18/8

หลักสูตร การออกแบบโครงสร้างอาคารสูง

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โดย

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ร่วมกับ

ฝ่ายการศึกษาต่อเนื่อง จุฬาฯ

Chapter I

Introduction to Concepts of Structural Design

Definition of Structures

Engineering : The assemblage of those parts which exist for the purpose of maintaining shape and stability. Its primary purpose is to resist any loads applied to the building and to transmit those to the ground.

Architecture : Art and Science of making form.

Primary Requirements that must be present in the structure of the building.

- Stability is needed to maintain shape
- Strength and stiffness
- Economy

Other factors :

- Structural system must relate to the building's functions. The structure must be appropriate to the function it is to shelter.
- Fire-resistant
- The structure should integrate well with the building's circulation systems. (Piping, Air ductings)
- The structure must be psychologically as well as physically safe. (High rise frame sways, Bouncing floors, etc.)

Structural Planning and Design

Structural planning is far more complex than structural design.
"Feeling for Structures."

Design : Art of proportioning.

<u>Idealization of Structures</u>

Real Structure → Idealized Structure

(Mathematical and Physical model of structures)

Structural forms in buildings

- Cable
- Post (Column)
- Lintel (Beam)
- Truss
- Arch
- Shell

<u>Building Codes</u>

<u>Accuracy of Computation</u>

<u>Loads</u>, <u>Load Factors and Safety</u>

$$\text{Factor of safety} = \frac{\text{Failing stress (yield stress, crushing strength)}}{\text{Working stress used in design}} \quad (2.4)$$

→ WORKING DESIGN

$$\text{Load factor} = \frac{\text{Ultimate load}}{\text{Working load}} \quad (2.5)$$

→ Ultimate DESIGN.

The distinction between a factor of safety and a load factor is thus essentially that one applies the safety margin to the stresses and the other to the loads. Either could be used for elastic design (see Chapters 4 and 5) or for ultimate strength design (see Chapters 9 and 10). In practice, however, factors of safety are traditionally used for elastic design, for which the maximum permissible (or working) stresses are obtained from eqn (2.4), while load factors are normally associated with ultimate strength design.

A constant load factor numerically equal to the traditional factor of safety evidently is of little benefit if one wants to design a more economical structure. A committee of the *Institution of Structural Engineers* [2.47] has proposed a series of load factors which take account of the principal variables. It bases the choice of the load factor on two groups.

Group X: *Probability of Collapse*, includes the following factors:
- A—Material, workmanship, inspection, maintenance.
- B—Accuracy of loading assumption, control of use.
- C—Accuracy of analysis, type of structure.

Group Y: *Seriousness of Collapse*, includes the following factors:
- D—Danger to human life.
- E—Economic losses.

In each factor of Group X there are four ratings: very good (vg), good (g), fair (f) and poor (p). In each factor in Group Y there are three ratings: not serious (ns), serious (s), very serious (vs).

The Committee assigned the following values to the factors, based on its collective judgement and experience:

Values of X factors

Characteristic			B = Very good	Good	Fair	Poor
A = very good	C =	very good	1·1	1·3	1·5	1·7
		good	1·2	1·45	1·7	1·95
		fair	1·3	1·6	1·9	2·2
		poor	1·4	1·75	2·1	2·45
A = good	C =	very good	1·3	1·55	1·8	2·05
		good	1·45	1·75	2·05	2·35
		fair	1·6	1·95	2·3	2·65
		poor	1·75	2·15	2·55	2·95
A = fair	C =	very good	1·5	1·8	2·1	2·4
		good	1·7	2·05	2·4	2·75
		fair	1·9	2·3	2·7	3·1
		poor	2·1	2·55	3·0	3·45
A = poor	C =	very good	1·7	2·15	2·4	2·75
		good	1·95	2·35	2·75	3·15
		fair	2·2	2·65	3·1	3·55
		poor	2·45	2·95	3·45	3·95

Factors above 2·5 are given in the above table in bold type, and the Committee recommends that it would be better, if the design passes into that range, either to alter the practical conditions envisaged, or to adopt statistical methods of load and strength assessment, or to use superior methods of calculation.

