ANALYSIS AND DESIGN OF STRUCTURAL ELEMENTS FOR A 5-STOREY FLAT

VOON SIAW CHEE

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ANALYSIS AND DESIGN OF STRUCTURAL ELEMENTS FOR A 5-STOREY FLAT

BY
VOON SIAW CHEE

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Alamat tetap: 21, Jalan Perumahan,
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APPROVAL SHEET

This project report attached here to, entitled "Analysis And Design Of Structural Elements For A 5-Storeys Flat" prepared and submitted by Voon Siaw Chee in partial fulfillment of the requirements for the degree of bachelor of engineering (Civil) is hereby accepted.

Date : 9/4/2001

(Dr. Ng Chee Khoon)

Lecturer

Civil Engineering Department

Faculty Of Engineering

University Malaysia Sarawak

Date : 9/4/2001

(Voon Siaw Chee)

21, Jalan Perumahan,

95000 Sri Aman ,

Sarawak, Malaysia.

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ABSTRACT

The project presented is a analysis and design of structural elements for a 5 – storeys residential Class 'C' flat. Three main structural elements namely slabs, beams and columns had been chosen in this study by using various softwares for analysis and design purposes. In reinforced concrete slab design, two different softwares namely *Advanced Technology & Solution* (ATS) and *STructural Analysis And Design* (STAAD III *Rel 22.3W 32-bit*) were used where ATS design slabs due to BS 8110 (1985) code while STAAD III *Rel 22.3W 32-bit* applied ACI 318 (1995) code. The slabs marked as 'S1', 'S8' and 'S20' from ground floor were selected as critical slabs for the following discussion. Similarly, three critical beams from typical floor were chosen for this purpose in reinforced concrete beam design. These beams were 5-span continuous beam marked as 'TB10' to 'TB14', 3-span continuous beam marked as 'TB26' to 'TB28' and 4-span continuous beam marked as 'TB38' to 'TB41'. Two softwares had been used were also ATS and STAAD III *Rel 22.3W 32-bit* which this case, both of the softwares designed beam to BS 8110 (1985) standard code. For reinforced concrete column design, another two spreadsheets known as Reinforced Concrete Council, RCC Spreadsheet (*RCC Column Design*) and *Shortcol* had been used to design columns to BS 8110 (1985) and ACI 318 (1995) code respectively by combination with manual calculations. One external and internal column marked as 'C3' and 'C6' played the role as critical columns in this design. Finally, The output results for each element were compared and analyzed between two softwares.

ABSTRAK

Projek ini melibatkan analisis dan rekabentuk elemen struktur bagi 5 tingkat pangsapuri kelas 'C'. Tiga elemen struktur utama iaitu papak, rasuk dan tiang telah dipilih dengan menggunakan pelbagai perisian komputer demi tujuan analisa dan rekabentuk. Dalam merekabentuk papak konkrit bertetulang, dua perisian struktur berlainan, iaitu *Advanced Technology & Solution* (ATS) dan *STructural Analysis And Design* (STAAD III *Rel 22.3W 32-bit*) telah digunakan di mana ATS merekabentuk papak berdasarkan piawai kod BS 8110 (1985) manakala STAAD III *Rel 22.3W 32-bit* mengikuti keperluan kod ACI 318 (1995). Papak bertanda 'S1', 'S8' dan 'S20' yang berasal dari tingkat bawah telah dipilih sebagai papak kritikal dalam perbincangan berikutnya. Selain itu, tiga rasuk kritikal dari tingkat tipikal telah dipilih untuk memenuhi projek objective ini dalam bahagian rekabentuk rasuk knkrit bertetulang . Rasuk tersebut adalah rasuk ala- berterusan 5 rentang ditanda dari 'TB10' ke 'TB14', rasuk ala – berterusan 3 rentang ditanda dari 'TB26' ke 'TB28' dan rasuk ala – berterusan 4 rentang yang ditanda dari 'TB38' ke 'TB41'. Dua perisian yang digunakan juga merupakan ATS dan STAAD III *Rel 22.3W 32-bit* di mana kedua- dua perisian tersebut telah merekabentuk rasuk dengan mengikut piawai kod BS 8110 (1985). Bagi rekabentuk tiang konkrit bertetulang, dua perisian iaitu Reinforced Concrete Council , RCC Spreadsheet (*RCC54 Column Design*) dan *ShortCol* telah terlibat dalam merekabentuk tiang dengan masing- masing mengikut piawai kod BS 8110 (1985) dan ACI 318 (1995) disertai dengan hasil pengiraan tangan. Satu tiang bahagian luar ditanda 'C3' dan satu tiang bahagian dalam ditanda 'C6' telah memainkan peranan sebagai tiang kritikal dalam rekabentuk ini. Akhir sekali, keputusan keluaran daripada kedua- dua perisian akan dibanding dan dianalisis selanjutnya.

