No. 9

タイ王国の建設事情

タイ王国プライマリー・ヘルス・ケアー訓練センター計画

基本設計調査報告書資料集

昭和57年10月

国際協力事業団

タイ王国の建設事情

タイ王国プライマリー・ヘルス・ケアー訓練センター計画

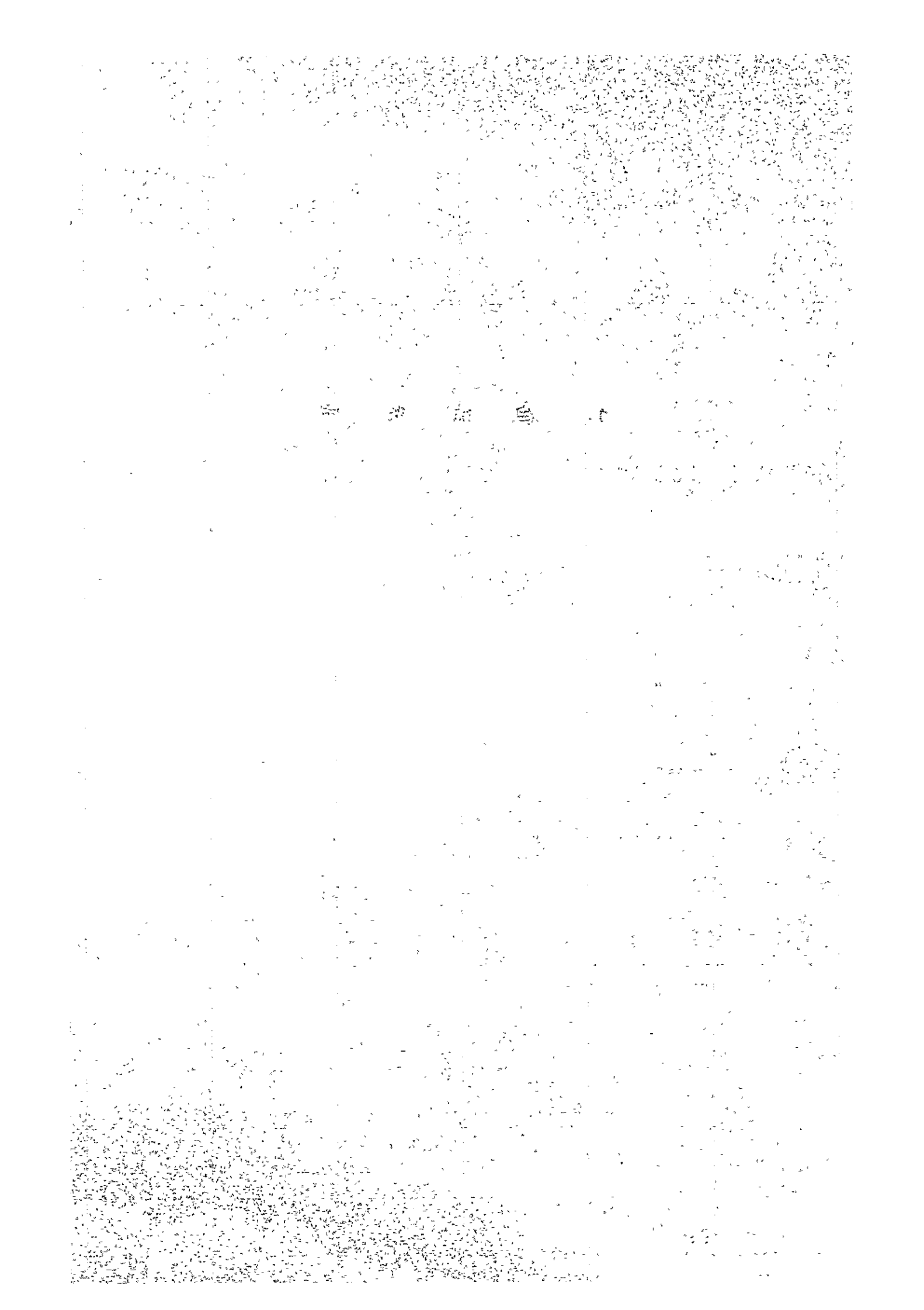
基本設計調査報告書資料集

昭和57年10月

国際協力事業団

目　　次

1. 自 然 条 件



1 自 然 条 件

1－1 気 象

各建設地の気象資料は，下記の通り。

-1) Climatological Data for the Period 1951-1975.

a) バンコク

b) コン・ケン

c) ナコン・サワン

d) ナコン・シ・タマラート

e) チョン・ブリ

-2) 年間雨量 1978～1980

-3) 年間気温（最高，平均，最低）1979～1980

-1)～-3) 出所：Ministry of Communication.

1－1－1) CLIMATOLOGICAL DATA FOR THE PERIOD 1951－1975

a) Station BANGKOK METROPOLIS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C.)													
Mean	25.5	27.1	28.6	29.5	29.0	28.5	28.0	27.8	27.5	27.4	26.6	25.3	27.6
Mean Max.	31.8	32.7	33.8	34.8	34.0	32.9	32.4	32.1	31.7	31.5	31.1	31.1	32.5
Mean Min.	20.4	22.7	24.5	25.6	25.3	25.0	24.8	24.6	24.4	24.3	22.9	20.6	23.7
Ext. Max.	36.0	36.6	39.8	39.0	39.4	36.8	36.0	35.3	35.7	34.5	35.1	35.2	39.8
Ext. Min.	9.9	14.9	16.5	19.9	21.1	21.7	21.9	21.2	21.3	19.8	14.2	10.5	9.9
Relative Humidity (%)													
Mean	73.0	76.0	77.0	77.0	80.0	80.0	81.0	82.0	84.0	83.0	79.0	74.0	79.0
Mean Max.	91.8	93.4	93.0	91.9	93.8	92.9	92.9	94.4	95.7	95.7	94.3	92.2	93.5
Mean Min.	49.5	53.5	55.5	56.6	61.3	63.4	64.4	65.2	67.9	67.7	61.2	53.5	60.0
Ext. Min.	27.0	17.0	25.0	28.0	30.0	46.0	47.0	48.0	49.0	49.0	36.0	31.0	17.0
Wind (Knots)													
Prevailing wind	NE	S	S	S	S	S	SW	S	SW	NE	N	NE	–
Mean Wind Speed	3.8	5.2	5.8	5.7	4.6	4.9	4.6	4.6	3.9	3.5	3.7	3.5	–
Max. Wind Speed	31 NNE	37 N	48 ENE	56 E	42 W	43 S,SW	43 SW,W	45 WNW	44 SSW	40 NE	45 ENE	31 NNE-SE	–
Rainfall (mm.)													
Mean	8.9	29.1	28.0	70 0	185.1	150.4	171.3	206.8	402.1	234.2	47.6	10.4	1543.9
Mean rainy days	1.8	2.8	3.6	6.4	15.8	16.5	18.4	20.8	21.6	17.4	6.0	1.6	132.7
Greatest in 24 hr,	39.3	73.0	52.8	133.5	124.2	82.9	108.8	97.8	153.7	123.2	81.2	32.0	153.7
Day/Year	31/61	11/64	24/73	23/51	15/66	6/59	30/55	26/71	23/68	5/60	2/69	8/72	23/68
Number of days with													
Haze	21.5	21.6	22.5	16.6	12.1	12.7	14.0	13.1	12.8	13.2	13.8	18.0	191.9
Fog	5.4	3.6	2.8	1.4	1.6	0.1	0.5	0.1	0.0	0.3	1.0	1.4	18.2
Hail	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Thunderstorm	0.6	1.3	3.6	8.8	15.3	10.1	9.6	10.6	15.2	13.6	3.4	0.7	92.8
Squall	0.0	0.0	0.2	0.2	0.3	0.4	0.4	0.1	0.1	0.0	0.1	0.0	1.8

b) Station KHON KAEN

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C.)													
Mean	23.2	25.9	28.7	30.3	29.5	28.7	28 2	27.7	27.2	26.7	25.1	23.2	27.0
Mean Max.	30.3	32.8	35.3	36 5	34.9	33.1	32.6	32.0	31.6	31.4	30.9	29.8	32.4
Mean Min.	15.7	18.7	21.9	24.1	24.6	24.6	24.1	24.0	23.6	22.2	19.3	16.1	21.7
Ext. Max.	37.2	41.0	41.8	42.8	41.2	37.4	36.8	37.0	35.5	35.5	37.2	35.8	42.8
Ext. Min.	5.7	10.4	10 3	14.0	20 9	20.7	20.2	20.8	19.3	14.0	9.4	5.6	5.6
Relative Humidity (%)													
Mean	64.0	62.0	61.0	64.0	72 0	76.0	77.0	80.0	82.0	80.0	70.0	66.0	71.0
Mean Max.	86.1	83.9	82 0	82.5	87.5	88.8	90.0	91.4	92.7	90.8	88.1	87.2	87.6
Mean Min.	43.6	42.3	41.3	43.9	53.8	60.7	62.3	65.0	66 6	60.3	50.7	45.7	53.0
Ext. Min.	11.0	10.0	12.0	18.0	29.0	33.0	41.0	37.0	46 0	26.0	21.0	15 0	10.0
Wind (Knots)													
Prevailing wind	NE	NE	NE	SW	SW	SW	SW	SW	SW	NE	NE	NE	–
Mean Wind Speed	3.5	3.3	3.7	4.0	3.8	4.2	4.5	4.0	3.1	3.7	4.2	4.0	–
Max. Wind Speed	33 NE	33 N-SW-NW	40 NE	46 W	47 SW-WNW	39 SW-W	55 W	40 E	33 N-SW-W	34 NE	35 N	35 NE	–
Rainfall (mm.)													
Mean	8.9	16 0	37.2	61.6	165.4	179.6	156.3	186.8	266 0	89.4	15.9	2.7	1187.8
Mean rainy days	1.3	2.6	4.4	6.4	13.9	14.4	16.2	17.8	18.0	9.6	1.7	0.6	107.1
Greatest in 24 hr.	29.2	63.4	70.2	65.7	96.9	123.8	92.8	99.0	141.6	124.5	81.0	26 6	141.6
Day/Year	24/69	3/66	12/52	6/65	10/52	12/70	26/63	14/61	8/51	26/69	10/74	20/71	8/51
Number of days with													
Haze	22.6	23.8	24.1	13.6	1.4	0.0	0.1	0.4	0.7	3.1	8.1	19.0	117.1
Fog	5.2	3.3	3.9	1.4	0.4	0.1	0.1	0.2	0.3	1.5	5.9	5.8	28.1
Hail	0.0	0 0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.1
Thunderstorm	0.3	1.4	6.1	11.9	17.6	13.9	13.4	11.7	13.4	6 0	0.5	0.0	96.2
Squall	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0

c) Station NAKHON SAWAN

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C.)													
Mean	25.5	28.4	30.7	31.9	30.7	29.6	29.1	28.4	28.1	27.9	26.8	25.2	28.3
Mean Max.	31.9	34.6	36.6	37.7	36.0	34.4	33.7	33.0	32.2	31.8	31.4	30.9	33.7
Mean Min.	17.5	20.9	23.5	25.1	25.0	24.6	24.2	24.0	23.8	23.5	21.1	18.1	22 6
Ext. Max.	37.0	39.8	41.2	42.5	42.7	41.0	38.9	37.8	36.3	35.9	35.7	35.8	42.7
Ext. Min.	6.1	12.0	14.2	17.0	20.3	21.4	20.9	20.9	20.4	18.4	11.9	8.2	6.1
Relative Humidity (%)													
Mean	63.0	62.0	61.0	63.0	70.0	74.0	76.0	78.0	82.0	80.0	73.0	67.0	71.0
Mean Max.	88.3	87.6	87.7	87.2	89.4	90.8	91.8	93.0	95.4	94.8	93 0	90.7	90.8
Mean Min.	42.3	41.1	40.3	41.9	51.5	57.4	59.1	62.3	66.5	64.2	55.2	47.0	52.4
Ext. Min.	16.0	10.0	15.0	20.0	23.0	34.0	36.0	38.0	47.0	38.0	25.0	25.0	10.0
Wind (Knots)													
Prevailing wind	E	S	S	S	S	S	S	S	S	S	E	N	—
Mean Wind Speed	4.0	4.6	6.2	6.4	5.4	5.8	5.2	4 6	3.4	3.2	3.6	3.8	—
Max. Wind Speed	33 NE	58 S	62 N	60 N	70 S	50 S	52 S	42 N	65 N	54 NE	27 NW	27 E	—
Rainfall (mm.)													
Mean	13.7	26.9	43.4	65.1	137.3	125.1	140.7	181.0	250.8	152.8	30.5	6.4	1173.2
Mean rainy days	1.4	1.8	3.1	5.0	11.8	13.6	15.5	17.4	18.0	12.4	3.1	1.0	104.1
Greatest in 24 hr.	60.9	69 6	87.1	84.9	89.0	61.8	96.1	90.3	121.2	147.0	121.6	45.6	147.0
Day/Year	11/75	3/53	23/70	11/72	14/70	1/56	29/73	26/65	23/64	8/51	14/66	16/66	9/67
Number of days with													
Haze	24.7	25.8	27.7	19.6	3.8	0.6	0.6	1.6	1.8	5.6	9.6	16.1	137.7
Fog	10.4	7.0	3.1	1.3	0.4	0.1	0.1	0.6	0.6	1.3	5.1	6.8	36.2
Hail	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorm	0.4	1.1	3.8	7.2	13.0	8.7	8.4	8.1	10.3	8.0	1.4	0.1	70.5
Squall	0.0	0.1	0 0	0.0	0.1	0 0	0 0	0.0	0.0	0.0	0.0	0.0	0.2

d) Station NAKHON SI THAMMARAT

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C.)													
Mean	26.2	27.1	28.1	28.9	28.6	28.7	28.3	28.1	27.8	27.1	26.2	25.9	27.6
Mean Max.	29.8	31.2	32.6	33.6	33.5	33.3	33.2	32.9	32.6	31.2	29.5	29.1	31.9
Mean Min.	21.8	21.6	22.1	23.1	23.7	23.5	23.0	23.1	22.9	22.8	22.6	22.3	22.7
Ext. Max.	34.6	35.4	38.0	36.8	37.3	37.7	36.5	36.9	36.6	34.7	34.2	32.6	38.0
Ext. Min.	17.6	17.2	17.8	18.6	20.2	20.7	19.4	19.5	19.4	20.2	18.0	17.1	17.1
Relative Humidity (%)													
Mean	80.0	77.0	74.0	75.0	77.0	74.0	73.0	74.0	77.0	82.0	85.0	83.0	78.0
Mean Max.	95.7	95.8	95.3	95.3	94 6	92.7	93.2	92.9	94.6	96.1	96.0	95.4	94.8
Mean Min.	66.3	60.9	57.4	58.1	60.0	57.5	56.7	57.6	59.5	67.2	73.4	71.8	62.2
Ext. Min.	42.0	36.0	38.0	38.0	38.0	31.0	37.0	27.0	38.0	42.0	46.0	52.0	27.0
Wind (Knots)													
Prevailing wind	E	E	E	E	SW	SW	SW	SW	SW	N	N	N	—
Mean Wind Speed	4.9	5 0	7.9	4.5	4.6	5.7	5.3	5.5	4.2	4.1	4.5	5.1	—
Max. Wind Speed	40 E	30 E	32 SW	40 SW	44 WNW	40 SW, NNW	35 SW,W	55 WSW	47 SW	50 NW	32 E	27 SE	—
Rainfall (mm.)													
Mean	221.3	58.6	48.4	93.0	171.5	80.9	112.5	107.5	157.8	361.1	579.9	508.4	2500 9
Mean rainy days	15.0	6 8	5 0	8.9	17.3	13.0	14.0	16.1	18.1	21.3	21.7	20.2	177.4
Greatest in 24 hr.	433.3	102.3	70.1	102.8	87.0	62.4	83.0	84.2	82.8	271.7	242.8	238.6	433.3
Day/Year	5/75	19/75	25/65	12/61	5/60	6/51	26/51	15/65	17/66	21/63	21/53	2/51	5/75
Number of days with													
Haze	19.3	21.1	25.8	21.9	14.3	16.1	18.9	18.5	16.1	11.9	9.5	12.2	205.6
Fog	1.6	3.4	4.9	3.5	0.9	1.7	3.6	2.0	4.7	2.5	0.6	0.9	30.3
Hail	0.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorm	0.9	1.2	5.0	12.7	18.0	12.2	11.0	9.3	12.5	12.4	7.5	4.2	106.9
Squall	0.0	0.0	0 0	0 0	0.0	0.0	0.1	0.1	0.0	0 0	0.0	0.0	0.2

e) Station CHONBURI

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C.)													
Mean	25.9	27.4	28.8	29.6	29.3	28.9	28 6	28.3	27.9	27.3	26.7	25.8	27.9
Mean Max.	31.3	32.1	33.2	34.1	33.3	32.5	31.9	31.6	31.2	31.3	31.1	31.0	32.0
Mean Min.	20.1	22.4	24.2	25.4	25.4	25.5	25.0	24.9	24.4	23.8	22.1	20.3	23.6
Ext. Max.	36.2	36.6	37.0	38.0	37.8	37.1	35.5	34.7	34.4	34.8	35.2	36.1	38.0
Ext. Min.	9.9	16.5	17.5	20.4	21.2	21.0	20.5	20.9	20.6	18.2	14.2	12.0	9.9
Relative Humidity (%)													
Mean	67.0	71.0	71.0	71.0	75.0	75.0	75.0	76.0	80.0	80.0	73.0	66.0	73.0
Mean Max.	85.0	88.2	87.8	87.6	88.8	87.6	88.5	90.0	92.3	93.0	89.5	85.1	88.6
Mean Min.	52.0	56.2	56.6	56.7	60.8	61.8	62.9	64.0	67.1	66.7	57.2	50.1	59.3
Ext. Min.	20.0	25.0	23.0	29.0	32.0	42.0	43.0	45.0	46.0	42.0	29.0	22.0	20.0
Wind (Knots)													
Prevailing wind	E	S	S	S	S	S	S	S	S	NE	NE	NE	—
Mean Wind Speed	6.4	7.0	7.1	6.4	5.9	7.1	6.6	6.5	5.3	5.0	6.2	6.6	—
Max. Wind Speed	40 NE	36 S,SW	37 NNE, SW	50 ENE	47 S,W, NW	55 SW,W	55 SW	55 SW	60 W	63 S	40 NE,S	37 NE	—
Rainfall (mm.)													
Mean	12.6	22.1	40 9	77.9	166.5	118.8	168.0	166.3	302.0	230.1	64.1	10.1	1379.4
Mean rainy days	1.7	3.4	4.8	8.2	15.2	15.0	16.9	19.6	20.0	17.6	6.7	1.6	130.7
Greatest in 24 hr.	37.7	92.1	103.4	74.7	126.2	65.4	110.6	131.0	124.2	145.4	91.8	37.7	145.4
Day/Year	18/75	25/58	13/54	23/47	11/54	23/72	22/51	27/71	26/63	14/52	4/75	1/70	14/52
Number of days with													
Haze	27.2	24.6	25.2	16.6	3.6	2.5	1.1	2.7	2.1	5.8	16.2	21.6	149.2
Fog	2.9	3.3	2.2	0.7	0.3	0.0	0.4	0.2	0.6	0 6	1.6	1.1	13.9
Hail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorm	0.7	3.2	6.6	15.4	15.9	7.7	7.7	7.9	11.0	11.0	3.8	0.7	91.6
Squall	0.0	0.0	0.0	0.4	0.1	0.4	0.0	0.0	0 0	0 1	0 0	0.2	1.2

1－1－2） ANNUAL RAINFALL DATA 1978－1980

Station	1978		1979		1980	
	Days	mm.	Days	mm.	Days	mm.
Bangkok Metropolis	133	1,236.4	95	1,133.4	108	1,471.0
Khon Kaen	125	1,390.2	85	1,177.4	107	1,331.8
Nakhon Sawan	126	1,208.5	88	678.3	110	1,222.5
Nakhon Si Thammarat	144	1,675.2	167	1,842.1	141	2,072.1
Chon Buri	121	1,489.8	94	740.9	116	1,314.2

1－1－3） ANNUAL TEMPERATURE DATA 1979－1980

Station	1979			1980		
	max.	mean	min.	max.	mean	min.
Bangkok Metropolis	33.7	28.5	24.5	33.7	28.5	24.7
Khon Kaen	33.1	27.1	22.1	33.0	26.9	22.4
Nakhon Sawan	35.1	28.7	23.4	34.4	28.4	23.5
Nakhon Si Thammarat	32.2	27.1	23.3	32.3	26.9	23.1
Chon Buri	33.8	28.4	24.3	33.4	28.2	24.3

1－2　地勢・地質

各地区の地勢・地質は下記資料より抜萃した。

-1　地勢について

出所："Five Faces of Thailand."

著者. Wolf Donner (Dr. rer. pol.)

出版. A Publication of The Institute of Asian Affairs.

-2　バンコクの地質

出所："Geotechnical Problems in Connection with Highway Constraction in the Bangkok Area, Thailand"

著者. Toshinobu Akagi (Prof. Toyo Univ.)

出版. １９７２年研究報告書第８号東洋大学

-3　ナコン・シ・タマラートの地質

出所：マハラート病院敷地内看護学校ボーリングデーター

1－2－1）地勢について

a）バンコク

(a) Topography

The natural foundation of the sub-region, i.e. of the area of Greater Bangkok, is an extensive and rather flat area formed over a long period by the sediments of the Chao Phraya and its tributaries and distributaries, originally emerging from the mountains which enclose the Central Region in the east, west, and north. Naturally, the slope of this centrally situated plain is extremely small. The upper reaches of the part commonly called the Bangkok Plain, near Chainat, are more than 44m. above sea level and have a slope of 0.014 per cent, equivalent to a difference of 1m. in height for every 7,000m. horizontally. As its lower part, i.e. in the sub-region, the slope is even more gentle and is, in fact, 0.004 per cent or 1m. in height for every 25,000m. horizontally; while the flattest territory lies towards the sea, south of the city.

A topographical survey in the metropolitan area over 282km.², conducted in 1958 during the preparation of the Greater Bangkok Plan, showed that the average elevation of the natural ground is about 1.10m. above sea-level, the relief moving from slightly above sea-level to approximately 2m.[1] An analysis of the topographical map (1:50,000) of the sub-region, however, though giving only a few altitudes, reveals that quite a number of points have been identified which lie 3, 4, and even 6m. above sea-level. The 6-metre point, for example, is found in the large river bend of the Chao Phraya, north-east of Phra Pradaeng. Geologically, the sub-region belongs entirely within the group of alluvium and terrace deposits and, insofar, does not show any distinction from the rest of the Chao Phraya valley or the central plains.

The area is characterized by Quaternary deposits which include unconsolidated silt, clay, sand, and gravel; beach and estuarine clay, sand and gravel; raised coral reefs and residual layers of laterite capping stabilized surfaces. In most localities the Quaternary deposits are less than 46m.[2]

Since it appears that there has been no significant movement of the earth's crust and that a tectonic stability has prevailed for a long time in the plains of the Chao Phraya river, another reason has to be found for the irregular undulations of the surface. These are undoubtedly due to silting from the river, a phenomenon which was carefully observed by Pendleton.[3] It may be summarized as follows:

Already several tens of kilometres north of the river mouth it can be observed that the immediate river banks lie remarkably above the mean river level, and even higher above the surrounding backland. The silting activities of the river which not only push the coast more and more into the gulf, also deposit solid particles along its banks, thus building up natural levees which, when developing undisturbed, reach just above the normal flood level. These levees, therefore, have in the course of history developed into locations for farmsteads, tree plantations, temples, small villages and markets, as they are the safest possible places in a vast area periodically subject to inundations. Insofar, the elevation near the river is, generally higher than in more distant places.

Naturally, extremely high floods can lead to the breaking of these natural levees and, consequently, substantial quantities of silt are released into the more deeply situated backlands. Depending upon the specific situation, such a breakthrough may become the beginning of a new channel which then will build up its own banks, while the old river bed will silt up and become dry. It seems that this interaction of silting, building up levees, the breakthrough of these levees and the creation of new channels is largely if not exclusively responsible for the differences in altitude of the sub-region.

At present, the sub-region is characterized by a decreasing number of water courses, since the development of motor traffic requires the substitution of them by roads. Thus, remarkable quantities of clay are carried from afar to fill in khlongs or to raise the level of residential plots, and road and railway tracks. Naturally, the alluvial deposits of fine silt have given the town unstable foundation conditions and hence mainly flat and low buildings or houses were built at or into the water ways. Four- to five-story buildings were, for a long time, the utmost which could be safely supported. It is only recently that modern and expensive foundation techniques have been used to construct buildings of the skyscraper type.

On the whole, the topography of the sub-region has a very flat, slightly undulated relief and an abundance of water ways ranging from the huge Mae Nam Chao Phraya down to drainage gullies (see figure 136).

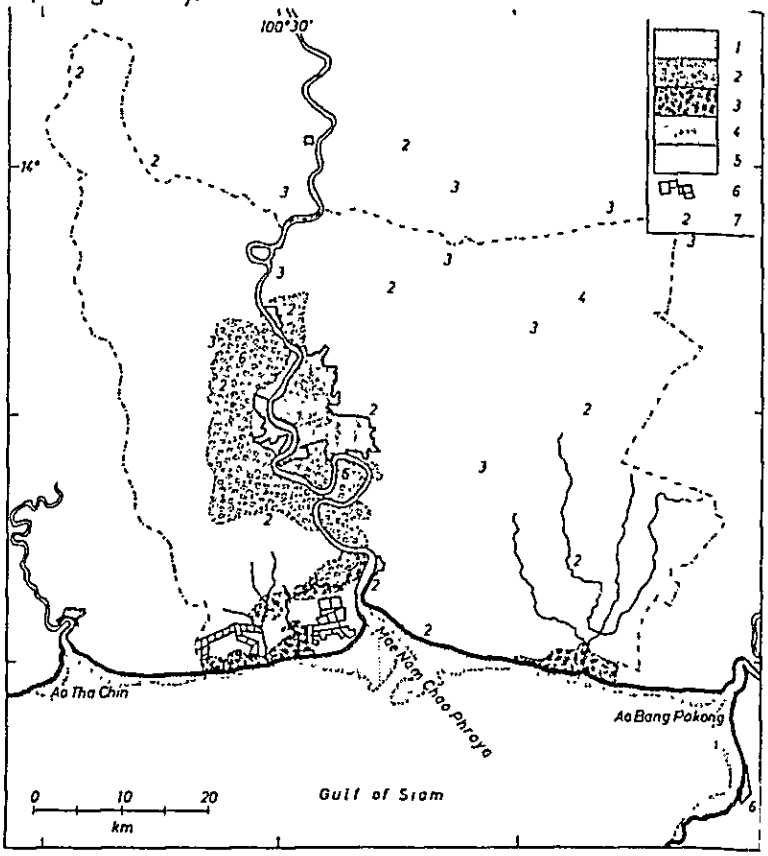


Fig. 136. *Physical orientation map of Greater Bangkok.*
Legend: 1=tidal flat, dry at low water; 2=fruit gardens; 3=mangrove, nipa, and other swamps; 4=densely built-up area; 5=mainly rice fields (paddies); 6=salt works; 7=altitude above mean sea level.
(Base map 1:250,000; other sources.)

b) コン・ケン

(a) Topography

Due to its surface structure, the North-East of Thailand can easily be marked off from the rest of the country and the neighbouring political units. Roughly speaking, the region is bordered by the Mae Nam Khong (Mekong) in the north and the east, by the Phnom Damrek Range in the south and by the Phetchabun Mountains in the west. It seems that the mountainous barriers in the south and especially in the west have been obstacles of greater importance than the mighty Mekong which never posed a really insurmountable hurdle. Geopolitically, this topographical shape has always influenced and is still influencing the ethnic, political and economic situation of Thailand's north-eastern provinces. A hypsometric analysis is given in table 114.

