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Use of Bamboo Shingles as Low Cost Roofing Material

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ဝါးကိုအိမ်မိုးဝါးကြွေပ်အဖြစ်စမ်းသပ်အသုံးချမှုကိုလေ့လာခြင်း

ဦးစိန်ဝင်း
ဘဏ္ဍာရေးနှင့် စီမံခန့်ခွဲရေးဌာနခွဲ
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်းချုပ်

မြန်မာနိုင်ငံလူဦးရေ၏ ၈၀%ခန့်ရှိသော လုပ်သားပြည်သူများသည် ကျေးလက်ဒေသများတွင် နေထိုင်ကြ၍ ၄င်းတို့အတွက်လိုအပ်သည့် တိုင်၊ မျော၊ ထင်း၊ ဝါးစသည့် ပစ္စည်းများအတွက်၊ သစ်တောများကို မှီခိုနေကြရပါသည်၊ ဝါးသည် လူအပေါင်းတို့အတွက် နေ့စဉ်အသုံးပြုနေရသောပစ္စည်းဖြစ်ပြီး၊ လူနေအိမ်များ၊ ပရိဘောဂများ၊ အခြားအိမ်သုံးပစ္စည်းများ၊ လယ်ယာလုပ်ငန်းသုံးပစ္စည်းများနှင့်တောင်း၊ နှီးစသည်တို့အတွက် မရှိမဖြစ်သောပစ္စည်းဖြစ်ပါသည်။ အစဉ်အလာအားဖြင့် သုံးခဲ့ကြသော အိမ်မိုးဝါး၊ သက်ကယ်နှင့် ဝါးကပ်များအပြင်၊ ဝါးကြွေပ်သည် ကျေးလက်ဒေသများ၌ တန်ဖိုးနည်းအိမ်ယာများ ဆောက်လုပ်ရာတွင် များစွာ အလားအလာကောင်းကြောင်း တွေ့ရှိရပါသည်။ ဤစာတမ်းတွင် ဝါးကြွေပ်ကို စနစ်တကျ ပြုပြင်အသုံးချနည်းများနှင့်တကွ ဝါးကြွေပ်ထုတ်လုပ်ရန်အချိန်နှင့် ကုန်ကျစရိတ်တို့ကို လေ့လာတင်ပြထားပြီး၊ တန်ဖိုးနည်းအိမ်ယာ အဆောက်အအုံများတွင် အသုံးပြုသင့်ပုံများကို ထောက်ခံတင်ပြထားပါသည်။

Use of Bamboo Shingles as Low Cost Roofing Material

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Abstracts

About 80% of the total population of Burma live in rural areas and they depend a great deal on forest products like posts, poles, firewood and bamboo. Among these, bamboo plays an enormously important role in day-to-day life, proving houses, furniture, utensils, farm implements, baskets and binding materials. Apart from traditional uses of bamboo thatch and mat roofing materials, bamboo shingles offer promise in the construction of low cost housing for rural community. This research presents the possibility of using bamboo shingles for low cost building by proper treatment of the bamboo and design. Time and cost studies were also made and suitable recommendations are put forward in this paper.

Contents

1. Introduction

Burma being an agricultural country, about 80% of its population live in rural areas. Their main source of building materials were extracted from the forests. With the increase of population, about 5.5 million house-holds are in need of durable roofing materials from time to time.

Traditional uses of bamboo thatch, bamboo mats, dried leaves of all kind are not durable and annual repairing cost become a noticeable expenditure for the working people. Therefore it becomes vitally important to find durable and low cost roofing materials from abundant and easily available forest produce like bamboo.

Regarding the use of bamboo as shingle, some villagers in remote areas has tried to use it in primitive ways. Some preliminary studies have also been carried out on its use (Khin Mg Kyaw, Kawlu Adee and Nyunt Naing).

2. Objective

This research aims at determining the durability of bamboo shingles after treating properly with locally available preservative like crude-oil. Time and cost analysis for the production of sample shingle are made in this research.

3. Materials

The following materials were used in this research-

3.1	Hack saw (with wooden frame) . .	2 Nos.
3.2	Chopper	1 No.
3.3	Auger	2 Nos.
3.4	Auger bit (Drill Bit)	3 Nos.
3.5	Planer	1 No.
3.6	Open drum	1 No.
3.7	G. I. Sheet	1 No.
3.8	Matured Kyathaung-wa	500 Nos.

