

Bamboo As An Engineering Material

An Annotated Bibliography

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Bamboo As An Engineering Material- An Annotated Bibliography

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Preface

Bamboo to the Eastern man has for ages been the source/fountainhead of a myriad uses. The house he lives in, the bridge he uses, the pipes through which he distributes water, are all made of bamboo. For these applications, he made use of some remarkable properties of bamboo such as its excellent strength. Bamboo is as strong as timber and some species exceed the strongest timbers in strength. At the same time, it is remarkably light.

Globally, there is a resurgence of interest in this ancient plant, in this age of information revolution and environmental consciousness. However, modern applications are being discovered everyday, several of which are based on bamboo's unique physical and mechanical properties. Bamboo is currently being looked upon as a low-cost panacea for the enormous housing problems faced by several developing countries.

This bibliography stems from a meeting of the IUFRO-P5-04.01 group "Building and Engineering with Bamboo" held on November 15, 1988, during the International Bamboo Workshop in Cochin, Kerala, India. It was commonly felt that although bamboo is an excellent structural material, being light-weight, circular and strong, and has been used throughout the tropics as a building material for centuries, engineers and architects find difficulty in accessing technical information on the strength and behaviour of bamboo and its varied use as an engineering material. It was agreed that there was an urgent need to compile such information for a ready reference by scientists, engineers and architects. A decision was therefore made to prepare an annotated bibliography on the physical and mechanical properties of bamboo, and on bamboo as a building and engineering material. A voluntary editorial board was formed from among the participants in the meeting.

Much bibliographic material was collected over the next year and sent to all editorial board members for review and comments. In order to further review and collate the bibliographic material into an easily usable form, a meeting of the editorial board was held at the IDRC Office in Singapore on September 10-12, 1990. This annotated bibliography is an outcome of this meeting.

This bibliography was made possible through the generous grants from the Dutch Government and the International Development Research Centre, towards travel, printing and other costs. We thank the members of the editorial board and their institutes for their participation in this exercise. We also acknowledge the contributions on Chinese literature received from the Bam-

boo Information Centre of the Chinese Academy of Forestry.

In an initial effort of this kind,, it is quite possible that several important contributions may have been missed out principally because of lack of accessibility as well as time constraints. We encourage all readers to send in their comments to Dr Jules J. Janssen.

We hope this bibliography will be a useful reference to all persons working with bamboo and that it will lead to greater use and wider application of bamboo. We are also pleased that the principal beneficiaries of this effort will be the developing countries.

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Dec '91

Chapter 1

Physical and mechanical properties

Abdullah, A.A.A.(1983).

Utilization of bamboo as a low cost structural material.

In: Proceedings of the Symposium on Appropriate Building Materials for Low Cost Housing, Nairobi, 7-14 Nov. 1983. (sponsored by CIB Rotterdam and RILEM, Paris) E & F N Spon, London and New York: 177-182.

The work being carried out at Universiti Pertanian Malaysia on the utilization of bamboo as a low cost material of construction is described. Mechanical properties as well as propagation techniques relating to some local species are presented.

Keywords: low cost construction, mechanical properties, utilization.

Abdullah, A.A.A. (1984).

Development of basic mechanical tests for Malaysian bamboos. Pertanika, 7(2): 13- 17.

Contains procedures for tests in bending, compression, tension and impact for *Bambusa vulgaris* based on British and Indian Standards.

Keywords: bending, compression, tension, test methods.

Abdullah, A.A.A. and Abdul Rahim A A (1984).

Basic strength properties of a few selected Malaysian bamboos, Journal of the Institute Jurutera Malaysia. 34: 68-71.

Results of a series of tests to determine basic strength properties of a few selected species of Malaysian bamboos are presented. The potential of bamboo becoming an important engineering material in the future is discussed in broad terms.

Keywords: mechanical properties, test methods.

Anon. (1979).

Chinese bamboo artisans preserve ancient craft. Engineering News Record, 202 (7): 44-45.

Short but interesting communication on the use of bamboo for scaffolding.

Keyword: scaffolding.

Atrops, J.L.(1969).

Elastizitaet und Festigkeit von Bambusroehren. (Elasticity and strength of bamboo stems). Bauingenieur, 44 (6): 220-225.

Results of tests to determine shear, tensile, compressive and flexural strength of several specimens of bamboo are given. Modulus of elasticity, specific gravity and moisture content data are also given. The results indicated that bamboo has considerably higher strength values than pine and oak.

Note: This paper is in German.

Keywords: bending, compression, mass per volume, mechanical properties, moisture content, shear, tension.

Chanda, A. and Guha, S.R.D. (1981).

Studies on the decay of bamboo (Dendrocalamus strictus) during outside storage - degradation of lignin. Indian Forester, 107(1): 54-59.

During outside storage lignin content in bamboo progressively decreased. This is generally caused by a white rot type of fungal decay. Results of analysis of sound and degraded lignin are discussed.

Keywords: natural durability, physical properties.

Chiang, F.C. (1969).

A preliminary study on structure of important bamboos in Taiwan. Bulletin Taiwan Forestry Research Institute, No 183: 20.

Anatomical description with microphotographs of several species of bamboo.

Note: Original in Chinese.

Keywords: anatomical structure.

Chiang, F.C. (1971).

A preliminary study in the structure of important bamboos in Taiwan.
Bulletin Taiwan Forestry Research Institute, No 799: 20.

The structure is described with photomicrographs of several species of bamboo.

Note: Original in Chinese.

Keywords: anatomical structure.

Chiang, F.C. i(1971).

A preliminary study in the structure of important bamboos in Taiwan.
Bulletin Taiwan Forest Research Institute, No 217: 22.

Structure with photomicrographs of several species of bamboos.

Note: Original in Chinese.

Keywords: anatomical structure, photomicrographs.

Chiang, F.C. (1974).

Physical properties of important bamboos in Taiwan.
Bulletin of Tawian Forestry Research Institute, No 24 1: 12.

Data for green, air-dry and oven-dry bamboo samples of fourteen bamboo species growing in Taiwan are given. Contains tables of mass per volume, shrinkage.

Note: Original in Chinese, tables with English captions.

Keywords: mass per volume, moisture content, shrinkage.

Chunwarim, W.(1976).

Physical properties of three Thai bamboos. Forest Research Bulletin, Faculty of Forestry, Kasetsart University 48: 46.

Physical and mechanical properties of three Thai species (*Bambusa arundinacea*, *Thyrsostachys siamensis* and *Dendrocalamus membranaceus*) are presented.

Note: The paper is in Thai and English. Tables and figures have English captions.

Keywords: mechanical properties, physical properties.

Culzoni, R.A.M.(1986).

Características dos bambus e sua utilização como material alternativo no

concreto (Bamboo properties and its application as an alternative material in concrete).

Master's thesis, Civil Engineering Department, Pontifical Catholic University of Rio de Janeiro Pue-Rio, Rio de Janeiro, 1986: 134.

This work is a detailed study concerning: anatomical structure, physical and mechanical properties including water absorption and specific weight of eight species of bamboos of Rio de Janeiro. Test results of several beams of 3-4 m spans made of lightweight concrete and different percentage of bamboo reinforcement, and pull-out test results for untreated and treated bamboo are presented.

Note: An abstract in English is given, the main text is in Portuguese.

Keywords: anatomical structure, beams, mechanical properties, physical properties, preservation, reinforced structure, shrinkage/swelling.

Dunkelberg, I.K. (1985).

Bamboo as a building material.

In: IL31, Bamboo. Editors: Institute for Lightweight Structures, University of Stuttgart, W. Germany: 38-260.

This contribution is broadly divided into two parts: part one deals with bamboo as a material, which includes classification, growth, anatomy, propagation, properties, chemical composition, harvesting, preservation and working of bamboo, part two deals with the use of bamboo in built structures based on field work in Southeast Asia. Numerous structural types have been covered.

Note: this reprint of the original thesis in German is presented in a bilingual format with German and English text.

Keywords: anatomical structure, architecture, building, fire resistance, physical properties.

Espiloy, Z.B. [1972].

Some properties and uses of bamboo.

Forpride Digest, 1(4): 6-7.

A short paper giving in general terms, physical properties and uses of 19 erect and 13 climbing bamboo species of Philippine.

Keywords: physical properties.

Espiloy, Z.B., and Sasondicillo, R.S. (1976).

Some biophysical and mechanical properties of Bambusa vulgaris.

Philippines Journal of Biology 5 (3): 375-386.

Biophysical and mechanical properties of *Bambusa vulgaris* are described.

Keywords: mechanical properties, physical properties.

Espiloy, Z.B. and Sasondoncillo, R.S. (1978).

Some characteristics and properties of giant bamboo (Giuntochloa aspera Kurz).

Forpride Dig&t, 7(4): 34-36.

A document presenting physical and mechanical properties of a single species of bamboo.

Keywords: anatomical structure, bending, compression, mass per volume, mechanical properties, moisture content, shrinkage, tension.

Espiloy, Z.B Valmonte, A.D. and Tongacan, A.L. (1979).

Some physical and mechanical properties of Schizostachyum lumampao.

Unpublished information from Forpridecom Library, College Laguna, Philippines.

Physical and mechanical properties of *Schizostachyum lumampao* are described.

Keywords: mechanical properties, physical properties.

Espiloy, Z.B (1982).

Silica content in spiny bamboo.

NSTA Technical Journal, (Oct-Dec): 38-43.

An article on silica-content. Includes a full analysis of variance, tables and diagrams.

Keyword: chemistry.

Espiloy, Z.B Ella, A.B. and Floresca, A.R. (1988).

Physico-mechanical properties and anatomical structure relationships of two erect bamboo species.

Philippine Lumberman 32 (4,5): 25-27, 35, 32-33, 35.

Results are given of studies on 3-year old *Bambusa blumeana* and *Giantochloa levis*. Density, shrinkage and bending strength are correlated with fibro-vascular bundle frequency as well as fibre and vessel dimensions.

Keywords: anatomical structure, bending, compression, mass per volume, moisture content, shrinkage.

Espiloy, Z.B.(1987).

Physico-mechanical properties and anatomical relationships of some Philippine bamboos.

In: Rao, A.N., Dhanarajan, G. and Sastry, C.B. (Eds.). Recent Research on Bamboos. Proceedings of the International Bamboo Workshop held at Hangzhou, People's Republic of China, October 6-14, 1985. Chinese Academy of Forestry, People's Republic of China and International Development Research Centre, Canada : 257-264.

The paper describes the physico mechanical properties and anatomical characteristics of *Bambusa blumeana* and *Gigantochloa laevis*. Relative density, shrinkage, moisture content, static bending and compression parallel to the grain have been correlated with anatomical characteristics such as fibrovascular bundle frequency and dimensions of fibre and vessel. The results showed an increase in compressive and bending strengths towards the top portion of the culm in both species. This is attributed to significant increase in relative density and fibrovascular bundle density.

Keywords: anatomical structure, bending, compression, mechanical properties, moisture content, physical properties, shrinkage.

Espinosa, J.C. (1930).

Bending and compressive strengths of the common Philippine bamboos. The Philippine Journal of Science, 41 (2): 121- 135.

An old publication, but the data are still relevant. It contains eight tables on bending and compression properties.

Keywords: bending, compression.

Ghavami, K. and Hombeeck, R.V.(1981).

Application of bamboo as a construction material part 1: Mechanical properties and water repellent treatment of bamboo.

In: Proceeding of the Latin American Symposium on rational organization of building applied to low-cost housing, Sao Paulo, Brazil, October 1981 : 49-58. In English, with abstract in Portuguese.

This paper presents the results of a series of tests carried out with local bamboos. The physical and mechanical properties of these bamboos are given. Also results related to water absorption of bamboo using different water repellent treatments are presented.

Keywords: mechanical properties, moisture content, physical properties, tension.

Ghavami, K. (1989).

Application of bamboo as a low cost energy material in civil engineering.

in: Proceedings of the Third CIB-RILEM Symposium, materials for low cost housing. Funavit, Mexico city, Mexico, 1989: 529-536.

Contains research results concerning the physical and mechanical properties of seven species of bamboos in Rio de Janeiro, and descriptions of a new water repellent material for bamboo for the use in permanent shutter slabs, and a new form of bamboo space structure.

Note: An abstract in Spanish is also given.

Keywords: mechanical properties, moisture content, physical properties, reinforced structures, shrinkage/swelling, space frame.

Godbole, V.S. and Lakkad, S.C. (1986).

Effect of water absorption on the mechanical properties of bamboo. Journal of Materials Science Letters 5(3): 303-304.

Results of experiments on the effect of water content on the mechanical properties of bamboo are discussed. The study has revealed that water absorption causes considerable reduction in strength and rigidity.

Keywords: mechanical properties, test methods, water absorption.

Heck, G.E. (1956).

Properties of Isome bamboos cultivated in the Western Hemisphere Report No. D 1765 of the US Department of Agriculture in cooperation with the University of Wisconsin Forest Products Laboratory, Madison, Wisconsin, USA

Physical and mechanical properties, and glueing characteristics of a few representative species of bamboos grown in Puerto Rico and South America, are presented.

Note: Information provided in the report was reviewed and reaffirmed in 1962.

Keywords: mechanical properties, physical properties.

Itoh, T. and Shimaji, K. (1981).

Lignification of bamboo culm (Phyllostachys pubescens) during its growth and maturation.

In: Higuchi, (Ed.). Bamboo production and utilization, Proceedings, XVII IUFRO World Congress, Kyoto, Japan, September 6-17, 1981. Wood Research Institute, Kyoto University, Kyoto, Japan: 104-110.

The paper deals with the lignification process of the whole culm of *Phyllostachys pubescens* during its growth and maturation and compares it with successive changes in external morphology. The lignin content is fairly constant in the culms over the year, with no aging effects on the lignification of the bambop culm.

Keywords: anatomical structure.

Jaikishen, Ghosh, D.P. and Rehman, M.A. (1956).

Studies, in moisture content, shrinkage, swelling at intersection point of mature Dendrocalamus strictus. Indian Forest Records (Wood Seasoning), 1(2): 22p.

Physical properties of the important Indian Bamboo, *Dendrocalamus strictus* are described in detail.

Keywords: physical properties.

Janssen, J. A.(1981).

Bamboo in building structures.

PhD thesis, Faculty of Architecture and Building, Eindhoven University of Technology, Eindhoven, Netherlands, : 235 p.

Comprehensive study of the physical and mechanical properties of *Bambusa blumeana*. These were related to the anatomical structure of the plant. Full scale joints and full scale 8m span frames were tested and the results documented.

Note: a comprehensive work with highly specialised information on the engineering use of bamboo.

Keywords: anatomical structure, bending, compression, connections, mass per volume, shear, tension, testing, trusses.

Janssen, J.J.A. (1981).

The relationship between the mechanical properties and the biological and chemical composition of bamboo.

In: Higuchi, Ed.). *Bamboo production and utilization, Proceedings, XVII IUFRO World Congress, Kyoto, Japan, September 6-17, 1981, Wood Research Institute, Kyoto University, Kyoto, Japan: 27-32.*

The paper describes how the strength and stiffness in compression, shear and bending of bamboo might be explained based on the fibre content and cell wall thickness.

Keywords: anatomical structure, mechanical properties, physical properties.

Janssen, J.J.A.(1986).

Creep and recovery in bamboo.

In: Bamboo Production and Utilization, Proceedings XVIII IUFRO World Congress, Ljubljana, Yugoslavia, Sept 7-21: 31-36.

A physical arid mathematical model has been used to determine creep and recovery behviour of bamboo; it has been validated with tests.

Keywords: bending, creep, physical properties, test methods.

Janssen J J A (1987).

The mechanical properties of bamboo.

In: Rao A.N., Dhanarajan G. & Sastry C. B. (Eds.). Recent Research on Bamboos. Proceedings of the International Bamboo Workshop held at Hangzhou, People's Republic of China from October 6-14, 1985. Chinese Academy of Forestry, People's Republic of China & International Development Research Centre, Canada : 250-256.

Bamboo is compared with steel, concrete and timber in terms of the energy needed for production, safety, strength and stiffness, and simplicity of production as a construction material. The relationship of the anatomical structure of bamboo to its mechanical properties and the long-term behaviour under load are described.

Keywords: anatomical structure, mass per volume, mechanical properties.

Kitamura, H. and Ishizuki, Y. (1953).

Studies on the physical properties of bamboo. IV Comparison of increasing movement of shrinkage by the difference of thickness.
Journal Japan Forestry Society, 35 (12): 388-392.

Research report on shrinkage, including correlation of shrinkage with the thickness of the tested specimen.

Note: In Japanese, with short summary in English.

Keyword: shrinkage.

Kitamura, H. (1963).

Studies on shrinkage of bamboo.
Bulletin Niigata University Forestry, (2): 1.

Shrinkage behaviour of bamboo is described.

Note: Original in Japanese.

Keyword: shrinkage.

Kitamura, H. (1975).

Physical and mechanical properties of bloomed bamboo culms, Bulletin College Agriculture, Utsunomiya University, g(2): 37-47.

Physical and mechanical properties of flowered culms of *Phyllostachys heterocycla* var *pubescens* are compared with those of green culms. Compressive and bending strengths, modulus of rupture and elasticity, hardness, impact bending, etc are compared between green, air-dry and oven-dry culms. Many of these properties were found to deteriorate after flowering.

Note: Original in Japanese, with English summary.

Keywords: bending, compression, elasticity, flowering, modulus of rupture.

Lakkad, S.C.and Patel J.M. (1981).

Mechanical properties of bamboo, a natural composite. Fibre Science and Technology, 14(4): 3 19-322.

Mechanical properties of bamboo, mild steel, polyester resin and glass reinforced plastic are compared. The mechanical properties of bamboo are found to compare favourably with those for other reinforcing materials. As tensile strength of bamboo is greater than that of resin, the author recommends bamboo fibre for reinforcement of plastic.

Keywords: plastic, reinforced structures.

Lakshmana,M.G. (1985).

Drying of some commercial Phillipine bamboos. FPRDI Journal, 14(1/2) : 8-19.

Data are given on the drying time and final m.c. of *Bambusa vulgaris* var. *striata*, *Dendrocalamus merrillianus*, *Phyllostachys nigra* and *Schizostachyum difusum*, scraped or unscraped and split or round, and air dried during July-Oct. or kiln-dried. Drying schedules are given for each species.

Keywords: drying, physical properties.

Lee, G.Y. (1976).

Studies on the physical propeties of weaving bamboo plate bypressed mould. Research Reports Forest Research Institute, Korea No. 23: 27-38.

Results are reported of studies on the density and shrinkage of *Phyllostachys edulis* and on the effects of moisture content and quantity of melamine resin glue on the physical properties of woven bamboo plate.

Keywords: mass per volume, panels, physical properties, shrinkage.

Liese, W. (1985).

Bamboos-biology, silvics, properties, utilization.
Schriftenreihe der GTZ, Deutsche Gesellschaft für Technische Zusammenarbeit, German, Federal Republic, No. 180, 132p

A comprehensive account of bamboo, including properties and utilization. The bibliography section contains 70 references.

Note: This book is in English.

Keywords: mechanical properties, physical properties.

Liese, W.(1986).

Characterization and utilization of bamboo.

In: Bamboo Production and Utilization, Proceedings XVIII IUFRO World Congress, Ljubljana, Yugoslavia, Sept 7-21: 11-1 6.

This paper presents various properties of bamboo and highlights the way in which these properties affect the utilization of bamboo.

Keywords: anatomical structure, physical properties.

Liese, W.(1987).

