EFFECT OF SHEAR WALLS IN TALL BUILDING

By

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Dissertation Submitted in Partial Fulfillment Of
The Requirements For The
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CERTIFICATION OF APPROVAL

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Civil Engineering Program
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Approved by,

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TRONOH, PERAK

JAN 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and the original work contained herein have not been taken or done by unspecified sources or persons.

SAM SITHA

ABSTRACT

Shear walls are concrete or masonry continuous vertical walls which may serve both architecturally as partitions and structurally to carry gravity and lateral loading. Their very high in-plane stiffness and strength makes them ideally suited for bracing tall buildings.

A research on the effect of shear walls of tall building against lateral wind load from different directions is investigated in this project. The objectives of this research are to determine the effective locations and the effective shape of shear walls which produce economic and safe tall building against wind load. STAAD software will be used for analyzing and designing.

This research will start with 30 stories building without shear wall; followed by the same building with different locations of plane shear wall to determine its effective location. The final building will be designed with flange shear walls and channel shear wall to determine the reduction of overall deflection, reduction of reinforcement and the change in usable area.

ACKNOLEDGEMENT

I am really indebted to those who have helped me to successfully complete my Final Year Project. They are the people who have assisted me directly or indirectly throughout the research. No substantial gratitude could ever measure up to the assistance, guidance and drive given to keep me striving towards accomplishing the goals.

I would like to acknowledge the contribution of all my lecturers, tutors and technicians as well as the Master students and PhD. Student who were always there to guide and share their experiences with me. Without their support, my final year project would not complete smoothly. Especially, I would like to thank Dr. Narayanan Sambu Potty, as the project supervisor and Dr. Nasir Shafiq, as the project co-supervisor for their support, advice, patient, help and guidance through out the project cycle. Special thanks to all my friends and colleagues for their great ideas, support, courage and sources of information given to me. Thanks for their full cooperation.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Tall towers and buildings have fascinated mankind from the beginning of civilization, their construction being initially for defense and subsequently for ecclesiastical purpose. The growth in modern tall building construction, however, which began in the 1880s, has been largely for commercial and residential purposes.

Tall commercial buildings are primarily a response to the demand by business activities to be as close to each other, and to the city centre, as possible, thereby putting intense pressure on the available land space. Also, because they form distinctive landmarks, tall commercial buildings are frequently developed in city centre as prestige symbols for corporate organizations. Further, the business and tourist community, with its increasing mobility, has fuelled a need for more, frequently high-rise, city centre hotel accommodations. Over the history of tall building structures, the changes in technology have been tremendous. Part of this comes from the daily strategies of human living. In the early years of skyscrapers, urban centers included mostly structures with a storefront next to the street, offices in the stories immediately above, and, finally in the upper levels, apartments for city dwellers. These types of buildings were difficult to arrange to take total advantage of structural and mechanical systems. Offices needed large open spaces with large loads from mechanical and electrical systems. The living quarters, with their more intimate spaces, needed closer column spacing, and had fewer vents and wires required to meet needs of comfort. Shallow floor-to-floor heights in the apartment areas were possible since they could be accommodated by a flat plate design. Offices needed grid or pan systems covered by drop ceilings to allow HVAC and electrical systems to be delivered to desired locations within each square. As the automobile became a transportation reality, people moved to the suburban areas and commuted to the city for work. This eliminated most mixed-use issues and allowed new forms of tall buildings, which could accommodate wider column spacing desired by businessmen. In recent years, the trend is returning to mixed-uses as limited natural resources, the expense, time and stresses of commuting draw people back into the city center. Hence, architects and engineers are returning to the challenges of structural design to accommodate people's total daily life. In addition to the past needs of storefronts, offices and apartments, parking is a major consideration in any new structure within the city. Considering structure alone, there are two main categories for high-rise buildings: one is structures that resist gravity and lateral loads and two are those that carry primarily gravity loads. Since tall buildings have the largest needs for resisting high magnitudes of wind, the lateral load resisting system becomes the most important and shear wall is one of the most important lateral load resisting systems.

1.2 PROBLEM STATEMENT

Nowadays, construction of tall building is everywhere around the world and there are lots of problems pertaining high rise building like earthquake, wind load and the complication of designing. The magnitude of wind load increases when the height of the building increases. The lateral loading due to wind is the major factor that causes the design of high rise buildings to differ from those low to medium rise building. With innovations in architectural treatment, increases in the strengths of materials, and advances in methods of analysis, tall building structures have become more efficient and lighter and, consequently, more prone to deflect and even to sway under wind loading. The effect of wind load can cause the building to sway and vibrate significantly if the building is very high and slender. This problem can make the building uncomfortable for use as accommodation, office or commercial building.