Table 114. *Hypsometric analysis of North-East Thailand*

Altitude (metres a.m.s.l.)	*Area (km².)*	*Area(%)*
sea level to 100	170	0.1
101–200	107,072	62.9
201–500	48,345	28.4
501–1,000	11,575	6.8
above 1,000	3,064	1.8
Total	170,226	100.0

Source: Gravimetric analysis by the author.

The western boundary of the region which comprises an area of 170,230 km². or 33.1 per cent of the kingdom, is mainly formed by the *Phetchabun Range,* a mountainous area of mixed geological composition. From the Mekong valley in the north to the Saraburi area in the south, the backbone of the Range belongs to the Ratburi formation and consists of massive limestone with embedded shale, sandstone, conglomerate and volcanic tuff. These carboniferous and Permian formations are largely surrounded by Phu Kradung formations, Jurassic and Triassic micaceous shales with siltstone, micaceous sandstone and conglomerate. Here, in the Phetchabun Range, igneous rocks can be found in places: porphyry, granite and basalt in the north (changwat Loei), porphyry and tuff between Phetchabun and Lop Buri and extended basalt deposits north-east of Lop Buri.

The mountainous barrier between the Phnom Damrek Range and the southern extent of the Phetchabun Range, in which nowadays the Khao Yai National Park is situated, is not named in any way in the more recent maps. To some extent, it could be regarded as a western extension of the Phnom Damrek Range, but there is no doubt that, geologically, the western part of what is sometimes called the *Sankambeng Range* is quite different. The Khao Yai National Park is situated upon a huge porphyry massive, unique of its kind in this area. The *Dong Paya Yen Mountains*, finally, which are mentioned in older maps, designate a range of foothills in the south-west corner which geologically are a continuation of the Phnom Damrek Range. For the administrative structure see figure 102, for the topographical orientation figure 103.

The *Phetchabun Range* runs nearly exactly north-south from the Thai-Laotian border in the north to the Sankambeng Range in the south where it allows road and railway to cross from the central plains to the North-East. In the north where we can speak of the Phetchabun Range proper, it is split lengthwise by the valley of the Pa Sak river. The western wing deteriorates from south of Phetchabun southward, and further on only limestone outcrops remain; the eastern wing continues to be a mountain barrier although its height rapidly becomes less. This part may, wholly or

partly, be identical to the ancient Dong Paya Yen Mountains. North of Lom Sak, the Phetchabun Range converges into a number of rather high mountains, and whereas the Pa Sak river drains to the south, the rivers of this area flow immediately north into the Mekong.

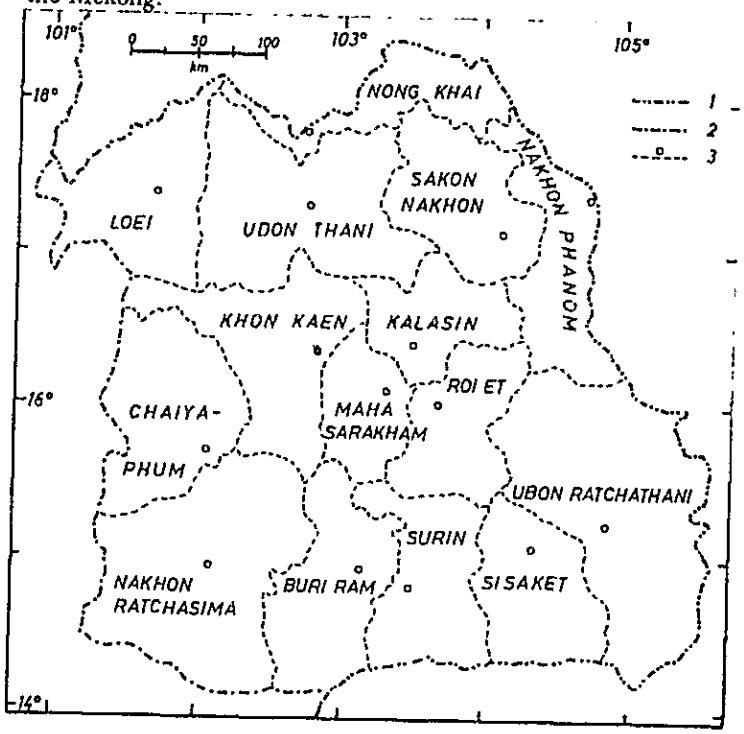


Fig. 102. *Administrative map of North-East Thailand.*
Legend: 1 = national boundary; 2 = regional boundary; 3 = changwat boundary with administrative centre.

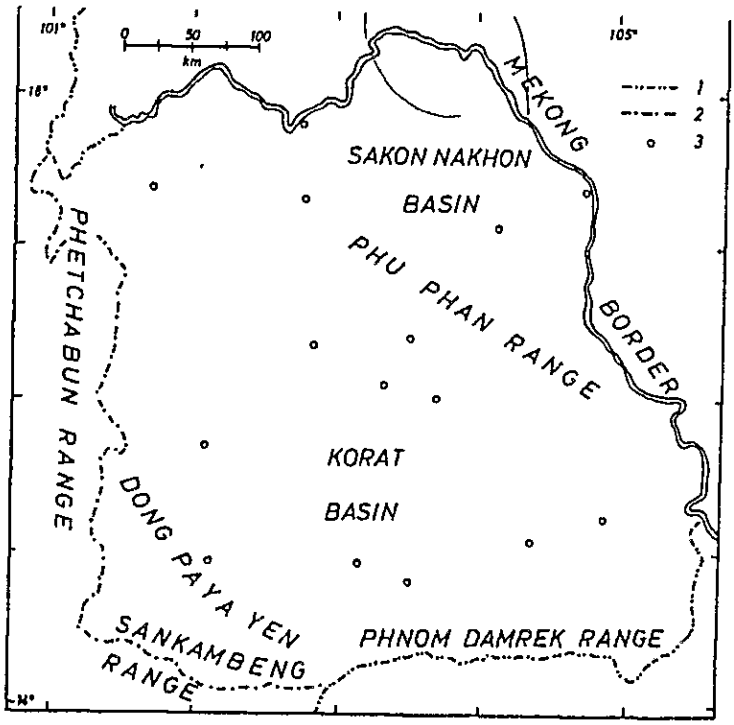


Fig. 103. *Physical orientation map of North-East Thailand.*
Legend: 1 = national boundary; 2 = regional boundary; 3 = changwat administrative centre.

The highest elevation of the whole massif is situated north-west of Lom Sak (Khao Paeng Ma Mountains, 1,746 m.) and belongs to the western wing where there are several other peaks surmounting 1,200 m. The eastern wing possesses a multitude of rather high mountains which partly appear as monadnocks like the Phu Kradung (1,316 m.) or the Khao Laem Kha (1,191m.). The highest elevation of the eastern wing is the Phu Luang (1,571m.) in changwat Loei. In the southern part, the range descends to less than 300 m. The total length from the valley of the Lam Takhong, near Pak Chong, to the bend of the Mekong north of Loei measures 350 km.

The Phetchabun range still presents an obstacle to traffic between the central plains and the North-East. Historically the first and until now the most important breakthrough for road and railway lies in the south where, between the proper Phetchabun Range and the Sankambeng Range, a pass of less than 500m. altitude allows comparatively easy access to the Korat Plateau.

Further north, a road and a railway connect Lop Buri with Chaiyaphum through the range; in the extreme north, the northern continuation of the Phetchabun road crosses a rather difficult stretch of the range to connect Loei with the Pa Sak valley. There is, up to now, no motorable road crossing the mountain range over a distance of not less than 250 km., but an expensive mountain road is now under construction to connect the Pa Sak valley at Lom Sak with Khon Kaen in the North-East.

The *Dangrek* or *Phnom Damrek Range* forms the border between the Khmer Republic (Cambodia) and Thailand's North-East region. It extends to less than 300 km. from the Chong Ra Phet (pass) in the west to the Chong Bok in the east where the boundaries of Thailand, Laos and the Khmer Republic meet. This stretch of flat hills consists of Phu Phan and Phra Wihan formations of massive sandstone and conglomerate, micaceous shale and siltstone. North of the range, hills of basalt rocks present an interesting change in the geological picture. Between south of Nakhon Ratchasima and south of Ubon Ratchathani, at least eleven important basalt hills have been found, among them Dongi Chan Yai (293 m.) and the Dongi Chan Noi (290 m.) in changwat Buri Ram. Further east there is the Khao Phanom Rung (377 m.).

The characteristic of the range is its gentle slope to the north in contrast to its steep declivity towards the south. Approaching the border from Thailand, the slow rise in elevation can hardly be realised. But once the frontier which runs along the crest line is reached, the steep slope to the south can easily be recognized.

Compared with the Phetchabun Range, this chain is modest in its elevations. The highest point lies in the extreme east at 756 m. of altitude (mountain without a name) but there are a few points over 600 m., namely Phalan Sung (670 m.), Phanom Ai Nak (638 m.), etc. in the eastern part of the range.

Quite a number of trading passes cross this chain but hardly any have real importance since they are not sufficiently developed for motor traffic. From the Thai side, the border crossing south-east of Surin (Ban Dan) is well maintained and shows a modest trade, but the all-weather road stops on the Khmer side.

The flat bowl of the North-East which covers the area between the marginal mountains and the Mekong river is split into a large and a small portion by the *Phu Phan Mountains*, visibly stretching between the Mekong near Mukdahan and the area south-east of Udon Thani. In fact, this folded range originates in the centre of the plateau and extends east into Laos, crossing the Mekong on the way and causing narrow channels and rapids in the river bed at Khemmarat, south-east of Mukdahan. Similar to the Damrek Range, this mountainous chain also consists of Phu Phan formations (which derive their name from here), sandstone and conglomerate, shale and siltstone. However, in certain central parts, Jurassic and

Triassic formations (Phu Kradung formation) appear.

The mountains which are the dominant topographic feature of the north-eastern plains are generally flat-topped, but numerous streams have cut deeply into the material. Therefore the appearance of the range is mature to old-aged in the erosional cycle. Reliefs of 300 — 500 m. appear specially rugged because they rise immediately from a low-lying alluvial plain. The highest elevations of the otherwise flat massif appear north and north-east of Kalasin. The highest mountains seem to be Phu Lop Wai (695 m.), Phu San Pa Yang (666 m.) and Phu Lam Chang (641 m.).

Some of the small streams which emerge from the range developed, in their upper basins, intermontane valleys or bowls due to erosion, as can be found in the upper valleys of the Huai Bang Sai in the east and of the Nam Yang in the centre of the massif.[8] Though the mountains form the hydrological divide of the north-eastern basin, it is no longer a traffic barrier since a state highway connecting Kalasin and Sakon Nakhon has opened up the area. Nevertheless, it cannot be denied that huge parts must still be regarded as remote and off the beaten track, and that terrorist groups seem to have their hiding places here.

The plains are summarized under the term *Korat Plateau* though this simplifies the facts. Actually, the wide and shallow basin which lies between 100 and 200 m. above sea level and which is interrupted by flat hills rising in only a few rare cases to more than 300 m., can be divided into two clearly defined sub-regions, the southern *Korat Basin* which is drained by the Mune/Chi system, and the northern *Sakon Nakhon Basin* which is drained by the Songkhram river. These rivers have their own access to the Mekong.

The bedrock of the plateau consists of cretaceous rocks such as sandstone, shale and siltstone, and there are considerable layers of rock-salt and other salt-bearing strata like gypsum, especially in geological depressions. Earlier geological investigators came to the conclusion that the Korat group sediments (salt and Khok Kruat formation, Phu Phan and Phra Wihan formation, Phu Kradung formation) were deposited on an underlying erosion surface during Mesozoic time.[9] The main valleys of the Mune and Chi rivers, and to some extent also the Songkhram valley, are of alluvium, eluvium and river gravel.

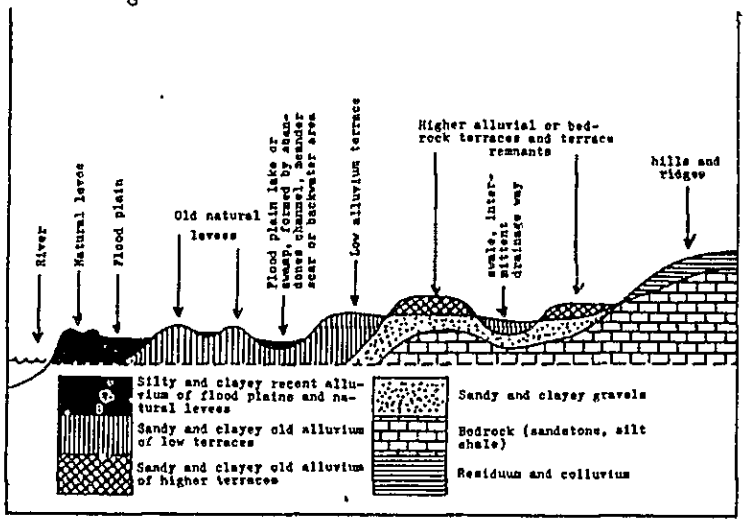


Fig. 104. *Idealized cross-section illustrating relationship between landforms and substrata material of a river plain and adjoining area (the Mekong at Pa Mong).*

The plains in the North-East are much influenced in their appearance and economic suitability by the rivers. The Mekong

offers especially interesting landforms which are also typical along the tributaries and actually can often only be understood in considering both the influences from the Mekong and its tributaries. In the immediate neighbourhood of the streams are the flood plains. often dotted with natural levees which are 1-5 m. higher. The plains are subject to regular floods, but the levees are not flooded except in extreme cases. Above these levels are the alluvial and bedrock terraces. The former have a width of 0.5-3 km. but reach normally not much more than 3 m. above the flood plain. The higher alluvial terraces or bedrock terraces finally reach up to higher altitudes, are free from floods but at the same time have only a thin layer of good soil and are hardly accessible for gravity irrigation.[10] See figure 104.

Due to the fact that the plateau has a very flat gradient, the drainage of rain causes considerable problems and extensive parts are covered with swamps, specially in the Sakon Nakhon Basin.

c) ナコン・サワン (*a*) *Topography*

The core of the sub-region is the "central plain", that is, the *flood plain* of the Mae Nam Chao Phraya and its tributaries, a very flat landscape with a hardly perceptible gradient. The 100m. contour line runs no less than 470km. north of the Gulf coast (Bangkok), when we follow the axis of the plain north to Si Satchanalai, changwat Sukhothai, on the border of the sub-region. Going from the Gulf coast north-west into the valley of the Mae Nam Kwae Noi, we remain for over 240km. below 100m. of altitude. The width of the lowland in the central valley ranges from 200km. in the southern part to 150km. in the middle and 60km. in the north. The valley of the Mae Nam Khwai Noi is, in contrast, extremely narrow.

The flood plain or lowland is framed towards the east, north and west by *marginal uplands* or foothills, low and high terraces, covered and built up mainly by sediment and debris carried down from the mountain chains. These marginal uplands usually do not exceed a width of 40 to 80km. before they reach the mountains proper: in the west the Central Cordillera, in the north the northern folded mountains and in the east the Phetchabun Range.

The plains and marginal uplands, however, do not present a picture of uninterrupted uniformity. They are dotted towards the west and north with *inselbergs*, small chains and groups of steep rocks rising precipitously from the lowlands or the marginal terraces. When travelling north from Bangkok, such outcrops appear at Phra Phutthabat, changwat Saraluri, where Khao Phlong suddenly rises up to 592m.; when travelling west, Khao Ngaem and Khao I Thao, near Ratchaburi, form similarly impressive rock hills, walls and peaks. But this is a phenomenon that appears again and again on the central plain, the inselbergs often being crowned by a *chedi* or monastery, offering an interesting view over the cultivated landscape of the lowlands. Between Nakhon Sawan and the Phetchabun Mountains, a number of small limestone massifs rise from a plain of about 50m. above sea level to several hundred metres: Khao Khok (498m.), Khao Soi Dao (558m.) and Khao Wang Plae (651m.) for instance.

More complicated than the plains and the marginal uplands is the structure of the *bordering mountain chains*, the geological composition of which can be taken from the latest geological map of Thailand.[1]

The western mountains are inhabited only by hill tribes who rarely have permanent settlements; they are barely accessible except on foot or by boat along certain rivers, and they have hardly been surveyed. The area is still densely forested and aircraft investigation faces the difficulty of frequent cloud and heavy rainfall

in this part of Thailand. Therefore, even detailed maps do not give proper names of the various ranges and many mountain peaks that have been named have not been measured; furthermore, there is some contradiction in the denominations which can be found in different maps. Some maps call the whole Central Cordillera simply Tenasserim Range, others give this name only to the portion south of the Three Pagoda Pass, and again others call this portion Bilauk Taung Range. This may partly be explained by the fact that Thais and Burmese give different names to the same mountain chain. Following the descriptions by Credner and Pendleton it seems reasonable to divide the mountains west of the Chao Phraya plain as follows.[2]

The northern main chain is the *Thanon Thong Chai Range* that originates south of the valley of Mae Sariang at about 18°N. running NNW to SSE as far as about 15°N. where it descends over hills and terraces towards the east and south to the flood plain of the Chao Phraya. So this range stretches over a distance of more than 300km., declining towards the west to the valley of the Mae Nam Moei, a main tributary to the Salween system, the valley of which is flanked by the Dauna Range in Burma. Here, therefore, the Thai-Burmese border is not identical with the watershed. The Thanon Thong Chai Range is between 75 and 100km. wide and can be crossed along a motorable road between Tak and Mae Sot, following one of the old trade routes in this area which, however, comes to an end at the Mae Nam Moei.

A substantial part of the range rises above 1,000m. Khao Mokochu, 1,960m., situated 115km. west of Nakhon Sawan, is said to be the highest peak, though there is a nameless small massif 60km. south-west of Kamphaeng Phet rising to about 2,190m. The morphology of the Thanon Thong Chai Range is determined by folds generally striking NNW to SSE that are, however, modified by the direction of the river systems crossing and cutting it. Particularly towards the south-east, the gradient of the range is quite steep. For instance, the distance from the Khao Nam Yen (1,530m.), west of Uthai Thani, to the foothills of 150m. elevation is not more than 14km.

The rivers have cut deep valleys; for instance the Huai Kha Kaeng, running north to south, has a valley bottom of less than 400m., with elevations of more than 1,200m. on either side. Generally, the rivers flow through precipitous canyons or restricted valleys rarely more than 1 or 2km. wide, an exception being the Mae Nam Moei, where, on the Thai side, amphoe Mae Sot is situated with an extensive cultivated plain. The Huai Kha Kaeng, the main tributary to the Mae Nam Khwae Yai, rises between 15° and 16°, where the range comes to an end with a mass of high and most difficult peaks. And at this point, the main range breaks into three distinct ridges: the Thanon Thong Chai Range proper (which here slowly flattens into the Chao Phraya plain), the Tenasserim Range, and the Meklong Mountains.

Geologically, massive light grey limestone predominates along the border and towards the Chao Phraya plain but there is a broad core of carboniferous granite stretching from the Mae Sariang area south over 135km., and again from the Tak area 200km. south, interrupted by smaller stretches of shale and sandstone, conglomerate, marine formations and semi-consolidated deposits. Towards the south-eastern outskirts of the massif, Tertiary basalts occur north of Kanchanaburi.

The *Meklong Mountains* follow the southern spurs of the Thanon Thong Chai Range to the west, striking in the same NNW to SSE direction which corresponds to the flow of the main rivers Mae Nam Khwae Yai and Mae Nam Khwae Noi; these join at Kanchanaburi to form the Mae Nam Mae Klong which emerges into the Gulf at Samut Songkhram. The Meklong Mountains show

in a particularly clear way the morphogenetic relations between the mountains and the adjacent areas towards the east and, here, also towards the south, which belongs to the marginal area of the Chao Phraya plain.

When approaching the mountains from the east, one must cross the marginal terraces where the high lands are spatially limited by the expansion of the surrounding plains. In these plains, a long series of buttes and inselberg-type hills follow the strikes of the folded structures. Behind Kanchanaburi the mountains appear rather abruptly and the alluvial plains gradually become narrower and narrower as one proceeds on the Khwae Yai and the Khwae Noi. Along the eastern tributary, the Khwae Yai, the valley is wider than along the western tributary, and along this smaller western tributary the fall of the stream is steeper. This is explained by the fact that, towards the west, the Meklong Mountains pass into the Tavoi Chain, part of the Tenasserim Range which rises here to 1,328m. (Tan Daung) on the border between Thailand and Burma. Within the Meklong Mountains, a relic of old flat topography with low relief lies between Si Sawat on Khwae Yai and Sankhlaburi on Khwae Noi. Older, mature hill land, at an elevation of 600m., is surrounded by mountains about 900 to 1,000m. high which are mostly made of limestone.[3]

Farther to the west we enter the schistose zone along the Burmese border with no relics of the old mature flat reliefs. There is no limestone through which water can percolate, preserving the original forms. In addition, the range is exposed on its western flanks to the south-west monsoon which brings great quantities of rain, causing erosion and denudation. And the powerful tributaries of the Khwae Noi, because of the steep slopes and the large quantities of water, have cut channels upstream most intensively and closest to the highest elevations. Along the Burmese border, the valleys of small tributaries of the Khawe Noi show slopes that lose 1,020m. over a horizontal distance of 6km., and between the two watersheds of Khwae Noi and Khwae Yai, near Khao Yai (1,739m.) a loss of 1,130m. over only 3km. has been measured. As a result only young landscape forms occur, and a long row of high peaks characterize the mountains along the boundary with Burma, rendering any kind of transport and communication extremely difficult.

Highest elevations within the Meklong Mountains, apart from the border peaks, are Khao Tong Thai (1,755m.) and Khao Yai (1,739m.). Geologically, the Meklong Mountains consist in their core of deposits of the carboniferous and Permian Ratchaburi Group: massive light grey limestone interbedded with shale, sandstone, mudstone, conglomerate and volcanic tuff; but there are long strips and islands of Triassic granite and granodiorite, Devonian and Silurian shale, sandstone, in many places metamorphosed, as well as Tertiary semi-consolidated fluviatile, marine and non-marine deposits of clay, sand, marl, etc. Towards the west, the geological composition becomes that of the Tenasserim Range.

The *Tenasserim Range* (also known as Tanaosi or Bilauk Taung Range), the westernmost of the three chains, covers a distance of approximately 400km., beginning at the Three-Pagoda-Pass (Phra Chedi Sam Ong) at 15°18′ N. and forming the watershed between Burma and Thailand south to about Prathuap Khiri Khan between 11° and 12° N., the narrowest part of the kingdom, where peninsular Thailand begins. Thus, the Tenasserim Range partly encloses the Meklong Mountains in the west, as has been shown.

A number of the highest peaks serve as border stones, among them Ngayannik Yuak Taung 1,531m.) and Palan Taung (1,455m.). This range, also sparsely inhabited and widely covered with impenetrable forest, declines rather steeply to the east, i.e.

Thailand, where there is only a narrow distance of 12 to 100km. to the shoreline. The range itself continues through Burma to the Andaman Sea, split into various chains, particularly by the mighty Tenasserim River.

The farther we go south, the closer the main range runs to the Gulf coast, but in the northern section the central granite chains of the Tenasserim Range, that run along the border crest, are supplemented by limestone chains, single mountains, and outcrops on the coastal plain. The most spectacular is the "Mountain-of-the-300-Peaks" (Sam Roi Yot), immediately on the shore at 12°13′ N., culminating in Khao Sam Roi Yot (588m.), a historic landmark for sailors.[4]

Seen from the coastal plain, the Tenasserim Range and its spurs appear rather impressive and forbidding, occasionally rising up to 500m. over a distance of a few kilometres. Geologically, it has a spine of cretaceous granite and granodiorite with a broad zone of Keng Krachan formation, extended in front of it towards the east, a thick sequence of poorly bedded greywacke, mudstone and siltstone. Sandstone occurs locally. It is a group of well bedded black and grey shale and light coloured sandstone.

Towards the north, the central plain is bordered by another strip of marginal uplands and terraces, foothills of the *northern folded mountains* with similar characteristics described earlier: it is limited in extent and very much interrupted by outcrops of rocks, low hills and mountains which suggest that bedrock lies not far below the alluvium, and since much of the surrounding marginal region has been formed as a result of rising crustal movements of the earth only those areas with predominantly low relief and a generally prevalent accumulation of alluvium can be considered as belonging to the marginal plains. In this sense the share of those marginal plains *vis-à-vis* the low-lying flood plain of the Chao Phraya is increasing towards the north and has a substantially higher impact on the landscape and its potential in the Upper than in the Lower Central Region.

In the north, these uplands are surmounted by mountainous chains (northern folded mountains). The westernmost, the Thanon Thong Chai Range which can be followed down to the peninsula, has already been described. The other northern chains were analysed only recently but it can already be deduced from their geological structure how and to what extent they penetrate into the Upper Centre. The Khun Tan Chain, running between the rivers Ping and Wang, with its broad granite zone, advances southward into the area of Tak. The Phi Phan Nam Mountains, between the rivers Wang and Yom, with predominant permo-carboniferous limestone, can be followed south into the area of Uttaradit and northern Sukhothai. Finally, the north-easternly Luang Prabang Range with sandstone formations runs far south and forms part of the Phetchabun Range, thus enclosing the upper central plain from the east. This brief enumeration merely serves to indicate to what extent the mountainous framework encloses and penetrates the plain, whereas the mountains will be described in detail in the sections on North and North-East Thailand respectively. However, the Central Region encloses a substantial part not only of upland but also of mountain chains and high peaks, as indicated in the topographical map (figure 44). The relationship of the different strata of altitude in the region is given in the form of a hypsometric chart (table 44).

The *central plain* proper, i.e. the flood plain of the Chao Phraya and its main tributaries, is extremely flat. Geologically alluvium, eluvium, valley fill and river gravel reach from the foothills of Kanchanaburi in the west to Kabin Buri (South-East sub-region) over a distance of 230 km. in the south of the region. Off Nakhon Sawan, this stratum is narrowed to less than 50 km. because of intruding mountains, but it widens again farther north where it

Table 44. *Hypsometric analysis of Central Thailand*

Altitude (metres a.m.s.l.)	*Area km².*	*Area (%)*
Sea level to 100	62,612	43.3
101—200	21,401	14.8
201—500	29,065	20.1
501—1,000	26,607	18.4
Above 1,000	4,916	3.4
Total	144,601	100.0

Source: Gravimetric analysis by the author.

