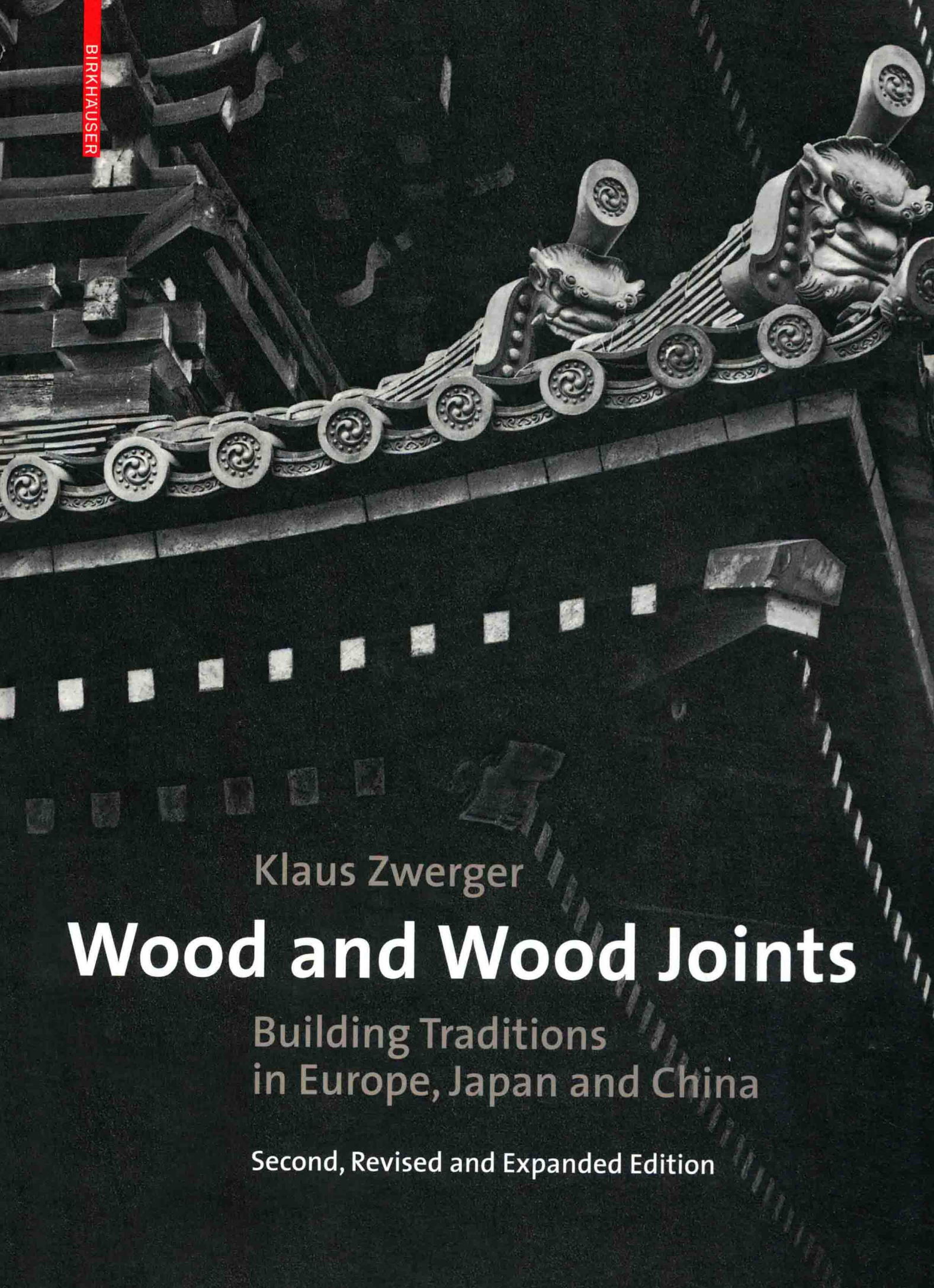

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Klaus Zwerger

Wood and Wood Joints

Building Traditions in Europe, Japan and China

Second, Revised and Expanded Edition

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With a Foreword by Valerio Olgiati

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Birkhäuser
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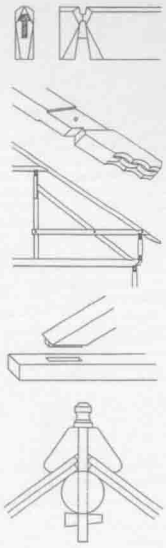

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Foreword

After searching for a copy of this book and in the knowledge that the English version was already out of print, we contacted the author and the publisher directly. Not only were we lucky enough to receive one of the last remaining copies but also learned that a new edition was in preparation. This is now available and we are delighted that this wonderful book can once again fascinate new readers.

