Bamboo use as a Construction Material

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Abstract:

Today, the world is undergoing vast changes. The technological revolution, population growth, environmental concern and more. As the population growth increases, the demand associated with it also increases. One of the demands, among the most, is owning houses. A high demand of owning houses in India is increasing. As most of the people in this country are poor, it should be a major concern to provide the people an alternative, which will reduce the cost of houses. Urgent and effective action is required to secure the demand in sustainable basis. To tackle the problem use of bamboo (shimel) as reinforcement is among the alternatives as the price of steel is becoming prohibitably high. Consequently, their utilization should be the concern of the society. Utilization driven production could ensure their sustainability.

Lack of awareness about their multiple use of bamboo and lack of scientific knowledge about their production, and main mechanical properties are impediments for conservation and utilization. Consented effects are needed to generate and adopt the required knowledge and technology in order to reduce the problem of owning houses.

This study is prepared to assist field personnel in the design and construction of bamboo reinforced construction mainly for low-cost houses

Cost comparison between steel and asphalt coated bamboo is presented as per cost breakdown referring to the present market assessment. As per cost analysis, use of bamboo reinforcement is a better and economical alternative in view of overall cost.

Finally recommendation and conclusion based on the study is forwarded.

I.INTRODUCTION

The provision of houses has been closely related to the economic development of any nation. Invariably the developed nations have a well developed system of houses. This necessitates that the improvement of housing systems be developed in a planned and organized manner with long term objectives. The short term objective may include the development of medium to small-scale houses.

It can be concluded from the income of most of the people in India, the long term objectives of developing the country's problems particularly owning houses need a substantial amount of financial resources. In the interim, however a short-term objective of developing houses needs to be assessed. One of such short-term objectives could be provision of low-cost houses to serve most people.

Ecosystems are largely affected by today's construction activities which uses energy extensively from its very beginning to its completion and even after for its maintenance in many forms. Alone construction sector has been accounted to consume 40% of total energy consumption directly or indirectly. Availability of construction material in a near vicinity and use of locally produced material saves a lot on construction cost and also in terms of energy. Bamboo is one such material which has extensive potential in building industry if used with proper treatment and trained workers. The housing sector in India is growing rapidly but with increased cost it is getting out of reach of people. We in India have 20-30 million families who have next to nothing to live under or no form of shelter at all.

The present paper deals with the utilization of bamboo as a construction /structural element in various building components such as floor, roof, beam, wall-panels, columns etc. Bamboo reinforcement as replacement of steel reinforcement is gaining immense importance today, mainly on account of the improvement in the economical aspect combined with ecological benefits.

Bamboo is an endogenous tree and is found in abundant in most part of the country. Though it is vulnerable to environmental degradation and attacks by insects and moulds, its durability can be enhanced with preservation condition, treatment and curing thus increasing its service life greatly. An engineered Bamboo can substitute steel in making tensile stresses of RCC members and also reduces the consumption of cement in building. Both cement & steel are the most dominant & energy intensive materials used in construction.

Bamboo has a proven testimony as one of the oldest construction material throughout the world. It provides a good thermal insulation and has an advantage of being renewable and

fast growing, contributes to higher carbon credit. With proper engineering, use of Bamboo in building can aid in the growth of alternative & sustainable development meeting the challenges of construction industry and growing housing sector.

Power is the basic necessity for the economic development of a country in the present day civilization. Development of all kind of industries including construction, agriculture, transportation, etc totally depends on generation of electrical energy. The present power generation which is consuming the resources on earth rapidly is still inadequate to meet the demand. The increasing demand for building materials combined with the higher costs of urban land is marginalizing huge numbers of poor people. This is primarily because we are not able to harness the renewable resources of energy through sustainable technologies, though these resources exist abundantly throughout.

The 'Building Sector' is the major source of demand for energy and materials that also produce by-product green house gases (GHG). However, a low-cost and renewable resource for permanent construction could be based on 'Bamboo'. In tropical regions, construction size bamboo reaches full strength already after 3-4 years.

Growing on hill sides and along roads and fields it does not encroach on agricultural land either. On the contrary, bamboo can prevent erosion and even revitalize devastated rain forest soil. Local economy can be promoted at all steps in the supply chain. Bamboo can even help the whole world by its remarkable CO2 sequestrating capacity. Bamboo has historically been used as a building material due to its inherent properties, being regenerating, biodegradable, with high tensile strength, and light weight. However, despite its innumerable qualities one does not get to see bamboo as popular building material.