Anatomy and properties of bamboo.

In: Rao, A.N, Dhanarajan, G. and Sastry, C.B. (Eds.). Recent Research on Bamboos. Proceedings of the International Bamboo Workshop held at Hangzhou, People's Republic of China, October 6-14, 1985. Chinese Academy of Forestry, People's Republic of China & International Development Research Centre, Canada : 196-208.

This paper summarizes available information on anatomy, and chemical, physical and mechanical properties of bamboo.

Keywords: anatomical structure, chemistry, mechanical properties, physical properties.

Li Yunlien and Li Yuzhen (1983).

Physico-mechanical properties of culmwood of Phyllostachys pubescens produced in uizhou.

Bamboo Research, Nanjing Technological College of Forest Products, (1): 62-74.

Research on mass per volume, compression, tension, bending, and moisture content of bamboo is reported. Properties are related to age and to the growing site, for 4 species, and are presented with many formulae and in 7 tables.

Note: Original is in Chinese; an English translation, provided by the Eindhoven University in the Netherlands, is available from the Bamboo Information Centre in China.

Keywords: bending, compression, mass per volume, moisture content, tension.

Limaye, V.D. (1948).

Effect of age and season of felling on the strength properties of bamboo. Indian Forester, 74(1): 17-18.

Specimens of *Dendrocalamus strictus* of young and mature culms extracted in winter and summer seasons were tested for physical properties, particularly strength. Mature culms and those extracted in winter were found to be stiffer and stronger.

Keywords: mechanical properties, physical properties.

Limaye, V.D. (1952).

Strength properties of bamboo (Dendrocalamus strictus). Indian Forester, 78(11): 558-75.

Results of tests conducted on an Indian species, *Dendrocalamus strictus*, are given along with those for *Bambusa balcoa*, *B nutans* and *B tulda*. For purposes of comparison, strength values for *Tectona grandis* and *Shorea robusta* are also given.

Keywords: bending, compression.

Lin, W.C., Kiang, T. and Chang,T.Y. (1977).

Studies on introduction and utilization of giant bamboo (Dendrocalamus giganteus) in Taiwan. Bulletin , Taiwan Forestry Research Institute, No.300, 18p.

A general account on the introduction and utilization of the giant bamboo, *Dendrocalamus giganteus*, is presented in this paper.

Note: In Chinese with English summary.

Keywords: physical properties, utilization.

Lu, Xiu-xin et al. (1985).

A study on the physico-mechanical properties of culmwood of Phyllostachys glauca of Shandong. Journal of Bamboo Research, Zhejiang Forestry Institute, 4 (2): 98- 106.

Research on mass per volume, compression, tension, bending, and moisture content of bamboo is reported. Properties are related to age and to the growing site, for 4 species, and are presented with many formulae and in 10 tables.

Note: Original is in Chinese with English summary; an English translation, provided by the Eindhoven University in the Netherlands, is available from the Bamboo Information Centre in China.

Keywords: bending, compression, mass per volume, moisture content, tension.

Ma, T.P., Jai, S.Y. and Tsou, C.T. (1977).

Experiment an the practical application and quality improvement of bamboo glulam.

Bulletin, Taiwan Forestry Research Institute, No.298, 8p.

Development of a dyeing system and its use in furniture making is described.

Note: In Chinese with English summary

Keywords: dyeing, furniture, manufacture.

Ma, T.P. and kwang, C.Y. (1980).

General properties of Taiwan commercial bamboos (I).

Bulletin, Taiwan Forestry Research Institute No 341: 15.

Physical properties of two Taiwanese species, viz *Phyllostachys pubescens* and *Dendrocalamus latiflorus*, are described.

Note: In Chinese with English summary.

Keywords: physical properties.

Ma, T.P., Jai, S.Y., Hwang, C.Y., Wang, S.L. and Hsiung, J.C. (1981).

Physical and machining characteristics of some important Taiwan bamboos.
Bulletin, Taiwan Forestry Research Institute No. 346: 77.

A few physiaal properties and machining characteristics of *Phyllostachys pubescens*, *P. makinoi*, *Dendrocalamus latiflorus* and *D. giganteus* are presented.

One of the very few contributions on machining characteristics of bamboo.

Note: In Chinese with a brief English summary.

Keywords: machining properties, physical properties.

Maeda, H., Tsuda, K. and Fukada, E. (1977).

Electrical and mechanical properties of bamboo and wood with various hydrations.

Reports on Progress in Polymer Science in Japan No. 20: 739-742.

Contains data on dielectric, elastic and piezoelectric constants of bamboo (0 to 74% relative humidity of the air).

Keywords: electric properties, physical properties.

Mamada, S. and Kawamura, Y. (1973).

On the dynamic viscoelasticity of bamboo species.

Mokuzai Gakkaishi (Journal Japan Wood Research Society), 11: 555-560.

This research report describes the relationship between the dynamic Young's modulus, the static Young's modulus and the mass per volume for bamboo. Contains 10 diagrams. The only existing article on this subject.

Note: in German (not in Japanese), with an English summary.

Keyword: E-modulus.

McLaughlin, E.C. (1979).

A note on the strength of Jamaica grown bamboo.

Wood and Fiber, 11 (2): 86-9 1.

Tensile strength of small specimens of *Bambusa vulgaris* of Jamaican origin were tested. Data on test method and results are presented. Correlation between tensile strength and modulus of elasticity is attempted.

Keywords: tension, test methods.

Meyer, H.F. and Ekelund, B. (1922-1923).

Tests on the mechanical properties of bamboo.

Proc. of the Eng. Soc. of China, 22, (7): 14 1- 169.

A clear overview of the state of the art of testing methods in those years.

Keywords: mechanical properties, test methods.

Mohmod, AL., Mustafa, M.T., Samad, M.R. and Midon, M.S.(1990).

Wear resistance of two commercial bamboo species in Peninsular Malaysia and their suitability as a flooring material.

In: Rao, I.V.R., Gnanaharan, Ft. and Sastry, C.B. (Eds.). *Bamboos - Current Research. Proceedings of the International Bamboo Workshop*

held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 223-230.

The paper evaluates the possibility of using bamboo as a substitute for timber in flooring. The abrasive resistance of both *Bambusa vulgaris* and *Gigantochloa scortechinii* at the longitudinal and the end grain surfaces was demonstrated to be superior to kempas, the common flooring timber and rubber wood, a light traffic flooring timber.

Keywords: abrasion, flooring.

Mohmod, AL., Wan Tarmeze Wan Ariffin and Fauzidah Ahmad (1990).
Anatomical features and mechanical properties of three Malaysian bamboos. Journal of Tropical Forest Science, 2(3) : 227-234.

The mechanical properties and anatomical features of one- to three-year old *Bambusa blumeana* Schult., *Bambusa vulgaris* var. *striata* Schrad and *Gigantochloa scortechinii* Gamble are reported.

Keywords: mechanical properties.

Mori, M. (1987).

Process of flattening pieces utilizing microwave heating. Mukuzai Gakkaishi (Journal of the Japan Wood Research Soc.) 33(3) : 630-636.

In tests using *Phyllostachys pubescens*, a temp. of 145 degree centigrade was best for softening pieces. Increasing the rate of deformation reduced the maximum strain of bamboo pieces. Cooling under pressure was necessary to set the bamboo in its flattened form. The set deformation of flattened pieces recovered considerably with hygrothermal treatment.

Note: In Japanese with English summary.

Keywords: mechanical properties, physical properties.

Nomura, T. and Yamada, T. (1977).

On the discrete diffraction of small angle X-ray scattering of bamboo (Phyllostachys mitis). Wood Research (Japan) No.62: 11 - 18.

Discrete diffraction depending on periodically recurring elements (interparticle interference) was observed both parallel and right angle to the fibre direction. Crystallite length and width calculated to be about 11 and 4.8 micrometre respectively.

Keywords: physical properties.

Nomura, T., Filho, M.T. and Azzini, A. (1988).

Production and utilization of bamboo in Brazil.

In: Bamboo Production and Utilization, Proceedings XVIII IUFRO World Congress, Ljubljana, Yugoslavia, Sept 7-21: 61-63.

An overview of the production and utilization of bamboo species in Brazil. Some data on fibre characteristics of Brazilian bamboos are included.

Keywords: anatomical structure, physical properties.

Ota, M. (1950).

Studies on the properties of bamboo stem. Part 3: On the form of stem of Madake (Phyll.ret.), Moso-chiku (Phyll.ed.) and Ha-chiku (Phyll.nigra). Bulletin Kyushu University Forestry 18: 37-58.

Contains an article on the sizes of a culm. Results presented as many tables and diagrams, with a full mathematical analysis.

Note: In Japanese, very short English summary.

Keywords: physical properties.

Ota, M. (1950).

Studies on the properties of bamboo stem. Part 4: Study on the form of specimen in the test of compressive strength. Journal Japanese Forestry Society, 32: 65-69.

This report studies the interaction between the form of the specimen and the result in the compression test.

Note: In Japanese, very short English summary.

Keywords: compression, test methods.

Ota, M. (1951).

Studies on the properties of bamboo stem. Part 5: Study on the effect of the absence of the outer-layer or the inner-layer of bamboo splint on the compressive strength parallel to the grain and the specific gravity (air dry). Journal Japanese Forestry Society, 33: 244-246.

A very detailed study on the subjects mentioned in the title. 3 tables with data.

Note: In Japanese, very short English summary.

Keywords: compression, test methods.

Ota, M. (1951).

Studies on the properties of bamboo stem. Part 7: The influence of the percentage of structural elements on the specific gravity and compressive strength of bamboo splint.

Journal Japanese Forestry Society, 19: 25-4 7.

This article reports in full studies on the relationship between the botanical structure and the compression strength. Data are presented in 8 tables and 13 diagrams. A statistical analysis is included.

Note: In Japanese, short English summary.

Keywords: anatomical structure, compression.

Ota, M. (1953).

Studies on the properties of bamboo stem. Part 8: The variation of the specific gravity and the compressive strength of bamboo splint in a node-interval.

Bulletin Kyushu University Forestry, 21: 71-82.

A research report on the subject as mentioned in the title. Data are presented in 5 diagrams and 2 tables.

Note: In Japanese, short English summary.

Keywords: compression, mass per volume.

Ota, M. (1953)

Studies on the properties of bamboo stem. Part 9: On the relation between compression strength parallel to grain and moisture content of bamboo splint.
Bulletin Kyusbu University Forestry, 22: 87- 108.

Research report with full statistical analysis on the subject given in the title. Data are presented in 7 diagrams and 8 tables.

Note: In Japanese, short English summary.

Keywords: compression, moisture content.

Ota, M. (1954).

Studies on the properties of bamboo stem. Part 10: On the relation between the tensile strength parallel to the grain and the moisture content of bamboo splint.

Bulletin Kyushu University Forestry, 23: 155- 164.

Full research report on the relationship between tensile strength and moisture content of bamboo. Contains 3 tables and 5 figures.

Note: In Japanese, short English summary.

Keywords: moisture content, tension.

Ota, M. (1955).

Studies on the properties of bamboo stem. Part 11: On the fibre-saturation point obtained from the effect of the moisture content on the swelling and shrinkage of bamboo splint.

Bulletin Kyushu University Forestry, 24: 61-72.

Full research report on the subject mentioned in the title. Full statistical analysis is provided. Contains 11 tables and 3 figures.

Note: In Japanese, short English summary.

Keywords: moisture content, shrinkage/swelling.

Ota, M. (1955).

Studies on the properties of bamboo stem. Part 72: On the form of the stairtype specimen in the shearing test parallel to the grain.

Bulletin Kyushu University Forestry, 25: 73-84.

Report on the form of the specimen in the shear test. Contains 3 tables and 6 figures.

Note: In Japanese, short English summary.

Keywords: shear, test method.

Ota, M. (1955).

Studies on the properties of bamboo stem. Part 13: On the relation between shearing strength parallel to grain and moisture content of bamboo splint.

Bulletin Kyushu University Forestry, 25: 12 1 - 13 1.

Full research report on the relationship between shear and moisture content.

Note: In Japanese, short English summary.

Keywords: moisture content, shear, test methods.

Pandey, L.K. (1983).

Moisture content of Dendrocalamus strictus.

In: Proceedings of the Eleventh Silviculture Conference, Dehra Dun, May 15-25, 1967, Vol. III, Dehra Dun, FRI & Colleges, 1983: 590-592.

The moisture content of *Dendrocalmus strictus* is reported with reference to its extraction and use as a raw material for paper pulp.

Keywords: moisture content, physical properties.

Parameswaran, N. and Liese, W. (1976).

On the fine structure of bamboo fibres.

Wood Science and Technology, 10: 231-246.

Data on the dimensions of fibres are presented.

Keywords: anatomical structure.

Prawirohatmodjo, S. (1990).

Comparative strength of green and air-dry bamboo.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). *Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988.* Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 218-222.

The paper compares the moisture content, bending strength, maximum crushing strength, tensile and shear strength of six species of bamboos of Indonesia in the green and air-dry condition. Although there is a general increase in strength when bamboo is dried from the green to the air-dry condition, it is much lower than that in wood. It is concluded that there is little risk in using green bamboo for construction purposes.

Keywords: mechanical properties, physical properties.

Rowall, R.M. and Norimoto, M. (1987).

Acetylation of bamboo fiber.

Mokuzai Gakkaishi (Journal of the Japan Wood Research Soc.), 33(11) : 907-910.

When over-dry fibres of *Phyllostachys bambusoides* were heated with acetic anhydride for various times, weight gains of 4.4 - 17% were obtained. Equilibrium moisture content decreased as weight gain increased. The reactivity and moisture sorption of bamboo fibres were compared with those of *Populus tremuloides* and *Pinus sylvestris*.

Note: In Japanese with English summary.

Keywords: physical properties.

Sanyal, S.N., Gulati, A.S. and Khanduri, A.K. (1988).

Strength properties and uses of bamboos.

Indian Forester, 114(10): 637-649.

Available data on the physical and mechanical properties of 10 species of bamboo are presented. Strength properties of bamboo are compared with teak and other timber species.

Keywords: mechanical properties, physical properties.

Sekhar, A.C. and Bhartari, R.K. (1960).

Studies on strength of bamboos: A note on its mechanical behaviour.
Indian Forester, 86(5): 296-301.

The article discusses the mechanical properties of bamboo in general. Strength properties of various species of bamboo grown in India are presented in a tabular form.

Keywords: mechanical properties, physical properties.

Sekhar, A.C. and Bhartari, R.K. (1961).

A note on strength of dry bamboo (Dendrocalamus strictus) from Madhya Pradesh.
Indian Forester, 87(10): 611-613.

Differences in the physical properties (mass per volume, bending and compression) of *Dendrocalamus strictus* at ages of 1 to 6 years are described.

Keywords: bending, compression, mass per volume.

Sekhar, A.C., Rawat, B.S. and Bhartari, R.K. (1962).

Studies on strength of bamboos: Bambusa nutans.
Indian Forester, 88(1) (January): 67-73.

Research on static and impact bending, compression and shear is reported for green and kiln-dry bamboo. Properties are related to the age, and the position in the culm, of the sample.

Keywords: bending, compression, shear.

Sekhar, A.C. and Rawat, M.S. (1964).

Some studies on the shrinkage of Bambusa nutans.
Indian Forester, 90(3): 182-188.

Shrinkage of bamboo during drying and its relationship to anatomical structure, growth characteristics and external conditions are described. Methods for preventing shrinkage and splitting are described.

Keywords: anatomical structure, mechanical properties, physical properties, shrinkage.

Sekhar, A.C. and Gulati, A.S. (1973).

A note on physical and mechanical properties of Dendrocalamus strictus from

different localities.

Van Vigyan, (*Journal Society Indian Foresters*). 11(3/4): 17-22.

Dendrocalamus strictus from seven different districts of India were subjected to static bending and compression tests, both for green and dry conditions, and compared with teak.

Keywords: bending, compression.

Sharma, S.N. and Mehra, M.L. (1970).

Variation of specific gravity and tangential shrinkage in the wall thickness of bamboo (Dendrocalamus strictus) and its possible influence on the trend of shrinkage, moisture content characteristics.

Indian Forestry Bulletin 1970, No 259: 7.

Study of properties of splints taken from 8th and 13th internodes from ground level. Variations in specific gravity and shrinkage are reported.

Keywords: mass per volume, shrinkage.

Soeprayitno, T., Tobing, T.L. and Widjaja, E.A. (1990).

Why the Sundanese of West Java prefer slope - inhabiting Gigantochloa pseudoarundinacea to those growing in the valley

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 215-217.

The physico-mechanical properties of the culm such as specific gravity, bending and tensile strength, anatomical properties of the culm such as fibre dimensions, and the fibro vascular bundle frequency of *Gigantochloa pseudoarundinacea* growing on hill slopes and valleys in West Java are compared. The results show that specific gravity, bending and tensile strength of the slope-inhabiting bamboo are higher than those growing in the valley.

Keywords: anatomical structure, mechanical properties, physical properties.

Suzuki, Y. (1948).

Studies on the bamboo. I. Distribution of physical and mechanical properties in the stem of Phyllostachys pubescens.

Bulletin Kyoto University Forestry, 36: 135-157.

Note: In Japanese, short English summary.

Deals with mass per volume, fibre-content, bending-strength, E-modulus and

shear. A research report with 11 tables and 18 diagrams.

Keywords: anatomical structure, bending, mass per volume, shear.

Talukdar, Y.A. and Sattar, M.A. (1982).

Shrinkage and density studies on two bamboo species.

Bano Biggyan Patrika, 9(1/2): 65-70.

Shrinkage during drying and density were measured for two species of Bangladesh: *Bambusa vulgaris* and *B. tulda*.

Keywords: physical properties, shrinkage.

Tamolang, F.N., Lopes, F.R., Semana, J.A., Casin, R.F., and Espiloy, Z.B. (1980).

Properties and utilization of Philippine erect bamboos.

Forpride Digest, 9(3/4) : 14-27.

The physical and mechanical properties of the erect bamboo species in Philippines and their uses are described.

Keywords: construction techniques, mechanical properties, physical properties.

Teodoro, A.L. (1925).

A preliminary study of the transverse strength of structural bamboo.

Agricultural Engineering, 6 (11): 266-267. (Philippines).

Presents data on bending, and testing methods. One drawing shows the testing machine. The data are presented in 3 diagrams and 4 tables.

Keywords: bending.

Ueda, K. (1980).

Mechanical properties of Moso bamboo, distribution of modulus of elasticity across the culm wall.

Research Bulletin, College Experiment Forest Hokkaido University, 37 (3): 8 17-836.

Research report on bending, compression and torsion of split bamboo; contains 12 tables.

Note: In Japanese with summary in English

Keywords: bending, compression, torsion.

Widjaja, E.A. and Risyad, Z.(1989).

Anatomical properties of some bamboos utilized in Indonesia

In: Rao, A.N., Dhanarajan, G. and Sastry, C.B. (Eds.). Recent Research on Bamboos. Proceedings of the international Bamboo Workshop held at Hangzhou, People's Republic of China from October 6-14, 1985. Chinese Academy of Forestry, People's Republic of China & International Development Research Centre, Canada : 244-246.

The anatomy of four bamboo species, *Dendrocalamus giganteus*, *Dendrocalamus asper*, *Gigantochloa robusta* and *Bambusa vulgaris* var. *striata* is correlated with their mechanical properties. There is a correlation between fibre length, modulus of elasticity and compression strength.

Keywords: anatomical structure, bending, compression, mechanical properties, tension, test methods.

