PUBLIC JUNIOR HIGH SCHOOL BUILDING NEEDS IN TAIWAN

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ABREGE

Le but de cette thèse est de proposer une solution architecturale au problème posé par la nécessité urgente de fournir un très grand nombre de places scolaires au niveau secondaire à Taiwan, non seulement à cause de l'extension du système scolaire d'une durée de six à neuf ans, mais dû aussi à la réalisation du Plan Karachi qui veut offrir avant 1980 l'instruction universelle au niveau primaire d'une durée d'au moins sept ans.

La solution présentée dans cette thèse est le résultat d'une étude des facteurs ci-haut mentionnés et des conditions sociales et physiques à Taiwan.

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ABSTRACT

This study is an attempt to accomplish an architectural solution to the problem caused by the sudden and massive need for public junior high school houses for rapidly increasing number of junior high school children in Taiwan, due to both extension of the educational system from six to nine year duration and to the adoption of the Karachi Plan aimed at providing universal primary education of at least seven year duration with 1980 as a target date for the archievement.

The solution presented in this thesis is the result of a study of the above mentioned factors and of the particular social and physical environment of Taiwan.

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Lao-Teh Hung

CONTENTS

the profile of TAIWAN

Taiwan, with population* of 13.8 million, is an island of 13,885 square miles. It measures some 240 miles, north to south, and 85 miles at its greatest width. It is bordered on the north by the East China Sea; on the east by the Pacific Ocean; on the south and southwest by the South China Sea; and on the west by Taiwan Strait. The Pescadores, an island group belonging to Taiwan, lie about 25 miles from the southwest coast.

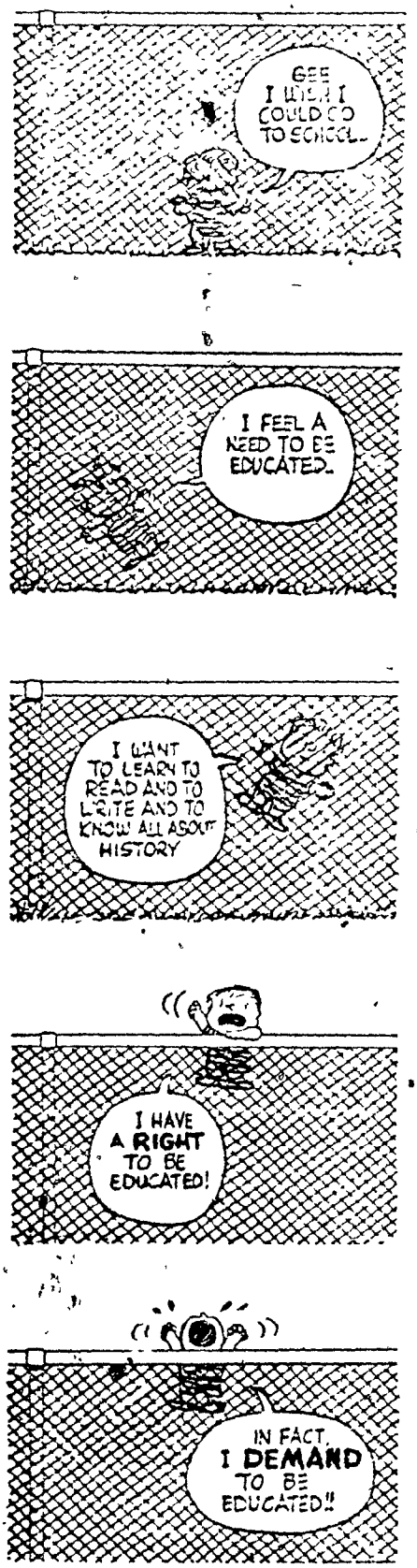
Coastal plains, running north to south in the western third of Taiwan, rise to the foothills and mountain range that occupy the rest of the island. The eastern slope is rugged and sparsely settled, while the western slope is fertile and contains one of the world's highest population densities.

Taiwan's rivers all flow from the central mountains, but only the Tanshui, flowing past Taipei, is navigable.

Surrounded by water and lying in a monsoon region, subtropical Taiwan has damp, warm summers and mild winters. Crops can be grown year-round except in the colder mountain heights, where snow occasionally falls.

Rainfall varies from 50 to 250 inches annually, depending on the region. The island is subject to Pacific Typhoons during the summer and early fall.

*figures are 1969 census


GEE I WISH I COULD GO TO SCHOOL.
I FEEL A NEED TO BE EDUCATED.
I WANT TO LEARN TO READ AND TO WRITE AND TO KNOW ALL ABOUT HISTORY
I HAVE A RIGHT TO BE EDUCATED!
IN FACT, I DEMAND TO BE EDUCATED!!

THE GOAL OF EDUCATION

Plato (428-348 B. C.), in his teachings on the state and laws says: "The goal of education should be to teach the child to associate feelings of joy with the concept of the good and feelings of pain with the concept of evil."

INTRODUCTION

The idea for this study was inspired by two significant statements, issued by the United Nations in 1948 and 1959, which declared in part as follows:

> EVERYONE has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory. Technical and professional education shall be made generally available and higher education shall be equally accessible to all on the basis of merit.
>
> Education shall be directed to the full development of the human personality and to the strengthening of respect for human rights and fundamental freedoms. It shall promote understanding, tolerance and friendship among all nations, racial and religious groups, and shall further the activities of the United Nations for the maintenance of peace.
>
> Universal Declaration of Human Rights
> December 10, 1948
> Article 26, Paragraphs 1 and 2

> THE CHILD is entitled to receive education, which shall be free and compulsory, at least in the elementary stages. He shall be given an education which will promote his general culture, and enable him, on a basis of equal opportunity, to develop his abilities, his individual judgement, and his sense of moral and social responsibility, and to become a useful member of society.
>
> Declaration of the Rights of the Child
> November 20, 1959
> Principle 7, Paragraph 1

This study was also prompted by a Regional Plan (Karachi Plan), adopted at the regional meeting of representatives of Asian member states on primary and compulsory education which was convened by UNESCO at Karachi in 1959-1960, for the provision of universal and free primary education for at least seven years' duration, with 1980 as a target date for its achievement.

However, the Government of Taiwan had found it difficult to prolong the period of compulsory education beyond six years until the 1968-1969 school year by making the county or municipal governments solely responsible for the supplementary junior high schools, which were changed to public junior high schools from the privately owned junior high schools when the new educational system commenced, so that the finances thus saved by the Government could be utilized for extending compulsory education in the public junior high schools (3 years) to the children just passing out of the elementary schools (6 years).**

This increase necessitates the construction of 171 public junior high school houses. Each of 460 school districts will have a public junior high school and their enrollment will rise by nearly 50,000 in the first year of the new system.***

The architectural program, therefore, is designed to meet this urgent and massive needs for the public junior high school houses.

Note: Information obtained from the following organizations:

*UNESCO. "The Needs of Asia in Primary Education - A Plan for The Provision of Compulsory Education in The Region." Paris, 1961. (Educational Studies &Documents, #41).

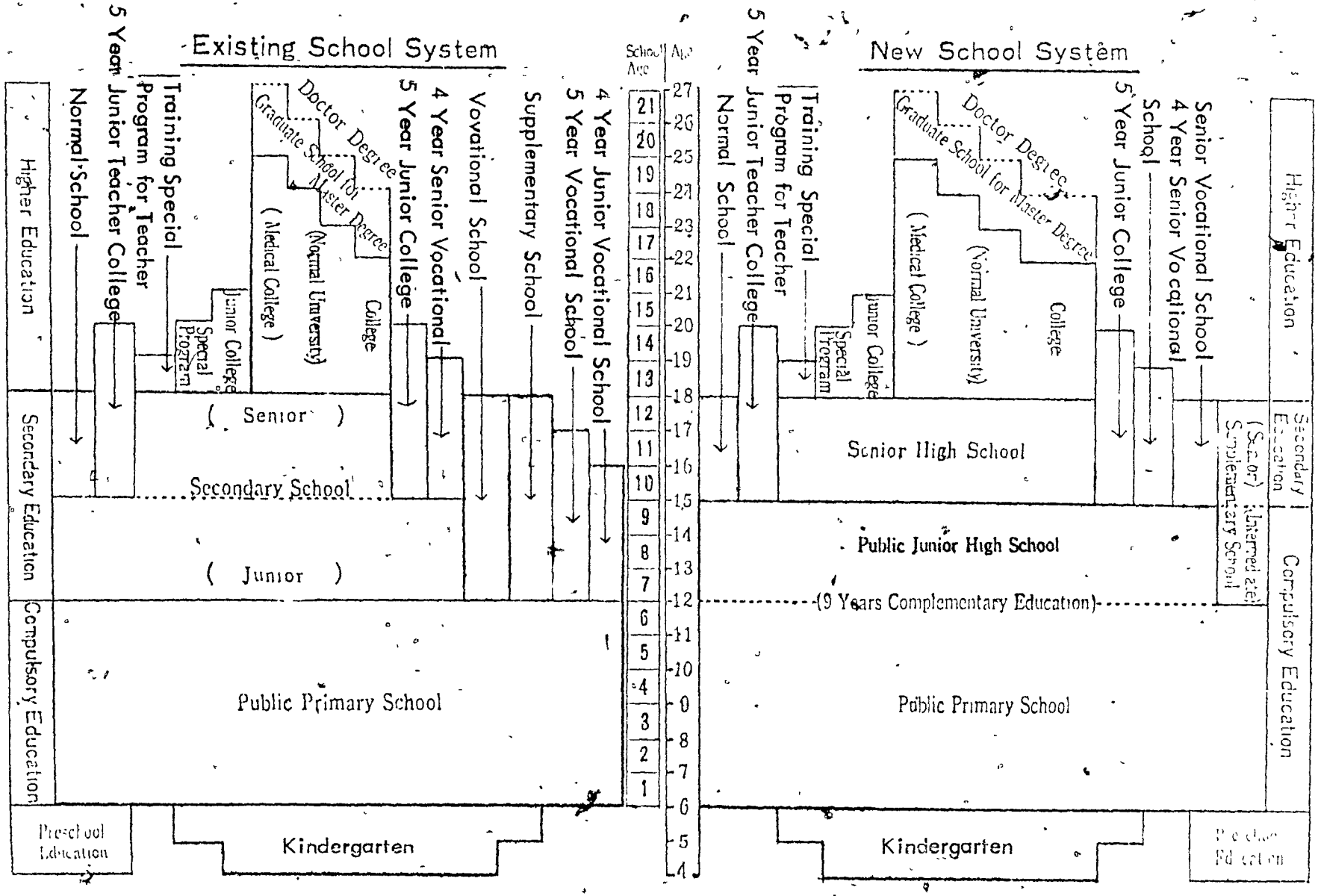
** UNESCO. "Report of Meeting of Ministers of Education of Asian Member States Participating in The Karachi Plan." Tokyo, 2 - 11 April. 1962

*** Department of Education, Taiwan, " A Brief Introduction to Education in Taiwan", Taichung, Taiwan, 1968; p. 13

A. NATURE OF EXISTING CONDITIONS

Diagram 1.1

PREVAILING SCHOOL SYSTEM



Indicates the level of education to which this study refers.

I. Educational Requirements

The educational requirements as they were evolved by the changes of the education system and by this study covered the following topics:

- new educational system,
- age groups and enrollment,
- curriculum activities and teaching methods,
- and school houses and class size.

I.1 New Educational System *

- The new educational system consists of four levels, i.e., pre-school education, primary education, secondary education and higher education.
- Nine-year compulsory education was put into operation on August 1, 1968. This new project has a great effect on both the primary education system and secondary education system as shown in Diagram 1.1.

I.1.a Primary Education

Compulsory education in Taiwan was conducted in primary schools until 1968. With the extension to nine years, it is conducted at two levels; the first level is the six-year primary school and the second level the three-year junior high school. Primary school and junior high school are two different levels in the school system, but in curriculum organization they are in a nine year straight sequence.

* Information from "A Brief Introduction to Education in Taiwan", Department of Education, R. O. C., Taichung, Taiwan. 1968.

1.1.b Secondary Education

Secondary education includes three types of school, i.e., academic secondary school, vocational school and normal school.

During the period prior to 1968, academic secondary school was composed of junior high school and senior high school. Both provided three years of schooling. Senior high schools and junior high schools could be set up separately or in combination. Since the nine-year free universal education was put into effect, junior high schools have been designated as public junior high schools, and senior high schools are separately established. Vocational schools were divided into junior vocational schools and senior vocational schools, each providing three years of schooling. In order to meet the extension of nine-year free education, junior vocational schools were transformed into senior vocational schools. Normal schools admitted junior high school graduates, provided three years of professional training in education and admitted students graduated from senior high schools or from senior vocational schools for one-year professional training. In order to upgrade the quality of teachers, all the normal schools were converted into five-year junior teachers' colleges, which admit graduates of public junior high schools and provide five years of professional and academic training.

1.2 Age Groups and Enrollment

It is claimed that public junior high schools are functionally differentiated from K-6* and secondary schools in that they are intended especially to meet the needs of early adolescents. The duration and grading of this school unit is 7-8-9. The unit is defined in terms of the conventional graded structure rather than on the basis of chronological age or physical maturity, although it has been established, by law, that enrollment occurs immediately after graduation from public primary school and usually at the age of 12 through 15. It was estimated that there would be 957,480 graduates from the primary schools in the first three years after the nine-year compulsory education program commenced. 70% of these graduates would be enrolled in public junior high school in the first school year of this new program. 78% came the second school year and 83% came the third.** Table 1.2.1. indicating the high percentage of student population in this age group to be enrolled for schooling public junior high school, namely from age-goup 8-9, 9-10, 10-11, and 11-12; Table 1.2.2. showing the marked increases in population of the enrollment of the secondary schooling.

Note: K-6 is the level of education ranging from kindergarten to primary school grade No. 6

Information obtained from the following organization:

*Department of Education, Taiwan, " A Brief Description of Preparation for Nine-Year Compulsaory Education Program", Taichung. 1968, p.28

**Dept. of Education, Taiwan, "A Brief Introduction to Education in Taiwan" Taichung, 1968, p.4

Table 1.2.1 Relation between the number of students in age group and the population of the corresponding age group.

age group	percentage			Population			number of students			primary schools		secondary schools		college and university	
	average	M	F	Total	M	F	Total	M	F	M	F	M	F	M	F
5— 6	5.0	5.3	4.6	400	205	195	20	11	9	11	9				
6— 7	92.4	93.1	91.7	393	204	192	366	190	176	190	176				
7— 8	97.5	98.0	96.9	394	202	192	384	193	186	193	186				
8— 9	95.9	98.0	95.2	384	197	187	371	193	178	193	178				
9—10	96.1	98.5	97.2	368	187	178	359	186	173	185	173				
10—11	97.1	99.0	95.1	360	195	165	363	193	170	193	170				
11—12	96.0	96.4	93.3	373	192	181	358	189	169	179	162	10	7		
12—13	52.0	59.1	44.8	365	182	174	185	107	78	32	28	75	50		
13 -14	48.4	55.9	40.5	345	177	168	167	90	68	7	7	92	61		
14—15	44.2	51.1	37.0	339	174	165	150	89	61	2	2	87	59		
15—16	32.2	39.2	34.8	345	176	169	111	69	42			65	40	4	2
16—17	27.6	34.0	21.0	293	150	143	81	51	30			45	28	6	2
17—18	23.2	28.5	17.9	271	137	134	63	39	24			33	21	6	3
18—19	17.0	21.6	12.6	235	116	119	40	25	15			17	10	8	5
19—20	11.4	14.4	8.5	210	104	106	24	15	9			6	3	9	6
20—21	11.6	19.6	6.9	138	51	87	16	10	6			2	1	8	5
21—22	11.5	23.5	6.3	113	34	79	13	8	5			1	1	7	4
22—23	5.7	9.0	3.3	158	67	92	9	6	3					6	3
23—24	4.0	6.0	2.1	177	83	94	7	5	2					5	2
24—25	2.7	4.4	1.1	184	90	94	5	4	1					4	1
over 25							16	14	2					14	2

Table 1.2.2 Expansion of Student Population

Year	number of students	ratio to whole population
1961	2,529,730	22.69 %
1962	2,690,942	23.30 %
1963	2,809,713	23.64 %
1964	2,949,017	24.06 %
1965	3,101,130	24.55 %
1966	3,235,851	24.90 %
1967	3,551,000	25.10 %

1.3 Curriculum Activities and Teaching Methods:

In order to arrive at specific area recommendations for a public junior high school, it is necessary to simulate educational programs suitable for this school level. Details of curriculum coverage and time allotment were recorded and analyzed. These time allocations are illustrated in Table 1.3.

The teaching method in junior high school in Taiwan still remains in the traditional type, teacher-centered manner in which general courses such as languages, social sciences, and mathematics are taught. Some other subjects such as physics, chemistry, art, and all technical trainings are taught in special rooms by group teaching. Modern research has shown that the traditional classroom alone no longer provides the most satisfactory learning environment. What is needed is a flexible arrangement which will provide the following:

1. large group instruction:

   where students learn from expertly prepared presentations of subject matter.

2. small group instruction:

   where students learn through discussion with teachers and other students.

3. independent study:

   where students learn largely by themselves.

Therefore, there is the need to regularly appraise the existing standards of accommodation which are affected by the development in the teaching methods and curricula.

Table 1.3 Subject Time Allocation for Public Junior High School Program (six-day cycle.)**

Subject	Grade 7 periods *a	Grade 8 periods *a	Grade 9 periods *a
Morality Education	2	2	2
Physical Education - Health	1	1	
Language			
Chinese	6	6	6
English	2 - 3	2 - 3	2 - 3
Mathematics	3 - 4	3 - 4	3 - 4
Social Studies			
History	2	2	1
Geography	2	2	1
Science	3	4	4
Physical Education - Gymnastics	2	2	2
Music	2	2	1
Fine Arts	2	1	1
Crafts (Home Arts - Girls)	2	2	2
Boy (Girl) Scout Training	1	1	1
Planting or Graphics		2 *b	
Vocational Education		1	
Guided Activities	1	1	1
Science			4 - 6 *c
English			4 - 6
Agriculture			4 - 6
Industrial Arts			4 - 6
Commercial Business			4 - 6
Home Economics			4 - 6
Art			4 - 6
Music			4 - 6
Total	33	36	35

* Note: a. each period is 50 minutes.
b. in the grade 8 program, students might select one option from between planting or graphics.
c. in the grade 9 program, students would select two options from among science, English, agriculture, industrial arts, commercial business, home economics, art and music.

