ANALYSIS AND DESIGN OF MULTI-STOREYED BUILDINGS USING STAAD.PRO AND ESTEEM

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ABSTRACT

ANALYSIS AND DESIGN OF MULTI-STOREYED BUILDINGS USING STAAD.PRO AND ESTEEM

In recent year the increase of population, commerce and trade and the cost of land in cities have resulted in a considerable increase in the number of tall buildings. At present, there are many factors effecting the selection and design of the high-rise building structural system. Therefore, various method of analysis in computer computation are easy available in the market. Two different softwares which are the STAAD.PRO and ESTEEM were used in the analysis and design the concrete and steel multi-storey buildings for 4 and 12 storey building. However, it is predictable that these computer softwares help us to understand how patterns affect the design of building, the performance impact and how they fit. The various types of loads (dead, imposed, lateral load) were computed based on the BS6399 and BS5950. The results were checked by various methods. Comparisons of the output from STAAD.PRO and ESTEEM (bending moment, axial force on the structures frame and etc were compared).

ABSTRAK

ANALYSIS AND DESIGN OF MULTI-STOREYED BUILDINGS USING STAAD.PRO AND ESTEEM

Pembangunan populasi, ekonomi, dagangan dan harga tanah telah membawa kepada peningkatan bilangan bangunan-bangunan pencakar langit. Sekarang, banyak factor yang diambil kira dalam memilih dan mereka bentuk system struktur bangunan-bangunan tinggi ini. Oleh sebab itu, pelbagai kaedah analisis dalam pengiraan computer banyak terdapat dalam pasaran. Dua perisian yang berbeza iaitu STAAD.PRO dan ESTEEM telah digunakan dalam proses analysis dan reka bentuk konkrit dan keluli untuk dua bangunan berbeza iaitu 4 tingkat dan 12 tingkat. Walaubagaimanapun, adalah dijangka bahawa perisian computer ini dapat membantu dalam pemahaman terhadap kesan bentuk bangunan dengan reka bentuknya, kekuatan dan kestabilannya. Pelbagai jenis beban (*dead load, live load, lateral load*) telah dikira dengan merujuk kepada BS6399 dan BS5950. keputusanny telah diperiksa dengan pelbagai kaedah. Perbandingan nilai keputusan daripada STAAD.PRO dan ESTEEM seperti momen lentur, daya ricih keatas rangka struktur dan lain-lain telah dibandingkan.

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LIST OF ABBREVIATIONS / NOTATIONS

V_s	Wind speed
H_o	Height from ground level
V_B	Basic wind speed
S_a	Altitude factor
S_d	Direction factor
S_s	Seasonal factor
S_p	Probability factor
Cr	Dynamic augmentation factor
S_b	Terrain and building factor
q_s	Dynamic Pressure
F	Wind force
C_f	Force coefficient for the building
A_e	Effective frontal area of the structure
b	Dimension of the building normal to the wind
d	Dimension of the building measured in direction of the wind
l	Greater horizontal dimension
w	lesser horizontal dimension
UDL	Ultimate design load
DL	Dead load
LL	Live load
M	Moment
F_y	Axial load in Y direction

f_{cu}	Characteristic strength of concrete
f_y	Characteristic strength of reinforcement
b_w	Average web width of the flanged beam
b_v	breadth of section (for a flanged beam this should be taken as the average width of the rib below the flange)
d	Effective depth of the tension reinforcement
A_s	Area of tension reinforcement
A_{sreq}	Area of tension reinforcement required
A_{smin}	Minimum area of tension reinforcement
A_{sprov}	Area of tension reinforcement provided
A_{sv}	Total cross section of links at the neutral axis, at a section
V	Design shear stress at the cross section
V_c	Design concrete shear stress
S_v	Spacing of links along the member

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In recent years, multi-storey building has gained popularity among Malaysians. Several factors have been identified which make up the demand factors for multi-storey building. Among the factors are the following:

1. Overall population growth: present and future housing requirements arise out of the total population growth by way of net natural increase, immigration, family formation, size of households and changing age distribution.
2. Urbanization: The potential demand becomes more apparent with population growth and also urbanization. By 2020, Malaysia's population will reach 70 million people and this means that 45 million people living in urban areas i.e. an increase of 264 per cent. This urbanization attracts people to the cities. People prefer living in the cities because of a high paying jobs, quality of life and cultural events. This means there will be an increased in demand for housing (***Table 1.1***).