Values of Y factors

Characteristic		D = Not serious	Serious	Very serious
E =	Not serious	1·0	1·2	1·4
	Serious	1·1	1·3	1·5
	Very serious	1·2	1·4	1·6

The ultimate load factor is then obtained multiplying X by Y. The following examples are taken from the Report:

Example 2.1. Consider a reinforced concrete tank designed for erection on a tower for use as a source of water supply in a country district.

The factors are assessed as follows:

A = g; B = vg; C = g; D = ns; E = s

Consequently from the two tables X = 1·45 and Y = 1·1. The ultimate load factor = 1·45 × 1·1 = 1·60.

Example 2.2. Consider the steel structure of the gallery of a metropolitan theatre.

A = g; B = vg; C = g; D = vs; E = s.

The ultimate load factor = 1·45 × 1·5 = 2·18.

Example 2.3. Consider the load bearing walls of a large block of flats, to be built of brick under ordinary municipal conditions.

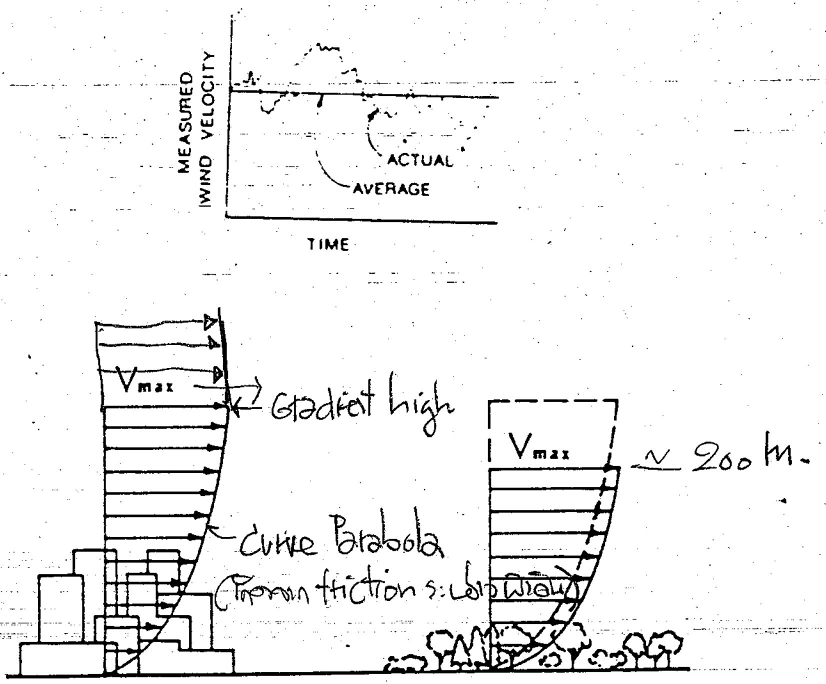
A = p; B = g; C = p; D = s; E = vs

The ultimate load factor = 2·95 × 1·4 = 4·13.