4. Methods

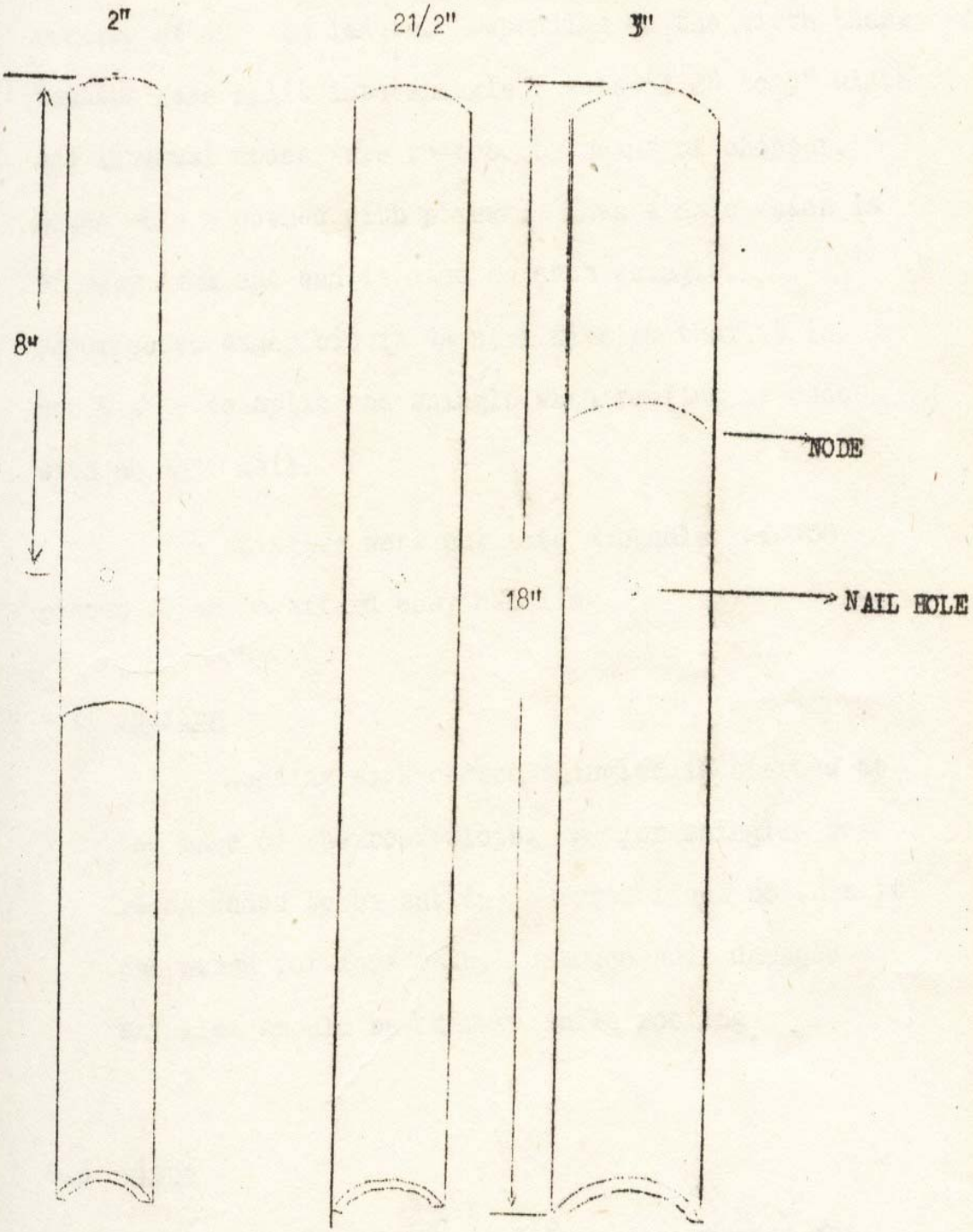
4.1 Preparation of Bamboo shingles

Matured Kyathaung-wa (*Bambusa polymorpha*) were cut during the open season (October through January). It is recommended to cut 18' in length so that there will be 12 sections of 18" each in length. Kyathaung-wa is available in various sizes ranging from 9" mid girth to 18". Matured bamboos (3 years old and over) were yellowish or redish in colour, frequently deep green with rounded spot on the bole. The bamboos were cut into section of 18" in length. Depending on the girth these bamboos were split into shingle pieces of 2" to 3" width and internal nodes were removed by means of chopper. Edges were smoothed with planer. Then a hold which is 8" away from one end is made on each shingle. Recommended auger bit is ¼ nail size so that it is not liable to split the shingle when roofing is made with an ¼" nail.

The shingles were put into a bundle of 100 pieces so as to afford easy handling.

PLATE - I

SCALE 4" INCH = 1' FEET



Recommended dimensions of Kyathaung-wa shingles for low-cost roofing. Holes should be bored in shingles 8 inches from top ends before nailing.

4.2 Roofing

Roofing with bamboo shingles is started at the base of the roof-slope. Bigger shingles were recommended to be put in inverted lines so that it can stand for more rain. Cracked and damaged shingles should be removed while roofing.

4.3 Slope

A slope of 26˚ to 35˚ is recommended for shingle-roofing. The higher the slope, the better for shingles in heavy rain-fall areas.

4.4 Treatment

Shingles in bundle were immersed in water for 7 to 10 days. Then these shingles were salved and leave for 72 hours to 144 hours air drying. Dried shingles were put in to an open drum and boiled with crude-oil at the rate of 4 gallons of crude-oil to 500 pieces of shingles. Care should be taken so that shingles were fully immersed in to boiling crude-oil. After boiling for 8 hours, the shingles were dripping on an corrugated iron sheet and dried. Then the shingles were ready for roofing.

