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## **Changes in the Chinese Timber Structures Building Code**

## **Änderungen in der chinesischen Holzbau-Norm**

## **Cambi nelle norme di costruzione in legno cinesi**

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# Changes in the Chinese Timber Structures Building Code

## Abstract

The introduction of the establishment, the main contents and the new additional parts of national standards of timber structures of China is given in this paper. The codes are Code for Design of Timber Structures, Code for Construction Quality Acceptance of Timber Structures, Standard for Methods Testing of Timber Structures and Technical Code for Partitions with Timber Framework.

**Key Words:** Timber Structure, the degree of dimension lumber, light wood frame construction, metal plate connection, construction quality, test method

The extremely uneven distribution, the unreasonable structure and the low quality of forest in China are the very reasons of the serious lack of forest resource for buildings. Consequently, the engineering application of timber structures has been great limited in the recent 30 years, during which the research of timber structural technology had no development. The technology and the establishment of the codes were much backward to the international advanced level at that time. In order to protect the forest resource, government has taken a lot of actions to reduce the amount of forest cutting, carried series policies to encourage the importation of timber products. A large number of imported dimension lumbars and engineered wood products are applied to the engineering programs. Therefore, the work of the establishment and recension of the codes for timber structures started. Up to now, the current national standards of timber structures of China are as follows.

- (1) Code for Design of Timber Structures GB 50005-2003;
- (2) Code for Construction Quality Acceptance of Timber Structures GB 50206-2002;
- (3) Standard for Methods Testing of Timber Structures GB/T 50329-2002;
- (4) Technical Code for Partitions with Timber Framework GB/T 50361-2005.

## 1 Code for Design of Timber Structures GB 50005-2003

The Code for design of timber structure GB50005-2003, established by the China Southwest Architectural Design & Research Institute and Sichuan Institute of Architectural Science, was implemented on January 1, 2004. This version is the recension of the original code GBJ5-88.

### 1.1 Background of Code for Design of Timber Structures

In 1952, the first version of engineering construction standard of our country was issued. It was called the Temporary Standard for Building Design with the content of timber structure section. Afterwards, the Temporary Standard for Design of timber structure was promulgated in the year 1955. This standard provides the basic condition for the correctly using the lumber and the security designing of timber structure construction.

Due to the demand of third-line constructure, the application quantity of timber structure in large or middle scale construction have risen during the year 1964 to 1965. However, some quality problems were made because the technical personels were not familiar with the feature of local lumber. In order to cooperate with the need of economic construction and relevant code establishment, a number of research works have done during this period. The researches covered extent from the basic calculation theories to expanding tree species for construction use. And fruitful results have been achieved.

On the basis of these results, the revision of the code No. 3-55 was finished, with the first draft in 1968. But due to various reasons, the code has not been completed smoothly. The applications of wooden structure were basically in a state of chaos at that time. The recension works have not been over until 1973, with promulgating the Code for design of timber structures GB107-73 and setting up corresponding management group at the same time. In GB107-73 standard, selection criteria of plywood and lumber are separated for the rational use of materials;

In the moisture content regulations, the technology for using the timber whose water content is greater than 25% was added; According to the test results, the vertical bending coefficient formula and tooth joint formula of compression members were amended; In addition, in order to strengthen the space stiffness, entirety and shock-resistant capacity of timber structure, the contents of support and anchor were increased. A timber structure design system which conforms to Chinese specific situation has basically been formed.

In October 1982, the Code for design of timber structure GBJ5-73 was amended based on the requirements of the former State Construction Committee (81) No.546 Document. The the revision work was finished in September 1987. In October 1988, the Code for design of timber structure GBJ5-88 was promulgated. The main content of this amendment is:

- The revision of timber structure design criteria and material intensity classification;
- The modification of eccentric compression formula of timber structure members
- Amendments of correction intensity coefficient of tooth joint;
- The first addition of the content of the glued timber structure;
- The recision of the content of timber rot-proof and fire resistance;
- The addition of construction quality which is required by design of timber structure.