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CHAPTER 1

INTRODUCTION

1.1 General

This study consists of Reinforced Concrete Design for a 5 storeys residential flat by using engineering software. Structural elements included in the projects are slabs, beams and columns. Those critical cases for each structural elements will be selected and focused in further discussion. Analysis will be made on those critical cases by comparing results from different engineering softwares.

The data, calculations and designs in this project conform to the recommendations of the current British Standard codes of practice for reinforced concrete, BS 8110 (1985). All the material properties and assumptions made are corresponding to the consultant standards, who is handling this project. These will be classified in the following chapter.

1.2 Objectives

This project is carried out due to apply the knowledge that learned in the university to the real design of reinforced concrete building. Besides, it aims at analyzing and identify the effective, satisfactory and capability between 2 different engineering softwares in reinforced concrete design with respect to each recommended standards and cost.

CHAPTER 2

PROJECT REVIEW

2.1 Project Background

The proposed Royal Malaysia Naval Base Project is situated at Sepangar Bay, Kota Kinabalu, Sabah. There are 8 packages of building construction works where it will be completed within 5 years approximately. The total cost of this project is fifty million Malaysian Ringgit (RM 50 000 000.00).

The 8 packages of design project are as following :

Package 1 : Residential

1	Officer's Mess
	Officer's Accomodation
2	Senior Rating Mess
	Senior Rating Accomodation
3	Junior Rating Mess
4	Junior Rating Accomodation
5	5 Storey class C Flat
6	5 Storey Class D/E Flat
7	5 Storey Class F Flat
8	4 Storey Class G Flat
9	2 Storey Class B Bungalow
10	2 Storey Class C+ Bungalow
11	2 Storey Class C Modified Semi Det House
12	Kindergarten / Bakat House
13	Primary School
14	Mosque
15	Community Hail

Package II : Workshop & Store

1	Electrical & Battery Workshop
2	Mechanical Workshop
3	Electronic Workshop
4	Ordnance Workshop
5	Hull Workshop
6	Weapon System Workshop
7	Store Building No 1
8	Store Building No 2
9	Store Building No 3
10	MT Garage
11	Ammunition Depot
12	Ammunition Office

Package III : Offices

1	HQ Building including Operation & Communication centre
2	Base Administration Building
3	Fleet Support Admin Building
4	RMN Volunteer Reserve Building
5	Bosun Building
6	Main Entrance
7	Radio Receiving Station

Package IV : Community Buildings

1	Shop Lots
2	Wet Market
3	Petrol Kiosk
4	Hawker Stall
5	Fire Station & Equipment
6	Main Canteen & Laundry
7	Petrol Station

Package V : Recreation

1	Swimming Pool & Pavilion
2	Stadium Complex
3	Multipurpose Hall
4	Hockey Pitch
5	Boat House

Package VII : Training

1	Small Arms Firing Range
2	Security Squad And Detention Centre
3	Parade Ground & Saluting Dias
4	Diving Center
5	Air Defence Building
6	Drill Shed
7	Paskal Building