II.STATEMENT OF THE PROBLEM

Developing countries such as India, which are suffering from the shortage of houses because of increase in population. A high demand of owning houses in India is highly increasing. In order to improve this sector however there is a need to invest a substantial amount of money in to the development of houses. As this may be difficult to achieve in the short-term, what other alternative exist? What can be provided as an alternative? This research, therefore, will attempt to address these questions, in particular to the provision of low-cost houses with a particular emphasis of applying cheap and available local material.

III. OBJECTIVES OF THE THESIS

The main objectives of this thesis are;

1. To study the various uses of bamboo
2. To study the bond between bamboo reinforcement and the surrounding concrete.
3. To study the methods of the bamboo used as structural member
4. To formulate conclusions and recommendations based on the work performed

IV.APPLICATION OF THE STUDY

After conducting further study, the material, solid bamboo, can be applied in the construction of low-cost houses.

The introduction of the foregoing section leads to the aims of this research. The direct aim of this research is to determine the opportunities and constraints of the application of bamboo construction technologies for low income households in India. Recommendations based on these conclusions can lead to the indirect aim of this research: providing for better housing opportunities for the target group: lower income households in selected rural villages of the India.

V.NEED OF THE STUDY

Developing countries such as India, which are suffering from the Shortage of houses and adverse consequences of deforestation, can not afford to see their remaining renewable natural resources decimated, by paying lip-service to their protection, production and wise use. The sensible thing for Ethiopia to do is to foster protection as well as the production and utilization of bamboo through considered management for construction industrial, household and soil conservation and environmental protection. Protection, development and utilization efforts must be guided by knowledge generated by relevant research. The ecology of the low and highland bamboos should be further investigated, and ways to improve the natural forests using various management practices and treatments need to be determined.

VI.METHODOLOGY

Bamboo provides goods and services useful to mankind. It is a source for food, fodder, furniture, building materials, paper, particle board, energy, and medicine. This low level of utilization is due to bamboo's susceptibility to biological and physical deterioration. The durability of bamboo products is believed to be short. Although various treatments are available to increase its service life, people are unaware of these technologies. Bamboo is still considered as a perishable material and, hence, useless, which has led to its neglect as a useful renewable resource. Its potential for construction and industrial use has yet to be popularized and accepted by both potential investors and growers. Practical demonstrations are the most effective ways of convincing people, and research and development directed towards this end is urgently needed. Viable markets for potential bamboo owners have to be created, by promoting bamboo-based investments, underpinned by the existing natural bamboo forest. Expansion and proper management of both plantations and natural bamboo forests will follow, driven by market forces. However, workable incentives and appropriate support, in the form of extension services, will be needed to accelerate this process. Links in the bamboo production, management, processing, manufacturing, end product distribution, and utilization chain, have to be established, strengthened and maintained, using functioning markets. Emphasis has to be given for research and development of bamboo use in India. Good lessons for bamboo utilization are available from tropical Asia. In Nepal, bamboo is used in more than 180 ways. More than 300 machine-intensive bamboo-processing factories have been established from 1985-1992 in Malaysia. Bamboo is widely used in large quantities for pulp and paper production in India, china, Indonesia and other Asian countries. Bamboo pulp is high grade, and the chemical recovery problems arising from high silica content

have now been solved by decalcification. In Burma, Bamboo is extensively used as a roofing material. Good quality activate carbon can also be produced from bamboo. Excellent quality particle board that meets Type 1, British standard, requirements is produced from bamboo. Bamboo is also used in Asia, at household and cottage-industry levels, to produce mats, scaffoldings, ladders, sticks, hand tools, brushes, pipes, umbrellas, toys, sports goods, musical instruments, spears, arrows, rafts, fishing rods, caps, baskets, flowerpots and many other items. In this way, rural people can satisfy their own needs and supplement their income. Bamboo is also the preferred material for shade construction in plan nurseries, and for props to support the growth of agricultural crops like banana, tomatoes, and flowers.