In 1999, in order to satisfy the needs of China's economic development and the development of the market economy after China's WTO accession, to accelerate the construction of China's wooden structure and the development of China's timber industry, the Code for design of timber structure GBJ5-88 was revised according to requirement of National Construction Section No.37 Document of the Ministry of Construction. The amendment was completed by China Southwest Architectural Design & Research Institute, Sichuan Institute of Science, Harbin Industrial University, Chongqing University, Sichuan Fire research Institute of Ministry of Public Security, Sichuan University, Suzhou Science and Technology Institute and other units.

American Forest and Paper Association, Canadian architectural design standards committee, New Zealand Forestry Commission and the European Wood Products Association all have sent representatives to this revision work. The revision has been officially launched since the end of 1999, lasting more than three years.

According to the No.189 post issued by the Ministry of Construction on October 26, 2003, The Code for design of timber structure GB50005-2003 has gone into effect since January 1, 2004, and meanwhile the original GBJ5-88 was abolished at the same time.

In July 2004, partial amendments were made on the national standard Code for design of timber structure GB50005-2003. The local amendments for approval were completed in September 2005. And the Ministry of Construction promulgated partial amendments of GB50005-2003 in November 2005.

## 1.2 Compilation procession of the Code GB50005-2003

In the process of revising the standards, four meetings and five symposia were held. During the process of making the first draft and the revised draft, the editors made the code with a lot of reference from different provinces, autonomous regions, local construction and research departments, Universities and individuals.

The content of the wood fire resistance part is based on the suggestions of more than 50 public security related offices, the fire research institutes and related code management agencies.

The revision of code received international widespread attention on July 2002, international seminar about the first draft was held in Beijing. The participants came from the European Union, Canada, the United States, New Zealand, Finland, Australia, Germany and other countries and regions.

The seminar caused tremendous repercussions. This is the first time to solicit opinion abroad in the revision of our national standard. It is an innovative work.

In the process of code revision, the revision group was invited to the United States, Canada, Northern Europe, New Zealand and other countries for academic exchanges and technical inspection. In all feedback, based on extensive research and repeated discussion, design and application of timber structure and advanced technology in foreign countries were summarized, shaping the the final draft.

In January 2003, the conference of the first draft of Code for design of timber structure was held by Standard Norm Department of Ministry of Construction. According to the opinions and suggestions of the Expert Group, The audit draft has been amended and finally became the final document requested for authorization to reported to the Ministry of Construction for final approval form.

## 1.3 Main content of the Code GB50005-2003

There are 11 chapters and 16 appendices in the Code GB50005-2003. The main content is as follows:

### (1) General rules

It is mainly used for clarifying the the purpose and scope of application of this code.

The standard applies primarily to the residential constructions, single-storied industrial buildings and multifunction large or medium-sized public buildings. And it isn't applicable to the design of temporary construction facilities or instrument structure, such as scaffold, templates, mast and so on. The general rules also explain clearly that: on the condition of ensuring the project quality, it is in line with China's forestry policy to gradually expand the use of tree species, especially the use of fast-growing species.

### (2) Nomenclature and sign

It is mainly used for the explanation of the nomenclature and sign in the code.

### (3) Material

There are relevant specifications about load-bearing structural materials; For example : there are three degrees for log, square timber & plank in ordinary timber structure; three levels degrees for the material of glued timber members; the material of dimension lumber used in Light wood frame construction divides into seven degrees. There are also specifications for imported timber.

**(4) Basic specifications for design**

It has defined the design principle of wooden structure, intensity design index of structure timber and deformation limits. The intensity design indexes of imported dimension lumber are included.

**(5) Calculation of timber structure members**

The code provides the formula of bearing capacity of different timber members. It includes axial tension members, axial compression members, member in bending members, member in two-way bending members, stretch bending and press bending members.

**(6) Calculation of timber structure joints**

It stipulates the constitution requirements of tooth joint, bolted connection and nail connection. And the constitution requirements of toothed plate in dimension lumber are also included.

**(7) Sawn and round timber structures**

It gives the all kinds of constitution requirements of sawn and round timber structures. For example: ordinary timber truss, scuttle, support system and constitution requirements in the earthquake region.