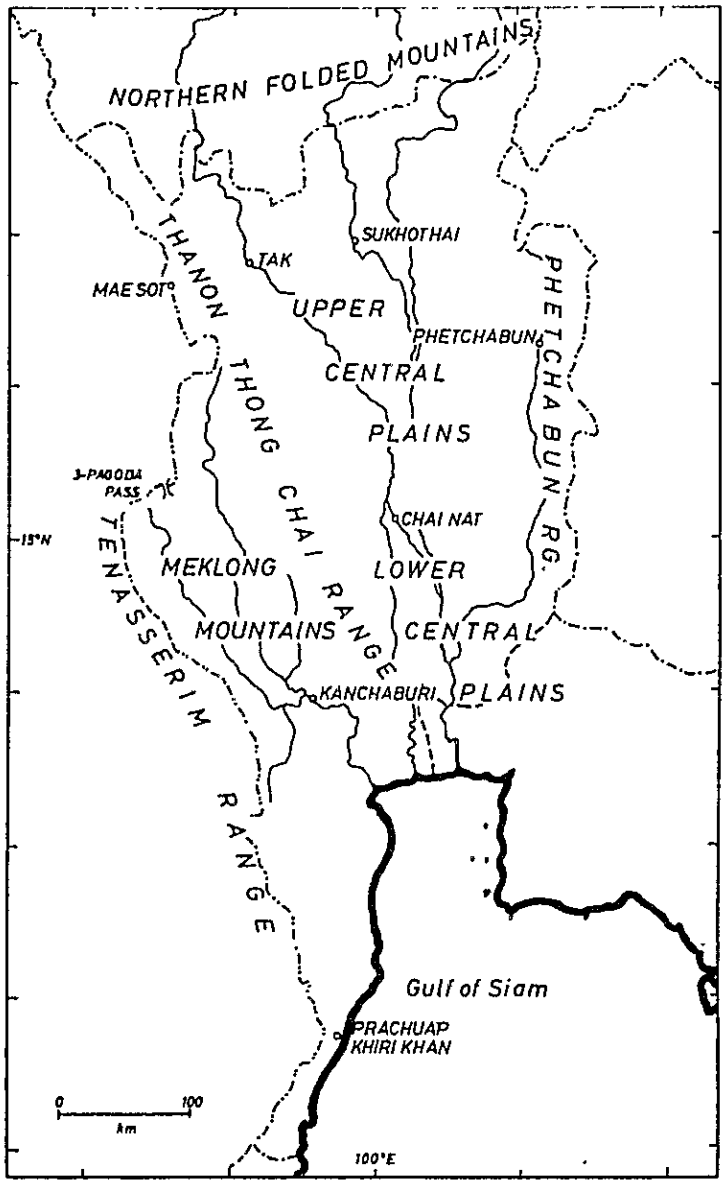


Fig. 44. *Physical orientation map of the Upper and Lower Central Region*

reaches 130 km. off Khampaeng Phet. Other alluvial plains stretch along the Gulf coast (Phetchaburi), along the valley of the Pa Sak river (Phetchabun) and the Ping river (Tak) but generally come to an end at Uttaradit.

Morphologically, the central plain is highly interesting despite its dull appearance with flat rice fields over hundreds of square kilometres. First of all, it can be divided into the "true plain of aggregation" and the "plains of deposition".[5] The former, as far as it lies above sea level, comprises a crescent reaching from the mouth of the Mae Nam Mae Klong in the west to Lopburi in the north and the mouth of the Bang Pakong in the east. This plain is purely one of aggregation and has been built up in an apparently synclinal depression reaching from the north to the south and farther into the Gulf of Siam. Borings to a depth of 125 m. in the Bangkok area at the beginning of this century revealed that the alluvium was composed of alternating silts, sands and clays, but the borings did not reach the bedrock. At present, ground water specialists estimate the depth of sediment underneath Bangkok as not less than 300 m.

The filling up of this depression was due to combined marine and river sedimentation continuing obviously for a very long time, and it becomes understandable that Lop Buri, 120 km. north of the present coast line and built at the edge of a sandstone massif facing the alluvial plain, was once a sea port.[6] Not far off the shore line, there is a flat sand bar composed of a series of sedimentary reefs which have been built up by the surf of the south-west monsoon (an onshore wind) much to the annoyance of sailors, as will be explained in the section on Greater Bangkok. The river carries down fresh water with suspended silt which mixes with sea water in the lagoon between bar and coast where the finer material settles, gradually filling the depression. In the course of time, the surf has built up successive off-shore bars, each with a sheltering lagoon, and inland material was brought down by the large rivers, the currents of which increase especially during ebb tide. This process, which can be seen going on in the South-East (Rayong) and along the peninsular east coast (Chumphon, Songkhla), has developed most impressive dimensions in the Chao Phraya delta which extends an estimated 4.50 to 6.00 m. farther south each year.

Consequently, the aggregation plain is extremely flat. In Bangkok, 30 km. inland, the streets lie 1.80 m. above mean sea level; in Ayutthaya, 70 km. inland, the land lies 4 m. and in Nakhon Sawan, 250 km. inland, about 25 m. above mean sea level. This is equivalent to a gradient of not more than 1:10,000.

With the appearance of the first limestone outcrops, small hills and chains rising precipitously from the plain, we have reached the plains of deposition where these hills show that the bedrock is not too deep under the alluvial deposit. Usually, its thickness remains between 10 and 15 m.

The *coasts* of the Central Region may be divided into two forms: the outer coasts and the inner coasts. The former are fully exposed to the breakers of the open sea which build up dunes of fine and coarse sand, often of considerable height. This makes it difficult for rivers to break through to the open sea. Such sand coasts predominate along the western shores of the Gulf between Phetchaburi and Prachuap Khiri Khan, only occasionally interrupted by stretches of mud, but frequently used for the establishment of holiday resorts, Hua Hin being the oldest and best known among them. The inner coasts are protected by bights, estuaries and islands, and a broad band of mud extends in front of them; this becomes dry during ebb and is covered only slightly during flood, thus keeping the surf down to a moderate force. These coasts are characterized by a dense vegetation (mangroves, nipa), typical of the northern shore of the Gulf, including the mouths of the Mae Nam Mae Klong, Ta Chin, Chao Phraya and Bang Pakong.

d) ナコン・シタマラート

(a) Topography

The general feature of the South is characterized by the mountain-chains running roughly north to south and mostly dividing the peninsula into a western and an eastern part (see figure 77).

The extreme north of the region is formed by the southern spurs of the *Tennasserim Range*, the main massif of which extends from the west of the Lower Central Region (about 14°N.) down to the area of Prachuap Khiri Khan (about 12°N.). From here, the border mountains turn towards the south-west in a sharp bend, and a chain of rather low mountains, reaching up to 833m. at the highest, runs towards the southern tip of Burma at Victoria Point.

From the upper reaches of the Mae Nam Kra Buri, near about 11°N., the border range may be described as splitting and thus forming an eastern wing running south; at this point is the beginning of another long mountain system, the *Phuket Range*. This mountain chain is one of the two main systems which run lengthwise through the peninsula, close to the west coast and south to the island of Phuket. It finally dives into the Andaman Sea, a few islands of the Archipelago of Phuket being the tops of submersed mountains. The total length is roughly 400km. and the width ranges from 25 to 75km.

The mountains form a rather well-closed, uninterrupted barrier, thus locking off the west coast from the eastern coastal plains. The mountains are generally smoothly shaped and reach heights of 600 to 900m., outstanding peaks being Khao Plai Bang To (1,050m.) and Khao Phra Mi (1,138m.).

The Phuket Range leaves little room for a coastal plain along the west coast; there are few settlements and a comparatively small area under cultivation. In addition, the heaviest rainfalls of Thailand occur here and render development work, to some extent, more difficult than it is along the east coast. Nevertheless, Thailand's tin mining is concentrated in this area. Where there is no human activity, evergreen tropical rain-forest covers the slopes making them impenetrable. Man has succeeded in cutting three most important connections through from the east to the west, namely the Isthmus Road from Kra Buri to Chumphon, the road from Takua Pa to Surat Thani, and the Phet Kasem Highway which crosses the range in its southern part near Phangnga.

The range also contributes to the physical shape of the famous *Isthmus of Kra*, the narrowest part of the Malay Peninsula between the estuary of the Mae Nam Kra Buri and the Gulf of Siam, Sawi Bay. Here, the width of the peninsula measures no more than 40km. and the mountain chain is crossed by the road at a maximum height of about 75m.

Nearly parallel to the Phuket Range, but about 100km. to the east, runs the Nakhon Si Thammarat Range, briefly called the *Nakhon Range*. The northern origin of this mountain massif lies under water in the Gulf of Siam, marked by a few islands such as Ko Samui, Ko Pha-Ngan, and Ko Tao. It stretches exactly southward towards the south-westernmost changwat of Satun where it comes to an end along the Malaysian border. The most impressive peak lies near the town of Nakhon Si Thammarat; it is named Khao Luang, 1,833m. high (according to various American maps) and is thus the highest mountain of the region.

A part of the range, the massif between Surat Thani and Nakhon Si Thammarat, bears a number of other outstanding peaks such as Khao Yai (1,438m.), Khao Nan Yai (1,410m.), Khao Khi Mot (1,330m.), etc., but different sources often give different altitudes.

Thus the Nakhon Range forms here a considerable barrier, but it quickly loses height towards the south. Between Thung Song and Trang, the range hardly surpasses 500m. and never reaches 800m. in the part down to the border. Nevertheless, the southern parts of the range are rugged enough to render road construction a difficult and costly enterprise. Though having an average height

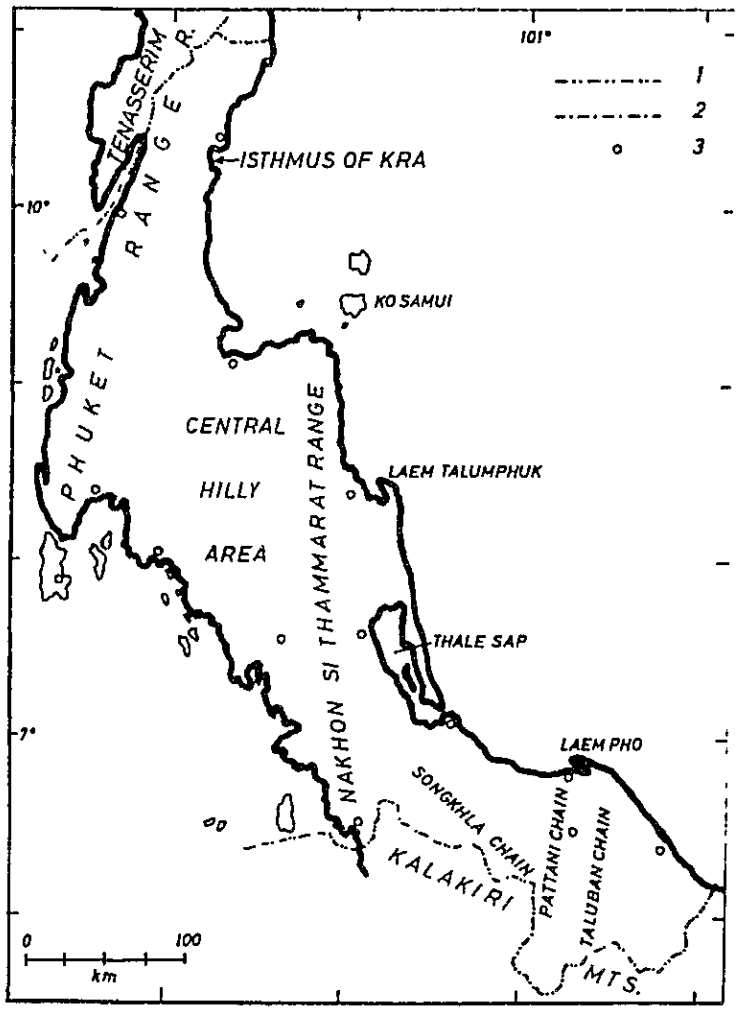


Fig. 77. *Physical orientation map of South Thailand.*
Legend: 1=national boundary; 2=regional boundary; 3=changwat administrative centre.

lower than the Phuket Range, the Nakhon Range also constitutes an important barrier which is broken through at present by only three motorable roads: the connection from Trang to Nakhon Si Thammarat, from Trang to Phatthalung, and from the area of Hai Yai to Satun.

Extensive parts of the Nakhon Range are covered with jungle and are largely uninhabited. To the east, it forms the limit of an extensive coastal plain which is of great economic importance.

To the west, between the massifs of the Phuket and the Nakhon Ranges an area remains which is partly rather flat land (the watershed of the Mae Nam Ta Pi system), but to a great extent filled with isolated peaks, limestone outcrops and small groups of mountains, all of them rising sheer out of the flat land. This area could be called the *Central Hilly Area*. The outcrops touch in the north, east of Phangnga, the western slopes of the Phuket Range, and at places form small but impressive mountain massifs, 300 to 500m. high, the most important one being Khao Phanom Bencha (1,350m.), south-east of Phangnga, which can easily be seen from the main road before and after Krabi. These intermittent hilly stretches with impressive limestone obstacles possess several clearly visible topographical walls hampering traffic considerably; they have few inhabitants and extensive areas with forest, shrub and wasteland, but on levelled valleys or soft slopes new rubber plantations have been developed recently. Though not forming an

uninterrupted mountain chain, the Central Hilly Area clearly shows an alignment which can be followed to the south where the same hills reappear on the island of Ko Lanta and minor islands south of it.

The border to the South is marked by a massif called the *Kalakiri Mountains* which mainly lies in Malaysia, but still has some spurs which run north into Thailand. The highest peaks on the border are Ulu Titi Basah (1,535m.) and Gunong Ulu Merah (1,452m.), both east of the border district of Betong. The summit of the Kalakiri massif lies at 5°14′ N. and 101°35′ E. and is Gunong Chamah (Karang) (2,176m.) on Malaysian territory. The massif is split up into a number of folds running south to north which penetrate Thailand and form the watersheds of some important rivers of the extreme south. The outstanding Pattani River is flanked by the *Pattani Chain* in the west and the *Taluban* (or Belubin) *Chain* in the east; the first range partly forms the border to the Kedah State of Malaysia and reaches an altitude of 1,266m.; the second range runs down from the highest border mountain mentioned earlier. To the east of the Taluban Range, the valley of the Sai Buri River extends farther into the coastal plain, occasionally interrupted by rather isolated hillocks and reaching a maximum altitude of 830m.

West of the Pattani Range, several minor rivers (Khlong Tha Pha/Khlong Nam Khan, Sa Kaum/Khlong Muang Hong, Khlong Lam Yai) flow from the Kalakiri Mountains towards the north. There is also a rather low spur formed by a number of low hills, called the *Songkhla Chain*[3].

A characteristic phenomenon all over the peninsula but most impressive on the eastern coastal plains consists of isolated *inselbergs*, single mountains, small groups of mountains or chains, reaching up steeply from the surrounding flat plain to altitudes ranging up to more than 400m. (for instance Khao Chia Buri, Phatthalung province, with 403m.). Generally, these precipitious buttes or crags consist of a fairly solid limestone. At first glance, it seems as though these crags are islands around which land has developed. Actually, as Credner observed, they are residuae of a gigantic process of river and creek erosion which removed the material between the remaining stocks by sheet erosion[4].

For an explanation of the existence of the crags this interpretation is certainly very useful and understandable. The traveller of the present time, however, sees many of the hills covered with rather thick vegetable growth, and even the isolated, steep and pure limestone crags are mostly no longer free of a plant cover which may support the slow process of disintegration of these gigantic geological monuments, a process, however, which, for the present, will hardly change the relation between steep rock and flat ground.

As counterparts to the mountains, the region possesses a number of marked *plains*, the most extensive and most important ones being along the east coast of the peninsula.

The west coast which extends from the Mae Nam Kra Buri estuary south-east towards the Thai-Malaysian border, hardly contains in its northern part plains worth the name. Here, the Phuket Range runs very close to the coast which is often covered with mangroves. In places, not much room is left beyond the main road. Where rivers have formed a low-lying delta, coastal plains extend somewhat deeper into the interior (as at Kapoe, Takua Pa) but the distance from the coast to the 100m. contour is rarely more than 10km., and the plain itself is often dissected by streams and swamps or is broken up into islands.

South, east, and south-east of Phangnga, such plains are more numerous though hardly larger; south of the Khao Phanom Bencha, the coastal area extends to nearly 100km. but is strongly dotted with limestone hillocks. South of Trang, finally, the coastal plain is

clearly defined by the Nakhon Range and extends to a maximum width of 50km.

Surprisingly, the narrow coastal strips farther north seem to be better cultivated, growing rubber and coffee, whereas the broader plains are still covered with dense forest and muddy mangrove swamps along the sea and generally lack transport facilities. Only recent surveys have revealed that here also rubber plantations are spreading.[6]

The eastern coastal plains present a different picture. Here the flat and sandy landscape predominates over the full length of the region from Chumphon to Narathiwat and though limestone towers or small mountains may interrupt the picture now and then, the mountain ranges never actually characterize the coastal line as they do in the west.

In the changwat of Chumphon, the coastal strip is narrow (as is the whole province), and though the border mountains with Burma lie up to 40km. from the coast, the area between them and the sea is largely dotted with minor chains and hills reaching up to 100 and 200m., and thus the strip does not form a proper plain. South of the town of Chumphon, the limestone outcrops decrease in number, and a plain develops which stretches over more than 150km. south without meeting a mountain barrier. This plain reaches a width from east to west (Phuket Range) south of Surat Thani of more than 100km. Taking the 100m. contour as the limit and including the upper valleys of the Mae Nam Khiri Rat, the width would even be 150km.

South of Surat Thani, the topographical picture changes again. In the east a new range of hills emerges from the sea and runs south; it contains a number of remarkable peaks (Nakhon Range), splitting the eastern plain in two. The plain along the coast is now again very narrow (5-45km.), but west of the range the lowland extends nearly to the west coast, interrupted only by a few ranges and limestone hills (Central Hilly Area). This inner plain accommodates a railway line.

Towards the south, the coastal plain increases while the inner plain shrinks until it reaches the border south of Satun. The eastern plain, attaining a width of up to 60km. near Phatthalung, starts being dissected south of Songkhla where the northward running spurs of the Kalakiri Mountains come close to the sea. Here small, well-defined coastal areas come into existence.

The plains, economically used for plantations as well as for field crops and as the basis for transport lines, are economically the most important parts of the region, but mining is also carried out in the mountains and the seas on both coasts provide fishing possibilities.[7]

A hypsometric analysis of the region shows the following relations between the various altitudes:

Table 90: *Hypsometric analysis of South Thailand*

Altitude metres a.m.s.l.	*Area* (km^2.)	*Area* %
Sea level—100	45,833	65.3
101—200	11,371	16.2
201—500	9,686	13.8
501—1,000	3,018	4.3
Above 1,000	281	0.4
Total	70,189	100.0

Source: Gravimetric analysis by the author.

Theories on how these plains came into existence sometimes contradict each other. The opinion once presented by Scrivenor[8] who suggested that the extended plains of the Malay Peninsula were built up by abrasion of the sea, may today be regarded as obsolete. Credner is definite that these plains were developed from

the material continuously transported down from the mountains by innumerable rivers and creeks which filled their beds with sediments, changed them and continued the transportation process. Due to the different quantity and velocity of the water, there is a process of erosion in the river bed during the rainy season, and a process of sedimentation during the dry months.[9] As to the eastern coast of the peninsula, a slow lifting of it may also have contributed to the formation of the plains, provided this theory is correct. Credner, at any rate, judges that under a river sediment layer of 10–15m. lies the deep, weathered bedrock, the same material which also rises above the plains.[10]

The western ingression coasts probably also once had plains which are now submerged, but they formed the foundation of newly built-up sediment coasts: the river sediments sank down in the shelter of the islands and the estuaries, forming the basis for extended mangrove swamps, whereas open coasts remained sandy. Thus, the western plains remained limited.

A characteristic feature of the peninsula are the two *coasts*. To the east the Thai Coast-line measures 933km. from Chumphon to Narathiwat; to the west the distance is shorter since from Ranong to Satun, there is a coast-line (without Phuket) of 740km.

Each of the coasts has a very clearly distinguished character. The difference is partly explained by the elevation above mean sea level which is not equal in east and west, and partly by the obvious changes of this elevation. The west coast is mainly formed by mountain ranges which come very close to the sea and allow alluvial plains to develop only in a few places. Many of the river mouths' valleys have developed estuaries, most impressively the Mae Nam Kra Buri, and so the west coast can generally be called a submerged or ingression coast. A swarm of islands (archipelago) easily shows the continuation of submerged mountain ranges, the islands being the highest peaks still rising above the water level. The area between Phuket and Satun is particularly dotted with many large and small islands: the island of Phuket is close to the end of the Phuket Range, the island of Ko Lanta is the end of the Central Hilly Area of which Khao Phanom Bencha is the outstanding summit. Ko Ta Ru Tao, finally, a substantial island near the Malaysian border, belongs to the Nakhon Range which thus crosses the whole peninsula from sea to sea.

But not only the morphology of the west coast indicates submergence: remains of buried mangrove trees have been exposed in hydraulic mining many feet below the present sea level and have been found along the shore-lines of Takua Pa and Phuket.[11]

Thus, the west coast possesses few beaches when compared with the east; there are plenty of mangrove thickets along the shore, many a section is steep and hardly accessible from land.

In contrast to this, the east coast is flat and sandy, and though rocky hillocks occasionally appear close to the shore-line, the proper mountain range rises well inland. Unlike the west coast, the eastern shore has been uplifted over the ages, and therefore the shore-line recedes much towards the east, giving rise to a comparative curvature along the shore. Features indicating uplift are the marine deposits found in many limestone caves high above the present sea level; and the rocks at the foot of the mountains, now on dry land, appear to be carved by the action of sea waves.[12]

Over considerable distances, the east coast is smooth and straight, interrupted only by unimportant river mouths. Occasionally, a larger river system has built up a delta, as in the case of the Phum Duang near Surat Thani. There are a few broader river mouths which have developed economically into ports, such as the Mae Nam Pak Phanang in the changwat of Nakhon Si Thammarat.

A description of the east coast of the peninsula cannot overlook two peculiar features, namely the spits of Nakhon Si Thammarat and Pattani, and the coastal lake north of Songkhla.

The normally smooth east coast of the peninsula which is only interrupted by a small number of bights such as Ao Sawi near Chumphon and Ao Ban Don near Surat Thani, shows a few striking *spits* which are narrow, low-lying tongues of sand and shingle, projecting into the sea, but then turning approximately parallel to the coast. Such spits can be seen in a very pronounced form near Nakhon Si Thammarat (Laem Talumphuk) and near Pattani (Laem Pho). This coastal feature strongly reminds one of a similar shape along the southern coast of the Baltic Sea, where wind has blown the coastal dunes in front of a river mouth and thus created a coastal lake with a small outlet. This process has, however, not yet reached completion in the examples quoted.

The spit east of Nakhon Si Thammarat, to take this example (see figure 78), has actually developed as a prolongation of the eastern coast between both the sea and the mouth of the Mae Nam Pak Phanang. It seems as though this tongue has built up between the sea current along the coast and the current of the river along its mouth. It rises to an altitude of 6m. above sea level, is mainly covered with natural vegetation and has a clearly sandy base which becomes evident on its point and shores. The length is nearly 20km. and the greatest width is 7km. Small creeks drain the spit towards the west.

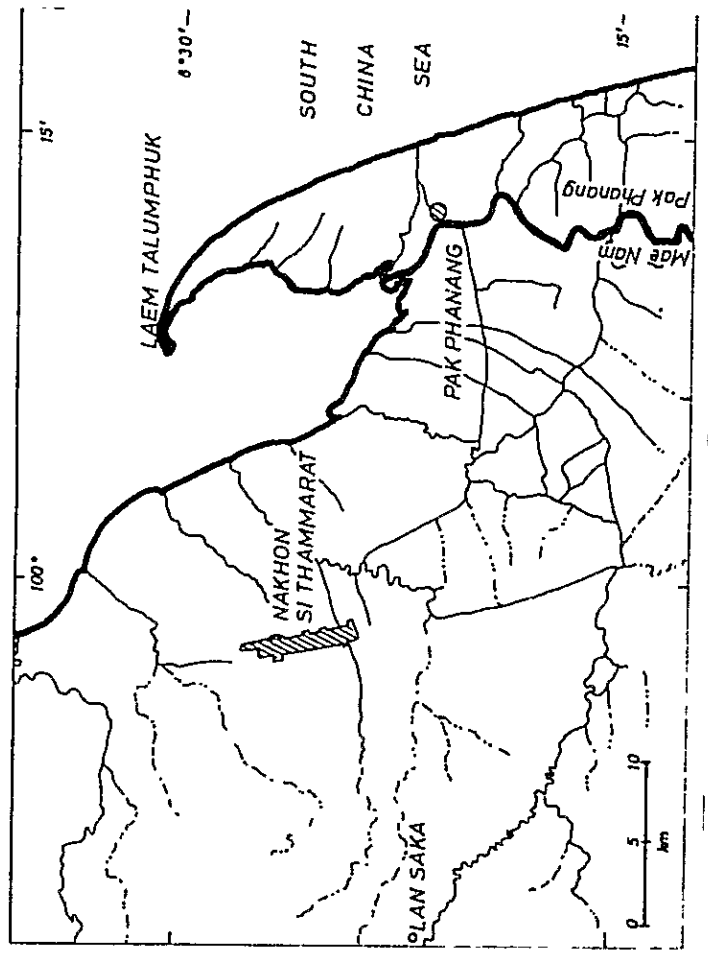


Fig. 78. *Laem Talumphuk and the mouth of Pak Phanang.*
A century ago, the bay between Laem Talumphuk and Nakhon Si Thammarat (Ao Pak Phanang) was used as a roadstead for the sailing boats. Now, the small town of Pak Phanang has developed into a bustling coastal port. (Base map 1:250,000.)

It seems fairly safe to say that these spits developed by the cooperation of the sea currents and the wind which, to some extent, moves the sandy shore; however, as Credner rightfully observes, it is strange that no dunes developed along the coast line. His explanation is that the strongest wind blows during the rainy season when the sand is soaked and will not move.[13] But obviously the wind works through the waves to move the sand.

It is remarkable that none of the more recent geographers bothers to describe or even mention this phenomenon. In the old days, when geography was often connected with sailing or riding to places of interest, more attention was given to such details. So it is not surprising that H. Warington Smyth, who had to sail when visiting the Thai peninsula, describes his observations minutely when exploring the coast between Nakhon Si Thammarat and Songkhla. In the following quotations, the obsolete names used by the authors are replaced and data are metricated:

When off the Nakhon Si Thammarat bight and just within sight of the masts of junks lying off the river, we stood away to sea to round Laem Talumphuk, the curious bar of sand which the north-east monsoon is throwing up by degrees round the mud flat of the Pak Phanang Bay, and which will undoubtedly in time create a new inland sea like the Songkhla one. The flats are extremely shallow, and, like the other bights on the coast here, are silting up very rapidly, to an extent on the outer banks of one fathom [1.82m] and at the river mouth of half a fathom [0.91m] since the 1874 charts.