** Figures taken from :
" Temporary Curricula Standard for Public Junior High School," Ministry of Education, Taipei, Taiwan, January 3, 1968.

1.3.1 STAFF REQUIREMENTS:

The staff requirements for a junior high school of 1,000 students in grades seven through nine are as follows:

1 Principal
1 Assistant principal
1 Librarian
1 Instructional media specialist
35 Academic teachers
2 Guidance counselors
2 Art teachers
2 Music teachers
5 Physical education teachers
2 Practical arts instructors
2 Home arts instructors
2 Language teachers
4 Clerical aides
8 Teacher aides
1 Secretary

The total of the staff is 69. The ratio of students to staff is 14.5 to 1.

1.4 School House and Class Size :

"At the time the program of Nine-year free education became effective 1968, there were 424 secondary schools in Taiwan. Of these, 14 were senior high schools, 141 were consolidated senior and junior high schools (including 68 private schools), 269 junior high schools (including 40 private schools). In 1968 all junior high schools were converted into public high schools.

This program necessitated the construction of 171 new schools and a many of additional classrooms. Each of 460 school districts had a junior high school and their enrollment rose by nearly 50,000 in the first year of the program."*

"At the present, school is required by regulation to have not more than 48 classes in urban areas and not more than 36 classes in rural areas. The gross areas of the site for each school shall range from 28,600 sq.m. (7.04 acres) for a 12-class school to 98,999.04 sq.m. (24.96 acres) for a 48-class school. The area of land per pupil place ranged from 36.83 sq.m. (409.2 sq.ft.) to 28.63 sq.m. (318 sq.ft.)"**

* " A Brief Introduction to Education in Taiwan " Dept. of Education of Taiwan, 1968

** " Standards & Guides For Desgning School Buildings " Dept. of Education of Taiwan, 1967.

Table 1.4

SCHEDULE OF MINIMUM REQUIREMENTS OF SPACE PER STUDENT OR STAFF FOR A JUNIOR HIGH SCHOOL IN TAIWAN

Unit of Accommodation	Square Meter Per Student Place
ACADEMIC AREA	
Classroom	1.34--1.56
Art	2.01--2.34
Music	1.34
Laboratories (not incl. preparation and storage)	
Physics	1.67--1.95
Chemistry	1.67--1.95
Biology	1.67--1.95
Workshops (not incl. prep. and stor.)	
Carpentry	3.75--4.69
Sheet metal, welding and blacksmith	4.02--4.69
Electrical	3.125
Unified arts	
Industrial arts shop and crafts room	3.75--4.69
Home economics	3.12
Library	1.56
ADMINISTRATION AREA	
Principal's office (incl. reception)	37.5
General office (incl. record space and staff launge)	3.75--4.02
AUDITORIUM	
Seating for 500	0.53
Toilet	0.12

Note : Figures indicated in this table are derived from :
" Standards and Guides for Desgning School Buildings," Department of Eduoation, R. O. C., Taichung, Taiwan. 1967

1.5 Curriculum and Space Requirements:
- A Sample Space Requirement For A Typical Public Junior High School In Taiwan -

The conversion of curriculum into teaching space needed for a typical public junior high school for grades 7,8 and 9 would be caculated as the following: *

Assuming those subjects will be taught in classrooms except science in a laboratory, vocational subjects in a workshop and physical education in gymnasium or outdoor playground.
Number of groups studing each subject is three (3);
(i.e. one group for each of grades 7, 8 & 9) thus,

(1) Classrooms: subject	(a) periods/wk	(b) number of groups	(a) x (b) space periods needed
Ethical Education	2	3	6
Native Language	6	3	18
History	2	2.5	5
Geography	2	2.5	5
Mathematics	4	3	12
Second Language	3	3	9
Total Space Periods			55

There are 48 periods in a week (see Table 1.3), then there are 48 separate periods of time for which one teaching space (i. e. one classroom) can be used.

Experience shows that, at most, a 90% utilization of the classroom space can be obtained. Thus, 43.2 space peiods of the 48 space periods are utilizable.

Experience also suggests that special rooms such as workshops and laboratories where equipments have to be prepared have an optimum utilization of 75%, thus, 36 space periods of the 48 space periods are utilizable.

Therefore, the number of classrooms needed for three (3) teaching groups is : 55 space periods divided by 43.2 namely 1.3 unit space.

Assuming each teaching group with 45 students, totally 135 students in grades 7, 8 & 9, therefore, in a school of 1,000 students there will be 1,000/135 x 1.3 or 9:58 units of classroom needed.

(2) Science Laboratory (Physics, Chemistry & Biology):
From table 1.3 there are 3 periods per week for grade 7, 4 periods per week for grades 8 & 9; torally 11 periods per week, thus, the number of science laboratories for three (3) teaching groups (i. e. 135 student places) is : 11/36 unit place.
Therefore, there will be 1,000/135 x 11/36 or 2.2 unit spaces required for a school of 1,000 students thru grades 7, 8 & 9.

* Statistics obtained from:
"Educational Buildings, Space and Cost Roms in Asian Region for Educational Planner," by D. J. Vickery, 1971

(3). Work Shops (for wood, metal & electricity vocational subjects) :

From Table 1.3, total periods per week for three (3) teaching groups are 13, thus, there will be 1,000/135 x 13/36 or 2.66 unit spaces of work shops required.

SUMMARY :

I. Teaching Area : 1,454.70 square meters;
From Table 1.4 , the minimum requirements for individual spaces are as follows:

1.34	sq. meter	per student place	for classroom
1.67	"	"	science lab
3.75	"	"	work shop
0.12	"	"	toilet

Therefore, the minimum space required for the teaching area in a school as whole will be :

9.58 (say 10) (cl.rm.) x 45 (student places) x 1.34 = 603 sq. m.
2.2 (say 2) (science) x 45 " x1.67 = 225.45 sq. m.
2.66 (say 3) (w. shop) x 45 " x 3.75 = 506.25 sq. m.
Toilets for 1,000 students x 0.12 sq.m./stnt. pl. = 120 sq. m.

II. Non-teaching Area :*

a. Principal Office per Unit = 37.5 sq. m.
b. Total Staffs' office = 3.75 sq.m. x 68 = 255 sq. m.
c. Library:
Reading Area = 1.56 sq.m. x 60 places (min.) = 93.7 sq. m.
Stack Area = 56 sq. m.
d. Music : (for 60 student places min.)
Choral or Practice Room = 81 sq. m.
Instrument Storage = 37 sq. m.
e. Auditorium & Gymnasium : (for 1,069 places); 902 sq. m.
including stage, seating area, storage, lockers & toilets.
f. Kitchen Area : 58 sq. m.
Kitchen for boiling water & steaming students' lunches;
Staff's dining &
Shop or Candy Stand
g. Reception, Information & Health Suite: 48 sq. m.
including: offices,
waiting area,
bedroom

* Fifures taken from :
"Standards & Guides for Desgning School Buildings," Dept. of Education, R. O. C., Taichung, Taiwan, 1967

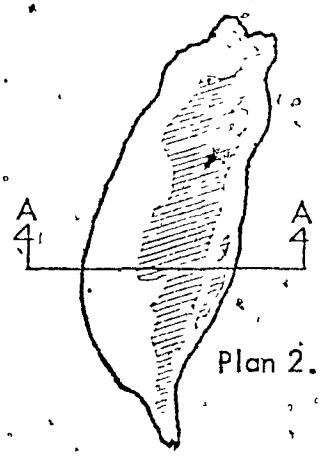
2. Natural Considerations

"The concentrated and sustained work of education takes place in schoolhouses, and the architect's job is to make such work not only possible, but enjoyable, since there is little education without pleasure. Educational buildings in the humid tropics will conform to the climatic needs by keeping direct sun from the walls and out of classrooms; by having open plans facing the breeze with the accent upon a high degree of cross-ventilation and protection from driving rain. Compromises have to be made in meeting the critical climatic conditions and other considerations at the same time but if these result in a concentration of architecture in a corporate form, only good will follow. To design a school to meet these extremes of climate it should ideally adjust itself. A good survey is essential to success."*

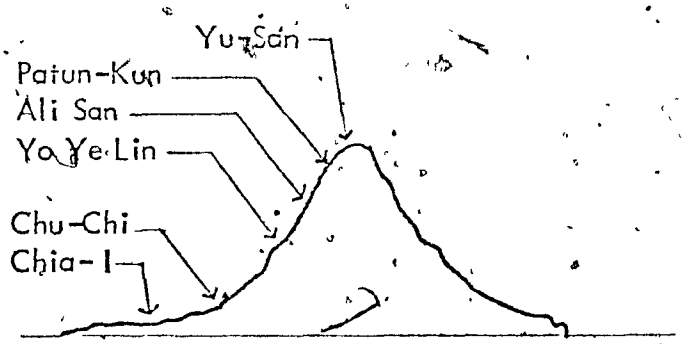
*Fry, Jane B. & E. Maxwell, "Tropical Architecture", London, England, 1965. p.157

2.1 Climate of Taiwan

The climate variation changes little in the flatlands which surround the



Plan 2.1



Section A-A

Central Mountain Range (Ta-yuan-shan). But there is much change vertically from the flat west coast up to the highest mountain range of Yu-Shan. The vertical zoning of the climate of Taiwan is illustrated in Plan 2.1., Section A-A and Table 2.1.

Table 2.1 The Vertical Zonation of Climate of Taiwan

Location	Elevation (m.)	Annual Rainfall (mm.)	Average Temp. (C)	Rain Factor
Chia-I	31	1,999	23.6	85
Chu-Chi	129	2,555	-	-
Yo Ye Lin	1,060	3,045	-	-
Ali- San	2,406	4,357	10.6	411
Pa Tun Kun	2,841	3,638	4.9	741
Yu- San	3,900	3,433	4.0	869

2. 2 Sun and Temperature Range

The climate of Taiwan, lying between the low latitudes of 22 N and 25 N, is subtropical in pattern, with high average annual temperature of 77 F (25 C). Temperatures higher than the yearly average sun temperature of 77 F (25 C) occur during four months from June to September in the northern part of Taiwan, five months from May to September in the middle part of Taiwan and six months from May to October in southern Taiwan. Table 2. 2 shows the annual average, maximum and minimum temperatures of various places on the island.

Table * 2.2 The Annual Average Temperature, Average Maximum and Minimum Temperature of Various Places of Taiwan (°C.)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. Aver.	Aver. Max.	Aver. Min.
Taipei	15.2	14.8	17.0	20.7	24.1	26.6	28.2	27.9	26.3	23.1	20.0	16.8	21.7	26.1	18.4
Chilung	15.5	15.2	16.7	20.2	24.1	26.5	28.2	28.0	26.5	23.4	20.3	17.3	21.8	25.1	18.9
Ilan	15.8	16.0	17.9	20.6	23.5	26.1	27.6	27.2	25.8	22.8	20.2	17.2	21.7	25.3	18.6
Hsinchu	15.0	14.6	17.0	20.5	24.1	26.7	27.9	27.7	26.5	23.7	21.5	16.8	21.8	25.7	18.6
Taichung	15.8	15.7	18.2	22.0	25.2	26.9	27.7	27.5	26.6	23.8	20.6	17.3	22.3	27.7	18.4
Tainan	17.0	17.1	19.7	23.4	26.3	27.4	27.8	27.5	27.1	24.8	21.8	18.5	23.2	28.9	19.1
Hengchun	20.3	20.5	22.3	24.6	26.5	27.4	27.5	27.2	26.7	25.3	23.4	21.3	23.4	28.2	21.6
Taitung	18.9	19.0	20.7	23.1	25.3	27.0	27.5	27.3	26.5	24.5	22.2	20.0	23.5	27.7	20.0
Hualien	17.2	17.4	19.0	21.6	24.1	26.3	27.2	27.1	26.0	23.6	21.2	18.7	22.5	26.5	19.3

* Table derived from the following report:
"A Report of Investigation on Fertilization of Soil of Taiwan," by Y.C. Tung, Taipei, Taiwan, 1951, p.98.

It is frequently higher than 84°F (30°C) in various places of the whole island. The highest sun temperature recorded was 101.5°F (38.6°C) in the Taipei area (northern Taiwan), 102.7°F (39.3°C) in the Taichung area (middle Taiwan) and 99°F (36.7°C) in the Kaohsiung area (southern Taiwan). It has never been lower than 59°F (15°C) in these three areas. Tables* 2.2.1.a_1, a_2, and a_3 show the percentage of overheated period of the daytime during the whole year in these three areas. Name, Taipei has 55%, Taichung has 70% and Kaohsiung has 78%. Thus, as far as the thermal comfort is concerned, the solar control for educational buildings in Taiwan is necessary.

2.2.1 Sun Data

(a) The School Day

"It is necessary to define the duration of the school day. Sun shades can be expensive to construct, and to exclude the sun for the entire period of occupancy of a classroom could add considerably to construction costs. A judgement must thus be formed on the exact time for which solar control is to be exercised."**

"During the working day there are two critical periods: the first is in the early morning and the second in the late afternoon."*** At both times the sun's altitude is low. But for the first half hour of the working day in most

*S.Y. Lin, "Solar Control and Shading Devices in Taiwan", Architecture and Planning Bimonthly, March 1969, p.p. 64,65,67.

**D.J. Vickery, A.R.I.S.B.R., UNESCO. "The Shading of School Buildings in Southeast Asia" Bangkok, 1963, p.1.

*** Note: In Taiwan the preasure of population of school age are such that school buildings are occupied in both the morning and the afternoon. Hours of attendance are from 8:00 AM to 5:30 PM.

Table 2.2.1.a Taipei Area Overheated Period Analysis

Temperature (°C) / Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
0	14.6	15.7	16.7	20.1	21.9	24.0	26.3	25.9	23.1	21.8	20.4	16.5
1	14.4	15.5	16.6	20.0	21.8	23.8	26.0	25.6	22.9	21.6	20.4	16.5
2	14.3	15.4	16.4	19.8	21.5	23.6	25.6	25.3	22.8	21.4	20.2	16.3
3	14.2	15.3	16.2	19.7	21.4	22.5	25.4	25.0	22.6	21.1	20.1	16.2
4	14.1	15.2	16.2	19.6	21.3	23.5	25.2	24.8	22.4	21.0	19.9	16.2
5	14.0	15.1	16.1	19.6	21.3	[illegible]	[illegible]	[illegible]	21.9	21.0	19.9	16.1
6	14.0	15.5	16.3	19.6	22.2	[illegible]	[illegible]	25.5	22.9	21.5	20.0	16.2
7	14.4	15.8	17.0	20.8	23.[illegible]	25.1	27.[illegible]	26.8	[illegible]	23.1	20.0	16.7
8	16.1	17.3	18.6	22.1	[illegible]	27.9	29.7	29.2	26.1	[illegible]	22.5	17.7
9	17.7	18.8	20.0	23.[illegible]	[illegible]	29.2	31.0	30.7	27.1	[illegible]	[illegible]	18.9
10	18.9	19.7	21.3	[illegible]	27.5	29.8	32.0	31.7	28.1	27.6	[illegible]	19.7
11	19.5	20.0	22.1	[illegible]	27.[illegible]	29.1	32.[illegible]	32.4	28.[illegible]	28.0	[illegible]	20.3
12	19.8	21.8	22.4	[illegible]	27.5	28.8	32.7	32.5	28.6	28.0	25.[illegible]	20.5
13	19.7	20.5	22.1	[illegible]	27.6	28.3	32.4	32.4	28.7	[illegible]	[illegible]	20.3
14	19.4	20.2	21.6	[illegible]	27.2	28.0	31.9	[illegible]	28.4	27.4	[illegible]	20.0
15	18.8	19.5	21.1	23.[illegible]	[illegible]	27.3	31.3	31.6	[illegible]	[illegible]	22.5	19.4
16	17.8	18.8	20.2	22.[illegible]	[illegible]	26.8	30.5	30.8	[illegible]	[illegible]	22.5	18.6
17	16.8	17.9	19.4	22.[illegible]	[illegible]	26.1	29.8	30.8	25.0	24.[illegible]	21.8	17.9
18	16.3	17.4	18.7	21.7	[illegible]	25.8	28.9	29.0	25.2	23.7	21.4	17.6
19	16.0	17.0	17.9	21.3	23.5	25.5	28.5	28.2	24.6	23.1	21.1	17.3
20	15.6	16.6	17.8	21.0	23.2	25.4	27.9	27.6	24.1	22.7	20.9	17.2
21	15.3	16.4	17.5	20.6	22.9	24.8	27.4	27.2	23.8	22.6	20.6	17.0
22	15.2	16.2	17.4	20.0	22.5	24.5	22.0	26.7	23.3	22.2	20.4	16.9
23	15.0	15.8	17.0	20.5	22.3	24.3	26.6	26.3	23.2	22.1	20.0	16.7
24												

hour

noon

sun-rise

sun-set

shading line

shading line

: Percentage of Overheated Period of Daytime within one year.

Table 2.2.1.a_2 Taichung Area Overheated Period Analysis

Temperature (°C)	Month											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
0												
1	13.0	15.7	17.3	21.0	22.3	24.5	25.5	23.9	23.0	21.4	20.1	15.9
2	12.7	15.6	17.1	20.8	22.1	24.3	25.3	23.3	22.8	21.1	20 0	15.7
3	12.5	15.3	16.9	20.6	22.0	24.1	25.1	23.1	22.5	20.8	19.7	15.5
4	12.3	15.1	16.7	20.5	21.8	23.3	24.3	24.8	22.4	20.6	19 5	14.4
5	12.2	14.8	16.4	20.3	21.7	23.8	24.6	24.5	22.2	20.4	19.4	15.1
6	12.0	14.8	16.3	20.3	21.7	[illegible]	[illegible]	[illegible]	22.2	20.2	19.2	15.0
7	11.7	14.8	16.5	20.8	21.9	[illegible]	[illegible]	[illegible]	23.1	20.3	19.3	15.0
8	12.7	15.7	17.6	22.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20.8	20.6	16.7
9	13:5	18.0	20.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]3.3	18.5
10	18.6	20.3	21.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20.8
11	20.6	22.0	23.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22.4
12	22.0	23.[illegible]	[illegible]	27.2	[illegible]	29.6	31.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]3
13	22.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]0
14	22.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]5
15	22.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]2
16	21.4	22.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21.9
17	19.8	21.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20.1
18	17.7	19.1	21.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18.6
19	16.4	18.1	20.2	23.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24.0	22.0	17.9
20	15.6	17.6	19.5	22.7	24.3	26.0	27.2	27,3	27.3	24.8	23.3	17.4
21	14.9	17.0	18.8	22.2	25.7	25.6	26.9	26.8	24.3	22.8	20.9	16.9
22	14.5	16.6	18.5	21.8	23.3	25.3	26.6	26.4	24.1	22.3	20.6	16.5
23	14.1	16.3	18.2	22.6	22.9	24.6	26.2	26.0	23.6	22.0	20.3	16.2
24	13.7	16.0	17.7	21.3	22.6	24.9	25.9	25.7	23.2	21.6	20.0	16.1

hour

noon

sun-rise

sun-set

shading line

shading line

[illegible] :Percentage of Overheated Period of Dayrime within one year.