**(8) Glued timber structures**

It provides the general specifications, design requirements and constitution requirements of glued timber structures.

**(9) Light wood frame construction**

It determines design requirements and constitution requirements of light wood frame construction. This chapter is the newly addition in the revision. It is the fruits of researches and the imbibition of foreign experiences on timber structure design and application.

**(10) Fire resistance of timber structure**

It gives relevant requirements on fire resistance of timber structure. The requirements include the combustibility and fire-resisting limits of members, the number of plies, the maximum permitted length and the fireproof partition area in different floors, and also the fire-resisting spacing.

**(11) Prevention of timber structure**

The code stipulates the prevention of corrosion and insect prevention requirements in timber structures.

**(12) Sixteen appendices**

It includes the wood material standards, field identifying points and chief material properties of main imported lumber, intensity design index of converted visually stress-graded imported lumber, and relevant requirements of light wood frame construction, etc.

## 1.4 New addition in the Code GB50005-2003

Many contents in the Code GB50005-2003 is brand new in the national standard. It fills the gaps in related technology of Chinese timber structure. Compared to the original code, the main newly added contents are:

- (1) Reliability index of timber structure was calibrated according to the new national "The design of construct the structure reliability unifies standard "and "Load code for the design of building structures".
- (2) National visually stress-graded and machine stress-graded system of dimension lumber were firstly established. And with the cooperation of several continents, design index transition ways were successfully worked out. The design indexes of dimension lumber in North America, Oceania and Europe were switched;
- (3) Added some contents: the specifications of the imported lumber application, the intensity sampling specifications of imported dimension lumber and field identifying points and chief material properties of main imported lumber;
- (4) Partially amendments and supplements were done to the member calculate section;
- (5) Tooth joint was added to the wooden structure connection;
- (6) Partially amendments and supplements were done to glued laminated timber structure;
- (7) The chapter of light wood frame construction was added;
- (8) Taking into account of the feature of timber construction, the content of fire resistance was set as a separate chapter;
- (9) Enriched the content of wooden structure protection (the prevention of corrosion and insect prevention).

The new addition above provided a reliable technical support to the wooden construction in China, especially the light wood frame construction, and application of imported lumber.

## 2 Code for Construction Quality Acceptance of Timber Structure GB50206-2002

### 2.1 Historical development background of Code for Construction Quality Acceptance of Timber Structure

The national standard Code for Construction and Acceptance of Timber Structure GBJ 5-64 was promulgated in 1964. It is the first code about the construction and acceptance of timber structure. In 1973, the Code GBJ 5-64 was revised. In this revision, amendments and supplements were done to the contents of lumber grading, material standards, wood preservation, production and installation of timber structure.

Since 1980, the revised version of the GBJ 5-64 has been revised and adapted edited, re-promulgating the Code for Construction and Acceptance of Timber Structure GBJ 206-83. This revision was charged by Harbin Institute of Technology. It is aimed at the actual situation of China's timber supply, expanded the scope of the use of tree species, refill the research result experience and the years of Chinese engineering practice of timber structure.

According to the requirement of National Development and Reform Commission, the Code GBJ 206-83 was revised in 2002. The revision was completed by Harbin Institute of Technology, China Academy of Railway Science, Northeast Forestry University, Tianjin Fire research Institute of Ministry of Public Security and Urban Planning and Design Institute of Wenzhou. The original Code for Construction and Acceptance of Timber Structure and Standard for Quality Inspection and Assessment were merged to a new national standard Code for Construction Quality Acceptance of Timber Structure GB50206-2002. The new code has been put into implementation since July 1, 2002.

## 2.2 Main content of the Code GB 50206-2002

There are eight chapters and two appendices in GB 50206-2002. Except the general rules, Nomenclature and basic specifications, the main contents are:

### (1) Square timber and log structure in Chapter 4.

Square timber and log structure in China are mainly used in wooden roof system which is supported by brick walls. Tooth joint and bolted connections are normally used. According to long-term research and engineering accident, the code stipulates that:

- All the bearing members must meet standards to prevent accidents. Wood Members failed to meet the standards requirements, e.g. There was an accident that the bottom chords and their connect plates was broke because the knags were too big and the wood grains were over the requirements.
- The limits of members profile, the bearing situation and environment moisture must not to be overpassed, which affect not only to prevent the excessive deformation, but also to prevent serious accidents. If the wood moisture content exceeds the limits, or even wet lumber is applied, member will seriously crack, especially making the whole roof excessive deformation.