Table 1.1: The Urban Population Growth Trend in Malaysia.

Year	Overall Pop. ('000)	Urban	% of Urban Population
1970	10877	2719	25
1980	13764	2884	21
1990	18010	7744	43
2000	22615	11353	50
2010f	27621	16645	60
2020f	33015	24403	74

Source: Malaysia Institute Economic Report (1991).

3. Mortgage finance: Mortgage finance is essential in converting potential demand for housing into actual demand. Therefore the availability of mortgage money at affordable interest rates and acceptable terms is always an important factor in both demand and supply of multi-storey building.

4. Other aspects of demand for condominium: Others demand is conditioned by the qualitative aspects such as the following:

   - accommodation: number of bedrooms, living rooms, bathrooms, storage etc.
   - quality of locality: superior, average or low cost.
   - construction: good quality finishes and facilities.
   - tenancy or ownership.
   - small or large section: build up area.

1.2 OBJECTIVE AND SCOPE

1.2.1 The objectives of this study are as follow:

- To study how different types of multi-storey building (concrete and steel) can be modeled, analyzed and designed using software.
- To compare the results of the STAAD.PRO with the ESTEEM.
- To study the static structural behavior of building under action of loading.
- To design the bracing system and shear wall for the building.

1.2.2 The scopes of project are as given below:

- To model, analyze and design 4 and 12 storeyed steel and concrete buildings using STAAD.PRO and ESTEEM.
- To determine bracing system/shear wall for above cases.
- To compare behavior of these 4 and 12 storeyed symmetric multi-storey building.

1.3 ORGANIZATION

This thesis is divided into seven chapters. Chapter one, *INTRODUCTION* which presents the reason for demand of multi-storey building, the objective and the cope of analysis.

Chapter two, *LITERATURE REVIEW* which presents the information of the structural of the multi-storey building and introduction to the sources of loads on structures and how loads can be quantified for the purpose of structural design.

Chapter three, *METHODOLOGY* which presents the methods of design and analysis of multi-storey building structure using by STAAD PRO and ESTEEM software.

Chapter four, *MODELING OF STRUCTURE* which is included the calculation of loads and analyzing of 4 and 12 storey concrete and steel building.

Chapter five, *RESULTS AND DISCUSSIONS* which presents the results which are obtained and discuss the results obtained from the STAAD.PRO and ESTEEM and also compare the results of these two software.

Finally, the last chapter will be chapter six *CONCLUSION*.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Various types of loads (dead, imposed and environmental) and their classification as permanent, median, and temporary or accidental due to the British standard BS6399: Basis of Design and Actions on Structures, is considered.

Loads due to wind and seismic effects are considered briefly. The statistical treatments of wind and wave loads, and their dependence upon wind speed and wave height respectively, are described. The importance of load characteristics, other than simply their magnitude, is considered. These characteristics include fatigue, and dynamic effect.

Structures are subject directly to loads from various sources. These loads are referred to as direct actions and include gravity and environmental effects, such as wind. In applying any quantitative load approach to structural analysis, the magnitudes of the actions need to be identified. Furthermore, if the structure is to perform satisfactorily throughout its design life, the nature of the loads should be understood and appropriate measures taken to avoid problems of, for instance, fatigue or vibration.

The magnitude of loads cannot be determined precisely. In some cases, for instance in considering loads due to the self-weight of the structure, it might be thought that values can be calculated fairly accurately. In other cases, such as wind loads, it is only possible to estimate likely levels of load. The estimate can be based on observation of previous conditions and applying a probabilistic approach to predict maximum effects which might occur within the design life of the structure. (In fact, the extensive wind records which are now available mean that wind loads can often be predicted with greater accuracy than self-weight).

In analyzing structures it is rare to consider all loadings acting simultaneously. This approach may be because the most severe condition for parts of the structure occurs when some other combination of load is considered. Alternatively it may be that the possibility of such a condition actually occurring is extremely small. Correlations can be produced from unexpected sources or from coincidences which, although physically unconnected, are temporarily connected. For example, floor and wind loads would normally be considered as unrelated.

In limit state design, characteristic values of actions are used as the basis of all calculations. They are values which statistically have only a small probability of being exceeded during the life of the structure. To provide a margin of safety, particularly against collapse, partial safety factors are applied to these characteristic values to obtain design quantities. In principle, different partial safety factors can be applied depending on the degree of uncertainty or variability of a particular type of action.