The sizes of the columns which eat up the space of the building expand larger when the high of the building is getting taller and it is counted as one of the big problems in tall building construction.

What will the author do in order to solve the problem of lateral loading and maximize the usage space in the building?

1.3 OBJECTIVES AND SCOPE OF STUDY

The main objective of the project is to find the effect of shear wall in tall building and the following are the sub objectives:

- To reduce the column size and also to terminate some of the columns that are not important when shear wall are used
- To study the maximum horizontal deflection on every floor of the building
- To minimize the amount of steel that is used for the design of columns and beams
- To study the change in useable space in the building due to the effect of shear walls

The scope of this project is listed as follows:

- To analyze and design several buildings with different heights and the buildings which are 30 stories, all the buildings are not more than 120m height.
- The analyses and design are done by using STAAD Programming 2004
- The design code used is BS 8110

1.3.1 The Relevance of the Project

The population in every city around the world is growing very fast which leads to the limit of land use in those cities. To overcome these kinds of problems, the engineers and architectures in every country had been thinking to utilize a full use of every piece of land in the city by building high rise building instead of low or medium high building. While high rise building is growing higher and higher, the problem of column size and wind load is getting more critical. In this project, the author will find solutions to reduce the column size and expand the floor area by introducing shear wall system. Shear wall system is not only helping to reduce the column size, it is also a good system to resist lateral wind load and dynamics load from earthquake. Several researches had been conducted to locate the effective location of shear wall and also the minimum thickness of shear wall.

1.3.2 Feasibility of completing the Project within Scope and Time frame

A number of studies on shear wall have been reported, so that relevant information about the project can be obtained from the journals. These journals can help the author to understand the project clearer in a shorter time. Even designing of tall building is complicated; the author still finds it feasible with the time frame given since STAAD Programming will used to make the design easier and speed up the process of designing in each step.

CHAPTER 2

LITERATURE REVIEW

2.1 SHEAR WALL

In reinforced concrete framed structures the effects of wind forces increase in significance as the structure increases in height. One way to limit the sway and provide stability is to increase the section sizes of the members to create a rigid, moment-resisting frame. However, this method increased column sizes thus increasing the building cost. It is rarely used for more than 7 or 8 stories. Another way is to provide stiff, shear resisting walls linked to a flexible frame. These can be external walls or internal walls around lift shafts and stair wells (a core) or sometimes both cases can be provided at the same time. Generally, shear walls are either plane or flanged in section, while core walls consist of channel sections. In many cases the wall is pierced by openings and it is called coupled shear wall because all the walls behave as individual continuous wall sections coupled by the connecting beam or slabs (Figure 2.1). Normally the walls are connected directly to the foundations. However, in a few cases where the lateral loads are relatively small and there are no appreciable dynamic effects, then they can be supported on columns connected by a transfer beam to provide clear space.