Table 2.2.1.a3 Kaohsiung Area Overheated Period Analysis

Temperature (°C) / hour	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
0	17.2	19.7	20.5	23.6	25.2	26.2	27.0	26.6	25.3	23.8	22.7	19.2
1	16.9	19.5	20.3	23.4	25.0	26.1	26.8	26.5	25.1	23.8	22.4	19.0
2	16.9	19.5	20.1	23.2	24.3	25.9	26.6	26.4	25.0	23.8	22.2	18.8
3	16.7	18.9	19.3	23.0	24.7	25.8	26.5	26.8	24.9	23.6	22.1	18.7
4	16.5	18.9	19.7	22.8	24.5	25.7	26.4	26.1	24.8	23.5	21.9	18.6
5	16.6	19.0	19.8	22.8	[illegible]	[illegible]	[illegible]	26.1	24.8	23.0	23.1	18.6
6	16.8	19.2	20.1	22.6	[illegible]	[illegible]	27.3	[illegible]	25.5	[illegible]	22.4	18.8
7	17.6	20.1	21.4	[illegible]	[illegible]	27.6	[illegible]	[illegible]	[illegible]	25.9	22.3	19.5
8	19.7	22.0	23.0	[illegible]	27.7	28.5	29.5	29.7	27.9	[illegible]	[illegible]	21.3
9	20.5	23.0	[illegible]	[illegible]	28.0	28.7	[illegible]	29.5	28.5	27.7	25.3	22.1
10	20.9	23.0	[illegible]	[illegible]	28.3	29.0	29.8	30.1	28.8	28.0	25.5	22.5
11	21.4	23.7	[illegible]	27.2	28.5	29.3	30.0	29.8	29.1	28.2	25.7	22.9
noon 12	21.7	23.9	24.7	27.4	28.5	29.3	30.0	29.8	29.3	28.3	25.9	23.2
13	22.1	[illegible]	24.9	27.6	28.6	29.4	30.0	29.9	29.3	28.3	26.2	23.5
14	22.0	[illegible]	[illegible]	27.5	28.5	29.4	30.0	30.0	29.2	27.9	[illegible]	22.5
15	21.7	23.6	24.5	27.2	28.2	29.2	29.7	29.8	29.0	27.7	23.6	22.1
16	20.3	23.0	[illegible]	24.6	27.7	28.8	28.4	29.4	28.4	27.0	25.3	22.4
17	20.0	22.2	[illegible]	25.8	27.1	28.2	29.0	28.8	27.3	26.5	[illegible]	21.6
18	19.5	21.3	20.6	25.2	[illegible]	22.5	28.7	[illegible]	26.9	25.9	23.9	21.0
19	19.1	20.9	21.9	24.9	26.2	27.0	27.8	27.8	26.5	25.5	23.6	20.7
20	18.7	20.5	21.6	24.6	25.9	26.8	27.6	27.4	26.1	25.2	23.2	20.2
21	18.5	20.2	21.0	24.3	23.7	27.6	27.3	27.2	25.8	24.0	23.0	19.9
22	18.0	20.0	21.1	24.1	25.6	26.4	27.2	27.0	25.6	24.6	22.7	19.7
23	17.7	19.8	20.8	23.7	25.4	26.3	26.6	26.9	25.4	24.3	22.6	19.5
24												

sun-rise

sun-set

shading line

shading line

[illegible] :Percentage of Overheated Period of Daytime within one year.

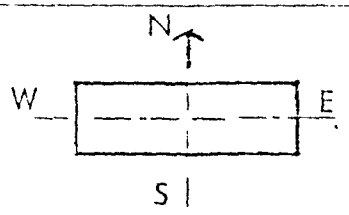
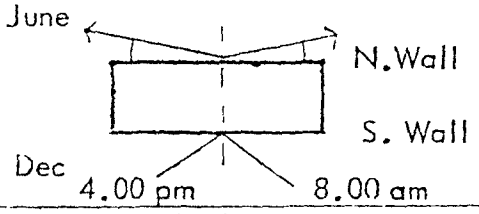
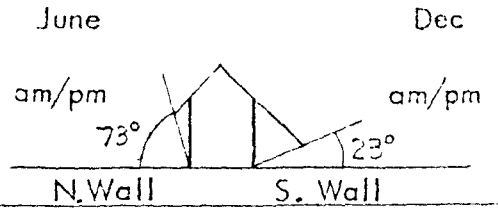
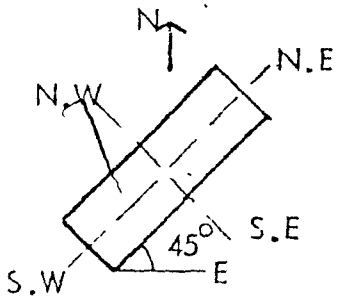
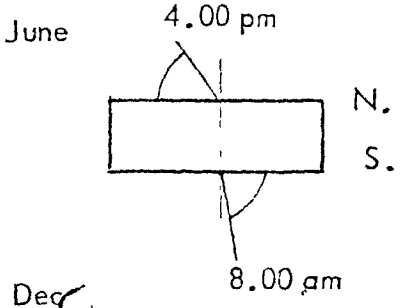
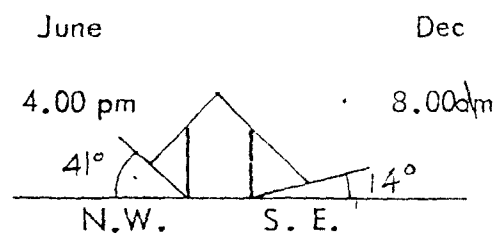
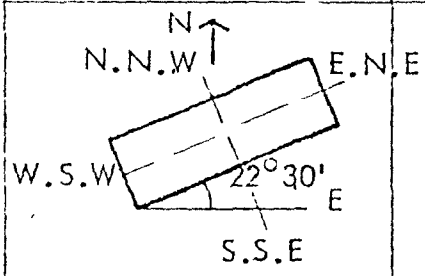
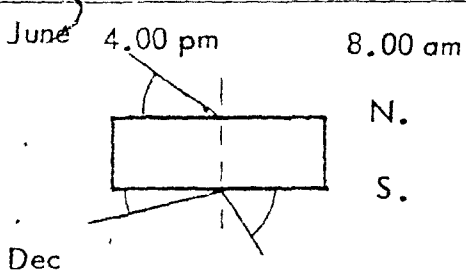
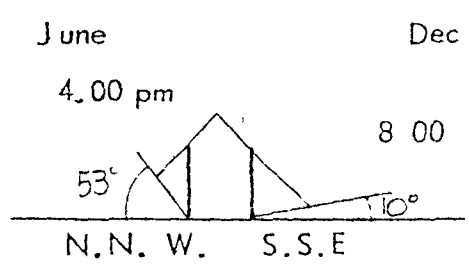
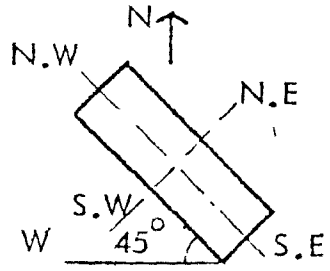
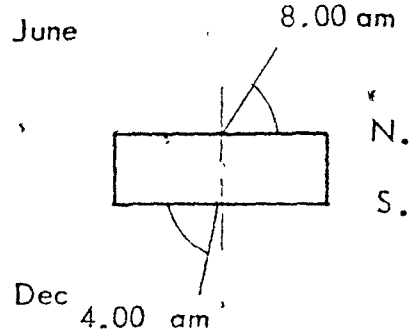
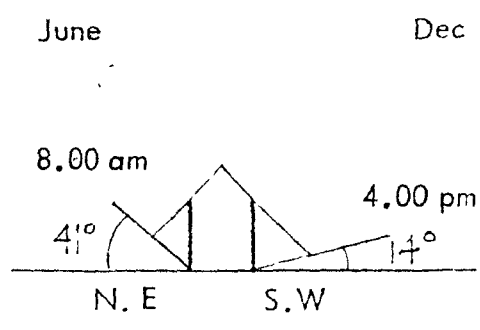
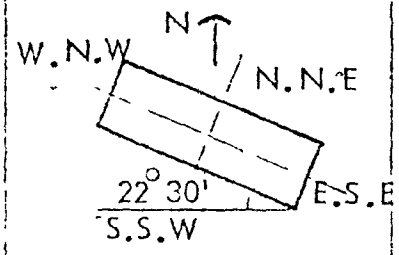
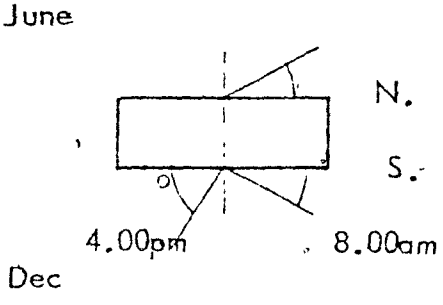
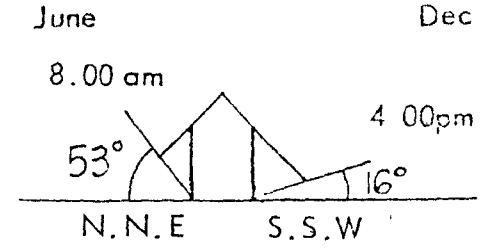
schools there is considerable movement, which decreases as the children settle down for the day's work. A little early direct sunshine about the solstices will not be too disturbing, and the start of the school day, from the point of view of solar control, can safely be put at 08:00 hours. To sit in direct sunshine after this time will certainly cause perspiration and discomfort.

A satisfactory end to the period of solar control is judged to be 16:00 hours, that is, about one hour and a half before the end of the second session. The total school day, from the point of view of solar control, is thus from 8:00 AM to 4:00 PM.

(b) Sun Angles

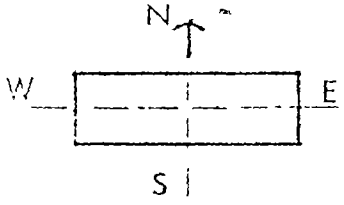
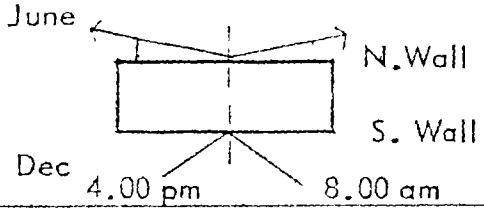
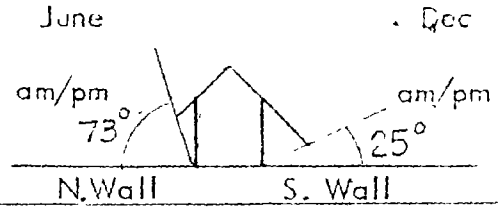
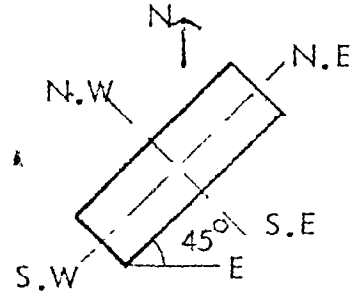
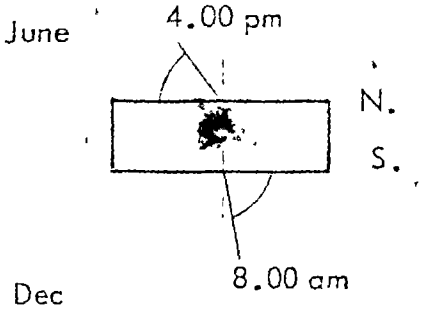
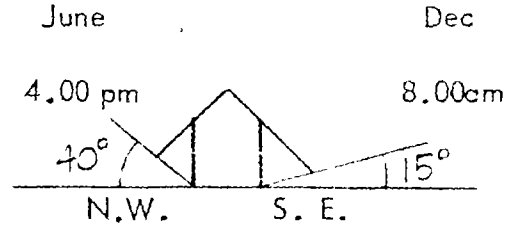
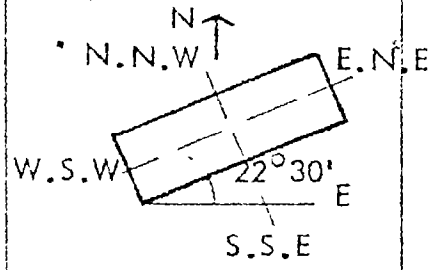
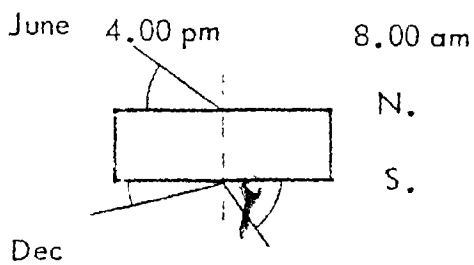
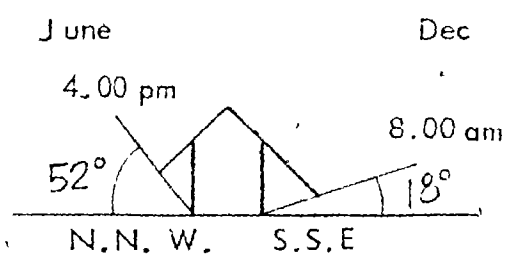
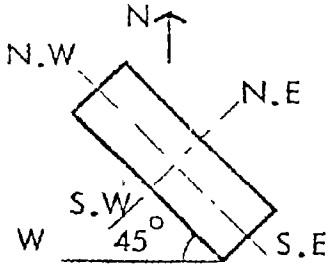
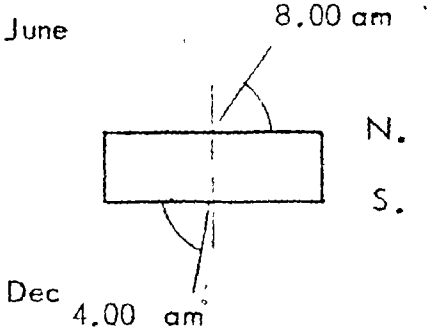
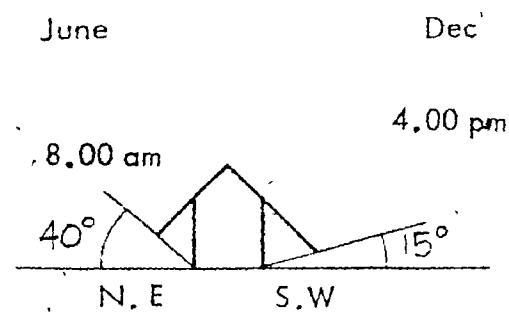
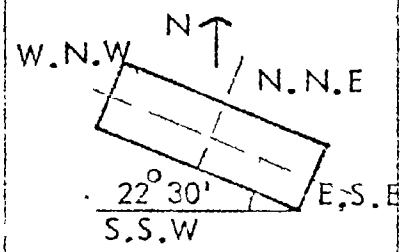
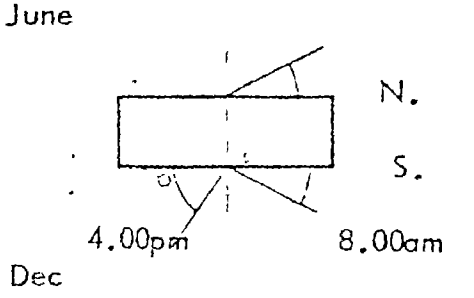
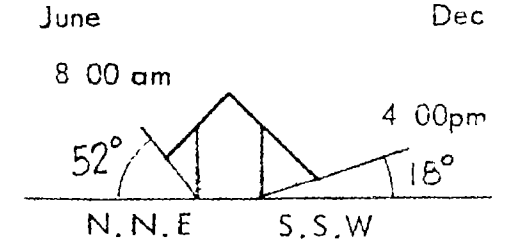
With regard to the orientation of school buildings, the three disgrams given as Fig. '2.1.1.b_1, b_2, b_3' below are for the three areas of Taipei (latitude 26°N), Taichung (latitude 24°N) and Kaohsiung (latitude 22°N):

Fig. 2.1.1.b, Sun Angles in Taipei Area

Shading	Critical Sun Angles During The School Day 8.00 am. – 4.00 pm.	Latitude 26° N
ORIENTATION	SUN ANGLE – Plan	SUN ANGLE – Section
		
		
		
		
		