The land is making everywhere, a fact which does not seem generally understood.... The land is also making rapidly in the kindred States of Pattani, Yering and Sai Buri, where the coast line is of recent formation.... The shoals off the spit run far to the northward, and we passed it at a distance of two miles....A number of fishermen live at Ban Laem and other villages at its southern end, their houses shaded by the wind-torn coconut palms and casuarinas, the only trees that have the hardihood to grow there. In the north-east monsoon these men follow their calling in the smooth water of the lagoons, to the west, and during the rest of the year their long boats will be met all up and down the coast lying bobbing on the seas, watching and waiting, or flying through the water in the direction of the jumping school of fish. From here, we took two days to Songkhla.[14]

On his way back, Smyth again took shelter in the bight of Nakhon Si Thammarat (Ao Pak Phanang) from a stiff wind:

A number of junks lay close in, and we beat in towards them and anchored just outside them. The native craft make a practice of contentedly lying in the mud at low water. It is a queer custom in such an open roadstead, but fairly safe at this season.... Still it is no place to be in when there is any chance of an on-shore gale, for there is no shelter for an ordinary vessel for eighty miles; it is entirely exposed, and an awful sea rolls in upon the banks.[15]

This description of the east coast as prohibitive for a proper harbouring of ships is still valid.

Smyth then describes the various khlongs and small rivers which enter the bay, some of them offering a connection to the town of Nakhon Si Thammarat; however, he does not mention the Mae Nam pak Phanang, nowadays entering the bight from the south as a respectable river and, at the same time; providing the port of the town:

We went off in the skiff in the afternoon at low water to learn the way in to the Khlong Pak Phaya... Farther south another stream, Khlong Pak Nakhon, is used for larger boats and most of the tin comes down that way from considerably south of Nakhon Si Thammarat. A few miles up a cross khlong joins the two.[16]

The author reports the rapid silting up of these rivers: "The entrance is filling up at a rate of 12.5cm. a year, and all the banks are creeping out to sea proportionately. Whereas fair-sized

craft some years ago could get up to Wat Tepo, now only canoes can thread their way so far up its tortuous course."[17]

We have quoted these observations of a traveller between 1891 and 1896 so much in detail to show the remarkable change of the coast and the hydro-geographical picture which has taken place since. This can be done best when regarding the eastern coast between Nakhon Si Thammarat and Songkhla as a whole, i.e. by including also the *coastal lake of Songkhla* (Thale Sap). Here again it is surprising that more recent geographers hardly mention this lake, let alone describe it or elaborate on its origin.

This lake is a lagoon approximately 80km. long and having a width reaching 20km. in the northern part, covering an area of roughly 60km². Towards the north, the lagoon extends into a mangrove swamp about another 30km. long. A few islands and peninsulas lie in the lake and so divide it into Thale Noi (small lake), Thale Luang (large lake) and, at the southern point, Thale Sap Songkhla. Towards the sea, the lagoon is barred by a sandy spit or bar the width of which ranges from 3 to 10km. There is an opening (*tief*) between lake and sea from the Thale Sap Songkhla which has a width of no more than 300m. The *tief* is protected by a small spit embracing the mouth from the south (Laem Sai), but in itself it is very shallow, largely blocked by extended sand bars, an obstacle to navigation (see figure 79).

The lagoon is fed by more than ten rivers coming from the Nakhon Range, but it is very shallow and navigable only by small boats. The surrounding is flat paddy land, interrupted occasionally by scattered forests and mangrove thickets. The general altitude of the surroundings of the lagoon remains a little above sea level, but there are a few outcrops of lime rocks which form sudden elevations between 100 and 400m.

The land between the lagoon and the sea is at present crossed by a few very small *khlongs*, or rather ditches which normally do not allow the plying of more than flat boats and in most cases are no more than drainage ditches. Nowadays it is rather densely populated, and rice is grown together with coconut palms. Quite a number of villages and the *amphoe* centre Ranot are located here. A bumpy road leads from the *tief*—with a ferry connection to Songkhla—to Ranot.

Here too the question of the origin of this strange coastal feature immediately arises. And even more than was the case with the spit of Nakhon Si Thammarat, the study of older geographical books helps us to understand how it was formed.

In 1840, one F. A. Neale sailed from Ligor (Nakhon Si Thammarat) to Talung (Phatthalung) in the *Victory*, a Siamese frigate of 1,400 tons, and he "sailed right through the channel between Ligor and the island of Tantalem . . . and there was a fine creek or river off Talung".[18] Translated into modern terms this obviously means that the land, which now closes off the Songkhla Lake from the open sea, was then an island named Tantalem. Captain A. Hamilton, who described the area at the turn of the seventeenth century, reported a low, uninhabited island named Papier reaching from Songkhla north to a point about 15km. (3 leagues) from Ligor River.[19] Earlier, legendary reports tell of a simple sand bank at the same place.

Smyth found that, for 90 miles, a long sand barrier ran without a break and thus protected the lowlands behind: in the north was the Tung (swamp) Ranot, hardly inhabited but notorious for its wild elephants, and to the south Ko Yai (or Pulo Tantalem) with a dense fishing population. Between them, a *khlong* formed an outlet to the north-east which was only open to the sea during the winter monsoon. The view from the sand barrier towards the west ran, as far as the eye could reach, to the mountains, 60km. away.

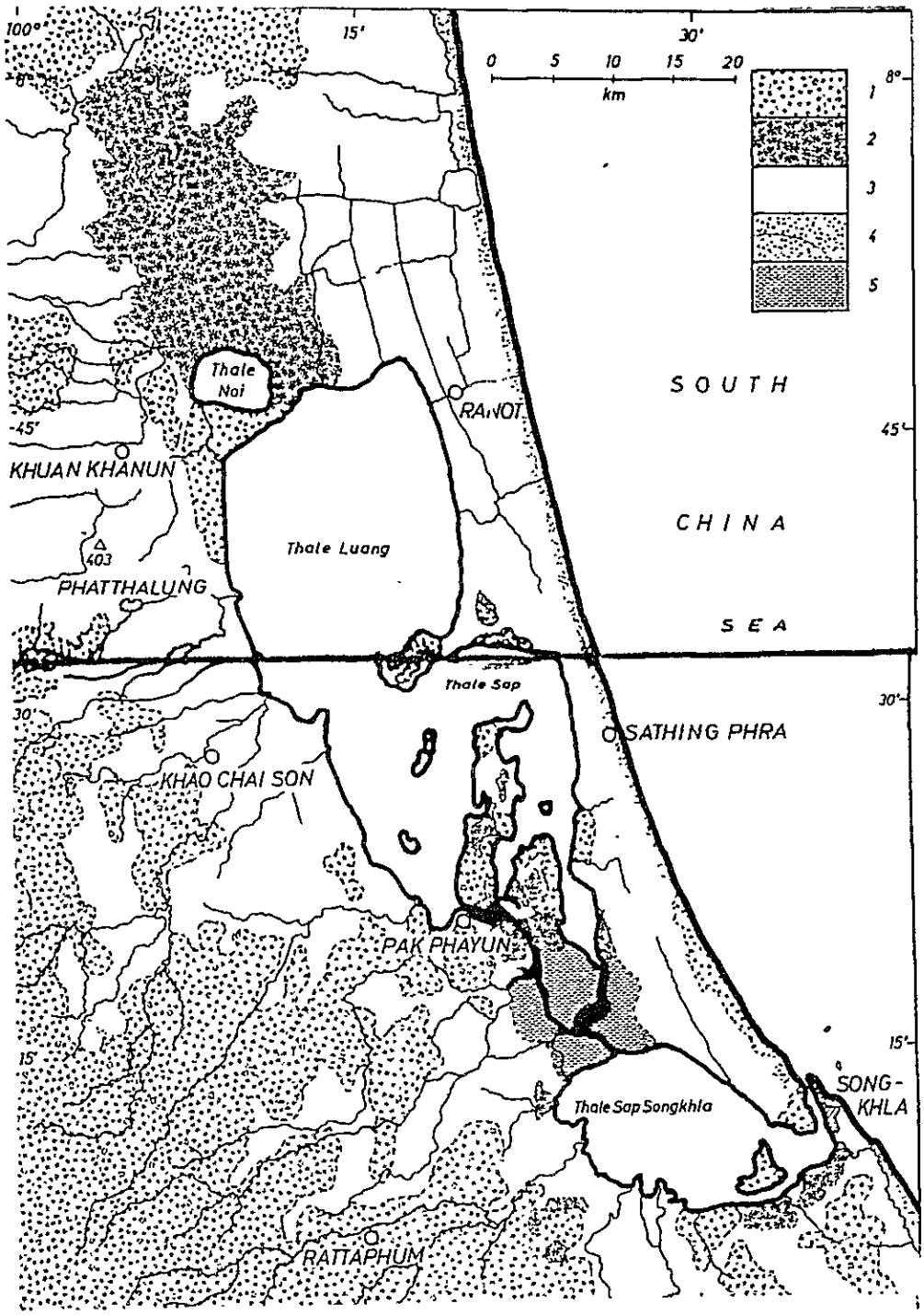


Fig. 79. *Physical map of the Thale Sap with Songkhla and environs.*
Legend: 1 = woods, brushwood; 2 = mangrove thickets; 3 = rice fields; 4 = dunes; 5 = swamps.
The process of converting former coastal waters and islands into continental land can still be recognized. Base map 1:250,000.

The vast fen-land extended, green with the sprouting padi near the scattered homesteads, and with the long lank grasses of the swamps. A few low isolated hills stood here and there, and only the wind in the reeds and the piping insects in the grass disturbed the silence.[20]

In principle, this picture has not changed much, though the population density has certainly increased.

An important topographical change, however, has taken place in the hydrological sector: the easy waterway connection between Nakhon Si Thammarat, described and used by Neale, was no longer available during Smyth's visit:

> The khlong from there, which goes north through the Tung Ranot, can at low-water season be solely used by light boats; it forms the only highway between Nakhon Si Thammarat and the south generally available, excepting a long detour by inland elephant trail, and to keep it open it will soon be necessary to dredge it.[21]

No dredging, however, will help now since this waterway has vanished. And a simple comparison between maps of different ages shows impressively the change of the whole area (see figure 80).

The reason for this striking change is, as has already been shown in Nakhon Bay, the enormous silting of the lowlands by the rivers, and it does not seem exaggerated when Smyth, nearly 100 years ago, remarked: ". . . . The fact is, the condition of the half-detached island north of Songkhla was once similar to that now presented by the Ko Samui and Talui groups".[22] In other words, assuming the present change continues, the islands now lying off-shore will one day be enclosed by the shore-line.

From this point of view it is interesting to consider the Lake of Songkhla in more detail. Again, more recent observations or measurements are not to hand and Smyth remains the best source.

The lake is dotted with small islands, some of them rocky and economically important places for the collection of bird's nests, some flat and agriculturally cultivated, some mere mangrove thickets. Since Smyth's time, islands have grown into peninsulas or been enlarged by the process of silting. This is only in logical continuation of tendencies which earlier travellers had already observed: The lake and the channels between their sections were extremely flat and silting from the rivers was a continuous process. Smyth measured at places 2 fathoms (ca. 3.60m.) and annual silting between 5 and 7.5cm. There is no reason to expect that this process has ceased, indicating that the Tale Sap and the Lake of Songkhla will become shallower and dredging problems will arise once the port of Songkhla is well developed.

Finally, a short account should be given of the off-shore *islands*. As mentioned earlier, practically all of them are continuations of the mountain chains on the peninsula and are geologically closely related to them. Many are sparsely inhabited or play their part only as fishing settlements. Agriculturally, the larger islands off the west coast, first of all Phuket, have become rubber-producing areas, as have the smaller islands in Phuket Bay. In contrast to this, the islands off the east coast have nearly completely turned into coconut producers after mining (still practised a century ago) lost its importance. The two island groups in the east, the Ko Samui group and the Ko Phaluai group, are the only islands of importance in this part of the Gulf of Thailand. They are mountainous and reach an altitude of 635m. (Kao Phlu, Ko Samui). Ko Samui and Ko Pha-Ngan, and the small Ko Katen are nearly wholly covered by coconut plantations.

In the west, the archipelago gives the coast the appearance of a Swedish *schären*-coast. Here, several groups can be distinguished: the Phuket Group in the centre, Ko Terutao and the Butang groups in the south, and many small off-shore islands along the rest of the coast. Apart from its role in fishery and plantations, Phuke leads also in tin mining.

General knowledge of Thai *geology* is still limited and that of the peninsula is particularly scarce, caused partly by the inaccessibility of extensive areas and the dense jungle cover which still prevails in a number of places. Yet, for the purpose of this introduction, a brief summary is given.

Map 1 is drawn from *Map of the Kingdoms of Siam and Cochin China* compiled by John Walker to accompany the journal of Mr. Crawfurd's mission; it was published in 1828. As far as the compilation of the coastal line in question is concerned, the source gives the following explanation: "The Malayan Peninsula throughout is delineated from the accurate nautic charts of Captain Horsburgh. From the Cape of Patani to the point of Kwi is taken from a Mohammedan mariner, a native of Siam, possessed of considerable intelligence—who was acquainted with the use of maps and the quarter-staff, and could even take an altitude of the sun with our quadrants; no mean proficiency in an Indian" (J. Crawfurd, op.cit., p. 598).

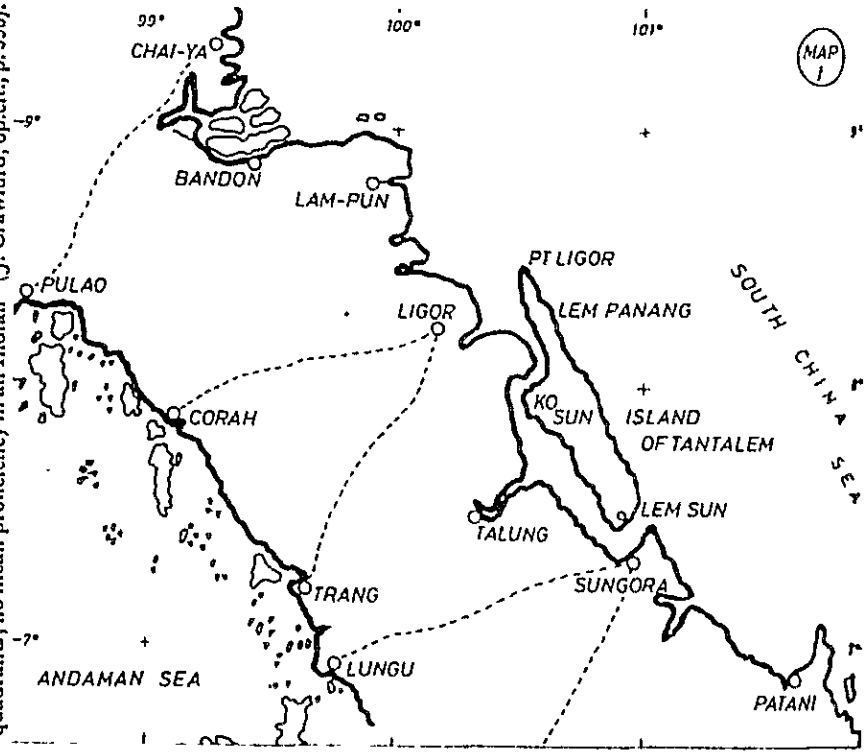
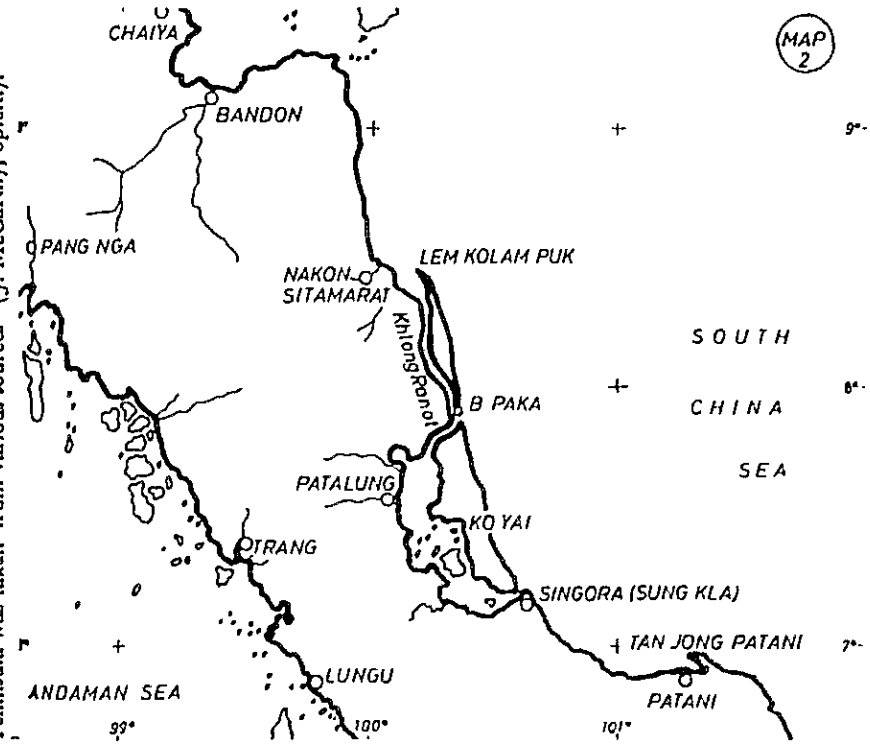
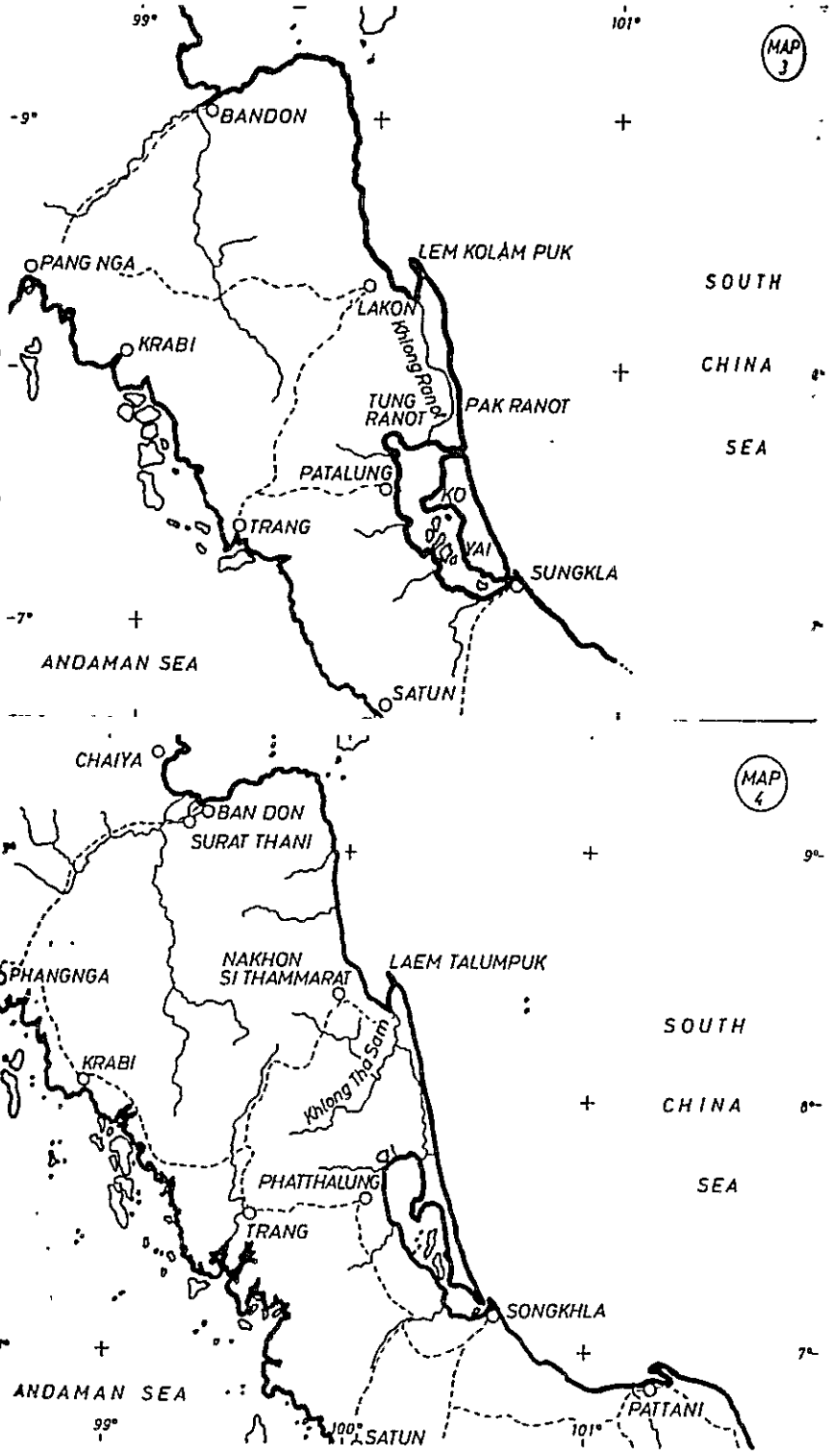


Fig. 80. *Comparative maps of the area Nakhon Si Thammarat—Songkhla.*
These four maps show (*a*) the development of mapping of this coastal area and (*b*) the change of the coastal line and the navigability of the coastal waters.

Map 2 is drawn from *Map of the Kingdom of Siam and its dependencies* from Government Survey under the direction of J. McCarthy who worked on this map between 1881 and 1893. According to the explanation, the coast line was reduced from the latest Admiralty Charts; the Malay Peninsula was taken "from various sources" (J. McCarthy, op.cit.).





Map 3 is drawn from the map *The Malay Peninsula* included in H. Warington Smyth's book, volume II, based upon a stay in Siam between 1891 and 1896. No explanations are given.

Map 4 is drawn from *East Asia Road Map* 1:1,250,000, Series 5308, sheet 4, compiled in 1962.

As an interesting fact, it may be mentioned that there is strong evidence of a pre-Cambrian origin of some formations found in the South, namely the Phuket series, but fossil discoveries have confirmed that at least Cambrian (Tarutao group) formations can be accepted as present. This very old formation stretches from the Ta Ru Tao island in the south-west of the Thai territory (red to brown arenaceous sandstone and quartzitic sandstone) to Khao Luang Nakhon Si Thammarat (red shale and sandy shale). The country as a whole is regarded as having been the site of marine deposition throughout

much of Paleozoic time; most of it was elevated and the rocks were regionally metamorphosed by diastrophic movements, approximately concurrent with the Saalien and Appalachian orogenesis, the Saalien revolution seemingly having involved most of Thailand. The extensive intrusion of granitic magma dates from the early Mesozoic period, perhaps from the late stages of the Saalien orogeny. A younger biotite-muscovite granite cropped out widely in the peninsula and along the Burmese frontier.

At the beginning of the Tertiary period, most of the country was above sea level, and a well-integrated drainage was established. The faulting and folding movements which led to the development of the structural basins, common in the peninsula, probably began in middle or late Tertiary time; and, especially along the coast, terrestrial sediments were deposited in association with marine materials. The structural movement probably continued side by side with accumulation, so that the basin sediments were warped and in places faulted. Local volcanic and intrusive activity occurred in many scattered localities of the kingdom, probably in late Tertiary time.

Throughout the Quarternary period and up to the present time, the important rivers have accumulated sediment supplied to them by tributaries which formed their courses by erosion in the upper reaches and by alluviation in the lower reaches. The accumulation of Quarternary alluvial deposits in the valley streams of the peninsula produced most of the rich tin deposits. In comparatively recent time, the peninsula has tilted slightly north-west, for its east coast on the Gulf of Siam has a smooth emergent shore-line backed by a broad coastal plain, whereas the shore-line on the Andaman Sea is marked by deep valleys and prominent headlands or off-shore islands such as those of Phuket Bay.[23]

The present Thai peninsula is mainly built up of pre-Quarternary sedimentary and metamorphic *rocks*. These rocks practically stretch from north to south, but consist of a number of rock types of different ages. The west coast and its mountain range, with substantial parts of the hinterland, is made of carboniferous, Devonian and Silurian rocks of the Kaeng Krachan formation, consisting of a thick sequence of poorly bedded greywacke, mudstone and siltstone; limestone occurs locally. There is also a group of well-bedded black and grey shale and light coloured sandstone with pebbles of quartz, quartzite, slate and granite.

The next remarkable zone towards the east is the Phu Kradung formation, forming a broad strip between the Phuket Range in the west and the Nakhon Range in the east, extending towards the south close to the shore and in the north forming part of the east coast north and south of Chumphon. It consists predominantly of dark brown, greyish brown and red micaceous shale, sandstone and conglomerate.

Between Nakhon Si Thammarat and the southern border, the areas between the igneous and the Quarternary rocks are filled with a Triassic marine formation of the Lampang group, including red beds and volcanic rock. A group of marine and non-marine sandstone, shale and conglomerate forms the upper part, with massive limestone and limestone conglomerate in the middle and then a sequence basal conglomerate with volcanic pebbles, red sandstone and shale. There are also rocks of the Kanchanaburi formation of the Tanaosi group, a group of shale, sandstone and sandy shale, in many places metamorphosed to phyllite, argillite, quartzite and slate; and bedded limestone is locally present.

The coastal and lower river valley areas are largely but not always formed by Quarternary to recent alluvium, eluvium, valley-fill and river gravel. The main area of this formation stretches along the eastern coast, mainly between Nakhon Si Thammarat and Songkhla, around Pattani and Narathiwat and to a smaller extent in places along the western coast.

e) チョンブリ

(a) Topography

South-East Thailand consists for the most part of flat lowlands below 100m. which are, however, mostly above the rice fields level and consist of soils unsuitable for rice cultivation, partly due to lack of water. This lowland, amounting to about 70 per cent of the total area, is bounded in the north by the *Sankambeng Range*, a rather closed massif which rises steeply from the southern lowlands to more than 200metres a.m.s.l., reaching its summit in the Kao Laem (1,351m.). This mountain range is still densely forested, scarcely populated and was opened to traffic and tourism only recently. To the south is the extensive valley of the Bang Pakong river, a river system which actually bears this name only in its lower part. Further upstream it is called Mae Nam Prachin.[3] South of this valley, the South-East strictly speaking begins.

Here the coastal lowlands extend deeply into the interior without reaching 100m. above sea level but occasionally they are interrupted by ridges which run north to south or north-west to south-east and rise abruptly from the plains, forming types of inselbergs or whole mountain massifs. Such mountain ridges reach up to 798m. (Khao Khieo) near the coast south-east of Chon Buri, and attain 1,633m. in the east (Khao Sai Dao Tai). To the south-east, folds of the Banthat Range partly form the Khmer border (see figure 65).