5. Experiments

Three experiments were conducted in this research namely -

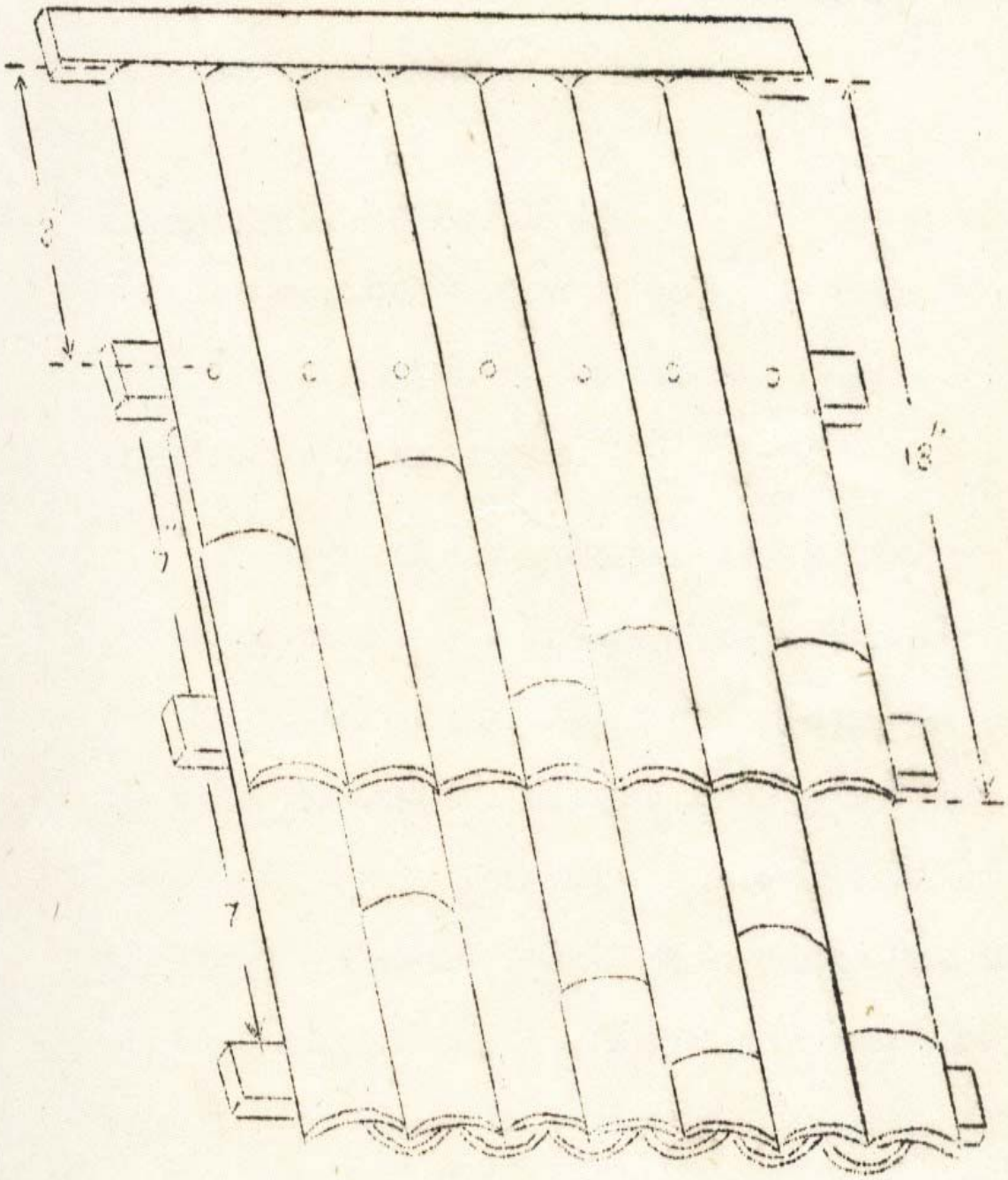
(a) Construction of an experimental hut (24' x 36') and
(b) Hydrolysis of bamboo shingles
(c) Shingle outturn study.

5.1 Construction of and Experimental Hut (24' X 36')

An experimental hut of 24' x 36' was built in FRI compound at Yezin early in 1978 and bamboo shingles of (2" – 3" x 18") were used as roofing materials.

Time, cost, and material used studies were made on this experiment. Annual treatment is given by applying crude-oil on the bamboo shingle roof in winter season. Durability assessment is also made in December every year.

SCALE- 2"INCH = 1' FEET



Beginning of roofing procedure. Nailing of shingles should begin from the lower end of the roof upwards. Inverted shingles are put in place first before nailing of top-shingles.

5.2 Hydrolysis of Bamboo shingles

As the starch content in bamboo is prime factor for the attack by the insects, it is essential to do hydrolysis.

An experiment for hydrolysis was carried out at Forest Research Institute Soil Laboratory. One hundred shingles each of three samples were randomly selected and immersed in 16 gallons of water in different container for 2 to 16 days. The starch and soluble substance were dissolved in water and sample from 3 different container were taken out at regular interval of 2 days each. The dissolved water samples were analyzed as follows results were tabulated in table 1.