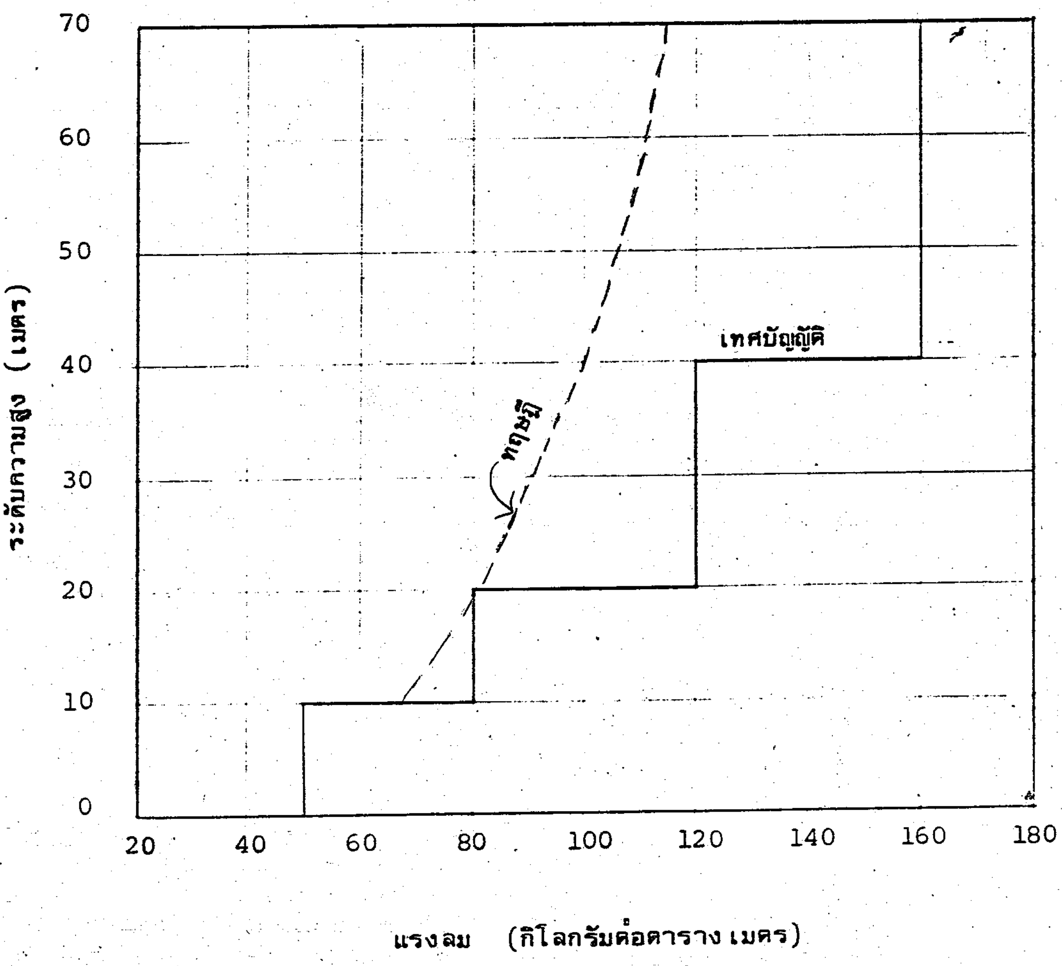
It will be noted that load factors determined by this method can be quite high, much more than the factors traditionally stipulated in building codes. The nominal factors of codes, however, do not provide the only safety margin. When unreliable materials are used, lower stresses may be assumed. Higher loads may be stipulated in uncertain loading conditions. Finally engineers and architects often increase arbitrarily the calculated structural dimensions in an unfamiliar situation. When a more rational method of assessing the load factor is employed, these additional safeguards can be discarded.

ACI:

