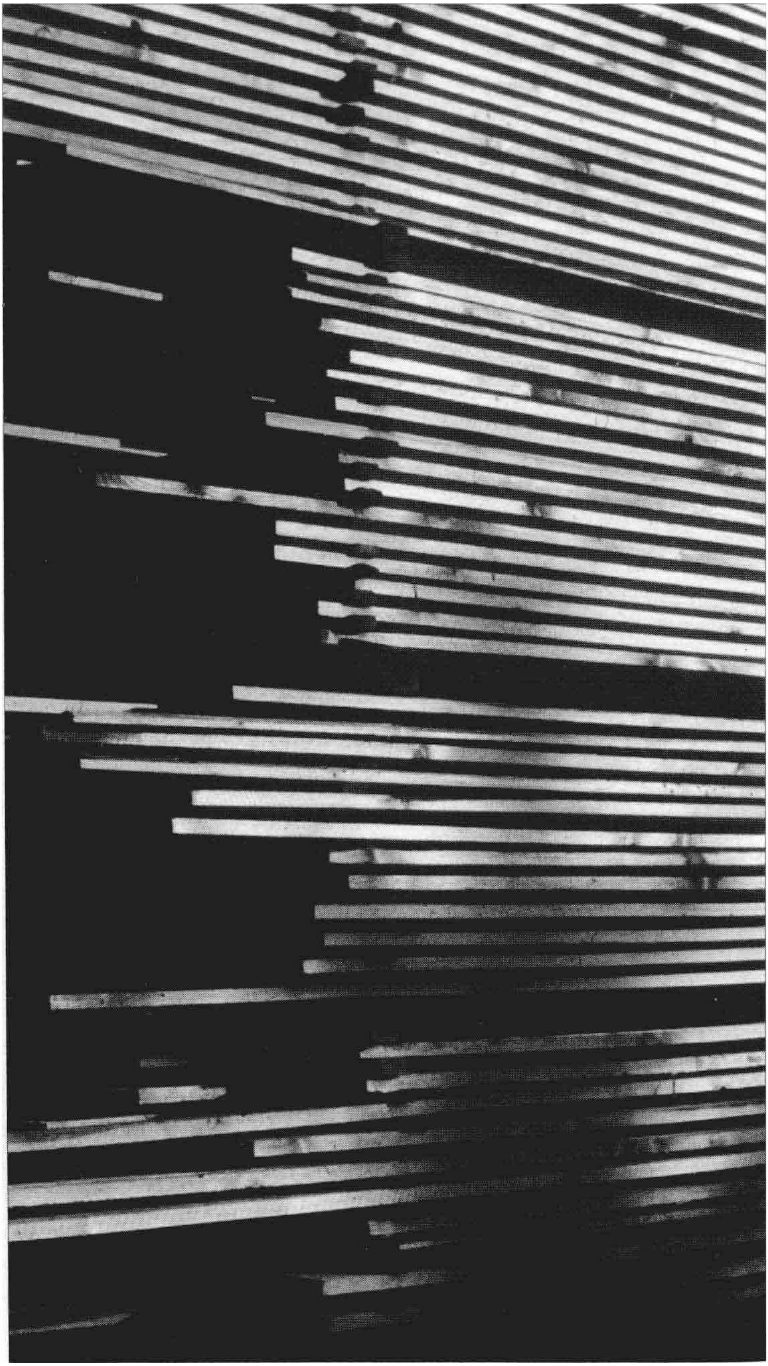
Wood swells and shrinks with changing moisture conditions. When wood dries, its volume is reduced, which is called shrinkage, and the reverse process, which causes an increase in volume, is known as swelling. This takes place because both the cell cavities and the cell walls contain water. As a hygroscopic material, wood is able to give off or absorb moisture according to the ambient conditions. This is also known as timber movement.