Wu, H.T. (1977).

Research on the kiln drying behaviour of Taiwan commercial bamboos. Quarterly Journal of Chinese Forestry, 16(2): 81-94.

Research activities on the kiln drying behaviour of commercially important bamboo species in Taiwan are reviewed in this paper.

Keywords: physical properties.

Wu, H.T. and Lan, H.F.(1986).

The effect of kiln temperature on the mechanical properties of makino bamboo. Forest Products Industries, 5(11): 15-23.

Data are provided on compression and tension parallel to the grain, static bending, cleavage strength and hygroscopicity of *Phyllostachys makinoiafter* drying at different kiln temperatures.

Note: Paper is in Chinese with an English summary.

Keywords: bending, cleavage, compression, mass per volume, moisture content, physical properties, tension, test methods.

Wu Shuen-Chao (1976).

Effects of the cutting rotation of bamboo on its mechanical properties.

In Proceedings of the International Symposium, New Horizons in Construction Materials, Lehigh University, Bethlehem, Pa. Envo Publication Co. Inc., Lehigh Valley 1: 555566.

Data on specific gravity and mechanical properties of six commercial species

of bamboo in Taiwan are presented and correlation of strength properties with culm age is attempted by means of statistical methods. Relationship between specific gravity and mechanical properties like crushing strength, modulus of elasticity, modulus of rupture etc is also presented.

Keywords: bending, compression, culm age, mass per volume, mechanical properties.

Xu, Y.L. and Gong, Y.Q. (1982).

*A study on the physico-mechanical properties of culm-wood of Phyllostachys glauca.
Bamboo Research, 1(1) : 50-58.*

Strength properties of 1-7 year old culms are reported. In general the density, compressive and tensile strength parallel to grain, and toughness increased with age, reaching maximum values at 5-6 years. Afterwards these properties decline.

Note: In Chinese with English summary.

Keywords: mechanical properties, physical properties.

Zhou, F. (1981).

*Studies on physical and mechanical properties of bamboo woods.
Journal of Nanjing Technological College of Forest Products, 2: 1-32.*

This article presents data on mass per volume, density of vascular bundles, swelling, compression, tension, bending and moisture content, all correlated with age, position on culm, growing site and cutting time. A very comprehensive work with 26 tables and 20 diagrams.

Note: in Chinese. Translation of captions of tables and figures to English by Eindhoven University. Copy of translations is available from Bamboo Information Centre (China).

Keywords: anatomical structure, bending, compression, mass per volume, moisture content, physical properties, shrinkage, tension, .

Zhou, H.M., Qian, D.Z, and Wang, A.F.(1985).

*A study on the physical and mechanical properties of acetylated and untreated bamboo (Phyllostachys pubescens).
Journal of Nanjing Institute of Forestry, 3: 13-34.*

Note: In Chinese with English summary.

Keywords: physical properties, preservation.

Chapter 2

Preservation

Abdurachim, R.A. (1964).

Bamboo preservation in Indonesia.
Rimba, Indonesia IX, (1): 66- 76

Methods of preservation of bamboo in Indonesia are described.

Keyword: preservation.

Abdurrohim, S. (1962).

Cold soaking treatment of twelve bamboo species.
Laporan, Babi Penelitian Hasil Hutan, Indonesia, No. 158: 5- 11

The result of cold soaking on 12 Indonesian bamboo species is reported. Data on time required for penetration of solution for round and split bamboos are also provided.

Note: In Indonesian with English summary.

Keyword: preservation.

Anon. (1937).

Bamboo cultivation in the USSR.
Economic Survey Monthly Bulletin, 9/1 0: 22-36.

Describes the steaming of bamboo in hermetically sealed chambers. On cooling, the culms become shiny as though the surface has been covered with natural varnish. The surface becomes resistant to atmospheric influences and pests.

Keyword: preservation.

Anon. (1945).

War against Bostrychidae.

Pest Control Pamphlet of Ordnance Factory, Kanpur, India No. 1, pp 16.

Discusses the biology of bamboo borers, both insect and marine organisms, and several control measures, some involving preservative treatments.

Keyword: preservation.

Anon. (1947).

Forest research in India and Burma.

Annual Report of the Entomology Branch, Forest Research Institute and Colleges, Dehra Dun, IV: 101-103.

A modified Boucherie method of treatment is described using aqueous solutions of inorganic salts or creosote.

Keyword: preservation.

Anon. (1948).

Use of bamboo as stickers in storing plywood and for roofing.

Annual Report of Forest Department, Uganda, 194 7-48: 22-23.

The need for treating split bamboo, whether used as stickers or for roofing, is stressed. An effective treatment against beetles is soaking in water for 6-8 weeks.

Keyword: preservation.

Anon. (1961).

I S I: Preservation of bamboo and cane for non-structural purposes.

Indian Forester, 87(3):169.

Discussion of Code of Practice for Preservative treatment of bamboos and canes for indoor and outdoor non-structural purposes presented in Indian Standard BDC 9 (486).

Keyword: preservation.

Anon. (1964).

Preservative treatment of green bamboo.

Forest Research in India, 1963-64. Part 1;F.R.I. Dehra Dun. 54p.

Report of experiments on diffusion treatment of green bamboos by different preservatives. Absorption data are given.

Keyword: preservation.

Anon. (1974475).

*Experiment on preservation of bamboo culms.
Report of Technical Research Institute Beppili, 6-7.*

General description on treatment of bamboo culm is given.

Keyword: preservation.

Bhadran, C.A.R. (1961).

Extension work on the use of treated poles, bamboos, fence posts, etc., in rural areas.

Journal of the Timber Dryers and Preservers Association of India, 7(1).

General paper on conservation of scarce timber and bamboo resources for rural uses by adopting preservative treatment before use. Chemical preservation by using portable, inexpensive equipment is recommended.

Keyword: preservation.

Chanda, A. and Guha, S.R.D. (1979).

*Studies on the decay of bamboo (Dendrocalamus strictus) during outside storage - degradation of cellulose.
Indian Forester, 105(6) : 444-450.*

Reports on results of a study conducted to find out the degradation of cellulose in *Dendrocalamus strictus* during outside storage. Holocellulose and a cellulose were analysed in untreated and preservative treated bamboo after 4, 8 and 12 months storage. The contents of both declined progressively with duration of storage. The effect of the preservation was slight.

Keyword: preservation.

Chanda, A. and Guha, S.R.D. (1979).

*Studies on the decay of bamboo (Dendrocalamus strictus) during outside storage - effect on hemicelluloses.
Journal of the Timber Development Association of India, 25(3): 10- 13.*

Reports on results of a study conducted to find out the effect of outside storage of bamboo on the hemicellulose content. Untreated bamboos and bamboos sprayed with various preservatives were stored outside for up to 12 months and analysed periodically to find changes in hemicellulose content. It is reported that the organisms causing decay attack xylose and to some extent glucose.

Keyword: preservation.

Ding, J.Y., Chang, C.H. and Wui, C.C. (1978).

The weathering test of bamboo (1).

Technical Bulletin, Experimental Forest, National Taiwan University, No. 722: 21-30.

Preservative treatment using Na-PCP and/or cupric acetate followed by a coating with epoxy resin was found very effective in preventing weathering of bamboo.

Note: In Chinese with English summary.

Keyword: preservation.

Englerth, G.H. and Maldonado, E. (1961).

Bamboo for fence posts.

Tropical Forestry, No.6: 2.

Instructions for felling, conversion, storage and preservative treatment of *Bambusa vulgaris* in Puerto Rico.

Keyword: preservation.

Fang, H.Y., Mehta, H.C. and Jolly, J.D. (1976).

Study of sulphur-sand treated bamboo poles.

In: Proceedings of the International Symposium, New Horizons in construction materials, Lehigh University Bethlehem, Pa.

Envo. Publication Co. Inc., Lehigh Valley 1: 489-497.

The paper presents the procedures for treatment of bamboo poles with sulphur and sand. The bond stress of the treated bamboo was studied by means of a simple pull test. The mechanism of treated bamboo-concrete interaction is also discussed.

Keywords: preservation, reinforcement in concrete.

Galvao, A.P.M. (1964).

Preservation treatment of bamboo by the cold soaking method.

Anats-de-Esaola Superlorde agricultura-Luza de Quelroz.

Piraclocaba, 24: 19-33.

Two-year old samples of round and split bamboo stakes at *Bambusa tuldooides* were air-dried and then soaked for 7-8 days in 5% PCP (Dowicide) in two different oil solvents. Absorption of preservative in kg per year of service life are estimated and given.

Note: Original in Portugese.

Keyword: preservation.

Guha, S.R.D. and Chanda, A. (1979).

Studies on the decay of bamboo (Dendrocalamus strictus) during outside storage 1. Effect of preservatives II. Effect on pulping qualities.

Indian Forester, 105 (4) : 293-300.

This paper reports the effect of preservative treatment on the strength properties of bamboos. A study conducted at FRI Dehra Dun revealed that preservative treatment reduced wood substance losses by 28-30% and pulp yield by about 30%

Keywords: natural durability, preservation.

Hamada, H. (1962).

Preservation of bamboo culms and products.

Report of Fuj Bamboo Garden (Japan): 6p.

Preservative treatment methods of culms of bamboo and other bamboo products are described.

Keyword: preservation.

Jain, J.C. (1978).

Role of wood preservation in rural life other than housing.

In: Proceedings of the VIII World Forestry Congress, Jakarta: 1-5.

General description of non-timber lignocellulosic material, including bamboo, available for use in rural India and need for preservative treatment for longer life. Treatment processes by displacement of sap are described.

Keyword: preservation.

Jayanetti, D.L. (1975).

Some methods of preservative treatment of bamboo.

Sri Lanka Forester, 12(2): 101-103.

An illustrated description of simple methods for impregnation of freshly-cut bamboos (*Bambusa arundinacea* and *B. vulgaris*).

Keyword: preservation.

Kirkpatrick, T.W. and Simmonds, N.W. (1958).

Bamboo borers and the moon.

Tropical Agriculture, Trinidad, 35, (4).

An article on the relation between the phase of moon and natural durability.

Keywords: natural durability.

Kumar, S. (1989).

Low cost huts for rural and tribal areas.

Journal of Timber Development Association of India, 35(3): 5-8.

The need for using treated bamboo in rural housing is stressed. The economical advantages of such treatment is calculated.

Keywords: economic aspects, low cost construction, preservation.

Kumar, S. and Dohriyal, P.B.(1990).

Preservative Treatment of bamboo for structural uses.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held in Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 199-206.

Reviews the work carried out in the Forest Research Institute, Dehra Dun, on bamboos, in relation to their structural use. Gives information on physical and mechanical properties of bamboos and natural durability. Describes different methods followed for treating green and dry bamboo with preservative chemicals.

Keywords: mechanical properties, physical properties, preservation.

Lakshamana, M.G. (1966).

The preservation of bamboo.

Wood Preservation Report. Forpridecom Library College Laguna, Philippines, 1(2): 92-94.

Methods of bamboo preservation are described.

Keyword: preservation.

Liese, W. (1959).

Bamboo preservation and soft rot - Report to the Government of India. FAO-EPTA Report No. 1106: 47p

Food and Agriculture Organization of the United Nations, Rome.

A report dealing with structure, physical properties and natural durability of important bamboo species of India. Methods of treatment specifically against soft rot are described.

Keywords: natural durability, physical properties, preservation.

Liese, W. (1963).

Bamboo preservation in Asian Countries
FAO/WTC/63/WP/11 Background Paper Fifth Conference on Wood Technology. FAO/WTC/63/WP/11: 1 1p
Food and Agriculture Organization of the United Nations, Rome.

Discusses the treatability of bamboo, and protective treatment methods employed in Asian countries (non chemical, chemical, open tank, pressure). Some comments on service life of treatment bamboo are included.

Keyword: preservation.

Liese, W. (1968).

Bamboo preservation in East Pakistan.
Consultancy Report, Bundesforschungsanstalt für Forst-und Holzwirtschaft, Institut für Holzbiologie und Holzschutz, Reinbek, Germany: 32 p.

Presents an outline of availability and fields of utilisation. Reviews the existing state of bamboo preservation in the country, treatability of Pakistan bamboo and economics of preservative treatment. Methods for protection (non chemical and chemical) are suggested. Recommendations for further studies on treatment and utilization are discussed.

Keyword: preservation.

Liese, W. (1980)

The preservation of bamboo.

In: *Bamboo Research in Asia*. Proceedings of IDRC sponsored Workshop held in Singapore, May 1980: 165-178, IDRC, Singapore.

Methods of treating bamboo for longer service life are described.

Keyword: preservation.

Liese, W. (1981).

Bamboo-methods of treatment and preservation.
Gate, (1): 9-11.

An article giving a complete overview of methods of preservative treatment of bamboo.

Keyword: preservation.

Mathur, B.C. (1989).

Improving the performance of low cost bamboo houses.

In: Proceedings of Third CIB-Rilem Symposium: Materials for Low Income Housing, 1989, Mexico.
Funav, Mexico City, Mexico.

Advantages and disadvantages of bamboo as a construction material are presented. It is suggested that the disadvantages can be overcome by adopting inexpensive methods such as choosing the correct species and preservative treatment.

Keywords: mechanical properties, natural durability, physical properties, preservation.

Mori, H. and Hideo, A. (1979).

Insect damage to bamboo materials and its preservation.

Science for Conservation, No. 18: 4 1-55.

Insect damage to bamboo materials is reported with examples, and a method of preventing insect damage is described.

Note: In Japanese.

Keyword: preservation.

Narayanamurti, D., Purushotham, A. and Pande, N.N. (1947).

Preservative treatment of bamboos Part I, treatment of green bamboos with inorganic preservatives.

Indian Forest Bulletin (n.s.) No. 137.

Describes treatment of bamboos with various inorganic preservatives employing various methods. The incision of inner wall aided liquid penetration.

Keyword: preservation.

Panga, G.A. (1937).

Preservatives for wooden and bamboo posts against ground inhabiting termites.

Philippines Agriculture, Los Banos 25(8): 680-88.

Describes experimental studies on protecting posts of wood and bamboo from subterranean termites. Setting them in holes in which three tablespoonful Paris Green is scattered has been reported to give protection.

Keyword: preservation.

Plumptre, R.A. (1964).

Recommendations for the preservative treatment of small round timbers by sap displacement and for fencing techniques.

Technical note for development. Uganda No. 116/64: 22p.

Gives recommendations and methods for treatment of poles of *Eucalyptus saligna* and *Bambusa vulgaris* with salts of Copper-Chrome-Arsenic with data on penetration.

Keyword: preservation.

Purushotham, A., Sudan S.K. and Vidyasagar (1954).

Preservative treatment of green bamboos under low pneumatic pressure.

Indian Forest Bulletin (n.s.) No. 178, Forest Research Institute and Colleges, New Forest, Dehra Dun, India.

Describes the Boucherie process of treatment, incorporating modifications to reduce treatment period. By application of pneumatic pressure over the preservative in a reservoir, treatment time is reported to be reduced to 3-4 hours.

Keyword: preservation.

Purushotham, A. (1963).

Instructions for treatment of timber, bamboos, etc. when facilities for pressure treatment are not available.

Journal of the Timber Dryers and Preservers Association of India, 9(4): 17-18.

General description of preservative treatment without pressure process.

Keyword: preservation.

Purushotham, A. (1970).

Protection of pulpwood (including bamboo) from deterioration due to biological agencies (fungi and insects) during transit and storage.

Journal of Timber Association of India, 16(2): 50-53

Describes methods of preservation of bamboo and pulpwood during transit and storage by use of prophylactic treatments.

Keyword: preservation.

Rehman, M.A. (1947).

No title. Indian Forest Records (2).

Seasoning and shrinkage data on 9 species of Indian bamboos are given.

Provides details of seasoning defects to which bamboos are liable. The shrinkage measurements on the mature and immature culms of different species indicate that all species of bamboos shrink considerably both in diameter and wall thickness during drying.

Keywords: preservation, seasoning.

Roonwal, M.L. and Chatterjee, P.N. (1951).

Benzene hexachloride as a successful anti insect prophylactic for bamboos in storage.

Journal of Scientific and industrial Research, 10B (12): 321-322

BHC, both at 0.5% and 0.33% strength of gamma isomer, gave complete protection for over a year against ghoon beetles.

Keyword: preservation.

Sharma, S.N. (1988).

Seasoning behaviour and related properties of some Indian species of bamboo.

Indian Forester, 114 (10) : 613-621.

Existing Indian technology for seasoning bamboo is reviewed in this paper. The methods described include air seasoning, kiln seasoning, baking over open fire, pre-treatment by water soaking and chemical seasoning. Shrinkage behaviour is also described.

Keywords: preservation, shrinkage.

Shibamoto, T., Inou, E.Y. and Kenjo, Y. (1960).

Studies on water-borne wood preservatives XVII, colour change of treated wood by weather procedure.

Journal of Japanese Wood Research Society, 6 (3) : 122- 128.

General description of colour changes in wood of *Cryptomeria japonica* and bamboo - *Phyllostachys edulis* on treating with 14 different preservatives by using different methods of treatment are described.

Note: Original in Japanese.

Keyword: preservation.

Singh, S. and Nigam, P.N. (1968).

Note on preservation of green bamboos by the modified Boucherie and the diffusion process.

Journal of Timber Development Association of India, 14(I): 20-23.

Average absorption and diffusion of preservative treatment on two species of Bambusa and two species of *Dendrocalamus* by $ZnCl_2$ show that it is adequate for use in bamboos to be used under cover.

Keyword: preservation.

Singh, B. and Tewari, M.C. (1978).

Studies on the effect of ponding on the preservative treatment of bamboos by pressure and diffusion processes.

Journal of Indian Academy of Wood Science, 9 (1) : 46-49.

The paper reports that ponding for one to four months increases the absorption of acid and creosote/furnace oil into bamboos.

Keywords: preservation, natural durability.

Singh, B. and Tewari, M.C. (1979).

Studies on the preservative treatment of bamboos by steeping. Open tank and pressure processes.

Journal of the Indian Academy of Wood Science, 10 (2): 68- 71.

Three methods of preserving bamboos are described in this paper.

Keywords: preservation, natural durability.

Singh, B. and Tewari, M.C. (1981).

Studies on the treatment of green bamboos by different diffusion processes. Part I-Dip diffusion and osmosis process.

Journal of the Timber Development Association of India, 22(1): 38-44.

The paper presents the details and results of experiments for treating bamboo using dip diffusion and osmosis process. It is reported that penetration of chemicals was greater in half split bamboos.

Keywords: preservation, natural durability.

Singh, B. and Tewari, M.C. (1981).

Studies on the treatment of green bamboos by different diffusion processes. Part II. Steaming and quenching and double diffusion.

Journal of the Timber Development Association of India, 27 (2) : 38-46.

This is the second part of the article by the same authors on treatment of bamboos by diffusion processes. This part of the paper reports the effect when steaming and quenching and double diffusion technique are used. Steam treatment significantly improved absorption compared with simple immersion.

Keyword: preservation.

Slob, J.W., Nangawe, P.F., Leer, E. de and Donker, J. (1987).
CCA impregnation of bamboo-leaching and fixation characteristics.

In: Rao, A.N., Dhanarajan, G. and Sastry, C.B. (Eds.). Recent Research on Bamboos. Proceedings of the International Bamboo Workshop held at Hangzhou, People's Republic of China, October 6-14, 1985. Chinese Academy of Forestry, People's Republic of China & International Development Research Centre, Canada, 321-336.