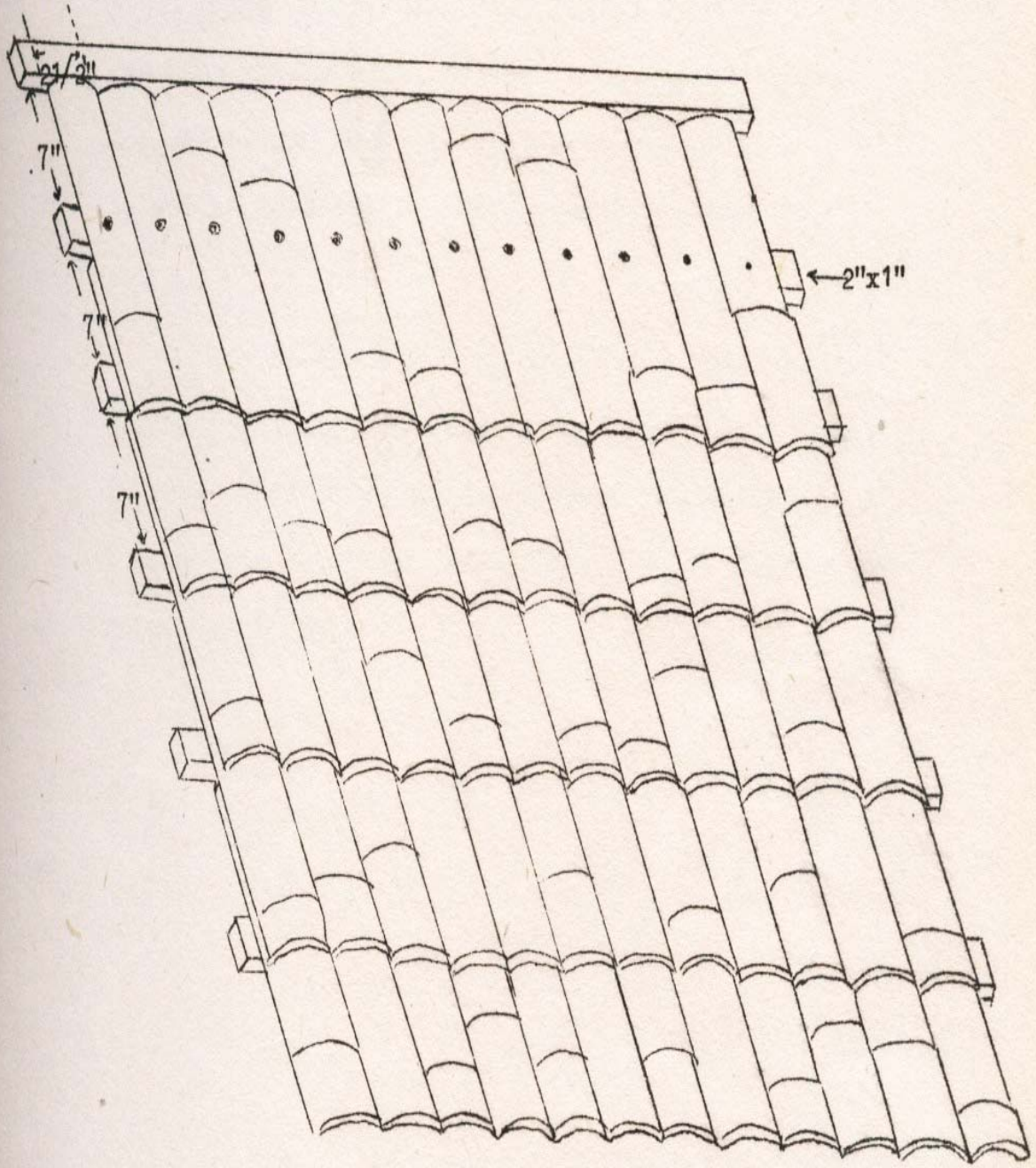
5.3 Laboratory Procedure

Five millilitres of the bamboo starch extract was put into a pyrex test tube, and this tube together with the tubes, containing the standards were given anise bath. The millilitrse of authorne reagent was then slowly added to each tube, allowing the reagent to run down the side of the test tube. The solutions were stirred slowly with a glass rod.

The tubes were then put into a boiling water bath for exactly 7.5 minutes and immediately cooled in ice. When cold, the absorbance was measured at 630 mm wave length by using Perkin Elmer spectrophotometer model 55 E.

PLATE III

SCALE 1 INCH = 1 FEET



Position of purlins on roof. 2" x 1" purlins should be placed 7 inches apart from each other.

Table 1. Hydrolysis of Bamboo Shingles

No. of days immersed in water	Starch and soluble substance contents in sample Mg / Lit			Average Mg /Lit	Fitted value
	A	B	C		
1	2	3	4	5	6
2	2.6	2.4	2.4	2.47	2.91
4	2.4	2.4	2.4	2.40	1.79
6	1.4	1.4	1.2	1.33	1.10
8	0.4	0.4	0.6	0.47	0.67
10	0.3	0.2	0.5	0.33	0.42
12	0.2	0.4	0.4	0.33	0.25
14	Nil	Nil	Nil	Nil	-