Illustrated with beautiful photographs and meticulous drawings, the book details the long tradition and development of timber construction in Europe and Asia. Architects and carpenters cultivated a highly developed understanding of this material and the possibilities it offered. The path of forces and the specific properties of the material fundamentally determined the formal appearance of timber constructions and their details.

Timber construction has always related closely to the engineer's way of working and, compared with load-bearing construction, was very highly developed.

The culture of building with wood, its tradition, its regional and climatic particularities, its influences and developments are documented in impressive detail in this book.

In the last few centuries, building with wood has changed dramatically. Adhesives and steel components have changed the character of its construction. In contemporary architecture, wood is used for surface cladding or in construction in the form of resin-soaked materials such as chipboard or sandwich panels. Knowledge and skills of the kind described in this book are rarely seen today.

My own buildings from the past few years have been made primarily of concrete. With concrete one can build houses that are made almost entirely of a single material. Reinforced concrete can sustain tensile and compressive forces, can be used as a slab or a bar and can be assembled on site in phases; the manifestation of an idea to form a larger whole.

All this is possible with wood as well. It is just that we no longer know what this material is capable of and lack the skills to work it. And that is something we can change.

In this respect, this book is a welcome inspiration.

Valerio Olgiati
Flims, December 2010

Introduction to the Second Edition

There are two questions which could be regarded as a thread linking the various sections of this book. Firstly: "What were the conditions which governed the development and form of timber connections?" And secondly: "Can the timber connections of Europe and Japan be compared?" Both questions are interdependent; the second cannot be answered without a detailed consideration of the first.

If all the essential factors which have contributed to the formation of a timber connection are elucidated, i.e. the material itself, the person working the material and the product thereby created, then we come to the conclusion that a juxtaposition of these two cultures of timber construction is indeed possible but that a balanced comparison of the achievements must be regarded as problematic, if we can countenance such a thing at all.

To the sensitive observer, wood joints often allow the train of thought of their creator to be followed. (The carpenter produced the joint; from its form we can deduce what he thought in each case!) The creator's design considerations have taken on a form which we today interpret as a reflection of what was once acknowledged as good. On the other hand, the care shown in the execution, the readiness to produce complex joints, has not always remained the same.

This book describes and explains joints made exclusively from wood, i.e. without adhesives and without metal connectors, together with their origins and evolution. To do this, I have studied the examples found today, examined the scientific literature available and, where information was lacking, carefully supplemented this in order to fill in the gaps. Particular attention is paid to the material as well as to climatic, technical, woodworking and artistic influences. It might appear problematic that in doing so the origins of certain types of joints are discussed in the context of very specific causes. If, for example, the development of splicing joints is dealt with in the chapter covering dependency on the occurrence of wood, then this should not be taken as being more important than any other factor in the creation of such joints; likewise the influence of climatic conditions for the description of board jointing. The reader is referred to the selective nature of the examples given in the chapter on the relationship between timber connections and building tasks.

The classification employed in the chapter on the types of wood joints, which the reader might feel is insufficiently differentiated, is intended to reflect the consideration given to the specific material properties – once decisive in influencing the construction. The characteristics of wood, no two pieces of which are ever identical, have certainly not been accorded adequate attention by every carpenter in the past, but, inevitably, to a much greater extent than is the case today. As long as it was used in its natural form – and that is the theme of this book –, the complexity of the material was accepted for what it was. For today's theoretical approach this means that any classification, if it is to achieve a more detailed distinction, must either set artificial limits and exclude phenomena, or lead to perpetual repetitions. On the whole, the influences described here which helped shape joints in Europe and Japan were able to be readily compared, at least in this selection. In order to make this clear, the aim has been to try to place a Japanese equivalent alongside

every example chosen from Europe. This, at the start perhaps confusing, method was the only solution, when seen in the light of the enormous wealth of material, to making the intended comparison easily comprehensible on our journey through thousands of years of timber architecture.

