Efficient Management of Bamboo Storage To Reduce Cost of Paper Production

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ABSTRACT

The importance of bamboo as fibrous raw material for pulp and papermaking is well known in our country. The present paper deals with a few aspects of efficient management of storage of bamboo. The emphasis has been made to have optimum inventory of bamboo at different places of storage. The proper selection of site for storage, layout of stacks in the yard in compliance to the insurance rules and easy approach for transport system, stacks design, etc. are also to be given due consideration to reduce cost of loading and unloading, prevention from fire hazards, preservation of rawmaterial and overall reduction in cost of rawmaterial. The paper also discusses in detail regarding the biological infestations take place due to prolonged storage. Details regarding types of infestations and remedial measures to check the same are also described. A brief detail regarding the experiments conducted to evaluate the efficacy of prophylactic treatment to check degradation of bamboo and its effect on papermaking characteristics are given along with the mill experience.

It has been finally concluded that by adoption of scientific forest management practices, systematic storage, optimum inventory and preservative treatment would definitely be helpful in checking woody substance losses at various stages of operation, which would ultimately give better pulp and paper quality with improved productivity.

The pulp and paper industry in India has got an important role in the industrial structure of the country. This industry can now be described as an industry similar to any major industry. The economic contribution of the industry in terms of employment potential, central and states finance, foreign exchange and to other segments of economy is very significant. The efforts are needed to organise the industry in suitable manner.

The production and consumption of paper and paperboards, the medium of propogation of knowledge and index of modern civilization, have increased both in bulk and variety. The paper industry has a challenging task ahead of providing the needs of growing population with increasing literacy and requirements of our industrially and technically developing country.

The Indian Paper Industry has an installed capacity of about 2.65 Million Tonnes. It has been visualised that, by the turn of the century the demand will go as high as 3.0 Million Tonnes as compared to 1.5 Million Tonnes today, However, over the last decade, the growth and capacity utilisation, have shown declining trend. One of the major factors for this is non-availability of fibrous rawmaterials.

In order to effectively solve the problem of rawmaterial supply one major step has been taken to use unconventional rawmaterials including straws, bagasse, mesta, waste paper, etc., But bamboo still accounts for over sixty per cent of fibrous rawmaterial consumed by the industry. Due to tropical climatic conditions continuous supply of bamboo from the forest to mills throughout the year is not possible. As the felling stops in the 'off season' for about 4 to 5 months, proper storage and preservation of bamboo are important for smooth running of the mills.

In most of the mills records pertaining to the losses of bamboo weight during harvesting, transportation and storage are not being maintained systematically; hence, no authentic data on this aspect are available. Most of the mills make routine measurement of yield and quality of pulp, based on the material going to digester and

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coming out of digester. This practice does not reveal losses in the storage, transport or during felling.

Apart from availablility of rawmaterial, the cost of rawmaterial also has significant effect on overall cost of production of pulp/paper. However, this varies from mill to mill depending on the various factors. Hence, sincere efforts are needed for its effective harvesting, storage and preservation to minimize the losses of rawmaterial and at the same time to produce pulp of good quality.

Bamboo harvesting and transport

A brief discussion on bamboo harvesting and transportation is essential to understand the basic problems of storage and preservation of bamboo.

There are two main varieties of bamboo i. e. Dendracalamus strictus and Bambusa arundinacea which are being used in India, for the production of paper grade pulp. D. Strictus is predominantly used compared to other variety. For extraction of this variety of bamboo from the natural forest set rules have to be followed for healthy growth of clumps. The felling of immatured bamboo clum results in financial losses at the same time the pulp and papermaking characteristics are adversely affected (Table–1).

In the forest mature bamboo culms are cut and removed from the clump. Culms after removal of twigs and branches are cut into pieces of about 2 meters length and tied into bundles containing 20-21 pieces for facilitating handling operations. These bamboo bundles, in initial stages are stacked in small stacks where felling is being done and subsequently transported to interim depots. From the interim depots bamboo bundles are transported by trucks to rail heads or dirctly brought to mill yard where they are stacked. From the rail heads bamboo bnndles are transported by wagons to the mill yards.