Leaching tests on bamboo impregnated with CCA revealed that As was leached extensively. The results obtained were in marked contrast to earlier laboratory findings with CCA impregnation on bamboo sawdust. The paper contains a detailed discussion of fixation of CCA into bamboo sawdust and pipes.

Keyword: preservation.

Sonti, V.R. (1990).
A workable solution for preserving round bamboo with ASCU (CCA type salts).

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore, 207-208.

The paper suggests that hollow bamboo can be preserved effectively with ASCU under pressure if notched in a pattern. This neither reduces the strength when used in compression or bending nor is there loss of preservative trapped in between the septa in comparison to the Taiwanese method of drilling through the septa.

Keyword: preservation.

Sulthoni, A. (1987).
Traditional preservation of bamboo in Java.

In: Rao, A.N., Dhanarajan, G. and Sastry, C.B. Recent Research on Bamboos. Proceedings of the International Bamboo Workshop held at Hangzhou, People's Republic of China, October-6-14, 1985. Chinese Academy of Forestry, People's Republic of China & International Development Research Centre, Canada, 349-357.

The paper lists both chemical and non-chemical methods of preservation of bamboo. The soaking of bamboo under water is advocated as a cheap and effective method. There is reduction in starch contents of the culm with immersion.

Keyword: preservation.

Sulthoni, A. (1990).

A simple and cheap method of bamboo preservation.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore, 209-211.

The paper compares the traditional method of bamboo preservation by soaking in water with cold soaking and coating with copper sulphate or diesel oil. These are evaluated on the intensity of damage by the post beetle and termites.

Keywords: insect attack, preservation.

Sumintardja, D. (1983).

New methods of using bamboo for low cost housing.

In: Proceedings of the Conference to Build and Take Care of What We Have Built with Limited Resources. Stockholm (sponsored by CIB, Rotterdam), National Swedish Institute for Building Research, Savle: 36-37.

A general paper dealing with non-conventional methods of using bamboo in construction in Indonesia where more than 70% of households are living in bamboo houses. Recommendations based on experiments on coating applied to bamboo after soaking them in ponds and rivers to increase durability are given.

Keywords: low cost housing, preservation.

Tewari, M.C. (1981).

Recent studies on the protection of bamboos against deterioration.

In: Higuchi, T. (Ed.). Bamboo production and utilization. Proceedings of the XVII IUFRO World Congress, Kyoto, Japan, September 6-17, 1981. Wood research Institute, Kyoto University, Kyoto, Japan: 172-177.

The paper shows that green bamboos are easily treatable by diffusion process. Ponding of bamboos prior to preservative treatment results in increased penetration and absorption of the preservatives, both by pressure and diffusion processes.

Keyword: preservation.

Tewari, M.C. and Singh, B. (1979).

Bamboos - their utilization and protection against biodeterioration.

Journal of the Timber Development Association of India, 25 (4) : 12-23.

Brief notes are given on distribution, size and yield, anatomy, gross structure, strength properties, use and biodeterioration of bamboo. A general account of preservative treatment for bamboo is also given.

Keywords: mechanical properties, natural durability, preservation.

T D PA : (1961).

A note on preservation of bamboos and canes for non-constructional purposes.

Journal of Timber-Dryers and Preservers Association of India, 7(1): 67-71.

Bamboos and canes used for several non structural purposes can best be treated under green condition through sap displacement by water soluble preservatives.

Keyword: preservation.

Yeh, C.L. (1980).

Studies on the moisture content based on green condition of three important bamboos in Taiwan.

Quarterly Journal of Chinese Forestry, 13(1) : 119- 130.

Data regarding moisture content green condition for use in drying and preservation are reported for *Dendrocalamus latiflorus*, *Phyllostachys pubescens* and *P.makinoi*.

Note: In Chinese with English summary.

Keyword: preservation.

Zhou,H., Jin, Z., Wang, S., and Wang, A. (1981).

An experiment on bamboo preservation.

In: Hsiung, W.Y. (Ed.). *Bamboo Research* Vol.1,
Nanjing Technological College of Forest Products: 11 I-I 12.

Describes an experiment carried out to ascertain the comparative efficiency of chemicals for preserving bamboo. Of the chemicals used, FBBCr (Cr-B-F, with borax and boric acid) was found the most effective.

Keyword: preservation.

Chapter 3

Application in buildings

A. STRUCTURAL

Abbas, LA (1938).

Evolution of the construction and building industries in Indonesia.
UNIDO, Vienna. Document No.ID/232/12:36p.

Covers general situation of the construction and building materials industry. Reports research and development in building and building materials, including bamboo for housing.

Keywords: building materials, low cost construction.

Anon. (1978).

Low cost housing systems for Guatemala.
Centro Mesoamerica de Estudios sobre Tecnologia Abropiada.
Guatemala City: 65p.

The report contains information on two wall systems for building low cost housing with earthquake-resisting characteristics. Local building technology, including the use of bamboo, is described. The San Lucan Project is also described and details given of criteria for site selection, selection of building materials and techniques, bamboo reinforced stone foundation, bamboo reinforced loam wall, pumic-filled bag wall system, curing bamboo with smoke and cost analysis. The book has several photographs and technical drawings.

Note: Text in English and Spanish.

Keywords: construction techniques, earthquakes, preservation, reinforced structures.

Anon. (1980).

Durable bamboo house.

Report No.3. Roof over our head.
National Building Organisation, New Delhi, India, 15.

The booklet contains information on treatment and use of bamboo materials in the construction of bamboo houses.

Note: Out of print.

Keywords: construction techniques, preservation.

Asia, S. (1939).

Hardening of bamboo.
Japanese Patent no. 131,868 of 28-9-39.

A process of hardening bamboo by treatment with Bismarck brown and two other basic brown dyes and thereafter with boiling solution of FeSO_4 or $\text{Fe}(\text{OHCL})_2$ is described. The employment of such hardened bamboo in building construction is explained.

Keywords: construction techniques, preservation.

Baier, B. (1985).

Detail studies of a bamboo grid shell.

In: Gass *et al* (Eds.). IL31 Bamboo. Institute for Lightweight Structures.
University of Stuttgart, W.Germany.

A study of a 6m span dome roof made from bamboo rods. Jointing method in grid shells is described with 9 photographs. 1 diagram of joint and 1 graph of bending tests on bamboo.

Note: Text in German and English.

Keywords: architecture, construction techniques, domes, joints, test methods.

Boughton G. N. (1990).

CIB - W18B activities towards a structural design code for bamboo.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 280-282.

This paper explains the benefits to be accrued by publicising an internationally recognized bamboo design code and provides a broad outline for the form of the code.

Keywords: design code.

Boughton G. N. (1990).

Typhoon damage to bamboo housing.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 251-257.

This paper examines the performance of a number of low cost houses in recent cyclones in the Philippines and estimates the areas in which it could be improved. In most cases the bamboo had adequate strength to carry the wind loads but the connections of the bamboo could not sustain the loads for the duration of the typhoon.

Keywords: joints, typhoons.

Chavez, R.A. and Boughton, G.N. (1990).

Tied bamboo connections under typhoon loads.

Civil Report 90/1. Curtin University of Technology, Australia.

School of Civil Engineering, Civil Report 90/1 :78p.

This monograph presents detailed research findings on the strength of connections between bamboo members lashed with rattan and nylon. It investigates material properties of the lashing and the behaviour of the connections under both static and dynamic loads.

Keywords: economic aspects, joints, test methods, typhoons.

Das, R.N. (1989 and 1990).

Better roofing on bamboo truss.

Indian Journal of Rural Technology 1: 19-32 and 2: 107- 118.

The papers present comparative cost analysis for triangular bamboo roof trusses and shows that they have advantages over timber roofing systems. Connections were made with bolts and mild steel straps.

Keywords: joints, roofing, trusses.

Duff, C.H. (1941).

Bamboo and its structural use.

The engineering society of China, Shanghai.

Lecture notes for the Engineering Society, with an overview of structural uses and mechanical properties.

Contains 3 tables, 13 figures.

Keywords: construction techniques, mechanical properties.

F.A.O. (1977).

Forestry department and watershed management in the upland regions, Phase III, Jamaica.

Terminal Report of FAO/UNDP project JAM/67/505.

Report No. FAO/FO-DP/JAM/67/505.2p.

Information is provided on utilization of bamboo for low cost housing and on establishing minor industries and handicrafts based on existing bamboo resources.

Note: The document is for restricted distribution only.

Keywords: low cost construction.

Fritz, J., Gass, S., Greiner, S., Reiner, R., and Voigt, M. (1985).

Using vegetal rods for arches, vaults, domes and shells.

In: Gass *et al* (Eds.). IL31 Bamboo. Institute for Lightweight Structures. University of Stuttgart, W.Germany: 304-319.

Structural forms of arches made from bamboos were explored and some calculations of stress and strain are given.

Note: Paper in German and English.

Keywords: architecture, domes, roofing.

Fritz, J., Gass, S., Greiner, S., Reiner, R. and Voigt, H. (1985).

Building with straight vegetal rods.

In: Gass *et al* (Eds.). IL31 Bamboo. Institute for Lightweight Structures, University of Stuttgart, W.Germany: 264-286.

This paper presents many examples of structural systems incorporating straight bamboo rods. There is also information relating to the strength of bamboo, some test data and method of analysis that gives a measure of the structural efficiency of the method.

Keywords: bending, compression, construction techniques, mechanical properties, tension, test methods, trusses.

Ghavami, K., Hombeek, R.V., Andrade, M.N. and Antunes, C.C. (1984).

Viabilidade de uma treliça espacial de bambu (Possibilities of bamboo space structures) .

Report RI 1 0/84. Civil Engineering Department Pontificia Universidade Catolica de Rio de Janeiro - 22460, Brazil: 32p.

In this work the possibilities of constructing space structures using bamboo is

discussed and several different types of joints are studied.

Note: The report is in Portuguese. An abstract in English is provided.

Keywords: joints, space frame.

Ghavami, K. and Moreira, L.E. (1990).

Desenvolvimento de estruturas espaciais de bambu (Development of bamboo space structures).

Report of the Civil Engineering Department, Pontificia Universidade Catolica de Rio de Janeiro/Pue-Rio, 7990: Brazil: 4-70p.

In this technical report, several bamboo space structures using *Dendrocalamus giganteus* and *Bambusa vulgaris* are analysed using computer program. Several detailed studies of the joints to be used in this type of structure are presented. A proposal for experiments on bamboo space structure is given.

Note: The report is in Portuguese. Abstract in English is provided.

Keywords: construction techniques, energy saving, joints, mechanical properties, physical properties, space frames, test methods.

Hagmueller, G.A. (1971).

Review of the use of wood in housing in Indonesia.

In: Proceedings of the World Consultation on the Use of Wood in Housing, with Emphasis on the Needs of Developing Countries, Vancouver, July 5-16.

Food and Agriculture Organisation of the United Nations, Rome:9p.

The housing requirement in Indonesia is briefly reviewed and technology of construction with bamboo, timber and non-wood materials is presented. Advantages /disadvantages of utilizing bamboo, non-wood materials, etc., in building construction compared to wood are discussed.

Keywords: building materials, construction techniques.

Herbert, M.R.M. and Evans, P. (1979).

The development of structural connections for bamboo.

Building Research Establishment, (143) : 36p.

Report on research on metal joints. The development of joints and the results are described with 33 figures and diagrams.

Keywords: joints, test methods.

Hsiung, W.Y. (1987).

Bamboo in China : new prospects for an ancient resources.
Unasyvla, 39(2): 42-49.

A brief discussion of distribution, production, management, uses, research, biology, silviculture and pest and disease control.

Note: Adapted from a paper presented to the XVIII IUFRO World Congress.

Keywords: construction techniques.

Iliffe Moon, P.H. (1973).

Bamboo scaffolding's vita/ role in HK building industry.
Asian Building and Construction, (Feb.): 24-25.

Informative description on scaffolding.

Keywords: construction techniques, scaffolding.

Iwai, Y. (1983).

Study on the formation process of bamboo producing centre for building materials, in the case of Kyoto.
Bulletin, Kyoto University Forestry, No.54: 67-83.

Describes the development of production centre for bamboo building materials in Kyoto after World War II, jointly by wholesalers, bamboo producers and manufacturers.

Note: In Japanese with abstract in English.

Keywords: building materials, construction techniques.

Janssen, J.J.A. (1981).

Bamboo trusses

In: Proceedings of the XVII IUFRO World Congress, Kyoto, division 5, 393.

Design methods are presented for bamboo trusses. Paper supported by test results. Different truss designs for different spans are calculated and described.

Keyword: trusses.

Janssen, J.J.A. (1981).

Bamboo trusses.

In: Proceedings of the Conference of Appropriate Technology in Civil

Engineering, London, Thomas Telford Ltd. London: 120-l 22

A comprehensive account is given of mechanical properties of some bamboo species, test results of trusses and joints, the ultra structure of bamboo, biological properties, chemical composition and loading system.

Keywords: mechanical properties, physical properties, trusses.

Janssen, J.J.A. (1981).

Bamboo trusses.

In: Higuchi, T. (Ed.). Bamboo production and utilization, Proceedings of the Congress Group 5.3A, Production and Utilization of Bamboo and Related Species, XVII IUFRO World Congress Kyoto, Japan, September 6-l 7, 1981. Wood Research Institute, Kyoto University, Kyoto, Japan: 158-l 63.

Bamboo trusses to support roofs with a free span of 8m were tested on full scale and on short and long term loading. The trusses failed due to limits to material strength in the upper members and not on account of joint strength.

Keywords: test methods, trusses.

Janssen, J.J.A. (1984).

Better bamboo trusses.

Batiment International, 12(6): 369-3772.

Overview of research on trusses with a free span of 8 m built and tested on full scale.

Keywords: test methods, trusses.

Janssen, J.J.A. (1987).

Building with bamboo.

Intermediate Technology Publications, London: 77p.

This is a handbook for the field practitioner, and includes many drawings. It deals with the cultivation, seasoning, and preservation of bamboo, its mechanical properties, methods of calculating strength and stiffness, construction methods for joints, trusses, bridges, and manufacture of woven bamboo products.

Note: A comprehensive manual, available from Intermediate Technology Publication Network.

Keywords: bridges, construction techniques, joints, mechanical properties, preservation, trusses.

Janssen, J.J.A. (1990).

The importance of bamboo as a building material.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 235241.

The paper outlines the state of the art on durability, mechanical properties, housing, larger industrial and social buildings, bridges, roads, bamboo reinforced concrete, woven bamboo and split bamboo for ceilings and walls, bamboo - boards and piles and rafts. It also includes a proposal to form a IUFRO subgroup on Building with Bamboo.

Keywords: housing, mechanical properties, physical properties, preservation.

Kliment, S., Rantaste, N. and Marshall, R. (1977).

43 Rules: How houses can better resist high wind.

Report No. N8SIR, 77- 1197. National Bureau of Standards, Washington D.C.:74p.

This guide describes a series of methods for improving the resistance of new and existing buildings against high winds. It includes guidelines for selecting the location, orientation and shapes of buildings, methods of construction, building details and the local production of connectors and fasteners. Although the booklet primarily covers construction with masonry and timber, selected details based on bamboo and adobe are also included.

Keywords: construction techniques, joints, typhoons.

Kumpe, G. (1937).

An experimental bamboo truss.

The Military Engineer, 129 (66): 288-289.

Informative article on a bridge with a span of 15 m for cars of 750 kg, built and tested on full scale.

Keywords: bridges, trusses.

Llmaye, V.D. (1943).

Bamboo nails, their manufacture and holding power.

Indian Forest Records, 3(3).

This paper describes the comparative merits of using bamboo and mill nails to fasten members of packing cases. Conclusions are drawn that glued bamboo nails have greater holding power than plain bamboo nails and that in

a packing case, combination of 75% bamboo and 25% mill nails is better than total bamboo nails.

Keywords: bamboo nail, joints.

Lopes, O.H. (1985).

Constructing with bamboo in South America.

In: Gass *et al.* (Eds.). IL31 Bamboo Institute for Lightweight Structures, University of Stuttgart, W.Germany:288-291.

Provides diagrams of bamboo connections and structural forms used in bridges and houses. A brief mention is made of bamboo ropes and bamboo reinforcement with splits as a reinforcing cage.

Keywords: construction techniques, joints, low cost construction, reinforced structures, trusses.

Marrero, J. (1944).

Utilization de la cano guadua on Equador.
Caribbean Forester, 5(3): 145- 151.

The guadua bamboo (*Guadua latifolia* and *G. angustifolia*) is a well known large-sized bamboo of Equador, Peru and Columbia. In Equador its use is multifarious. In round and flattened form it serves a variety of constructional purposes.

Note: in Spanish.

Keywords: construction techniques.

Masani, N.J. and Pruthi, K.S. (1972).

Comparative study of strength, deflection and efficiency of structural joints with steel bolts, timber bolts and bamboo pins in timber framed structure (for use in chemical industries sheds and antimagnetic constructions).
Indian Forest Leaflets, I E Branch, FRI, Dehra Dun, No. 193: 1 Op.

Comparative study of different bolts and pins in connections showed that timber bolts and bamboo pins can be used to replace steel fasteners in wooden construction.

Keywords: bamboo pins, fasteners, steel bolts.

Mathur, G.C. (1980).

Low energy technology for low cost housing in developing countries.

In: Proceedings of the Conference, Energy Resources and Conservation Related to Built Environment, Miami, USA (sponsored by Florida International University and International Institute for Housing and Building, Miami). Pergamon Press, New York and Oxford: 114-1 22.

A general descriptive paper on low cost housing in developing countries utilizing low energy material. Among the materials described for such housing are bamboo, mud, stone, etc.

Keywords: energy saving, low cost construction.

McClure, F.A. (1956).

Bamboo in the economy of Oriental people.
Economic Botany 1 0(4):335-6 1.

A general account of bamboos used for various purposes including house construction.

Keywords: construction techniques.

Minke, G. (1985).

Bamboo arch and grid structures - new opportunities for extremely lightweight roof structures made from bamboo.

In: Gass *et al.* (Eds.). IL31 Bamboo. Institute for Lightweight structures, University of Stuttgart, W.Germany: 342-347.

This paper shows a number of creative forms for bamboo structures made from splits and full sections.

Note: Text in German and English.

Keywords: architecture, construction technique, domes.

Mishra, H.N. (1990).

Know-how of bamboo house construction.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-1 8 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 242-249.

The design of a house made principally of bamboo and suitable for a medium-sized family in a rural environment is described. The methodology of reinforcing mud-walls using treated bamboos, making of wire-pin and gusset-pin-jointed trusses, wire-bound roof grids etc. have been elaborated in the paper.

Keywords: housing, roofing, trusses.

Norton, J. (1987).

Limitations on improving earthquake resistance etc.
Trialog, 12: 2 1-23.

improving houses in earthquake areas by bamboos in the walls is explained with drawings.

Keywords: earthquakes, reinforced structures.

Punham, R. and Mishra, H.N. (1989).

Laboratory and field investigations on bamboo trusses and their feasibility for rural housing.
Journal of the Indian Academy of Wood Science, 20(1): 57-65.

Development of bamboo trusses, and research on strength and stiffness is described with 1 table and 8 figures.

Keywords: joints, trusses.

Qihuang Li, Dezhao la and Changkun (1985).

A brief introduction to the bamboo tower in Zurich, Switzerland.

In: Rao, A.N., Dhanarajan, G. and Sastry, C.B. (Eds.). *Recent Research on Bamboos. Proceedings of the International Bamboo Workshop held at Hangzhou, Peoples Republic of China, October 6-14, 1985.* Chinese Academy of Forestry, People's Republic of China and International Development Research Centre, Canada: 339-341.

