No. 2 SEPTEMBER, 1938.

SIAM
SCIENCE BULLETIN

DEPARTMENT OF SCIENCE

MINISTRY OF ECONOMIC AFFAIRS

BANGKOK, SIAM.

NO. 2 SEPTEMBER, 1938.

SIAM
SCIENCE BULLETIN

DEPARTMENT OF SCIENCE
MINISTRY OF ECONOMIC AFFAIRS
BANGKOK, SIAM.

SIAM SCIENCE BULLETIN

Published by the Department of Science

Ministry of Economic Affairs

BANGKOK, SIAM.

NO 2 SEPTEMBER, 1938.

CONTENTS

Preliminary Studies of Certain Physical Properties of Some Siamese Soils[1]

BY

Magdaleno M. Cero

Department of Science, Bangkok.

Introduction

In this laboratory, as in many others, mechanical analysis continues to be used as the standard method of characterizing the soils physically. Because of the impracticability of extensive mapping of soil texture on the basis of laboratory measurements alone, the U. S. Bureau of Soils demonstrated the effectiveness of using the "feel" of the soil in the field, checked with very occasional mechanical analyses made in the laboratory.

One of the more recent studies of these methods of measuring soil texture in the United States was made by Davis and Bennett (1927). In Australia, where similar soil survey methods are employed, Prescott, Taylor, and Marshall (1934), correlating the experience of the American soil survey with their own, established for their mineral soils a quite similar relationship between the mechanical composition and estimates of texture in the field. But lately, Laken and Shaw (1936), found that the textural class shown in triangular diagram by Davis and Bennett no longer holds true as a basis for checking field texture through the use of mechanical analysis by the pipette or centrifugal methods.

1. This paper originally appeared in the Department of Science journal "Vidyasastra" Vol. I, No. 1, September 1936. In the light of subsequent experience, the discussion has been greatly condensed and revised for publication in this bulletin. Thanks are due to Dr. Robert L. Pendleton and Marcelino G. Canlas of the Department of Agriculture and Fisheries, H. S. M.'s Government, for considerable help in preparing this paper.

Even though the relationship between the results of mechanical analysis and soil texture estimation are now fairly well understood and known, it is becoming more clearly realized that the texture alone is quite inadequate to characterize the soil physically, and even less so its relation to plants. Bennett (1926) gave some striking illustrations of this. And in his outstanding book on tropical soils, Mohr (1933), long an advocate of mechanical analysis, suggested that this determination might better be called "granule analysis". Mohr also pointed out the limitations of the determination. From the agricultural point of view, our first concern is to know how soils respond to cultivation and to other agricultural operations when they contain varying amounts of water. The measurement of the range of the amounts of water present in an upland[2] soil when the best tilth can be produced is of great importance. Some idea of not only the quantity but also the nature of the soil colloids in different soil types is also of value. For the ability of the soil to hold and give up plant food, as well as the amount of swelling when moistened and the amount of shrinkage when dried, depends upon the kind as well as the amount of these colloids. It is true that the amount of "clay" as measured by the mechanical analysis is, in a way, a measure of the colloidal content of the soil, but the amount of this "clay" is by no means always an index of its effects in the soil. The use of the rapid Bouyoucos (1927) hydrometer method for estimating the sand, silt, and clay has been considered by competent workers as satisfactory for measuring the quantity of the colloidal fraction of the soil and hence for a "mechanical analysis" of the soil.

2. By "upland" is meant a soil other than a padi soil,—padi soil are usually cultivated when saturated with water.

Because of an appreciation of the limitations of mechanical analysis, and because Keen, Bodman, Haines, among others consider certain of the "single-value soil constants" so favorably as promising indices of the physical character of the soil, the measurement of certain of these "constants" was undertaken in this laboratory.

It is hoped that by obtaining the "single-values" of a large number of soils of this country, more or less characteristic numerical values or ranges of values will be found for the various types and broader groups of the soils of Siam. If valid, single numerical values are always more useful than a group of numbers, such as must result from a mechanical analysis.

It is expected that this paper is but the first in a study of more significant ways of characterizing Siamese soils physically.

Methods and Procedures

The methods used in the meaurement of some of the physical properties of Siamese soils are those of Bodman and Perry (1931) for the sticky point and rolling-out limit, and Keen-Raczkowski (1921) for determination of the apparent and real specific gravity, absorption of water, pore space, and volume expansion.

In the determinations of both the sticky point and the rolling-out limit, when commencing to moisten the dry soils, it was found necessary to add more water than what seemed to be the correct amount. This is because it has been found in this laboratory that when the soil taken was air-dried and then worked out at once to either the sticky point or the rolling-out limit, the values obtained were lower than if the moistened and puddled mass was allowed to stand for 30 minutes and then worked up again with further additions of water. This is probably because of the time needed for the water to uniformly penetrate the entire soil mass. This effect is particularly marked in the case of heavy soils where the clay content is relatively high. Soils with a high content of colloids absorb more water but absorb it more slowly. Consequently precautions were taken to eliminate this effect by allowing the moistened samples to stand for at least 30 minutes before working the soil to determine either the rolling-out limit or the sticky point. And in the Keen-Raczkowski 'Box Experiment', soils passed through 1 mm. sieve were used instead of the 100 mesh.

As listed in table 1, the samples used in this preliminary study were collected in widely scattered parts of Siam. In table 2, are given the sticky point, rolling-out limit, and the non-sticky plastic range of the samples. The 'Box-Experiment' values, as given in table 3, are of the surface horizon only.

Discussion of Results

Since in a number of cases the samples at hand for this study were not accompanied by adequate data, or at least data referring to some sample is not available at this time, and since it may be presumed that at least in a number of cases, the samples are hardly generally representative of the localities from which they were taken, it seems desirable here to limit the discussions to general observations upon the physical data which have been obtained on these soils in the laboratory. The considerable number of incomplete profiles represented is an added reason for brevity in discussion.

Table 1, gives the color of the soil as observed dry in the laboratory and the texture of the soil as determined by the "thumb and finger" or "field test of texture". It will be noted that there are a relatively large number of soils with either very light or very heavy textures. From field experience thus far and according to personal information from Dr. Robert L. Pendleton of the Department of Agriculture and Fisheries, this seems to be characteristic of the soils of Siam, and is the results of the prevailing soil forming processes acting upon the principal soil forming materials which occur in this country. Credner (1935)

Table I.[1]

A BRIEF DESCRIPTION OF THE SOILS USED

Sample No.	*Horizon*	*Location and Description.*
		SONGKLA
1703	S	Light yellowish brown loamy sand.
1704	T	Light brownish grey loamy sand.
1705	S	„ „ „ loam.
		KORAT
1710	T	Light reddish grey brown coarse loamy sand.
1711	S	Medium chocolate brown fine sandy loam.
1714	T	Dark greyish brown very fine sandy loam.
1715	T	Light chocolate rown very fine sandy loam.
		PAK CHONG
1760	S	Dark greyish brown silty loam.
		NON WAT
1783	T	Light brownish grey sandy loam.
		KOH MAK
1813	T	Medium brown loam.
1815	T	Reddish brown clay loam.
1819	T	Light greyish brown silty clay loam.
		HUA HIN
1838	T	Light greyish brown very fine sandy loam.

1. Surface (T) samples are of 15 cm. deep, while subsoils (S) are the next 15 cm. The subsoil of (T) is the number immediately below. In some cases, only the surface sample is present while in other cases only the subsoil.

Table I. (Cont'd.)

Sample No.	*Horizon*	*Location and Description.*
		PLOEN CHITR
		Expt. Sta. Bangkok
2150	T	Dark brownish grey clay.
2151	S	,, ,, ,, ,,
3152	T	,, ,, ,, ,,
2153	S	,, ,, ,, ,,
2154	T	,, ,, ,, ,,
2155	S	Medium ,, ,, ,,
2156	T	Dark ,, ,, ,,
2157	S	,, ,, ,, ,,
2158	T	,, ,, ,, ,,
2159	S	,, ,, ,, ,,
2160	T	,, ,, ,, ,,
2161	S	,, ,, ,, ,,
2170	T	,, ,, ,, ,,
2172	T	,, ,, ,, ,,
2173	S	,, ,, ,, ,,
2174	T	,, ,, ,, ,,
2175	S	,, ,, ,, ,,
2176	T	,, ,, ,, ,,
2177	S	,, ,, ,, ,,
2178	T	,, ,, ,, ,,
2179	T	,, ,, ,, ,,
		KUAN NIENG .
2279	T	Yellowish brown very light silty loam.
2280	S	,, ,, clay loam.
2281	T	Light greyish brown loamy sand.
2282	S	Greyish white sandy loam.
2283	T	Light greyish brown loamy sand.

Table I. (Cont'd.)