1.40DL + 1.70LL

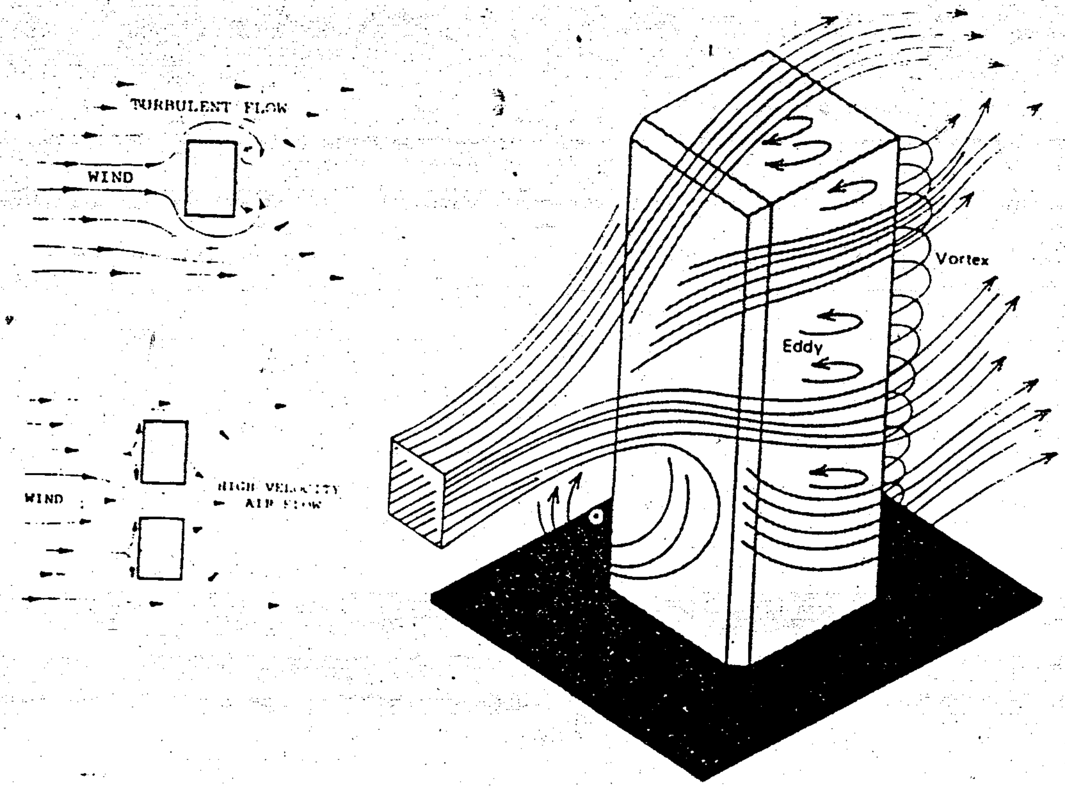


รูปที่ 1 ความสัมพันธ์ระหว่างความเร็วลมกับเวลาและความสูงจากพื้นดิน



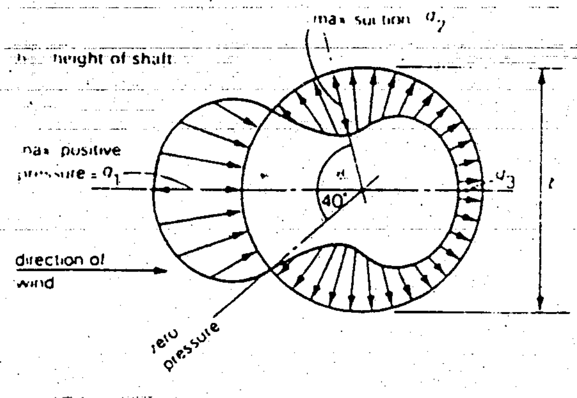
หมายเหตุ ความเร็วลมสูงสุดในกรุงเทพ 103.7 กม./ชม.