The details of construction of a bamboo tower with five floors are given.

Keywords: construction technique.

Reyes, V.D. (1976).

Some aspects of the use of bamboo for low cost house construction.
FORPRIDECOM Technical Note No. 167: 2p.

The paper presents various aspects of the use of bamboo for house construction in the Philippines.

Keywords: housing, economic aspects, low cost construction.

Roudakoff, G. (1947).

Note sur les construction en bambou.

Bulletin de l'Universite de l'aurore. 8: 4 18-428.

An overview of the mechanical properties and structural uses, with 9 tables and 12 drawings.

Note: In French.

Keywords: construction technique, mechanical properties.

Schaur, E. (1985).

Some characteristic forms of bamboo structures.

In: Gass *et al.* (Eds.). IL31 Bamboo. Institute for Lightweight Structures, University of Stuttgart, W.Germany: 320-336.

This contribution covers forms of traditional bamboo structures, and tensile structures. Structures made from split bamboo such as grid shells and basket shells are also described.

Note: Paper in German and English.

Keywords: architecture, construction technique, roofing.

Schaur, E. and Vasavda, R.J. (1988?).

Investigations of bamboo as a building material.

Bilateral cooperation in architecture. In ternational Bureau, Kernforschungsanlage Julich (Germany):4p.

This brochure describes experiments on building and testing grid shells made from split bamboo. The development and test methodology suitable for light weight architecture from scale models to full scale fabrication are described with three photographs.

Keywords: domes, low-cost construction, space frames.

Sharma, Y.M.L. (1988).

Production and utilization of bamboos and related species in the south Asian region in the rural sector.

Indian Forester, 114(10) : 603-609.

Discusses the silviculture, management and utilization aspects of the most commonly used bamboo species in the Asian countries, particularly in the rural sector.

Keywords: construction techniques.

Sonti, V.R. (1983).

Low cost dome structure using CCA treated bamboos.

Journal of the Timber Development Association of India, 29(4):35-40

Design details are given of a dome, constructed out of CCA treated bamboos, without metal fasteners. This is reported as more economical than traditional construction.

Keywords: economic aspects, domes.

Sonti, V.R. (1990).

Delft wire-lacing tool and a unique application-making a geodesic dome of 18m diameter.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 250.

A geodesic dome of approximately 18m, diameter and 9m height, using round CCA - preserved bamboos, has been put together using the wire-lacing tool developed by the Delft Centre of International Cooperation and Appropriate Technology, Netherlands.

Keywords: domes, joints.

Trojani, F. (1930).

Passerelles en bambou. (Footbridges in bamboo).

Bulletin Economique, Indo-China: 369B-373B.

Design drawings and strength data for three types of bridges for pedestrians and light traffic are given.

Note: In French.

Keywords: bridges, trusses.

Varmah, J.C. and Pant, M.M. (1981).

Production and utilization of bamboos.

Indian Forester, 107(8) : 465-476.

A review of the establishment, cultivation, preservative treatment and utilization of bamboos in India. A detailed list of different uses is given together with the most suitable species in each case.

Keywords: economic aspects, housing, low cost construction.

Voigt, H. (1985).

Bamboo tower at the phenomena in Zurich.

In: Gass *et al.* (Eds.). IL31 Bamboo. Institute for Lightweight Structures, University of Stuttgart, W.Germany.

Description of large exhibition pavilion in Zurich using bamboo. Text supported by 13 photographs.

Note: Paper in German and English.

Keywords: architecture, construction techniques.

Wu, S.C. (1982).

Research and development of the production and utilization of bamboo in Taiwan, R. O. C.

Forest Products Industries, i(1) : 18-26.

This paper, presented at the XVIII World Congress in Kyoto, 1981, contains data on the production and use of six main species of bamboo. The species are *Phyllostachys makinoi*, *P. pubescens*, *Bambusa stenostachya*, *B. dolichoclada* and *Dendrocalamus latiflorus*. Various uses such as construction of sheds, manufacture of boards and furniture making are also described.

Keywords: economic aspects.

B. NON-STRUCTURAL

Anderson, E.H. (1981).

Environmental, indigenous, colonial and contemporary buildings in Honduras. Central America.

In: Proceedings of the Conference, International Passive and Hybrid Cooling, Miami, USA. American Section of the International Solar Energy Society Network, Del., USA, 80-84.

A general paper dealing with importance of energy conservation with reference to Honduras and the importance of energy responsive buildings using local materials like palm leaf thatching, bamboo for walling, clay tile for roofing etc.

Keywords: energy saving, low cost housing.

Anon. ().

Usos de bambu curado en construcciones de vivienda y otros edificios en paises de escasos recursos economicos.

(The use of treated bamboo in house construction and other buildings in

developing countries.)

Acad. Asesoría centroamericana de desarrollo, Guatemala: 1 Op.

An internal report on bamboo as a construction material; many drawings and pictures.

Note: In Spanish.

Keywords: architecture, low cost housing.

Castro, D. (1966).

El bambu en la construcción.

Arquitectura, Madrid, (May): 43-48.

An article on designs for housing in Columbia with detailed description and 12 pictures.

Note: in Spanish.

Keywords: architecture.

Castro, D. (1985).

La Guadua, the vertasil bamboo.

Bogota, Columbia.

An illustration of new building designs (dwellings, public buildings, bridges) made from Guadua, a species of bamboo found in many parts of Latin America. The book contains a number of photos and illustrations of traditional and modern buildings, their processes of development and construction details as well as ideas on the benefits and development possibilities of such building designs.

Note: Text in Spanish and English.

Keywords: architecture, construction techniques, joints, low cost housing, panels.

Ciecior, B.D. (1985).

On the strength of bamboo - six criteria for its application.

In: Gass et al. (Eds.). IL31 Bamboo. Institute for Lightweight Structure, W.Germany: 412-417.

The versatility of bamboo and six criteria of application are described and supported by photographs (compatibility, technical maturity, economic competitiveness, sociopsychological acceptance, ecological safety and inherent innovation potential).

Note: Text in German and English.

Keywords: architecture, construction technique, economic aspects.

Desarkar, B.K. (1984).

Bamboo as material for house building and home industry.

In: Proceedings of All India Bamboo Study Tour and Symposium.
Forest Research Institute, Dehra Dun, India.

General description of use and economics of bamboo in rural housing. Use of bamboo in different industries is also described.

Keywords: housing, industrial uses.

Dietz, A.G.H. (1977).

Innovative uses of materials for housing in developing areas.

International Journal for Housing Science and its Applications, 1 (2): 132- 164.

A review paper on technical and economic aspects of some innovative materials for housing in developing areas. Bamboo is among the materials suggested for roofing. Need for further research on the subject, and implication of utilising such materials on the housing industry, are also discussed.

Keywords: economic aspects, roofing, low cost housing.

Gass, S. (1986).

In: Proceedings of Conference on Lightweight Structures in Architecture, Sydney, Australia. Unisearch Limited. The University of New South Wales, Kensington, NSW, Australia. 2V:661-668.

This paper describes principles of grid shell design and construction. Experiments at the Institute of Lightweight Structure in Stuttgart are described with reference to loadbearing capacity of grid shells, shell geometry, edges and openings. Photographs of experimental set up and built form in continuous veneer laminated timber supported by text.

Note: Title of paper not mentioned.

Keywords: architecture, domes, grid shells, space frames.

Hache, V. (1981).

Bamboo, its economical potential in the Third World.

Gate, (1): 7-8.

Short overview of bamboo of economic potential, with 6 photos.

Keywords: economic aspects.

Hidalgo, L.O. (1981).

Manual de construction con bambu.

Estudios Tecnicos Colombianos L tda. Construction rural I/ 98 1.

A manual for using straight bamboo and canes for building construction. Several sketches provide comprehensive information on the following topics: material impregnation, material use, construction details, house design, water pipelines and bridges.

Note: In Spanish.

Keywords: architecture, bridges, construction techniques, joints, low cost housing, pipes.

Janssen, J.J.A. (1987).

Building with bamboo.

International Technology Publications, London: 77p.

This handbook is already dealt with in chapter 2.

Keywords: matting, panels, walls.

Karamchandani, K.P. (1961).

Role of bamboos as construction material.

In: Proceedings of Symposium on Timber and Allied Products, New Delhi 1959:383-443.

General description on use of bamboo in construction.

Keywords: construction technique.

Lozada, J.H.A. (1985).

A residential estate constructed from bamboo in Manizales, Columbia.

In: Gass *et al.* (Eds.). IL31 Bamboo. Institute for Lightweight Structures, University of Stuttgart, W.Germany: 292-293.

Discusses a housing project in South America using bamboo. Text is supported by 4 photographs and 3 diagrams.

Keyword: architecture.

Mishra, H.N. (1983).

Structural use of bamboo in rural housing.
Indian Forester, 114(10): 622-634.

Practical aspects of the use of bamboos in rural housing in India are discussed, based on techniques developed at the Forest Research Institute, Dehra Dun. Topics covered include: choice of species, bamboo properties, seasoning and preservative treatment, design, construction and testing of bamboo trusses and main features of bamboo houses.

Keywords: economic aspects, low cost housing, preservation, trusses.

Munandar, M. (1986).

The technology manual on bamboo as a building material.
Institute of Human Settlements, Ministry of Public Works, Bandung, Indonesia:
60p.

This work presents a comprehensive description of the use of bamboo in Indonesian buildings. It lists species commonly used in construction in Java, problems with treatment and grading, basic strength testing and applications. The work includes a large number of figures and photographs.

Keywords: construction techniques, low cost housing.

Mundi, E.K. (1978).

Construction and building material industry in the United Rep. of Cameroon, UNIDO, Vienna, Document No. UNIDO- 1 O/232/12: 20p.

The paper presents characteristics of different non-conventional building materials including bamboo and also deals with technology transfer. Additional references are made to appropriate technology and building designs.

Keywords: building materials, low cost housing.

Otto, E. and Gass, S. (1985).

Building with vegetal rods - an overview.

In: Gass *et al.* (Eds.). IL31 Bamboo. Institute for Lightweight Structures,
University of Stuttgart, W.Germany: 16-36.

Includes principles of structural behaviour of vegetal rods, including bamboo in columns and beams, individually and in combination; frames, frameworks, rafter roofs, arches, grid shells and suspended structures. Text is supported by schematic diagrams which express structural behaviour, and by photographs.

Keywords: architecture, construction techniques, space frames.

Purushotham, A. (1963).

Low cost structures.

Journal of the Timber Dryers and Preservers Association, 9(3): 2-26.

Description is given of various low cost experimental structures fabricated and erected utilising treated bamboo and other materials. Design details and costing are included.

Keywords: low cost housing, economic aspects.

Purushotham, A. (1965).

Low cost structures (Twin rooms with arched roofs).

Journal of the Timber Development Association of India, 11(4): 3-6.

Details are given of design and construction of two-room bamboo houses with bamboo-mud reinforced walls.

Keywords: economic aspects, housing, reinforced structures.

Purushotham, A. (1965).

Low cost structure-a further contribution.

Journal of the Timber Development Association of India, 12(4): 11- 16.

Design and cost details are given of low cost buildings using prefabricated bamboo mats for reinforcement of mud walls.

Keywords: economic aspects, low cost housing, reinforced structures.

Ranjan, M.P. (1985).

Structure of bamboo baskets.

In: Gass *et al.* (Eds.). IL31 Bamboo. Institute for Lightweight Structures, University of Stuttgart, W.Germany: 356-367.

Classification of basket-forming processes, weave structures and weave edges based on bamboo woven forms and structures. Text is supported by 49 line drawings of woven construction details.

Note: Text in German and English.

Keywords: construction technique, matting, walls.

Rao, A.N. (1983).

Low cost housing or lower the cost of housing.

In: Proceedings of the Symposium on Appropriate Building Materials for Low Cost Housing: Nairobi (sponsored by CIB. Rotterdam, RILEM,

Paris) (E. and F.N. Spon. London and New York, 326-329).

A general paper pleading for studies on improving living conditions of people by better shelter within affordable cost by employing local materials, skills and technology. Examples are given of Indian experience with bamboos and bamboo mattings, among other local materials.

Keywords: low cost housing, matting.

Ravalio, P.M. (1986).

Timber for low cost housing in the Philippines.
UNIDO Document No. 10/WG-447/16: 67p.

A general document on current traditional house construction in the Philippines using bamboo and other building materials, and considering earthquakes and social aspects.

Keywords: earthquakes, economic aspects, low cost housing.

Schaur, E. (1985).

Bamboo-a building material of the future. Unanswered questions, development possibilities.

In: Gass *et al.* (Eds.). IL31 Bamboo. Institute for Lightweight Structures, University of Stuttgart, W.Germany: 418-417.

The paper examines the possibilities of further development of bamboo buildings from the silvicultural, social and economic points of view.

Note: Text in both German and English.

Keywords: architecture, economic aspects, low cost housing.

Seeland, K.T. (1980).

The use of bamboo in a Rai village in the upper Arun valley.
Journal of Nepal Research Centre, Humanities. (4): 175- 183.

Overview of all uses of bamboo.

Keyword: architecture.

Soedarmadi (1972).

Some notes on bamboo-frame construction in Indonesia.
Masalah Bangunari, 17(1-2): 3-6.

General paper on use of bamboos in construction work in Indonesia.

Keywords: low cost housing.

Soundarajan, P. and Kacamci, A.C. (1979).

A novel technique using bamboocrete as roofing material.
Appropriate Technology, 6(2):20.

The paper describes how low cost modular roof sections can be made from bamboo reinforced concrete by a patented method developed in India.

Keywords: reinforced structures, roofing.

Taylor, B.B. (1988).

Bamboo city, a refugee camp.
Mimar Architecture in Development, 20: 44-51.

On the design of a bamboo refugee camp in Thailand. The architectural design is represented in 27 drawings and photographs.

Keywords: architecture, low cost housing, refugee camp.

Tewari, M.C. (1974).

Utilization of secondary species of wood and other ligno-cellulosic materials for low cost structures.
Journal of the Timber Development Association of India, 20(3): 1-8.

General paper on different lignocellulosic material, including bamboo for use in housing after preservative treatment.

Keywords: physical properties, preservation.

UNIDO and UN Centre for Housing, Building and Planning (1989).

Technical and economic comparisons between wood and other building materials commonly used in tropical regions.
UNIDO, Vienna, 1969: Document No. UNIDO 10/WD-49/3:8p.

The paper discusses the different materials such as clay, cement, stone, sand, bamboo and wood used as construction material in housing in tropical regions. Also gives comparative study of the use of these materials.

Keywords: building materials, economic aspects, low cost housing.

Vasavada, R. (1986).

Grid shells using bamboo as light weight structural material.

In: Proceedings of Conference on Light Weight Structures in Architecture, Sydney, Australia. Unisearch Limited. The University of New South Wales, Kensington, NSW, Australia. 2V:669-673.

This paper describe experiments on building and testing grid shells made from split bamboo.

Keywords: architecture, domes, grid shells, low cost housing, space frames.

Winkler, R.A.O. (1979).

Introduction to bamboo as a building material.

German Appropriate Technology Exchange, M 6/1, 1 1/79: 12p.

Project description with drawings for buildings and houses in Indonesia.

Keywords: architecture, low cost housing.

Chapter 4

Structural reinforcement

Anon. (1951).

Bamboo houses. Bombay Sentinel of August 15, 1951.

A popular article gives details of 2 storeyed houses of bamboo and concrete built in Bombay adopting the procedure found in Colombo. Merits and problems discussed.

Copy of paper cutting available in Forest Research Institute, Dehra Dun, India.

Keywords: construction techniques, reinforced structures.

Bajaj, A.N. (1981).

Laboratory and field investigations on bamboo reinforced concrete-efficiency of water repellants.

Journal of the National Buildings Organisation, 26(2): 1- 14.

The paper discusses issues relating to use of bamboo as reinforcement material in cement concrete. It compares the strength characteristics of mild steel and bamboo and suggests measures to overcome problems encountered in using the material as reinforcement. Gives methods for placing the reinforcement in position, and provides observations on untreated strips as a reinforcement material.

Keywords: reinforcement in concrete.

Bajaj, A.N. (1983).

Introduction of new techniques in timber and bamboos for economical structures.

Journal of the National Building Organisation, India, 28: 1 1 - 14.

Methods for economising the use of wood are described. An outline is given

on the use of locally available secondary timbers for structural purposes. A method for making bamboo reinforced concrete is described.

Keywords: economic aspects, low cost housing, reinforced structures.

Balaguru, P.N. and Shah, S.P. (1985).

Alternative reinforcing materials for less developed countries.
International Journal for Development Technology, 3(2): 87-105.

A paper of general nature dealing with development of concrete reinforcement with locally available natural fibres or cheaper man-made fibres such as polypropylene. The potential of bamboo is emphasised as it is a renewable resource and can successfully be used as reinforcement in rural structures.

Keywords: low cost building, reinforcement (general).

Behera, H. (1951).

Fabricated cement articles.
Indian Patent No. 40,868 of Jan 10, 1951.

Hydraulic cement mixed with pulps and fibres of vegetable matter, including bamboo, is made plastic with water and moulded into desired pattern. Roofing tiles, ceiling boards etc. were made from such boards.

Keywords: roofing, panels.

Betwanger, C. (1986).

Bamboo mesh as reinforcement in concrete.

In: Use of Vegetable Plants and Fibres as Building Materials, Joint Symposium, Rilem/CIB/NCCL, Baghdad, October 1986: C45-C50.

A paper on the use of bamboo mesh as reinforcement in concrete.

Keywords: reinforcement in concrete, test methods.

Berwanger, C. et al. (1986).

The flexural strength of bamboo reinforced concrete inverted T- beams.

In: Use of Vegetable Plants and Fibres as Building Materials, Joint Symposium, Rilem/CIB/NCCL, Baghdad, October 1986: C51 -C60.

Research report on using bamboo reinforced concrete for T beams; three tables and one drawing.

Keywords: reinforcement in concrete.

Brink, F.E. and Rush, P.J. (1966).

Bamboo reinforced concrete construction.

Report of US Naval Civil Engineering Laboratory.

United States Naval Civil Engineering Laboratory, Port Hueneme, California:
12 p.

The report is prepared to assist the field personnel in the design and construction of bamboo reinforced concrete. The information is compiled from reports of test programmes of various researchers and represents consensus of opinion. Comments on the selection and preparation of bamboo for reinforcement are given. Construction principles and design procedures are discussed. Six design examples are presented.

Keywords: construction techniques, reinforced structures.

Chadda, L.R. (1956).

The use of bamboo for reinforcing soil-cement.

Indian Concrete Journal, 30: 200-201.

Describes bamboo used to eliminate cracks in walls, 4 tables.

Keywords: reinforcement in concrete.

Cook, D.J., Pama, H.P. and Singh, R.V. (1978).

Magazine of Concrete Research, 30(104): 145-151.

Experimental and theoretical investigations to determine the characteristics of bamboo in reinforced concrete columns subjected to uniaxial and biaxial loads. Studies to establish the mechanical properties of bamboo related to its use as a reinforcement are also described. There are also comments on the applicability of accepted methods for production of the ultimate load of reinforced concrete columns subjected to uniaxial and biaxial loads.

Keywords: reinforcement in concrete.

Datta, K. (1936).

Versuche über die verwendung von bambus in betonbau. (Experiments on the use of bamboo in reinforced concrete).