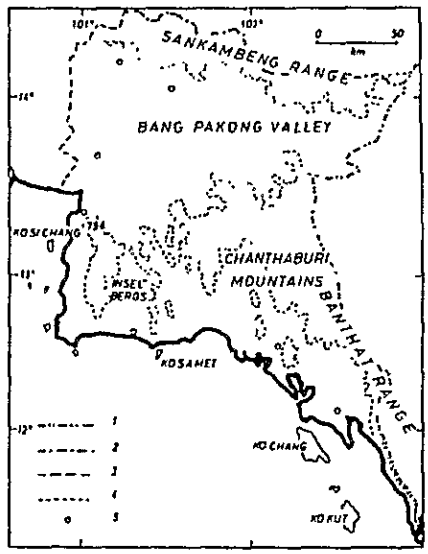


Fig. 65. *Physical orientation map of South-East Thailand.*
Legend: 1 = national boundary; 2 = regional boundary; 3 = sub-regional boundary; 4 = 100-m-contour line; 5 = changwat administrative centre.

A hypsometric analysis of the sub-region shows that lowlands from sea level up to 100m. are predominant and that higher altitudes, above 1,000m., do not play an important part (table 65).

Before going into a more detailed description, it is useful to explain the geological background of this landscape, because it helps to understand the actual situation geographically as well as economically. Geologically, the northern border mountains (Sankambeng Range) belong to the Korat Group, containing rocks which are predominant in the north-eastern region of Thailand: pre Triassic porphyry in the west (Saraburi-Nakhon Nayok), Phu Phan and Phra Wihan formations, namely sandstone, conglomerate, shale and siltstone in the centre and east in the higher elevations, and finally the Phu Kradung formation with predominantly micaceous shale on the southern slopes, where it meets the ancient bedrock in the valley of the Prachin river.

Table 65. *Hypsometric analysis of South-East Thailand*

Altitude (*metres a.m.s.l.*)	*Area* (km.²)	*Area* (%)
0- 100	25,621	70.4
101- 200	5,696	15.7
201- 500	3,432	9.4
501-1000	1,529	4.2
above 1000	116	0.3
Total	36,394	100.0

Source: Gravimetric analysis by the author.

It is believed that the area was originally covered by a Tertiary sedimentary rock, predominantly sandstone. Such bedrock still forms the surface along the east coast of the Gulf of Siam, and in the centre from Kabin Buri (Prachin river valley) in the north to near Trat in the south. Called the Kanchanaburi Formation, this layer is a group of shale, sandstone and sandy shales, and is in many places metamorphosed, e.g. to quartzite and slate and, locally, limestone.

Along lines of disturbances, molten rock was forced up, raising the surface into ridges and high mountains, forming batholiths and metamorphosing parts of the neighbouring sedimentary rocks through heat and pressure. The batholiths cooled into granite with large quartz crystals and, after a weathering process of the overlying rocks, were finally exposed. The high quartz content of the granite finally resulted in rather coarse soils and sands.

Later, there was localized volcanic activity in this region. Especially in the Chanthaburi area, a dark, silica-poor magma was forced up, the liquid rock flowed out over the surface, cooled quickly and later weathered into clayey soils with a considerable iron content and having a red colour. In some portions of these rocks there are crystals of semi-precious stones.

Formations of igneous rocks of different age and composition can now be found east of the coastal strip (carboniferous granite), followed by pre-Permian gneiss and schist. Triassic granite and granodiorite form the highest elevations of the Chanthaburi Mountains (Khao Sai Dao Tai, Khao Sa Bab), and there are finally Tertiary basalts in a few places in the eastern border zone of the area. Embedded into these igneous rocks, extended massifs of sedimentary and metamorphic rocks lie between Rayong and Chanthaburi (predominantly limestone) and up to the eastern border areas, consisting of formations of the Korat Group (Phu Phan and Phu Kradung formations) which form part of the Banthat Range.

Finally, parts of the region consist of Quaternary and Recent rocks and soils. Alluvium, eluvium, etc. form the eastern extension of the Bangkok Plain along the Prachin river valley up to Kabin Buri and there are locally limited alluvial river plains in the southern coastal area formed by the Rayong river, Mae Nam Prasae, Khlong Chanthaburi, Mae Nam Welu, Khlong Yai (Trat), their tributaries and other rivers of secondary importance.

There is evidence of the sea level having moved up and down in the course of centuries, thus changing the coastal areas.[3] The geological map shows, e.g., the continuation of the Triassic granite of Bang Lamung towards the islands of Ko Lan and Ko Phai; the continuation of the pre-Permian gneiss and schist of Chon Buri south towards the island of Ko Samet; and the Korat Group formations from the Banthat Range as far as Ko Kut. The Tertiary igneous rocks of Ko Chang suggest a relationship with the geological

history of similar areas to the north on the continent.

These are the forces which created the landscape of the South-East as the traveller meets it today. For the sake of easier understanding it is useful to divide the area into a northern and a southern part. The northern part consists of the changwats of Nakhon Nayok, Chachoengsao and Prachin Buri which, though partly reaching far into the almost uninhabited and little-used mountains of the south, are characterized by their contact with the Bangkok Plain and their consequent land use. Here, the rice growing areas still determine the cultural landscape though marginal upland soils dominate the centre and the east. In the southern part, rice growing is the exception, confined to the few places where soils and water conditions permit the cultivation of this crop. Other crops such as cassava, sugarcane, rubber and fruit trees characterize the cultural landscape of this part of the sub-region.

The *Bang Pakong valley* (Mae Nam Prachin) stretches from the Bangkok Plain east towards the Khmer border. The depression crosses the divide between the Bang Pakong system in the west and the Tonle Sap system in the east, a divide, however, which can hardly be realised since it lies only between 60 and 70m. above sea level west of Watthana Nakhon. So it can be said that this depression offers an ideal natural connection between Bangkok and Thailand on the one side and the Cambodian economic sphere on the other. No doubt this depression played an important part in the history of the region. The valley is now served by an all-weather road and a railway, which provide connections to the capital.

The northern part of the sub-region extends from the central rice plain towards the east without changing its character at first. However, rice growing decreases more and more the farther one travels east. It can be said that the domination of rice cultivation disappears beyond the line Phanom Sarakham—Si Maha Phot—Kabin Buri and that rice fields are an exception east of Sa Kaeo. Instead the more elevated areas are planted with orchards and there are vegetable plantations under tube-well irrigation. The marginal soils are frequently interrupted by outcrops of rocks which indicate that bedrock lies not far beneath the alluvium.

In recent years, however, this cultural landscape has changed considerably. The rather dry forest which formerly covered the centre of the eastern part of the valley down to the Khmer border has disappeared in favour of rice fields which now extend beyond Kabin Buri east to the border. Ancient forest land actually gave way to about 73,000 ha. of rice land in the period up to 1970.

South of the valley, the landscape is covered by evergreen tropical forest, largely subject to human degradation and thus converted into shrub land. This region is hardly accessible and has neither roads nor villages.

The southern part of the sub-region consists, as mentioned, of a rather extensive lowland, interrupted by single mountains (inselbergs) and ridges in the west and mountain massifs in the east. Settlement and cultivation is confined to a rather narrow coastal strip in the west and to the most important river valleys in the south. The interior is densely forested, largely degraded and so inaccessible and uninhabited. Rice cultivation is predominant still in the northern coastal plain down to Chon Buri but is then replaced by other crops. In the south, in some of the river valleys, a limited area is under rice. The most important crops are cassava, sugarcane, and rubber.

To the north, north and south of Si Racha, a line of hills runs close to the coast with steep slopes towards the sea and there are places with several parallel ridges between which are depressions forming lagoons. The short rivers draining towards the west often run in broad ravines, sometimes used for paddy cultivation. Towards Sattahip in the south the coastal plains become more extensive and

the hills recede into the interior.

Topographically, the south-north hills are confined to the west coast and they form a fairly straight line from Khao Khieo (798m.) in the north to the Khao Nang Yong (416 m.) in the south. These north-south elevations run parallel to the Chao Phraya depression and they follow the same direction as the Phetchabun Mountains which border the North-East in the west, the western cordillera of Thailand.

The island of Samet is the landmark east of which the direction of the mountains runs north-west to south-east. The elevations follow the direction of the foldings in the south-west corner of the Korat Plateau (Dong Paya Yen) and the mountains within Cambodia. Here a number of more or less isolated massifs reach, from the Khao Yai (777m.) in the north to Khao Chamao (1,036m.). East, north of Chanthaburi, are the *Chanthaburi Mountains*, granitic masses rising up to 1,633m. (Khao Sai Dao Tai), forming the highest elevation of the whole sub-region.

To the south-east the Chanthaburi Mountains pass over into the Phnom Banthat or *Banthat Range*, the centre of which lies on Cambodian ground (Phnom Tumpor, 1,563m.) and which may be called part of the Cardamom Range, in the Khmer Republic. The Thai-Khmer border runs along this massif without necessarily following its crest. On Thai soil, the highest of these mountains is Ka Ngang (947m.).

The dense primary vegetation of the area has been penetrated by men through the valleys of the most important rivers which offered landing facilities at their mouths, irrigation water and extensive areas of level land. Thus the most important trading centres developed here; Rayong on the Khlong Yai, Klaeng on Mae Nam Prasae, Chanthaburi on the river of the same name and Trat near the Khlong Krabi.

The *coastal line* of the sub-region measures 515km. and runs smoothly without much indentation but with wide bays on the west coast (Ao Sammae, Ao Bang Lamung, Ao Bang Sare) and wide sandy beaches in the south which often bear sandbanks. Rivers frequently form swampy stretches at their mouths covering extensive areas. The mouth of the Mae Nam Bang Pakong north of Chon Buri, the mouth of the Mae Nam Prassae south of Klaeng, and many more rivers to the east are good examples. They transport huge quantities of silt and sand to the river mouth where it is deposited as a barrier through which the river then has to meander its way, often forming lagoons and accumulating numerous sand dunes. This phenomenon is typical at the mouth of Khlong Yai/ Khlong Kha south of Rayong, by this means pushing the coast line out into the sea in the course of centuries.[4] Figure 66 shows this in detail.

Off the coast are numerous *islands* which are mostly a continuation of the mountain ridges of the coastal plain. Thus the Chanthaburi Mountains and the Kho Sa Bap are continued to from Ko Chang, Ko Kut, etc., the coastal ranges continue in Ko Samae San, and it seems that off the western coast the many islands indicate the tops of a sunken mountain range. The numerous islands along the coastal line thus continue the morphology of the continent. They are immersed heights of a landscape probably similar to the coastal landscape. Here is an ingression coast with a relief now immersed but once developed above sea level.[5]

The economic use of the islands is limited. Some are not inhabited but others carry a few villages, with modest paddy fields in the deltas of the small rivers. Often, the forest is already degraded and replaced by brush wood. Normally, these islands have steep slopes but remain below 500m. but there are some very flat ones, such as Ko Mak, Ko Kradat and others where the original forest has disappeared and is now replaced by tree cultivation with only

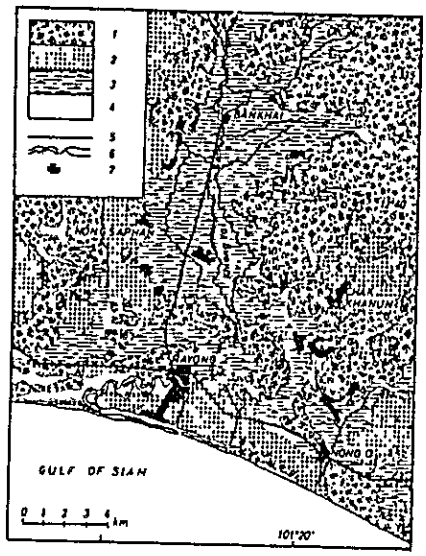


Fig. 66. *Model area South-East Thailand: Rayong and environs.*
Legend: 1=woods or brushwood; 2=plantation (rubber, coconut, fruit); 3=rice fields; 4=other land use; 5=main road; 6=river; 7=agglomerated settlements.

moderate results due to a leached out soil. The two largest islands, Ko Chang and Ko Kut, are rocky, still partly forested and reach heights of 661m. and 250m. respectively. Land under cultivation is confined to limited coastal plains and river mouths.[4] Of much greater importance is Ko Si Chang, a rather small island off Si Racha, which has served for centuries as an anchorage for seagoing vessels which are unable to cross the sand barriers into the Chao Phraya river and the Bangkok port. Here, the Khao Kieo, rising up from the coastal plain to 798m. about 30km. to the northeast from Ko Si Chang, serves as a landmark visible from afar.

1－2－2）バンコクの地質

東洋大学工学部赤城助教授「バンコック地区地質研究報告」１９７２年

Geotechnical Problems in connection with Highway Construction in the Bangkok Area, Thailand

Toshinobu Akagi

Introduction

In connection with the feasibility study for the proposed Ring Road project, Part II, in Bangkok, Thailand, a preliminary investigation was conducted by the writer during the summer of 1972 regarding (a) geology and general subsurface conditions, (b) design and construction problems to be anticipated, (c) behavior of foundations of structures, (d) availability and properties of various construction materials and (e) pavement design problems. The study consisted essentially of literature survey, interviews of engineers in the Bangkok area and field reconnaissance, but included no exploratory borings nor laboratory testing specifically conducted for it. This report presents a summary of the partial results of this study mainly on the items (a) and (b).

In the Bangkok area a wealth of information is available concerning its general geology and the engineering properties of the subsurface soils, particularly of the Bangkok clay which is now well known for its low strength and high compressibility. A bibliography relative to the subject is compiled and attached to this paper as an appendix.

Geology and Subsurface Conditions

Bangkok is located on the bank of Chao Phraya River, some 20 km north of its estuary to the Gulf of Thailand. This river with many tributaries is the main drainage of the Northwest Highlands and the Chao Phraya Plain, Fig. 1. It is a basin filled with marine and alluvial deposits, forming an extremely flat plain about 300 km long and 100 km wide, and being completely surrounded by highlands except on the south.

* Associate Professor in Civil Engineering, Department of Civil Engineering, Toyo University.

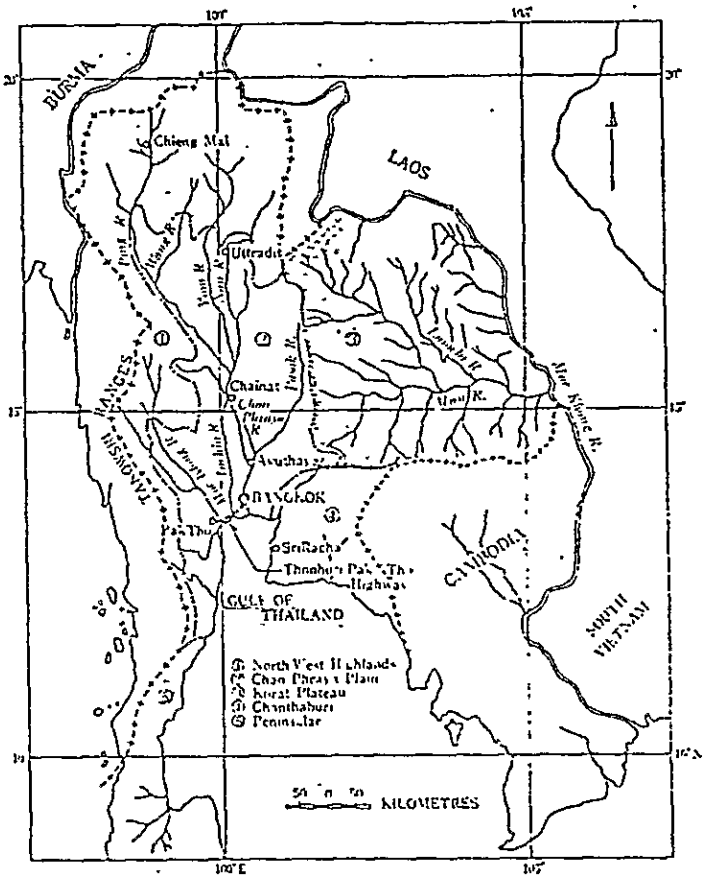


Fig. 1 Physiographic Provinces of Thailand (Muktabhant et al, 1967)

The depression of the Chao Phraya basin is the result of the late Tertiary structural movements of the earth crust. It is speculated that, in the last 20,000 years, the rate of rise in sea level generally exceeded the rate of deposition from Chao Phraya River and invasion of the sea over the land occurred until 8,000 to 4,000 years ago, during which time the marine clays were deposited. Then land building began and an extensive deltaic plain has been formed. The marine clays were subjected to wetting and drying cycles from tidal movement of approximately ±1.0 m during emergence of the land, and then built up above mean sea level by the terrestrial deposition of silt and clay size particles in the annual flood waters (Cox, 1968).

The alluvial deposits thus accumulated gradually moved the shore southward, presently at an annual rate of 4 to 5 m and formed a very flat plain; +18 m near Chainat at the head of the delta, +4 m at Ayuthaya and in the average

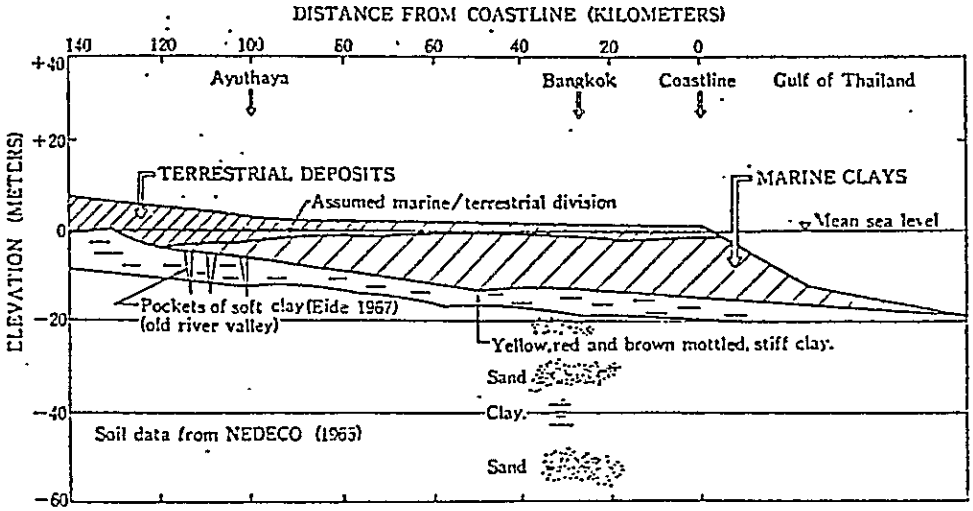


Fig. 2 Cross Section Through Chao Phraya Delta, Thailand (Cox, 1965)

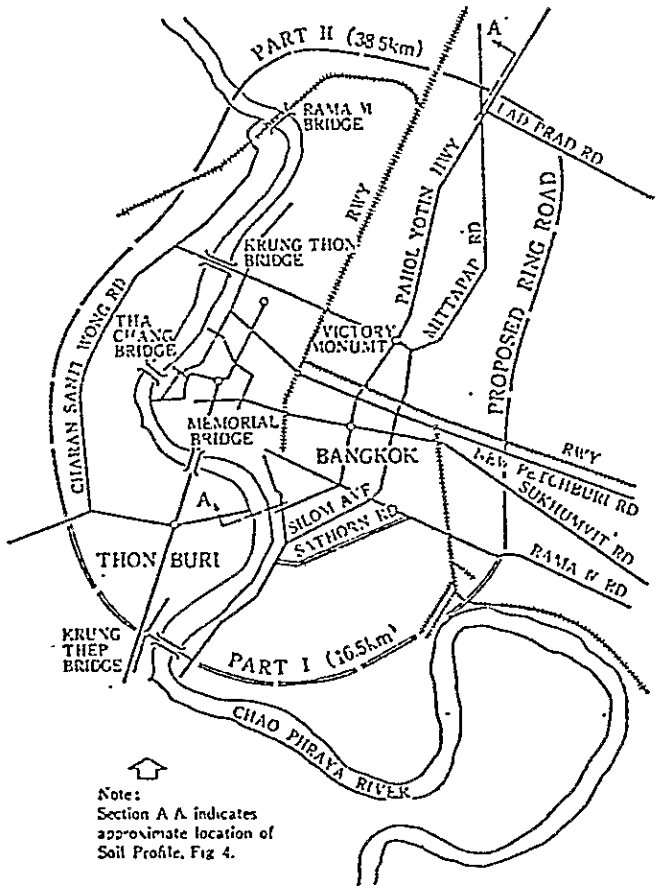


Fig. 3 Plan of Bangkok-Thonburi Area

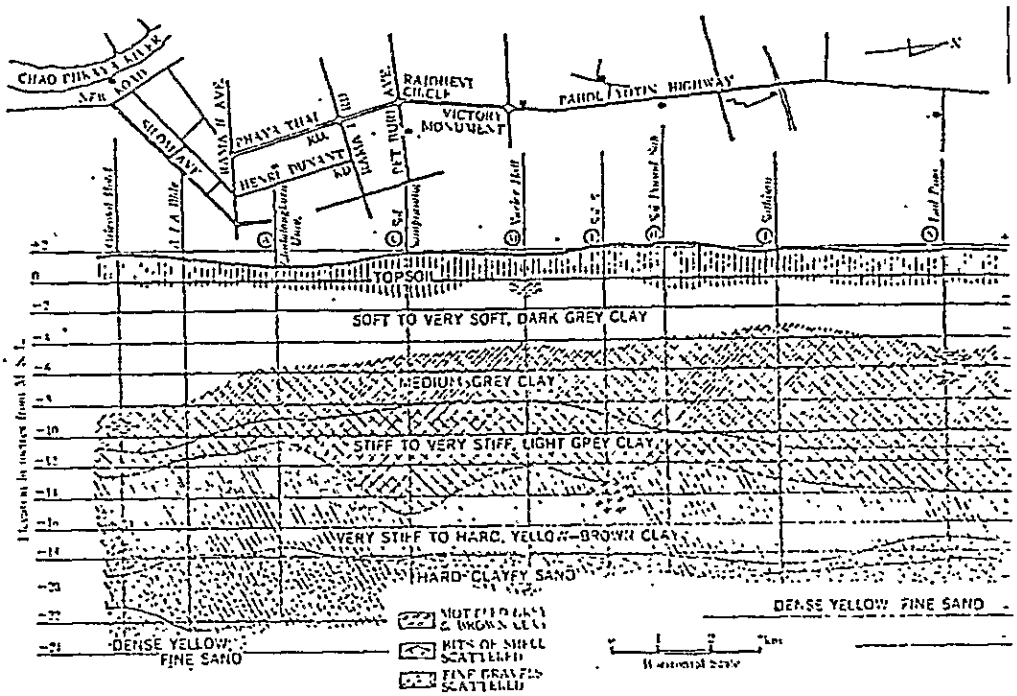


Fig. 4 Soil Profile Along Pahol Yotin Highway (Muktabhant et al, 1967)

+1.80 m (1.0 to 2.0 m) in Bangkok, all above the mean sea level. The situation described as above is best illustrated by a geologic section through Chao Phraya Delta, Fig. 2.

The general subsurface condition of the Bangkok area is illustrated typically by a soil profile running approximately north-south through Bangkok, Fig. 4. Its approximate location is indicated in the area plan, Fig. 3.

For engineering purposes, the soil profile in Bangkok can generally be divided into four layers and described as follows:

(1) A weathered crust of 2±1 m, usually composed of mottled gray-brown clay having cracks due to alternate cycles of wetting and drying. In some areas, miscellaneous fill, generally clayey, is encountered. The water table is at El. +1.0 to 1.5 m above M. S. L.

(2) Very soft to medium dark gray clay, referred to as the soft Bangkok clay, that usually extends to El. −12±2 m.

(3) Stiff to hard, gray and yellow brown, clay of variable thickness.

(4) Dense sand and gravel layers, with some sandy clay, that occur alternately at El. −22±2 m to an indeterminate depth of at least 300 m (Moh et al,

1969).

Near the bank of Chao Phraya River, a thick deposit of loose clayey sand may underlie the soft Bangkok clay.

Engineering Properties of Subsurface Soils

1. Soft Bangkok Clay, Layers (1) and (2)

Physical Properties: Bangkok clay is primarily a normally consolidated marine clay which occurs as a fairly homogneous and isotropic deposit, but contains some fine sand and silt lenses and occasional shell fragments. Typical physical properties of this clay are summarized in Table 1. The clay is composed of quartz, feldspar and the clay minerals of montmorillonite, illite and kaolinite.

Table 1 Typical Physical Properties of Bangkok Clay

	Soft Bangkok Clay Layers (1) and (2)	Stiff Bangkok Clay Layer (3)
Color	Dark gray	Mottled brown and grey
Consistency	Very soft to Medium	Stiff
Natural Water Content	50~88 (60~70)	20~30
Liquid Limit	55~95 (75)	53~65 (59)
Plastic Limit	23~33 (28)	21~24 (23)
Plasticity Index	20~60 (47)	32~42 (37)
Liquidity Index	0.7~1.0 (0.85)	0.1
% Finer than 2 μ	40	44
Activity	0.6~1.1 (0.8)	0.83
Soluble Salt Content (gr/liter)	1.5~15 (2.5~10)	5.6
Organic Matter (%)	1~5 (3)	0.8
Specific Gravity	2.65~2.75 (2.70)	2.74
Wet Density : Above 2±1 m depth	1.65~1.80 (1.74)	—
(t/m^3) Below 2±1 m depth	1.45~1.75 (1.65)	—
Dry Density	0.84~1.13 (1.13)	1.61
Void Ratio	1.4~2.2	(less than 1)
Sensitivity	3~7 (5)	1.3
Main Reference	Ladd, et al (1971)	Nelson, et al (1970)

Note : Numbers in parentheses indicate representative values.