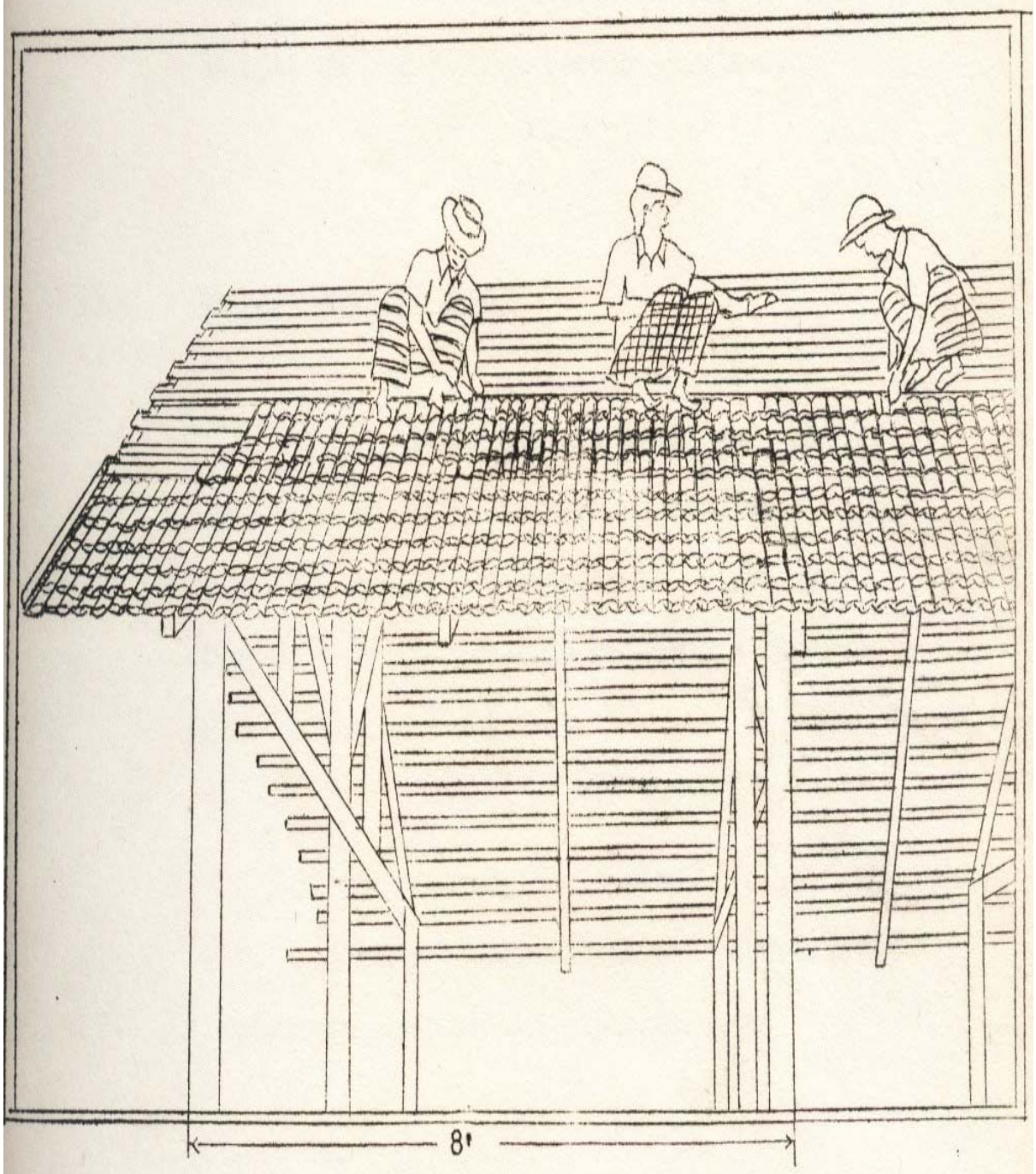
Fitted line $Y_t = 4.7372\ (0.783745)t$

Days	Starch Reduction %	Cumulative %
Up to 3 days	23.7	23.7
3-4	18.6	42.3
4-5	14.6	56.9
5-6	11.4	68.3
6-7	8.9	77.2
7-8	7.0	84.2
8-9	5.5	89.7
9-10	4.3	94.4
10-11	3.4	97.4
11-12	2.6	100

From, this experiment, it is quite evident that 10 days immersion in water is quite sufficient for the depletion of starch and soluble substance from bamboo shingles.

PLATE IV

SCALE - 1" INCH=2" FEET



Roofing of 24' x 36' x 19' experimental building at FRI, Yezin, using treated Kyathaung-wa shingles.

5.4 Shingle Outturn Study

Bamboo shingle outturn study was made by splitting 500 Kyathaung-wa and tabulated according to girth classes. The sizes vary from 9" to 18" and shingle outturn is recorded in ½ inch girth interval.

Outturn of shingled is tabulated in table 2 and a graph is drawn showing the correlation between net outturn and girth classes. (Graph 1).

Table 2. Bamboo Shingle Outturn

Girth (inch)	No. of Bamboo	Gross Shingle Outturns	Rejected Shingles due to		Net Shingle Outturns	Gross Shingle/ Bamboo Outturn	Rejected Shingles/ Bamboo due to		Net Shingle/ Bamboo Outturns
			Natural	Handling			Natural	Handling	
9.0	32	1152	41	32	1079	36.0	1.28	1.0	33.72
9.5	31	1200	49	26	1125	38.71	1.56	0.84	36.29
10.0	42	1908	45	36	1827	45.43	1.07	0.86	43.50
10.5	21	984	44	29	911	46.86	2.10	1.38	43.38
11.0	23	1104	40	33	1031	48.0	1.74	1.44	44.83
11.5	21	1010	28	27	955	48.10	1.33	1.29	45.48
12.0	51	2400	85	60	2255	47.0	1.67	1.18	44.22
12.5	17	842	38	18	786	49.53	2.24	1.06	46.24
13.0	19	996	31	29	936	52.42	1.63	1.53	49.26
13.5	24	1368	40	33	1295	57.0	1.67	1.38	53.96
14.0	34	2040	106	48	1886	60.0	3.12	1.41	55.47
14.5	9	540	12	11	517	60.0	1.33	1.22	57.44
15.0	17	1104	32	11	1061	64.94	1.88	0.65	62.41
15.5	21	1272	51	50	1171	60.57	2.43	2.38	55.76
16.0	18	1224	45	33	1146	68.0	2.5	1.83	63.67
6.5	28	1788	71	46	1671	63.86	2.54	1.64	59.68
17.0	32	2304	61	42	2201	72.0	1.91	1.31	68.78
17.5	16	1248	41	37	1170	78.0	2.56	2.31	73.13
18	44	3636	80	54	3502	82.64	1.82	1.23	79.59
Total	500	28120	940	655	26525				

Gross shingles outturn / bamboo = 56.24
Rejected shingle due to natural defects / Bamboo = 1.88
Rejected shingle due to handling / bamboo = 1.31
Net shingle outturn / bamboo = 53.05