To guarantee the construction quality of timber roof, the production and erection quality of trusses and purlins should be checked, and also the safety and quality of roof wooden skeleton. To ensure the roof longitudinal stiffness, the institution of top chord lateral bracing shall be inspected. The support system is anchoring with roof top chord & gable wall. The anchorage reliability should deserve special attention.

### (2) Glued timber structure in the Chapter 5

Glued timber structure is composed of glued laminated timber. The original content in the code came from in the technologies of former Soviet Union. The technologies have been inspection through pilot project. In this code, the classification standard & the testing methods of glued timber were referred to ISO/TC165 & European or American standards as much as possible. It will be convenient to check the imported glued laminated timber structures.

This code classifies the veneer sheet into three grades according to our national convention. The material quality standard is basically at the same level with international standards. The compulsory clause in the code requests that veneer sheets in all grades must conform to the specifications of material quality standard table. When classifying with the cooperation of the elasticity coefficient & visually stress-graded, besides the inspection of the visually stress-graded material, the inspection of elasticity coefficient still must conform to the experimental methods in appendix A.4.

Original regulations only require testing the shear strength of the specimen glue-line. The specimen is produced at the same time with the glued members. At present, the specimen which is intercepted from produced glued member must be inspected in the international verification testing. The code stipulates the requirement & index of shear strength & durability of testing glue-line.

Finger joint the key technologies with involves security. Therefore, the code requests that the timber flaws and processing deficiencies in the scope of finger joint must not overpass the limits. And it recommends the flinger joint profile according to the research results of our country. In order to guarantee the quality of glued timber structure, quality of production quality and appearance should also be checked.



(3) Light wood frame construction in the Chapter 6.

This chapter was newly added to the content of this amendment. It was compiled on the basis of research on relevant North America criteria.

If the profile of the dimension lumber is smaller, the lumber flaws & processing deficiencies will effect more seriously. And the flaws or deficiencies will be sealed in the frame for a long time. Therefore, the code requests that the material of dimension lumber should conform to the specifications of material quality standard table. The moisture content must be controlled to below 18%.

Except the dimension lumber of light wood frame construction, the consumption wood-base plate is much greater. Because its quality affects the structure security & function, the code requires that there must be concentrated dead-load & uniform load test on the wood-base plates. Its ultimate bearing capacity & maximum deflection must conform to the specifications.

The main joint in the light wood frame construction is ordinary wire nail joint. To ensure safety and reliability of the connection, there are some relative regulations on the nail & the nail joint in the code.

(4) Prevention of timber structure in the Chapter 7

China is the hometown of the timber constructions, but the wooden buildings are almost non-existent. Only in Shanxi Province can we find wooden buildings which have been preserved for hundreds of or thousands of years. It is benefited from the local dry climate. The reason of the ancient wooden structure destruction is the war, the fire or the decay & worm (the chief is termite).

The service circumstance is classified into three grades. The classification is affected by the factors, such as: the moisture condition, the insect damage extent, whether or not locating on subtropical belt or tropical zone, etc. The lowest amount and the penetration are specified depending on the selected antiseptic substance, in response to the timber type, like the sawn timber, glued laminated timber, plywood and the structure composite timber.

### **3 Standard for Methods Testing of Timber Structures GB/T 50329-2002**

National Standard Standard for Methods Testing of Timber Structure GB 50329-2002 has been put into effect on July 1, 2002. There are 12 chapters and 10 appendices in the standard. The following are the main points.

(1) The standard is applicable to the short term dead-load test of timber structure or the timber members or the joint of buildings & ordinary structures. The standard clearly divided the wooden structure test into two types, they are confirmatory test and checking test. If the test is for special topic research, it could refer to the standard according to the research target. The test is not classified by the standard specimen test or the model member test or the full size member test. By the way, the standards also have specifications on the material selection & testing equipment.