Strength Characteristics: Some typical undrained strength data are shown versus depth in Fig. 5 which summarizes the results of unconfined compression tests and field vane shear tests from nine exploratory borings, put down widely

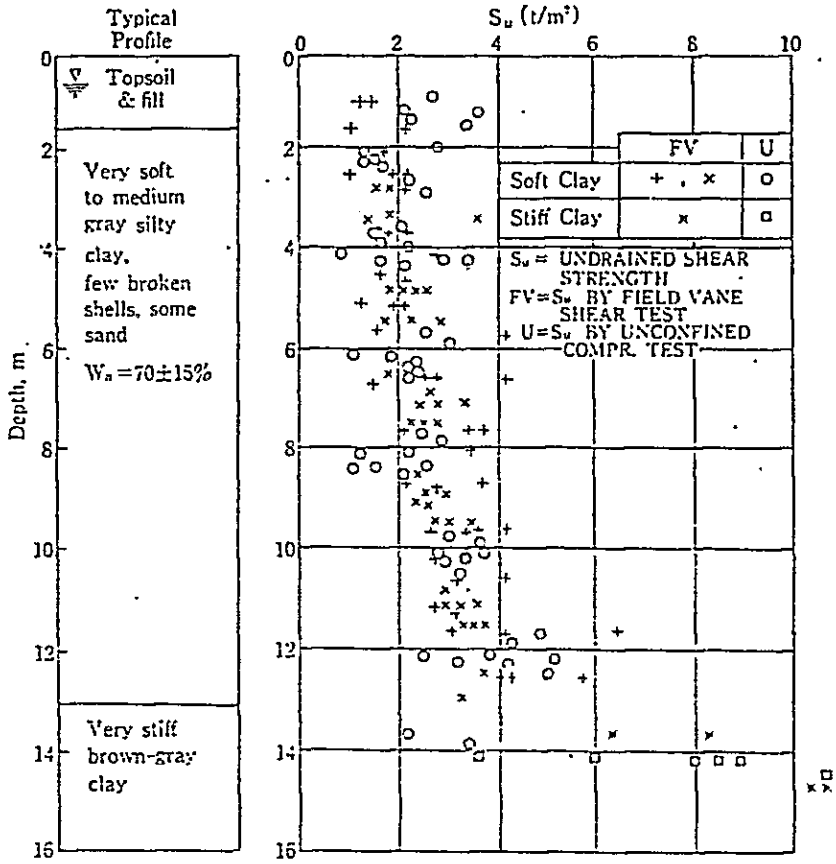


Fig. 5 Typical Field Vane and Unconfined Strength Data on Bangkok Clay (Ladd, et al 1971)

apart, covering the City of Bangkok fairly well.[1] The upper 4 to 6m of the Bangkok clay is commonly referred to as the weathered crust, which is thought to be due to desiccation, ion exchange reactions and weathering of the clay minerals by the leaching water.

Compressibility Characteristics: The Bangkok clay has not been subjected to greater vertical stresses than the existing overburden pressures, but appears slightly overconsolidated throughout the depth. This overconsolidation is considered to be due to the pronounced secondary consolidation of the sediments after deposition as the clay has high plasticity and appreciable organic contents; the rate of secondary consolidation is quite large. The coefficient of consolidation, c_v, determined from routine oedometer tests varies from 0.5 to 2.0×10^{-4} cm²/sec. It appears however that, below a consolidation pressure of approximately ($3.0\times10^{-3}\sim1.2\times10^{-2}$

15 t/m², the coefficient is primarily governed by the stress history of the clay, being higher in the range of 5 to 18×10^{-4} cm²/sec.

$(3.0\times10^{-2}\sim1.08\times10^{-1}$ cm²/min$)$

2. Stiff to Hard Bangkok Clay, Layer (3)

This zone consists of an overconsolidated clay having a maximum past pressure in the neighborhood of 45 t/m². Overconsolidation of the clay has in general been attributed to desiccation. Typical physical properties of the stiff Bangkok clay are summarized also in Table 1.

According to the results of 15 borings (Muktabhant, 1967), the standard penetration resistance (N-values) ranges from 6 to more than 50, averaging about 25, and the unconfined compressive strength varies from 12 to 53 t/m².

3. Dense Sand and Gravel, Layer (4)

The hard clay is underlain normally by strata of yellow dense fine sand at an elevation between −20 and −24, M. S. L. The top boundary is not always clearly defined but usually encountered in a transition stage of yellow brown clayey sand.

Geotechnical Engineering Problems

1. Embankment Stability

Because of the extremely soft and highly compressible nature of the Bangkok clay, it poses a serious threat to stability of even low embankments which are only a few meters in height, and makes it difficult to predict their settlement behavior on the basis of laboratory test results.

In connection with the Bangkok-Sri Racha Highway project, Eide (1967) analysed several failures of trial embankments and found that recalculation of these slides based on the conventional Swedish circle method employing vane shear strength yeilded an average factor of safety of 1.5. A safety factor as large as 2.0 was calculated for a failure which extended from the embankment to a side borrow pit. Cox (1968) pointed out that the conventional slope analysis did not take into account horizontal forces between embankment and natural soils, and inclusion of these forces would indicate a factor of safety close to unity at failure.

Table 2 Summary of Trial Embankment Results

Site	Station	Section No.	Information Required	Height (m)	Maximum Pressure (t/m²)
1	54+800	1	Stability and Settlement	4.20	7.22
2	63+600 (Rice Field)	1	Stability	4.70 (Failure)	7.31
		2	Settlement	0.97	1.65
		3A	Settlement	2.45	4.21
		3B	Settlement	1.38	2.31
		3C	Settlement	0.75	1.21
3	13+700 (Old Coconut Plantation)	1	Stability	2.64 (Failure)	4.96
		3A (a)	Settlement	1.83	3.29
		3A (b)	Settlement	1.93	3.30
		3B	Settlement	1.09	1.57
		3C	Settlement	0.70	1.17

Considerable lateral stresses are developed by arching in the embankment during settlement and act outwards from the center toward the toe. Fissures and slickensides noted in the Bangkok clay could also result in a lower in-situ shear strength than is measured by either laboratory compression tests or field vane shear tests.

Undrained strength analyses may, however, have a factor to make the results too conservative when appreciable consolidation takes place during construction. In the Thon Buri-Pak Tho Highway project, vane shear tests were carried out before and after construction in the weathered crust beneath the trial embankment. It was revealed that the vane shear strength in this crust had increased from its initial value of 1.2 t/m² to an average value of 2.2 t/m² in several months. For this project three large trial embankments were constructed with extensive instrumentation a few years before the highway construction began in 1970, Table 2. The embankments which were deliberately built to failure for a stability study failed when the height reached 2.6 m on a coconut plantation field and 4.2 m on a rice field (Cox, 1970). Another embankment failure was reported near Bangkok when it was built to a height as low as 1.6 m.

Brand (1971) gave an interesting account for an embankment failure which had taken place some 20 km north of Bangkok. Concrete piles, 15 m long and 30 by 40 cm in cross-section, were driven in an attempt to improve the marginal

Thon Buri-Pak Tho Highway (Cox, 1971)

Start of Construction (Settlement Period to Feb. 71-yrs)	Immediate Settlement (cm)	Settlement to Feb. 71 (cm)	Settlement Rate-cm/cycle of 0.1-1 yr (Secondary Coefficient-C_α)	Maximum Lateral Movement (cm)
15/6/67 (3.7)	30.0	168	—	12.4
11/6/69	34.2	—	—	9.0
1/6/69 (1.7)	2.0	7	7.2 (0.005)	0.8
5/9/69 (1.5)	8.2	47	55.0 (0.038)	3.5
9/8/69 (1.6)	1.7	13	16.5 (0.011)	1.0
28/8/69(1.5)	1.0	4	2.4 (0.002)	0.4
4/9/69	25.0	—	—	8.5
19/11/69 (1.3)	8.4	45	51.0 (0.040)	4.0
19/11/69 (1.3)	8.6	43	51.0 (0.040)	5.0
12/11/69 (1.3)	2.2	18	22.5 (0.017)	1.2
3/11/69 (1.4)	1.3	8	8.5 (0.005)	0.4

stability of a retaining wall for a roadway embankment located along a canal, and two days after pile driving the embankment slid into the canal together with the wall and piles. This failure was attributed to excess porewater pressures developed in the soft Bangkok clay due to pile driving.

2. Embankment Settlement

Chandrangsu (1957) reports his experience in 1939 about the embankment construction of Sukumvit Highway in the Bangkok area: the actual quantity of material dumped to form embankment of about 1 m in height was twice as much as the quantity calculated from the cross-section. He recalls similar excessive settlements observed during road construction in the vicinity of the city including the Bangkok-Don Muang Highway, and pointed out that the settlements were far greater than those due to elastic compression and consolidation of the soil layers underneath.

According to Eide (1967), a 3 m high railway embankment located 6 km south of Ayuthaya, settled 2.5 m: it was first built as a single track some 65 years ago and then expanded to a double track about 15 years ago. His investigatiou showed that only 1.2 m of the total settlement was due to consolidation and the remaining 1.3 m due to shear deformation in the form of plastic flow in the clay at constant water content. He also estimated the settlement during construction

was 0.7 to 0.8m. At this location it was found that the soft Bangkok clay filled an old river bed being about 14m deep. Therefore, the condition may be considered comparable to that in the Bangkok area.

Construction difficulty was encountered in a section near Bangkok (Circeo, 1968) when low fills experienced settlements over 30% of their heights in one year period. The most critical section, only 1.5m high, settled a total of about 1m during the construction period of approximately 18 months.

Table 2 summarizes the results of an extensive trial embankment program constructed for the Thon Buri-Pak Tho Highway project (Cox, 1971). Typical time-settlement curves obtained during this program are shown in Fig. 6. It is to be noted that settlements for a relatively short period are sizable and the rates of secondary consolidation considerable.

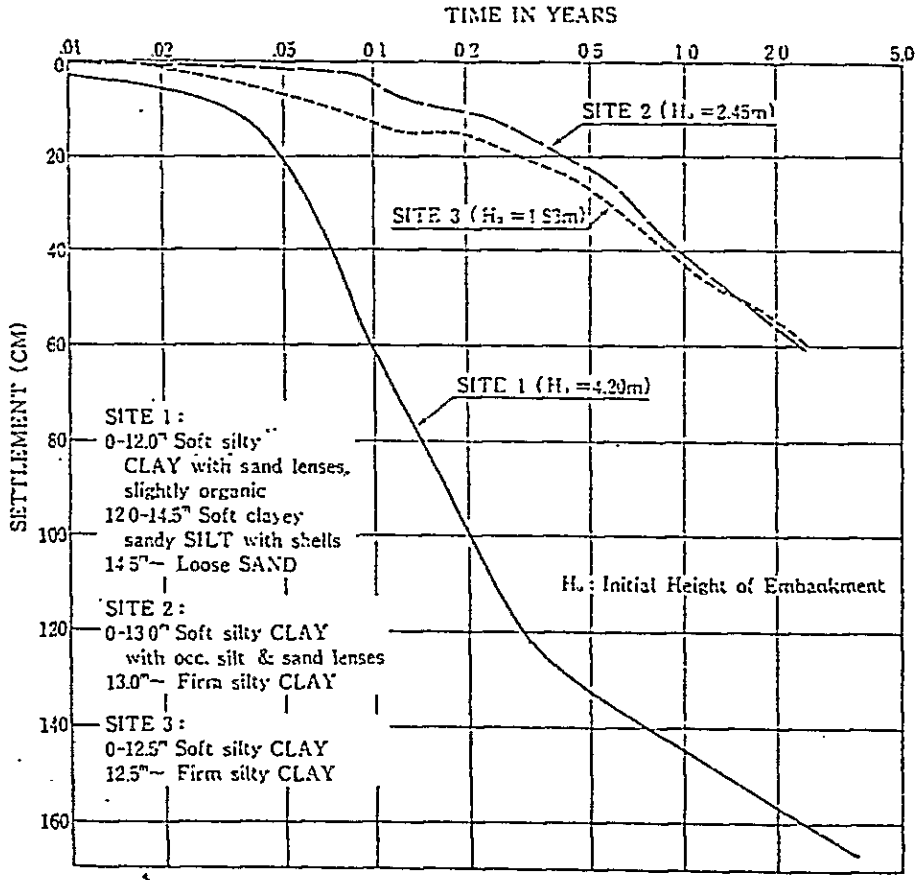


Fig. 6 Results of Trial Embankment Programs for Thonburi-Pak Tho Highway (General Enginering Co. Ltd, 1972)

In addition to the fact that large shear flows make settlement predictions next to impossible, presence of thin lenses of silt and sand in the soft Bangkok clay complicates the settlement rates considerably.

The actual settlements, however, do not always exceed the predicted ones. In connection with the Bangkok-Sri Racha Highway project (N. G. I., 1967), a trial embankment of 1.7m in height was constructed near Bangkok. The settlement was calculated to be on the order of 1m, approximately 20cm of which should occur during the first year. As it turned out, however, the settlements, actually measured, were only 7cm in the first few months and practically no more settlements were observed for the subsequent six months. It was reasoned that the average embankment load 3.3t/m^2 was very close to, but still too small to exceed the critical load (apparent preconsolidation load) and the Bangkok clay behaved as an overconsolidated clay, although it was normally consolidated in terms of its stress history.

All the indications are, therefore, that the values from laboratory results should not be applied directly to field cases. Forecasting settlement and its rate for the soft Bangkok clay is still at present such a complex and unsubstantiated process that it is much safer to make the use of empirical, observed time-settlement relationships on a similar subsurface condition with similar loading than to estimate them by analytical means alone. In this regard, it is highly recommended for any sizable highway project that at least one trial embankment be constructed at each representative site as early as possible and such relations be established for the most economical construction.

3. Approach Embankment

In the Bangkok area, evidences of excessive differential settlements are observed at practically every connection between the bridge abutment and the approach embankment, characterized by damages of various degrees caused in sidewalks and railings at the end of the bridge. Although the pavement in such transition is usually covered by thick asphalt overlays, the design vertical curve has been so badly impaired that vehicles approaching a bridge have to slow down in order to avoid possible driving hazards, at least unpleasant feeling of bumps every time they get on and off the bridge.

In an attempt to cope with this problem, two schemes have been employed for some of the recent highways constructed to a higher standard. These measures consist of the use of relief piling beneath the approach embankment and the use of lightweight fill material for the embankment after preloading.

In a test fill program for the Bangkok-Sri Racha Highway project, sand drains, 20 cm in diameter, were installed to depths ranging from 3 to 13 m beneath a 2.1 to 2.3 m high embankment which was built on a stratum of the Bangkok clay, 14.5 m in thickness. Where the sand drains were deepest, it settled as much as 1.3 m in a period of 15 months but was still settling at a rate of 3 cm a month. It was concluded that the sand drains were generally effective to accelerate the settlement, but not effective enough to limit its rate to a tolerable level within the expected construction period. The use of relief piling was then recommended for bridge approaches in this project.

Also in the Asian Highway project, relief piles were employed for bridge approaches in areas where the soft Bangkok clay was present. The purpose of relief piling is to minimize differential settlements between the embankment and the bridge abutment and also to increase stability of such relatively high embankment. The piles actually used were 20 to 30 cm diameter timber piles for pile lengths less than 16 m, and 22 cm square prestressed concrete piles for lengths greater than 16 m.

To take the maximum advantage of the preloading effect, it appears very effective to replace a heavy fill material after an adequate preloading period by a lightweight material such as rice husk ash. The rice husk ash has been used apparently successfully on approach embankments to railway bridges on the Eastern Line and the high approaches to the Rama VI Bridge. The Department of Highways has also used this material at least on three bridge approaches before it was decided to employ the combined scheme of sand preloading and lime-stabilized rice husk ash for the Thon Buri-Pak Tho Highway presently under construction. This scheme is reported to have been successful in reducing post-construction settlements of the approach embankments.

Rice husk is used as fuel for steam engines in many rice mills and the ash may be found in adequate quantities at scattered locations. Laboratory tests indicate that the rice husk ash is composed chemically of silicon dioxide (about

90%) and the dry density under repeated loading is on the order of 0.8 t/m³, showing high frictional resistance but no cohesion (Williams et al, 1971) and that effective compaction may also be attained by mixing clay with lime and the ash (Lazaro et al, 1971). According to the results of a field test (General Engineering Co., 1967), the ash stabilized with 6% of hydrated lime showed the maximum dry density of 0.64 t/m³ at the optimum moisture content of 90% and it was suggested that the maximum wet density in situ may reach 1.35 t/m³.

Summary and Conclusions

1. The Bangkok area is situated in the vast flat alluvial plain of Chao Phraya River and the subsurface condition appears to be fairly uniform. The area is mantled with a deposit of soft Bangkok clay, typically 12 to 16 m in thickness. The top few meters are in general slightly stiffer, forming a weathered crust. Beneath this deposit exists a layer of stiff to hard clay, several meters thick, and at a depth of 21 to 25 m, is underlain by dense sand and gravel strata with some sandy clay extending to undetermined depths. Groundwater level is generally encountered close to the ground surface.
2. The Bankok clay is a normally consolidated, sensitive clay with a consistency of "very soft to soft" and with a high compressibility and a high rate of secondary consolidation. This clay appears to be slightly overconsolidated throughout the depth and the "critical load" due to this effect is of great engineering significance in terms of stability and settlement problems.
3. Because of its extremely low strength and high compressibility, it has been found almost impossible to evaluate reliably the stability and settlement of an embankment founded on the Bangkok clay by means of the conventional design analyses alone.
4. It is recommended, therefore, that at least one prototype trial embankment be constructed at each of the representative sites at an earliest practicable time. Settlement plates, piezometers and surface stakes should be installed beneath and around the embankment, and field measurements be taken regularly until construction starts. Only with such field data would it be

possible to predict with reasonable accuracy the performance of the embankment on a similar subsurface condition and to make an economical design of the highway embankment in Bangkok area.

5. In order to minimize post-construction settlements, approach embankments for structures will have to be pile-supported, or to consist lightweight fill material such as lime-stabilized rice husk ash after sufficient preloading. Or else, stabilization by means of sand-compaction piles or chemico-lime piles (using quick lime) would also prove to be effective.
6. It is recommended that embankment be constructed in stages and field measurements for stability and settlement be maintained at close intervals of distance during construction. Maintenance of such measurements will have to be included in the special provisions for the construction specification.

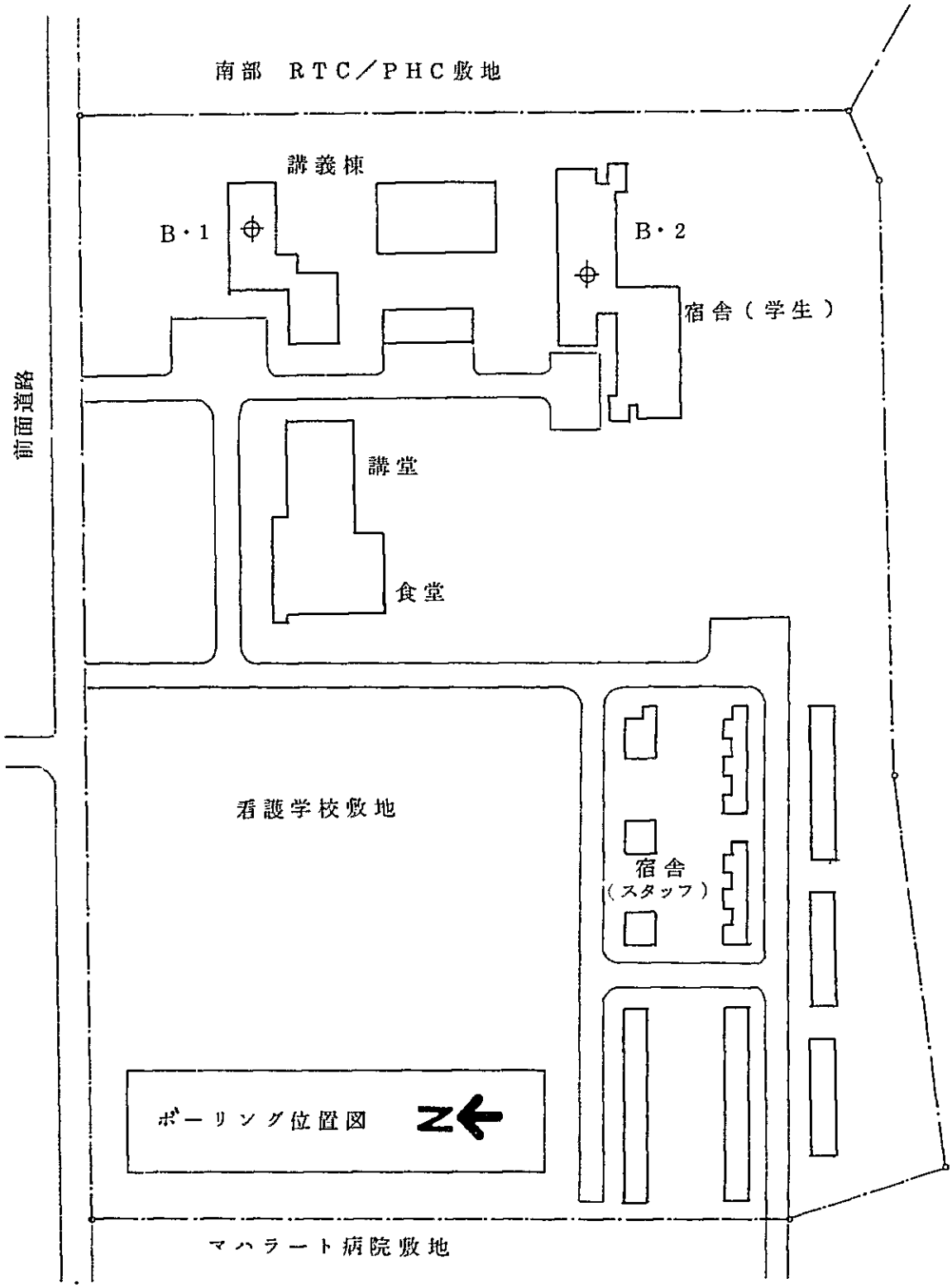
Acknowledgements

The writer wishes to express his appreciation to Overseas Technical Cooperation Agency and Pacific Consultants International, both based in Tokyo, Japan, which provided the writer with this opportunity and also with generous assistance during the course of this investigation.

1－2－3　ナコン・シ・タマラートの地質

ここに添付するボーリング・データは南部R.T.C／PHC建設地の西に隣接する敷地のものである。

当敷地には，アメリカの援助による看護学校及び宿舎が建設中である。



GROUND WATER OBSERVATION				W. E. C. BORING LOG	BORING NO.1
DATE	TIME	EL of HOLE	EL of WATER		SURFACE ELV. 3.269 M
			FLOODED	LOCATION NAKHONSRITHAMMARAT	DATE START
					DATE FINISH

SOILS DESCRIPTION	SOIL PROFILE	SAMPLE TYPE NO	DEPTH, M	STANDARD PENETRATION BLOWS/FT	LIQUID LIMIT / PLASTIC LIMIT / NATURAL MOISTURE CONTENT %	One half Unconfined Compressive Strength / peak remolded INSITU VANE SHEAR / One half Pocket-Penetrometer Rdg / SENSITIVITY KSC	TOTAL DENSITY T/M³
GROUND LEVEL			0.00	30 60	20 40 60 80	1 2 3	1 2
MEDIUM LI-GREYISH BROWN CLAY, TRACE OF DECAYED WOOD -1.30	CH	PA.1					
		ST.2					
MEDIUM GREY SILTY FINE SAND, TRACE OF MICA -4.00	CL	ST.3					
		ST.4					
VERY STIFF DARK GREY SANDY CLAY, TRACE OF MICA, OCCASIONAL DECAYED WOOD -7.50	CL	ST.5	5				
		SS.6		16			
VERY STIFF LI-GREY & YELLOWISH BROWN CLAY WITH BLACK-MOTTLED COLOUR, TRACE OF FINE SAND -11.80	CL CH	SS.7		12			
		SS.8		18			
		SS.9	10	22			
DENSE YELLOWISH & REDDISH BROWN SILTY FINE SAND -13.50	CH	SS.10		46			
STIFF LI-GREY & YELLOWISH BROWN CLAY TRACE OF FINE SAND -14.40	CH	SS.11		19			
MEDIUM TO DENSE LI-GREY FINE TO COARSE SAND	SC	SS.12	15	45			
		SS.13		32			
DENSE KU-GREY CLAYEY FINE SAND TRACE OF MICA -17.25		SS.14		40			
END OF BORING			20				

GROUND WATER OBSERVATION				W. E. C. BORING LOG	BORING NO. 2
DATE	TIME	EL of HOLE	EL of WATER		SURFACE ELV. 8.283 M
			FLOODED		DATE START 24. 1. 24
				LOCATION NAKHONSRITHAMMARAT	DATE FINISH

SOILS DESCRIPTION	SOIL PROFILE	SAMPLE TYPE NO	DEPTH, M	STANDARD PENETRATION BLOWS/FT	LIQUID LIMIT / PLASTIC LIMIT / NATURAL MOISTURE CONTENT (%)	One half Unconfined-Compressive Strength (KSC) / peak & remolded INSITU VANE SHEAR / One half Pocket-Penetrometer Rdg / SENSITIVITY	TOTAL-DENSITY (T/M³)
GROUND LEVEL			0.00	30 60	20 40 60 80	1 2 3	1 2
STIFF LI-GREY CLAY WITH YELLOW MOTTLED COLOUR TRACE OF ROOTS -2.00	ML & CL	ST 1					
SOFT DARK GREY CLAY, TRACE OF FINE SAND -4.00	ML & CL	ST.2 ST.3					
VERY STIFF GREYISH BROWN SANDY CLAY -6.00	CL	ST.4	5				
VERY STIFF LI-GREY & YELLOWISH BROWN CLAY, TRACE OF FINE SAND, OCCASIONAL CALCAREOUS -12.00	MH & OH	SS.5 SS.6 SS.7 SS.8	10	41 19 18 20			
DENSE LI-GREY VERY FINE TO COARSE SAND TRACE OF MICA, OCCASIONAL GRAVEL & CLAY -16.30	SC	SS.9 SS.10 SS.11	15	45 100 24			
HARD LI-GREY YELLOWISH BROWN-CLAY -16.95		SS.12		60			
DENSE LI-GREY CLAYEY FINE TO COARSE SAND -18.45	CL	SS.13		32			
END OF BORING			20				