$Y = 32.705537 – 1.35963\ G + 0.20640719\ G^2$

CORRELATION BETWEEN NET SHINGLE OUTTURN AND GIRTH

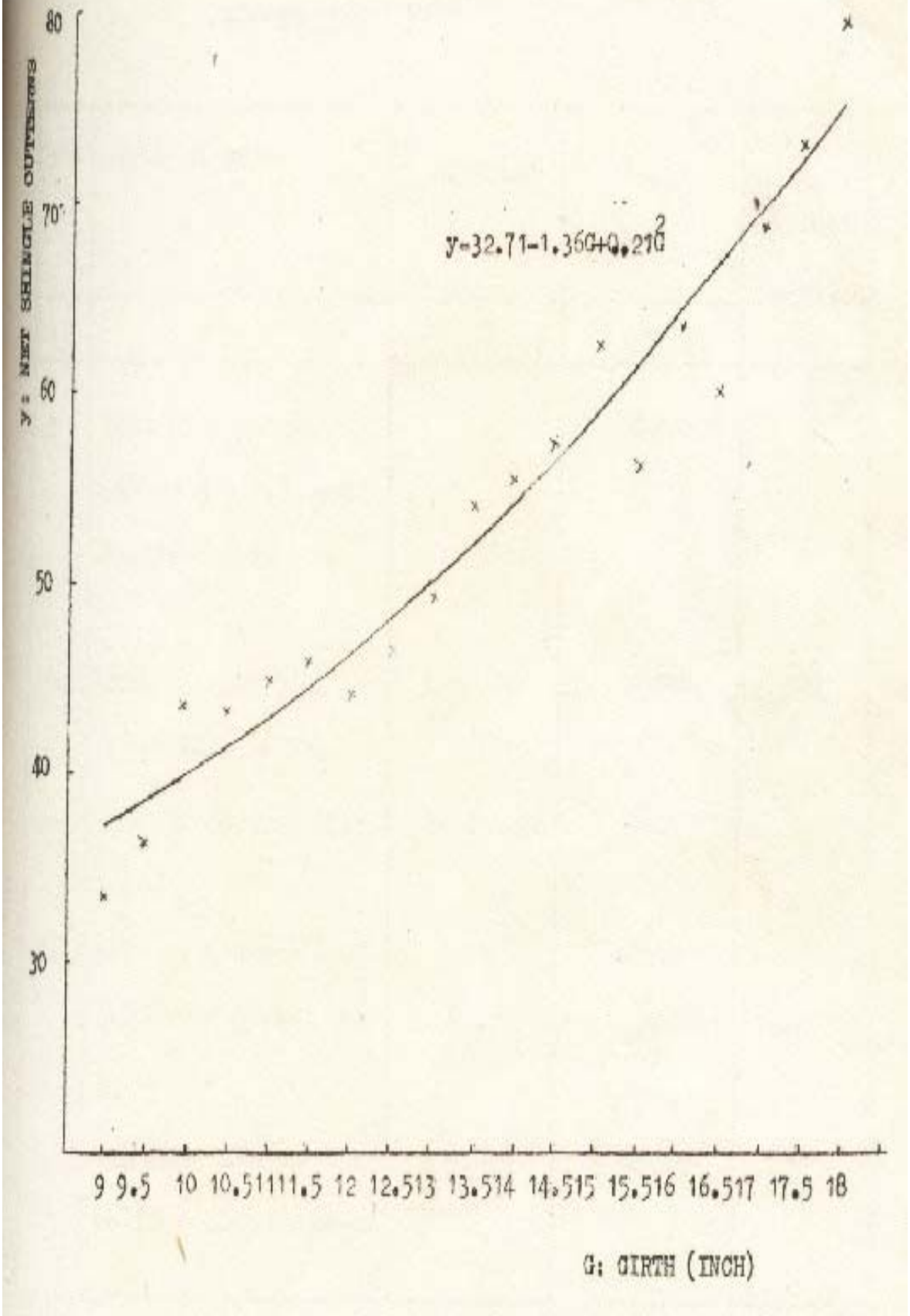


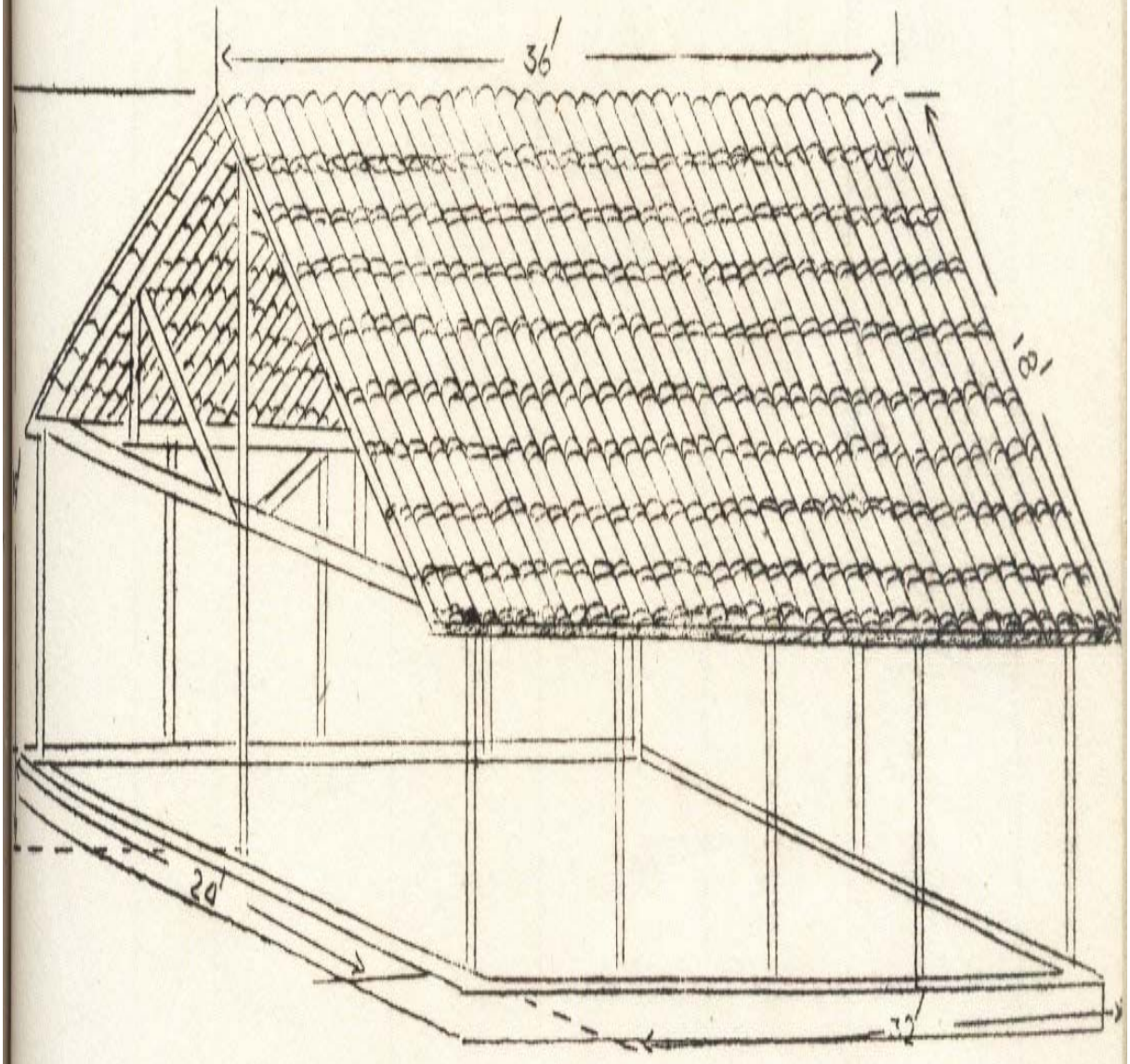
Table 3. Time and cost study for preparation of Bamboo Shingles