Sample No.	*Horizon*	*Location and Description*
2284	S	Light greyish brown loamy sand.
2285	T	,, ,, ,, ,, loam.
2286	S	,, yellowish grey brown loamy sand.
		SRIRACHA
2554	T	Whitish grey sand.
2556	T	,, ,, ,,
2558	T	,, ,, ,,
		CHIENGMAI
3022	T	Greyish brown silty loam.
3024	T	Light greyish brown silty loam.
3025	S	Yellowish greyish brown clay loam.
3026	T	Light greyish brown silty loam.
3027	S	,, ,, ,, ,, clay.
		PRE
3040	T	Yellowish brown silty loam.
3041	S	Medium brown loam.
3042	T	,, ,, ,, light silty clay loam.
3043	S	Medium brown light silty clay loam.
3044	T	Light greyish brown light silty clay loam.
3045	S	Medium greyish brown light clay loam.
3070	T	Light reddish brown loam.
3071	S	Medium greyish brown heavy loam.
3072	T	Medium greyish brown silty clay loam.
3073	S	Medium greyish brown silty loam.
3074	T	Light yellowish brown silty clay loam.
		NARADHIWAS
3085	T	Grey light clay.
3086	S	Light greyish white clay.

Table I. (Cont'd.)

Sample No.	*Horizon*	*Location and Description*
		TRANG
3087	T	Yellowish brown clay loam.
		UBOL
3171	T	Dark grey clay loam.
		CHANDHABURI
3274	T	Dark reddish brown clay loam.
3248	T	Light reddish brown heavy clay loam.
3249	T	,, ,, ,, ,, ,, ,,
3250	T	Dark reddish brown heavy clay loam.
3251	T	Yellowish brown light clay loam.
3252	T	Medium yellowish brown medium clay loam.
3253	T	Light reddish brown medium clay loam.
3254	T	Medium reddish brown medium clay loam.
3255	T	Brick red medium clay loam.
3256	T	Medium reddish brown light clay loam.
3257	T	Brick red heavy clay loam.
3258	T	,, ,, ,, ,, ,,
		HAADYAI
3280	T	Light greyish brown very fine sandy loam.
3281	S	Light greyish brown loam.
3284	T	Grey fine sandy loam.
3285	S	Light grey fine sandy loam
3287	T	Grey very fine sandy loam.
3288	S	Light grey fine sandy loam.
3290	T	Light brownish grey fine sand.
3291	S	Light yellowish brown light sandy clay loam.

Table I. (Cont'd.)

Sample No.	*Horizon*	*Location and Description*
		HAADYAI
3293	T	Grey fine sandy loam.
3294	S	Light grey light fine sandy loam.
3296	T	Light greyish brown fine sand.
3299	T	Light grey sandy loam.
3300	S	Light grey fine sandy loam.
3301	T	Yellowish grey very fine sandy loam.
3302	S	Yellowish brown light clay loam.
3304	T	Grey very fine sandy loam.
3305	S	,, ,, ,, ,, ,,
3307	T	Greyish brown fine sandy loam.
3308	S	Yellowish brown fine sandy loam.
3310	T	Brownish grey sandy loam.
3311	S	Yellowish grey brown light clay loam.
3313	T	Brownish grey sandy clay loam-
3314	S	Yellowish brown sandy clay loam.
3316	T	Browish grey clay loam.
3317	S	Yellowish brown clay loam.
3318	T	Greyish brown clay loam.
3319	S	Greyish brown very fine sandy loam.
3323	T	Dark greyish brown fine sandy loam.
		SU-NGIE GOLOK
3327	T	Light greyish brown loam.
3328	S	Yellowish brown clay loam.
3329	T	Medium greyish brown sandy clay loam.
3330	S	Yellowish brown sandy clay. loam.
3331	T	Dark brown clay.
3332	S	Light brownish grey light clay.

Table I. (Cont'd.)

Sample No.	*Horizon*	*Location and Description*
		SADAO
3343	T	Light yellowish brown light clay loam.
3345	T	Light purplish grey fine sandy loam.
3348	T	Dark grey medium sand.
		SRIRACHA
3394	T	Greyish brown sandy loam.
3396	T	Grey coarse loamy sand.
3397	S	Light yellowish brown light loamy sand.
3398	T	Grey loamy sand.
3400	T	Light greyish brown clay loam.
3401	S	Light chocolate brown light clay loam.
3402	T	Coffee brown very fine sandy loam.
3403	S	Brick red loam.
		JOLBURI
3404	T	Grey coarse sand.
3405	T	Grey sand
3406	T	Grey sand.
3407	T	Grey medium coarse sand.
		SRIRACHA
3408	T	Light grey loam.
3409	T	Light brownish grey sand.
3410	T	Light brownish grey sandy loam.
		CHANDHABURI
3411	T	Reddish grey brown clay loam.
3412	T	Greyish brown sandy clay loam.
3413	T	Grey fine sand.

also notes the same conditions. The parent rocks from which many of the soils, including most of those from Sriracha and Jolburi, are coarse grained "granites", while most of the Haad Yai soils and those from the northeast have been derived largely from fine grained sandstones. These groups of rocks give predominantly sandy loams, loamy sands, fine sandy loams, etc., since the other minerals than quartz have been broken down, some of the products having been carried away in solution or as colloidal sols; even most of the clay has been moved down to the deeper horizons. The parent rock of the red clay soils of Chandhaburi is very deeply weathered, largely a dark magmatic rock, with practically no quartz. Consequently the autochthonous soils on these rocks are clay loams and clays, with little or no sand, but with a high proportion of iron oxides since the rocks are relatively rich in this element. The soils of the main central plain, having been developed from the silts and clays carried down by the Menam Chao Phya and other rivers, are naturally clays or heavy clay loams.

1. ***Sticky point and rolling-out limit.*** As Robinson (1936) says, the sticky point is that point at which the maximum imbibitional capacity of the soil colloidal material is just satisfied, so that the soil particles adhere most closely together. And at or below this amount of moisture, the soil mass does not stick so strongly to any external object, hence for plowing "upland" soils, it is most probable that this moisture content is best, since the soil should not stick to the implements. The range in moisture content between the sticky point and the rolling-out limit is called by Bodman and Perry (1931), the "non-sticky plastic range". The moisture content at rolling-out limit, apparently less than at the sticky point, is such that the binding forces between the soil particles just begin to markedly decrease, so that the soil mass no longer acts as a whole but breaks up into a large number of small crumbs or separate soil grains. In other words, the rolling-out limit is the lower critical limit of soil moisture at which it easily yields to external forces. The rolling-out limit is thus a practical index of the minimum amount of moisture present for effective and economical cultivation.

All cultivated mineral soils may be divided into two groups, first, those like the soils of the temperate zones which are cultivated moist, but not when saturated or submerged under water, and second, the rice soils of the tropics which are usually cultivated, or puddled, preparatory to planting, only after the soil has been flooded and submerged. Frequently these two groups of soils are termed "upland" and "lowland" soils, or the latter group may be called a little more exactly "lowland rice soils" or "padi soil". The single value physical soil constants which have been devised and applied in the temperate zone for the characterization of those soils, while certainly suitable for "upland" tropical soils, cannot be expected to give as important and significant information regarding the characteristics of soils handled as differently and existing under as different conditions as the "lowland rice soils" of the tropics. Probably different types of constants, measured in other ways, will have to be devised to give an adequate physical characterization of the lowland rice or padi soils. With the exception of the samples from Ploen Chitr, the soil samples used in this study are mainly "upland" soils.

In table 2, the data[3] for sticky point and rolling-out limit have been arranged according to georgraphical regions; the "non-sticky plastic range" is the difference between the rolling-out limit and the sticky point. In comparing the results for the surface and deeper soils, the sticky point and rolling-out limit values for the two horizons do not show any consistent differences. In only a few cases the value for the deeper

3. All values for sticky point and rolling-out limit as well as the non-sticky plastic range are given in percentages.

Table II.