1－3　地震・風向

建築構造計画に必要とされる地震，及風向資料は下記の通り

-1) 世界地震分布図

-2) 東南アジア地震・震源表分布図

1961～1967 深度 0～100 Km

M≧4

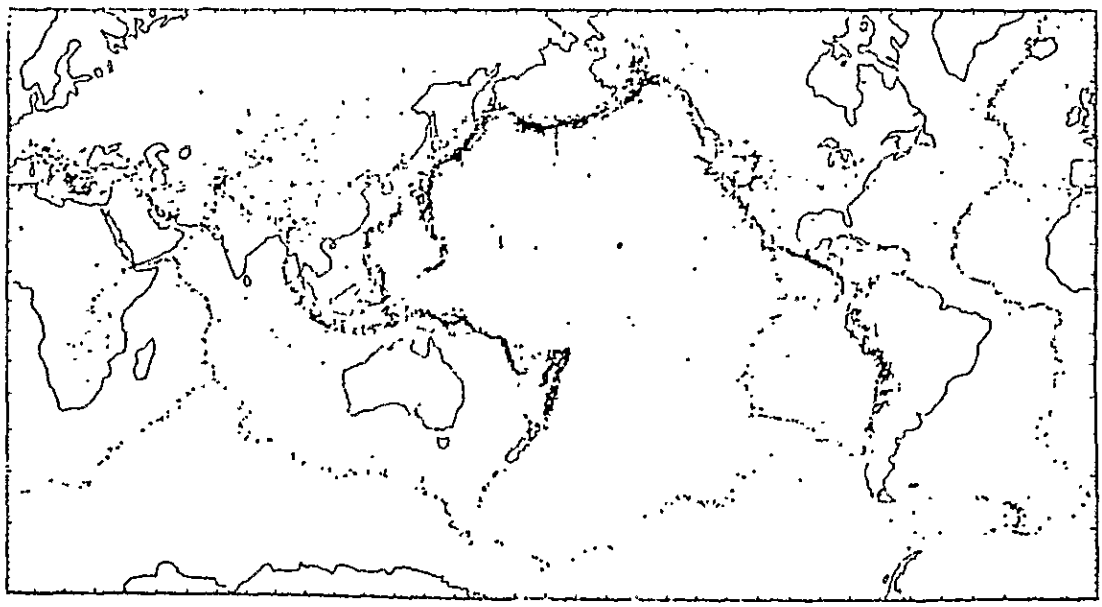
-1), -2)共出所：理科年表昭和５７年度版

-3) 風向・風力

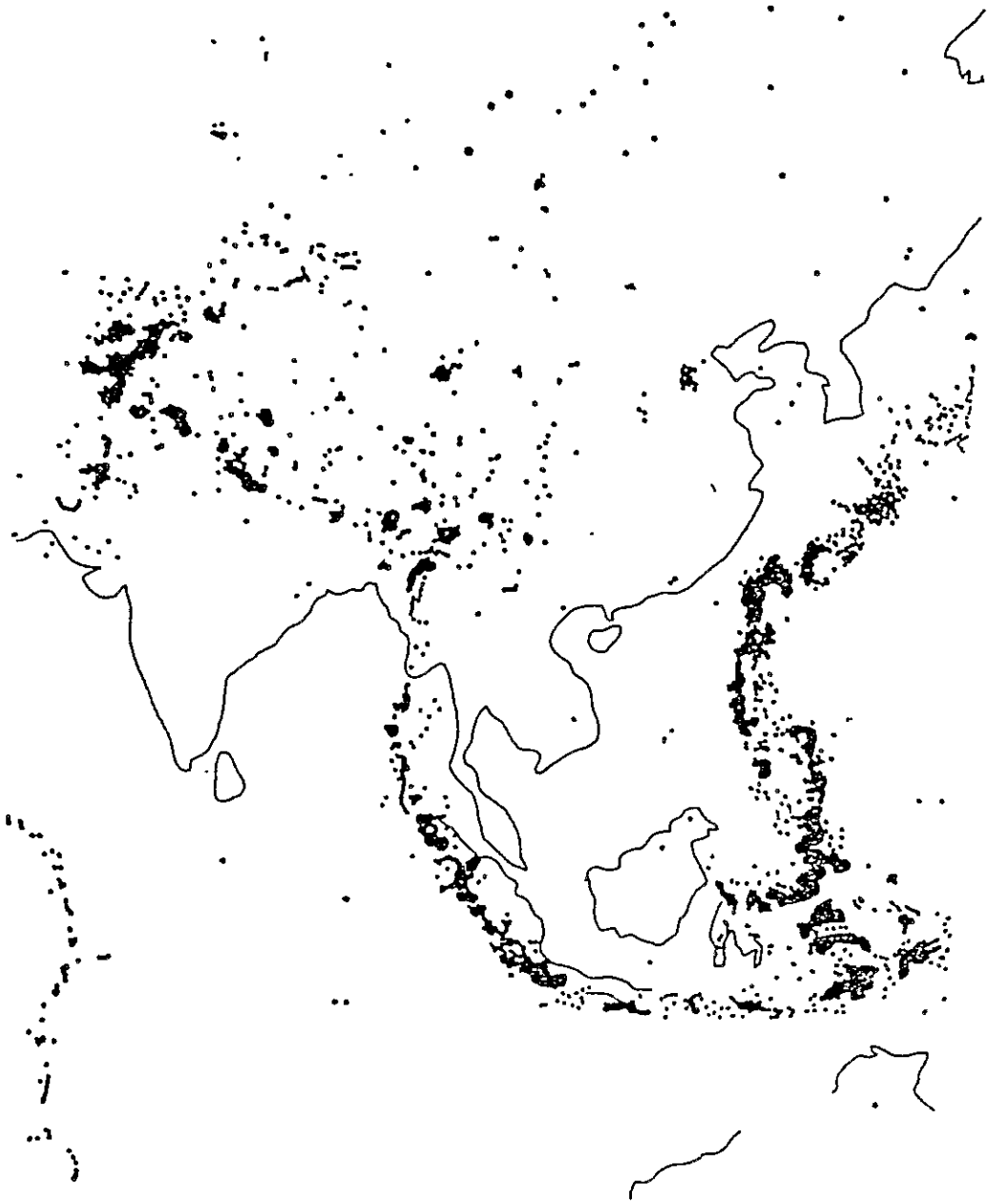
出所：ministruy of Agriculture.

但し，風力については気象条件の資料参照

1－3－1　世界地震分布図

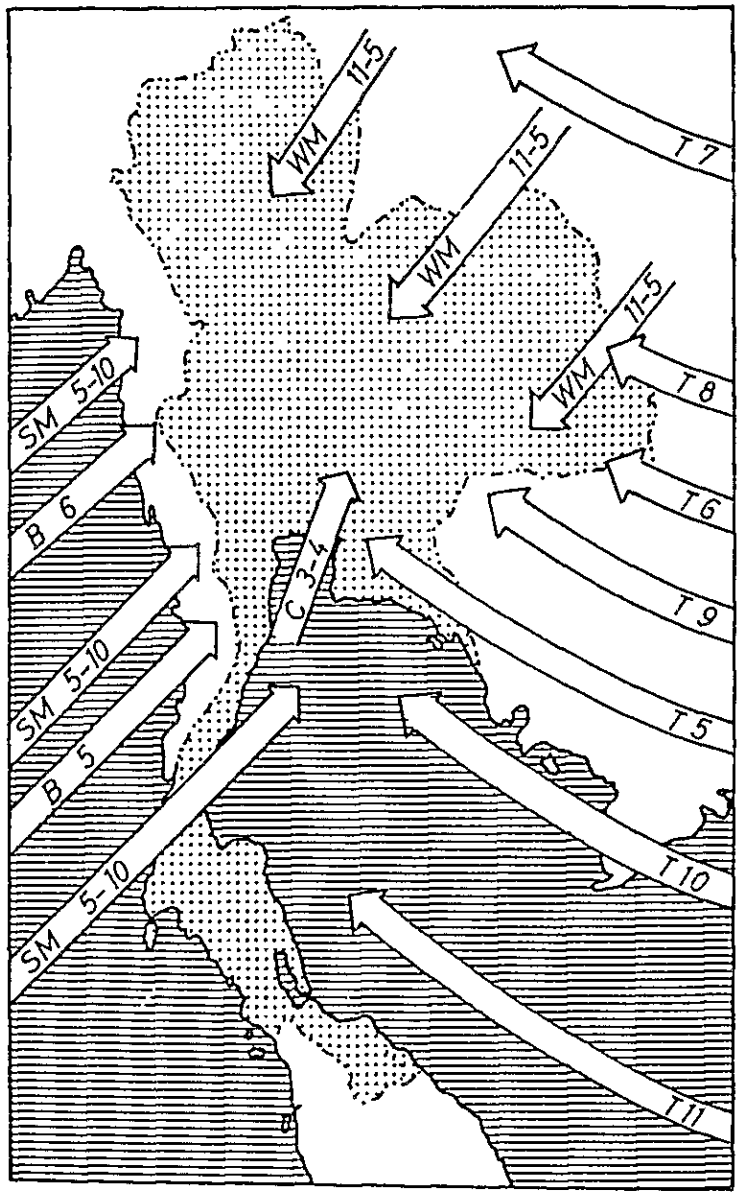


1－3－2）東南アジア地震源分布図



（1961～1967・深度 0－100Km）

1－3－3）風向・風力

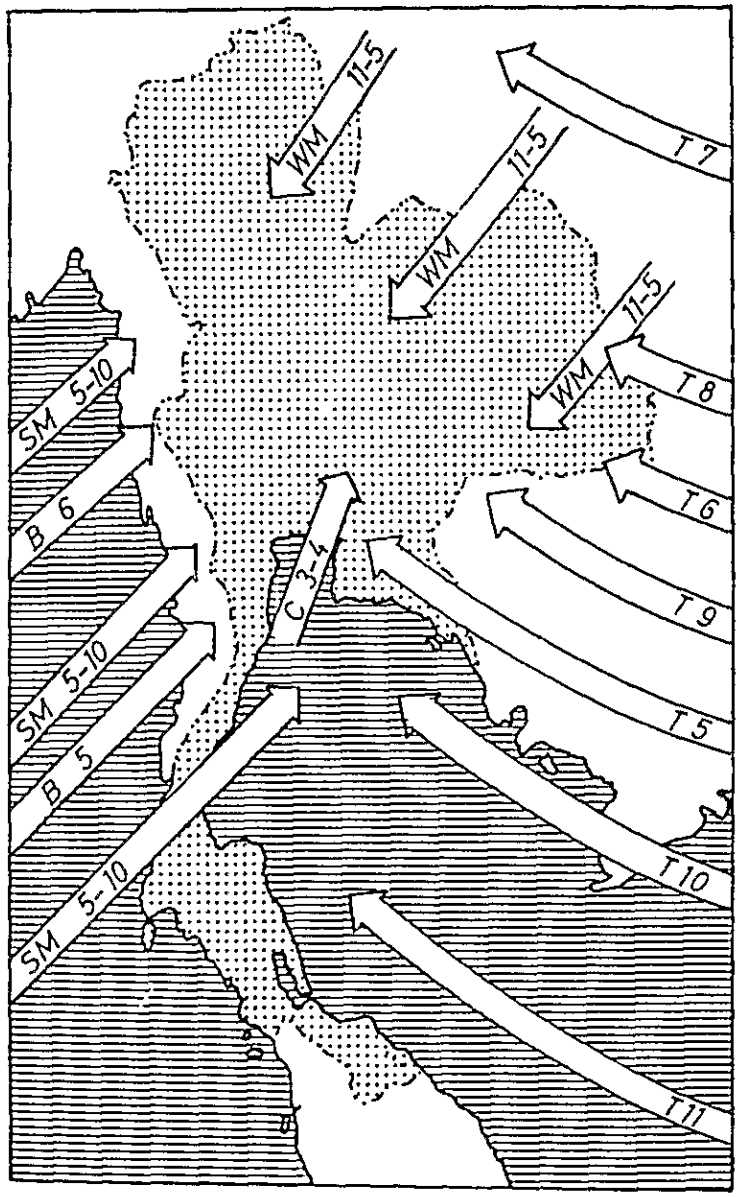


Winds influencing the climates of Thailand.

Legend: SM=summer monsoon; WM=winter monsoon; B=Bengal cyclone; C=convection (local storms); T=typhoon. The numbers indicate the months in which the wind prevails.

2. 建築に関する行政

1－3－3）風向・風力



Winds influencing the climates of Thailand.

Legend: SM=summer monsoon; WM=winter monsoon; B=Bengal cyclone; C=convection (local storms); T=typhoon. The numbers indicate the months in which the wind prevails.

2. 建築に関する行政

2 建築に関する行政

2－1 建築関連法規

関連する諸法規並びに諸規準は，次のようなものが該当すると思われる。名称は全て，タイ語を英訳されたものである。それらについて日本に該当する法令及び説明を記す。

-1) Building Control Act.

「建築基準法」に該当する。

-2) Bye-Laws of The Bangkok Metropolis.

「建築基準法施工令」，「地方条令」に該当しバンコク首都圏の条令である。尚，他地区にもこれに類する条令はあるとの事。

-3) City Planning Act.

「都市計画法」に該当する。

-4) Prevention and Repression of Fire Risk Act.

「消防法・施工令」，「建築基準法（防災関係）」に該当する。尚，上記法の補足としてMinisterial Regulationがある。

-5) Factories Act

工場建設に関する法である。補足としてMinisterial RegulationとNotification of Ministry of Industryがある。

-6) Act on the Architectural Profession.

「建築士法」に該当。

-7) Act on the Engineering Profession.

土木・電気等の技術士法である。

-8) Construction Profession Act.

「建設業法」に該当。

-9) Fuel Oil Act.

石油に関する法。

-10) Metropolitan Electrical Authority Act.

バンコク首都電力公社による電力供給法。

-11) Provincial Eleetrical Authority Act.

地方電力公社による電力供給法。

-12) Thai Standard for Electrical Safety.

「電気設備技術規準」に該当。

-13) Thai Industrial Staudard. (TIS)

日本の「JIS」に該当。各資材の品質，大きさ等の規格である。

上記関連法規・規準のうち，-1) ー英訳版ー を資料として添付する。

2－1－1　Building Control Act.

BUILDING CONTROL ACT 1979

INTERNATIONAL TRANSLATIONS
22 SILOM ROAD, BANGKOK 5, THAILAND
☎ 233-7714

BUILDING CONTROL ACT

1979

BHUMIBOL ADULYADEJ REX.
Given on the 8th day of May 1979
Being the 34th Year of the Present Reign

By Royal Command of His Majesty King Bhumibol Adulyadej it is hereby proclaimed that:

Whereas it is expedient to amend the law on the control of the construction of buildings and the law on re-consiruction of fire area control and congregate them into one same law;

His Majesty the King, by and with the advice and consent of the National Legislative Assembly, in its capacity as Parliament, as follows:

SECTION 1. This Act shall be called the "Building Control Act 1979".

SECTION 2. This Act shall come into force on the day following its publication in the Government Gazette. A Royal Decree shall be issued to specify the localities and their area to which the Act applies.

SECTION 3. The following shall be repealed คือ.

(1) The Control of the Construction of Buildings Act 1936;

(2) The Control of the Construction of Buildings Act (No. 2) 1961;

(3) Announcement of the Revolutionary Party No. 192 dated 31 July 1962;

(4) Re-Construction of Fire Area Control Act 1933;

(5) Re-Construction of Fire Area Control Act (No. 2) 1953.

SECTION 4. In this Act:

"Building" means any masonary or timber dwelling house, shed, shop, floating house, warehouse, office or other structure in which persons may dwell or use, including:

(1) any spectator's stand or other erection for people to assemble;

(2) any dam, bridge, culvert, passage or drain, dock, slipway, landing stage, wharf or landing, fence or wall including gate abutting or near public ways or any structure for use by the public in general;

(3) any signboard or structure for fixing or installing signboard.

(a) being fixed or installed over a public way and having a area exceeding one square metre or weighing, with the structure included, more than ten kilogrammes;

(b) being fixed or installed at a place where the horizontal distance from a public way being less than the vertical distance from the ground level and having an area or weight exceeding that prescribed in the Ministerial Regulation;

(4) any area or structure for vehicle parking, turning around, and entrance of a building specified under Section 8 (9).

(5) any other structure specified in the Ministerial Regulation.

Which shall include the various parts of such building.

"Public place" means any place that is open to the public or that the people in general are allowed to enter or pass through whether payment is required or not.

"Grounds-plan" means a map of the area of land showing the outlines, location and boundaries of the land and building constructed, modified, torn down, removed, used or reused, including the brief outlines and boundaries of the adjoining public place(s) and building(s).

"Design plan" means a drawing or outline made for the benefit of constructing, modifying, tearing down, removing, using or reusing a building, which shows essential particulars of the various parts, dimensions and symbols of materials, and functions of the building sufficiently complete for such purpose.

"Supplementary particulars to a design plan" means detailed information on quality and kind of the materials and the method for implementation or construction, modification, tearing down, removal, use or reuse of the building to be in accordance with the design plan.

"To modify" means to alter, add to, reduce or expand the physical characteristics of the boundaries, design, shape, proportions, weight or area of the structure of the building or its various members already existing to be different from the original, and which is not a repair or modification specified in the Ministerial Regulations.

"To repair" means to restore or replace the various parts of the building back to good condition.

"To remove" means to take off or away such parts which form the structure of the building as a post, beam, joist or other parts of the structure specified in the Ministerial Regulations.

"Fire area" means an area in which a fire broke out and burnt down from 30 household buildings and up or covered an area from one rai and up, including the surrounding areas within the thirty-metre radius.

"Supervisor" means a person who is charged with the duty of direction and control of the construction, modification, tearing down or removal of the building.

"Operator" means the owner or possessor of the building who constructs, modifies, tears down or removes the building himself, including the person who undertakes to perform the said work for money payment or not and the sub-contractor.

"Inspector " means the person appointed by the local authority as the inspector.

"Engineer" means an engineer or architect of the Department of Public Works or who is appointed by the local authority as the engineer.

"Local authorities" mean Municipalities, Sanitary Disrricts, Changwat Administrative Organizations, Bangkok Metropolis, Pattaya City, and other local administrative organizations announced by the Minister as the local authorities under this Act.

"Bye-law" means a law or regulation issued by virtue of the Legislative power of the local authorities such as Municipal ordinances, Sanitary Districts' regulations, Changwat's bye-laws, bye-laws of Bangkok Metropolis, or bye-laws of Pattaya City, etc.

"Local Competent Officer" means:

(1) the mayor, for a municipal area;

(2) the sanitary council chairman, for a sanitary district area;

(3) the Changwat Governor, for a Changwat Administrative Organization;

(4) the Bangkok Metropolis Governor, for the Bangkok Metropolitan area;

(5) the Pattaya City Deputy, for the Pattaya City area;

(6) the head of a corporation of a local administrative organization announced by the Minister as a local authority under this Act, for such local authority area.

"Minister" means the Minister in charge and control of the execution of this Act.

SECTION 5. The Minister of Interior shall have charge and control of the execution of this Act and shall have the power to issue Ministerial Regulations to

(1) prescribe fees not to exceed the rates in the schedule annexed to this Act or to exempt fees;

(2) prescribe application form for permission, licence certificate, substitute, and order or other forms required for the execution of this Act;

(3) prescribe other activities for the execution of this Act.

Ministerial Regulations shall come into force upon their publication in the Government Gazette.

Chapter 1

General Provisions

SECTION 6. This Act shall not apply to the throne or Royal Palaces.

SECTION 7. The Minister shall have the power to issue Ministerial Regulations granting exemption from or easing restriction on or specifying conditions for the execution of this Act in connection with the following building either in part or in the entirety:

(1) the buildings of Ministries, Bureau and departments under official use or use for public benefits;

(2) the buildings of local authorities under official use or use for public benefits;

(3) the buildings of state organizations lawfully established under use for activities of the organizations or use for public benefits;

(4) ancient places, monasteries and temples, and various buildings used for religious activities and construction of which is specifically and already controlled by law;

(5) office buildings of international agencies or office buildings of the agencies established under the agreements between the Thai Government and the Governments of foreign countries;

(6) office buildings of foreign embassies or consulates;

(7) temporary building for use in constructing permanent buildings or buildings for temporary use with a definite period set for removal.

SECTION 8. For the benefits of strength, safety, fire prevention, public health, environment conservation, city planning, architecture, and facilitating traffic and other activities required for the execution of this Act, the Minister, by advice of the Buildings Control Committee, shall have the power to issue Ministerial Regulations specifying:

(1) the characteristics, design, shape, proportion, area and site of a building;

(2) weight bearing, withstanding, endurance, and characteristics and properties of the materials used;

(3) weight bearing, withstanding and endurance of the building or the ground supporting the building;

(4) design and method pertaining to the installation of the system of water supply, electricity, gase and fire prevention;

(5) design and number of bath-rooms and toilets;

(6) electrical lighting system, ventilation, drainage and garbage and refuse disposal;

(7) characteristics, level and area of open space outside the building or the building line;

(8) distance or level between a building and another building or boundary of other person's land, or between a building and a road, trak, soi, footpath, or public land;

(9) area or structure for vehicle parking and turning ground and entrance to a building of some type or category, including characteristics and size of such area or structure;

(10) area prohibited for construction, modification, tearing down, removal and use or reuse of building of some type or category;

(11) criteria, procedures and conditions for construction, modification tearing down, removal, use or reuse of a building;

(12) criteria, procedures and conditions for application for permission, permission approval, licence renewal, issuance of certificate and substitutes under this Act.

SECTION 9. Subject to the provision under Section 10, a local authority shall have the power to issue bye-laws specified under Section 8 in so far they are not inconsistent with the Ministerial Regulations issued under Section 8.

SECTION 10. In the case of a necessity or where it is justificable by specific special reason, a local authority may issue bye-laws on some certain matter that are inconsistent with or contrary to those provided in the Ministerial Regulations issued under Section 8, upon having the consent from the Buildings Control Committee and the approval from the Minister.

SECTION 11. The bye-laws issued under Section 9 or Section 10 shall be effective upon their publication in the Government Gazette.

SECTION 12. The Ministerial Regulations issued under Section 8 or the bye-laws issued under Section 9 or Section 10 that are in consistent with or contrary to the law on city-planning shall be prevailed by the law on city-planning.

SECTION 13. In the case it deems appropriate that construction, modification, tearing down, removal and use or reuse of a building of any type or category in any area of the time no Ministerial Regulation or bye-law under Section 8 (10) has been issued, the Minister, by advice of the Public Works Department Director-General or the local competent officer, as the case may be, shall have the power to announce in the Government Gazette the temporary prohibition for construction, modification, tearing down, removal and use or reuse of the building in such area and shall proceed to issue Ministerial Regulations or bye-laws within one year from the effective date of the said announcement.

If the Ministerial Regulations or bye-laws are not issued within the period pursuant to paragraph one, the said announcement shall be repealed.

Chapter 2

Buildings Control Committee

SECTION 14. There shall be a Buildings Control Committee comprising the Public Works Department Director-General as the Committee Chairman, one representative each of the Ministry of Public Health, the Ministry of Industry, the Department of Local Administration, the Highways Department, the Department of Public Prosecutions, the Department of Town and Country Planning, the Office

of the National Environment Board, the Bangkok Metropolis, the Office of the Board for the Control of Engineering Profession and the Office of the Board for the Control of Architectural Profession, and not more than four qualified persons who are appointed by the Minister as Committee Members, and the Head of the Office of the Buildings Control Committee as the Member and Secretary.

SECTION 15. A Member who is appointed by the Minister shall hold office for a term of three years.

In the event of an appointment of either an additional or replacement Member during the term of office of the Members already appointed, the newly-appointed Member shall hold office for the remaining period of the term of office of the already appointed Members.

A Member who terminates office may be re-appointed but not for more than two successive terms.

SECTION 16. Besides vacating office upon expiration of the term of office pursuant to Section 15, the Members shall vacate office upon:

(1) death;

(2) resignation;

(3) being dismissed by the Minister;

(4) becoming a bankrupt;

(5) becoming an incompetent or quasi-incompetent person;

(6) being sentenced to imprisonment by final judgement or being imprisoned by lawful order, except where the offence has been committee through negligence or is petty one.

SECTION 17. A meeting of the Buildings Control Committee is required to be attended by not less than half the total number of the Committee Members to constitute a quorum. In the event the Committee Chairman is absent or is unable to perform his duty, the attending Members shall elect one Member among them as the meeting chairman.

A decision of the meeting shall be determined by a majority.

A Committee Member shall have one vote and, when votes on each side are equal, the casting vote shall be given by the meeting chairman to decide the question.

SECTION 18. The Buildings Control Committee shall have the power and duty to

(1) give advice in the issue of the Ministerial Regulations under Section 8;

(2) give consent for the issue of the bye-laws under Section 9 or Section 10;

(3) give recommendations and suggestions to the local competent officers in their execution of this Act;

(4) execute other duties provided in this Act.

SECTION 19. The Buildings Control Committee may a sub-committee for consideration and execution of any task entrusted by the Buildings Control Committee.

The provision of Section 17 shall be applied to the meetings of the sub-committee mutatis mutandis.

SECTION 20. The Office of the Buildings Control Committee shall be established within the Department of Public Works and shall have the duty to administer technical and administrative work for the Buildings Control Committee, to give consultation and suggestion to the Committee for Appeal Consideration, and to co-ordinate work and give assistance to the Local Authorities in the execution of this Act.

Chapter 3

Construction, Modification, Tearing Down, Removal, and Use or Reuse of Buildings

SECTION 21. No person shall construct a building unless the owner of such building has obtained the licence from the local competent officer.

SECTION 22. No person shall modify a building, unless the owner of such building has obtained the licence from the local competent officer.

SECTION 23. No person shall tear down the following buildings, unless the owners of such buildings have obtained the licences from the local competent officer:

(1) a building of more than fifteen metres in height which the distance between the building and another building or a public land is less than the height of the building;

(2) a building which is less than two metres distant from another building or a public land.

SECTION 24. No person shall remove a building, unless the owner of such building has obtained the licence from the local competent officer.

SECTION 25. The local competent officer shall refuse to consider any application for construction, modification, tearing down or removal of a building that has the characteristics of or is classified under the controlled engineering profession under the law on engineering profession or under the controlled architectural profession under the architectural profession, if the engineer or architect responsible for such work implementation as specified in the application is not a lincensee for engagement is the controlled engineering profession or in the controlled architectural profession, as the case may be.

SECTION 26. Upon receiving the application pursuant to Section 21, Section 22, Section 23 or Section 24, the local competent officer shall consider and issue a licence or a written notification of disapproval order together with reasons for disapproval to the applicant within fourty-five days from the day on which the applicant is received.

In the event the local competent officer is unable to issue the licence or the notification of disapproval order within the time period specified in paragraph one due to a cause, such period may be extended not more than two times and each time for not more than fourty-five days. In such event, however, the applicant must be notified in writing of the period extension and its justification each time before the expiration of the time period specified in paragraph one or the extension thereof, as the case may be.

In the event the local competent officer issues a license or disapproval order, he shall notify the applicant of such action without delay.

SECTION 27. In considering the applicant pursuant to Section 26 the local competent officer shall have the power to order the applicant to modify the site plan, design plan, supplementary particulars to the design plan, or calculation sheets already submitted to be correct to and in accordance with the Ministerial Regulations issued under Section 8 or the bye-laws issued under Section 9 or Section 10, and Section 26 paragraph three shall be applied *mutatis mutandis*.

After the applicant for the licence has modified the site plan design plan, supplementary particulars to the design plan, or calculation sheets in accordance with the order of the local competent officer, the competent officer shall make examination and consideration and issue the licence within thirty days. But if and in the case the applicant has modified same in deviation in material part from that ordered by the local competent officer, it shall be regarded that the application is newly submitted and the proceeding pursuant to Section 26 shall be taken.

SECTION 28. In the case the person who calculates the design plan, suplementary particulars to the design plan and calculation sheets submitted together with the application pursuant to Section 21, Section 22, Section 23 or Section 24 is a licensee for engagement in the controlled engineering profession under the law on engineering profession, the local competent officer shall examine and consider only the parts that do not deal with particulars pertaining to technical engineering and, however, in accordance with the criteria, procedures and conditions prescribed in the Ministerial Regulations.

SECTION 29. In applying for permission to construct, modify, tear down, or remove a building, the applicant for the licence shall specify the name together with the statements or consent of the work supervisor in the application for the licence.

The work supervisor may be any person or the owner of the building, except where it is prohibited by the law on engineering profession or the law on architectural profession.

SECTION 30. If the licensed person is to remove the work supervisor whose name is specified in the licence or the work supervisor is to resign from the duty, the local competent officer shall be so informed, in writing, in so far as, however, it does not affect the civil duty and rights between the licensed person and such work supervisor.