Item	Type of work	Duration	Cost K – P	Shingle Outturn (Average)
1	**2**	**3**	**4**	**5**
1.	Cost of Kyathnaung bamboo @ 1.50 each for 20 culms	-	30-00	
2.	Cutting. splitting smoothing, holding.	8 hours	20-00	700
3.	Cost of dipping into water	7-10 days	7-00	
4.	Cost of crude-oil @K 5.50 / - per gallon for 3 gallons.	-	16-50	
5.	Handling charges for boiling with crude-oil	8 hours	10-50	
			K 84-00	700

1. Production cost for one bamboo shingles is 12 Pyas.
2. One skilled labour can produce 350 shingles in 8 working hours.

PLATE V

SCALE - 1" INCH = 8' FEET



Completed experimental building with roofing of treated Kyathaung-wa shingles.

Table 4. Comparison of different type of roofing materials Estimated cost and durability (1250 sq. ft)

Serial No.	Type of root	Total No. of pieces	Estimated costs K – P	Roofing distance	Durability (years)
1	**2**	**3**	**4**	**5**	**6**
1.	Thatch	1,250	887.50	4"	2-3
2.	Bamboo mat	1,750	1350.00	2"	3-4
3.	IN Leaves	1,875	918.75	2"	2-3
4.	C. I. Sheet 6’ (32-G)	131	8222.50	5 ½ '	30-40
5.	Bamboo Shingles	18,750	3187.50	8"	20-30 (a)
6.	Dani	1,250	512.50	4"	2-3
7.	Salu	450	422.50	6"	2-3

(a) Estimate only

Table 5. Comparison of cost for different type of roofs (1250 sq. ft)

Serial No.	Type of roof	Timber used (Po) ton	Cost of Material & construction	Roofing K-P	Total Cost K-p
1	2	3	4	5	6
1	Thatch	2.14	4568*	887-50	5455-50
2	Bamboo mat	2.14	4568*	1350-00	5918-00
3	In leaves	2.14	4568*	918-75	5486-75
4	C.I. sheet	1.71	4052*	8222-50	12274-50
5	Bamboo Shingles	2.39	5068*	3187-50	8255-50
6	Dani	2.14	4568*	512-50	5080-50
7	Salu	2.14	4568*	422-50	4992-50

* Calculated at K 1,200 per ton (Pyinkado), and K 2,000 for carpenter charges.
** Carpenter charges is K 2,200

6. Results

From this research, the following results were analysed:-

7.1 1,500 bamboo shingles of size 2" - 3" x 18" were required for 100 sq. ft.
7.2 A viss of 1¼ " iron-nail is required for 100 sq. ft.
7.3 Production and treatment cost of a shingle is 12 Pyas.
7.4 A skilled-labour can produce 300-350 bamboo shingles in 8 working hours.
7.5 10-days immersion in water is enough for the depletion of starch and soluble substance from bamboo shingles.

7. Recommendations

7.1 Bamboo shingle roofs can be easily produced by the working people.

7.2 It is especially beneficial for the peasants since the cost of material can be reduced if the bamboo is extracted and processed personally.

7.3 It is nice looking and has cooling effect.

7.4 It is not highly inflammable as other roofing materials like thatch, bamboo mat and dried leaves. It is also much more durable than these materials.

7.5 Other bamboo species like Wabogyi, Waphyu, Myinwa, can also be used as bamboo shingles.

8. Application

Bamboo shingle roofing can be practiced in all areas where bamboos are available. Bamboo shingles after due treatment as prescribed in this research paper is recommended for low cost building construction in both urban and rural area of Burma in place of traditional low cost roofing materials like thatch, bamboo mats, dani, In leaves and Salu which are highly inflammable.