Bamboo shoots are a popular food in Asia, and the nutritional value is comparable to those of many commercial vegetables. The roots grow in all directions forming a complex network of up to more than1m depth belowground, which effectively holds soil particles together, thereby, preventing soil erosion and promoting water percolation. The aboveground part of bamboo helps to reduce erosion caused by rain, by interception, and also shelters the soil from wind erosion. Bamboo litter fall improves soil structure and fertility. The high growth rate of bamboo is of course closely associated with high eater and nutrient consumption. This makes it suitable for vegetation filter purposes, a biological means of waste purification, whereby most of the pollutants in the waste are used for biomass production through the plant growth process. Increased biomass production means that carbon sequestering is enhanced and oxygen release increases. These are not unique characteristics for bamboo, but it does excel most species in growth rate. These qualities all make it an ideal species for urban plantations as hedges, as a buffer near water bodies and surrounding waste deposits. This is in addition to its uses in production, e.g. to supply bio fuel and products construction and furniture industries for urban populations.

VII. BAMBOO – A GREEN GOLD

Bamboo is rightly called the green gold as it qualifies under many of the categories listed for green building materials.
Globally, there is a resurgence of interest in Bamboo in this age of information revolution and environmental consciousness. Bamboo is being currently looked upon as an alternate low cost material for the enormous housing problem faced by several developing countries. To increase the self sufficiency of developing countries indigenous materials must be exploited to the full. Bamboo is one such material with a long history of usefulness. Several countries in Asia and Latin America still depend on bamboo as an important source of building material not only for construction of rural houses but also for pucca houses and public buildings in towns and cities.
Bamboo a potential environmental friendly material for housing and construction
Fast growing nature of bamboo to provide sustainable supply to meet the demands of the building industry and many positive aspects of modern engineering materials found in bamboo has renewed interest of engineers and architects to use bamboo as an engineering material. Some of the advantages of bamboo are:

i. High tensile strength compared to that of mild steel – can be used for reinforcement in place of mild steel

ii. High strength to weight ratio and high specific load bearing capacity

iii. Requires less energy for production compared to material like steel, plastics, aluminum etc.

iv. Physical-mechanical properties of bamboo which grows to maturity in 4 to 5 years compares favorably with that of hardwood which requires 40 to 50 years to attain maturity.

v. Service life of bamboo can be enhanced considerably by providing suitable preservative treatment.

vi. Studies as in China, India have further established its versatility to be converted into panel and composite material possessing enhanced strength properties suitable for structural applications.

vii. Like wood bamboo also possesses high residual strength to absorb shocks and impacts–this makes it highly suitable material for construction of houses to resist seismic and high wind forces.

viii. Bamboo along with fast grown plantation species is very efficient in sequestering carbon and contributes to the reduction of green house effect.

VIII.POTENTIAL APPLICATIONS OF BAMBOO IN HOUSING/CONSTRUCTION

Bamboo trusses

Traditionally timber trusses or rafter-purling have been in vogue for sloping roofs from time immemorial. Bamboo trusses offer a good substitute for supporting roof loads and transmitting them to the foundation through columns. Bamboo trusses are fabricated using culms having an outer diameter of 75-100 mm. When the top and bottom chords and strut members are properly jointed by suitable fastening devices, a truss can resist compressive and tensile forces conglomerate and as such act as a stronger supporting component even in earthquakes compared to rafter-purlin system

Bamboo trusses

Bamboo roofs skeleton:

Consists of bamboo truss or rafters over which solid bamboo purling are laid and lashed to the rafter or top chord of the truss by means of G.I wire, cane, grass, sutli or bamboo leaves but not the nails for fear of splits in the bamboo. A mesh or grid made of halved bamboo is laid and lashed to the purling and roof covered.

Bamboo roofs skeleton

Wall Infill Panel:

The non-load bearing infill wall comprises of treated split bamboo grid 19 x 9 mm wired together at 150 mm spacing. The grid is tied to MS dowels passing through the columns and to the wall plate using nails and binding wires. Chicken mesh is fixed to the outside face of the grid. A 3:1 mix cement mortar is applied over the grid to a finished thickness of 50mm. When the cement mortar is applied to the walls, they become very strong, but retain the lightness and resilience. These characteristics make the construction inherently resistant to dynamic forces and are therefore beneficial in the earthquake prone areas. Walls are required to resist both static and dynamic forces. Static forces such as self weight and roof loads can be dealt with by calculation. Dynamic force will include impacts, wind and earthquake forces. Tests were carried out both for impact and racking strength based on Indian standard specifications for doors.