Table—1

PULP AND PAPERMAKING CHARACTERISTICS OF BAMBOO OF DIFFERENT AGE

		One year	Two years	Three years	Four years
1. PROXIMATE CHEMICAL ANALYSIS					
Hot water solubility,	%	10.1	8.8	8.5	7.6
1.0% NaOH solubility,	%	26.3	23.4	22.6	22.0
Alcohol Benzene solubility,	%	7.8	7.4	7.2	6 9
Pentosans,	%	22.3	20.1	17.4	17.1
Holocellulose,	%	63.9	65.5	68.9	70.9
Klason lignin,	%	24.9	26.9	27 2	27.6
Ash,	%	2.85	3.11	3.32	4.60
2. PULPING DATA					
A.A. on O.D. chips as Na_2O,	%	16.0	17.0	17.0	17.5
'H' Factor,		1120	1120	1120	1120
Total Pulp yield.	%	41.3	45.4	46.5	46.8
Kappa No.		23.8	25.1	26.3	26.5
3. BLEACHING WITH CEHH SEQUENCE					
Total Cl_2 consumed	%	8.17	8.96	9.27	9.43
Brightness, Elrepho,	%	79.8	80.5	78.8	80.0
Viscosity, Cp (CED)	%	8.3	9.1	10.4	10.6
4. PHYSICAL STRENGTH PROPERTIES AT 30°SR					
Burst factor,		38	40	40	45
Tear factor,		80	84	90	98
Breaking length,	KM	6.40	6.50	6.90	7.30
Double folds,	No.	85	100	130	160
Strength index,		1810	1890	1970	2140

Storage of Bamboo

Bamboo is mostly stored in outside location from the time of felling to pulping. There are three important locations for storage i.e. forest, interim depot/rail heads and mill yard. At the felling site freshly felled bamboo pieces after bundling are collected and arranged in stacks of 50 bundles each in criss-cross fashion with two bundles each thereafter. In most of the cases the moisture content of bamboo at this stage remains around 40% and such a high moisture content bamboos are very much prone to biological infestations during the storage period. The prolonged detention and bad storage practices lead to biological infestation.

The stacks at interim depots and rail heads are larger consisting of 10,000 to 15,000 bundles per stack. At this stage the condition of bamboo, primarily depends on the storage pattern at felling site. In case the infestation is carried from felling site, further deterioration would be there if no preventive measures are taken. At the same time, uncertainity of duration of detention prohibits the preservative treatment.

The largest area at one site of storage of bomboo is the mill yard. The bamboos of varying conditions, areas, duration of storage, degree of infestations, moisture content, ete., are brought to the yard. The stacks 300–400 Tonnes bamboo are made which are normally done on levelled ground or raised concrete platforms.

The quantity and duration of storage at differnt places, as mentioned above, should be decided keeping in view that the minimum quantity is stored at all the places for minimum duration. However, it may be be noted that this practice has to be very cautiously followed otherwise it may sometime interrupt the constant supply of bamboo to the mills. It is generally practicised that at felling site total bamboo requirement of mill for 3 months, at rail heads and interim depots for about one month and at mill site for about 2 months are stored. Apart from this 'first in fiirst-out' practice is to be strictly adopted as far as possible.

The storage yard site should be selected where there is no stagnation of water in rainy season and should be properly cleaned before storage of bamboo. The layout of yard at all the places of storage plays an important role with regard to convenience and cost. Layout should be made in such a manner that it has easy approach to transport facilities i.e. truck, rail, internal transport system of mill, etc. These measures will reduce cost of loading and unloading significantly. Apart from this, the stacks should also be made in compliance to 'insurance rules'. This practice not only prevents the fire hazards but with this we would be able to save valuable rawmaterial which is otherwise destroyed due to fire incidences.

The prolonged storage of bamboo not only leads to financial losses or biological infestations but also to the changes in the chemical constituents. This can be seen from Table–2. These changes in chemical constituents ultimately adversely reflect on the cost of pulp and paper production.