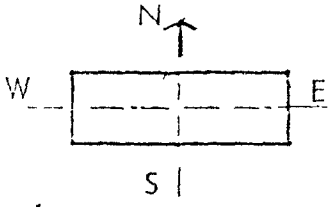
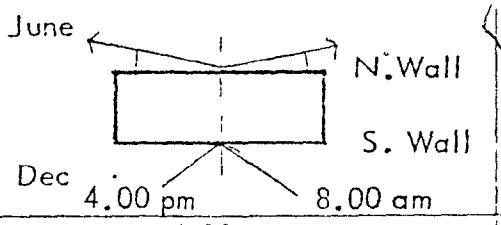
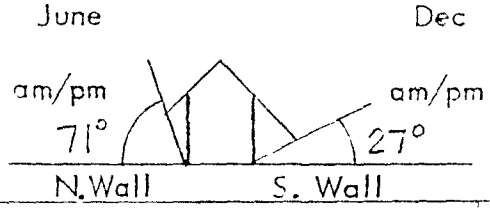
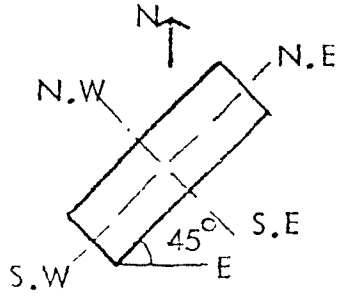
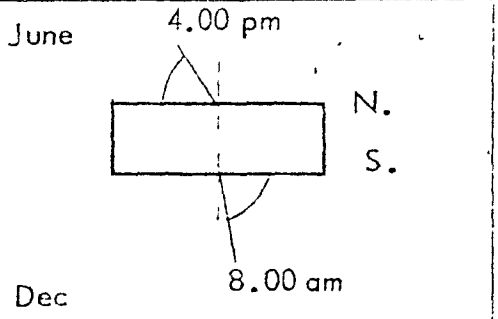
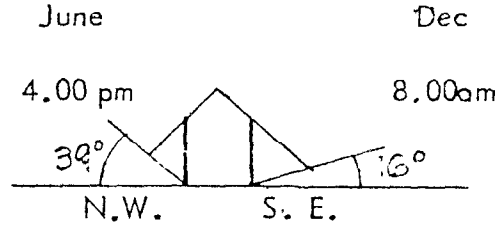
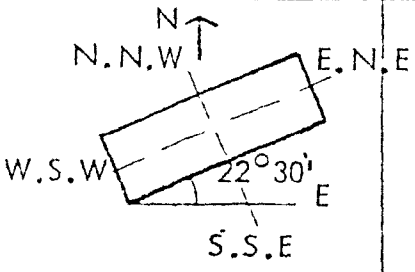
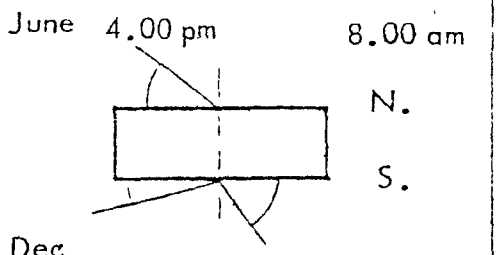
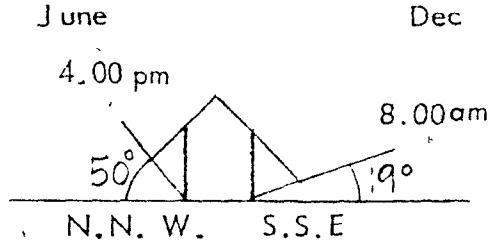
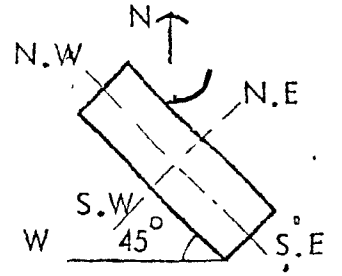
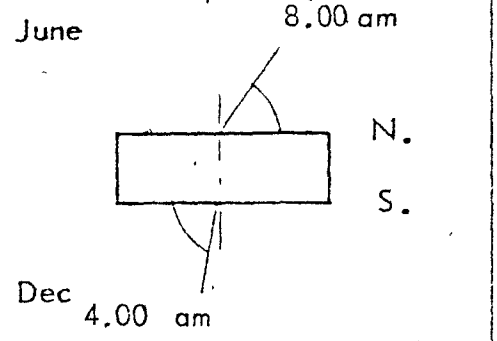
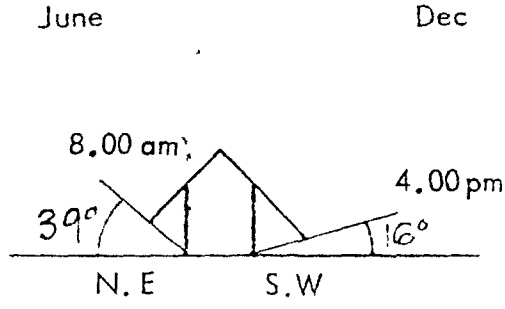
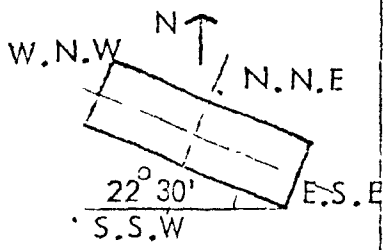
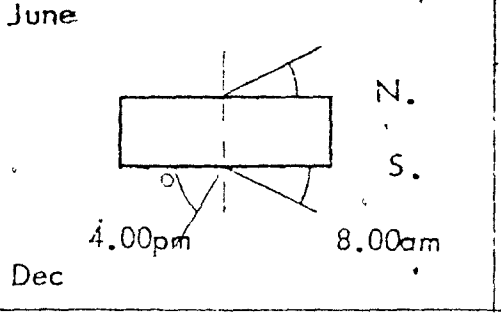
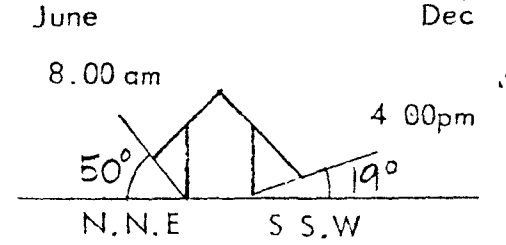
All angles shown are derived from altitude and azimuth angles and are adjusted having regard to the orientation of the building and (for section angles) are turned into the plan of paper.

Fig. 2.1.1.b_2 Sun Angles in Taichung Area

Shading	Critical Sun Angles During The School Day 8.00 am. – 4.00 pm.	Latitude 24° N
ORIENTATION	SUN ANGLE – Plan	SUN ANGLE – Section
		
		
		
		
		

All angles shown are derived from altitude and azimuth angles and are adjusted having regard to the orientation of the building and (for section angles) are turned into the plan of paper.

Fig. 2.1.1.b_3 Sun Angles in Kaohsiung Area

Shading	Critical Sun Angles During The School Day 8.00 am. - 4.00 pm.	Latitude 22° N
ORIENTATION	SUN ANGLE - Plan	SUN ANGLE - Section
		
		
		
		
		

All angles shown are derived from altitude and azimuth angles and are adjusted having regard to the orientation of the building and (for section angles) are turned into the plan of paper.

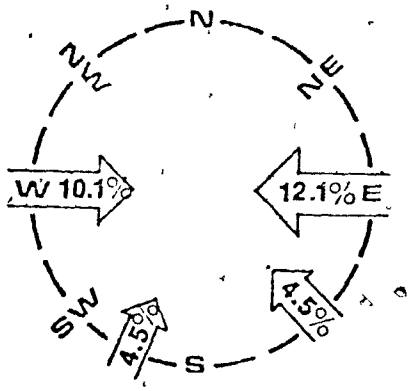
2.3 Winds and Typhoon:

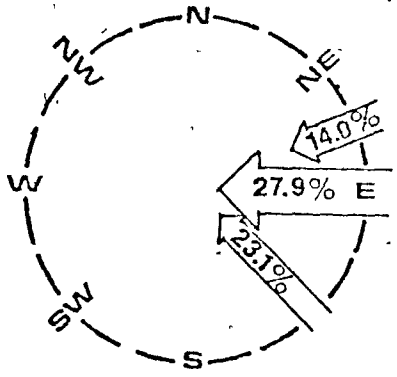
"The major winds flowing toward the island of Taiwan are north-easterly and south-westerly, and are known as the Monsoons. The former occurs from October until the next March, while the latter occurs from May until September. The major winds are not constant, since they are affected and complicated by cyclonic depressions."* Diagram 2.3.1 is reproduced for easy interpretation." There are occasional storms of great violence, known as Typhoons in the east mostly occurring in July, August or September. The violent Typhoon, blowing onto Taiwan from the Pacific Ocean is usually accompanied by heavy rain. At these times the rainstorms cause floods in the densely populated, low-lying parts of the island. They often cause great damage to both planting and buildings, and take a heavy toll of human lives."* Fig. 2.3.2 showing Taiwan is in storm area.

*C. H. Chi, "Two Natural Damages in Taiwan - Typhoon and Earthqucke," Taiwan Weather Bureau, Taipei, 1969, pp. 1,4, 5.

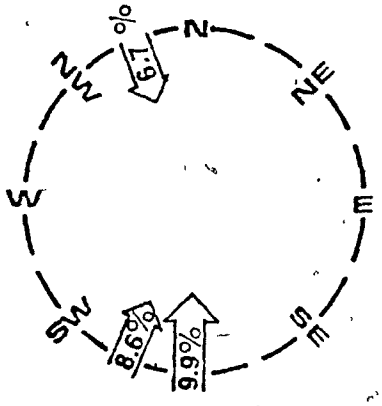
Diag.2.3.1 Wind Diagrams* (based on frequency)

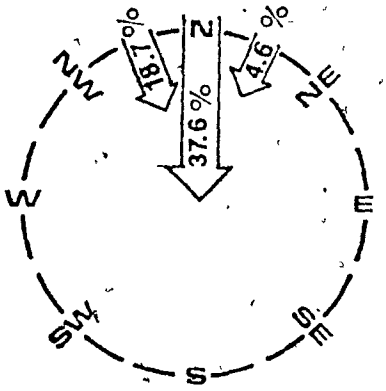
Taipei Area



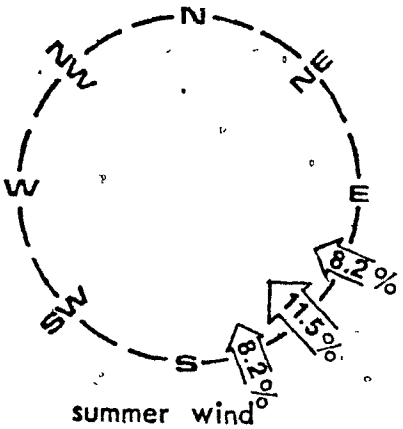


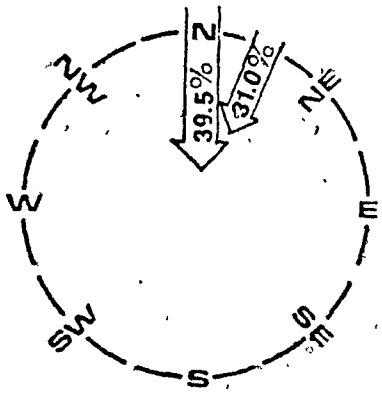
Taichung Area





Kaohsiung Area





* Diagrams were reproduced for easy interpretation, data information based on reports from Taiwan Weather Bureau, & Ke-hsun Chi's "The Distribution of Rainfall in Taiwan" Taipei, Taiwan, 1969, pp. 4,10.

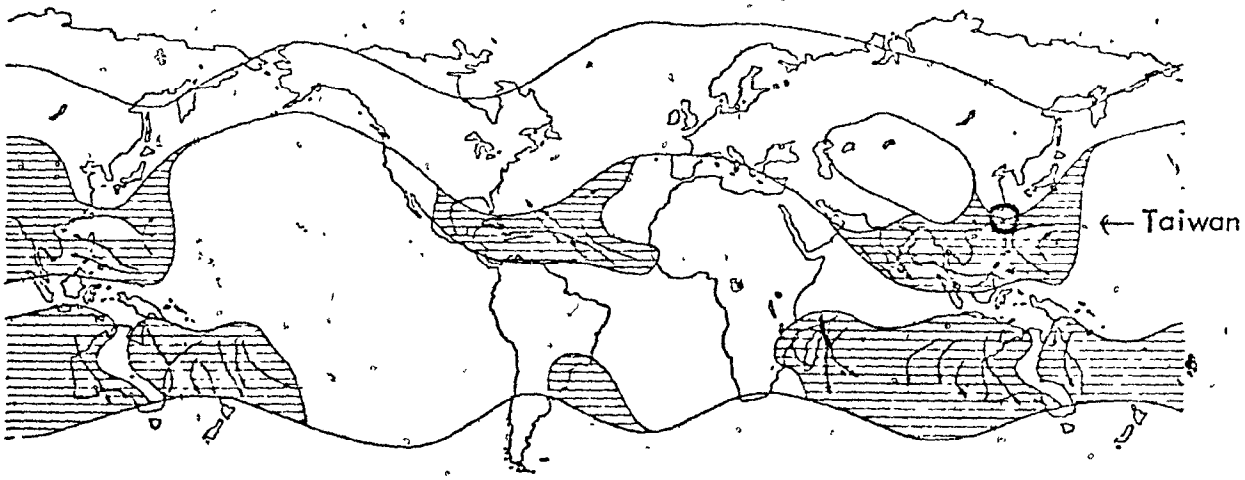


Fig. 2.3.2 Storm Area and Wind Direction*

*Fry , Jane B. & and E Maxwell,"Tropical Architecture", London, England. p.30

2.4 rain and humidity:

(a) Rain:

The accumulation of normal annual rainfall distribution in Taiwan is the result of a combination of summer type and winter type. In the winter period, the heaviest rainfall seems to be concentrated in the belt of 500 to 1,000 meters above sea level over the windward slope of Taiwan's northeastern mountains due to the lower condensation level caused by the northeasterly monsoon which travels a long distance over warm seas south of Japan. In summer, the heaviest rain belt is a little higher (about 1,000 meters) and is found over the Ta-wu Mountains at the southern tip of Taiwan.

The variation of rainfall pattern within the year is controlled by the prevailing wind direction. In October the rainfall pattern in the island suddenly changes to a winter type of precipitation and the amount of rainfall over the western portion of Taiwan decreases very rapidly. In May, this pattern begins to change which seems to be about one month earlier than the whole circulation change in eastern Asia. The most important aspects of this are the rapidly increasing amount of rainfall over Ali-shan and Ta-wu-shan regions. Roughly, rainfall concentrates in northeast portion of Taiwan in winter, then moving to the middle portion of mountain terrain in spring, centers on southern mountains in summer, then displaces to the eastern near coast in fall.

Figure 2.4.1 shows the varied distribution of rainfall on Taiwan.

Table 2.4.2 shows in figures the annual amount of rainfall in various places in Taiwan.

Table 2.4.3 shows that the west coast is wetter than the east coast of Taiwan.

Fig. 2.4.1 THE AVERAGE ANNUAL RAINFALL OF TAIWAN

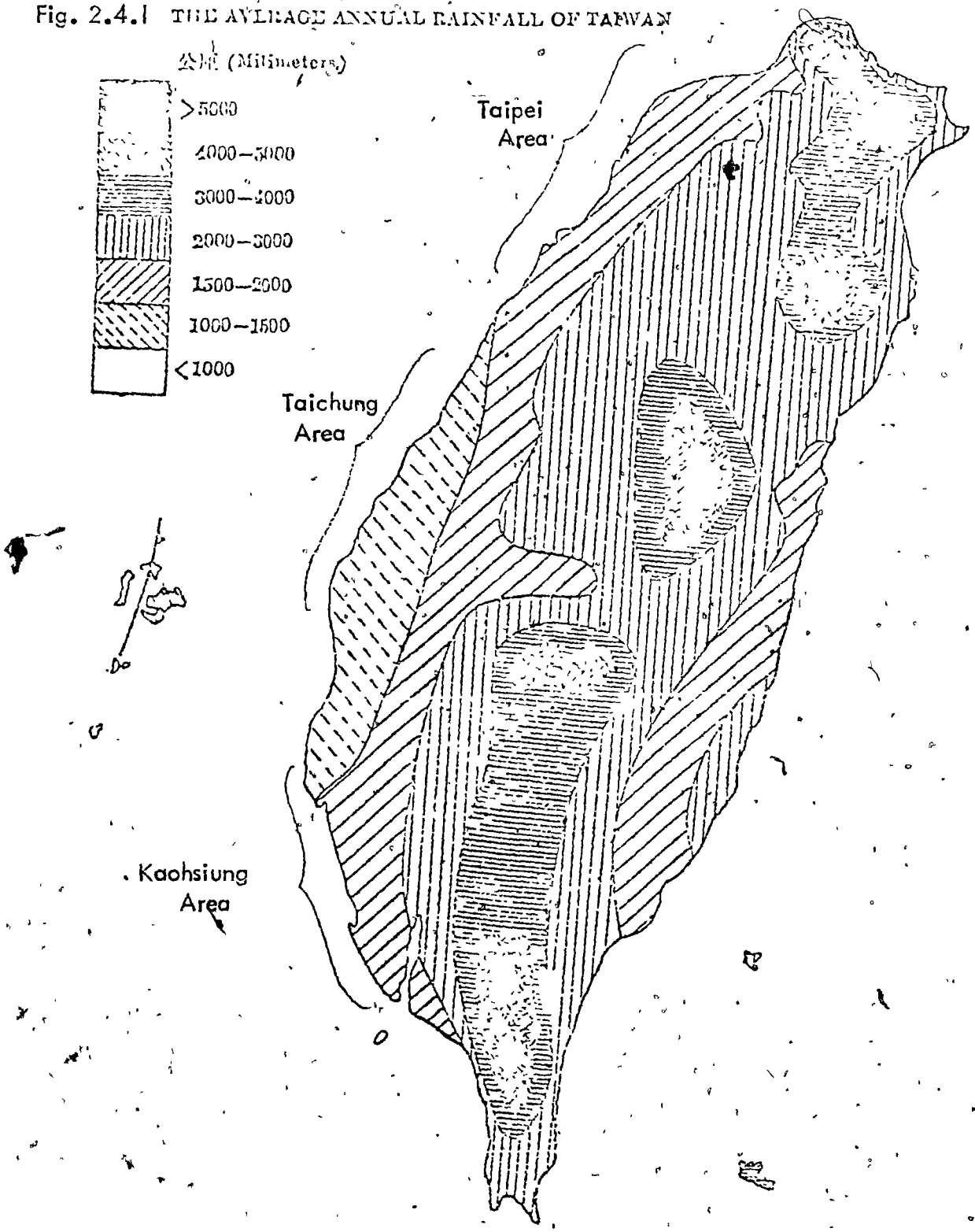


Table 2.4.2 The Annual Amount of Rainfall in Various Places in Taiwan (mm)*

月份 Month	一月 Jan.	二月 Feb.	三月 Mar.	四月 Apr.	五月 May	六月 June	七月 July.	八月 Aug	九月 Sept.	十月 Oct.	十一月 Nov.	十二月 Dec.	全年 Total.	日數
Taipei 臺北	89	140	183	169	227	304	228	300	295	113	60	73	2,111	50
Chilung 基隆	297	281	302	211	270	263	131	165	233	227	228	289	2,899	43
I-Lan 宜蘭	113	120	174	125	230	19	150	205	259	404	294	227	2,559	36
Hsinchu 新竹	68	132	183	180	219	251	149	186	105	36	31	42	1,580	44
Miao-Li 苗栗	63	110	192	178	255	296	242	256	131	35	26	41	1,844	41
Taichung 臺中	33	68	114	130	228	371	295	338	139	22	16	28	1,783	50
Tainan 臺南	19	36	52	68	176	376	423	441	163	55	16	17	1,820	50
Chia-I 嘉義	25	41	80	91	195	379	434	457	242	32	16	25	1,999	45
Kaohsiung 高雄	12	23	36	59	221	346	392	446	154	36	16	10	1,713	47
Pintung 屏東	14	31	47	67	185	424	582	616	310	68	15	13	2,408	42
Henchun 恆春	22	30	42	43	178	402	536	562	281	139	39	15	2274	50
Hua-Lien 花蓮	63	86	111	115	199	177	263	220	269	247	108	70	1,927	45
Taitung 臺東	37	44	64	71	170	198	349	300	289	174	61	36	1,793	45

Table 2.4.3 The Rain Factors of Various Places of Taiwan**

地點 Locations	年雨量 Annual Rainfall (mm.)	年平均溫度 Aver. Temp. (°C)	雨量因子 Rain Factor
Taipei 臺北	2,111	21.7	98
I-Lan 宜蘭	2,559	21.7	117
Hsin-chu 新竹	1.560	21.8	78
Taichung 臺中	1,783	22.3	80
Tainan 臺南	1,820	23.2	78
Chia-I 嘉義	1,999	23.6	85
Tiatung 屏東	2,408	23.3	104
Kaohsiung 高雄	1,713	23.3	73
Henchun 恆春	2,274	23.4	92
Taitung 臺東	1,793	23.5	76
Hualien 花蓮	1 927	22.5	86

* Statistics, Charts and Maps taken from:
Yun-chi Tung, "A Report of Investigation on Fertilization of Soil of Taiwan", Taipei, Taiwan, 1931, p.98.