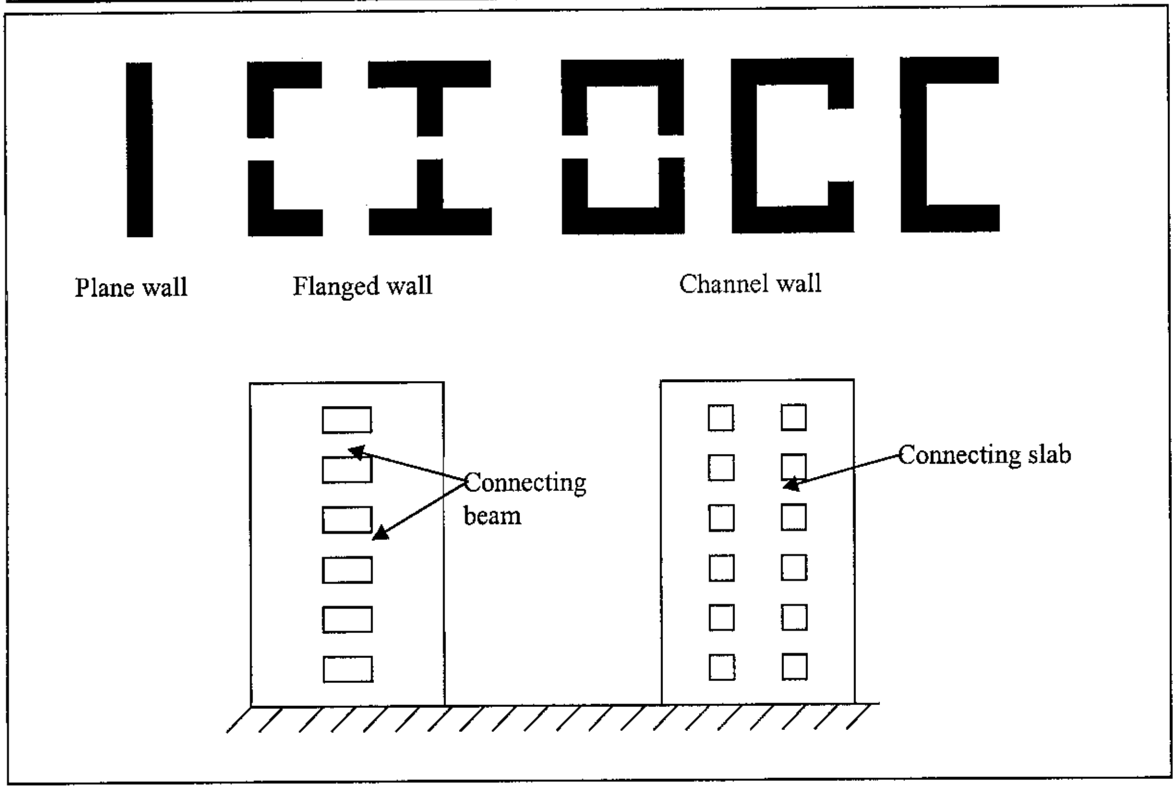

Figure 2.1, Shape of Shear wall

The shape and plan position of the shear walls influences the behavior of the structure considerably. Structurally, the best position for the shear walls is in the center of each half of the building. This is rarely practical. However, since it dictates the utilization of space, so they are positioned at the ends.

This shape and position of the walls gives good flexural stiffness in the short direction, but relies on the stiffness of the frame in the other direction. This arrangement provides good flexural stiffness in both directions, but may cause problems from restraint of shrinkage. As does this arrangement with a single core, but which does not have the problem from restraint of shrinkage.

However, this arrangement lacks the good torsion stiffness of the previous arrangements due to the eccentricity of the core (Figure 2.2). If the core remains in this position then it must be designed explicitly for torsion. It is far preferable to adopt a symmetrical arrangement to avoid this.