Sticky point, rolling-out limit, and non-plastic range values of the Soils (On the 105°C. Oven-dry Basis)

	SURFACE SOIL				SUBSOIL			
Region & Locality	Sample No.	Sticky Point	Rolling-out limit	Non-sticky Plastic Range	Sample No.	Sticky Point	Rolling-out limit	Non-sticky Plastic Range
		Per cent	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*
NORTH 1. Chieng-mai	3022	26.97	22.20	4.77	—	—	—	—
	3024	22.81	19.66	3.15	3025	23.33	17.82	5.51
	3026	37.98	25.62	12.36	3027	38.53	28.16	10.37
2. Pre	3040	19.01	14.82	4.19	3041	17.46	14.84	2.62
	3042	40.40	30.60	9.80	3043	37.94	28 04	9.90
	3044	36.57	26.49	10.08	3045	32.23	27.10	5.13
	3070	21.36	16.52	4.84	3071	24.32	21.65	2.67
	3072	40.05	28.52	11.53	3073	33.50	27.70	5.80
	3074	38.70	27.48	11.22	—	—	—	—
CENTRAL Ploen Chitr (Bangkok)	2150	36.84	23.46	13.38	2151	39.36	26.85	11.51
	2152	38.55	25.54	13.01	2153	40.06	25 70	14.36
	2154	38.70	25.31	13.39	2155	39.24	25.02	14.22
	2156	37.60	23.98	13.62	2157	39.65	26.21	13.44
	2158	37.44	24.55	12.89	2159	38.51	24.39	14.12
	2160	37.28	24.65	12.63	2161	36.93	25.07	11.86
	1270	36.66	26.54	10.12	—	—	—	—
	2172	37.58	24.59	12.99	2173	38.80	24.69	14.11
	2174	39.10	25.28	13.82	2175	39.13	26.69	12.44
	2176	37.86	24.38	13.48	2177	38.25	26.76	11.49
	2178	38.34	23.68	14.66	2179	37.21	25.55	11.66
NORTH-EAST 1. Korat	1710	17.23	12.54	4.69	1711	17.45	11.82	5.63
	1714	17.50	13.05	4.45	1715	18.11	12.39	5.27

Table II. (Cont'd.)

Region & Locality	SURFACE SOIL: Sample No.	Sticky Point	Rolling-out limit	Non-sticky Plastic Range	SUBSOIL: Sample No	Sticky Point	Rolling-out Limit	Non-sticky Plastic Range
		Per cent	Per cent	Per cent		Per cent	Per cent	Per cent
2. Pak Chong	1760	32.70	19.20	13.50	—	—	—	—
3. Non Wat	1783	16.22	11.43	4.79	—	—	—	—
4. Ubol	3171	51.15	39.07	12.08	—	—	—	—
SOUTH								
1. Hua Hin	1838	14.84	11.15	3.69	—	—	—	—
2. Trang	3087	30.76	23.68	6.90	—	—	—	—
3. Kuan Nieng	2279	24.82	14.20	10.62	2280	20.85	13 87	6.98
	2281	15.44	9.78	5.66	2282	14.73	10.93	3.80
	2283	15.77	14.77	1.00	2284	14.89	12.60	2.29
4. Haad Yai	2285	20.06	14.75	5.31	2286	14.58	9.91	4.67
	3280	17.95	13.92	4.03	3281	15.45	13.97	1.48
	3284	10.87	10.03	.84	3285	12.44	9.10	3.34
	3287	15.62	11.35	4.27	3288	13.44	8.58	4.86
	3290	15.09	10.62	4.47	3291	17.27	10.45	6.82
	3293	13.19	10.89	2.30	3294	12.47	8.86	3.61
	3296	16.37	11.09	5.28	—	—	—	—
	3299	16.48	11.20	5.28	3300	13.37	10.61	2.76
	3301	15.91	13.46	2.45	3302	19.44	13.52	5.92
	3304	14.66	11.35	3.31	3305	13.71	10.50	3.21
	3307	15.60	9.84	5.76	3308	16.20	10.65	5.55
	3310	15.71	9.36	6.35	3311	16.76	11.74	5.02
	3313	17.76	13.83	3.93	3314	16.77	10.94	5.83
	3316	23.75	15.79	7.96	3317	25.71	18.05	7.66
	3318	27.96	20.80	7.16	3319	16.33	11.88	4.45
	—	—	—	—	—	—	—	—
	3323	14.63	8.07	6.56	—	—	—	—
5. Sadao	3343	21.24	14.37	6.87	—	—	—	—
	3345	13.11	8.64	4.47	—	—	—	—
	3348	11.46	8.86	2.60	—	—	—	—
6. Songkla	—	—	—	—	1703	15 13	10.08	5 05
7. Nara-dhiwas	1704	22.20	17.76	4.44	1705	22.37	14.63	7.74
	3085	50.80	34.25	16.55	3086	58.22	36.92	21.30
8. Su-ngie Golok	3327	28.92	22.52	6.40	3328	34.51	24.32	10.19
	3329	18.36	17.11	1.25	3330	18.15	14.37	3.78
	—	—	—	—	3331	55 84	42 05	13.79

Table II. (Cont'd.)

	SURFACE SOIL				SUBSOIL			
Region & Locallity	Sample No.	Sticky Point	Rolling-out Limit	Non-sticky Plastic	Sample No.	Sticky Point	Rolling-out Limit	Non-sticky Plastic Range
SOUTH-EAST		*Per cent*	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*
1. Chandhaburi	3248	46.46	40.17	6.29	—	—	—	—
	3249	49.46	39.96	9 50	—	—	—	—
	3250	49.95	37.37	12 58	—	—	—	—
	3251	28.87	20.40	8.47	—	—	—	—
	3252	35.33	23.12	12.21	—	—	—	—
	3253	35.04	22.60	12.44	—	—	—	—
	3254	37.15	28.79	8.36	—	—	—	—
	3255	39.98	32.84	7.14	—	—	—	—
	3256	29.87	23.04	6.83	—	—	—	—
	3257	40.82	33.06	7.76	—	—	—	—
	3258	43.45	26.55	16 90	—	—	—	—
	3412	34.28	26.58	7.70	—	—	—	—
	3413	14.95	7.44	7.51	—	—	—	—
2. Sriracha	3394	13.89	9.73	4.16	—	—	—	—
	3396	9.28	6.64	2.64	3397	8.75	4.55	4.20
	3400	27.83	19.50	8.33	2401	19.37	13.57	5.80
	—	—	—	—	3403	17.98	9.39	8.59
	3408	19.70	13.16	6.54	—	—	—	—
	3409	9.40	5.10	4.30	—	—	—	—
	3410	15.61	11.08	4.53	—	—	—	—
3. Jolburi	3404	10.90	7.38	3.52	3405	9.03	4.79	4.24
	3406	10.23	6.46	3.77	3407	9.52	4.97	4.55
4. Koh Mak	1813	39.61	33.65	5.96	—	—	—	—
	1815	40.60	32.15	8.45	—	—	—	—
	1819	47.50	36.09	11.41	—	—	—	—

samples are higher, a condition which has evidently resulted from the eluviation of the clay, especially in the light textured samples. For example, sample No. 3070 from Pre gives a sticky point of 21 and a rolling-out limit of 16 for the surface soil while the deeper soil gives a sticky point of 24 and a rolling-out limit of 21. In most cases, the surface horizon values are higher; possibly the organic matter in the surface soil was of significance in raising the values. Organic matter gives what may be termed false sticky point and rollling-out limit values which are high. Attention is called to sample No. 3332, a light brownish grey light clay, actually a peaty sod, yet giving values higher than that of any of the other samples.

Comparing the sticky point determinations of the various samples, surface and deeper, certain ranges of values appear, and may usefully be set down: Sand is represented by six samples with values between 9 and 11. Only two samples of fine sand were encountered, these give almost the same values of 15 and 16. The loamy sand values are more or less widely distributed with 22 as the highest and 8 the lowest, although the grouping is mostly around 15. Sandy loam is represented by six samples with the values falling around 15 with 13 and 16 as the extremes. Nineteen fine sandy loam samples have 18 as the upper extreme and 10 as the lower, though most of the values lie between 13 and 16. Three of the five samples of silt loam came from Chiengmai, one from Kuan Nieng, and the other from Pak Chong. These silt loams from widely separated localities vary rather widely; of these the lowest is 19 and the highest is 37, both from Chiengmai. Loam is represented by 9 samples whose values fall mostly around 20, with but two samples varying widely from the rest, 10 and 39. Sandy clay loam is represented by 5 samples, the first four falling very close to 17 while one sample, 3412, from Chandhaburi, give a rather high value of 34. There are six samples of silty clay loams with values ranging from

36 to 40, with 47 and 24 as the extremes. As would be expected of clay loams, which represent a considerably wider range of physical composition, the sticky point values spread over a much wider range, namely between 16 and 51, though the great majority of the values lie between 25 and 40. The clay loams were represented by 25 samples, the largest number of samples judged to belong to one soil type. The sticky points for the clays, represented by 24 samples lie between 36 and 40; 21 of these samples were from Ploen Chitr, just outside of Bangkok City on the southeast. But the highest sticky point values for clays are 56 and 55 both from Su-ngie Golok, in South Siam.

The sticky point determinations show wide ranges in almost all the soil types, but more especially the clay loam and clay types. The reason for the clay loams and clays showing a wider range of values is because of the probable variations in the composition of the clay fractions.

As are to be expected, the rolling-out limit values are lower than the sticky point while more or less following the trend of the sticky point values, that is, if the sticky point is relatively high, the rolling-out limit value is also high. This is generally true both for the surface and deeper samples. For example in sample No. 3042 from Pre, the sticky point is 40 and the rolling-out limit value is 30. While in sample No. 3409 from Sriracha, the sticky point is 9 and the rolling-out limit is 5. In practically the same way, the "non-sticky plastic range" values differ for different groups of soils.