** Ibid. p.10

(b) Humidity

The annual average absolute humidity in various places of Taiwan, except the middle portion, is around 15- 20 mm. It is higher in summer than in winter. Compared to the relative humidity, it is annually around 78-85%. The humidity decreases from the north of Taiwan to the south.

Table 2.4.4 shows the annual average relative humidity of various places of Taiwan in percentages.

Table 2.4.4 The annual average relative humidity of various places of Taiwan (%)*

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Aver.
Taipei	84	84	84	82	82	81	78	78	79	80	81	83	82
Chilung	84	84	84	83	83	83	78	79	79	79	80	82	81
Yulan	84	83	84	85	88	87	83	83	86	80	88	85	85
Hsinchu	82	85	85	84	83	82	81	80	80	77	79	78	81
Taichung	81	82	82	82	82	82	81	82	80	78	78	78	81
Tainan	79	79	79	79	81	84	83	84	82	78	78	79	81
Hunchun	73	74	74	76	79	84	85	85	81	75	73	72	78
Taitung	74	75	77	79	82	82	81	81	80	77	75	74	78
Hualien	78	81	81	82	85	84	81	81	81	78	78	78	81

* Statistics taken from:
Yun-chi Tung, " A Report of Investigation on Fertilization of Soil of Taiwan"; Taipei, Taiwan; 1951. p.100

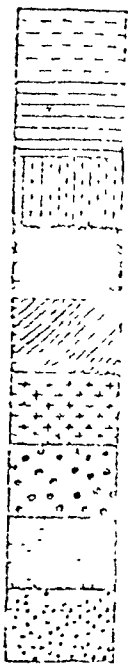
2.5 Soil Variations:

The major soil formation of Taiwan is of slate alluvial soils, which run, in general, from the north to the south of the island.

Fig. 2.5 given in the following page shows the formation of soil groups in the whole island of Taiwan. *

* Information and figures obtained from:
Yun-chi Tung, "A Report of Investigation on Fertilization of Soil of Taiwan", Taipei, Taiwan, 1951, pp. 91, 96

Fig. 2.5 Soil Formation of Taiwan Island



弱灰化高山土 (slightly podsolized Alpine soils)

灰棕壤與灰化黃壤 (gray brown podsolic and yellow podsolic soils)

黃壤與幼紅壤 (yellow and young red soils)

老紅壤 (old red soils)

鹽鹼土 (saline and alkaline soils)

海成沖積土 (marine deposit soils)

砂岩頁岩沖積土 (sandstone and shale alluvial soils)

粘板岩沖積土 (slate alluvial soils)

結晶片岩沖積土
(gneiss alluvial soils)

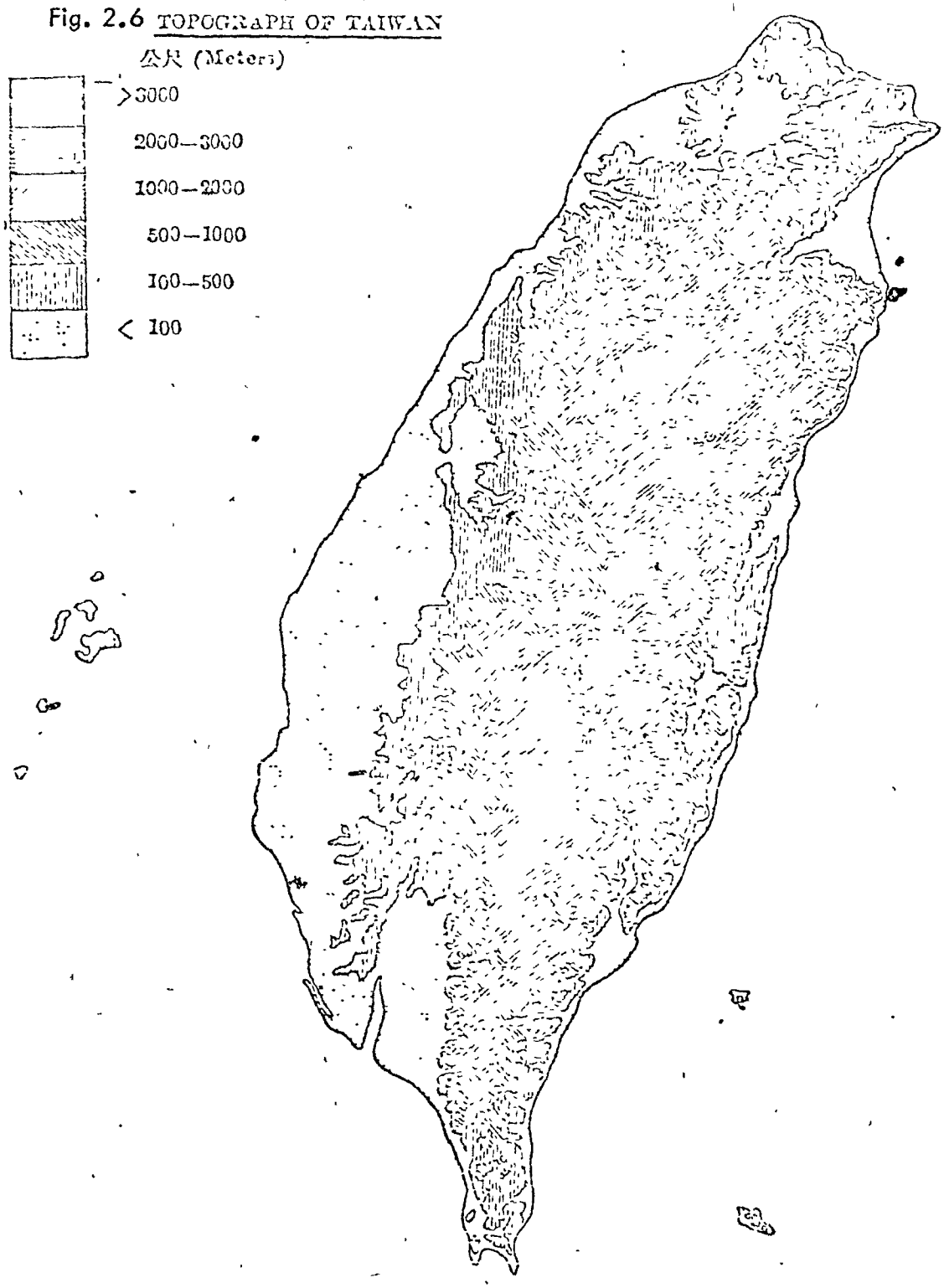
2.6 Topography:

The south-western portion of Taiwan is fairly flat. The Central Mountain Range running from the north tip to the south tip occuppies the largest portion of the whole island. The elevation varies noticeably from the western flatlands up to and over the north-south axis of the Central Mountain Range, then with a sudden descent to the edge of the east coast.

Topographical variations of Taiwan are shown in Figure 2.6

* Information and figure obtained from:
Yun-chi Tung, "A Report of Investigation on Fertilization of Soil of Taiwan", Taipei, Taiwan, 1951, p.95

Fig. 2.6 TOPOGRAPH OF TAIWAN



2.7 Earthquake :

"The island of Taiwan (Formosa) is pre-eminently an earthquake country".*

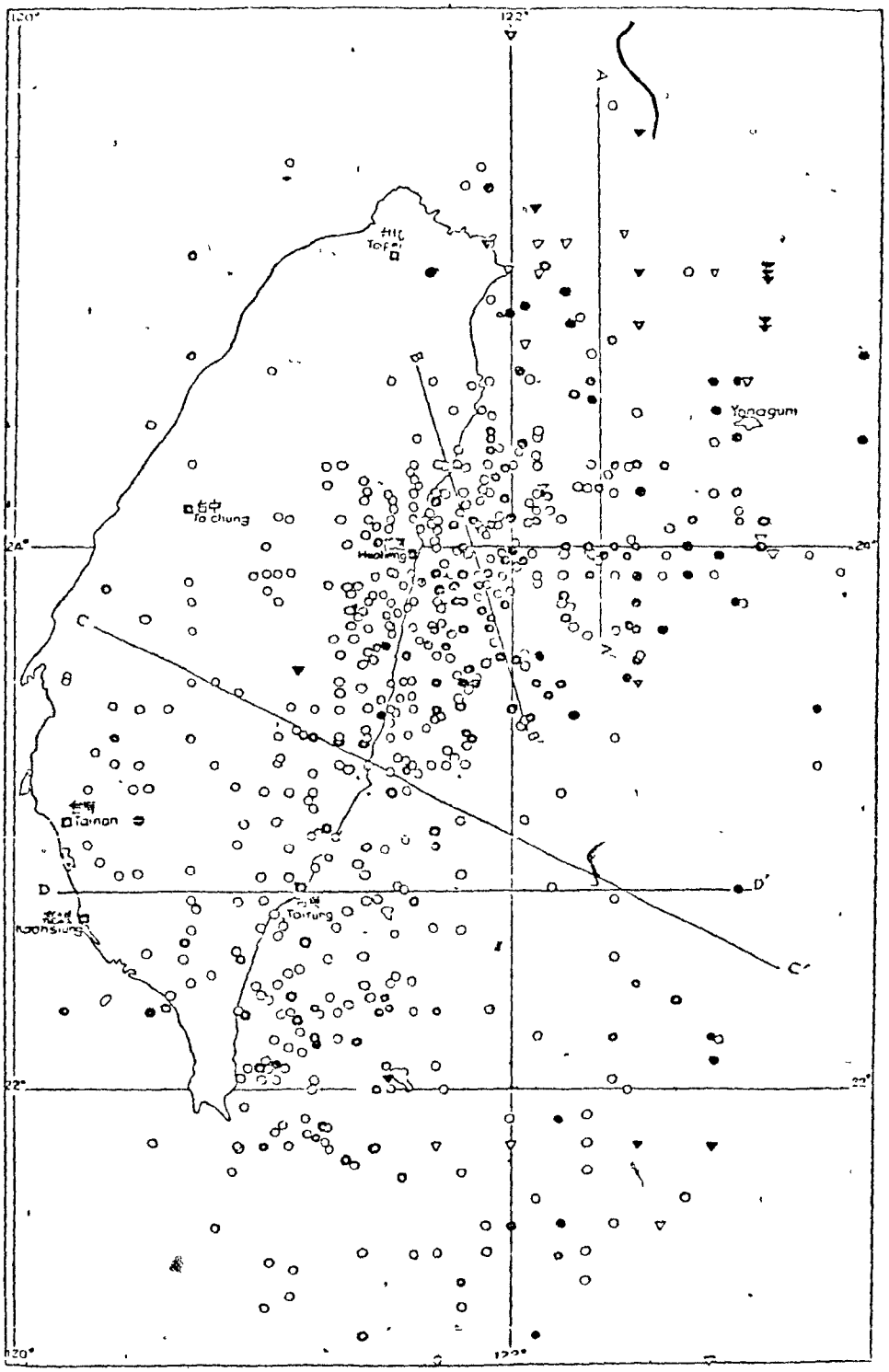
"The disastrous earthquakes in Taiwan have generally occurred in the densely populated southwestern part of the island, where the ground is flat. The eastern coast is by no means free from the visitation of strong shocks, although the amount of the seismic damage has been insignificant. The latter circumstance is probably due to the mountainous nature of these districts and the scarcity of inhabitants, the seismic disturbances occurring, in many cases, under the ocean".** Figure 2.7 shows the frequency of earthquake and the distribution of earthquake origins in and near Taiwan.***

* Bulletin of the Imperial Earthquake Investigation Committee, vol.,1,Tokyo,Japan, 1907, pp. 53,63

** Ibid. vol.II, p.156

*** D. N. Lee, Proceedings of theGeological Society of China,no. 5, Taipei, Taiwan, 1963, p.112

Fig. 2.7 The Frequency & The Distribution of Earthquake Origins in and near Taiwan



Map showing the distribution of epicenters in and near Taiwan. Symbols for shocks of various focal depths: open circle, 0-20 km, heavy-line circle, 21-40 km, solid circle, 41-60 km, open triangle, 61-80 km, heavy-line triangle, 81-100 km, solid triangle, greater than 100 km. Location of profiles indicated.

3. Existing Building Industry:

The best way to characterize the development of the Taiwan building industry is through figures of the increasing production. Table 3. shows the total volume of building from 1966 to 1970 in square meters of gross floor area;* the increase in the total construction volume is about 190%.

時期 PERIOD	房屋建築 CONSTRUCTION OF BUILDINGS①			
	磚造房屋 Brick Construction	鋼筋混凝土房屋 Reinforced Concrete Construction	木造房屋 Wooden Construction	其他房屋 Others
Unit	平方公尺 m^2	平方公尺 m^2	平方公尺 m^2	平方公尺 m^2
1966	1,771,160	1,017,431	50,820	27,588
1967	2,553,651	1,053,033	45,766	51,918
1968	3,152,269	1,407,819	59,671	39,805
1969	4,076,882	1,582,618	75,205	75,978
1970	3,070,822	2,250,597	66,815	115,849

Table 3. Based on data of completed buildings which were authorized in advance by the government according to the various urban development plans and were duly inspected and approved by authorities concerned.

The development during the last five years has followed two paths: rationalization of traditional building methods and industrialization. There is a fundamental difference between the effects of these two lines of development. As long as the traditional methods are the same and the basis for the entire process on the whole remains unchanged, it is only possible to rationalize up to a certain limit. But in order to meet the enormous growing demand for buildings of all kinds it is necessary to industrialize the production of building and therefore the basic principles of production will have to be changed.

* Table taken from:
The Industry of Free China (Taiwan), Volume 35, No. 2, 1971, p. 99.

3.1 Resources and Materials for Building :

The building materials supply is fairly satisfactory, particularly as regards to cement and cement products. Cement is in good supply, 3,000,000 to 4,400,000 metric tons being available annually. Fair quantities of asbestos-cement roofing sheets, standard size 6 ft. x 2ft. 4 in. (1.80 x 0.75 m.) are produced and used locally. Cement roof and floor tiles are also available locally and in sufficient quantities to supply domestic needs. Standard size 16 in. x 8 in. x 8 in. concrete blocks are very popular in buildings.

Adequate supplies of machine-made bricks are produced in the main cities. Hand-made bricks are also produced in rural areas in small kilns.

Aluminum roofing sheets are locally produced at the rate of about 11,000 metric tons per year and steel products (structural sections and corrugated sheets, etc.) at the rate of 140,000 metric tons per year.

Most of the timber comes from mixed forest areas, the majority of the varieties being cedars, hemlocks and Mongolian oaks. The coniferous forest of Taiwan is among the best stands of timber in the world. Timber production such as lumber being at the rate of 550,000 m^3 yearly, plywood being at 140,000,000 m^2 can be expected to provide a stable source on which a large-scale industry might be based.

Bagasse boards, made from sugar factory waste fibers, are in comsiderable popular demand and are widely used for linings and ceilings.*

*Sources obtained from the Monthly Bulletin of Statistics of United Nations and "Taiwan Economic Statistics" by the Overall Planning Division of the Council for International Economic Cooperation and Development, Taipei, 1970, p.p. 86,92,94.

3.2. Transportation:

In Taiwan, transportation is indeed a critical part of the technology posing many unanswered problems.

highways

Highway physical capacities have been appraised, redesigned and developed since 1966. As far as industrialized buildings are concerned, new design considerations should be given to highway movements which may grow substantially and bring about a serious restriction on the movement of heavy industrialized building units.

The densest mileage of highly improved roads is located in the most populated west flatlands of the island.

railways

The railroads do not cover the island so completely as highways. There are two main lines - the west coast line and the east coast line. The former reaches from Taipei through Taichung to Kaohsiung, and the latter runs from Hualein (located in the middle of the east coast) to Taitung (in the southeast coast of Taiwan). These two lines are the major links of rail transportation which can make it possible to have the distribution of building modules over long distances from central plants.

waterways and airways

Waterways are physically not available for the distribution of building modules. Airways are neither economic nor feasible in short or long distance lift and delivery of building modules.

Table 3.2. shows the distribution of inter-city traffic of railways and highways from 1965 to 1969.*

Table 3.2. Ton-Kilometers (unit: 1,000)

	Railways	Highways
1965	2,415,428	608,177
1966	2,435,109	715,514
1967	2,542,264	783,716
1968	2,709,618	988,757
1969	2,612,802	1,169,179

*Sources from "Taiwan Economic Statistics" by the Overall Planning Division of the Council for International Economic Cooperation and Development, Taipei, Taiwan, 1970, p.p. 109. 111.