(2) The standard provides a statistical method to test data, including a general rule, the judgment and processing of abnormal value, estimation of parameter, and regression analysis.

(3) The standard provides bending test methods for wooden member, test methods for axial compression bar, test methods for eccentric compression bar and measuring methods for striated bearing proportional limit. The bending test methods specify that symmetrical four-point bearing & continuous load methods should be applied. The smallest span of specimen should be 18 times of cross-section height. Furthermore, the cross section of the biggest flaws should locate within pure bending zone.

(4) There are specifications on test methods for timber structure tooth joint & round steel pin joint in the standard. They are suitable for the connection test of Chinese traditional timber construction.

(5) The standard specifies that the way to check the adhesive ability is mainly fit for the test of glued timber structure. It is the test for mass-produced structure commercial glue. The test method of glued finger joint was conducted according to the international standard ISO Standard and foreign relevant standards.

(6) The specified roof-testing method is primarily suitable for the plane truss which is used in the roof structure. It includes square timber or log roof, steel-wooden roof and glued timber roof, while light wood truss with metal tooth joint is not involved. It also specifies the loading procedure of roof test.

## **4 Technical Code for Partitions with Timber Framework GB/T 50361-2005**

### **4.1 Compilation procession of the Code GB/T 50361-2005**

The compilation of the standard started in September, 2003, charging by National building materials bureau standard norm center and China Southwest Architectural Design & Research Institute. Three compilation meetings were held at the time, one of which is symposium on fire control. The standard establishment group also organizes experts to carry on the academic exchange & the technical inspection to Northern Europe.

On the basis of soliciting opinions from all sides, the audit draft has been completed after extensive research, repeated discussion and absorbing foreign practical experience & advanced technology. And again after the expert review & standard establishment group's revision, the standard was sent to Ministry of Construction for approval in April, 2005.

The implement of the standard was since March 1, 2006. Its standard serial number is GB/T 50361-2005. It is the latest national standard about technologies of timber structure.

### **4.2 Brief introduction of main content in GB/T 50361-2005**

There are eight chapters in the new standard. The main contents are:

(1) The Chapter 1 specifies that this standard is suitable for the design & construction & inspection & maintenance of residential building, the office building and non-load-bearing wall in lower industrial architecture. It stipulates that the partitions with timber framework is fit for the non-load-bearing external wall or partition wall of residential building or office building with six stories or less than six stories, as well as the partition wall in 7~18 stories ordinary residential building with the room area less than 100m<sup>2</sup> or the office building with the height below 50 m.

(2) The Chapter 2 defines the nomenclature and sign. Chapter 3 gives the basic rules.

(3) In the Chapter 4, there are specifications on the selected lumber, joint, heat insulator, soundproof material, protective material of the partitions with timber framework & fire protecting performance of the material.

(4) In the Chapter 5, there are specifications on calculation of partitions & joint, as well as the design of thermal insulation, sound insulation, energy-saving, fire resistance, wall surface, prevention & privileged sites

(5) The content of the Chapter 6, 7, 8 are: Construction & production, quality & inspection, maintenance & management.

## 5 Conclusion

After the promulgation of wood-related standards in recent years, many of timber associations & timber industry companies all over the world have conducted a lot of market research in China. They were busy finding partners for co-operation to join the new market of China's timber industry. It played an important part in promoting China's timber industry.

As demand of timber structure growing continuously, some new national standards have been compiled from this year. For example: Technical Code for Glued Timber Structure, Technical Code for Light Timber Truss, and Technical Code for Timber Structure Construction. The Code for Construction Quality Acceptance of Timber Structures GB 50206-2002 has been revised.

The establishment of Technical Code for Glued Timber Structure & Technical Code for Light Timber Truss was charged by China Southwest Architectural Design & Research Institute. We have already had the contract with foreign timber industry associations to cooperate to complete the two new standards. And the establish work has started.

As the continuous development of timber structure technology and the arisement of new demand, the new national technical codes about timber structure will be sure to emerge continuously.