2. *Results of the Keen-Raczkowski 'Box-Experiment'*. According to the formulae given by Keen-Raczkowski (1921) the following values have been calculated; (1) apparent and real specific gravity, (2) amount of water taken per volume of soil, (3) pore space, and (4) the volume expansion. The results are shown in table 3.

The differences in apparent specific gravities between

Table III.

Results of the Keen-Raczkowski "Box Experiment"

(On the 105°C. Oven-dry Basis)

Place or Locality	Lab. No.	Moisture	Apparent Sp. Gr.	Amount of water taken	Pore Space	Real specific Gravity	Volume Expansion
NORTH		*Per cent*	*Grams per c.c.*	*Per cent*	*Per cent*		*Per cent*
1. Chieng-mai	3022	0.93	1.111	44.30	50.60	2.215	0.60
	3024	1.57	1.337	37.20	47.20	2.271	3.20
	3026	4.37	1.115	51.90	53.90	2.291	1.20
2. Pre	3040	1.99	1.349	40.60	44.30	2.386	1.00
	3042	2.84	1.042	76.30	56.70	2.425	4.90
	3044	2.91	1.132	52.80	56.60	2.452	3.50
	3072	2.94	1.138	49.60	55.10	2.422	3.70
	3074	2.93	1.098	58.10	58.50	2.353	5.40
CENTRAL							
1. Ploen Chitr (Bangkok)	2150	8.23	1.260	50.60	56.70	2.312	18.00
	2152	8.02	1.289	49.40	55.70	2.293	20.30
	2154	7.88	1.291	50.60	57.10	2.385	37.90
	2156	9.68	1.263	51.20	59.30	2.482	24.90
	2158	7.90	1.252	27.20	56.70	2.423	16.60
	2160	7.80	1.263	45.40	55.80	3.388	15.70
	2170	7.99	1.233	52.40	58.00	2.334	16.00
	2172	7.46	1.271	50.20	56.80	2.441	16.80
	2174	7.81	1.272	48.70	55.40	2.287	23.20
	2176	8.01	1.277	50.40	56.10	2.325	20.70
	2178	9.13	1.194	54.50	58.30	2.352	48.40

Table III. (Cont'd.)

Place or Locality	Lab. No.	Mois-ture	Ap-parent Sp. Gr.	Amount of water taken	Pore Space	Real specific Gravity	Volume Expan-sion
NORTH-EAST		*Per cent*	*Grams per c.c.*	*Per cent*	*Per cent*		*Per cent*
1. Korat	1710	11.00	1.471	29.10	42.40	2.243	4.10
	1714	1.45	1.468	27 70	43.70	2.425	2.50
2. Pak Chong	1760	7.49	1 332	52.80	53.90	2.275	18.80
3. Non wat	1783	2.09	1.494	26.30	40.80	2.358	5.10
4. Ubol	3171	9.56	0.910	70.20	62.30	1.286	7.40
SOUTHEAST							
1. Chandhaburi	3247	9.18	1.027	64.40	65.30	2.697	5.10
	3248	9.31	1.134	53.30	60.70	2.678	5.00
	3249	10.69	1.166	56.20	64.10	2.620	9.70
	3250	14.20	1.150	52.40	61.20	2.232	6.60
	3251	3.66	1.288	39.60	49.90	2.342	5.90
	3252	3.66	1.313	40.30	52.70	2.556	5.20
	3253	4.20	1.314	37.80	47.90	2.310	3.90
	3254	7.32	1.232	43.50	55.00	2.432	5.10
	3255	10.49	1.183	46.30	54.50	2.290	3.40
	3256	4.27	1.311	40.10	47.90	2.405	3.80
	3257	10.71	1.228	46.20	58.20	2.505	5.50
	3258	6.06	1.262	42.30	57.00	2.540	2.20
	3411	3.39	1.033	51.50	62.80	2.642	6.00
	3412	3.59	1.244	57 50	63.80	3.432	9.10
	3413	0.95	1.7[illegible]4	23.30	38.60	2.651	7.10
2. Sriracha	2554	0.25	1.598	22.80	—	2.496	—
	2556	0.27	1.533	22.20	—	2.356	—
	2558	0.47	1.530	22.90	—	2.382	—
	3394	2.40	1.761	27.10	40.00	2.459	7.10
	3396	1.21	1.697	22.30	35 70	2.551	7.50
	3398	0.71	1.581	21.20	33.40	2.354	7.20
	3400	0.32	1.341	37.10	48.40	2.353	7.40
	3402	0.79	1.481	30.30	47.80	2.608	7.40
	3408	1.29	1.581	18.90	44 10	2.497	5.60
	3409	0.91	1.879	16.40	47.20	3.134	2.80
	3410	0.35	1.661	27.00	45 20	2.558	4.50
3. Jolburi	3404	1.95	1.756	22.90	38.50	2.645	8.70
	3406	0.79	1.697	16.40	35.80	2.439	5.80

Table III. (Cont'd.)

Place or Locality	Lab. No.	Mois-ture	Ap-parent Sp. Gr.	Amount of water taken	Pore Space	Real specific Gravity	Volume Expan-sion
		Per cent	*Grams per c.c*	*Per cent*	*Per ccnt*		*Per cent*
4. Koh Mak	1815	6.56	1.845	56.80	59.70	2.455	4.70
	1819	7.06	1.435	55.20	59.20	2.339	6.40
SOUTH							
1. Hua Hin	1838	1.54	1.437	29.10	40.60	2.351	2.90
2. Trang	3087	3.92	1.211	43.60	52.70	2.368	3.30
3. Kuan Nieng	2279	1.50	1.377	34.40	45.90	2.455	—
	2281	—	1.517	25.10	38.30	2.453	—
	2283	—	1.415	30.50	42.00	2.360	.60
	2285	0.75	1.332	32.50	42.90	1.653	2.30
4. Haad Yai	3280	1.64	1.467	29.30	42.10	2.414	3.50
	3284	0.47	1-585	23.10	33.90	2.336	2.40
	3287	0.71	1.493	25.80	25.30	2.395	5.20
	3290	0.73	1.516	26.50	39.50	2.452	4.70
	3293	0.70	1.529	25.80	38.70	2.470	1.50
	3296	0.87	1.634	22.20	39.60	2.540	4.60
	3299	1.04	1.533	27.20	41.70	2.575	9.80
	3301	1.92	1.527	28.40	44.30	2.685	3.80
	3304	1.12	1.515	26.00	46.30	2.518	1.20
	3307	1.57	1.555	25.70	35.20	2.305	2.40
	3310	1,17	1.602	23.40	38.00	2.517	2.40
	3313	—	1.577	24.80	38.80	2.407	4.70
	3316	2.05	1.414	33.80	46.20	2.285	5.20
	3318	3.16	1.280	37.10	48.40	2.354	3.20
	3319	1.05	1.580	26.80	40.70	2.568	2.60
	3323	0.96	1.538	27.40	40.40	2.476	2.70
5. Sadao	3343	3.70	1.380	35.40	46.70	2.367	6.80
	3345	0.07	1.727	21.80	35.50	2.555	5.60
	3348	0.95	1.622	23.70	36.70	2.554	1.70
6. Songkla	1704	15.29	1.263	34.90	45.30	2.121	2.30
7. Naradhiwas	3085	3.91	1.026	61.20	40.90	2.329	6.80
8. Su-ngieGolok	3327	4.92	1.280	41.70	51.10	2.294	9.10
	3329	4.80	1.410	32.90	47.10	2.435	6.00
	3331	39.60	0.938	89.50	67.90	2.104	7.20

the different soil types is conspicuous. The "heavy"[4] soils from Bangkok have apparent specific gravities around 1.25 while the "light" soils from Sriracha and Jolburi have values from 1.5 to 1.65 and even as high as 1.879. A very significant difference between a heavy and light soil may be noted by comparing No. 3171, a dark grey clay loam from Ubol, and No. 3409 a light brownish grey sand from Sriracha, with specific gravities of 0.910 and 1.879 respectively. Among the clay loams which represent medium textured soils, the apparent specific gravity falls around 1.28, while the sandy loams and fine sandy loams mostly fall between 1.4 to 1.6.

The results of the real specific gravity determination seem to indicate that real specific gravity is not very closely related to soil types. For example, the clay soils of Ploen Chitr gave from 2.2 to 2.4 real specific gravities, while those from Chandhaburi whose values are of wider spread than the clays of Ploen Chitr, range from 2.2 to 2.6. However, the results of the real specific gravities for sandy soils seem to show higher values than the clay or clay loam soils. Attention is directed to the loamy sand and sandy soils of Sriracha, Kuan Nieng, Su-ngie Golok, and Hua Hin, which give 2.3 to 3.1. But the highest real specific gravity value was 3.432 obtained from a sandy clay loam sample No. 3412 where most of the sand particles are quartz. The sandy soils are higher in real specific gravity than the "heavier" textured soils.