2.2 DEFINATION

For the purposes of this code of practice the following definitions apply.

2.2.1 Dead load

The load due to the weight of all walls, permanent partitions, floors, roofs, finishes and all other permanent construction including services of a permanent nature.

2.2.2 Imposed load

The load assumed to be produced by the intended occupancy or use, including the weight of movable partitions, distributed, concentrated, impact and inertia, loads, but excluding wind loads.

2.2.3 Storage height

The height of the space between a floor and a physical constraint to the height of storage formed by a ceiling, soffit of a floor, roof or other obstruction.

2.2.4 Wind load

The load due to the effect of wind pressure or suction.

2.2.5 Accidental load on key or protected element

The ultimate load assumed, during a single accidental loading event to apply to structural elements essential to the residual stability of the building.

2.3 Permanent Actions

Permanent actions, as the name implies, are always present and must be considered in all cases. They comprise what are traditionally referred to as dead loads, but may also include permanent imposed loads due, for instance, to machinery or stored material.

2.3.1 Dead loads

Dead loads are calculated from the unit weights or from the actual known weights of the materials used. Where there is doubt as to the permanency of dead loads, such loads should be treated as imposed loads. Where permanent partitions are indicated, their actual weights are included in the dead load. The weights of tanks and other receptacles, and of their contents, are considered as dead loads. These loads should be calculated for the cases when a tank or receptacle is full and when it is empty.

2.4 Variable Actions

Variable actions comprise loads which are not always acting but may exist at various times during the normal use of the structure. They include loads due to the occupation of a building and imposed load and wind loads (environmental loads). They do not include accidental conditions such as fire, explosion or impact.

2.4.1 Imposed floor and ceiling loads

2.4.1.1 Floors

2.4.1.1.1*General*

The loads appropriate to the type of activity/occupancy for which the floor area will be used in service are given in ***Table 2.1***. The loads in ***Table 2.1*** should be treated as the unfactored or characteristic loads for design purposes. They should be considered as the minimum values to be adopted. Where higher values are considered more appropriate, based on knowledge of the proposed use of the structure or proposed installation of equipment, machinery, stacking systems, etc., they should be used instead.

Table 2.1 Minimum imposed floor loads

Type of activity/occupancy for part of the building or structure	Examples of specific use		Uniformity distributed load kN/m^2	Concentrated load kN
A Domestic and residential activities (Also see category C)	All usages within self-contained dwelling units Communal areas (including kitchens) in blocks of flats with limited use (See note 1) (For communal areas in other blocks of flats, see C3 and below)		1.5	1.4
	Bedrooms and dormitories except those in hotels and motels		1.5	1.8
	Bedrooms in hotels and motels Hospital wards Toilet areas		2.0	1.8
	Billiard rooms		2.0	2.7
	Communal kitchens except in flats covered by note 1		3.0	4.5
	Balconies	Single dwelling units and communal areas in blocks of flats with limited use (See note 1)	1.5	1.4
		Guest houses, residential clubs and communal areas in blocks of flats except as covered by note 1	Same as rooms to which they give access but with a minimum of 3.0	1.5/m run concentrated at the outer edge
		Hotels and motels	Same as rooms to which they give access but with a minimum of 4.0	1.5/m run concentrated at the outer edge
B Offices and work areas not covered elsewhere	Operating theatres, X-ray rooms, utility rooms		2.0	4.5
	Work rooms (light industrial) without storage		2.5	1.8
	Offices for general use		2.5	2.7
	Banking halls		3.0	2.7
	Kitchens, laundries, laboratories		3.0	4.5
	Rooms with mainframe computers or similar equipment		3.5	4.5
	Machinery halls, circulation spaces therein		4.0	4.5
	Projection rooms		5.0	To be determined for specific use
	Factories, workshops and similar buildings (general industrial)		5.0	4.5
	Foundries		20.0	To be determined for specific use
	Catwalks		—	1.0 at 1 m centres
	Balconies		Same as rooms to which they give access but with a minimum of 4.0	1.5/m run concentrated at the outer edge
	Fly galleries		4.5 kN/m run distributed uniformly over width	—
	Ladders		—	1.5 rung load

(Source: Table 1 : BS 6399 : Part 1 : 1996)

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