The reader will notice that many dates remain vague or are not even hinted at. There is a good reason for this. The date of the completion of a building can be ascertained. The evolution of a construction form, e.g. the spar roof, can now be traced back further and further thanks to more intensive research work in recent years. Nevertheless, there still remains the fact that there may have been other, even earlier examples which have in the meantime been destroyed and which will always remain an unknown variable. Looked at in this way it is perhaps easy to understand why the regular listing of dates has not even been considered.

A word or two about the constantly recurring Japanese terms is necessary. Generally, no capital letters are employed unless the word is a proper name. The names of people are reproduced in the traditional Japanese form, i.e. the surname before the forename. Temples or shrines are cultural centres of Buddhism or Shintoism. A Japanese person can deduce from the name Todai-ji that the object in question is a ji, i.e. a temple. However, in addition to ji there are a number of other Japanese terms which all mean temple and yet others for shrine, jinja, for instance. In order to avoid tautological constructions like "Todai Temple Temple", in the case of a conflict we have decided not to distinguish between shrine and temple for the reader from other cultures. The difference can be recognized from various details on or around the structure, and it is irrelevant for the wood joints presented in this book. Those who travel to Japan will quickly discover the, even for visitors from the West, immediately recognizable distinguishing features.

Of all the many messages I received in response to the first edition of this book in 1997, not one took issue with the fact that Europe and Japan were rather unequal partners to compare with one another. For myself, however, this aspect became a matter of increasing concern. So when the publisher approached me with the intention of bringing out a new edition, I felt compelled to put this right and expressed the wish to add a chapter on historical timber construction in China.

There are many fascinating lines of development in timber architecture, but if asked to name the most advanced cultures of building with wood I would, without hesitation, choose the European and East Asian. I have consciously avoided speaking of Western or Far Eastern building traditions. The term "Far East" reflects a eurocentric standpoint that refers back to the era of European Imperialism. In the British Empire, the term "Far East" served to divide the Asian continent from the territories of the Near and Middle East. Today we speak of South Asian, Southeast Asian, and East Asian regions. The variety of timber constructions in Southeast Asia mirrors to a certain extent its geography. One can trace reciprocal influences between the developments in Southeast Asia and those in East Asia. In the border region in particular, it is often not possible to clearly identify the local architecture as specifically Southeast Asian or East Asian.

Nevertheless, when one follows the historical developments, it is possible to trace very clearly the developments of Chinese timber construction. For them, the ruling periods of foreign dynasties

were not seen as a break but, on the contrary, as an enrichment (Liao, Yuan) and – depending on one's viewpoint – an endpoint or a culmination (Qing). The Japanese building culture, as previously mentioned, owes its development to a not inconsiderable degree to examples and techniques imported from elsewhere, such as Korea, but above all from the vast Chinese Empire.

In the new chapter I have again followed the principle of a colourful mixture of vernacular buildings and so-called high architecture. There are two main reasons for this. The first is that the organisation of the book is based on criteria that have nothing to do with this distinction. The second can be attributed to a firm belief that singular examples of high architecture "must be seen in relation to, and in the context of, the vernacular matrix, and are in fact incomprehensible outside that context, especially as it existed at the time they were designed and built".[1] That said, this viewpoint should in no way call into question the fact that a whole series of constructional phenomena in vernacular architecture are drawn from examples of high architecture. I do not, however, subscribe to the general opinion that developments in elite architecture, where they are sometimes described as being characteristic of architectural styles, gradually diffuse into vernacular architecture where they then reappear as imitations.

Had I wished to follow the same principle of direct comparison between European and Japanese building technology for the Chinese examples too, I would have had to rewrite the entire book. This was neither in the interest of the publisher nor in mine. I decided instead to append the chapter on Chinese architecture as a self-contained chapter. The reader will have no difficulty in comparing the examples shown with those from Japan or those from Europe. That is not least thanks to the critical and sensitive work of Andreas Müller, who was the editor in charge of both the first edition and this expanded edition.

Amos Rapoport was of the opinion that buildings can be examined in a variety of different ways: "One can look at them chronologically, tracing the development over time either of techniques, forms, and ideas, or of the thoughts of the designer, or one can study them from a specific point of view."[2] The comparison of Europe and Japan mixes both approaches, as does the study of buildings in China, albeit taking a rather different viewpoint. This approach creates a formal connection between the existing section – which has been checked and slightly changed, with some new photographs – and the new chapter. With this addition one can now legitimately speak of a comparison of the developments in Europe and East Asia.

