NOME: JOHN STEWART e CHARLES COSTAIN, Chimici Conservatori, Parks Canada - KEITH BLADES, Specialista nel restauro di costruzioni in muratura, Lavori Pubblici - Canada.

TEMA: MATERIALI

TITOLO: ESAME E TRATTAMENTO DI SFALDAMENTI MURALI CAUSATI DA SALI. COMPLESSO DEL PARLAMENTO DI OTTAWA.

SOMMARIO:

L'ala Est del Complesso del Parlamento di Ottawa è uno dei più significativi elementi del patrimonio architettonico canadese. Nel corso di recenti lavori di restauro furono rilevati gravi sfaldamenti nei muri interni dell'entrata principale, nella torre di Sud-Ovest.

Il presente saggio tratta del programma di ricerca che ha permesso d'identificare la causa del fenomeno e dei vari metodi di consolidamento e di prevenzione consigliati per evitare ulteriori danni.

Le analisi chimiche delle efflorescenze e di alcuni campioni prelevati dai muri, insieme ad un esame architettonico della torre, hanno permesso di attribuire tali sfaldamenti alla penetrazione di acqua piovana contaminata.

Il metodo di consolidamento intrapreso fa affidamento sul regolare mantenimento delle superfici esterne delle costruzioni e sulla sorveglianza delle condizioni atmosferiche all'interno della torre per eliminare ogni possibile danno futuro.



NOBUO ITO

# WOOD AS A MATERIAL FOR JAPANESE BUILDINGS

## 1. *The Kinds of Timbers*

Japan is situated in the temperate zone and has a mild, humid climate which has favoured the growth of abundant forests throughout the country, therefore wood has been the most important material for Japanese buildings throughout the ages.

The trees growing in Japan could be grouped into the broad-leaved and the coniferous trees. Of the two groups, the conifers have been used for the material for buildings, and among them, notably the Japanese cypress (Chamaecyparis obtusa Endl.). The timber of this tree has been treasured as material for buildings, since the olden days, because of its fine grain, beautiful texture, high durability and pleasant aroma. However, as it has become more and more difficult to be obtained, due to the uncontrolled felling throughout the ages, it has been replaced by the Japanese pine tree (Pinus densiflora Sieb. et Zucc. and P. thunbergli Parl.) since about the 14th C. A.D. Though the pine tree is a very good material as far as its durability is concerned, it easily exudes resin and suffers from attack by insect pests. Further, a straight timber could not be obtained easily by our ancestors with their still undeveloped technique, because this tree tends to form a sinuous stem unless in a favourable environmental condition.

Among the conifers, there is also the Japanese cryptomeria (Cryptomeria Japonica D. Don) which grows abundantly in Japan. Though this tree has been used since the olden days as a useful material for smaller objects because of its fine texture and softness which facilitates the workmanship, it has been considered unsuitable for buildings because of the doubt over its durability and its susceptibility to weathering. However, it can be found in some of the lighter buildings such as the tea houses of the *sukiyazukuri* buildings of the period after the 17th C. It is also used very often as the framework of sliding screens, *fusuma* and *shoji*, because it is very light and does not exude resin. Further, it is also used for shingles just as sawara cypress (Chamaecyparis pisifera Endl.).

Another tree belonging to the broad-leaved trees used extensively as a building material is the Japanese zelkova (Zelkova serrata Makino) which can be found in buildings starting from the 8 th C. The timber of this tree is used in such parts of the building as the corners where a great amount of weight is applied. This is because the wood of this tree is very resistant against compression. Further, its particularly beautiful texture caused the people after the 17th C. to prize buildings constructed only of this wood.

After the 17th C., it was forbidden to use the important coniferous trees and zelkova for buildings other than such religious or public buildings as temples shrines and palaces. Therefore, the ordinary people built their houses with timbers of broad-leaved trees such as *tsuki*, the so-called " blue Japanese zelkova ", Japanese chestnut, and western chinquapine grouped as miscellaneous trees, which, though hard and difficult to work on, are very durable.

After the Meiji era, the Taiwan cypress Chamaecyparis taiwanensis Masamune et Suzuki) was imported from Taiwan for reparing old buildings. Today, a great amount of timbers of various trees are imported from the United States, Canada and Siberia to meet the needs of the contemporary building industry, though they are never used for repairing the cultural property.

## II. *The Technique of Working*

The only way to discern the technique of carpentry of the olden days is to judge from their traces on the surviving old buildings. We can judge from what we can find that the techniques have not changed so much except for a little development seen around the 15th and the 16th C.