B. DESIGN APPROACH

B. DESIGN APPROACH:

1. Industrialized Construction Method:

As mentioned previously (see the introduction, page 8), the programme of the prolongation of compulsory education from six to nine years, and the ever-increasing growth in population of school age in Taiwan have brought about an urgent and massive demand for school building facilities. These demands can not be entirely met by traditional construction methods. They are neither fast nor economic enough.

A solution to this dilemma is the use of a system of industrialized structures. In this study, all alternative types of construction methods and the use of alternative materials has been given due consideration. Steel and timber, although both are entirely satisfactory materials for use in prefabricated systems, are considered not to be used. Steel has to be imported as far as massive needs are concerned, and it is both expensive and requiring foreign exchange for its purchase. Apart from this difficulty the life of steel structures in the sea coast areas of Taiwan has obviously made steel unsuitable for prefabrication of structures like the type required in school, but there are certain difficulties in the use of timber in Taiwan. Although there are large natural resources of timber (see part A, sec. 3.1), the massive exploitation and processing of this timber resource cannot be achieved due to the law for the protection of soil flow. Considering the climatic nature of Taiwan, termite attacks and other forms of destructive forces such as rainfall and typhoon (see part A, sec. 2.3) which are prevalent, timber has very short life. It is, therefore, unwise to depend on timber as a material for prefabrication on a large scale of building production. It is realized that the pressures of population, especially in Taiwan with the highest density of population in the world, are causing land shortage. Consequently most new building design are of multi-storied design. School buildings are no exception to this general trend and multi-storied schools are to be found in urban areas. The greater the population density, it seems, the higher

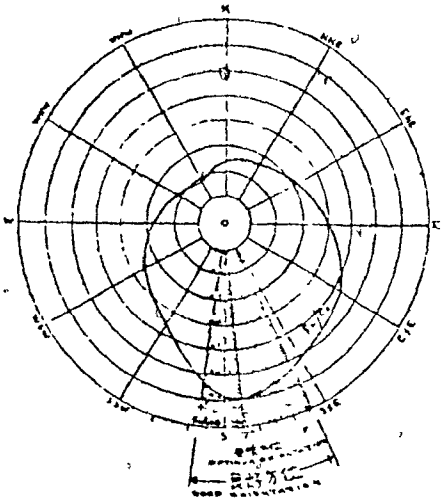
the school buildings rise. Consideration must also be given to the disastrous seismic disturbance in choosing material for school buildings under these circumstances. Therefore, it is the writer's opinion that the reinforced precast members are the ideal materiol for the factory production of school buildings. They are durable, strong and can be produced at fair cost. Cement is produced in large quantity annually and has been one of the major items of exports (see part A, sec. 3.1). Cement factories are spreading over the whole island of Taiwan. This is the advantage of establishing either the temporary or permanent plants to produce the system components as far as the economical aspects of transpotation are concerned (see part A, sec. 3.2). Due to transportation conditions, all system components should be designed in such dimensions as they can be easily transported by road, rail or waterways, according to local transportation regulations.

2. Climatic Control:

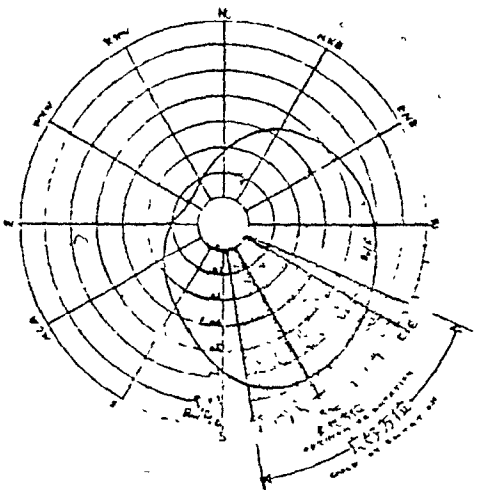
(1) Orientation:

a. In response to solar over-heat:

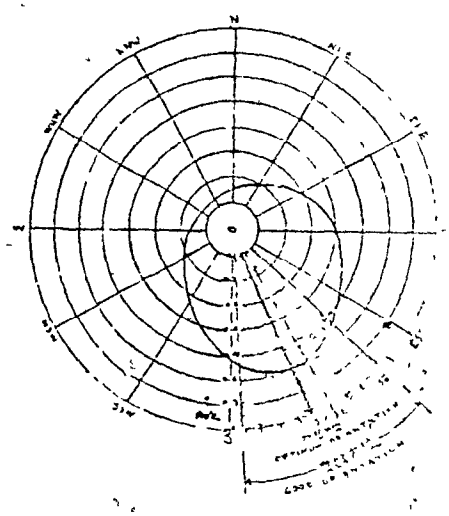
The normal methods of sun control will not be completely effective unless the buildings are correctly oriented. The following figuires B.1, B.2 and B.3 indicate the good orientations in three local areas in Taiwan.



B. 1 Taipei Area



B. 2 Taichung Area



B. 3 Kaohsiung Area

b. In response to the direction of air movement:

As far as the building orientation is concerned, consideration should also be given to the direction and velocity of air movement outdoors. Every locality has its own characteristic wind blow showing the average velocity and direction of prevailing breezes month by month throughout the year. Therefore, the building should be oriented so that the inlet openings of building will face the prevailing breezes (see part A, sec. 2.3).

(2) Ventilation:

To obtain efficient natural ventilation within a building, it is necessary that inlet openings and outlet openings of walls have approximately the same area. Rooms having windows on two exposures (preferably opposed sides) will have far better ventilation than those having windows on a single exposure. If prevailing breezes blow at right angles to building walls ventilation will be better than in buildings having their window walls placed at an acute angle to prevailing winds. Where windows are built into one wall only, certain air inlets should be provided at a low level in the oppoite wall.

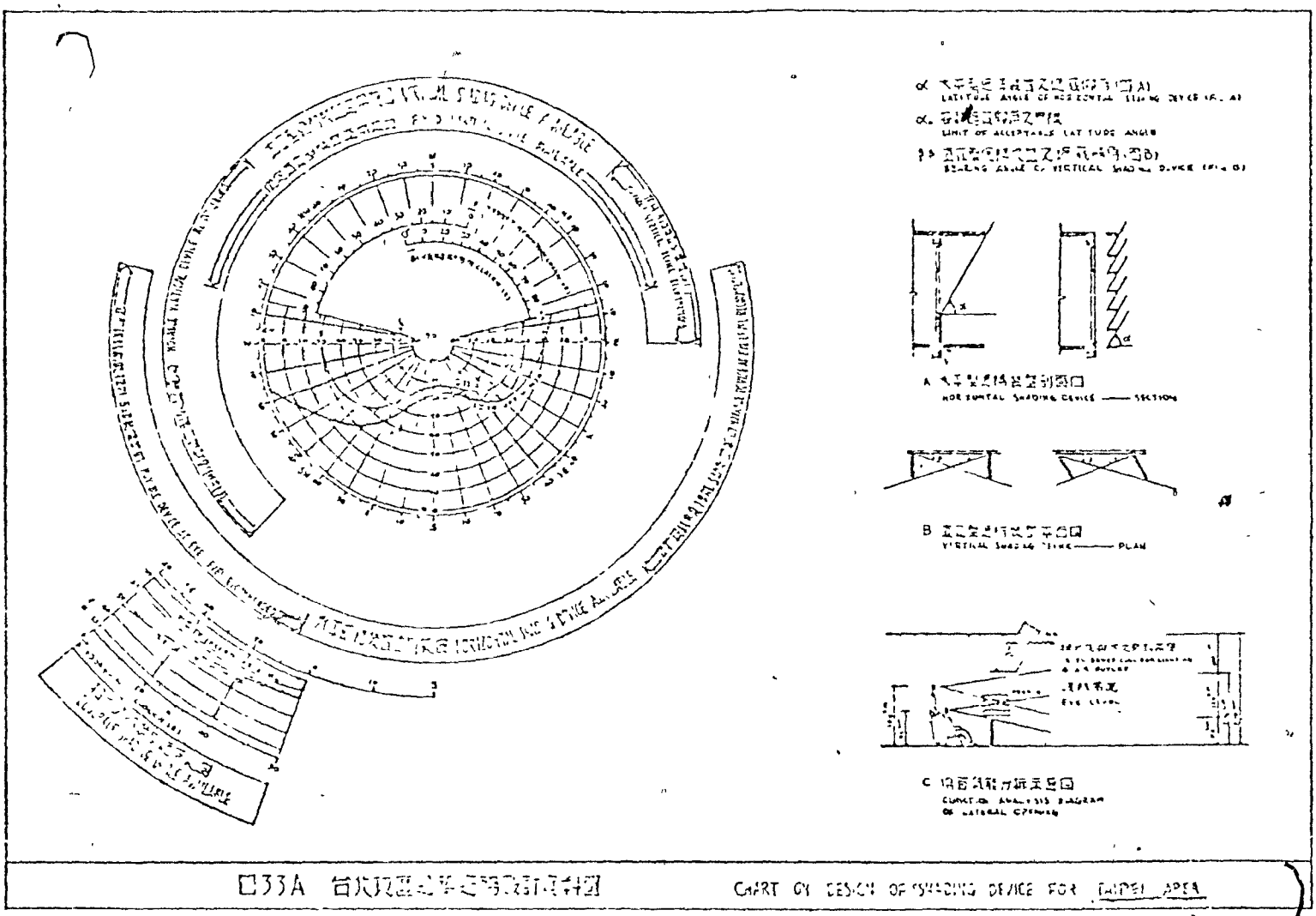
(3) Shading:

As to thermal comfort, one of the most effective methods of solar control is to provide shading devices at the building openings to obstruct the direct sun's rays and prevent uncomfortable glare from the direct rays of the sun. Figures B.4, B.5, and B.6 indicate three different latitude angles for three major localities in Taiwan, and recommend the eggcrate type of shading device to be adopted.

(4) Rain and Typhoon:

a. Should high level louvered shutters not be provided at window walls, the centrally pivoted swing sash would be preferred, for it is unlikely that this type of window will need

Figure B.4* Chart on Design of Shading Device for Taipei Area.



* The following three charts B.4, B.5, and B.6 taken from:
"Solar Control and Shading Devices in Taiwan", by S. Y. Lin, published in "Architecture and Planning Bimonthly", March, 1969, Taipei, Taiwan, p.p. 64, 65, 67.

Figure B. 5 Chart on Design of Shading Device for Taichung Area.

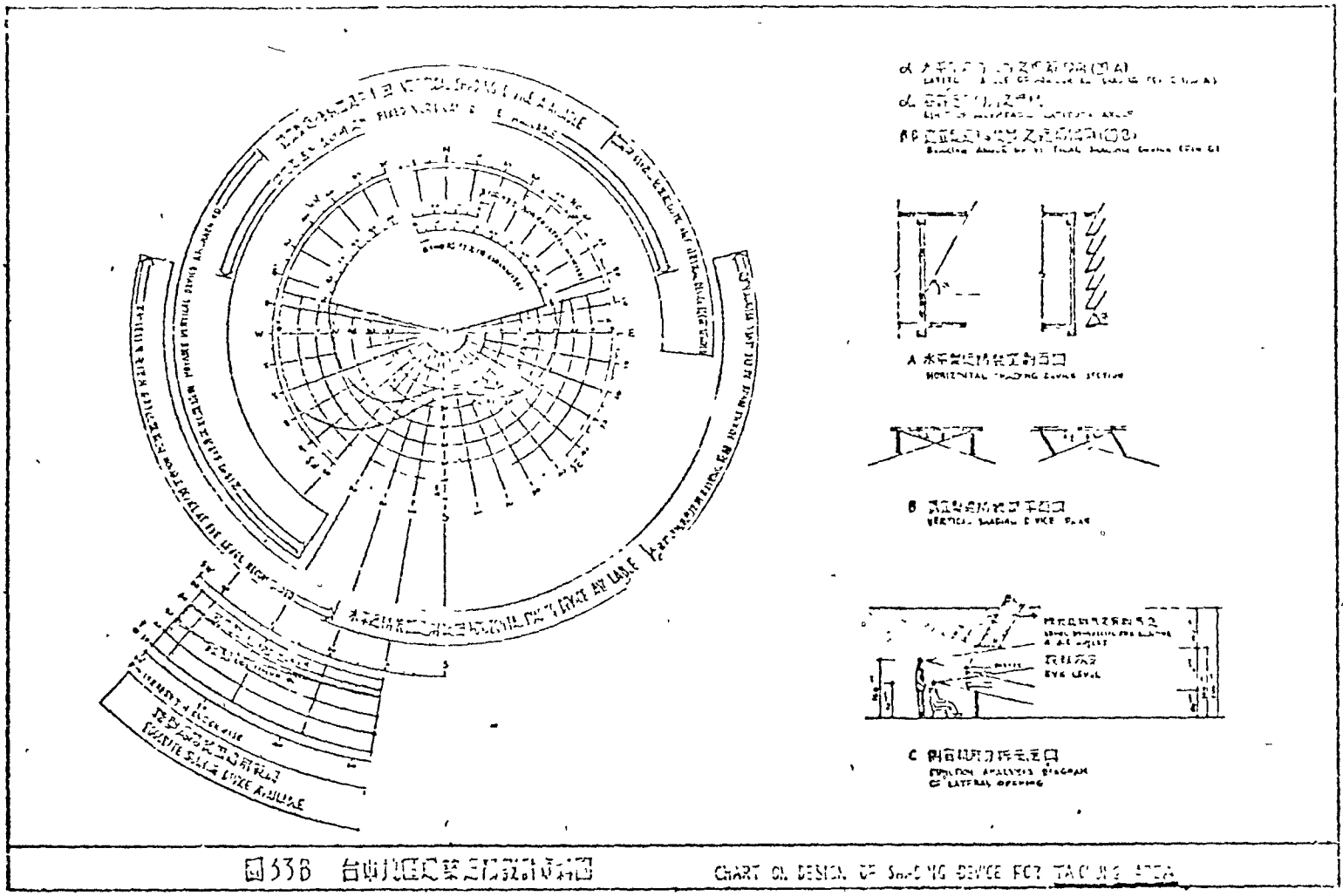
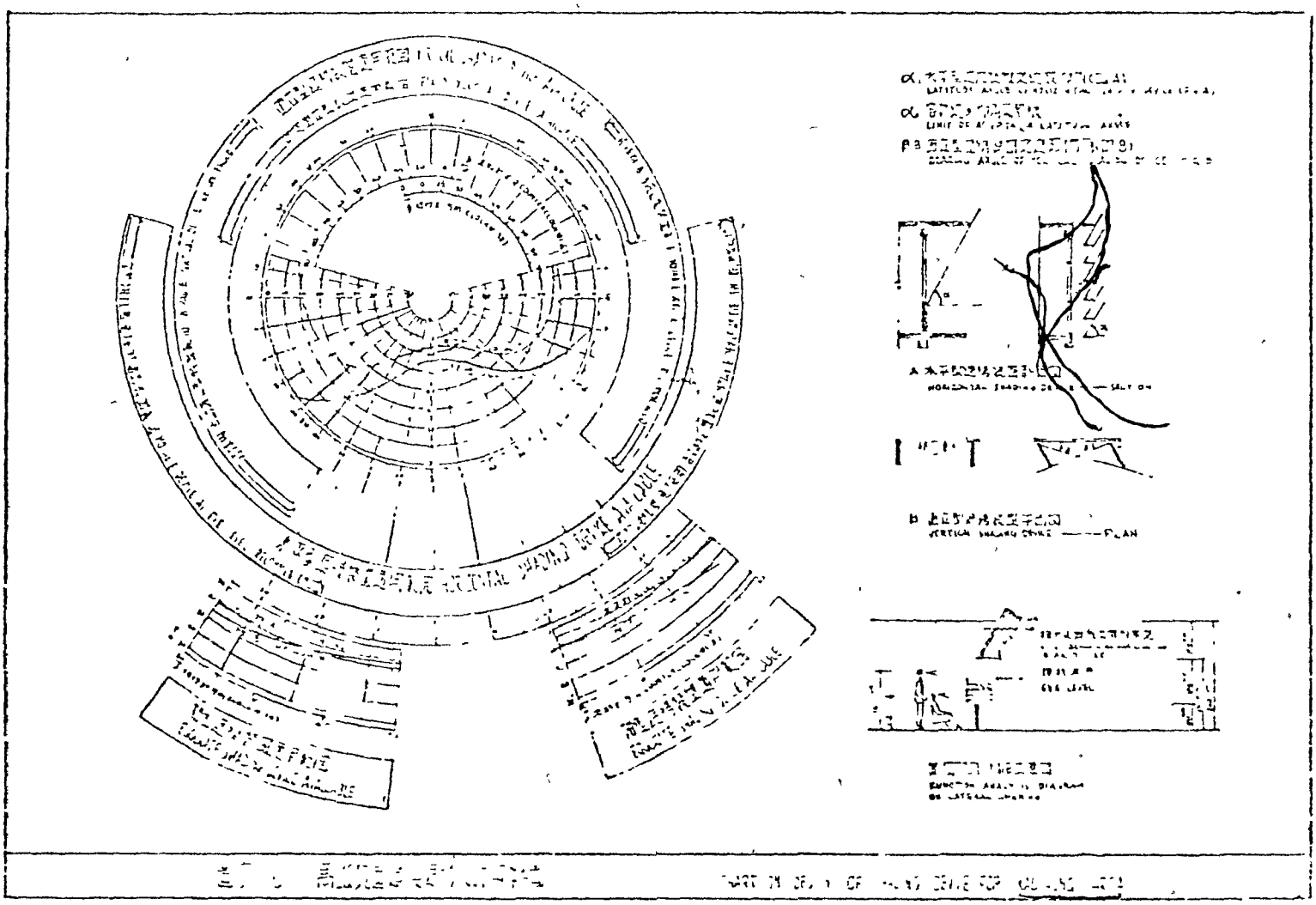


圖338 台中地區遮陽設計圖 CHART ON DESIGN OF SHADING DEVICE FOR TAICHUNG AREA

Figure B. 6 Chart on Design of Shading Device for Kaohsiung Area.



to be completely closed in heavy rain, and it has the additional advantage that it can act as a sun shading device.

b. Although the school is off during the time of typhoon storm, serious engineering consideration still has to be given to the design of window construction to prevent the damage which is mostly caused by the storm rain generated by the typhoon.