Table—2

PROXIMATE CHEMICAL ANALYSIS OF DENDROCALAMUS STRICTUS

(—60. +80 Fractions)

All values expressed on 100 g. O.D. Material

Particulars	MONTH OF STORAGE												
	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1. Ash	3 66	4.05	2.92	3.23	2.37	4.52	2.64	3.26	4.4	3.6	3.19	2.68	3.93
2. Silica	2.16	2.66	2.41	1.94	1.51	3.26	1.70	2.83	3.29	2.21	2.36	2.16	3.70
3. Cold H_2O soluble	12.5	6.6	7.5	4.95	4.56	2.84	3.35	2.35	2.35	2.49	2.11	1.49	2.32
4 Hot H_2O soluble	14.1	7.7	9.07	6.06	5.93	3.37	4.81	4.19	3.74	4.38	3.72	2 56	4 04
5. 1% NaOH solubility	29.75	22.37	24.23	21.97	19.44	23.6	20.0	21.1	18 9	18.1	17.8	17.8	20 6
6. Alc.: C_6H_6 solubility	7.2	3.6	4.6	3.3	3.4	2.7	1.9	1.9	1.33	2.33	1.81	1.57	1.18
7. Lignin (corrected for ash)	21.2	24.1	25.1	25.1	24.3	25.5	27.4	24.9	25.5	25.4	26.0	26 8	25.7
1. Alpha-Cellulose	45.5	48.7	47.5	48.3	49.3	49.8	48.3	47.2	49.3	49.1	51.2	49 3	51.3

Biological Infesiations

As soon as the bamboo is felled, the activity of certain tissues, that can resist the infestation, is lost. Consequently they are liable to biological infestation mainly due to attack by fungi, insects, etc.,

(a) Fungal degradation :

Bamboo in ground contact are readily colonized by a large range of micro organism mainly fungi. Majority of the early invadors like molds and staining fungi do not attack the wood substance but derive their nutrition mainly from the cell lumen contents. After few weeks on the ground, soft rot fungi may produce relatively small amounts of decay in bamboo. However, the more destructive wood destroying fungi eg. Basidiomycetus usually attack bamboo only after few months.

Brown rots attack primarily the cell wall carbohydrate leaving behind a net work consisting of modified lignin, with small amount of more resistant crystalline cellulose. The affected wood develop brown colour. In the final stage, the decayed wood is converted into powdery mass of varying shades of brown.

White rot fungi attack both cellulose and lignin leaving behind a spongy mass. The affected wood is usually white or grayish white in colour. These changes cause loss in pulp yield as well as pulp strength and brightness.

(b) Borer degradation :

Borer attack to bamboo is one of the most common and easily identified problem of storing bamboo. Borer belongs to two families of powder pest beetle i. e. Bostrychidae and Lyctidae. In the initial stages of infestation yellow powdery substance falls from the bamboo after threshing. In the advanced stage the infested bamboo is full of pin holes and yellow powder. Immature bamboos are very much prone to such infestation.

The optimum conditions of temperature for growth of larvae are developed with thermoplastic action in the large sized stacks which is due to restricted circulation of air and the presence of green bamboo (above 25 per cenr moisture content), and subsequently cause the higher rate of borer infestation in all varieties of bamboo.

Bamboos coming from poor soil and dry areas are more susceptible to pest attack than bamboos from fertile, moist and more productive sites. A few bamboo varieties e. g. Melocanna bambusoides Bambusa tulda, Bambusa bulcooa and Dendrocalamus hamiltonii are not at all affected by borers even when stacked with bamboo bundles of Dendrocalamus strictus under active borer infestation.

(c) Termite degradation :

Termite is the most important biological agency due to which substantial loss of woody substance takes place at various sites. Its attack starts from the bamboos, which are in contact with ground and most of the time it goes up upto a height of 1—2 Meters in large stacks. The termite causes very heavy damage to woody substance and sometimes no woody substance is left in some of the bundles. The main cause of termite infestation is dampness of the ground, wich helps them set up its colony. As and when favourable climatic conditions are there they attack the woody substance.

Preventive treatment :

After the critical review of the various adverse affects of degradation during the storage of bamboo, adoption of feasible, efficient and economic methods of treatments are needed. As far as bamboo stored for papermaking is concerned,two major areas to which preservative treatment can be applied are the place of stacking and secondly the bamboo itself.

Ground treatment :

The proper ground preparation is essential before stacking. The raised concrete platforms should be made specially at mill yards in case stacking is to be done on ground, it should be levelled with proper draining provisions, and free from litters. the ground is usually treated for anti-termites with different concentrations. the effectiveness of the treatment is to be assessed based on experience and accordingly the treatment rotation (treatment schedule) can be made.

Bamboo treatment :

The treatment would depend upon duration of storage and end-use of bamboo. The attack of borer can be prevented by leaching cut starch, sugars and other water solubles from freshly cut culms by submerging them In water for a minimum of three days or more.