First of all an axe was used to cut trees from the forests and mountains, an instrument used probably all over the world. The timbers thus acquired were then floated on the river, tied together as rafts, and transported over the waters to the port nearest to the place of construction, and stored on the water till put to dry out for use. This seemingly slow process of transportation practised in ages past until trucks and trains recently took over, was actually a very important and an advantageous step providing time for the timbers to dry in a very natural way.



The structural members of the Japanese buildings seem, at first sight, to have various uncountable shapes. Whether curved, sculptured or ornamented, whether rhombic or L-shaped in section, however, they all come from the basic shape of the long tree log cut along the fibers with round, square or wedgeshaped section.

The technique for cutting these basic sectional shapes was developed in two stages, one before and the other after the 15th C. A.D. Before the 15th C. when the rip-saw had not yet been invented, wedges were hammered into the side of the logs lengthwise at certain intervals to split them in half. Then the half log was split again to obtain a member with quarter-circular section. The members with square or rectangular section could be obtained from this member. If the quarter-circular section was split further radially, a wedge-shaped section could be obtained.

Such a technique of shaping the members was workable only with logs with straight grains and without knots. Further, the yield rate obtained by this technique was generally very low with probably only about 10% of the whole log produced into usable timber.

The members obtained by this splitting of the logs were then finished roughly by shaving the surface with an adze. This was the final finish, for the members to be used for the hidden parts of the building. However, the surface of the members for parts that could be seen were planed with the spearshaped chisel called the *yariganna*. Although this was the final finish for most of the members including those used for dressing, sometimes when a very refined finish was necessary, the surface was smoothened out with scouring rush because planing with the *yariganna* left on the surface indentations shaped like the leaves of the willow tree.

In addition to the above method, the saw had been used to cut lumbers widthwise since the olden days. Though this has remained the same even till today, the saw used in those days was leave-shaped, and had a row of blades lined along the convex edge of the saw. This was a multipurpose saw that could start sawing from any part of a timber even starting from a hole.

As for developmens after the 15th C. there are two important inventions. One is the invention of the rip-saw called *oga*, the great saw. The second was the invention of the plane with a stand. It is to be noted here, that the usage of saw and plane in Japan is the opposite of those of Europe because they cut or plane when they are pulled.

The members thus obtained in rough shapes are further worked to more accurate sizes and shapes. First of all, the sap wood is eliminated from the members to be used for the structure because it has the defect of being susceptible to insect pests. Then the timbers are worked to regulate their sizes, to from jointings of to make curves. In this process L-shaped squares and wooden inking tools are used to draw working lines. The L-shaped square is a steel-made rule with scales on both sides as well as the vertical and horizontal sides and its peculiarity is that the scales on one side of the vertical side is $\sqrt{2}$ times as long as the rest. This L-shaped square enables the architect to solve practically the complicated problems of construction, for instance he can mark the necessary lines on the members lying in the 45° angle. The marked timbers are worked with saws, chisels, gimlets, etc. Although chisels and gimlets have developed along with time, their principle forms have always remained the same.

## III. *Construction*

In Japanese architecture, all the members must be cut to the correct measurements and worked to the necessary jointings before assembling, and the changing of any of these worked elements during the construction work is considered a carpenter's disgrace.

Since the object of this report is to elaborate in the characteristics of wood as a material and the utilization of these characteristics, and not to explain the structure of the wooden buildings, the explanation on the workmanship such as the jointings to put the members together will be omitted.

The wood is a very resistant material in the direction of fibres with its compression strength reaching as high as 400 kg/cm$^2$, which is equal to the value expected of concrete. In contrast to this, the compression strength in either the tangent or the radial direction of the tree rings is quite weak having only a tenth of that in the fibre direction. However, this strength can rise to a certain extent when the earlywood is crushed by the compression and latewood is piled up to increase the strength. This is the general tendency of the strength of wood. However, these values of strength are not acknowledged as the maximum values for the calculation of contemporary wooden structures. Instead, a tenth of these values, 50 kg/cm$^2$ for fibre direction and 5 kg/cm$^2$ for the other two directions, is used as allowable stress. The reason for having this safety factor is because wood is a material with flaws such as knots, cracks and cross grains, and from which constant strength can not be expected.