รูปที่ การเปรียบเทียบแรงลมที่คำนวณได้ตามทฤษฎีกับเทศบัญญัติ



รูปที่ การไหลของลมผ่านสิ่งกีดขวาง

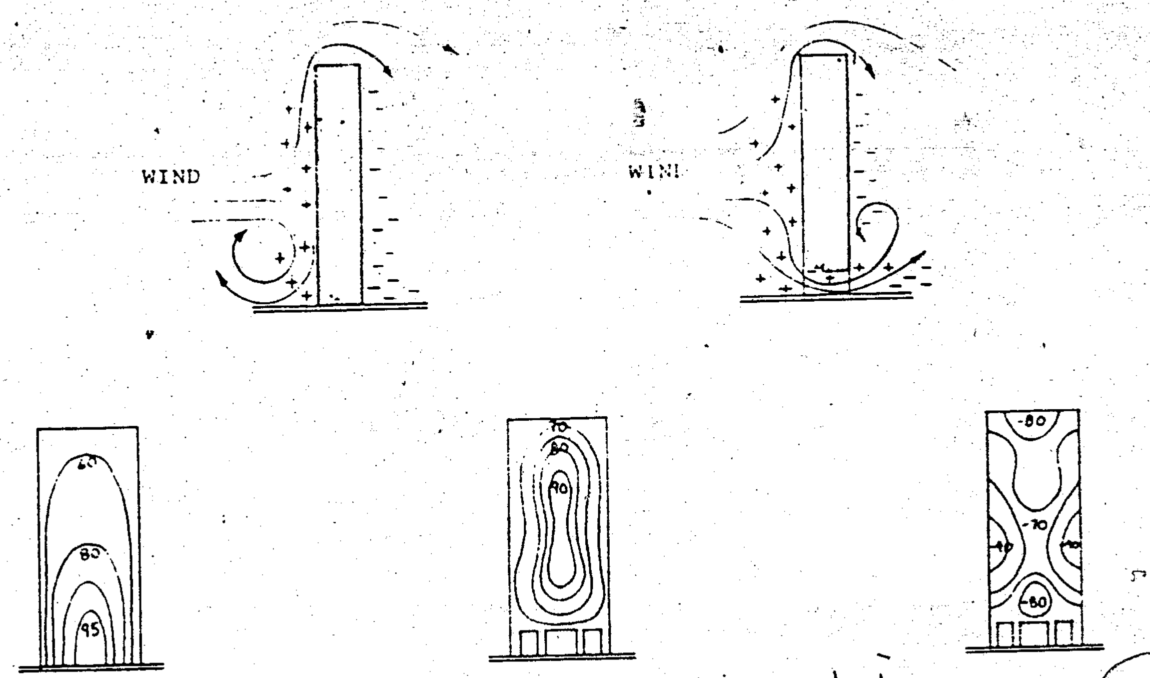
Variation of pressure on vertical cylindrical surface



Surface of shaft	$\frac{h}{b}$	q_1	q_2	[illegible]	q
Rough or with projections	10	$+1.0w_s$	$1.25w_s$	70	$0.40w_s$
	$\not>2\frac{1}{2}$	$+1.0w_s$	$1.05w_s$	80	$0.30w_s$
Smooth	10	$+1.0w_s$	$1.45w_s$	80	$0.35w_s$
	$\not>2\frac{1}{2}$	$+1.0w_s$	$1.30w_s$	80	$0.25w_s$

Interpolate for intermediate values of *h/b*

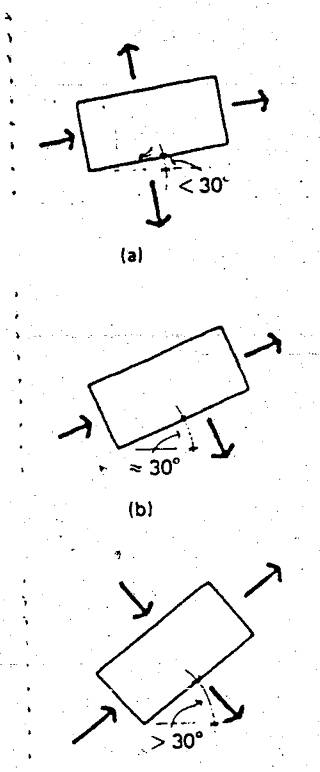
รูปที่ สภาพการกระจายของลมบนผิวตั้งของรูปทรงกระบอก