Package VII : Naval Air Station

1	Office Building
2	Store
3	Hanger
4	Helicopter Operation & Associated Works

Package VIII : Hospital

1	Hospital

The parties involved in the project are :

Owner : **EKRAN BERHAD**

16th, Floor, Wisma Ting Pek Khiing

No. 1 Jalan Padungan,

93100 Kuching, Malaysia

Project Management / : **Hashim & NEH (Sarawak) Sdn. Bhd.**

Consultant 1st Floor,Lot 117. Section 43

Jalan Batu Lintang, 93200 Kuching

Sarawak, Malaysi

Architect : **ARKITEK VISIREKA SDN. BHD.**

81- 2, Jalan 3/ 23 A,

Damai Kota , Jalan Genting Kelang,

Setapak, 53000 Kuala Lumpur, Malaysia.

2.2 Designed Building Description

The 5 storeys residential flat, namely class 'C' is one of the buildings in phase 1. The class C flat is covers an area of 800 m^2 approximately, in which the length and the width of the flat is 50 m and 16 m respectively. The floor to floor height is 3.2 m and the total height of the building is 17.5 m. The class C flat consists of ground floor, typical floor from first floor to third floor, fourth floor, roof and two staircases.

Ground floor boundary is purposed for car park basement without brick wall construction. There are a switch board room, located at the corner side with approximate area of 9 m^2 (3 m x 3 m). Typical floor formed by three apartments at each storey in which each apartment consists of three bedrooms, three toilets, one kitchen, one living room, one dining room, one balcony, one store and one pantry. The architectural design for apartments at both sides of the flat are same rather than the middle apartment. Meanwhile, fourth floor only covers the middle apartment including roof of the typical floors.

Two staircases are constructed separately at the end of the middle apartment, which is in front of the building. The length and the width for each staircase is 5.05 m and 2.80 m respectively, which forms the total area of 14.14 m^2 . Each one link the building from fourth floor until ground floor.

The residential flat will take approximately ten months to be completed and estimated to accommodate about 72 persons for the whole block.

The elements in each apartment with approximate area are shown in Table 2.2.a and Table 2.2.b .

(Table 2.2a) Side Apartments

Item	Elements Description	Approximate Area
1	Master Bedroom	5.15 m x 4.15 m
2	Bedroom 2	5.95 m x 3.15 m
3	Bedroom 3	5.00 m x 4.15 m
4	Guest Room	4.68 m x 4.15 m
5	Kitchen	4.15 m x 4.15 m
6	Drying	3.15 m x 2.16 m
7	Toilet	2.15 m x 2.00 m
8	Store	1.65 m x 1.20 m
9	Pantry	1.20 m x 1.20 m
10	Living	6.59 m x 4.15 m
11	Family + Dining	9.16 m x 2.80 m
12	Balcony	4.50 m x 1.00 m

(Table 2.2b) Middle Apartment

Item	Elements Description	Approximate Area
1	Master Bedroom	5.15 m x 3.15 m
2	Bedroom 2	4.50 m x 3.50 m
3	Bedroom 3	4.10 m x 2.90 m
4	Guest Room	3.80 m x 3.35 m
5	Kitchen	3.65 m x 3.48 m
6	Drying	3.65 m x 2.00 m
7	Toilet	2.75 m x 1.60 m
8	Store	2.55 m x 1.75 m
9	Pantry	2.55 m x 1.00 m
10	Living	5.15 m x 2.15 m
11	Family	5.15 m x 2.95 m
12	Dining	4.75 m x 3.80 m
13	Balcony	4.90 m x 1.50 m

2.3 Materials

The materials used is reinforced concrete, which includes the concrete and steel reinforcing bars. The reinforcing bars used during construction is high yield tensile hot rolled steel , namely Y type steel. The nominal diameter are 10 mm, 12 mm, 16 mm, 20 mm and 25 mm. The shear link is always kept at R8 size in designation, where R stands for mild steel type.