The old buildings, in general, have for their structural members timbers with straight grains with very few knots. Therefore, they may be



assumed to have very sturdy structure, although their structural strength can not be calculated exactly with modern methods. The greatest characteristic found in the usage of timbers in the old buildings is the fact that the timbers were used with the assumption that a considerable amount of stress concentrated at certain points. The most representative example of such a point is the bottom of the column standing directly on the rough, unworked surface of the foundation stone. Here, the bottom surface of the column is carved out and only its peripheral part touches the stone. This helps the column to fit the foundation stone well, because a part of its bottom surface is crushed when the weight of the building is put on it.

This is nothing other than an example of a workmanship that takes the ultimate strength of wood into full consideration. The same can be seen at various other parts of a building. It may almost be said that wherever members are piled up in the process of construction, the wood is crushed more or less and therefore the height of the whole wooden building shrinks, with it the structure becoming stable. It is said that when a five-storied pagoda is built, the building shrinks more than 10 cm in whole. Another destiny that befalls a wooden building during its construction is the creep phenomenon of wood. This phenomenon is seen most notably at such parts as the eaves built in a cantilever construction, because the creep is extreme especially when a very heavy weight such as that of the tiles is put on that part. Therefore, a carpenter must construct the height of the eaves a certain measurement higher than the designed height. This surplus measurement called " agekoshi " can be calculated only through the long experience of a skillful carpenter.

## IV. *Deterioration*

As the years go by, the wood used for buildings will deteriorate in various ways.

The first kind of deterioration is the weathering. It is the thinning of wood on the surface, and is caused by the various influence of the natural forces such as the sun, air, wind and dirt, though its mechanism has not yet been clarified fully. The weathering first starts with the earlywood leaving only the latewood in ribs, but gradually affects also the latewood, and after that again the earlywood. This process is repeated. The weathering proceeds the quickest at the foot of a building at such parts as the surface of a column directly above the side members such as the *nageshi.* The speed of weathering is about 3 mm/100 year. The foot part of the *Horyuji* temple, the oldest building in Japan said to be built about 1300 years ago in the 7th C., is worn out as much as over 3 cm at places.

The second kind of deterioration is the rotting. Though some trees such as the Japanese pine is very well preserved in water, most of the trees very easily, become rotten in water. The cause of rotting is the decomposition of wood by the wood rotting bacteria.

The third kind is the deterioration by insect pests. Termites propagate with the presence of water. The termites first come out of the earth, get into the colums from their roots, climb up the building gradually and finally cause a great damage. Other insects that cause damages to the wooden building are wood borers and bees which bore holes in the building.

The fourth kind of deterioration is the deformation through the creep phenomenon. The timber used horizontally sags with time, making the building unstable. However a phenomenon such as this is a characteristic natural to wood and cannot be helped.

The fifth kind of deterioration occurs at such part as the joints. The cause of this type of deterioration is the horizontal force originating from earthquake, wind, vibration, etc. When the joints are weakened, the whole building starts to lose its stability. When there is the leaking of rain in addition the loss of stability is even greater.

## V. *Care and Restoration*

As the old wooden buildings still surviving in Japan are the precious heritage of the past that have escaped various hazards, we must endeavour to preserve these buildings as much as possible for the coming generations.

One way to preserve the wooden buildings in a good condition is to eliminate all effect of water — especially in a country situated in a humid and temperate region such as Japan. In order to do this, we must constantly be on guard against the climbing of water from earth and the leaking of rain water. For example, a simple care taken, such as eliminating of grass or avoiding of placing things around the buildings, can prove to be very effective. Further, the leaking of rain water can be prevented by regular re-roofing at certain intervals depending on the materials of the roof.

The second way is to avoid the insect pests. For example, to prevent the destruction of buildings by termites, the termite tunnels must be discovered and eliminated at an early stage.

The third way is to restore the buildings regularly, retightening the frameworks once in a hundred years and completely dismantling the building once every two or three hundred years, since loosening of the buildings caused by the vibration throughout the years, creep or partial destruction cannot be avoided. When a building is dismantled, the rotten and destroyed parts are restored by replacing them with new wood. In the worst cases, a whole member must be replaced. In the recent years, a material, a mixture of microballoon and epoxy resin, whose specific gravity does not differ so greatly from wood, and which can be worked very easily with saws and chisels, has been developed, thanks to the development of synthetic resins. This material can be used as a supplementary material for wooden members, though at the present stage it is advisable to replace wood with wood as much as possible rather than with this new material, because it has the defect of not having the exact qualities of wood such as the strength in the fibre direction or stability against temperature change.

NOM: NOBUO ITO - Japon.