1 Rapoport, 1980, p. 284
2 Rapoport, 1969, p. 15

The properties of wood

"By applying appropriate tools and techniques to a good piece of timber, a woodworker's imagination is limited only by the nature of his material – a material that often seems to have a life of its own."[1]

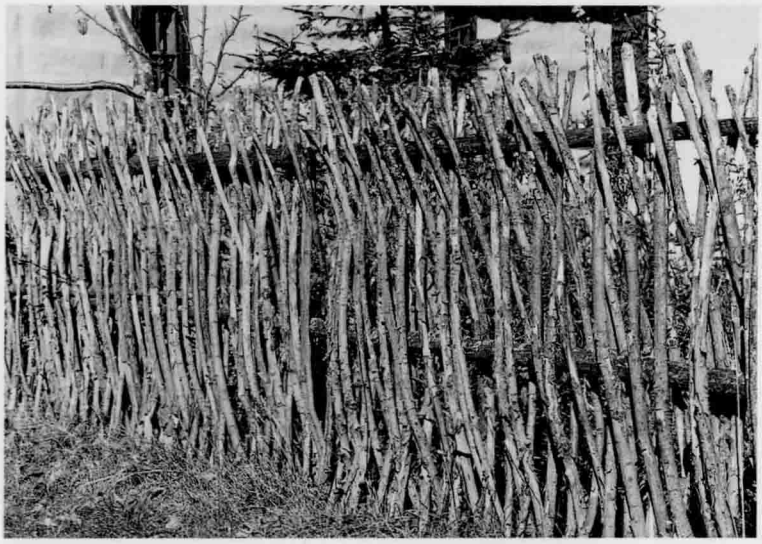
Every material is distinguished by characteristics peculiar to itself. Knowledge of these is a necessary prerequisite for processing the material appropriately. Wood lets us know quite definitely and unpleasantly when it is not being treated correctly, whether due to negligence or lack of knowledge. But wood also obstructs us when we try to unravel its mechanical, physical and chemical properties. Many modern textbooks attempt to present the material in a way which justifies this theoretical approach to its use. Twisted fibres, bows and colour discrepancies are only referred to, if at all, as abnormalities to be cut out; beauty, as a non-technical term, is an unknown word.

All the properties of wood are interlinked. They interact with each other or are dependent on each other in such a way that this textbook-type of classification is quite simply inadequate if we wish to explain the connection between the characteristics of wood and the culture of woodworking.

The loading capacities of timber in tension (Fig. 1) and compression (Figs 2 & 3), in bending (Fig. 4) and shear, i. e. the mechanical properties, need to be considered directly and visually, as apprentices once did on their long way to becoming masters. The practical reappraisal of what had been seen in active work and daily routine was in any case only achieved competently by very few. The size of the cross-section is of fundamental significance for the loading capacity. The oversized members often encountered in older elements, possibly not unaffected by considerations of proportion, i. e. partly determined by aesthetics, undeniably contributed to the preservation of the material. Other authors dispute such oversizing and prove "that the timber constructions investigated from the period between 1000 and 1800 are often loaded to the limit of their capacity."[2] According to David Gilly in 1797: "For example, the machine master Reuss from Dresden cut the heavy truss posts in the town's opera house to suit the machinery in such a way that a narrow opening was created through both truss posts. He was very well aware that the truss posts would remain capable of taking any load likely to be put on them."[3] Examples of oversizing are the (sometimes) original columns of Norway's stave churches,[4] Switzerland's wooden bridges, which are capable of carrying today's heavy road traffic,[5] or Japanese temples and shrines. The fire in the Horyu-ji in 1949 can be regarded as an example of just what stresses wood can withstand even after 1200 years. The colossal dimensions of the columns, each 1.5 m in diameter, are certainly to thank for the fact that sufficient undamaged timber remained to guarantee the survival of a large part of the structure intact.[6] In total contrast to this are the sometimes "stupidity prescribed standardized sizes for all posts which would have been heavier in places if the construction had been logically worked out."[7]

1 The joints of the diagonal bracing members on this bridge between Appenzell and Schlatt in Switzerland are so tightly restrained that settlement at the corner in the left foreground has caused the wood to split.

2 In technical terms the loading capacity parallel to the grain is greatest. However, in a structure, as compressive forces increase so does the susceptibility to buckling. – Cowshed on a farm in Zaunhof, Tyrol, Austria.