In the event of removal or resignation pursuant to paragraph one, the licensed person shall temporarily suspend the work implementation until the new work supervisor is available and a written notification together with a letter of consent of the new work supervisor has been submited to the local competent officer.

SECTION 31. No person shall arrange to have a building constructed, modified, torn down, or removed in diviction from the approved site plan, design plan and supplementary particulars to the design plan and the methods and conditions specified by the local competent officer in the licence, however, except;

(1) where it is not inconsistent with the Ministerial Regulations issued under Section 8 or the bye-laws issued under Section 9 or Section 10;

(2) where it is a case prescribed in a Ministerial Regulation.

In the event the construction, modification, tearing down or removal of a building is in violation of the provision in paragraph one, it shall be regarded that it is an act of the work supervisor, unless he can prove it to be other person's.

SECTION 32. Buildings classified under the controlled use category are the buildings for use for the following business:

(1) warehouses, theatres, hotels or medical treatment places;

(2) commerce, industry, education, public health or other activities prescribed by Ministerial Regulations.

Upon the licensed person having completed the construction, modification or removal of the building classified under the controlled use category, the owner or possessor of such building shall not use or allow other person to use the building for the activities specified in the licence, unless the local competent officer has issued a certificate stating that the building has been completely constructed, modified or removed accordingly as licensed.

The owner or possessor of the building pursuant to paragraph two shall not use or allow other person to use such building for any activity pursuant to paragraph one except that specified in the licence for construction or modification or removal.

SECTION 33. The owner or possessor of a building which is not classified under the controlled use category shall not use or allow other person to use the said building for any activity specified under Section 32 paragraph one, unless the licence has been obtained from the local competent officer and the provisions of Section 26 and Section 27 shall be applied mutatis mutandis.

The provision of paragraph one shall be applied to the reuse of a building classified under controlled use category for one activity to other activity mutatis mutandis.

SECTION 34. The owner or possessor of the building, that is required to have an area or structure for vehicle parking, turn about or entrance pursuant to Section 8 (9), shall not modify or use the vehicle park, turn about or entrance for other activity either in the entirety or in part unless the licence has been obtained from the local competent officer.

SECTION 35. The licence issued under Section 21, Section 22, Section 23 or Section 24 shall be valid throughout the period specified in the therein. The person who wishes to renew the licence shall submit an application before such licence expires and, after having submitted the said application, may carry on his business until the local competent officer orders dis-approval for renewal of such licence.

SECTION 36. The Licence issued under Section 21, Section 22, Section 23, Section 24 or Section 33 shall not be transferable, unless written permission has been obtained from the local competent officer.

SECTION 37. In the event that a person who has obtained the licence under Section 21, Section 22, Section 23, Section 24 or Section 33 dies, his heir or executor who wishes to continue to construct, modify, tear down, remove, use or reuse such building shall notify the local competent officer in writing within thirty day from the day of the death of the licensed person. In this case, it shall be regarded that the said heir or executor is the person who obtains the licence on behalf of other person.

SECTION 38. During the construction, modification, tearing down or removal, as the case may be, of a building, the licensed person is required to keep one set of the licence, site-plan, design-plan, and supplementary particulars to the design-plan at the area of the said licensed work ready for inspection by the Engineer or the Inspector.

The possessor of a building classified under the controlled use category shall display the certificate pursuant to Section 32 or the licence pursuant to Section 33 at a conspicuous place at the building.

SECTION 39. In the event a licence or certificate is lost, destroyed or damaged at a material part, the holder of such licence or certificate shall apply to the local Competent Officer for a substitute licence or certificate within fifteen days from the day of knowledge of the loss, destruction or damage.

Application for a substitute licence or certificate and issue of a substitute licence or certificate shall be in accordance with the criteria, procedures and conditions prescribed in the Ministerial Regulations.

The substitute licence or certificate shall be effective according to the law as the licence or certificate, as the case may be.

Chapter 4

Authority and Duty of Local Competent Officer

SECTION 40. In the event that there arises a violation of Section 21, Section 22 or Section 24, or any construction, modification or removal of any building that violates Section 31, the local competent officer shall the power to order the owner or the possess or of the building, the operator or work supervisor, as the case may be, to order suspension of the activity implementation. And if the building may endanger health, life, body or property, the local competent officer may forbid the owner or possessor of the building to use or allow other person to use the building in the entirety or in part.

After having effected the order pursuant to paragraph one, the local competent officer shall consider to issue order pursuant to Section 42 paragraph one or Section 43 paragraph one, as the case may be, without delay but not to be later than thirty days from the day of receipt of the order for the said suspension.

SECTION 41. In the event that there arises a violation of Section 23, or any tearing down of any building that violates Section 31, the provisions of Section 40 paragraph one and Section 43 shall be applied mutatis mutandis, provided that the local competent officer issues his order pursuant to Section 43 promptly and not to be later than thirty days from the date of the order for the suspension of the tearing down of the building.

In the event of non-compliance with the order of the local competent officer pursuant to paragraph one, if the local competent officer is of the opinion that the building of which the removal has been suspended may endanger health, life, body or property, the local competent officer shall have the power to have the removal carried out and have the provisions of Section 42 paragraph three, paragraph four and paragraph five applied mutatis mutandis.

SECTION 42. In the event that the procedures pursuant to Section 40 have been effected and such acts have brought about no changes in accordance with the Ministerial Regulations Issued under Section 8 or the bye-laws issued under Section 9 or Section 10, the local Competent Officer shall have the power to order the tearing down of the building in the entirety or in part within the prescribed period which shall not be less than thirty days except where there is reasonable cause, may be extented by the local competent officer.

The person whom the local competent officer orders to tear down building pursuant to paragraph one shall tear down the building in accordance with the criteria procedures and conditions prescribed in the Ministerial Regulations issued under Section 8 (11) or the bye-laws issued under Section 9 or Section 10.

In the event of non-compliance with the order of the local competent officer pursuant to paragraph one, the local Competent Officer shall bring the matter to the Court requesting order for the tearing down of the building. If the facts found through legal proceedings are that there is actually a violation of Section 40, the Court shall order the tearing down of the building and in such order the tearing down of the building and in such order the Court may specify the owner or possessor of the building, the operator or the work supervisor or the local Competent Officer as the person responsible for the tearing down as deemed appropriate for each case. In the event that the Court deems it proper for the local Competent Officer to be responsible for the tearing down, the local competent officer may proceed to tear down the building only after an announcement to that effect has been posted up at the area specifying the schedule for tearing down not less than seven days in advance.

In the case the tearing down is to be done by the local competent officer, proper must be taken. However, no person shall command any indemnity from the local competent officer and all expenses for such work shall be borne by the owner of the building.

The local competent officer shall have the power to confiscate all the construction materials and articles removed from the part of the building that is torn down for sale and hold the proceeds in lieu of the property in accordance with the criteria, procedures and conditions prescribed in the Ministerial Regulations. And if the owner does not claim for the property or the proceeds within one year from the day of notification for tearing down, the property and proceeds shall become the property of the state.

SECTION 43. In the event the act pursuant to Section 40 is not inconcistent with the Ministerial Regulations issued under Section 8 or the bye-laws issued under Section 9 or Section 10 or is inconsistent but still cannot be corrected or put right, the local competent officer shall have the power to order the owner of the building to apply for the licence or order the owner of the building or the operator to put the building right within the prescribed period, which must not be less than thirty days and, if with reasonable cause, may be extended by the local competent officer.

In examining the application for the licence pursuant to paragraph one, the local competent officer shall have the power to order the applicant to modify the site-plan, design-plan, supplementary particulars to the design-plan or calculation sheets already submitted to be correct and in accordance with the Ministerial Regulations issued under Section 8 or the bye-laws issued under Section 9 or Section 10 within the prescribed period.

If the owner of the building does not submit the application or the owner of the building or the operator does not correct the building pursuant to paragraph one or does not amend the application for the licence pursuant to paragraph two, the local competent officer shall have the power to order the tearing down of the said building in the part deemed appropriate and the provisions of Section 42 paragraph two, paragraph three, paragraph four and paragraph five shall be applied mutatis mutandis.

SECTION 44. In the event Section 32 or Section 33 is violated, the local competent officer shall have the power to order the owner or the possessor of the building to the use of the building in the part that has not been certified or licensed until Section 32 or Section 33, as the case may be, is complied with.

SECTION 45. In the event Section 34 is violated, the local competent officer shall have the power to order to owner or possessor of the building to suspend such act. And it the act is to modify the area or structure for vehicle parking, turn about or entrance, the local competent officer shall have the power to order it be restored to its former condition within the prescribed period and the provision of Section 42 shall be applied mutatis mutandis.

SECTION. 46. In the event the building being constructed, modified or removed with a licence under this Act or having been constructed modified or removed before the day on which this Act comes into force is in the condition or is used in the manner that may endanger health, life, body or property or may not be safe from fire or may cause nuisance to or may affect maintenance of quality and environements, the local competent officer shall have the power to order improvement to be in accordance with the criteria, procedures and conditions prescribed in the Ministerial Regulations.

In the event of a failure to comply with the order of the local competent officer pursuant to paragraph one and such building may cause serious harm to health, life, body or property, the local competent officer shall have the power to order the building to be torn down and the provision of Section 42 shall be applied mutatis mutandis.

SECTION 47. An order or notification of the local competent officer under this Act shall be made in writing and forwarded by registered mail to an applicant a licence, licensed person, the owner or possessor of a building, operator or work supervisor, as the case may be, at his domicile, or in a memorandum to be signed by the said person in acknowledgement.

In the event the local competent officer cannot forward a written order or a memorandum for acknowledgement pursuant to paragraph one, such

order or notification, as the case may be, shall be posted up at an open and conspicuous place at the building or site of building being constructed, modified, torn down, removed, used or reused and it shall be regarded that the applicant for the licence, licensed person, owner or possessor of the building, operator, or work supervisor has received such order or notification since the day following the seven-day period after the day the order or notification being posted up.

SECTION 48. In performing his duty under this Act, the local competent officer is empowered to enter the building or the building grounds, that causes reasonable suspect that this Act is being violated or is not being complied with, during the time from sunrise to sunset or during work hours of such place and, for this purpose, shall have the authority to question for facts or order the persons being present at the place to present documents or other relevant evidence.

SECTION 49. The local competent officer shall have the power to appoint any Government official or local authority official, who is knowledgeable or qualified as prescribed in the Ministerial Regulation, as the Inspector or Engineer.

Chapter 5
Appeals

SECTION 50. There shall be a committee for appeals consideration.

(1) for the Bangkok Metropolis or a Changwat Administrative Organization to comprise the Interior Ministry Under-Secretary of State as Committee Chairman, the Public Works Department Chief Engineer as a Committee Member and other persons, not to be more than six, appointed by the Minister as Committee Members, and the head of the Office of the Buildings Control Committee as Committee Member and Secretary.

The Committee Members appointed by the Minister must not be the officials of the Bangkok Metropolis or a Changwat Administrative Organization or members of Bangkok Metropolis Council or a Changwat Council.

(2) for a municipality, sanitary district, the Pattaya City, or other local authority to comprise the local Changwat Governor as the Committee Chairman, the Changwat Public Prosecution Officer Changwat Provincial Police Chief, Changwat Chief Physician and other persons, not to be more than five, appointed by the Interior Ministry Under-Secretary of State as Committee Members and a Committee Member elected by the Committee for Appeals considera tion as Secretary.

The Committee Members appointed by the Interior Ministry Under-Secretary of State must not be the officials of the local authority or the local authority council.

The provisions of Section 15, Section 16 and Section 17 shall apply to the Committee for Appeals Consideration mutatis mutandis.

SECTION 51. The Committee for Appeals Consideration shall have authority and duty as follows:

(1) to consider and rule appeals against the orders of the local competent officer;

(2) to summon by written letter any concerned person to give state-ments or to order such person to submit documents or other relevant evidence for consideration in ruling appeals;

In performing the duty under (3) the Committee for Appeals Considera-tion or the person authorized by the Committee for Appeals Consideration may enter the building or building grounds which is the cause for the appeal during the time from sunrise to sunset.

SECTION 52. Any applicant for a licence, licensed person and person who is given an order by the local competent officer pursuant to Section 26 paragraph one Section 27 paragraph one, Section 41 paragraph one, Section 42, Section 43, Section 44, Section 45 or Section 46 who disagrees with an order of the local competent officer is entitled to appeal to the committee for appeals consideration against such order by filing a written petition to the official at the

Office of the Under-Secretary of State for the Bangkok Metropolis or a Changwat Administrative Organization area or at the Changwat or Amphoe Office for a municipality, sanitary district, the Pattaya City or other local authority area within thirty days from the day of receipt of such order.

The Committee for Appeals Consideration shall rule the appeal within thirty days from the day of receipt of such appeal and then notify the ruling to the appellant and the local competent officer. The ruling shall be final. But if the appellant still disagrees with the ruling, he may bring the case to the court of justice within thirty from the day of receipt of the ruling notification.

The local competent officer shall act in accordance with the ruling of the Committee for appeals consideration or decision or judgement of the Court of justice.

During the appeal the appellant or the local competent officer shall not treat the building which is the cause for the appeal in any way, except that the building is dangerous to persons or property or is in the state that requires immediate action.

The provision of Section 47 shall apply to the notification of the appeal ruling *mutatis murandis*.

Chapter 6

The Engineering and the Inspector

SECTION 53. The Engineer or the Inspector shall have the authority to enter the site in which construction, modification, tearing down or removal of a building is under way to see whether this Act is being complied with or not and, for this purpose, shall have the power to question for facts or order the being present or working at the place to present documents or other relevant evidence.

SECTION 54. When there is reasonable cause to suspect that any building has been constructed, modified, torn down or removed in a way that violated or did not comply with this Act, or there is reasonable cause to suspect that any building is being used or reused in such a way that violates or does not comply with Section 32, Section 33 or Section 34, or any building that has characteristics pursuant to Section 46, the Engineer shall have the power to enter such building and the building grounds to inspect and, for this purpose, shall have the authority to question for facts and order the persons being present or working at the place to produce documents or other relevant evidence.

SECTION 55. In performing the duty pursuant to Section 53 or Section 54, the Engineer or the Inspector shall do so during the time from sunrise to sunsent or during the wore time of such place and, for this purpose, shall produce his identification card upon request by the persons concerned.

The identification card shall be in the form prescribed in the Ministerial Regulation.

Chapter 7

Fire Area

SECTION 56. When a fire breaks out in any area that has the characteristics of a fire area, the local competent officer shall announce the display of the fire area at the office of the local authority and at the place of the fire by having a brief map showing the boundary lines of the fire area and specifying prohibitions under this Act.

SECTION 57. Within fourty-five days from the day the fire broke out, no person shall construct, modify, repair, tear down or remove any building in the fire area and the person licensed to construct, modify, tear down or remove buildings in the said area before the day of the fire shall suspend his activity under the licence during the said period.

The provisions of Section 40, Section 41, and Section 42 shall apply to the violation in paragraph one mutatis mutandis.

The provision in paragraph one shall not apply to:

(1) construction of temporary buildings for the benefits of relief of distress carried out or controlled by the authorities;

(2) modification or repair buildings as necessary for temporary dwelling or use.

SECTION 58. The local competent officer shall consider whether the fire area should be improved or not by taking into consideration the benefits in fire prevention, public health, environmental quality maintenance town and country planning, architecture and traffic facilitation, then submit his recommendations along with a brief map showing the boundary lines of the fire area. In the case that the fire area cover the areas under more than on local competent officers, the local competent officers concerned shall jointly consider and submit recommendations within fifteen days from the date of the fire.

The Buildings Control Committee, after having considered the opinions of the local component officer, shall submit its opinions together with notes to the Minister for consideration and instructions for the local competent officer to announce to the people in the fire area as to whether the area will be improved or not. The said announcement shall be posied up at the office of the local authority and or the place where the fire broke out within fourty-five day from the date of the fire.

SECTION 59. In the case it is announced that there is to be no improvement of the fire area, the prohibitions pursuant to Section 57 paragraph one shall then be cancelled.

In the case it is announced that the fire area is to be improved, the prohibitions pursuant to Section 57 paragraph one shall remain in force for another sixty days from the day of the improvement announcement, and the Office of the Buildings Control Committee shall make an improvement diagram of the fire area to be submitted to the Minister for announcement in the Government Gazette as the effective improvement diagram of the fire area within the said time period.

SECTION 60. After the improvement diagram of the fire area has been announced, no person shall construct, modify, tear down, or remove buildings in the area according to the improvement diagram of the fire area to deviate from those prescribed in the diagram and all the licences for construction, modification, tearing down or removal of buildings issued before the improvement diagram of the fire area is announced and become effective which are inconsistent with the said diagram shall be cancelled.

The provisions of Section 40, Section 41 and Section 42 shall apply to the violation of the provision in paragraph one mutatis mutandis.

SECTION 61. In the case where it is necessary to acquire any land or immovable property for utilization as prescribed in the improvement diagram of the fire area, such land or immovable property shall be appropriate by applying the law on immovable property appropriation mutatis mutandis.

SECTION 62. If a fire breaks out in any locality that has the characteristics of a-fire area, if such locality still has no Royal Decree, this Act shall apply and it shall be regarded that there is a Royal Decree promulgating this Act in such locality as from the day the fire break out. But if, later on, it is announced that there is to be no improvement in the fire area pursuant to Section 58, it shall be regarded that the said Royal Decree is cancelled as from the day on which the local competent officer effects the announcement.

Chapter 8
Miscellaneous Provisions

SECTION 63. In the duty performance of the Committee for Appeals Consideration, the persons assigned by the Committee for Appeals Consideration, cases comparision committee members, local competent officers, Engineers or Inspectors under this Act, the applicants for licence, licensed persons, owners or possessors of buildings, operators, work supervisors or concerned persons being present at the places shall provide them appropriate facility and assistance.

SECTION 64. In performing duty under this Act the Committee for Appeals Consideration, persons assigned by the Committee for Appeals Consideration, cases comparison committee members, local competent officers, engineers and inspectors shall become the officers under the Criminal Code.

Chapter 9

Penalty Provisions

SECTION 65. Any person who violates or does not comply with Section 21, Section 22, Section 23, Section 24, Section 31, Section 32, Section 33, Section 34, Section 42 paragraph two, Section 52 paragraph four, Section 57 or Section 60 is liable to a fine of not exceeding ten thousand baht.

In addition to the penalty pursuant to paragraph one, a person who violates or does not comply with Section 31, Section 32, Section 42 paragraph two or Section 57 shall also be liable a fine of five hundred baht per day throughout the time he still violates or until he performs correctly. A person who violates Section 34 shall also be liable to a fine of one thousand baht per day throughout the time he still violates.

SECTION 66. Any person who does not comply with Section 30 paragraph one, Section 38 or Section 39 is liable to a fine of not exceeding one thousand baht.

SECTION 67. Any person who violates Section 30 paragraph two or violates the order of the local Competent Officer pursuant to Section 40 paragraph one or Section 44 is liable to a fine of five hundred baht per day throughout the time he still violates.

SECTION 68. Any person

(1) who does not come forward to give statements or to deliver documents according to the written summon of the Committee for Appeals Consideration pursuant to Section 51 (2) without meaningful reason; or

(2) who obstructs the duty performance of the Committee for Appeals Consideration, persons assigned by the Committee for Appeals Consideration, local competent officers, engineers or inspectors pursuant to Section 48, Section 51, Section 53 or Section 54, or does not comply with Section 51, Section 53, Section 54 or Section 63, as the case may be.

Shall be liable to imprisonment for not exceeding one month or to a fine of not exceeding one thousand baht or to both.

SECTION 69. If an offence under this Act is committed by an operator, the offender shall be liable to twice the penalty provided for such offence.

SECTION 70. If an offence under this Act is committed in connection with a building for agriculture, industry, education or public health or is an act in the trade for rent, hire-purchase, sale or distribution in return for money payment of any building, the offender shall be liable to imprisonment for not exceeding two years or to a fine of ten times the penalty provided for such offence or to both.

SECTION 71. In the event of a violation of or not complying with Section 21, Section 22, Section 23, Section 24, Section 34, Section 42 paragraph two, Section 52 paragraph four, Section 57 or Section 60, it shall be regarded as being the act of the owner or possessor of the building, operator, work supervisor or the appellant pursuant to Section 52 paragraph four, as the case may be or being the act made according to the order of the said persons, unless such persons can prove that it is the act of other person.

SECTION 72. In the event a juristic person commits an offence under this Act, it shall be regarded that all the Directors or Managers of such juristic person are the joint offenders with the juristic person, unless it can be proved that such act of the juristic is made without their knowledge or consent.

SECTION 73. In the event of an offence under this Act, it shall be regarded that the owner or possessor of the land or building nearby or adjoining the building where the offence occurs or the persons whose living or use of the land or building is affected by the said offence is the injured person according to the law on the criminal procedure.

SECTION 74. There shall be a Cases Comparison Committee.

(1) for Bangkok Metropolis, to comprise the Bangkok Metropolis Governor, representative of the Public Prosecution Department and representative of the Police Department;

(2) for other Changwat, to comprise the Changwat Governor, Changwat Public Prosecution Officer who is assigned by the Public Prosecution Department Director-General and the Changwat Provincial Police Chief.

All the offences, for which penalty is a fine only, under this Act or the offence under Section 68 shall be considered by the Cases Comparison Committee and once the fine imposed, it shall be regarded that the case is dismissed according to the law on criminal procedure.

In the event the investigation officer shall deliver the case of a person, who has committed an offence pursuant to paragraph one who has submitted to being fined, to the Cases Comparison Committee for imposing fine within seven days from the day of the consent to fine.

Transitory Provisions

SECTION 75. All the applications for any permission submitted before the day this Act comes into force and are still under consideration by the local Competent officer of the Public Works Department Director-General and any permission granted under the law on control of the construction of buildings or the law on re-construction of fire area or the performance by the licensed persons according to the licensed activity, as the case may be it shall be regarded that theyare applications for permission and the granting of permission under this Act mutatis mutandis.

In the event that the said application for permission or the consideration to grant permission is different from the application for permission or the consideration to grant permission under this Act, application for permission or consideration to grant permission shall be in accordance with this Act and the local competent officer shall issue an order pursuant to Section 27 for the applicants for licence to perform correctly within thirty days. If an applicant for a licence does not comply with the order of the local competent officer within the said period, his application shall not be considered.

SECTION 76. A licensed building for construction or modification that has been completed before the day this Act comes into force, even if it has the characteristics of a building classified under the controlled us category, shall be exempted from having to comply with Section 32 paragraph two.

SECTION 77. Any locality in which a great number of buildings have been constructed in the state's public land before the day this Act comes into force has turned into or may cause condition that is unsuitable or unsafe for dwelling, fire prevention, public health, environmental quality maintenance, town and country planning and traffic facilitation, upon the Royal Decree prescribing buildings improvement area being issued in that locality, the local competent officer shall issue order, one or many, as follows:

(1) issue an order for the owners or possessors of the buildings to tear down the buildings within a period not exceeding six months from the day of receipt of the order, but such order for tearing down buildings shall be made with the purpose of orderliness of the country, local development or for the benefits of the public in using public land;

(2) issue an order within thirty days from the day the Royal Decree prescribing buildings improvement area comes into force for the owners or possessors of the buildings to modify or alter the buildings to be correct according to this Act within a period not exceeding sixty days from the day of receipt of the order;

(3) issue an order for the owners or possessors of the buildings to get rid of or stop the cause that brings about or may bring about condition that is unsuitable or unsafe for dwelling, fire prevention, public health, environmental quality maintenance, town and country planning and traffic facilitation within a period not exceeding sixty days from the day of receipt of the order;

(4) issue an order for the owners of the buildings to sign the land lease with the local competent officer according to the criteria, procedures, conditions and rates of rent specified by the Ministry of Interior.

An owner or possessor of the building who complies with the orders of the local competent officer pursuant to paragraph one shall be exempted from punishment; but if such a person does not comply, he shall be liable to a fine of not exceeding fifty thousand baht and shall be also ordered by the local competent officer to tear down the building within a period to be prescribed. If such person refuses to tear down the building within the said period, he shall be liable to a fine, on a daily basis, of one thousand baht per day throughout the time he still does not comply or until he consents to the local competent officer having the building torn down. In the latter case, the provisions of Section 42 paragraph four and paragraph five shall apply mutatis mutandis.

The Royal Decree pursuant to paragraph one shall have a map showing the boundary lines of the area annexed to the Royal Decree, and the local competent officer shall have the power to arrange for the lease of land in that area for revenue for local maintenance. However, the land shall still remain the state's public property.

The land lease pursuant to paragraph one (4) shall have the lease period as agreed upon but shall not exceed ten years. The lease shall not be renewed. Upon expiration of the land lease period, any owner or possessor of a building who refuses to tear down and remove his building out of the area prescribed in the Royal Decree shall be liable to imprisonment for not exceeding three years or to a fine of not exceeding thirty thousand baht, or to both, as well as to a fine, on a daily basis, of one thousand baht per day throughout the time he still refuses

or until he consents to the local competent officer tearing down the building. In the latter case, the provision of Section 42 paragraph four and paragraph five shall apply mutatis mutandis.

SECTION 78. The appeals under the law on control of the construction of buildings filed before the day this Act comes into force are appeals against the orders of the local competent officer that have been submitted to the Committee for Appeals Consideration under this Act.

SECTION 79. All the Ministerial Regulations, bye-laws, Changwat's bye-laws, regulations, rules, notification or orders issued under the Control of the Construction of Buildings Act 1936 or the Re-Construction of Fire Area Control Act 1933 shall remain in force only in the parts that are not inconsistent with or contrary to the provisions of this Act.

SECTION 80. Any locality that had Royal Decree promulgating the Control of the Construction of Buildings Act 1936 or the Re-construction of the Fire Area Control Act 1933 before the day this Act comes into force shall be regarded as having the Royal Decree promulgating this Act.

Counter-signed

S. HOTRAKIJ

Deputy Prime Minister.

SCHEDULE OF FEES

(1)	Construction licence	each 200 baht
(2)	Modification licence	each 100 baht
(3)	Tearing down licence	each 50 baht
(4)	Removal licence	each 50 baht
(5)	Reuse licence	each 200 baht
(6)	Certificate licence	each 50 baht
(7)	Substitute licence or certificate	each 10 baht

(8) Licence renewal the same as (1) to (4)

(9) Inspection of construction plan or building modification, as follows:

(a) building of not more than three storeys or not more than fifteen metres tall, fees shall be calcualted from the total area of all the floors at 2 baht per square metre;

(b) building of more than three storeys or more than fifteen meters high, fees shall be calculated from the total area of all the floors at 4 baht per square metre;

(c) building of the category that any one of its storey floor has to receive weight exceeding five hundred kilograms per sq.m. fees area of all the floor at 4 baht per sq.m.

(d) sign board, the fees are calculated from the total area determined by the longest part times the widest part at 4 baht per sq.m.

(e) building of the type that its length must be measured such as dam, drainage, fence or wall, fees are calculated by the length at 1 baht per metre.

In calculating fees for design plan inspection fraction of square-metre or metre from one half up shall be regard as one full unit, less than one half shall be disregarded.