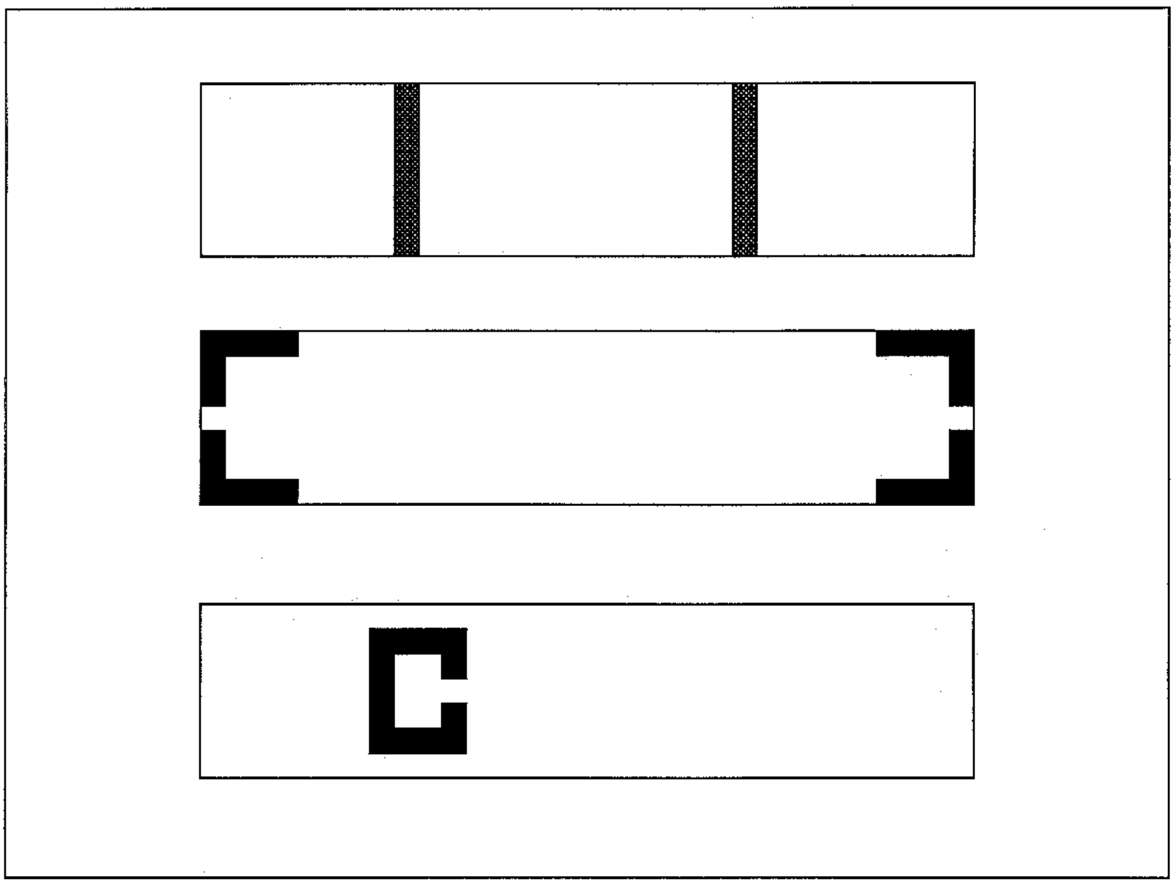

Figure 2.2, Positions of shear wall

Possible wall failure modes due to horizontal loads are (Figure 2.3):

- Flexural
- Horizontal shear
- Vertical shear

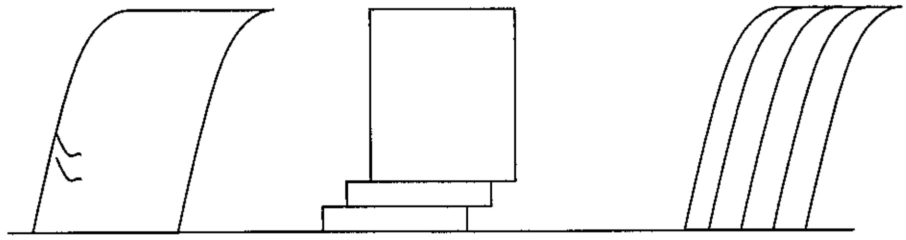

Figure 2.3, Shear Wall failure

The analysis of a framed building with shear walls subjected to horizontal and vertical loads is essentially a three dimensional problem. With a proliferation of computer programs available a three dimensional analysis presents no great difficulty provided the modeling techniques fully reflect the behavior of the structure. Sometimes, especially where a dynamic analysis is required, it is the only method that can be used.

A tall shear wall building typically comprises an assembly of shear walls whose lengths and thicknesses may change, or which may be discontinued, at stages up the height. The effects of such variations can be a complex redistribution of the moments and shears between the walls, with associated horizontal interactive forces in the connecting girders and slabs. As an aid to understanding the behaviors of shear structures, it is useful to categorize them as proportionate or non-proportionate systems.

Proportionate Non-twisting

A proportionate system is one in which the ratios of the flexural frigidities of the walls remain constant throughout their height. A structure that is symmetrical on plan about the axis of loading will not twist. At any level i, the total external shear Qi, and the total external moment Mi, will be distributed between the walls in the ratio of their flexural rigidities. The resulting shear and moment in a wall j at a level i can be expressed as

$$Q_{ji} = Q_i \frac{(EI)_{ji}}{\sum (EI)_i}$$

And
$$M_{ji} = M_i \frac{(EI)_{ji}}{\sum (EI)_i}$$

Proportionate Twisting

A structure that is not symmetric on plan about the axis of loading will generally twist as well as translate. In a proportionate shear wall structure that twists under the action of horizontal loading. The resulting horizontal displacement of any floor is a combination of a translation and a rotation of the floor about a center of twist, which, in a proportionate structure, is located at the centroid of the flexural rigidities of the walls. Assuming that the stiffness of a planar wall transverse to its plane is negligible, the X-location of the center of twist from an arbitrary origin is:

$$\bar{x}_{ji} = \frac{\sum (EIx)_i}{\sum (EI)_i}$$

In a proportionate structure, the centre of twist and the shear center axis of the structure coincide. Consequently, the effect of horizontal loading on the structure is to produce at level i a resultant shear Qi and a resultant horizontal torque, which is equal to the product of the resultant shear Qi and its eccentricity e from the shear center, which is Qie. The resultant shear in any wall j at level i is a combination of its shear of the external shear and the shear due to resisting its share of the external torque at that level, which may be expressed as

$$Q_{ji} = Q_i \frac{(EI)_{ji}}{\sum (EI)_i} + Qi * e \frac{(EIc)_{ji}}{\sum (EIc^2)_i}$$

And the moment in the wall can be obtained by integrating the shear Qji, which is:

$$M_{ji} = M_i \frac{(EI)_{ji}}{\sum (EI)_i} + Mi * e \frac{(EIc)_{ji}}{\sum (EIc^2)_i}$$

2.2 STAAD Modeling

STAAD programming is a structural analysis and design programming. In this project, STAAD software is used to design and analyze the high rise building in order to find the effective location of the shear wall.