THEME: MATERIAUX

TITRE: LE BOIS EN TANT QUE MATERIAU DES MONUMENTS JAPONAIS.

RESUME:


Le bois a toujours été le plus important des matériaux pour la construction des monuments japonais. Depuis très longtemps, le bois des cyprès japonais a été considéré comme le matériau de construction le plus précieux en raison de ses nombreuses propriétés exceptionnelles. D'autre part, le pin, le « cryptomeria » japonais, le « zelkova » japonais, le châtaignier japonais, et le « chinquapine » de l'ouest ont également été utilisés.

Autrefois, le bois était fendu avec des coins, coupé à la scie, dégrossi à l'herminette, et aplani avec un ciseau lancéolé. Après le 15ème siècle, l'invention de la scie à refendre et de la planeuse sur pied a permis à la technique de production des matériaux de construction d'évoluer rapidement.

Avec le temps, les constructions en bois des monuments se détériorent. Les causes en sont l'exposition aux intempéries, la pourriture, les insectes, la végétation, et les déformations.

Les monuments en bois exigent un soin quotidien et des réparations périodiques. Lors d'une réparation d'un monument, le remplacement de certains éléments est inévitable. Ces dernières années, un matériau synthétique fait de bulles microscopiques et de résines époxydes dont les propriétés sont semblables à celles du bois a été mis au point.




NAME: NOBUO ITO - Japan.

SUBJECT: MATERIALS

TITLE: WOOD AS A MATERIAL FOR JAPANESE BUILDINGS.

SUMMARY:


Wood has been the most important material for Japanese buildings through the ages. Since ancient times, the timber of the Japanese cypress has been treasured as a material for building because of its various excellent characteristics. Besides, pine tree, Japanese cryptomeria, Japanese zelkova, Japanese chestnut, and western chinquapine have also been used.

In old days, timbers were split with wedges, cut with saw, shaved roughly with adze and planed with the spear shaped chisel. After the 15 th century, when the rip-saw and plane with stand were invented, the technique of producing building materials made a step forward.

As the years go by, deterioration occurs in the timbers of buildings. The causes are: weathering, rotting, insects, vegetation and deformation.

Wooden buildings require daily care and periodical repairs. Whenever a building is repaired, the replacement of some elements is inevitable. In recent years, a synthetic material made of micro balloons and epoxy resins whose characteristics are similar to those of wood have been developped.

NOMBRE: NOBUO ITO - Director General del « National Research Institute of Cultural Properties », Tokio - Japon.

TEMA: MATERIALES

TITULO: LA MADERA, MATERIAL DE EDIFICACION EN JAPON.

SUMARIO:

A través de los siglos, la madera fué el principal material de los edificios japoneses. Desde tiempos remotos, el tronco del ciprés japonés fue apreciado como material a causa de sus innegables características. Por otra parte, también fueron utilizados el pino, el criptomeria japonés, el « zélcova » japonés, el noyal japonés y el « chinquapine ».

En la antiguedad, los troncos eran hendidos a golpes de cuña, cortados a lo ancho con sierras, descortezados con doladeras (azuelas) y aplanados con el cincel. Después del siglo XV, cuando se inventaron nuevas sierras y el cepillo, avanzaron las técnicas de producción para las partes del edificio.

Con el transcurso de los años, se producen deterioros en la madera del edificio. Las causas son la intemperie, las plagas de insectos, la putrefacción, el fenómeno de usura y deformación.

Los edificios de madera exigen cuidados cotidianos y reparaciones periódicas. Cada vez que se repara un edificio, resulta inevitable reemplazar algunos elementos.

Recientemente, se ha desarollado un material sintético hecho con microesferas cuyas características son similares a los de la madera.



Имя : НАБУО ИТО (Япония)

Предмет : МАТЕРИАЛЫ

Название : ДЕРЕВО КАК МАТЕРИАЛ ДЛЯ ЯПОНСКИХ ПОСТРОЕК

Краткое Описание : В течении веков дерево было самым главным материалом для Японских строений. С самых древних времен дерево Японского кипариса рассматривалось как драгоценнийший материал для постройки благодаря его разных замечательных свойств. Наравне с соснами, Японские криптомерии, Японские зелковы , Японский каштан и Северно-Американсая сосна "чинкуэпайн" так же употребляются.

В былые времена дерево раскалывали при помощи клиньев, пилили пилами, грубо обтесывали скребком и окончательно отделывали копье -образным долотом. После 15го столетия, когда были изобретены очень большие пилы, для прямой распилки больших кусков также как и рубанок на подставке с вертящимся ножем, техника производства составных частей для постройки сделало шаг вперед.