---

4. While there is a very frequent use of the term "light" and "heavy" in speaking of soils, these expressions refer to the ease or difficulty of working the soil, and have no reference to the actual weight of the soil. In practical agriculture, the real specific gravity of the soil is of little importance. But for construction of dams, or in mining where the weight of a certain given volume of soil is to be determined, the knowledge of the real specific gravity may be quite important.

In the amount of water taken up by the soil, after allowing it to absorb all it can within 24 hours, there is a marked difference among different soil types. The highest amount of water absorbed was obtained from sample No. 3331, a clay of Su-ngie Golok with 89.5 per cent, the same organic sample that gives the highest sticky point value. This is followed by a silty clay loam sample No. 3042 of Pre which gives 76.3 per cent. These two extremely high values may be due to different causes. In the first case, the Sungie Golok sample has a very large proportion of organic matter, while the water in the second case, may be held more by surface tension rather than by the absorbtive or cohesive force exerted by soil colloids.

The clay soils of Ploen Chitr, Bangkok, give fairly uniform values of from 48 to 50 per cent. Although lower than some of the clay loams, yet as a whole the clays are higher in amount of water absorbed. For the Chandhaburi samples, which are mostly reddish brown clay loams, the amount of water absorbed is around 45 per cent. The sandy loams, and fine sandy loams are mostly represented by the samples from Haad Yai, whose values range between 22 and 29 per cent with most of them around 26 per cent. Similar values were obtained for sandy loams and fine sandy loam samples from Korat, Hua Hin, Sriracha, and Sadao.

In the amount of pore space, the same marked differences may also be noticed between the soils from different localities. It is notable that the reddish brown clay loam soils of Chandhabun contain higher amount of pore spaces than the clay soils of Ploen Chitr and the other clay loams such as those from Trang, Haad Yai, and other places. These reddish brown clay loams are very high in clay content, ranging from 60 to 80 per cent, and have good "crumb structure" which probably are the causes for the presence of a high amount of pore space which fall around 60 per cent, while those from Ploen Chitr, is 58 per cent. The fine sandy loams and sandy loams of Haad Yai mostly lie between 38 per cent and 40 per cent while the stilt loams of Chiengmai gave values around of 50 per cent. It can be generally observed that the amount of pore space is directly related to the amount of water absorbed.

In the case of volume expansion, the values are probably governed by the amounts and types of colloids. The clay types of soil are generally known to contain higher amount of colloids than other types of soils, and the results of the volume expansion determination agree with this popular conception. In table 3, it is found that the clay soils of Ploen Chitr give the highest values of from 15 to 23 per cent while the clay loams from Chandhabun give only from 2 to 9 per cent. For the loamy sands, sandy loams, fine sandy loams, and sandy clay loams, the values for volume expansion are very variable and uncertain. For example, there are values of fine sandy loams represented by samples No. 3284 with 2.4 per cent, No. 3304 with 1.5 per cent, and sample No. 3394 with 7.1 per cent. Of loamy sands, there are values of 2.3 per cent for No. 1704, 0.6 per cent for No. 2283, and 7.2 per cent for No. 3398. And for loams there are values in percentages of 9.1, 5.6, and 2.3 as represented by sample Nos. 3327, 3408, and 2285 respectively. In some cases, samples of sands did not expand at all. Attention is called to samples Nos. 2554, 2556, and 2558 of Sriracha. These differences simply show that in the sandy soils where colloids may be absent or are present only in a very small amount, expansion is not only absent in some of the samples but is very uncertain and not at all correlated among the very "light" soils. Without considerable additional data, including chemical analysis and some determinations on the amount and kind of colloids, no adequate explanation of these divergencies is possible.

From the above discussions, there seems to be a direct relation between the amount of water taken up and the pore space. This can be noted in the Ploen Chitr and Chandhaburi samples where the amounts of water taken up range from 45 to 65 per cent and the pore space from 47 to 65 per cent. And for the Haad Yai and Jolburi samples, which are soils of light texture than those of Chandhaburi and Ploen Chitr, the range in the amount of water taken up is from 21 to 37 per cent while the pore space is from 25 to 45 per cent. In another case, when the amount of water taken up by a soil is low, the amount of pore space is also correspondingly low. These two values are also indirectly related to apparent specific gravity. That is, when the amout of water taken up and the pore space are high, the apparent specific gravity is low. For example, the amount of water taken up and pore space for Ploen Chitr and Chandhabun samples are relatively higher than those for Sriracha and Jolburi samples. But the apparent specific gravities of the samples from the former places are lower, ranging from 1.00 to 1.30 as compared to those of the latter places, which vary from 1.50 to 1.80. The same relation seems to hold true for the real specific gravity.

Summary

Using an assortment of soil samples from widely scattered places in Siam, and representing varied soil types, an endeavor has been made to measure the following "single-value soil constants": rolling-out limit, sticky point, specific gravity-apparent and real, the amount of water absorbed at saturation, the pore space, and the volume expansion. A considerable proportion of the samples, represented the upper most 15 cm. of the profile in place of adequately representing the surface or some other particular horizons of the soil profile.

Comparisons have been made between the various samples calling attention to the wide variation in some of the values, as related to the nature of the soils dealt with.

There is also included estimations of the soil class, obtained by using the field method of judging texture as developed by the U. S. Bureau of Soils.

The values obtained indicate that in most cases, the sticky point and rolling out limit are higher in the surface soil than in the subsoil, but in other samples the reverse is true and confirms the conviction from observation that there has been a definite eluviation of the clay from the surface into the lower horizons. It was also found out that heavy soils give sticky point of about 30 to 40 per cent and rolling-out limit of about 24 to 30 per cent and are represented by the clay and clay loam types. The light soils give sticky point values of about the following ranges: sands, 9 to 11; fine sand, 15 to 16; loamy sand, around 15; sandy loam, about 15; fine sandy loam, 13 to 16; loam, is around 20; and silt loam is 19 to 37.

The results of the Keen-Raczkowski method show that there is a direct relation between the amount of water taken up and the pore space, while both are inversely proportional to the apparent specific gravity.

Literature cited

Bennett, H. H. 1926. Some comparisons of the properties of humid-tropical and humid-temperate American soils; with special reference to indicated relations between chemical composition and physical properties. Soil Sci. *21*: 349-375.

Bingham, E.C. 1922. Fluidity and plasticity. New York.

Bodman, G. B. and Esther P. Perry 1931. The interrelationships of certain single-valued soil properties. Soil Sci. *31*: 365-378.

Bouyoucos, G. J. 1927. The hydrometer as a new method for the mechanical analysis of soils. Soil Sci. *23*: 343-350.

Coutts, J. R. H. 1930. 'Single value' soil properties: A study of the significance of certain soil constants. (III). Note on the technique of the Keen-Raczkowski 'Box' experiment. Jour. Agric. Sci. *30*: 407-413.

Credner, W. 1935. Siam. 1st. ed., xvi + 422. 12 maps, 70 illus. 27 figs. J. Engelhorns Nachf. In Stuttgart, Germany. (From the translation on "Boden" by Dr. Robert L. Pendleton, Department of Agriculture and Fisheries, Bangkok.)

Davis, R. O. E. and H. H. Bennett, 1927. Grouping of soils on the basis of mechanical analysis. U. S. Dept. Agric. Circular 419: 1-15. Fig. 1-2. *Cited in* Experiment Station Record 57: 613. 1927.

Haines, W. B. 1930. Studies in the physical properties of soils. (V). The hysteresis effect in capillary properties, and the modes of moisture distribution associated therewith. Jour. Agric. Sci. *20*: 97-116.

Keen, B. A. 1920. Single value soil properties: A study of the significance of certain soil constants. (IV). A further note on the technique of the 'Box experiment.' Jour. Agric. Sci. *20*: 414-416.

Keen, B. A. 1931. The physical properties of soils. A Rothamsted Monograph on Agricultural Science. vii + 380 p., 2 plates, 93 figs. London: Longman, Green and Company.

Keen B. A. and J. R. H. Coutts 1928. "Single value" soil properties: A study of the significance of certain soil constants. Jour. Agric. Sci. *18*: 740-765.

Keen, B. A. and H. Raczkowski 1921. The relation between the clay content and certain physical properties of a soil. Jour. Agric. Sci. *11*: 441-449.

Mohr, E. C. Jul. 1933. De bodem der tropen in het algemeen, en die van Nederlandsch-Indie in het bijzonder. Vol. *1*. pt. 1, p. 86. Koloniaal Institut, Amsterdam. (From an unpublished translation by Robert L. Pendleton.)