Der Bauingenieur 3/4, 17-27.

As bamboo is hygroscopic, it swells when embedded in concrete. It shrinks with age and gets loose. By moisture proofing with white lead, this can be reduced. Bamboo concrete beams can be used as substitutes for steel reinforced concrete.

Note: In German.

Keywords: reinforcement in concrete.

Ghavami, K. and Hombeek, R.V. (1981).

Investigations in the use of bamboo for reinforced concrete beams. Report-Civil Engineering Department. Pontificia Universidade Catolica of Rio de Janeiro. Dec/Lem-BCI. Rio-Brazil 198 1:40p.

Detailed study concerning the preparation and the execution of tests on mechanical and physical properties of *Bambusa vulgaris* and the testing procedure for two bamboo reinforced concrete beams.

Keywords: beams, mechanical properties, natural durability, preservation, reinforcement in concrete, test methods.

Ghavami, K. and Hombeek, R.V. (1981).

Application of bamboo as a construction material Part II. Bamboo reinforced concrete beams.

In: Proceedings of the Latin American Symposium on Rational Organisation of Building Applied to Low-Cost Housing, Sao Paula, Brazil: 58-66.

Presents the results and analysis of pull-out tests for treated bamboo and also the results of bamboo reinforced concrete beams subjected to bending. Practical construction procedures are described and suggestions made for further research.

Note: In English with abstract in Portuguese.

Keywords: reinforcement in concrete.

Ghavami, K. and Culzon B.A. (1987).

Utilizacao do bambo como material em habitacao de baixo custo (Use of bamboo as a construction material in low cost housing).

In: Proceedings of the CIB- International Symposium on Transfer and Production of Housing Technology in Research and Practice. HABITEC 87.IPI-CIB April 1987, Sao Paulo, Brazil: 1881-1 88.

Presents the state of the art of using bamboo in low cost housing and the method of testing to establish the mechanical properties of bamboo. Also details the method for the surface treatment for use in construction with concrete material.

Note: In Portuguese with abstract in English.

Keywords: beams, low cost housing, mechanical properties, physical properties, preservation,

Ghavami, K. and Zielinski, Z.A. (1988).

Permanent shutter bamboo reinforced concrete slab.

The paper describes state of the art of the application of bamboo in civil engineering with tables and figures of the physical and mechanical properties from available literature. Includes methods of treatment of bamboo when used as reinforcing elements in concrete. A proposal for testing permanent shutter slabs considering several variables is given.

Note: This report is available at the Civil Engineering Department- Pontificia Universidade Catolica, PUC-Rio, Brazil.

Keywords: beams, mechanical properties, physical properties, reinforcement in concrete, slabs, testing.

Ghavami, K. (1990).

Study of bamboo reinforced lightweight concrete beams.

In: Proceedings of the Third Iranian Congress of Civil Engineering, University of Shiraz, Shiraz: I- 9.

This paper is concerned with physical and mechanical properties of bamboo used in a series of experimental tests carried out on simply supported lightweight concrete beams subjected to two point loads at the third of the span. A comparative study of normal steel lightweight reinforced concrete and bamboo reinforced lightweight concrete is presented. The bamboo segments were treated with Negrolin.

Keywords: beams, mechanical properties, physical properties, preservation, reinforcement in concrete.

Ghavami, K. (1990).

Estruturas de concreto armadas com bambu (Bamboo reinforced structure)

In: Proceedings of the Sixth Symposium on Concrete and Prestressed Concrete, (6th CECAP). Universidade Catolica do Rio de Janeiro: PUC-Rio, Brazil: 214-241.

A short review of historical application of bamboo, with comments on the advantages and disadvantages in relation to other commonly used materials in civil engineering. The physical, mechanical and water absorption properties of *Bambusa multiplex ræush*, *Bambusa mu/top/e Distich*, *Bambusa tridoldia*, *Bmbusa guada superba*, *Bambusa vulgaris Imperial*, *Bambusa vulgaris schard*, *Dendrocalamus giganteus* are presented. Tests on 3 simply supported lightweight concrete beams subjected to point load using treated bamboo segments for reinforcement are described in detail.

Note : In Portuguese with abstract in English.

Keywords: beams, construction technique, mechanical properties, natural

durability, physical properties, preservation, reinforced structure, reinforcement in concrete, testing.

Ghavami, K. and Bzeda, E. (1990).

Utilizacao do bambu em estruturas de concreto armado

(Application of bamboo in reinforced concrete structures).

Report - Civil Engineering Department. Pontificia Universidade Catolica do Rio de Janeiro/PUGRio, 1990:70p.

A short summary of the anatomical structures of bamboo and a list of the most commonly available bamboos in Brazil. Includes methods of preservation and problems related to the use of bamboo as a reinforcement in concrete structures. A critical review of several recent papers on bamboo reinforced structures is included. The results of several tests establishing the shear resistance of bamboo diaphragms are given.

Note: In Portuguese with abstract in English.

Keywords: anatomical structure, beams, economical aspects, mechanical properties, physical properties, preservation, reinforced structure, test methods.

Ghavami, K. (1990).

Application of bamboo as a low-cost construction material.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore, 270-279.

This paper presents the results of investigations and outlines variables in studies for the solution of problems in the use of bamboo as structural elements in bamboo reinforced concrete and bamboo space structures. Some bamboos of Brazil have been classified according to their physical and mechanical properties. Several curing methods and water repellent materials have been considered for reducing their water absorption and improving their bonding ability with concrete.

Keywords: low cost housing, reinforcement in concrete.

Glenn, H.E. (1950).

Bamboo reinforcement in portland cement concrete

Clemson Agriculture College of S. Carolina, USA Bulletin No. 4.

Test results on bending, tension, compression, bond strength between bam-

boo and concrete are reported. The ultimate failure load increased with increasing percentage of bamboo reinforcement up to an optimum value of 3-4% of the cross-sectional area of the concrete. Principles of the design and construction of bamboo reinforced concrete are reported. Laboratory findings were applied in the construction of a workshop building, a stadium and two dwelling houses.

Keywords: construction techniques, reinforcement in concrete.

Gram, H.E. (1983).

Durability of natural fibre in concrete.

Thesis, Swedish Cement and Concrete Research Institute, Stockholm: 255p.

The durability of bamboo fibres in a cementitious environment is discussed. It is shown that the lifetime of a bamboo fibre in alkaline environment is very short.

Keywords: reinforcement in concrete.

Janssen, J.J.A. (1987).

Using bamboo as a reinforcement.

Appropriate Technology, 14(2): 12- 13.

An article on the constraints of using bamboo in reinforcement. Mainly deals with the behaviour of bamboo in the alkaline environment.

Keywords: reinforcement in concrete.

Jindal, U.C. (1984).

Mechanical properties of a natural fibres reinforced composite-bamboo.

Indian Forester, 11 O(4): 38 1-395.

The paper reports the results of a study in which bamboo specimens soaked in araldite with various proportions of hardner were tested.

Keywords: reinforcement (general).

Jindal, U.C. (1990).

Tensile strength of bamboo fibre reinforced plastic composites with different stacking sequence.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore, 231-234.

Multilayered bamboo fibre-reinforced plastic composites with different stacking sequences have been developed using a simple casting technique. These possess very high tensile strengths from 263.9 to 386.1 MPa (or N/mm). The mechanical behaviour is brittle but strong and these composites can be used for various structural applications where strength and lightness are important considerations.

Keywords: reinforcement in plastic.

Kankam, J.A. et al. (1983).

Bamboo reinforced concrete beams subjected to third point loading. AC/ Structural Journal, (Jan-Feb): 61-67; discussion in Nov.-Dec.

Research report dealing with reinforced concrete beams.

Keywords: reinforcement in concrete.

Kankam, J.A., Ben-George, M. and Perry, S.H. (1986).

Bamboo reinforced concrete two-way slabs subjected to concentrated loading.

The structural Engineer, 648(4): 85-92.

Eleven bamboo-reinforced concrete two-way slabs simply supported, were subjected to concentrated central loading. Concrete strength, span/depth ratio, bamboo percentage, and the treatment given to bamboo reinforcement were varied. Punching failure always followed the full development of the flexural collapse mechanism and the punching load was always greater than the yielding theory load. Methods of predicting cracking and punching load are suggested on the basis of results.

Keywords: reinforcement in concrete.

Krishnamurthy, D. (1990).

Building with bamboo - a solution for housing the rural poor.

In: Rao, I.V.R., Gnanaharan, Ft. and Sastry, C.B. (Eds.). *Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988.* Kerala Forest Research Institute, India and International Development Research Centre, Singapore, 258-269.

Three different techniques are described in the paper for improving the bond characteristics of bamboo, namely bitumen-coated and sand-surfaced bamboo strips, and bitumen coated strips with coir rope wound around to form a ribbed surface. The last one proved to be the best. Bamboo reinforced concrete beams behaved similar to conventional beams in bending. Load

deflection curves showed that the deflection is greater than that found with conventional beams. The paper gives a detailed design of precast elements for housing.

Keywords: low cost housing, reinforcement in concrete.

Kurian, M.P. and Abdul Kalam, A.K. (1977).

Bamboo reinforced soil-cement for rural use.
The Indian Concrete Journal, 51(12): 382-289.

Research report on foundations using bamboo reinforced concrete with 2 tables and 8 figures.

Keywords: construction technique, reinforcement in concrete.

Liao, K.F. (1980).

Studies on the manufacture of bamboo and plastic composites. 1. The manufacture of bamboo and plastic composites treated with thermoplastic monomers.

Scientific Research Abstracts in Republic of China, Part 1 : 619-620.

Results of a study for the manufacture of bamboo and plastic composites treated with thermoplastic monomers are reported.

Keywords: reinforcement in plastic.

Manga, J.B. (1983).

Feasibility of bamboo as reinforcement for ferrocement housing walls.
Journal of Ferrocement, 13(4): 345-349.

A study on the feasibility of using locally available bamboo in Indonesia as a reinforcement material in concrete walls of buildings. Simple laboratory tests have indicated that such walls are cheaper than brick walls and are safe.

Keywords: economic aspects, low cost building, reinforcement (general), test methods.

Masani, N.J. and Dhamani, B.C. (1970).

Note on the economy in the use of seasoned timber bamboo concrete construction.

Journal of the Timber Development Association of India, 16(2):37-49.

The technique of using specially split bamboo as reinforcement in cement concrete construction is described. Contains reinforcement and construction details and a cost analysis of structures.

Keywords: economic aspects, reinforcement in concrete.

Masani, N.J., Dhamani, B.C. and Singh, B. (1977).

Studies on bamboo concrete composite construction.

Forest Research Institute and Colleges, Dehra Dun, India, 39p.

This report includes results of laboratory tests and long-term construction trials. The use of bamboo for reinforcing concrete is illustrated and specifications for the material are listed. Costs of making a concrete slab reinforced with bamboo or steel are compared.

Keywords: construction technique, economic aspects, reinforcement in concrete.

Masani, N.J., Dhamani, B.C. and Singh, B. (1977).

Studies on bamboo-concrete composite construction.

Forest Research Institute and Colleges, Dehra Dun, India, 29p.

A report of laboratory tests and long-term construction trials performed at Dehra Dun on the use of bamboo for reinforcing concrete. The paper gives details and specifications for the materials.

Keywords: construction techniques, reinforcement in concrete.

Masani, N.J. (1977).

Bamboo concrete grain silos for rural area.

Journal of the Timber Development Association of India, 23(3): 14-20.

Construction details are given of two types of experimental grain silos of 2 tonnes capacity for rural areas. The silos use split bamboo reinforced brick and concrete.

Keywords: bricks, grain silos, reinforcement in concrete.

Masani, N.J., Dhamani, B.C. and Singh, B. (1977).

Studies on bamboo-concrete construction.

Philippines Forest Research Institute: 164p.

Describes the use of bamboo as reinforcement material in different components used by the construction industry.

Keywords: reinforcement in concrete.

Mansur, M.A. and Aziz, M.A. (1984).

Mechanical properties of bamboo mesh reinforced cement composites.

In: Proceeding of Conference on Mechanical Behaviour of Materials, Stockholm, Sweden. Pergamon Press, Oxford and New York, 443-450.

This paper covers mechanical properties of bamboo-mesh reinforced cement composites, particularly with reference to mortar flexural strength, stress-strain curves, cracking, sealer treatment, tensile strength behaviour of composites.

Keywords: mechanical properties, reinforcement in concrete.

Mehra, S.P., Ghosh, P.G. and Chadda, L.R. (1965).

Consideration as material for construction of bamboo reinforced soil-cement, with special reference to its use in pavements, Part 1. Civil Engineering and Public Works Review: 1457- 146 1.

Describes physical characteristics of the constituents of bamboo soil-cement, water proofing of bamboo, properties of bamboo and bondage between treated bamboo and soil cement used in reinforced and clear covers. Flexural strength of bamboo reinforced soil-cement beams are given.

Keywords: mechanical properties, physical properties.

Mehra, S.R., Ghosh, R.G. and Chadda, L.R. (1965).

Consideration as material for constructon of bamboo reinforced soil- cement with special reference to its use in pavements, Part 2. Civil Engineering and Public Works review, 1643- 1645.

Describes structural designs of bamboo-reinforced soil-cement beams, detailing of reinforcement, flexural and crushing strength of beams and economics of such construction.

Keywords: construction techniques, economic aspects.

Mehra, S.R., Ghosh, R.G. and Chadda, L.R. (1965).

Consideration as material for construction of bamboo reinforced soil-cement with special reference to its use in pavements, Part 3. Civil Engineering and Public Works Review, 1766- 1768.

Tests on central and edge loading on full size bamboo reinforced and plain soil-cement slabs with bonded thin concrete wearing course were carried out, and values for deflection and failure are given. Results of tests are discussed.

Keywords: reinforcement in concrete, testing.

Minke, G. (1964).

Earthquake resistant low cost houses utilizing indigenous building materials and intermediate technology.

In: Balkema, A.A. (Eds.). Proceedings of the Conference on Earthquake

Relief in Less Industrialised Areas (sponsored by the Swiss Society of Engineers and Architects, Zurich). A.A.Balkema Rotterdam and Netts and Boston, MA, USA: 105108.

Two earthquake resistant building techniques with materials such as foam, sand and bamboo are described. They were tested for earthquake resistance in Kassel, W.Germany and found to be satisfactory. The technique was therefore utilized in a low cost housing project in Guatemala.

Keywords: earthquakes, low cost building, reinforcement (general).

Pakotiprapha, B., Pama, R.P. and Lee, S.L. (1979).

Study of bamboo pulp and fibre cement composites.

International Journal for Housing Science and its Applications, 3(3): 167-90.

Important characteristics of bamboo fibre reinforced composites are presented. Beneficial effects of bamboo pulp in improving the first crack strength of the composite and of bamboo fibres in providing post cracking ductibility are identified. Results of experiments to evaluate the performance of the composites under service conditions (as per ASTM requirement for building boards) are also presented.

Keywords: bamboo in ferrocement.

Pakotiprapha, B., Pama, R.P. and Lee, Seng-Lio (1983).

Analysis of a bamboo fibre-cement paste composite.

Journal of Ferrocement, 13(2): 14 1 - 159.

The paper deals with analytical investigations on the mechanical properties of bamboo fibre reinforced cement composite in compression, tension and bending. Includes data on effects of random orientation of fibre, fibre length on strength of the composite and bond slip characteristics of the fibre.

Keywords: bamboo in ferrocement.

Ramaswamy, H.S., Ahuja, B.M. and Krishnamurthy, S. (1983),

Behaviour of concrete reinforced with jute, coir and bamboo fibres.

International Journal of Cement Composites and Lightweight Concrete, 5(1): 3-13.

Fibres of bamboo and other materials (jute and coir) were studied for their suitability for incorporation in cement concrete. It is reported that physical properties of these fibres do not show any deterioration in a concrete medium.

Keywords: bamboo in ferrocement.

Sambajpati, J.N., Rahman, S. and Chowdhury, I.C. (1980).

Comparative study of low-cost grain-storage structures.
Indian-Journal of Agricultural Sciences, 50(b): 497-501.

Four low cost structures for storage of rice are compared. Of the four structures the one made of bamboo splits and plastered with mud and cow dung was the most suitable.

Keywords: reinforcement in mud.

Shimada, H. (1939).

A chemical study of the bamboo used in concrete.
Japan Journal of Engineering, 13: 17-25.

While using bamboo reinforcement, it is necessary to ensure that bamboo is prevented from being affected by alkali. Measures to be taken to ensure this are discussed.

Note: In Japanese only.

Keywords: reinforcement in concrete.

Smith, P.D., Amedoh, A., Nana-Acheampong, H. and Bailey, W.A. (1979).

Bamboo fibre as reinforcing material in concrete.
Appropriate Technology 6(2) 8 - 10.

Reinforced cement panels and planks manufactured with different amounts of manually produced bamboo fibres were tested for strength and fracture properties. Trials showed the importance of random fibre orientation and adequate compaction of materials.

Keywords: bamboo in ferrocement, reinforcement in concrete.

Stubblefield, D.J., Falconer, J.P.R. and Moore (1972).

Innovative urethane foam composites for housing.

In: Proceedings of Third International Cell Plant Conference, Montreal, SPI, New York: 320-348.

Presents the development of a bamboo reinforced urethane foam composite roofing material for tropical areas. Describes the preparation of this material by either a pour or *freth* technique in a contact moulding operation or by a spray *in situ* operation.

Keywords: reinforcement in urethane foam.

Subramanyam, B.V. (1984).

Bamboo reinforcement for cement matrices.

In: New Reinforced Concrete. Surrey University Press, Guildford, England.
v2: 141-194.

This chapter covers the available information on various aspects of bamboo as reinforcement for cement matrices. The advantages and limitations of bamboo are discussed with reference to behaviour of bamboo reinforcement, the physical structure, physical and engineering properties, use of bamboo in cement concrete structural members (beams, slabs and columns), soil-cement, cement-mortar and thin bamboo-cement composite called bamboocrete. Some examples of application are discussed.

Keywords: low-cost housing, physical and mechanical properties, reinforcement in concrete.

UNIDO (1978).

Appropriate technology for cement and building materials.

UNIDO, Vienna, Document No.UNIDO-ID/WO-282/104:16p.

The paper describes appropriate technology using conventional materials in housing, including bamboo. It considers the construction industry, housing needs for poor rural areas, slums, and choice of technology and materials.

Keywords: building materials, housing.

Winatto (1982).

Rural rainwater cistern design in Indonesia.

In: Proceedings of the International Conference on Rainwater Cistern Systems, Honolulu (sponsored by the Dept. of the Interior, Washington DC and the University of Hawaii at Manos, Honolulu).

The paper describes the development of house top concrete cisterns in Indonesia in which bamboo is used as reinforcement material.

Keywords: bamboo in ferrocement, water supply.

Yadav, T.O. and Pant, N.C. (1976).

Improved bamboo basket for safe storage of wheat seed in Assam region.

Entomologists Newsletter, IARI Division of Entomology, New Delhi, 6(1 1-12): 65-66.

Method of manufacture of an improved bamboo basket is described in this paper. The method involves making two baskets, one of which goes inside the other and incorporates a plastic sheet.

Keywords: reinforcement (general).

Chapter 5

Panel products

Angustin, H. (1982).

Annotated bibliography on the utilization of agricultural residues (1960- 1972). UNIDO, Vienna, 1982: 108.

Annotated bibliography on the utilization of agricultural residues. Includes references on fibrous plants, including bamboo suitable for the production of particle board and fibre board.