4 The pliability of wood can be exploited in very simple ways. – Zuberec, Slovakia.

3 As a rule, horizontal timbers subjected to compressive loads cannot buckle; instead they are crushed. Therefore, the growth rings of rift-sawn wood are placed opposing the compression whenever possible. – Sill of a timber-framed building in Oslo, Norway.

5 The corner column of this barn in Zaunhof, Tyrol, Austria, is made from two older columns. This can be recognized from the lap-joint housings and nail holes of former bracing members.

And yet wood itself is relatively light, as the one time normal transportation of houses and churches indicates quite clearly. The village of Kiscsány in Hungary supplies a rather curious example of this. When in 1764 the local church threatened to sink into the marshy ground, strong wooden axles were laid beneath the sill beams of the building and then fitted with wheels. Oxen, helped by the whole community, then proceeded to pull the church 1,500 m to safety.[8] Even today, we take advantage of this fact which once shaped the term "goods and chattels". In Switzerland old storehouses are, literally, led to a new lease of life as holiday homes![9] In Japan too, there is some evidence to suggest that shrines were built as movable objects. Even today there are customs which require shrines to be carried around on certain festive occasions.[10]

When still usable wood was no longer needed to fulfil its original function, there were sufficient reasons to recycle it. (Fig. 5) It saved its user a great deal of work and, above all, had already proved its worth. Numerous instances of reused timber have been found even in buildings which, even when subjected to closer scrutiny, did not appear to make use of such savings. During repair work, non-original members, carefully removed from other places, have been discovered again and again in the so-called "hidden roofs" (see p. 193ff.) of Japanese temples.[11] Spectacular examples of this procedure are provided by a barn in Jordans, Buckinghamshire, England, built from the wood of the *Mayflower*,[12] or the use of beams and spars from St Mary's Church in Munich, Germany, to make violins.[13]

"Out of all the natural materials wood has the most balanced characteristics and can be relatively easily worked."[14] This is probably one of the reasons why timber has been used for building even in Iceland, which has no trees.

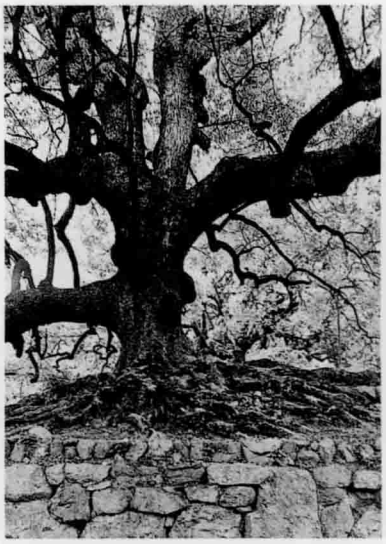
Humans were at least at one time convinced that each tree had a soul. In Japan the view is held even today that such a soul can also be bestowed on pieces of wood. On the surface this soul materializes in the beauty of the wood. The close bond with the material is revealed not least in the fact that it remains almost totally untreated.[15] Only if you walk barefoot or in socks across a wooden floor will you appreciate its texture, learn the difference between a few wide planks and many narrow ones. They are chosen for the beauty of their grain, and that depends

to a large extent on the conversion of a trunk. The deep admiration, indeed almost religious worship which trees are assigned in Japan is expressed in one word: *kodama*, the spirit of the tree.[16]

If we look for positive characteristics in wood, then one of the first that comes to mind is its warmth. And this can be actually depicted. The average wall thickness of the houses in Goms, a valley some 1,500 m up in the Swiss mountains, is only 140 to 150 mm.[17] However, this definition would not correspond to our modern concept of warmth; a constant room temperature according to our tastes would very quickly kill off traditional timber construction.

Looking at a tree we might be able to glean how the forces of nature act on it and within it. (Fig. 6) The older the tree, the more it might have to tell us – what chaos it has had to face, how it overcame this, how it regained its balance again and again, defying the force of gravity. It demonstrates a diversity of forms which we only have to copy in order to employ them properly. It is not so very long since we knew how to use the tree as nature gave it to us. For those for whom the tree was too short to span the required width, they had to accept intermediate posts, those "tyrants of the floor layout". (Figs 7 & 8) It was only the development of the truss post (see p. 186 ff.) which allowed unsupported spans to be gradually increased. (Fig. 9)