Prescott, J. A., J. K. Taylor, and T. J. Marshall. 1934. The relationship between the mechanical composition of soil and the estimate of texture in the field. First commission of the International Society of Soil Science. pp. 143-153. Fig. 1-3.

Robinson, G. W. 1936. Soils their origin, constitution and classification. 2nd. ed., xvii + 442., 17 illus. 5 pts. London: Thomas Murphy and Co.

Wall Board from Coconut Meat[1]

BY

LEK LAKSHANAHUTA

and

SOFRONIO BALCE

I. Introduction.

Wall board from the coconut meat by using one or more kinds of binder in particular fall under "wall plaster" or "plastic" in general. Although some of the products are included under the generic term "plastic", they have a long industrial history. It was only the past decade that the industry as a whole had shown such phenomenal expansion. A "plastic" may be defined as a substance which under the influence of heat and pressure become soft and plastic, and whilst in that state can either be moulded into a definite shape in a mould, or can be extruded through a die to give rods and tubes.

Plastic bodies are subdivided into--

a. thermo-setting materials, which become plastic under heat and pressure and on continued treatment become hard and infusible, and

b. non-thermo-setting materials, which become plastic under heat and pressure, but require cooling in order to set them (1).

It has been inevitable that plastics, by virtue of their nature, manipulability and amenability to fashioning processes, should encroach into all fields of industrial and domestic commodities. The average person, and even those intimate with these matters

1 This paper is the thesis submitted by Lek Lakshanahuta, now in the Department of Science, Bangkok, Siam, in partial fulfilment of the requirements for the degree of Bachelor of Science (Chemistry) of the University of the Philippines, Manila, P.I.

are not always aware of the progress made in any direction, or appreciative of the wide scope of application. It would be difficult to suggest any phase of human activity in which plastic materials are not utilized, but it is not the intention here, as the title of this article may at first sight imply, to deal with architectural and domestic applications. On the contrary this presentation will be merely introduced to those interested in knowing how the coconut meat which is usually a waste can be used as a substitute for the commercial wall boards.

The idea in undertaking this work is to study the possibility of using dried and fat free coconut meat as a raw material with certain common binders in making wall boards.

Before proceeding, however, to the methods and processes by which a wall board may be made from coconut meat, it may be worthwhile to make a review the literatures on the subject.

II. Review of Literature.

The art of plastering is intimately connected with the comfort and safety of the occupancy of the building. Yet few outside the trade understand the nature of the materials and the details of the work required to produce the desired results. The recently aroused interest in building has carried with it interest in plastering.

The essential constituents of plaster are usually a cementitious materials, inert aggregate, and water. The duration of the hardening process and the ultimate hardness of the plaster depend upon the kind and quantity of binder used. In the large majority of cases, the binder is either lime, gypsum or glue (3).

The plastic materials consists essentially of a filler (sand, earth, cinders, sawdust, wood flour, talc, asbestos, ect., with or without addition of mineral or organic coloring matters) and of a binder compose of, e. g. bone glue with the addition of a small amount of water and also a fat or wax that is solid at ordinary temperature (4).

A general description given below are the most common types of plastics using in the plastics industry.

Each of these materials has its own outstanding field upon which rivals may encroach but never really treated its domination (2).

CASEIN has a varity of colors but is not mouldable. If the piece is simple, like a button, and water is not a factor nor accuracy over a period of time important, the application is proper. The largest application of this material is in the button trade.

CELLULOSE ACETATE is primarily for appearance and secondarily for strength. Its disadvantage is its low heat-resistance. Acetates must be cooled before removal, and therefore require specially constructed moulds with channels for rapid interchange of steam and water. Cellulose acetate is produced in sheet, rod and tube form, also as a moulding powder.

CELLULOSE NITRATE (CELLULOID) is the oldest of the plastics, and for certain purposes is unrivalled, It is only produced in sheet, rod, and tube forms. It is equal to the acetates in appearance and superior to them in strength. Its great disadvantage is inflammibility, but it is stable in all climates and all humidities, and can be moulded or shaped.

COLD MOULDED stands alone in heat-resistance but is severely limited by its brittleness and lower strength. For a small production the tool costs are lower than phenolics or ureas. Colors are very much on the dark side.

LAMINATED PLATED PLASTICS have a broad field all their own. Their ability to give the surface imitating onyx, marble and wood, makes them excellent facing materials. Their extreme strength and good machining qualities fit them into any field where the tooling is comparatively simple.

PLASTIC WOOD.—This material, although somewhat of a novelty, has already proved itself invaluable in many trades, such as pattern maker, engineers, cabinet-makers and joiners.

RESINS-CAST PHENOLIC.—These are by far the most beautiful, both in surface and color combinations. In simple forms, permitting casting with little or no finishing, they displace ureas, but where thin sections, accuracy or complicated shapes are called for they must machined, and so are at a disavantage. Jewelry, knobs, simple handles offer no difficulties. Where sheer beauty is paramount it frequently is the proper answer.

RESINS-PHENOLIC offer such a variety of compounds, ranging from the standard all-purpose wood-flour base to canvas for strength, asbestos for heat and water, mica for dielectric, that their quality of being mouldable for almost any shape many times overcomes their primary drawbacks. It is often more economical to sacrifice some of the outstanding qualities for commercial considerations.

RESINS-UREA.— Ureas are filling a definite field all their own. All the colors of the rainbow, with depth of surface and translucency, give them a marked advantage in any article which must catch the eye. They have sufficient heat resistance for table and kitchen ware to be washed in hot water.

Urea and phenolics can be moulded in the same type moulds, on the same kind of presses and at about the same temperature. Ureas require positive moulds, so that not all phenolic moulds are best adapted to be interchangeable, but simple, and, in many cases, slow production, can be made in ureas from phenolic moulds.

RESINS-VINYL.—Vinyls termo-plastic, in contradistinction to the phenols and ureas, are thermo-setting. They are, however, unaffected by aging or exposure to direct sunlight, and have great mechanical strength and flexibility.

RUBBER-HARD.—This material is widely used, both in its moulded form and machined from standard sheets, rods and tubes. It is also known under the name of Ebonite.

On account of the sulphur used in its manufacture, metal parts inserted in the material should be plated, or preferably tinned.

SHELLAC.—This material is probably the oldest form of binder used in the plastics industry, but, due to the difficulties in its production, the product has not always been of a standard quality. A large amount of research work is now being done in this and other directions, some of which may lead to very interesting results as to the future of this material.

Qualities and Types of Plastics Available (2).

The qualities and types of plastic boards and mouldings available are almost innumerables but the principal types in question may be broadly classified as under :-

1. Bakelite types.
   - (a) Laminated paper boards, self colored.
   - (b) Laminated paper board, with Bakelite type veneer.
   - (c) Laminated paper board, with Beetle type veneer.
   - (d) Moulded laminated.
   - (e) Moulded laminated with Bakelite type veneer.
2. Beetle types.
   - (a) Laminated paper boards.
   - (b) Moulded boards.

3. Cellulose Acetate Sheets.
4. Plywood Base Materials.
   (a) With Bakelite type veneer.
   (b) With Beetle type veneer.
   (c) With cellulose acetate type veneer.
5. Asbestos Cement Boards.
6. Cast Resin Products.
7. Compressed Wood Boards.
8. Glass substitutes.

Apart from simple quantities like thickness, sheet or panel size, density, general qualities of surface and appearance and color, simple test methods for evaluating performance are outlined in the following section.

Some Test Methods for Evaluating Performance.

(a) Permanency under the action of strong light.
(b) Effect of water immersion.
  (1) Percentage gain in weight.
  (2) Dimensional stability.
  (3) General stability.
(c) Effect of dry heat.
  (1) Percentage loss in weight.
  (2) Dimensional stability.
  (3) General stability.
(d) Effect of exposure to cyclic changes in temperature and humidity.
(e) Mechanical tests for strength, impact, etc.
(f) Effect of heating and humidifying under stress.
(g) Effect of solvents and chemicals.
(h) Fire hazard.
(i) Damage from insect pests.

Some Comments on Applications.

In all circumstances in practice, varied exposure conditions are unavoidable, and for the present purpose these must be kept in view for the convenience under three groups viz:-

(a) Conditions where reasonable control of temperature and humidity exists, e. g. general interior fitting of houses, hotels, public buildings, etc.

(b) Interior conditions, where little or no control is possible, e. g. bathrooms, kitchens, vestibules, shop windows, and certain types of open buildings.

(c) Exterior conditions, or their equivalent, e. g. vehicles, street machines, booths and equipment, shop fronts, etc.

Again, expenses, service life, and quality are factors governing choice, and often for one of those reasons a material may be condemned which is an exactly equivalent application may prove satisfactory, if this quantity is not a controlling factor.

The most recently manufactured binders and plasticizers which entered the field of plastics industry are given below (7).