Note: Paper prepared for the UNIDO International Forum on Appropriate Industrial Technology New Delhi and Anand, India, 1978. (Doc. No.UNIDO-IDAWG.83/16).

Keyword: bibliography.

Anon. (1985).

Product catalogue for bamboo processing machinery.
CeCoCo Chuo Boeki Goshi Kaisha, Ibaraki City, Osaka, Japan-8.

Illustrated catalogue of bamboo processing machinery, including machinery for cross cutting, outer-joint removing, hand splitting tools, automatic splitting, inner joint removing and splitting, shaving and width sizing, slicing machines width/thickness, round stick making machine, circular saw round skewer making machine, round stick end shaving machine, polisher for small pieces, small automatic bamboo blind weaving machine, bamboo slitting machine and bamboo skin peeling machine. Photographs and principle diagrams including machine specifications provided as a table for each machine.

Keywords: machinery, weaving.

Anon. ().

Studies on the dyeing conditions of bamboo - on the permeability of dyestuff

for *Phyllostachys edulis*.

Research Reports of the Forest Research Institute, Jiniu, S. Korea, 23: 83-87.

Data are given on the rate of penetration for different dyes.

Note: In Korean. Tables have English captions.

Keywords: dyeing, panels.

Chen, T.Y. and Wang, Y.S. (1981).

A study of structural particle board made from bamboo waste.

Quarterly Journal of Chinese Forestry, 14(2): 39-60.

The paper outlines the trial manufacture and mechanical properties of particle boards made from mixtures of slender and fine particles. Urea formaldehyde and phenol formaldehyde glues were used.

Note: In Chinese with English summary and English captions.

Keywords: manufacture, mechanical properties, panels, particle board.

Chen, T.Y. and Chang, M.J. (1983).

Properties of opened bamboo board.

Forest Products Industries, 2(1): 2- 16.

Brief information is given on manufacturing boards from large diameter low grade bamboo (*Dendrocalamus latiflorus*). by splitting culms, opening them flat and edge gluing the split pieces. Data on shrinkage, bond strength, tension, shear and compression strength of such boards are provided.

Note: In Chinese. Tables and figures have English captions.

Keywords: manufacturing, mechanical properties, panels, ply bamboo.

Chen, T.Y. and Shueh, S.H. (1985).

Studies on cement bonded bamboo particle board and bamboobars for reinforcing concrete.

Forest Products Industries, 4(2) : 2- 16

Bending strength and compressive strength of particle boards made from moso bamboo (*Phyllostachys edulis*) shavings and portland cement were studied and reported in this paper. It is also reported that mixing China fir (*Cunninghamia lanceolata*) with bamboo improved compressive strength but reduced bending strength.

Note: In Chinese with English summary.

Keywords: mechanical properties, panel, particle board.

Chu, B.L., Chen, T.Y. and Yen, T. (1982).

Influence of the form of bamboo and particle board on their bending strength and thermal conductivity.

Forest Products Industries, 3(3) : 29 1-3 18.

Results are given of uniaxial tensile tests on flat pressed and corrugated bamboo particle boards and of strength properties of moso bamboo (*Phyllostachys edulis*). Data on thermal conductivity of particle board and composite boards (bamboo particle board laminated with wood veneer) are presented.

Note: In Chinese with English summary. Figures and Tables have English captions.

Keywords: mechanical properties, panels, particle board, thermal conductivity.

Chung, D.H. (1982).

A study on the quality analysis of wood and bamboo products.

Technical Bulletin, Experimental Forest, National Taiwan University, No. 134: 17.

Presents physical and mechanical properties (moisture content, strength) of 30 groups of plywood, including bamboo plywood, produced in Taiwan.

Note: In Chinese. Figures and tables have English captions.

Keywords: mechanical properties, panels, plybamboo, plywood.

Deng, W.Z. (1985).

A study on cold pressing - manufacturing process for bamboo veneers.

Journal of Bamboo Research, 4(1): 77-85.

The manufacturing process of bamboo veneers, called cold pressing, is described.

Note : In Chinese with English summary.

Keywords: manufacturing, panel.

Ding, J.Y. (1979).

Studies on manufacturing technique and paintability of resin treated bamboo board.

Technical Bulletin, Experimental Forest, National Taiwan University, No. 123: 145 159.

A heating system installed in a furniture factory at Detmold, W.Germany for manufacturing resin treated bamboo board is described. Methods for painting are also discussed.

Note: In Chinese with English summary.

Keywords: manufacturing, panel, reinforcement in plastic.

Ding, Jan-Yin (1981).

A study of bamboo weaving board.

In: Higuchi, J. (Ed.) Bamboo production and utilization. Proceedings of the XVII IUFRO World Congress, Kyoto, Japan, September 6-7, 1981. Wood Research Institute, Kyoto University, Kyoto, Japan: 136-140.

The preparation of bamboo board by treating woven mats with a mixture of melamine-urea resin and vinyl acetate-acrylamide copolymer followed by hot freezing is described. Bamboo skin weaving board could not be made by this technique and it was necessary to use other supporting materials. The physical properties of glue and products have been tested and are discussed in the paper.

Keywords: panels, weaving.

Ding, J.Y. (1981).

Studies on laminated bamboo weaving board and bamboo bark weaving board.

Quarterly Journal of Chinese Forestry, 27(5): 343-349.

Study conducted on laminated bamboo boards manufactured using a combination of VAC-AA and UMF resins (ratio 2:8) is reported in this paper.

Note : In Chinese with English summary.

Keywords: manufacturing, panel, reinforcement in plastic.

Gulsheng, G. (1987).

Bamboo plywood - a new product of structural material with high strength properties.

In: Rao, A.N., Dhanarajan, G. and Sastry, C.B. (Eds.). Recent Research on Bamboos. Proceedings of the International Bamboo Workshop held at Hangzhou, People's Republic of China, October 6-14, 1985. Chinese Academy of Forestry, People's Republic of China & International Development Research Centre, Canada 337-338.

The paper describes the procedures involved in making bamboo plywood and the comparative merit of the product.

Keyword: plybamboo.

Hayashi, D. and Sugiyama, S. (1986).

Investigations on the production of veneers of mosochiku (Phyllostachys pubescens mazel).
Wood Industries, Tokyo, 23 (19): 22-27.

Study on veneer cutting properties of this bamboo, including measurement of resistance to cutting in two directions, radius of bending of veneers in the radial direction, and density in air-dry condition.

Note: In Japanese with English abstract.

Keywords: bending, cutting, manufacturing, veneer.

Herbert, M.R.M. (1979).

An assessment of the potential of bamboo cored decking. Building Research Establishment, (145): 11.

Research on this type of boards presented with two diagrams and one photograph.

Keywords: composite boards, panels.

Indian Plywood Industries Research Institute (1982).

Development of improved and new products from bamboo mats. Research Report of the Project on Bamboo Mat Board sponsored by the All India Handicraft Board, Indian Plywood Industries Research Institute, Bangalore, India: 115p.

This is the final report of the project on development of bamboo mat board. The process is: pressing of woven bamboo slivers into adhesive bonded boards of various thicknesses (3,5, layers) or into bamboo mat wood veneer board. Also describes application of these boards in walling, ceiling, roofing, grain storage silos, etc.

Keywords: ceiling, composite board, plybamboo, roofing.

Jain, N.C., Gupta, R.C. and Bist, B.S. (1971).

Reduction of consumption cost of phenol formaldehyde resin in bamboo boards.
P/RI Journal, 1(3): 1 00- 103,

The paper deals with processes involved in manufacturing bamboo mat boards and suggests methods for reducing phenol formaldehyde requirement.

Keywords: manufacturing, plybamboo.

Kurolwa, I. (1980).

Prefabricated quencha construction.

in: Balkema, A.A. (Eds.). Proceedings of the Conference on Earthquake Relief in Less Industrialised Areas (sponsored by the Swiss Society of Engineers and Architects, Zurich). A.A. Balkema Rotterdam and Netts and Boston, MA, USA: 115-1 21.

A low cost building technique termed as Quencha is described. Prefabricated wood and bamboo panels are plastered into mud and straw and finished with cement mortar and gypsum. Buildings constructed with these panels were found to be resistant to earthquake.

Keywords: earthquakes, low cost building, panels, reinforcement in mud.

Lo, M.P. and Tasi, C.M. (1975).

Experiment on the manufacturing of bamboo (Phyllostachys edulis and P. makinoi) particle board 1 splinterboard.

Technical Bulletin, Experimental Forest, National Taiwan University, No. 11 1: 527-544.

Details of experiments conducted in the National Taiwan University on the manufacture of the particle board from bamboo.

Keywords: particle board.

Ma, T.P., Jai, S.Y. and Tsou, C.T. (1976).

Experiment on the manufacture of bamboo glu-lam. Bulletin, Taiwan Forestry Research Institute, 285:14p.

Describes preservative treatment laminae of *Phyllostachys edulis* and *Sinocalamus latiflorus*, steamed and kiln dried to 10-12% moisture content. Also discusses bamboo laminated with different adhesives, which showed similar glu-lam characteristics as wooden veneers, except for higher modulus of elasticity.

Note: In Chinese. Tables have English captions.

Keywords: manufacturing, modulus of elasticity, moisture content, panels.

Ma, T.P. et al. (1982).

The manufacturing and application of flat-sliced lamboo veneer. Bulletin Taiwan Forest Research Institute, 371: 12p.

A description on how to manufacture laminated lamboo veneer and its application. Results are presented in eight tables and four photographs.

Note: In Chinese with summary in English.

Keywords: manufacturing, panels, plybamboo.

Ma, T.P. and Wang, C.Y. (1983).

Effect of moisture content and steam-stain duration on the mechanical and machining properties of lamboo.
Bulletin, Taiwan Forest Research Institute, 389: 14p.

A research report on the problems described in the title. Data are presented in 16 tables.

Note: In Chinese; tables with captions in English and summary in English. (Lamboo=laminated bamboo).

Keywords: mechanical properties, moisture content, plybamboo.

Mashramkar, P.M. (1974).

Solid waste from wood and bamboo as an asset for profitable uses.
Indian Pulp and Paper 28 (7 0- 11): 1 1- 15.

The potential of utilizing bamboo chips and dust and other fibrous residues for particle board or insulation board is described in a general manner.

Keywords: insulation board, particle board.

Mestdagh, M. and Verker, S.A. (1969).

Particle board from annual plant wastes.
UNIDO, Vienna, Document No. UNIDO ID/WD 83/5:45p.

The paper discusses application of agricultural residues, including bamboo, for the production of particle board, considering special aspects of phenolic flax board. Presents results of tests on different panels made of jute, hemp, cotton, stalks, maize, coconut, fibre and bamboo.

Note: Paper prepared for UNIDO Expert Working Group.
Meeting on the Production of Panels from Agricultural wastes.

Keywords: mechanical properties, particle board.

Mistry, J. (1988).

Knock-down bamboo office partition system for northeast India.
National Institute of Design, Ahmedabad (Diploma thesis): 150p.

Description of product development strategy for local crafts of northeast India. Collection of new designs for contemporary products with technical drawings and photographs of products. Includes experiments in lamination of split bamboo with synthetic adhesives to generate composite rigid members as a

timber substitute; development of joinery system and panel production with variety of honey-comb and solid infill panels by sandwiched construction of woven bamboo mats. Frames made of composite materials examined as a potential industrial material. Use of technology in other applications is suggested.

Keywords: composite boards, construction technique, joints, low cost building, mechanical properties, panels, walls.

Narayanamurti, D. and Bist, B.S. (1948).

Studies in building boards - preliminary studies on building boards from bamboos.

Indian Forest Leaf/et No. 103: 4p.

Culms of green *Bambusa arundinacea* and *Dendrocalamus strictus* were cut into strips, soaked in water, woven into mats, steamed, treated with phenolic resins, and dried. The boards possessed satisfactory strength properties.

Note: One of the early attempts to make boards from bamboo.

Keywords: manufacturing, panels.

Narayanamurti, D. (1958).

Building boards from bamboos.

Composite Wood, 3(1): 1- 13.

Results of tests on building boards made of bamboo strips by different processes are presented. Service tests have indicated that these boards compare favourably with plywood panels, when used as ceiling, etc.

Keyword: panels.

Richman, A. (1987).

Weaving bamboo grass mats brings hope to Thai villagers.

Annual Report, 1987. Appropriate Technology International, Washington: 4 1-42.

Report on bamboo mat weaving with three photographs.

Keywords: plybamboo, low cost housing, weaving.

Rowell, R.M. and Norimoto, M. (1988).

Dimensional stability of bamboo particleboards made from acetylated particles.

Mokuzai Gakkaishi (Journal of the Japan Wood Research Society, 34(7): 627-629.

Acetylated bamboo (*Phyllostachys bambusoides*) particles and unacetylated particles were subjected to water soaking tests. Boards made from acetylated particles swelled to a lesser extent than those made from unacetylated particles.

Keywords: panel, particle board, swelling.

Singh, R. (1969).

Fibrous building materials produced from industrial wastes.
UNIDO, Vienna, Document No.ID/WG-44/80: 96p.

The paper discusses the use of different agricultural residues such as coconut husk, sugarcane, jute stalk, wood, cotton, rice husk, bamboo and industrial wastes from petroleum refineries as building materials and panels. Gives details of experimental work in India.

Note: Paper prepared for UNIDO Expert Working Group Meeting on Fibre-Cement Composites, Vienna, 1969.

Keywords: panels, particle boards, plywood.

Song, Y.W. and Win, S.H. (1981).

Studies on the improving effects of bending strength and bending creep behaviours of bamboo particle boards.
Quarterly Journal of Chinese Forestry, Taiwan, 14(1):71-94.

Research Report. Data presented in six tables and 16 diagrams.

Keywords: bending, particle boards.

Sonti, V.R. (1978).

Wood. Wood-based and wood working machinery industries in India.
UNIDO, Vienna, Document No.UNIDO-ID/WG. 151/26:33p.

While describing wood processing and wood technology, mention is made on the use of bamboo also for the production of fibre and particle board and plywood with reference to the production processes and problems.

Note: Paper prepared for the UNIDO International Forum on Appropriate Industrial Technology, New Delhi and Anand, India, 1978.

Keywords: manufacture, particle board, plywood.

Tsai, C.M., Lo, M.P. and Poon, M.K. (1978).

Study on the manufacture of uni-layer and three layer particle boards made from bamboo and wood particles.

Technical Bulletin, Experimental Forest, National Taiwan University, No.121:41-62.

It is reported that particle board can be made using residues of *Phyllostachys edulis* and shavings of *Chamaceyparis formosensis* with urea-formaldehyde resin as binder and that the properties of the boards met the specifications of Chinese National Standard 2216.

Note: In Chinese with English summary.

Keywords: panel, particle board.

Tsai, C.M. (1982).

The elimination of formaldehyde liberation from ureamelamine formaldehyde resin treated bamboo woven panel.

Quarterly Journal of Chinese Forestry, 15(1) : 35-51.

Methods for the liberation of formaldehyde from resin treated panels of *Dendrocafarus latiflorus* are discussed in this paper.

Note: In Chinese with summary and tables in English

Keywords: panels, reinforcement in plastic.

Verbestel, J.B. (1968).

Some experience with and possibilities for the manufacture of particle board from non wood fibrous raw materials.

In: Proceedings of the Second Session of the FAO Committee on Wood Based Panel Products, Nov. 6-8.

Food and Agriculture Organization of the United Nations: 27p.

The potential and possibilities of manufacturing particle boards from agriculture residues and bamboo are discussed and properties of particle boards manufactured from such material are described. One drawing and nine photographs are included.

Note: In English, French and Spanish.

Keywords: panels, particle board.

Vermass, C.H. (1981).

The manufacture of particle board based on unconventional raw material. UNIDO, Vienna, Document No.UNIDO-ID/WO 338/5: 17p.

Paper on manufacture of particle board based on agricultural residues including bamboo. Covers topics related to harvesting, storage, physical properties and application of these materials with resins and cement, and compares

products with articles made of wood.

Note: Paper presented in the Seminar on Economic Criteria for the Selection of Wood Working Machinery and Plant Systems. Hannover.

Keywords: manufacture, panels, particleboard.

Wang, S.Y. and Huang, N.C. (1982).

Studies on the mechanical properties of compreg bamboos.

Technical Bulletin, Experimental Forest, National Taiwan University, No. 137: 43p.

The physical, mechanical and sanding properties of bamboo treated with phenolic resin adhesive are given. Compreg bamboo has lower water absorption and higher resistance to boiling water.

Note: The paper is in Chinese with English summary.

Keywords: compreg, mechanical properties, panels.

Wang, S.Y. & Joe, I.S. (1983).

Studies on the properties of bamboo composite panels (thermal conductive behaviour).

Forest Products Industries, 2(3): 29-44.

Low-density panels were constructed using *Sinocalamus latiflorus* as face and back layers, filled with polyurethane or polystyrene foam. Thermal properties are presented.

Note: In Chinese with English summary.

Keywords: composite boards, panels, plybamboo, thermal conductivity.

Wang, S.Y. and Joe, I.S. (1983).

Studies on the properties of composite panels of bamboo.

(1) static bending behaviour.

Forest Product Industries, 2(2) : 17-3 1.

Describes static bending behaviour of composite panels of bamboo, constructed with plybamboo faces and either cores of polyurethane, polystyrene foam, or hollow cores.

Note: In Chinese with English summary.

Keywords: mechanical properties, panel, plybamboo.

Yee, C.F., Le, C.H. and Hwang, C.B. (1945).

Ply bamboo.

Technical Report, BurAeronaut, Res. Chengtu (now Nanching, Kiangsi) 26:52.

Gives a detailed account of the method of manufacture, strength and durability of bamboo plywood produced during World War II. Bamboo sheets were woven and glued together much the same way as plies of wood.

Note: In Chinese.

Keywords: manufacturing, panels, ply bamboo, weaving.

Yeh, C.M. and Hsiung, J.C. (1975).

The effect of electrocoating used in wood and bamboo furniture material.

Bulletin, Taiwan Forestry Research Institute, 269: 12p.

The effect of finishing methods such as electrocoating, spraying and brushing on products made from wood and bamboo panels are described.

Note: Article in Chinese with English summary. Tables are provided with English captions.

Keywords: manufacturing, panels.

Chapter 6

Geotechnical applications

Douglas, A.R. (1990).

Bamboo inclusions in soil structures.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 294-300.

This paper gives an account of reinforcement of soil structures with polymeric materials called geosynthetics. The application of bamboo inclusions in soil structures is described.

Keywords: soil reinforcement.

Low, K.S. (1990).

Utilization of bamboos for engineering purposes.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 301-306.

The use of bamboo in reinforced earth structures such as highway/road embankments, vertical retaining walls etc is described. The stiffness and relatively high tensile strength make bamboo suited for use as an earth - reinforcing material. The paper describes full-scale tests in Malaysia using bamboo as reinforcement in the construction of reinforced-earth structures. The tests show that strain gauges can be employed for strain measurements in large-scale work.

Keywords: roads, slope reinforcement, test methods.

Poorooshash, H.B., Azeveolo, R. and Ghavami, K. (1988).

Analysis of slopes reinforced with bamboo elowets.

In: Proceedings of International Geotechnical Symposium on Theory and Practice of Earth Reinforcement. October 1988, Fukuoka, Japan: 467-472.

The paper presents the application of bamboo for slope reinforcement in Brazil. It also describes the behaviour of bamboo for prevention of slope instability.

Keywords: landslide, slope reinforcement.

Purushottam, A. (1965).