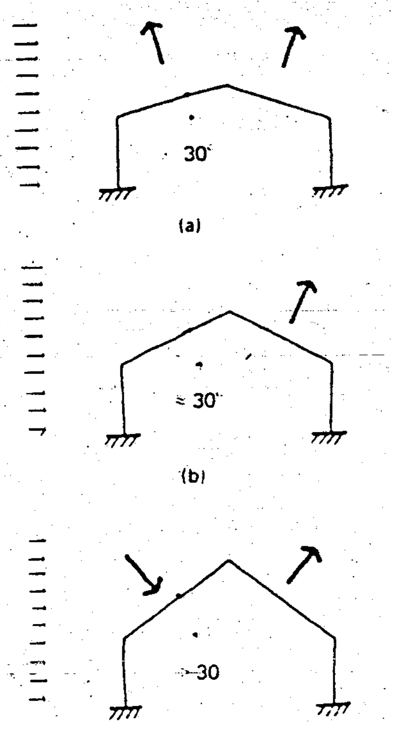
Load Action on High-Rise Buildings

ถ้าเอา Wind load input ที่ถูกต้อง → ที่โมเดลรูป.

รูปที่ แรงดันของลมที่วัดได้บนอาคาร

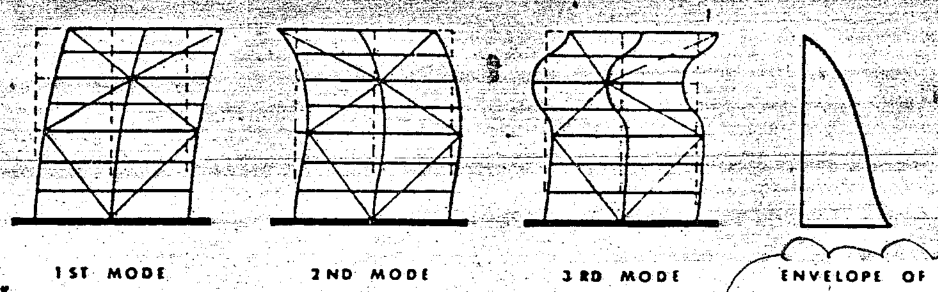


Wind effects on plan orientation.

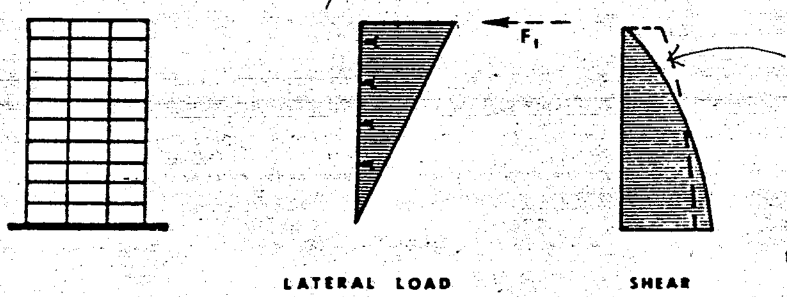


Wind effects on gable angles

รูปที่ ผลกระทบจากทิศทางของลมต่อแรงลมบนอากาศ

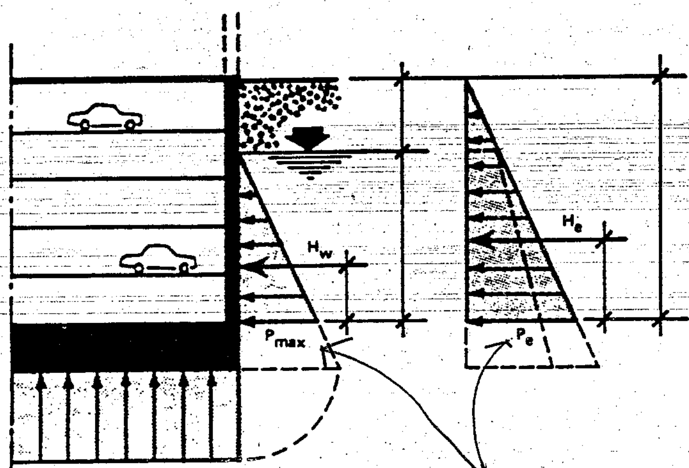


Vibration mode shapes of a building.



Lateral seismic force distribution.

รูปที่ ไหมดการสั่นไหวของอาคารและแรงเฉือน



Lateral earth and water pressure on building substructure.

รูปที่ แรงดันดินและน้ำใต้ดินต่อผนังห้องใต้ดิน