Moisture content must be specified for construction timber. Here a distinction is made between:

Green	more than 30% wood moisture
Semi-dry	more than 20% but maximum 30% wood moisture
Dry	up to 20% wood moisture

Construction timber should always be installed in a dry state, if possible at the moisture level expected at the location. Timber equilibrium moisture indicates the moisture levels at which only small changes of dimensions take place. For rooms this means:

Closed on all sides, heated	9 ± 3%
Closed on all sides, unheated	12 ± 3%
Covered, open	15 ± 3%
Structures exposed to weathering on all sides	18 ± 6%



Wood moisture indicates the percentage of water contained, with reference to absolutely dry wood. But movement in wood is not a single, once-and-for-all process; it happens after the timber has been installed as well. According to the ambient atmospheric humidity, which is lower in winter than in summer, timber shrinks and swells seasonally as well.

Types of cut

Because of the difference between the water content of sapwood and heartwood, as well as between early and late wood inside the annual rings, shrinkage rates differ, and thus the cut timber becomes distorted. The key factor here is its position in the trunk.

Timber can be cut tangentially to the heart or radially, i.e. at right angles to the annual rings, and this affects the degree of volume change. According to the type of wood, the degree of shrinkage is usually more than double for tangentially cut than for radially cut wood. Longitudinal shrinkage is negligible.

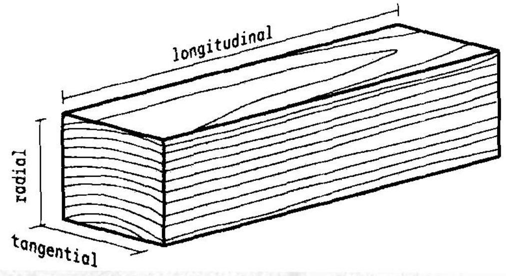


Fig.3:
Isometric drawing of squared timber showing radial and tangential sides

\\Hint:
One of the most important rules for timber construction is that wood must always be installed to allow for movement caused by shrinking and swelling, e.g. by leaving sufficiently large gaps between the timber components. Ideally a form board should be fastened with one screw only, in the middle or at the edge, so that the wood can move crosswise to the fibre direction (see chapter External walls).

The difference in volume change also means that planks or squared timber cut from one trunk at right angles distort differently. Tangential planks bend (bow) outwards on the side away from the heart, due to the shortening of the annual rings. Only the centre board, the heart board, remains straight, although it becomes thinner in the sapwood area. Figure 4 shows the reduction in volume (green colour) as cut timber shrinks.

Properties

Wood's finely porous structure makes it a relatively good material for insulation. The thermal conductivity coefficient of the coniferous timbers (softwoods) spruce, pine and fir is 0.13 W/mK, that of the deciduous timbers (hardwoods) beech and ash 0.23 W/mK. So in comparison with brick at

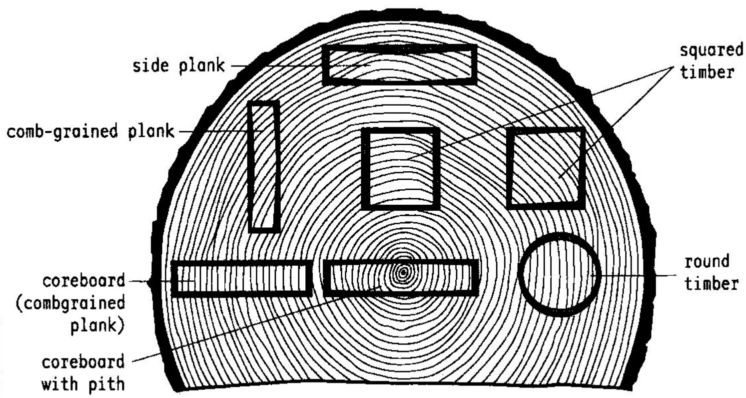


Fig. 4:
Cross section of trunk, types of cut

\\Hint:
The side of a piece of tangentially cut timber furthest from the heart is designated the left-hand side, and the side facing the heart the right-hand side. The anticipated deformation should be taken into account when the timber is used for building.