Bamboos can also be treated by submerging them in preservative tank or by diffuser methods or steaming and quenching method, etc. However, these practices are not very much feasible since the bamboo extraction in India is mainly done from natural forests wich is spreaded in very wide range of areas.

For the pulp and paper Industry use of Prophylactic treatments by using the chemicals are very much practically feasible. Careful selection of preservatives is needed to ensure its high toxicity to fungi and insects; resistance to easy leaching by water (rainfuall), stability of chemical to chemical and thermal transformation and also its penetrability into the wood. Careful handling of the chemicals is required as most of the preservatives are hazardous to health. The common chemicals used for prophylactic treatment are Borax-boric acid, sodium penta chloro Phenate, Benzene Hexa chloride, Arsenic-copper-chromate, acid chromate, copper chrome-boric composition,etc., A combinations of these chemicals are also used for this purpose. The mode of treatment of bamboo is also a very important factor. There are normally two ways of treating bamboo stacks: (i) fumification (ii) spraying the solution. Fumification of stacks is very effeetive mode of treatment; however. keeping in view the forest operations and storage, it is not quite feasible for Indian Pulp and Paper Industry. The water solution of chemicals can be sprayed at the time of stacking of bamboo. This mode of treatment can be efficiently used in our system, though it would not yield the same results as of 'fumification'. This mode of treatment can be used for treating stacks at forest sites as well as interim depots/rail heads. The economics of the mode of treatmcut and chemical consumption are also to be critically examined before choosing the prophylactic treatment. The chemicals used as preservatives should not be inflammable.

At Pulp and Paper Research Institute, experiments were conducted by storing the bamboos in small stacks for a period of one year to study the effect of storage on infestation and also the losses of woody substance. Certain prophylactic treatment methods were also tried by using ground sterilisation treatment and bamboo treatmeut by the chemical formulation developed at the Institute. These formulations were developed after the preliminary investigations on prophylactic treatment on bamboo. The effects of storage and prophylactic treatment on pulp and papermaking properties were also evaluated and are given in Table-3. The losses of wood/pulp yield at various stages of pulp and papermaking are also recorded in Table—4.

The study revealed that the serious damage is caused due to storage of bamboo for long period. Apart from loss of woody material, it adversely affects the pulp and papermaking characteristics. The prophylactic treatment helps in checking the biological infestation to appreciable extent.

Bamboo is major rawmaterial for papermaking for M/s. J.K. Paper Mills. The efforts are made to follow the efficient management practice in forest operations and storage of bamboo. In spite of all this, due to some reason or other, bamboos are to be stored for longer period than the optimum period recommended, at all the places of storage. It has been also observed that losses of woody substance were high depending on total duration of storage. After the above mentioned experiments carried out by the Institute at pilot scale, the storage area at mill yard and bamboo stacks were subjected to prophylactic treatment method suggested. It has been observed that by this treatment the termite infestation could be eliminated signficantly while borer infestation to some extent. Further studies are in progress to effectively check the borer infestation to desired level.

Remedial measures :

The following remedial measures are also to be taken to prevent the biological infestation and also for getting improved pulp and paper properties ;

A) At Felling site

1. No immature bamboo i. e. less than three years old, should be cut and tied with mature bamboos in bundles. Because, these bamboos are quite prone to infestation due to various reasons mentioned above. Apart from these, they cause damages of infestation to bamboo bundles and also to the stacks. Apart from this, the immature bamboo cutting adversely affects the future propagation of clump and also the pulp and papermaking properties as can be seen from Table—1.
2. During felling occasional culm or internodes having infestations of any nature should be avoided to check the further deterioration.