3. Seismic Forces:

(1) Resisting elements of building to the seismic forces shall be moment resisting frames or shear walls or a combination of both.

(2) As to the configuration of a structure, symmetry in plan is very desirable. Unusual shaped plans result in highstress concentration areas and must be specifically designed for. Structural elements must be tied together to make them respond to earthquake motion as a unit, or structural separations may be required.

(3) Most building materials are adoptable to use as resisting elements. Brittle materials must be avoided. Ductile materials are most desirable. *

4. Soil Investigation:

Two actions must be fulfilled prior to the ground-break for the building construction:

(1) Preliminary investigation for site selection.

(2) Final investigation of soil after structure is oriented at the site.

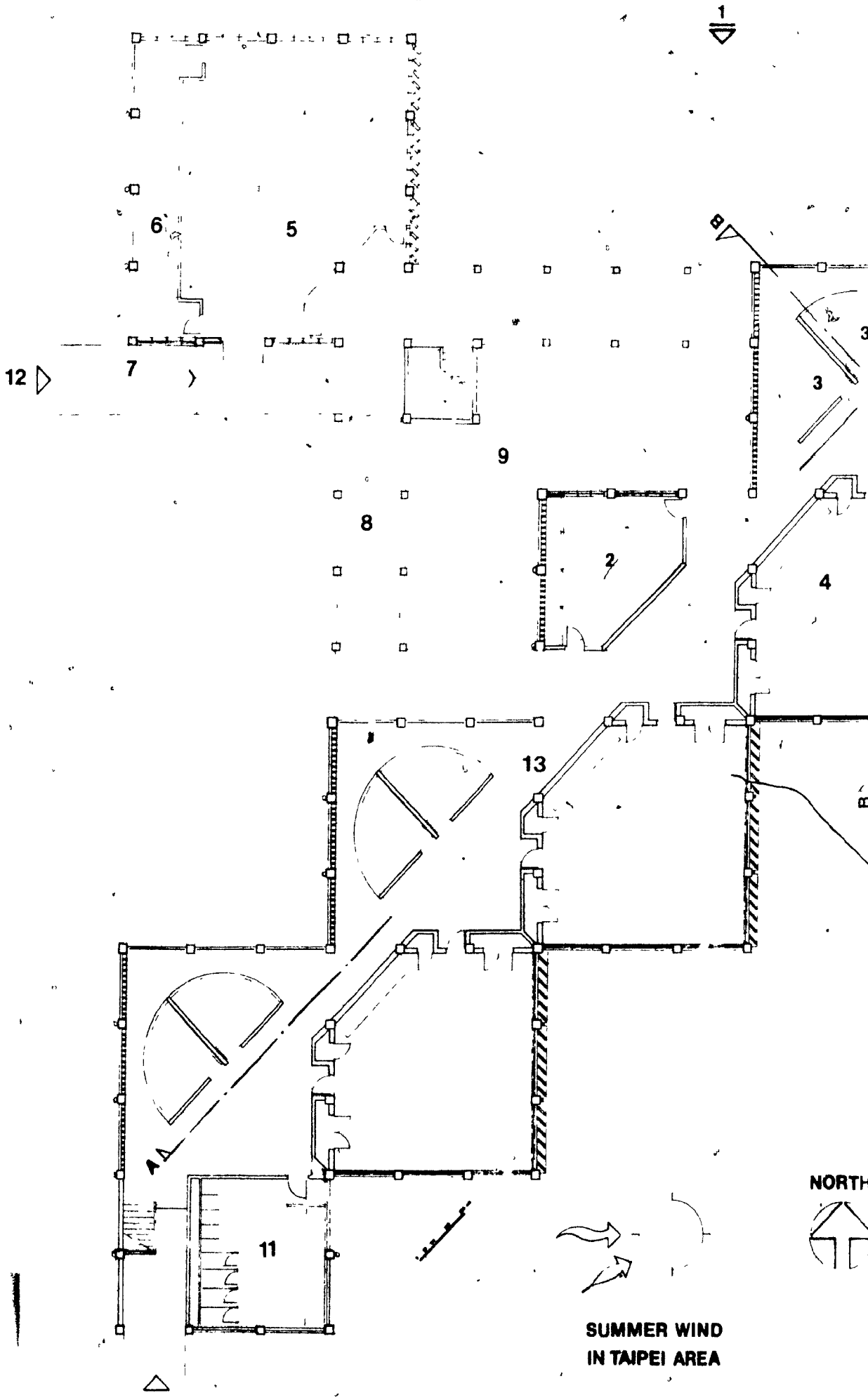
SUMMARY:

To further explain the concept of this design approach, the architectural presentation will follow in part C.

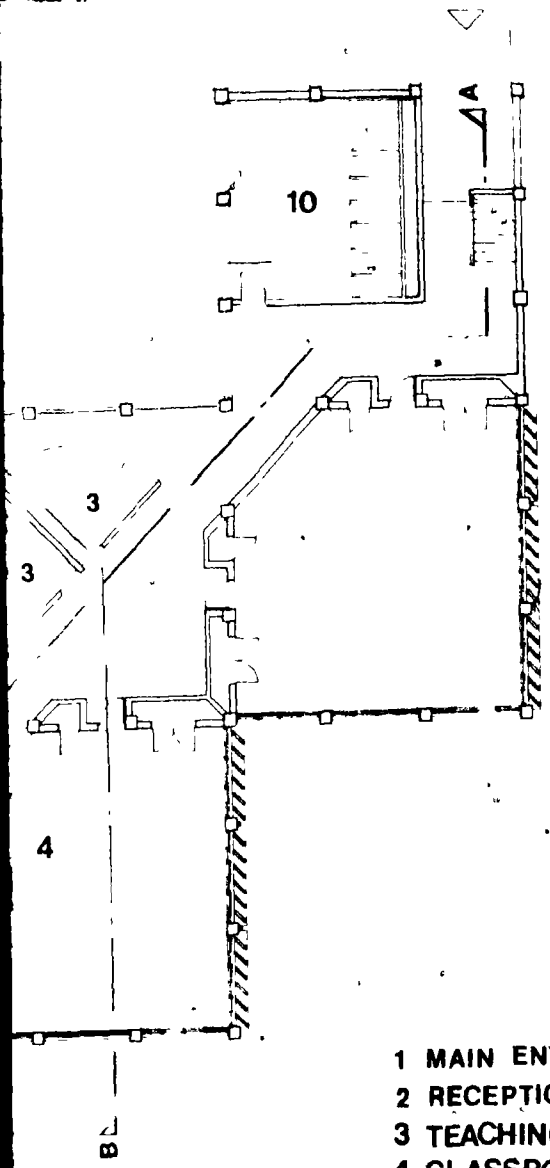
* These three recommendations taken from: "Aseismic Design Concept" writen by Harold P. King, C.E.C.; Benioff, Steinmann, King; Sherman Oaks, California, 1965.

C. PROTOTYPICAL DESIGN

NOTE: The architectural solution presented in the following drawings is an application of the recommended design approach for the Taipei area only; solutions for the other two major areas should vary as to meet local conditions.



1 of 2



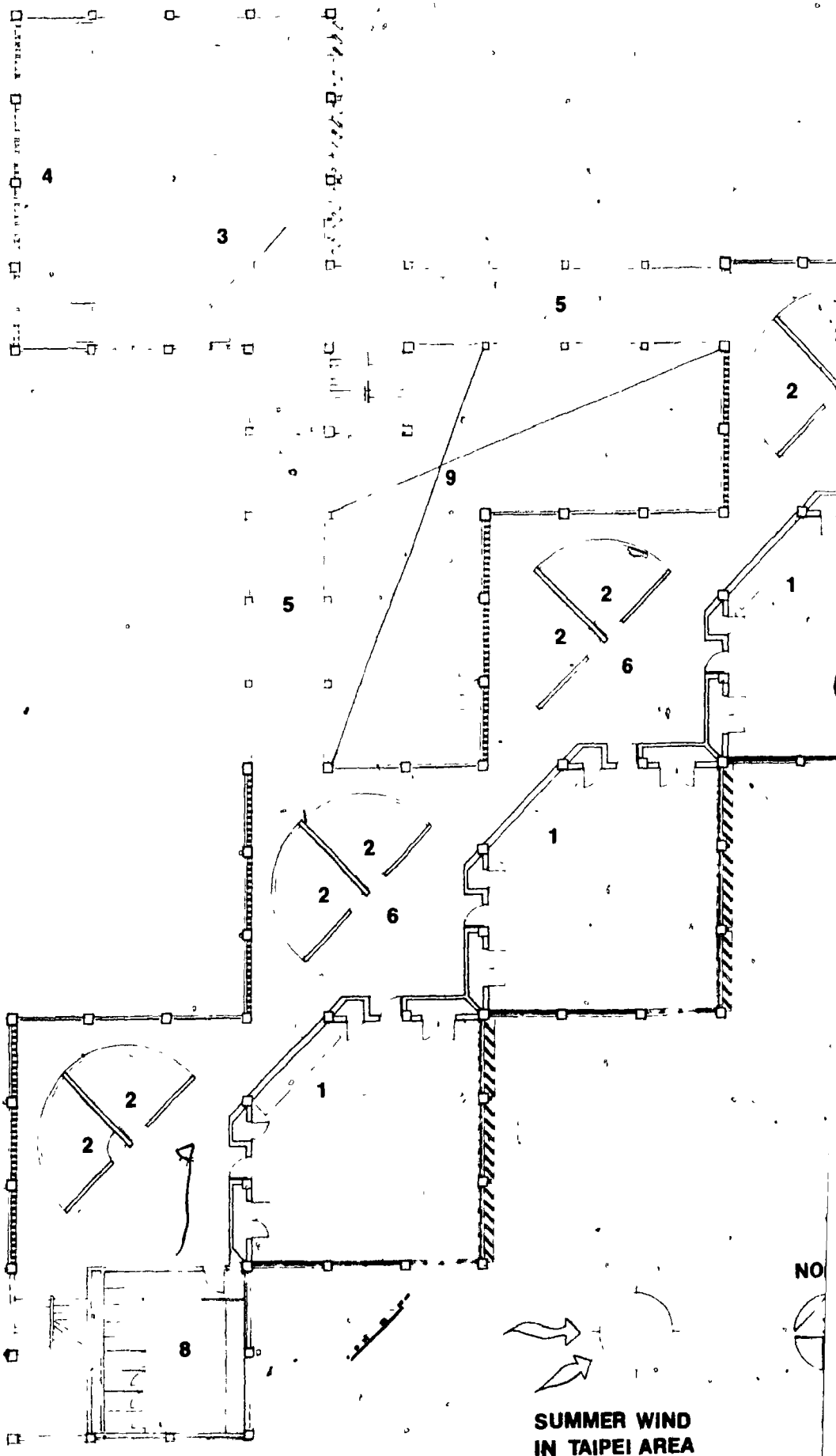
1 MAIN ENTRANCE
2 RECEPTION
3 TEACHING PLANNING
4 CLASSROOM
5 WORK SHOP
6 REST AREA
7 RAMP
8 LINK
9 COURT
10 GIRLS'
11 BOYS'
12 SERVICE
13 CORR

NORTH

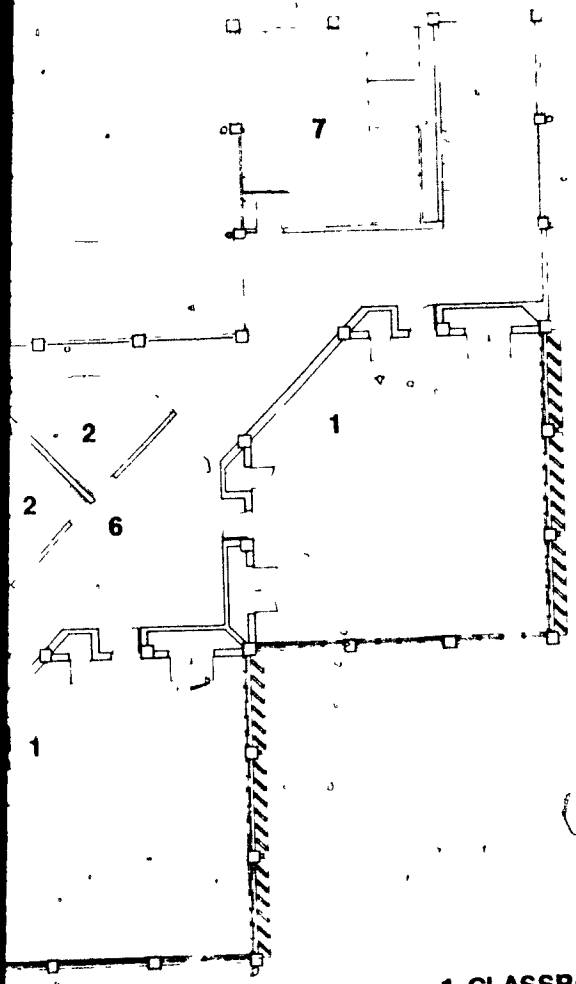
2 of 2

FIRST FLOOR PLAN

1 prototype building design for public junior high schools in Taiwan



1 of 2

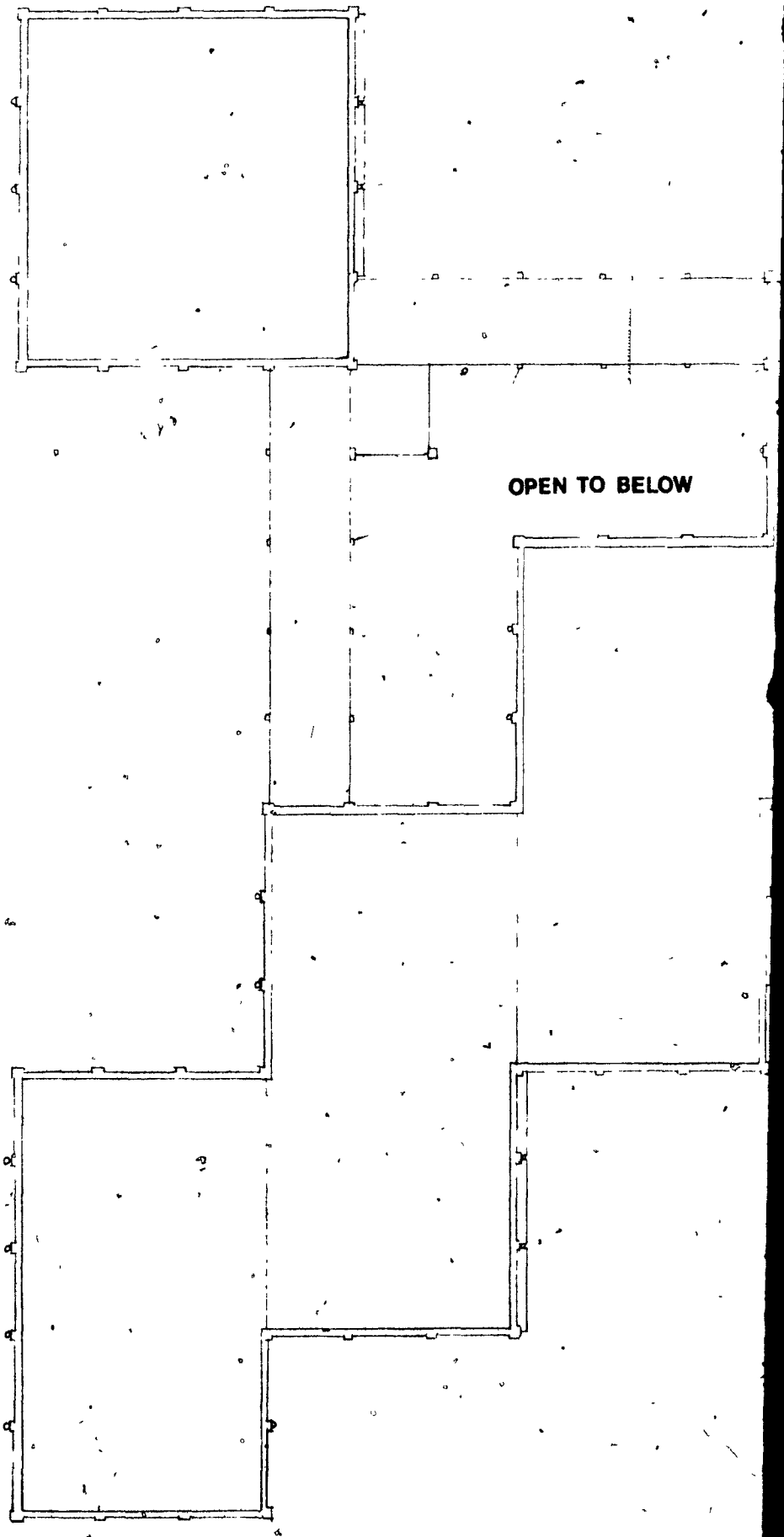


1 CLASSROOM
2 TEACHING PLANNING
3 MULTI-PURPOSE LABORATORY ON SECOND FLOOR, HOME SCIENCE ON THIRD FLOOR
4 REST AREA
5 BRIDGE LINK
6 CORRIDOR
7 GIRLS' TOILET
8 BOYS' TOILET
9 OPEN TO COURT BELOW