(1) Stixso. A silicate adhesive of special interest to corrugated paperboard industry. The properties of the liquid and the solid components are so adjusted as to regulate accurately the degree of penetration into the paper surface. The adhesive remaining on the surface sets rapidly and stays where it is put. The setting process is not a heat reaction, and high speeds are possible without extreme heat. The resultant product gives a board of unprecedented stiffness without warping or distortion.

(It is manufactured by Philadelphia Quartz Company.)

(2) Plasticizer 3 GH. Plasticizer 3 GH effectively increases the flexibility of Vinylite and many other synthetic resins It is also an excellent plasticizer for cellulose esters and has the remarkable characteristic of being effective at low temperatures

even when used in moderate amounts. Plasticizer 3 GH has a low vapor pressure and water solubility, and high resistance to discoloration by ultraviolet light.

(It is manufactured by Carbide & Carbon Chemicals Corp.)

(3) Dry Plasticized Size. This new paper size is in dry powdered form, capable of being shipped in bags. It is composed of a complete saponified rosin soap, the rosin of which has been plasticized with agents to reduce its melting point and raise its effective water proofing property. It is a substitute, in combine form, for mixtures of rosin size and emulsions of such materials as waxes, oils, and plastic resins, previously used in paper trade.

(This product is manufactured by Herculues Powder Co., Inc.)

Papier Maché form into various shapes has been widely used in the United States and abroad. Such products were made by sticking together sheets of specially prepared stiff paper with glutinous substances, and placing the prepared sheets in wood or metal forms to produce the desire shapes. These were placed in ovens until the whole mass became dry and hard. The pieces were then coated with varnish, made of asphalt and resin dissolved in linseed oil, or other suitable solvents, and again placed in the ovens so that the insulating varnishes were made to penetrate the surface layers of the paper. This process was repeated until the paper became covered with a hard, tough, waterproof, insulating surface. As the varnishes employed were the principal insulating elements, it is obvious that the quality of the product depend upon them.

Another form of material which has practically disappeared employed cabinet-maker's glue as a binder for vegetable or mineral fillers. The glue was mixed with the powder fillers and moulded in heated dies or rolled in sheet form. Products therefrom were generally treated with formaldehyde, chromates, or other chemical reagents to render the glue waterproof and chemically stable.

Seaweed, treated by various chemical means, has been utilized in an experimental way as a binder with asbestos or other filler, but no chemical moulding mixtures or moulded products have as yet been obtained from seaweed derivatives (6).

On account of the fact that when cocount meat is moulded it develops mold, due to its instability to resist the influence of moisture. Various processes were tried by the authors to render them less susceptible to mold growth. These depend on the use of lime compounds, aluminates, etc., and while it has been found possible to convert the silicated into somewhat insoluble form, other products of reactions are always present, which are just readily affected by moisture, or otherwise objectionable.

III. Materials and Procedure.

MATERIALS.

Dried coconut meat

Binders:-

- Gypsum powder.
- Lime.
- Coconut-milk solid powder.
- Animal Glue.
- Formaldehyde.
- NH_4OH.

Apparatus.

Carver hydraulic press (with only one heating unit employed), usual laboratory facilities; beakers, flasks and the like have been used.

Sapal[a] was prepared from coconut meat by passing through roller mill. As may be seen from tables 1 and 2, ten nuts gave 372 grams of air dried *sapal* representing about 10% of the original fresh meat.

---

a Shreded coconut meat after oil and water had been pressed out as much as possible.

TABLE 1.

SHOWING PROPORTIONS OF DIFFERENT FRACTIONS OF COCONUT MEAT AFTER EXTRACTION

Number of nuts	Weight of meat (kilos)	Weight of fresh *sapal* (grams)	Weight of cream (grams)	Weight of aqueous fraction (gms. by diff.)
10	3.7	936	1772	992

TABLE 2.

MOISTURE CONTENT OF *SAPAL*

Original weight (grams)	Loss on air drying (grams)	Air dried *sapal* (grams)	Moisture of oven dried *sapal*			
			I	II	III	Ave.
			%	%	%	%
936	536.4	372.7	12.2	11.9	12.4	12.1

As may be seen in table 3 the moisture content of the gypsum is about 8.4% which means that the gypsum is partly dehydrated.

TABLE 3.

MOISTURE CONTENT OF GYPSUM

Loss at 45° C.				Loss at 110° C.				Loss at 250° C.			
I	II	III	Ave.	I	II	III	Ave.	I	II	III	Ave.
%	%	%	%	%	%	%	%	%	%	%	%
1.26	1.46	1.47	1.4	8.0	8.08	8.26	8.11	8.44	8.47	8.3	8.4

PROCEDURE:

The coconut meat was ground and rolled by the electric mill, and dried at ordinary room temperature.

Determination of moisture of gypsum powder over the sand bath at 250°C. was performed by using 3 weighed samples. When the constant weight was obtained, the loss in weight corresponding to the moisture, was calculated as the percentage.

The other determinations of moisture for the gypsum powder with 45°C. 110°C. and 250°C. (in the electric oven) were also performed. The calculation of the percentage of moisture is the same as above.

The percentage of the moisture of the coconut meat plastic in the electric oven was also performed and calculated as above.

The procedure in which the samples of the coconut wall board (plastic) generally made is the following:-

20 grams of *sapal* and a certain amount of binder were accurately and separately weighed. Both *sapal* and binder were thoroughly mixed in a 600 cc. beaker. To prevent attack of mold, formaldehyde and ammonia were added drop by drop and was well mixed. The mixture was transferred to an iron mould and placed on the electrical heater of the hydraulic press at 220°C. When the required period of time (as shown in table 5) was reached, the desired pressure was applied for 20-30 minutes. The plastic was then taken out, turned over and placed in the mould again and pressed with the same pressure and of the same length of time as the former one. The purpose of turning the plastic over was to heat both faces equally.

IV. Discussion of Results.

TABLE 4.

THE MOISTURE CONTENT OF THE COCONUT MEAT WALL BOARD.

(Dried at 110°C.)

TRIAL	Weight of pressed *sapal* (Grams.)	Per cent (24 hrs.)	Per cent. (48 hrs.)
I (Sample No. XIII)	16.5508	8.01	11.00
II (Sample No. XIV)	15.9510	8.47	10.13
III (Sample No. IV)	15.6142	8.24	10.62
	Averages	8.24	10.58

The results in table 5, shows the different moulding properties of *sapal* when moulded with gypsum. The weights of *sapal* used were varied and so with the weight of gypsum, amount of temperature, time of baking, and pressure applied in order to obtain the best result. Through the examination of table 5, it is shown that sample XXIV gives the best result for a combination of 20.0008 grams of *sapal* and 1.2112 gram of of gypsum heated at 130°C. for 40 minutes under a pressure of 14,000 pounds per square inch. Both sides of the moulded mixture of *sapal* and gypsum were of plane faces, and were considered very good. On the other hand, samples I to VII were poor or at most only fair on account of warping after applying pressure of from 9000 to 12000 pounds per square inch for 130° to 230°C. for 8 to 20 minutes. In some cases, the plastics were rather fragile and not compact as shown by samples VIII to X.

TABLE 5.

SHOWING MOULDING PROPERTIES OF *SAPAL* WITH GYPSUM.

Sample	Wt. of *sapal* (Grams)	Wt. of gypsum (Grams)	Temp. of the heater (°C.)	Time of baking in the mould. (Minutes)	Moulding pressure lbs/sq. inches.	Results of moulding
I	25.0004	.5032	180	15	9000	Both sides heated. Warped.
II	20.0024	.3092	193	15	10000	Same as I.
III	20.0020	.4000	200	15	11000	Both sides heated. Plane, but warped.
IV	20.0006	.4014	130	20	12000	Both sides heated. Plane, good.
V	20.0000	.4032	210	20	11000	Same as I.
VI	20.0000	.4006	220	8	12000	One side heated only. Warped.
VII	20.0006	.4002	220 fall down to 185 when changed.	16	11000	Both sides heated. Warped little. Fair.

TABLE 5. – Contd

Sample	Wt. of *sapal* (Grams)	Wt. of gypsum (Grams)	Temp. the heater (°C.)	Time of baking in the mould. (Minutes)	Moulding pressure lbs/sq, inch.	Results of moulding.
VIII	20.0000	.4004	175	18	11000	After heated side (a) 8 min pressed, & took it out; changed & heated side (b), heated 8 min, while pressing. Not compact.
IX	20.0000	3002	200 fall down to 180 when changed	14	12000	Both sides heated. Baked 7 min. stopped current, then pressed, took out, turn over. Heated 7 min. on side (b) while still pressing, compack but fragile.
X	20.0000	.4000	220 fall down to 170 when changed	14	11000	Same as IX.

TABLE 5.— Contd.