Potential applications of bamboo composites in housing/construction

Bamboo Mat board partition wall/ceiling

Door and window shutters

It is easy to make low cost paneled door and window shutters by laminating panels of bamboo mat boards and stiles and rails of thin sections of wood with either gluing or nail-gluing. A 7-ply 5mm thick board is adequate in a single panel shutter whereas 3-ply, 2.5mm thick board can safely be used in a double door shutter having a maximum panel width of 30 cm. Thin bamboo mat board of 2-ply and 3-ply make excellent skin for hollow core flush doors due to high modulus of rigidity and good impact resistance of the board. A few experimental doors of this type used under exterior conditions are still in good condition after 12 years.

Bamboo laminates for floor

These laminates are finding wider applications for flooring, wall paneling in door and window frames, furniture, etc. as alternate for wood and wood based products. The boards have a natural elegant pattern with beautiful colors. The panels are treated with anti-insects and anti – decay chemicals and bonded with urea or phenol resin adhesives depending upon end use application.

Bamboo Mat Corrugated Sheet (BMCS):

Bamboo mat corrugated sheet [BMCS]:

Roofing materials such as asbestos cement corrugated sheet(ACCS), corrugated fiber reinforced plastics(CFRP), Corrugated aluminum sheet(CAS) Corrugated galvanized iron sheet(CGIS)which have been established for more than several decades, are being subjected to scientific scrutiny on several counts, including their impact on workers health and environment., their energy requirement for their manufacture, and sustainable supply of raw materials. Of late priority is being given, and rightly so to green building materials, based on renewable resources. BMCS is one such material. It is made of four or more bamboo mats bonded with an adhesive and pressed in a specially designed sinusoidal platen dies. They have very high potential as eco-friendly roofing material. The load deflection curves of various corrugated roofing materials indicate the comparative advantage of BMCS over other corrugated materials. The load bearing capacity of BMCS is comparable to that of ACCS and CGI sheets and much superior to ACS. BMCS being light in weight possess high resilience. BMCS is water proof and resistant to decay, termites/insects and fire. The thermal conductivity of BMCS(0.1928 Kcal/m°c) is lower compared ACCS.(0.3422 Kcals/ m°c) and provides better thermal comforts compared to houses having ACCS or CGIS as roofs.

These sheets have been already used as roofing material in demonstration houses built by using Bamboo based housing technology

IX.BAMBOO REINFORCED CONCRETE

a) Introduction

In this study bamboo is given consideration for use as reinforcement for the construction of low-cost houses in India. As a high demand of owning houses in India is highly increasing, urgent and effective action is required to secure the

demand in sustainable basis. The results of this investigation form the basis of the conclusions and recommendations .

b)Bending Test of Reinforced Concrete Beams

Concrete is strong in compression but weak in tension. As a result, cracks develop whenever loads, or restrained shrinkage of temperature changes. The later give rise to tensile stresses in excess of the tensile strength of the concrete. In plain concrete beams, the moment due to applied loads are resisted by an internal tension-compression couple involving tension in the concrete. Such a beam fails very suddenly and completely when the first crack forms. In reinforced concrete beam bamboos are embedded in the concrete in
such a way that the tension forces needed for the moment equilibrium after the concrete cracks can be taken care by in the bamboo bars. In order to study the behavior of the bamboo reinforced concrete beam subjected to force acting transverse to their longitudinal axis, bending test is selected. Two types of bending tests, Mid - Span loading and Two point loading, are conducted.

b)Selection of Bamboo

The following factors were considered in the selection of bamboo culms for use as reinforcement during the test;

1. only bamboo showing no defects are used
2. bamboo with little variation in diameter along the length is selected.
3. bamboo having shorter internode dimension has to be selected in orders to acquire more nodes to increase bond.

c)Preparation of Bamboo

Sizing: The bamboo was cut with sharp saw. During cutting great care was taken not to split the specimen, because splitting will result in continuous tearing of fiber.

Water Proof Coatings: After selecting and sizing, water proof coating is applied because it reduces swelling when the bamboo contacted with concrete. Without coating, bamboo will swell before the concrete has developed sufficient strength to prevent cracking and the member may be damaged. The type of coating used is asphalt emulsion. Only a thin coating shall be applied. A thick coating will lubricate the surface and weaken the bond between the concrete and bamboo.