Appendix I

Comparison of structural timber used in different type of roofing
(Roof size 32" x 40")

Table 6. Bamboo Shingle Roofing

Item No.	Particulars	Timber used				Total cu. Ft
		Size	Length	Number	Running feet	
1	2	3	4	5	6	7
1.	Posts	5" x 5"	10'	10	100	17.36
2.	King post	5" x 5"	18'	5	90	15.62
3.	Post plate	5" x 2"	18'	10	180	12.50
4.	Common Rafter Collar, Strut	4" x 2"	18'	33	594	33.00
5.	Purlin	2" x 1"	18'	120	2160	30.00
6.	Varge Board	6" x 1"	18'	15	270	11.25
TOTAL						119.73 2.39 tons

Table 7. Corrugated Iron Roofing

Item No.	Particulars	Timber Used				Total cu. ft.
		Size	Length	Number	Running feet	
1	2	3	4	5	6	7
1	Posts	5" x 5"	10'	10	100	17.36
2	King post	5" x 5"	18'	5	90	15.62
3	Post plate	5" x2"	18'	10	180	12.50
4	Common Rafter Collar, Strut	4" x 2"	18'		220	15.22
5	Purlin	3" x 2"	18'	23	414	17.25
6	Varge Board	6" x 1"	18'	10	180	7.50
Total						85.45 1.71 tons

Table 8. Bamboo Mat Roofing

Item No.	Particulars	Timber used				Total cu. ft
		Size	Length	Number	Running feet	
1	2	3	4	5	6	7
1.	Post	5" x5"	10'	10	100	17.36
2.	King post	5" x 5"	18'	5	90	15.62
3.	Post plates	5" x 2"	18'	10	180	12.50
4.	Common Rafter Collar, Struct	4" x 2"	18'		220	15.22
5.	Purlin	3" x 2"	18'	23	414	17.25
6.	Rafter	2" x 1"	18'	86	1548	7.50
	Total					106.95 2.14 tons

Appendix II

Detailed cost analysis for 32' x 40' roofing area

Serial No.	Type of roofing	Particular	Cost K-p
1	2	3	4
1.	Thatch	(a) 1250 Nos. @ K 50 per hundred	625-00
		(b) Cost of bamboo @ K 6 per 100 sq. ft. for 1250 sq. ft	75-00
		(c) Labour charges for roofing @ k 15 per 100 sq. ft. for 1250 sq. ft.	187-00
		(d) Cost of Pyinkado timber for building structure (36' x 24') @ k 1200 per ton for 2.14 tons	2,568-00
		(e) Carpenter changes for the above	2,000-00
		Total	5,455-50
		per sq. ft.	4.3644
2.	Bamboo mat roofing	(a) Cost of 1750 mats @ K 50 per hundred	875-00
		(b) Cost of nail @ K 18 per 100 sq. ft for 1250 sq. ft.	225-00
		(c) Labour charges for roofing @ K 20 per 100 sq. ft. for 1250 sq. ft	250-00
		(d) Cost of Pyinkado timber for building structure (36' x 24') @ K 1200 per ton for 2.14 tons.	2,568-00
		(e) Carpenter charges for the above	2,000-00
		Total	5,918-00
		per sq. ft.	4.7344
3.	In leaf	(a) 1875 No. @ K 35 per 100(byit.)	656-25
		(b) Cost of bamboo @ K 6 per 100 sq. ft. for 1250 sq. ft.	75-00
		(c) Labour charges for roofing @ K 15 per 100 sq. ft. for 1250 sq. ft.	187-50
		(d) Cost of Pyinkado timber for building structure (36' x 24') @ K 1200 per ton for 2.41 tons	2,568-00
		(e) Carpenter charges for the above.	2,000-00
		Total . .	5,486-75
		per. sq. ft.	4.3894

4.	C. I. sheet roofing	(a) Cost of 6' C.I.sheet @K 60 per sheet for 131 Nos. (Govt.rate).	7,860-00
		(b) Cost of nails @K 4 per 100 sq.ft. for 1250 sq.ft	50-00
		(c)Labour charges for roofing @K 25 per 100 sq.ft. for 1250 sq.ft	312-50
		(d) Cost of Pyinkado timber for building structure (36' x 24') @K 1200 per ton for 1.71 ton.	2,052-00
		(e)Carpenter charges for the above.	2,000-00
		Total	12,274-50
		Per. sq. ft	9,8196
5.	Bamboo shingles roofing	(a) Cost of 18750 shingles @ K 12 per 100	2,250-00
		(b) Cost of nails @ K 25 per 100 sq. ft. for 1250 sq. ft.	312-50
		(c) Labour charges for roofing @ K 50 per 100 sq. ft. for 1250 sq. ft.	625-00
		(d) Cost of Pyinkado timber for building structure (36' x 24') @ K 1200 per ton for 2.39 tons	2,868-00
		(e) Carpenter charges for the above.	2,200-00
		Total	8,255-50
		per sq. ft	6.6044
6.	Dani roofing	(a) Cost of 1250 byit @ K 20 per 100.	250-00
		(b) Cost of bamboo @ K 6 per 100 sq. ft. for 1250 sq. ft.	75-00
		(c) Labour charges for roofing @ K 15 per 100 sq. ft. for 1250 sq. ft.	187-50
		(d) Cost of Pyinkado timber for building structure (36' x 24') @ K 1200 per ton for 2.16 tons.	2,568-00
		(e) Carpenter charges for the above.	2000-00
		Total	5,080-50
		Per sq. ft.	4.0644
7.	Salu roofing	(a) Cost of 450 byit @ k 36 per 100.	162-00
		(b) Cost of bamboo @ K 6 per 100 sq. ft. for 1250 sq.ft.	75-00
		(c) Labour charges for roofing @ K 15 per 100 sq.ft.	187-50
		(d) Cost of Pyinkado timber @ K 1200 per ton for 2.14 tons.	2,568-00
		(e) Carpenter charges for the above	2,000-00
		Total ..	4,992-50
		Per. sq. ft ..	3.994