Sample	Wt. of *sapal* (Grams)	Wt. of gypsum (Grams)	Temp. of the heater (°C)	Time of baking in the mould. (Minutes)	Moulding pressure lbs/sq. inch.	Results of moulding
XI	20 0016	.4020	160	12	14000	Same as X. The hydraulic press did not work for 2nd. pressing
XII	20 0020	.4984	165	20	11500	Both sides heated. Plane, Good.
XIII	20.0016	.5236	165	20	11000	Both sides heated. Plane, Good. (a)
XIV	20 0014	.5016	165	20	11000	Both sides heated. Plane, Good. (b)
XV	20.0016	.5174	165	20	12000	Both sides heated. Plane, Good. (c)

(a) No shrinkage after 48 hours in oven at 110°C.
(b) After 48 hours in oven at 110°C the shrinkage was .02/5.72 of its diameter (5.72 cm.)
(c) Same as (a).

TABLE 5.—Contd.

Sample	Wt. of *sapal* (Grams)	Wt. of gypsum (Grams)	Temp. of the heater (°C.)	Time of baking in the mould. (Minutes)	Moulding pressure lbs/sq. inch	Results of moulding.
XVI	20.0018	.7093	160	10	11000	One side heated only. The hydraulic press was out of order. Poor.
XVII	20.0036	.7006	160	20	11000	Both sides heated. Plane. Good.
XVIII	20.0056	.7074	160	20	12000	Both sides heated. Warped little. Fair.
XIX	20.0024	.9042	160	20	13000	Both sides heated. Plane. Fair.
XX	20.0026	9036	160	20	12000	Both sides heated. Good.

TABLE 5.—Contd.

Sample	Wt. of *sapal* (Grams)	Wt. of gypsum (Grams)	Temp. of the heater (°C)	Time of baking in the mould. (Minutes)	Moulding pressure lbs/sq.	Results of moulding.
XXI	20.0000	.9046	160	20	12000	Both sides heated. Fair.
XXII	20.0006	1.2102	160	40	14000	Both sides heated. Hard, warped little. Fair.
XXIII	20.0018	1.2072	160	40	14000	Both sides heated. Plane, Good.
XXIV	20.0008	1.2112	130	40	14000	Both sides heated, plane. Very good.
XXV	20.0083	1.5058	180	40	15000	Both sides heated, warped. Fair.
XXVI	20.0033	1.5006	185	40	14000	Both sides heated, plane. Good.
XXVII	20.0046	1.5042	200	40	14000	Both sides heated. Warped Fair.

TABLE 6.

SHOWING MOULDING PROPERTIES OF *SAPAL* UNDER GYPSUM, LIME, AND FORMALDEHYDE TREATMENTS.

Sample	Wt. of *sapal* (Grams)	Wt. of gypsum (Grams)	Wt. of lime.	Am't. of formal dehyde (cc)	Temp. of heater (°C.)	Time of baking in the mould. (mins.)	Moulding pressure lbs. sq. inch.	Results of moulding
XXVIII	20.0000	1.2084	1.1274	...	250	40	14000	Both sides heated. Hard. Good.
XXIX	20.0026	1.2086	1.2032	...	210	40	14000	Both sides heated. Good.
XXX	20.0046	1.2010	1.2126	3	200	40	14000	Both sides heated. Hard. Good.
XXXI	20.0018	1.2060	1.2020	3	200	40	14000	Both sides heated. Good.
XXXII	20.0032	...	1.2022	...	210	25	14000	Both sides heated. Hard. Good.
XXXIII	20.0016	...	1.2004	3	210	25	14000	Same as XXXII
XXXIV	20.0030	1.2006		3	220	25	14000	Both sides heated Fragile when taken out to turn over Little warped inside Plane. Good.

Table 6, shows the moulding properties of *sapal* under separate or combine treatments of gypsum, lime, and formaldehydé. Results seem to indicate that the combine treatment of gypsum and lime gives good hard wall board as in samples XXVIII and XXIX. And the same combination with an added treatment of formaldehyde, also gives satisfactory result. *Sapal* and lime without gypsum, with or without formaldehyde is also a satisfactory combination. But gypsum alone and *sapal* with formaldehyde gives a slight warping of the wall boord plastic produced.

Fat-free *sapal* as material for wall board plastic was also tried in combination with coconut milk powder, animal glue and some samples treated with formaldehyde or ammonia or both as shown in table 7. When 10 grs. fat-free *sapal* was mixed with .8004 gr. of coconut milk powder at 200°C. for 60 minutes under a pressure of 12,000 pounds per square inch, the wall board was only plain, hard and good. But better result was obtained when 16 grams of *sapal* was mixed with 2.1 grams of animal glue baked for 80 minutes showing a fine hard finished product. This was treated with formaldehyde alone. The best result was obtained in sample XXXIX, when 0.7992 gr. of coconut milk, 1.2006 gr. of gypsum and 2.1 grs. animal glue were used. An equally good result was obtained from 15.0000 grs. of *sapal* with 0.1188 gr. of coconut milk powder and 5.25 grs. of animal glue when treated with 5 cc. of formaldehyde and 5 cc. ammonium hydroxide, heated at 210°C. for 100 minutes under 12,000 pounds pressure per square inch.

TABLE 7.

SHOWING MOULDING PROPERTIES OF FAT-FREE *SAPAL* WITH COCONUT MILK POWDER, ANIMAL GLUE. FORMALDEHYDE, AND AMMONIA TREATED,

Sample	Wt. of *sapal* (fat-free) (Grams)	Wt. of coconut-milk powder solid (Grams)	Wt. of animal glue (Gms.)	Am't. of formal-dehyde (cc)	Temp. of heater (°C)	Time of baking in the mould. (mins.)	Moulding pressure lbs/sq. inch.	Results of moulding.
XXXV	10.0000	.8004	---	---	200	60	12000	Both sides heated. Plane, hard, good.
XXXVI	16.0000	---	2.1	5	200	80	12000	Both sides heated. Plane, hard. Very good.
XXXVII	10.0000	.8794	---	5	200	70	12000	Both sides heated. Hard. Good.
XXXVIII	16.0000	---	2.1	---	200	60	12000	Both sides heated. Hard. Good.
XXXIX	16.0000	.7992 plus 1.2006 Gypsum	2.1	5 plus 5 NH_4OH	200	100	12000	Both sides heated. Very hard. Very good. Plane.
XL	15.0000	.1188	5.25	5 plus 5 NH_4OH	210	100	12000	Same as XXXIX.

Water Absorbtion Test (24 Hours Immersion).

Sample	*General Stability*		*Comment*
X	Little crumbled.		Good.
XIX	Crumbled wholly.		Poor.
XX	"	"	"
XXI	"	"	"
XXVI	"	partly.	Fair.
XXVII	"	"	"
XXIX	"	very little.	Good.
XXXII	"	"	"
XXXVI	"	"	Very good.
XXXVIII	"	wholly.	Poor.
XXXIX	"	little.	Good.
XL	"	"	Very good.

Result of exposure to mold in wet closet for 1 week.

Sample	*Treatments*	*Result*
XVI	Without formaldehyde	Positive.
XVII		"
XVIII		"
XXX	With formaldehyde	Negative.
XXXI		"
XXXIII		"
XXXIV		"
XXXVI		"
XXXVII		"
XXXIX		"
XL		"

V. Summary.

Attempts have been made to prepare wall board from coconut meat and the experience and results obtained are very encouraging, and if extended, may prove successful.

Temperature and kinds of binders are the most important parts in making of wall board plastics. If the mould were made of copper not iron, as in these experiments, the heat would be transmitted more uniformly to the entire body of the plastic. Aside from the fact that no copper mould was available there was also difficulty in using the Carver Press when one of the two heating units was out of order.

Acknowledgements.

The writers wish to express sincere gratitude to Mr. Antonio A. Sanz and Mr. Magdaleno M. Cero for their helpful suggestions and valuable criticisms.

Bibliography.

1. Bautista, Pelagio S. 1936. The industries v. II, no. I.
2. British Plastic Year Book, 1937. Plastic Press Ltd , 19/23 Ludgate Hill, London, E. C. 4.
3. U. S. Bureau of Standards. Circular no. 151, January 9, 1929.
4. Constantin di Neyman, 1934. Rev. gen. mat. plastiques, 10, 375 376. *Cited in* Chemical Abstract, 853,[3] 1935. American Chemical Society.
5. Griffin, R.C. 1927. Technical methods of analysis. McGraw Hill Book Company, Inc.,
6. Hemming, Emile. 1923. Plastic and molded electrical insulation. Chemical Catalog Company, New York.
7. Industrial and Engineering Chemistry, v. 30, no. I, 1938. American Chemical Society.

Printed at the
"DAILY MAIL PRESS"
Si Phya Road, Bangkok.
By Choo Limsaroj—Publisher 1938.

กรมพัสดุ

๗๕๐ ถ. ๖.๙๑
พิมพ์ที่โรงพิมพ์เดลิเมล์