Table—3

EFFECT OF STORAGE AND PROPHYLACTIC TREATMENT IN PULP AND PAPERMAKING

		Initial	Control	Group treated	Ground and Bamboo treated
1. PROXIMATE CHEMICAL ANALYSIS					
1%NaOH solubility,	%	18.14	18.25	17.12	15.1
Alcohol-Benzene solubility,	%	6.2	3.7	2.74	3.92
Holocellulose,	%	70.1	69.5	68.1	69.9
Lignin,	%	27.6	28.8	28.98	29.5
Ash,	%	3.75	2.06	3.61	3.73
2. PULPING					
A.A. added on O.D. chips as Na_2O,	%	17.0	20.0	18.5	18 0
'H' factor		1048	1048	1048	1048
Total Pulp yield,	%	49.2	45.5	47 6	48.1
Kappa No.		25.1	28.8	27.3	26 6
3. BLEACHING WITH CEHH SEQUENCE					
Total Cl_2 consumed,	%	9.1	11.0	10.05	10.0
Brightness, Elrepho,	%	78.0	77.9	77.4	77.2
Shrinkage,	%	8.5	16.2	13.4	9.8
Viscocity (CED), Cp		5.5	4.8	4.8	4.9
4. PHYSICAL STRENGTH PROPERTIES AT 40°SR					
Burst factor		23.5	22.5	25.5	27.0
Tear factor		55.3	33.0	39.0	42.0
Breaking length,	KM	6.70	5.23	5.95	6.30
Double folds,	No.	20	9	13	21

Table—4

NET LOSS OE PULP DURING STORAGE

Particulars	Initial Wt. (OD)	After STORAGE % Loss	After STORAGE Wt. Kg.	After CHIPPING % Loss (—3mm)	After CHIPPING Wt. Kg.	After PULPING % Loss	After PULPING Wt. Kg.	After BLEACHING % Loss	After BLEACHING Wt. Kg.
Initial	100	Nil	100	0.7	99.3	51.5	48.2	8.5	44.1
Control (A)	100	13.9	86.1	5.2	81.6	54.9	36.8	16.2	30.8
Ground treated (B)	100	11.2	88.8	4.2	85.1	53.0	40.0	13.4	34.6
Ground & Bamboo treated (C)	100	5.8	94.2	2.2	92.1	52.5	43.7	9.8	39.4

NB : 1. Bamboos in sound conditions were stacked.

2. Bamboos were stacked for one year.

3. Good soil and water conservation practices around the clump will facilitate healthy growth of bamboo. Forest fire and one-sided felling of bamboo are to be avoided.

4. Stacking at felling site should be done after cleaning the litters and decayed vegetation. The place should not be under any overhead shade.

5. It is desirable to plan transportation operation in such a way that bamboo bundles get at least two months of desication (drying) in the forests which is faster in small stacks having usual 50 bundles.

6. Periodical inspections in the first months is absolutely essential. Infested bamboos should be separated and either treated before further stacking or used immediately.

7. The borer susceptible areas in the forest should be marked and the felling programme in these areas accordingly started early in the session, before vigorous period of emergence of borer population, which usually commences in March-May.

B) At other sites

1. Stacking of bamboo at the interim depots/rail heads and mill yard should be done on the areas properly levelled, free from litters and decayed materials. Grasses, weeds and bushes etc. must be removed and place should be cleaned as far as possible before stacking. Ground tratment with various effective chemicals is highly recommended.

2. The stacking area should have proper water draining system. Stacking on raised cements and truncated walls facilitates better water drainage and help in improving aeration.

3. Small size stacks, preferably with stack height of 3 Meters is advisable. The suggested stack dimensions are 13 m x 13 m x 3 m.

4. Prophylactic treatment of bamboo, to be stored for more than 3 months, is recommended. No preservative treatment will be effective, if the borer invasion has already set in. Hence, prophylactic treatment should be given to uninfested bamboos.

5. Good yard management practice is to be formulated and executed to use bamboo on first-come first to be used based.

CONCLUSION

The scarcity of fibrous rawmaterial has forced most of the paper mills to review the existing process systems for effective and efficient use of rawmaterial available to them. The bamboo, which still constitutes the major rawmaterial, particularly for big paper mills, requires efficient extraction from forest, proper storage and desired preservative treatment. The adoption of scientific forest management practices, a few have been discussed above, alongwith systematic storage and preservation would definitely be helpful in checking the woody substance losses at various stages of operations which would ultimately give better pulp and paper quality. By achieving these the cost of paper production would be signifiacntly reduced alongwith the smooth working of the mill.

References :

1. Jauhari, M. B., etal, Ippta, Vol. VIII, No. 3, p. 122 (1971).
2. Bakshi, B.K., etal, Ind. Pulp & Paper, Vol. 22 No.9 p. 503 (1968).
3. Maheshwari, Subhash, Ph. D. thesis, Sambalpur University, 'Studies on some aspects of pulp and papermaking characteristics of Orissa bamboo', (1982).
4. Bakshi, B.K., Ind. Pulp & Paper, Vol. 29, No. 2-3, p. 7 (1974).