Surface Roughening: Since bamboo as a very smooth texture, the bond with concrete will be very weak. Therefore it needs attention to improve the bond by roughening the surface of bamboo. To overcome this problem, the bamboo was dipped in to AC80/100 grade hot asphalt and then coarse sand was applied on top of the coated surface. The result of the test is expected to show that asphalt acted as water repellant and the sand sprayed on the asphalt helps to increase the bond.

X.BAMBOO IN EARTHQUAKE-PRONE AREAS

The recent earthquake in India, that literally shook people's lives on January 26, 2001, was an event of catastrophic proportions. It caused widespread damage to life and property, both of which if not avoided could have been minimized. The count of human life losses rose above 25,000. Over 370,000 houses were completely destroyed and over 922,000 partially destroyed, total damages exceeding 5 billion US Dollars. Around 50% of this damage, upto 2.5 billion US Dollars was incurred due to household property damage.

It is obvious that a lot of these losses could have been minimized if the houses were better engineered. However, an expectation of this sort is quite difficult to fulfill. In a developing country like India, a person from the lower economic strata is incapable of building engineered houses. Most "lower-income" group houses are built by just hiring a mason or a contractor, neither qualified to engineer the building. Also the chief building system preferred by these people is bearing masonry using brick, clay block or cement block. These systems, if not reinforced, are most susceptible to complete collapse during seismic activity.

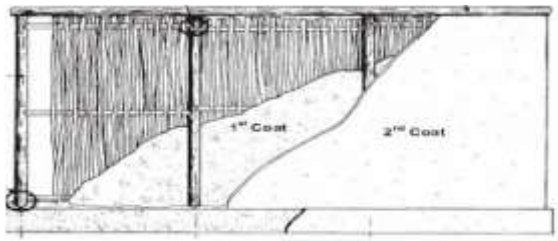
The objective of this thesis is to provide a comprehensive set of guidelines for the benefit of the average house-builder to construct seismically safe, reinforced bearing masonry using bamboo as alternative reinforcing material. Researches in the past have proved bamboo to be the fastest renewable natural building material and a worthy alternative to steel. However, the merits of bamboo have been continuously overlooked with the advent of "modernity" in building construction.

XI.BAMBOO HOUSING –IKRA HOUSING

Traditional construction in north-eastern region consists mostly of typical bamboo houses, known locally as 'Ikra', and also known as Assam-type housing. These housing typologies are common throughout the Northeast India. Majority of such houses are used for residential purposes. Typically these houses are built with light weight locally available material like bamboos, wooden planks, thatch etc. Such houses have a proper system of bamboo/wooden beam-column and fulfill the earthquake safety requirements of rectangularity and simplicity. Ikra houses are single-storey structures consisting of brick or stone masonry walls up to about 1 m above the plinth. This masonry supports the walls consisting of bamboo woven together with a wooden frame, and plastered with cement or mud plaster. The roof generally consists of GI sheets supported on wood/bamboo trusses, which laterally connect the parallel walls. Bamboo superstructure is connected to the masonry foundation walls using steel angles, and flats with bolts and nails. There were no reports of any significant damages to Ikra structures during past earthquake.

These housing types have demonstrated some of the basic principles of earthquake safe construction of non engineered buildings like appropriate sitting and location on firm soils, good building configuration i.e. its form and shape in plan and elevation; location and size of major structural elements; number, location and size of openings; and connection details of non-structural elements with main structural system. Due to proper connection between different elements, such houses have a proper integral action due to which they act as a single unit.

Bamboo housing system –Ikra housing



Bamboo strips plastered with mud or cement.

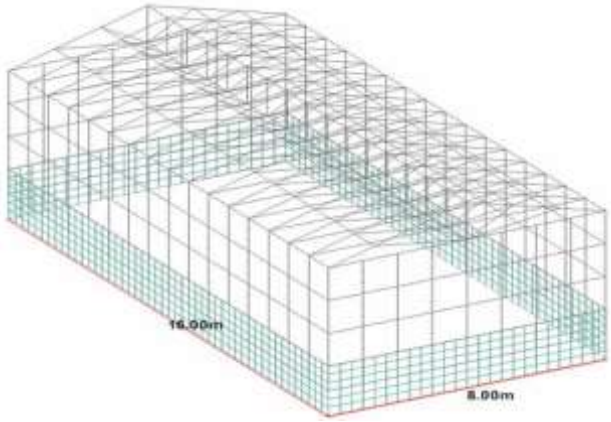
III. MODERN CONSTRUCTION PRACTICES

The recent practices in construction of houses are load bearing system and Reinforced concrete frame system. Both the systems are very popular throughout the India and around the world.