Bamboo mat as expedient.

Journal of the Timber Dryers and Preservers Association, 11(1): 7- 13.

The paper gives details of studies on bamboo mats used as expedients i.e. lining on slushy and snowy roads to help movement of vehicles. Bamboo mat expedients were found to be much better than poles.

Keywords: matting, roads.

Chapter 7

Hydraulic applications

Allison, S.V., Sternberg, Y.M. and Knight. Ft. (1978).

Well casings and screens from single stalks of bamboo and a manually operated s/otter.

Appropriate Technology, 5(1): 10- 11.

Describes a machine capable of slotting bamboo culms to a predetermined slot size (0.5 mm width before wetting). Bamboos slotted using this type of machine was used in Assam for domestic well casings and screens.

Keywords: tube wells.

Clay, E. (1980).

The economics of the bamboo tubewell: dispelling some myths about appropriate technology.

Ceres:FAO Review on Agriculture and Development No. 75: 43-47.

A critical and economical appraisal is made of the potential of utilizing bamboo for tubewells.

Keywords: economic aspects, tubewells.

F.A.O. (1977).

Rural home techniques: labour saving ideas: food, water, transport.

Human Resources, institution and Agrarian Reforms Division, FAO of the United Nations, Rome, Economic and Social Development Series No.5/4:68p.

An illustrated handbook containing description and instruction on fabricating simple home utilities like cooking platforms, containers, water pipes, etc., in which bamboo is one of the materials used.

Note: In English, French, Spanish and Arabic

Keywords: waterpipes.

Kirchhof, W. (1990).

Waste - water treatment by low cost bamboo trickling filter and pond systems.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 31 O-31 9.

The construction details of low cost bamboo trickling filters and a waste water pond system have been given in the paper. The advantages and disadvantages of both types of filter systems are compared. Both the systems can be used as small - scale waste water treatment plants.

Keywords: economic aspects, waste-water treatment.

Lipangile, T.N. (1987).

The use of bamboo as waterpipes.

In: Rao, A.N., Dhanarajan, G. & Sastry, C.B. (Eds.). Recent Research on Bamboos. Proceedings of the International Bamboo Workshop held at Hangzhou, People's Republic of China, October 6-14, 1985. Chinese Academy of Forestry, People's Republic of China & International Development Research Centre, Canada : 315-320.

The use of bamboo as a water-piping material in Tanzania is described. 150 km of bamboo pipelines have been laid in 28 villages supplying water to 100,000 people. Information is included on preservation techniques, capacity to withstand pressure, maintenance and economics.

Keywords: economic aspects, mechanical properties, preservation, water-pipes.

Lipangile, T.N. (1987).

Bamboo and wooden water pipes.

Ambio, 16(5): 299-301.

A brief account of research activities and progress in Tanzania on the use of bamboo and wood to construct water pipes and storage tanks.

Keywords: storage tanks, waterpipes.

Lipangile, T.N. (1990).

Maintenance and operation of a bamboo pipe water supply system.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore: 307-309.

The paper briefly describes the management, handling, maintenance and operation of a bamboo pipe water supply system in Tanzania.

Keywords: waterpipes

Mgeni, A.S.M. and Swai, C.M.S. (1982).

Bamboo water pipes.

Commonwealth Forestry Review, 6 1(4) : 285-286.

It is reported in this paper that bamboo is used as water pipes in Tanzania.

Keywords: waterpipes.

Rahman, M. (1976).

A preliminary report on two experimental tube wells in Comilla Kotwali Thana. Bangladesh Academy for Rural Development, Comilla, Bangladesh: 16.

This is a report describing the design, cost and labour input for the construction and operation of two different tube wells designed to use bamboo. According to the report the cost can be reduced by 60% if bamboo is used.

Keywords: economic aspects, tube wells.

Senapathi, P.C., Salm, S.K. and Sharma, S.D. (1977).

Design and construction of bamboo tube-well for irrigation.

Agriculture and Agro-Industrial Journal, 1 0(8): 25-26.

The paper describes the design and construction of a bamboo tubewell for irrigation. It is suggested that a successful bamboo tubewell can be constructed up to a depth of 80 feet.

Keywords: irrigation, tubewells.

Chapter 8

Bibliographies and handbooks

Anon. (1948).

Bamboos.

In: *The Wealth of India - A dictionary of Indian Raw Materials and Industrial Products* Vol.1: 145-1 54.

Natraj Publishers, 17 Rajfen Road, Dehra Dun, India.

A concise account of bamboo resources of India and their uses (including specifically in building construction) is given.

Keywords: construction techniques.

Anon. (1961).

Bamboo in Indonesia.

A brochure of the Regional Housing Centre, Bandung. Lembaga Penyelidikan Masalah Bangunan. Djl. Tamansari 125, Bandung, Indonesia: 27p.

The brochure is a review of the Regional Housing Centre's knowledge about bamboo used for house building in Indonesia. A brief description of Indonesian bamboo species, their regeneration and production is given. It is mentioned that about 70% of all houses in the country contain bamboo. Preservative treatment, surface coating, use as reinforcement with concrete, and traditional structures in building are discussed. Information on physical and mechanical properties are provided and suggestions given for further research. A list of Indonesian literature on bamboo is added.

Keywords: construction techniques, preservation.

Anon. (1972).

Bamboos.

In: *Indian Forest Utilization.*

Compiled by the Editorial Board, Forest Research Institute and Colleges, Dehra Dun, Manager of Publications, Civil Lines, Delhi. Vol.II: 645659.

In the chapter on grasses, bamboos and canes (Chapter XXVII), general description of bamboo and uses are given. Mention is made of use for scaffolding, roofing, walling, flooring in building construction, among various other uses.

Keywords: construction techniques.

Austin, R., Ueda, K. and Levy, D. (1970).

Bamboo (reprinted 1977).

Weatherhill Inc, New York, London and Tokyo: 2 15.

This book conveys the cultural importance and the practical application of bamboo in China and Japan in an informative way using many photos and illustrations. It also contains valuable information on the cultivation of bamboo and yield improvement.

Keywords: applications, construction techniques, cultivation, handicrafts.

Dunkelberg, K. (1985).

Bamboo as a building material.

In IL31 Bamboo institute for Lightweight Structures, University of Stuttgart, W. Germany Editors Gass et al. : 38-260.

This contribution is broadly divided into two parts with part one dealing with bamboo as a material which includes classification, growth, anatomy, propagation, properties, chemical composition, harvesting, preservation and working of bamboo. Part two covers the occurrence of bamboo in built structures based on field work in Southeast Asia. Numerous structural types have been covered. This reprint of the original thesis (Muenchen, Germany, 1978) in German is presented in a bilingual format to include German and English text.

Note: This work represents a definitive study of housing and structural forms built with bamboo.

Keywords: architecture, construction techniques, low cost housing.

Elbourn, C.A. (1978).

Bamboos: annotated bibliography covering the published literature for 1973-77.

Annotated Bibliography F15, CAB, Oxford: 32p.

A bibliography of references from the CAB Database. Contains 260 references on bamboo grouped under the following sections: Anatomy, morphology,

chemistry; flowering and fruiting; Biology, ecology, diseases, injuries, pests; Silviculture, management; Pulping, utilization; Grassland and understorey. Author index .

Keyword: bibliography.

Farrelly, D. (1984).

The Book of Bamboo.

The Sierra Club, San Francisco: 340.

A review of literature in English on the cultural importance and application for various uses. Information on distribution, cultivation, treatment and processing methods is also dealt with.

Keywords: applications, appropriate technology, bibliographies, construction techniques, glossaries, low cost housing.

F.R.I., Dehra Dun, India (1960).

Annotated Bibliography on Bamboo.

Forest Research institute and Colleges, Dehra Dun, India: 121p.

An annotated bibliography covering distribution, silviculture, management, preservation and utilization of bamboo. There are 209 references covering period up to 1960.

Keyword: bibliography.

Gamble, J.S. (1896).

The Bambusae of British India.

Annual Review of Botanical Garden, Calcutta. Vol. VII.

Detailed information on taxonomy, distribution, propagation etc. of Indian bamboos is given. Extensive notes on uses, including rural dwellings and geotechnical application, are also given. Authentically illustrated with 119 plates.

Note: Original publication is out of print. Reprinted in 1978. Available from National Botanical Gardens, Howrah, Calcutta, India and Kerala Forest Research Institute, Peechi, India.

Keywords: anatomical structure, construction techniques, soil reinforcement.

Gamble, J.S. (1910).

The Bamboos of the Philippine Islands.

Philippine Journal of Science, 5(4) Section C.

A comprehensive account of Philippine bamboos is given, including usage in buildings.

Keywords: construction techniques.

Gass, S., Drusedau, H. and Hennicke, J. (Eds.) (1985).

Bamboo.

Publication IL31, institute for Lightweight Structures, University of Stuttgart, Pfaffenwaldring 14, 7000 Stuttgart 80, Germany

A collection of papers on architectural use of bamboo and bamboo in lightweight structures.

Note: The whole work is presented in both German and English. The document is available from the publisher.

Keywords: architecture, construction techniques.

George, J. (1982).

Annotated bibliography on the utilization of agricultural residues and non- wood fibrous material for the production of panels, 1972- 1979. UNIDO, Vienna, Document No. UNIDO/ID-506/Add 1: 122p.

This is an annotated bibliography on the use of agricultural wastes, including bamboo, for the production of particle and fibre board, and considering also economical processing, testing, quality control, marketing aspects, etc. for the years 1972-1 979.

Keywords: bibliography, panels.

Higuchi, T. (1986).

Bamboo production and utilization.

Proceedings of Project Group P5-04, Production and Utilization of Bamboo and Related Species, XVIII IUFRO World Congress, Ljubljana, Yugoslavia. Sept 7-21, 1986: 110.

Proceedings of a world conference on bamboo, with papers on botany, silviculture, utilization and exploitation of bamboo.

Keywords: anatomical structure, applications, silviculture.

Hsiung, W.Y. (1986).

Research and development of production and utilization of bamboos in China. In Proceedings of Bamboo Production and Utilization, XVIII IUFRO World Congress, Ljubljana, Yugoslavia, Sept 7- 12, 1986: 4- 10.

A summary paper of bamboo production and utilization in China. It also presents a state of the art of research related to bamboo in China.

Keywords: construction techniques, panels, physical properties.

Janssen, J.J.A. (1980).

Bamboo - a series of articles on the use of bamboo in building construction. University of Technology, Eindhoven, Netherlands: 125.

This collection of articles covers preservation, house construction, building of bridges, rafts and ferries, bamboo pipes for water distribution, and the use of panels in wet weather.

Note: Out of print. Reprinted in 1987 under the title "Building with bamboo". See entry in chapter 3A.

Keywords: construction techniques, plybamboo, preservation, water pipes.

Lessard, G. and Chouinard, A., (Eds.) (1980).

Bamboo Research in Asia: Proceedings of a Workshop held in Singapore, 28-30 May, IDRC, Canada, 228p.

Papers and recommendations of this conference jointly organized by IDRC and IUFRO are presented in the form of a text book with comprehensive bibliography at the end. The first part of the book is devoted to country reports from China, India, Indonesia, Japan, Malaysia, Philippines, Sri Lanka and Thailand on the growing and use of bamboos. The second part contains special papers describing characteristics and use of bamboos.

Keywords: construction techniques, housing, panels, preservation, test methods.

Liese, W. (1987).

Research on bamboo. Wood Science and Technology 2 1: 189-209.

A review of the research on bamboo presented as the academy lecture, 18th IUFRO World Congress 1986. 24 photos.

Keywords: anatomical structure, low cost housing, preservation, properties.

Londono, M., Francisco, M.A. and Montes, B. (before 1970).

La Guadua, su application en la construction. Editorial Bedout: 790.

A handbook on building with bamboo. Many design drawings for houses and buildings.

Note: In Spanish.

Keywords: architecture, low cost housing.

Mathur, G.C., Ratra, R.S. and Bindlish, D.D. (1964).

Bamboo for house construction.

Publication of the N. B. O., National Building Organisation, Ministry of Works and Housing, Nirman Bhavan, New Delhi, India, 37p.

After dealing briefly with its distribution in India, production etc., the authors have discussed advantages of joints, foundation, doors, windows, ceiling, flooring etc. Some information on bamboo reinforced concrete tile, pipes and drains is also provided.

Keywords: construction techniques, reinforcement.

Mathur, N.K. and Sharma A.K. (1986).

Annotated bibliography on bamboos - covering literature from 1960- 1982, Controller of Publications, Govt. of India, Delhi: 14 1p.

An annotated bibliography covering world literature on bamboo covering ecology, silviculture, logging, transport, protection, management and utilization. There are 1103 citations.

Keywords: bibliography.

McClure, F.A. (1953).

Bamboo as a building material.

Publication of the U.S. Department of Agriculture.

US Department of Agriculture, Foreign Agriculture Service, Washington, D. C. : 52p.

This publication covers in a general manner utilization of bamboo in building construction in various countries.

Different species used are discussed with several illustrations. Makes the important observation that more studies are essential before bamboo can be used with confidence for reinforcement. It is recommended for use in construction as non-load bearing members and as panels.

Keywords: construction techniques.

Porterfield, W.M. (1926).

Bamboo and its uses in China

Chinese Economic Information (Booklet Series No.2) 77p.

A comprehensive account of Chinese bamboos - their distribution, cultivation and uses (including in building construction) is given. It includes a bibliography and a map showing known bamboo regions in the country.

Keywords: construction techniques, cultivation.

Raizada, M.B. and Chatterjee, R.N. (1956).

World distribution of bamboos with special reference to the Indian species and their more important uses.

Indian Forester, 82(5): 2 15-2 18.

A general account of bamboos comprising 30 genera and 560 species. Important uses (including house building) are mentioned.

Keywords: construction techniques, cultivation.

Rao, A.N., Dhanarajan, G. and Sastry, C.B. (Eds.) (1987).

Recent Research on Bamboos.

Proceedings of the international Bamboo Workshop held at Hangzhou, People's Republic of China, October 6- 14, 1985. The Chinese Academy of Forestry People's Republic of China and International Development Research Centre, Canada.

This proceedings contains 50 papers on several aspects of bamboo. These are classified under seven sections: Bamboo resources and country reports; Cultivation and production; Growth and propagation; Structure and properties; Diseases; and Utilization and Socio-economics. An excellent collection of papers, particularly those from China.

Keywords: construction techniques, economic aspects, hydraulic applications, mechanical properties, panels, physical properties, preservation.

Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.) (1990).

Bamboos - Current Research.

Proceedings of the International Bamboo Workshop, Cochin, India, 14- 18 November, 1988. Kerala Forest Research Institute, India & International Development Research Centre, Canada: 394 p.

A collection of papers covering resources, bamboo forestry, propagation, growth, pests and diseases, properties, utilization of bamboo.

Keywords: anatomical structure, construction techniques, hydraulic applications, mechanical properties, panels, physical properties, preservation.

Ridout, L.M. Comp. (1983).

Bamboos II. Annotated bibliography

Commonwealth Agricultural Bureaux, Oxford, No. F32, 94p.

A bibliography of reference from CAB database covering the period 1978 to 1982. Entries are organized under following sections: General anatomy, morphology, chemistry, biochemistry, physiology, flowering, fruiting, generation, taxonomy, evolution, ecology, distribution, diseases, injuries, pests, silviculture, management, understorey, weed bamboos, properties, processing, preservation, decay and uses. An author index is also provided.

Keywords: bibliographies, construction techniques, panels, preservation.

Riviere, A. and Riviere, C. (1878).

Les bambous, vegetation, culture, multiplication en Europe, en Algerie et generalement dans tout le basin Mediterreen Nord de l'Afrique, Maroc, Tunisie, Egypt. Paris: 364p.

A classical study of bamboos, particularly East Asian species, dealing with taxonomy, distribution, general physical characteristics, propagation, properties and uses (including usage in construction).

Note: In French. The book is out of print. Available in the library of Forest Research Institute, New Forest, Dehra Dun, India.

Keywords: cultivation, physical properties, .

Sskhar, A.C. and Rawat, B.S. (1956).

Strength tests on bamboos.
Indian Forest Leaflet No. 147.

Discusses different types of physical and mechanical tests on bamboo, and discusses procedures adopted at Forest Research Institute, Dehra Dun, India.

Keywords: mechanical properties, physical properties, test methods.

Tesoro, F.O. and Espiloy, Z.B. (1990).

Bamboo research in the Philippines.

In: Rao, I.V.R., Gnanaharan, R. and Sastry, C.B. (Eds.). Bamboos - Current Research. Proceedings of the International Bamboo Workshop held at Cochin, India, 14-18 November, 1988. Kerala Forest Research Institute, India and International Development Research Centre, Singapore, 15-21.

A paper on the research activities in the Philippines.

Keywords: construction techniques, preservation, properties.

United Nations (1972).

The use of bamboo reeds in building construction.

Publication of the Department of Economic and Social Affairs of the United Nations, New York. Document No.ST/SOA/113: 95p.

In this publication the consultants for United Nations, D. Narayanamurti and Dinesh Mohan, have discussed the utilization of bamboo and reed in various forms (full, half, split, board, mat and slab) as components in building viz., foundation, framing, flooring, roofing, walls, trusses, doors and windows, pipes and troughs, and joints and fasteners. Illustrated examples of such utilization from several countries have been provided.

The study includes information on harvesting, curing and storage of bamboo culms as well as structure, properties and preservative treatment in respect of a few species.

Note: The publication is out of print. Copies are available for reference with the library of Indian Plywood Industries Research Institute, P.B.No. 2273, Tumkur Road, Bangalore, India.

Keywords: construction techniques, mechanical properties, physical properties, preservation.

Vanstone, J.H. (1929).

The Raw Materials of Commerce, 4 16 p.

Uses of bamboo are described in one chapter. Mention is made of about 200 species distributed in the tropical and subtropical areas. Uses listed include posts for houses, masts for vessels, waterpipes, roofing tiles, (in split form) etc.

Note: The publication is out of print. Available in Forest Research Institute, Dehra Dun, India.

Keywords: construction techniques, roofing, waterpipes.

White, D.G. (1948).

Bamboo culture and utilisation in Puerto Rico.

U.S. Dept. of Agriculture Experimental Station, Puerto Rico, Circular No. 29.

A brief history of introduction of bamboo (about 30 species) in Puerto Rico is given. Propagation, harvesting, storage, preservative treatment and utilisation (in building construction included) are discussed.

Keywords: construction techniques, preservation.

Other Publications by the IDRC Bamboo and Rattan Research Network

- Rattan: A Report of a Workshop held in Singapore, pp 76 (1979)*
Bamboo Research in Asia, pp 228 (1980)*
Proceedings of the Rattan Seminar, pp 247 (1985)
Recent Research on Bamboos, pp 393 (1987)
Proceedings of Colloquium on Rattan Propagation, pp 48 (1987)
The IDRC Bamboo and Rattan Research Network in Asia, pp 20 (1988)
Bamboos - Current Research, pp 394 (1990)
Recent Research on Rattans, pp 275 (1989)
Proceedings of the Seminar on Tissue Culture of Forest Species,
pp 215 (1989)
A Guide to the Collection of Bamboo, pp 24 (1989)
Proceedings of the International Bamboo Workshop (Chiangmai) -
1992 (under preparation)

**Out of print.*

Film/Videos

Bamboo - The Miracle Grass

Rattan - A Hidden Resource.

These publications can be obtained from:

**International Development Research Centre
(IDRC)**
Tanglin P O Box 101
Singapore 9124
Republic of Singapore.