2.4 Materials Properties

Young's Modulus of steel bars, E_s = 200 KN/ mm^2

Characteristic cube strength of concrete , f_{cu} = 25 N/ mm^2

Characteristic strength of reinforcement, f_y = 410 N/ mm^2

Characteristic strength of shear reinforcement, f_{yv} = 250 N/ mm^2

Clear cover for beam = 25 mm

Clear cover for slab = 20 mm

Maximum aggregate size = 20 mm

CHAPTER 3

METHODOLOGY

Good value for money is perhaps the most important criterion in structural design. The designer should take into account not only the cost of materials but also the buildability, the time required to build, the cost of temporary structures, the cost of maintenance over a period of time and in some cases the cost of demolition or decommissioning. Thus , there is a mutual agreement between the developer and client on some design matters, as well as design restriction on structural elements in order to fulfill this role.

3.1 Reinforced Concrete Slab Design Method

Solid slabs were divided into two types which are the one- way spanning and two- way spanning. One way spanning slab is when the length of the longer side of a slab was more than twice the length of the shorter side. Two way spanning slab is when slabs are carrying uniformly distributed loads and are reinforced in two direction at right angles. In this particular project, slabs had been designed by using two softwares which are *Advanced Technology & Solution* (ATS) and *STructural Analysis And Design* (STAAD III ***Rel 22.3W 32-bit***).

3.1.1 Design Assumption And Restriction

In this particular design project, all slabs were treated individually where every slab was designed one after another by using engineering software although they were continuously connected along many spans.

The maximum thickness of each slab was 115 mm. Slab reinforcements were to be standardize at size of Y10- 300 and Y10- 200 for top and bottom steel respectively, although in some cases there might be less reinforcements needed. Furthermore, big slab should be separated by adding an extra beam underneath in order to fulfil previous mentioned reinforcement for all slabs of the building.

For edge continuity of each four slab sides, it was important to consider the condition represented by adjacent slab. The side of slab was said to be continuous when the adjacent slab was at the same level. Otherwise, it was said to be discontinuous when the adjacent slab was dropped or raised and this case always happen in toilet or balcony.

If there were 2 adjacent slab with different condition, the big portion of the edge should be taken into account when determining the continuity of slab. However, designing as discontinuous edge will cause smaller loading rather than designing it as continuous edge. In turn, it would need more steel and distribution steel in construction practices. Thus, it should be careful in comprising between this two factor because designing it in either way would affect the loading transferred to related beams later on.

3.1.2 Loading

The concrete density for all the slabs was taken as 24 KN/m^3. The working loads for slabs which had been considered in this particular design project were self –

weight of slab, assumption of unfactored dead and live load which could be obtained from Table 5 of BS 6399 : Part 1 (BSI , 1984) as shown in Table 3.1.

Table 3.1

Load Type	**Item**	**Load Value (KN / m^2)**
Self – weight of slab		2.76
Unfactored dead load		1.20
Unfactored live load	Bedroom, Guestroom, Master room	1.50
	Store, WCSHR (Toilet), Dining, Living , Family	2.00
	Kitchen, Drying, Balcony, Pantry, Lobby	3.00
	Ground floor slab	2.50
	Switch room	5.00

3.1.3 Analysis Of Slabs

Three ground floor slabs had been chosen for discussion in this study as shown in Fig. 3.1, which are Slab 1 ('S1'), Slab 8 ('S8') and Slab 20 ('S20'). 'S1' had 2 continuous edges since it was same level with the adjacent slabs. The other two edges were categorized as discontinuous because there was no adjacent slab. For 'S8', both long edges were continuous as the adjacent slabs were same level. Contrary, one short edge was classified as discontinuous since the adjacent slab 'S19' raised by 100 mm in height. In turn, the other side was continuous due to its big portion was being covered by the continuity case. 'S20' had four continuous edges because itself raised by 100 mm in height. The detail loading for each is shown in Fig. 3.2.