IV. MODEL CONFIGURATION

A. Ikra housing model

For the model, a real life structure school building located near Dispur, Assam is modeled in software. The plan dimension of the building is 8m x 16m.



Model of bamboo (Ikra) housing system

In bamboo (Ikra) housing system, for main structural member bamboo is used. As the material used in bamboo housing is flexible
(modulus of elasticity is very less compared to other material).

XII.CONCLUSION & RECOMMENDATION

CONCLUSION

In these days of advanced quality consciousness, affordable alternatives are a must for the success development and marketing of any product. The absence of standards hindered the construction of bamboo at low-income level and it has also impeded the acceptance of bamboo as a wood substitute of choice in the construction industry.

On another plane, the lack of studies kept building designs away from bamboo, even from expressing their opinion to use it as a building material. Engineers prefer to work with a well known system or matter by solid knowledge of its properties, backed by the existence of a minimum code of specification on which they can base their judgment and design decision.

In order to ascertain the sustainability of various structural purposes their physical and mechanical properties are required to be tested. Despite many inconveniences such as lack of scientific knowledge, lack of testing standards, etc during the research work, promising test results are obtained. High early strength cement is preferred to minimize cracks caused by swelling of bamboo when bamboo cannot totally be water proofed. Bamboo reinforced concrete design is similar to steel reinforced concrete design if its mechanical properties are properly utilized. The experimental study was found out to give encouragement. It identifies the potential for an alternative method for low-cost construction for areas where steel reinforcement is costly. In this case, bamboo might replace steel in light constructions as the tensile element in reinforced concrete design.

Even though the results obtained on this study are promising, further studies will be required to put complete confidence on the material presented here and to make the bamboo reinforced concrete construction more effective and effective.

REFERENCES

[1] Environmental Sustainability with Green Building Technology (ICESGBT), Editor: Prof. K.S. Babai, Department of civil engineering, Meenakshi Sundararajan Engineering College, Chennai.

[2] Bamboo Reinforcement,MARKOS ALITO, ADDIS ABABA UNIVERSITY www.etd.aau.edu.at

[3] Ikra Housing, www.bvmengineering.ac.in

[4] Earthquake-prone areas bamboo-reinforced masonry www.sefiindia.org/rangarajan/bamboo/design

[5] Wimbush, S.H. 1945. The African Alpine Bamboo. Emp. forest J.24,23-39

[6] Newcombe, K.J. 1989. An economic justification for rural Afforestation: The case of Ethiopia. In: Environmental Management and Economic
Development. Schramm, G. and Watford, J.J.(eds). John Hopkins for the World Bank, Baltimore, Md., pp. 117-138.

[7] Mamo, A. 1995. Environment, population and agricultural development in Ethiopia. In: proc. Conference in Ethiopian Agriculture: Problems of Transformation. Aredo, D. and Demeke, M.(eds). Addis Ababa, Ethiopia. Department of Economics, Addis Ababa University and Ethiopian Economic Association., Addis Ababa, Ethiopia.PP.65-86.

[8] Ethiopia: Forestry Action Program. 1994. Final Report, vols. I-III, Ministry of
Natural Resources Development and Environmental Protection, Addis Ababa, Ethiopia.

[9] Legesse, N.1992. Indigenous Trees of Ethiopia: Biology, Uses and Propagation Techniques. Addis Ababa University, Addis Ababa, Ethiopia.

[10] Pohjonen, V. 1989. Establishment of fuel wood plantations in Ethiopia.
Silva Carelica 14. University of Joensuu, Finland. pp.1-388.

[11] Liesse, W.1985. Bamboos: biology Silvics, Properties and Utilization. GTZ,
Eschborn, Germany.
[12] Adkoli, N.S. 1991. Bamboo in the Indian bamboo industry. In: proc. Fourth International Bamboo Workshop on Bamboo in Pacific Asia. FORSPA publication 6, technical document GCP/RAS/134/ASB, FORSPA, Chiangmai, Thailand and IDRC, Ottawa, Canada, pp.251-255.