NORTH

2 of a

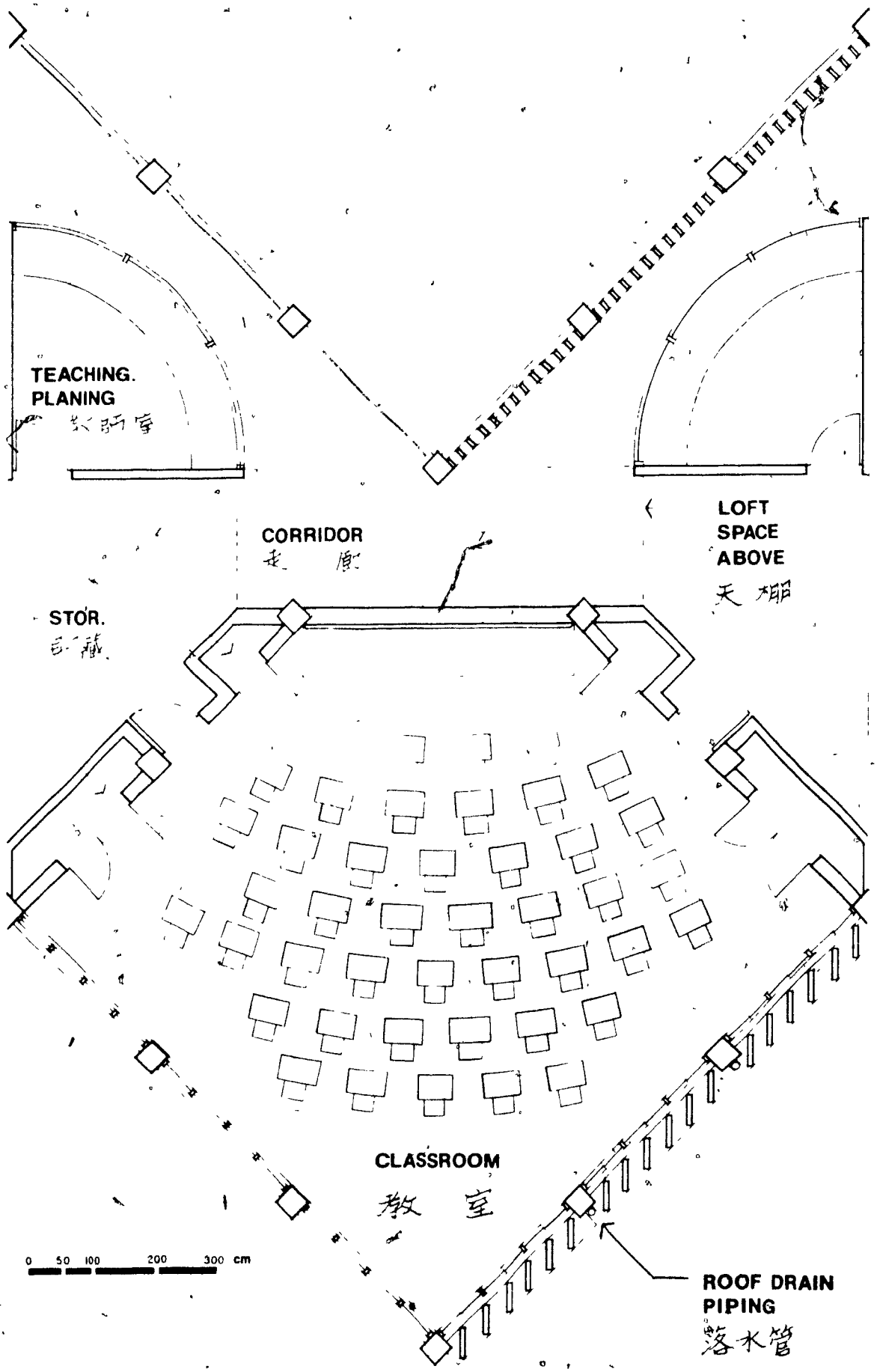
SECOND & THIRD FLOOR PLAN



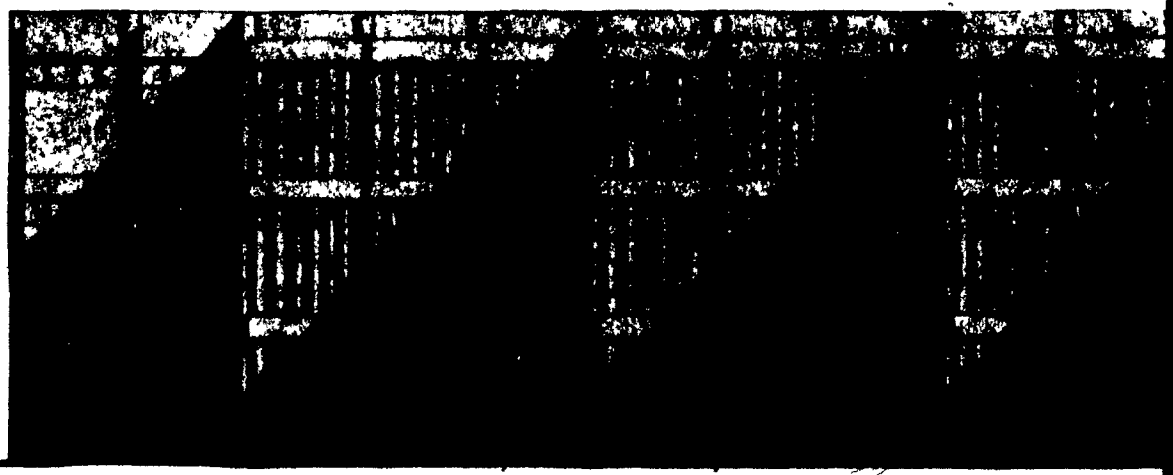
1 of 2

2 of a

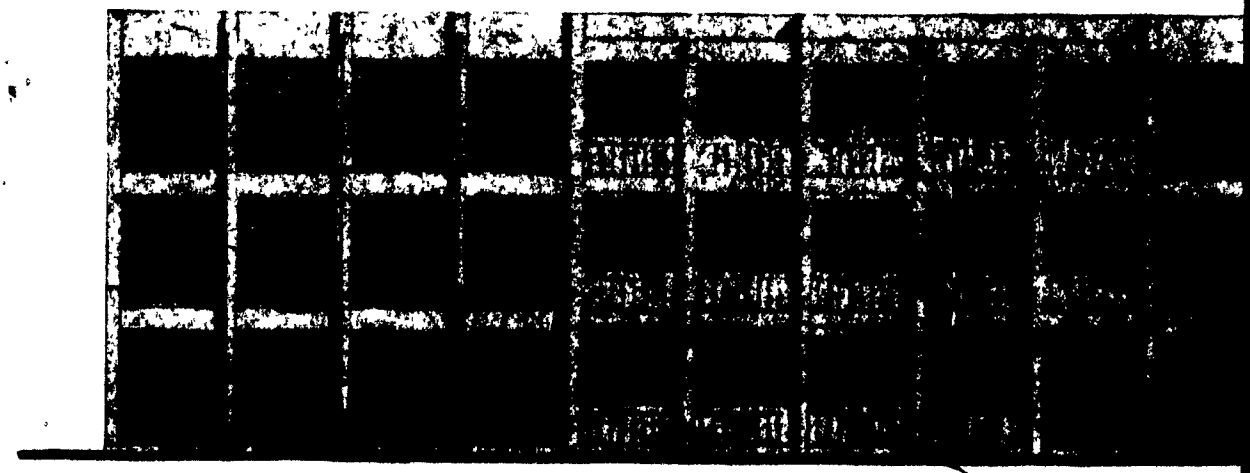
ROOF PLAN



TYP. TEACHERS' OFFICE & CLASSRM FL. PLAN



EAST ELEVATION



WEST ELEVATION

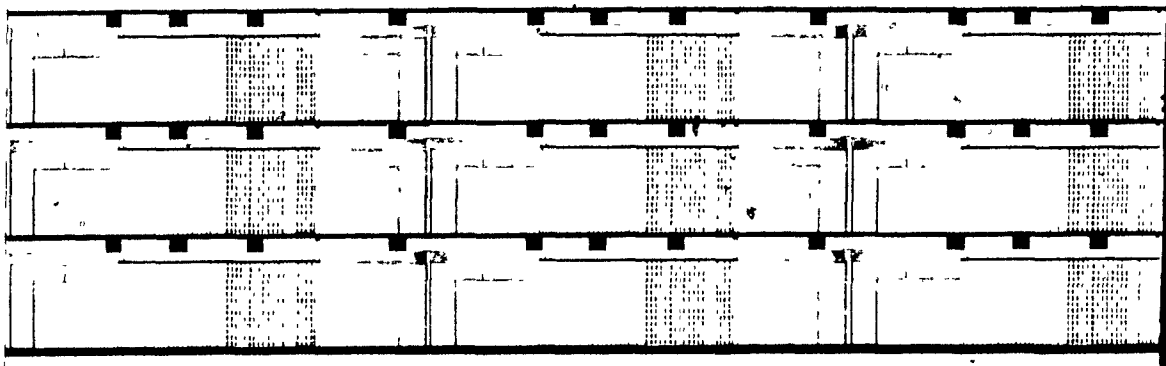
0 200 400 600 cm

1 of 2

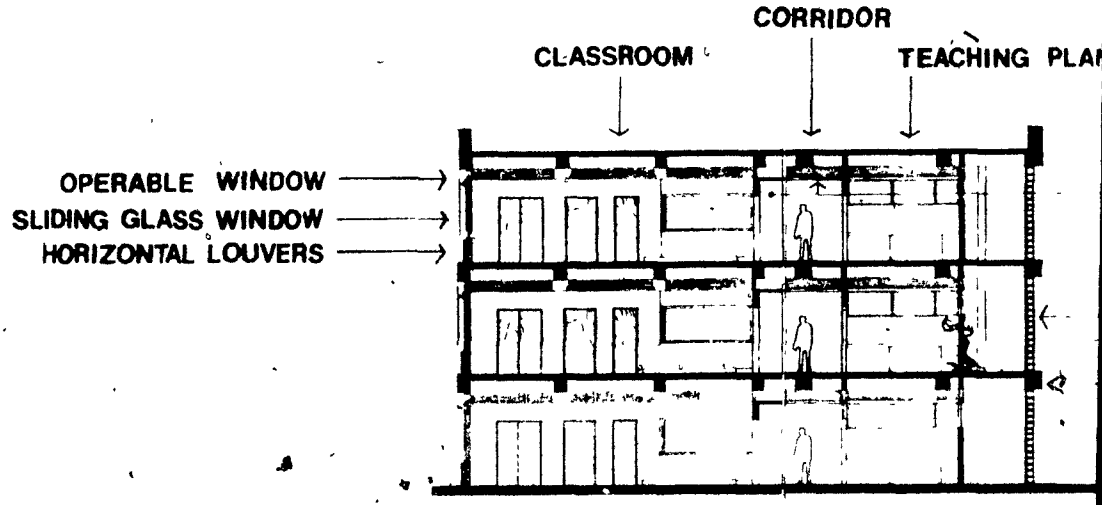
2 of a

ELEVATIONS

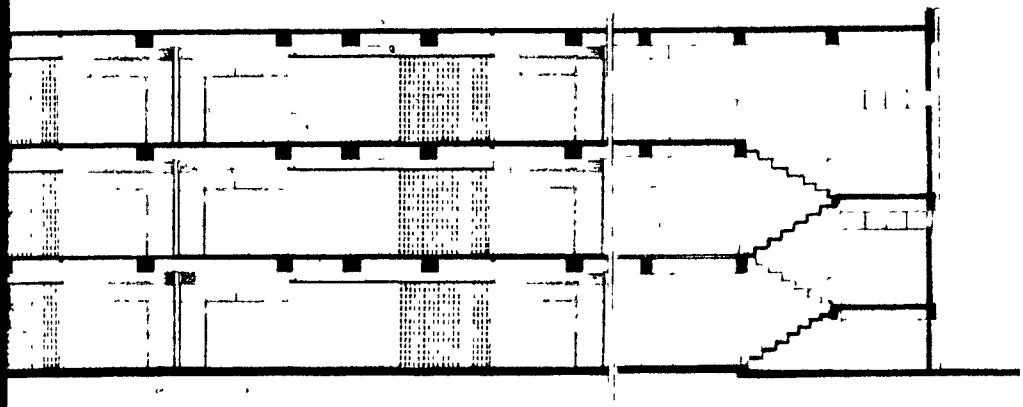
5 prototype building design for public junior high schools in Taiwan



BUILDING SECTION A – A



BUILDING SECTION B – B



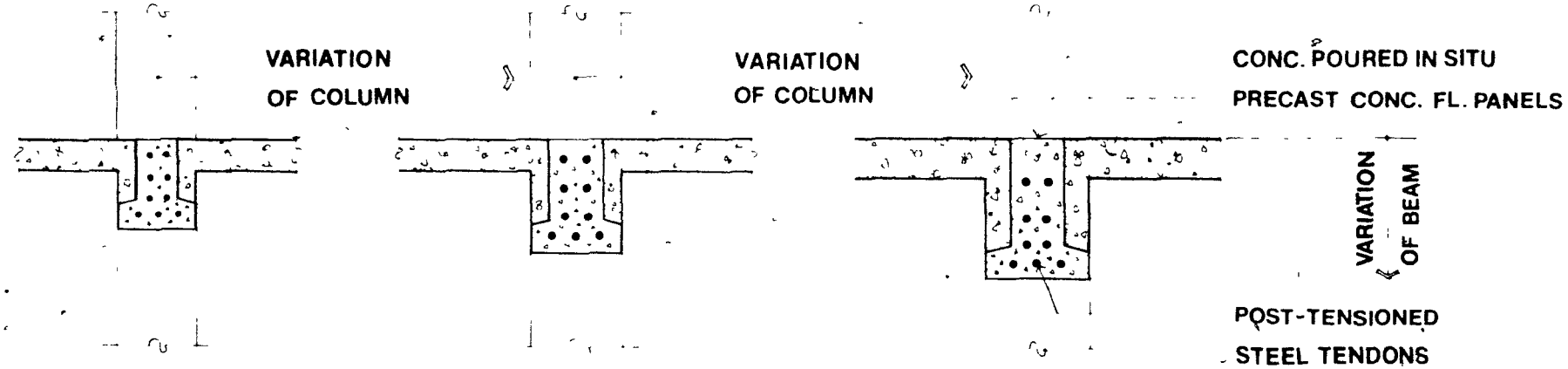
PLANNING

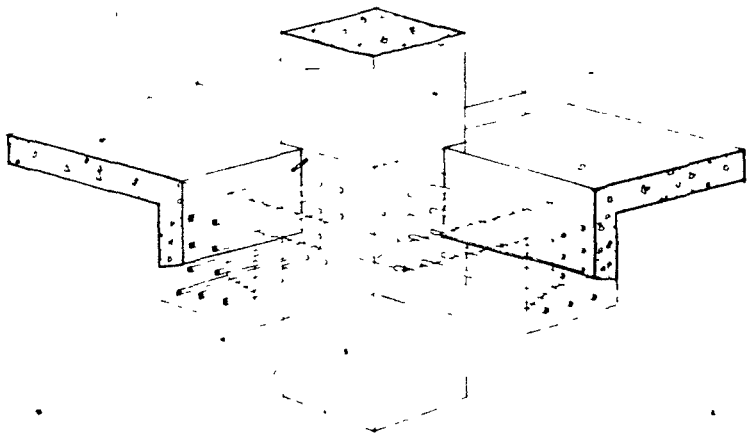
— LOFT SPACE & STORAGE
USED AS SOUND BARRIER

— SOLAR SCREEN MASONRY WALL

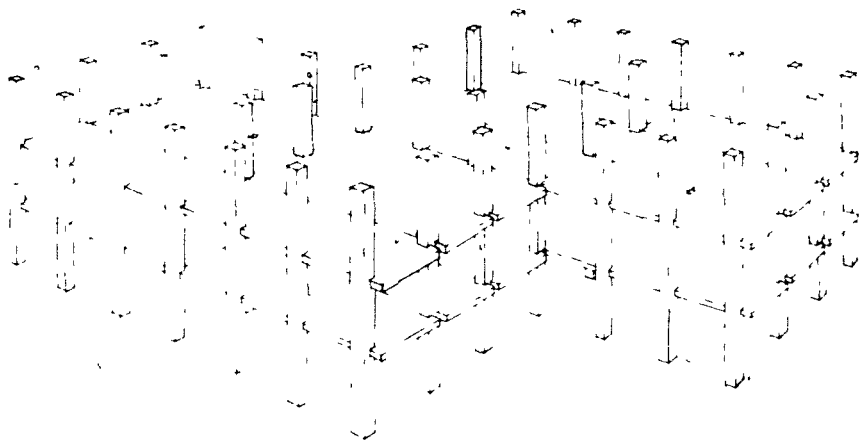
2 of 8

BUILDING SECTIONS





JOINTING DETAIL



ASSEMBLING SYSTEM

STRUCTURAL COMPONENTS

BIBLIOGRAPHY

UNESCO. "The Needs of Asia in Primary Education - A Plan for The Provision of Compulsory Education in The Region." Paris, 1961. (Educational Studies &Documents, #41).

UNESCO. "Report of Meeting of Ministers of Education of Asian Member States Participating in The Karachi Plan." Tokyo, 2 - 11 April. 1962.

Department of Education, Taiwan, " A Brief Introduction to Education in Taiwan", Taichung, Taiwan, 1968

" Temporary Curricula Standard for Public Junior High School,"Ministry of Education, Taipei, Taiwan, January 3, 1968.

" Standards and Guides for Desgning School Buildings," Department of Education, R. O. C., Taichung, Taiwan. 1967

"Educational Buildings, Space and Cost Roms in Asian Region for Educational Planner," by D. J. Vickery, 1971

Fry, Jane B. & E. Maxwell,"Tropical Architecture", London, England, 1965

Taiwan Weather Bureau, & Ke-hsun Chi's "The Distribution of Rainfall in Taiwan" Taipei, Taiwan, 1969

Yun-chi Tung, "A Report of Investigation on Fertilization of Soil of Taiwan", Taipei, Taiwan, 1951,

S.Y. Lin, "Solar Control and Shading Devices in Taiwan", Architecture and Planning Bimonthly, March 1969

D.J. Vickery, A.R.I.S.B.R., UNESCO. "The Shading of School Buildings in Southeast Asia; Bangkok, 1963

C. H. Chi, "Two Natural Damages in Taiwan - Typhoon and Earthquake," Taiwan Weather Bureau, Taipei, 1969

Bulletin of the Imperial Earthquke Investigation Committee, vol., 1, Tokyo, Japan, 1907

D. N. Lee, Proceedings of theGeological Society of China, no. 5, Taipei, Taiwan, 1963

"The Industry of Free China (Taiwan)", Volume 35, No. 2, 1971

"Taiwan Economic Statistics" by the Overall Planning Division of the Council for International Economic Cooperation and Development, Taipei, 1970

"Solar Control and Shading Devices in Taiwan", by S. Y. Lin, published in "Architecture and Planning Bimonthly", March, 1969, Taipei, Taiwan

"Aseismic Design Concept" by Harold P. King, C.E.C.; Benioff, Steinmann, King; Sherman Oaks, California, 1965.