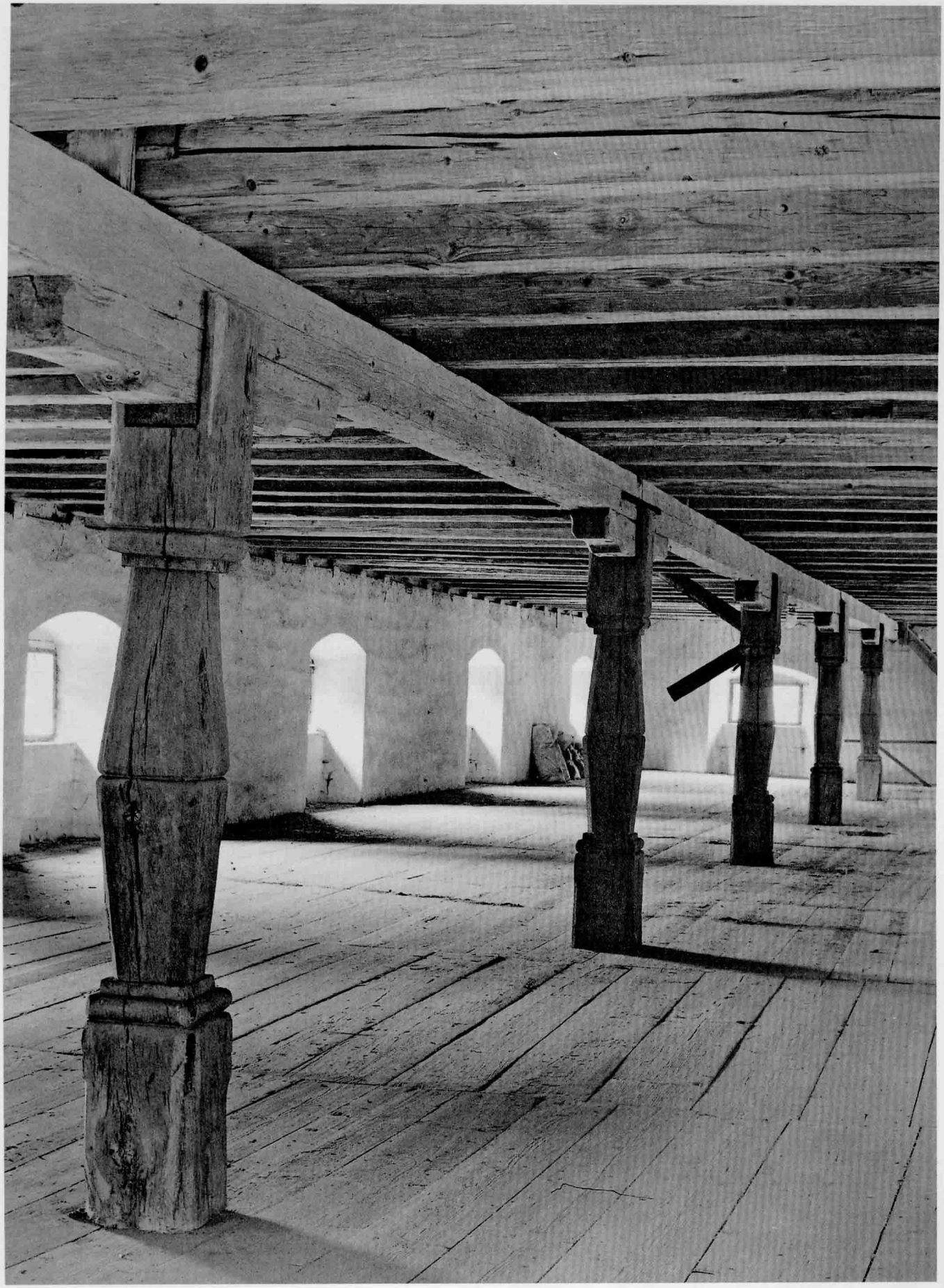
The bond between the woodworker and the wood itself had already begun back in the forest. The location and appearance of a tree were decisive criteria for its later use. The master builder himself selected it. The farmer, in the capacity of master builder, observed the forest, whether it was his or not, and so knew about just a few more details which could be significant



6 Camphor tree in front of the Shoren-in in Kyoto, Japan.

8 The roof in the Senyo-kaku in Miyajima, Hiroshima, Japan, is supported by columns arranged on a grid.

9 Two-part truss posts carry the tie beams in Schloß Thürntal, NE Austria.



7 Granary beam supported on columns.
– Primmersdorf, NE Austria.