С прохождением времени дерево строений портится. Причины этому : погода, гниение, насекомые, ползучие растения и искривление.

Деревянные строения нуждаются в ежедневном уходе и переодическим починкам. При починки неизбежна замена некоторых частей. В последнии годы были выработаны синтетический материал, состоящий из чрезвычайно маленьких шариков и древесная смола, "эпокси", имеющая черты схожие с теми что у дерева.

NOME: NOBUO ITO - Giappone.

TEMA: MATERIALI

TITOLO: IL LEGNO QUALE MATERIALE USATO NEGLI EDIFICI GIAPPONESI.


SOMMARIO:

Il legno è stato il più importante materiale usato attraverso i secoli negli edifici giapponesi. Sin dai tempi antichi, le travi di cipresso giapponese sono state utilizzate come materiale per costruzione a causa delle sue varie ed eccellenti caratteristiche. Inoltre, il pino, il « criptomeria » giapponese, lo « zelkova » giapponese, il noce giapponese e il « chinquapino » occidentale sono stati usati.

Nei tempi passati, le travi erano tagliate con asce, tagliate da seghe, sgrossate e spianate con una forbice lanceolata. Dopo il 15° secolo l'invenzione di una sega speciale e della piallatrice a piede ha permesso alla tecnologia dei materiali da costruzione di fare notevoli passi avanti.

Col tempo, deterioramenti sono avvenuti nelle travi degli edifici. Le cause sono le intemperie, la putrefazione, gli insetti, la vegetazione e le deformazioni.

I monumenti di legno richiedono cura e riparazioni periodiche. Quando un edificio viene riparato, la sostituzione di alcuni elementi è inevitabile. Negli anni recenti, un materiale sintetico fatto di piccole sfere e di resine epossidiche, le cui caratteristiche sono simili a quelle delle cellule del legno, è stato utilizzato vantaggiosamente.






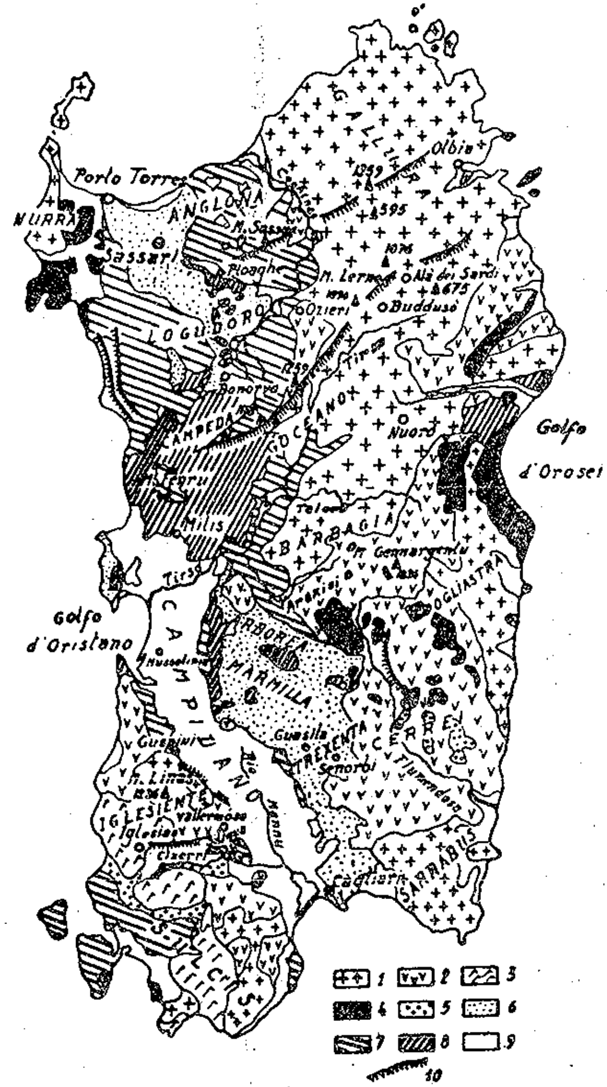


Fig. 1 - Schema geologico della Sardegna: 1) granito; 2) scisti cristallini; 3) calcari primari; 4) calcari giurassici e cretacici; 5) calcari e grés eocenici; 6) calcari e marne miocenici; 7) trachiti; 8) basalti; 9) quaternario; 10) principali fratture tettoniche (dal Le Lannou, Pastori e contadini .....).