2.2.1 Modeling

Before modeling the building, the characteristic of the building should be known. The properties of the materials which will be used, the property of concrete and the property of the reinforcement bar have to be known. After that the engineers have to assume the initial size, thickness and length of the concrete and also the impose load, wind load, finishing load and of course the self weight of the members. After the information for the designing is obtained, the structure can be modeled using the graphical information or by manually by writing the code as given below. If the graphical information is used, the same code will be automatically generated.

```
STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 03-Nov-07
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
2 4 0 7; 3 11 0 7; 4 2.75 3.5 7; 5 4 3.5 7; 6 11 3.5 7; 7 4 0 10; 8 11 0 10;
9 2.75 3.5 10; 10 4 3.5 10; 11 11 3.5 10; 12 4 0 13; 13 11 0 13;
14 2.75 3.5 13; 15 4 3.5 13; 16 11 3.5 13; 17 4 0 16; 18 11 0 16;
19 2.75 3.5 16; 20 4 3.5 16; 21 11 3.5 16; 22 4 7 7; 23 11 7 7; 24 4 7 10;
25 11 7 10; 26 4 7 13; 27 11 7 13; 28 4 7 16; 29 11 7 16;
MEMBER INCIDENCES
2 2 3; 6 2 5; 7 3 6; 11 7 10; 12 8 11; 16 12 15; 17 13 16; 18 17 18; 21 17 20;
22 18 21; 23 6 11; 24 11 16; 25 16 21; 26 5 10; 27 10 15; 28 15 20; 29 4 9;
30 9 14; 31 14 19; 32 2 7; 33 7 12; 34 12 17; 35 3 8; 36 8 13; 37 13 18;
38 22 23; 39 28 29; 40 23 25; 41 25 27; 42 27 29; 43 22 24; 44 24 26; 45 26 28;
46 5 22; 47 10 24; 48 15 26; 49 20 28; 50 21 29; 51 16 27; 52 11 25; 53 6 23;
55 6 4; 56 11 9; 57 16 14; 58 21 19; 59 24 25; 60 26 27;
ELEMENT INCIDENCES SHELL
61 4 6 11 9; 62 9 11 16 14; 63 14 16 21 19;
ELEMENT PROPERTY
```

```
61 TO 63 THICKNESS 0.175
DEFINE MATERIAL START
ISOTROPIC CONCRETE
E 2.17185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
END DEFINE MATERIAL
CONSTANTS
MATERIAL CONCRETE MEMB 2 6 7 11 12 16 TO 18 21 TO 53 55 TO 63
MEMBER PROPERTY BRITISH
2 18 23 TO 25 29 TO 45 55 58 TO 60 PRIS YD 0.35 ZD 0.35
6 7 11 12 16 17 21 22 46 TO 53 PRIS YD 0.35 ZD 0.45
MEMBER PROPERTY BRITISH
26 TO 28 56 57 PRIS YD 0.5 ZD 0.3
SUPPORTS
2 3 7 8 12 13 17 18 FIXED
MEMBER OFFSET
26 TO 28 38 TO 45 55 TO 60 START 0 -0.2 0
29 TO 31 END 0.2 0 0
29 TO 31 START 0.2 0 0
26 TO 28 38 TO 45 55 TO 60 END 0 -0.2 0
2 18 32 TO 37 START 0 0.2 0
2 18 32 TO 37 END 0 0.2 0
LOAD 1 DEAD
FLOOR LOAD
YRANGE 0 3.5 FLOAD -1
SELFWEIGHT Y -1
LOAD 2 LIVE
FLOOR LOAD
YRANGE 0 3.5 FLOAD -3.5
LOAD COMB 3 COMBINE
1 1.4 2 1.6
PERFORM ANALYSIS PRINT ALL
START CONCRETE DESIGN
CODE BS8110
DESIGN BEAM 2 18 23 TO 45 55 TO 58
FYMAIN 413688 MEMB 2 6 7 11 12 16 TO 18 21 TO 53 55 TO 58
DESIGN COLUMN 6 7 11 12 16 17 21 22 46 TO 53
CONCRETE TAKE
END CONCRETE DESIGN
FINISH
```

Once the code is completed, the analysis can be performed. Figure 2.4 show a model generated by STAAD pro.

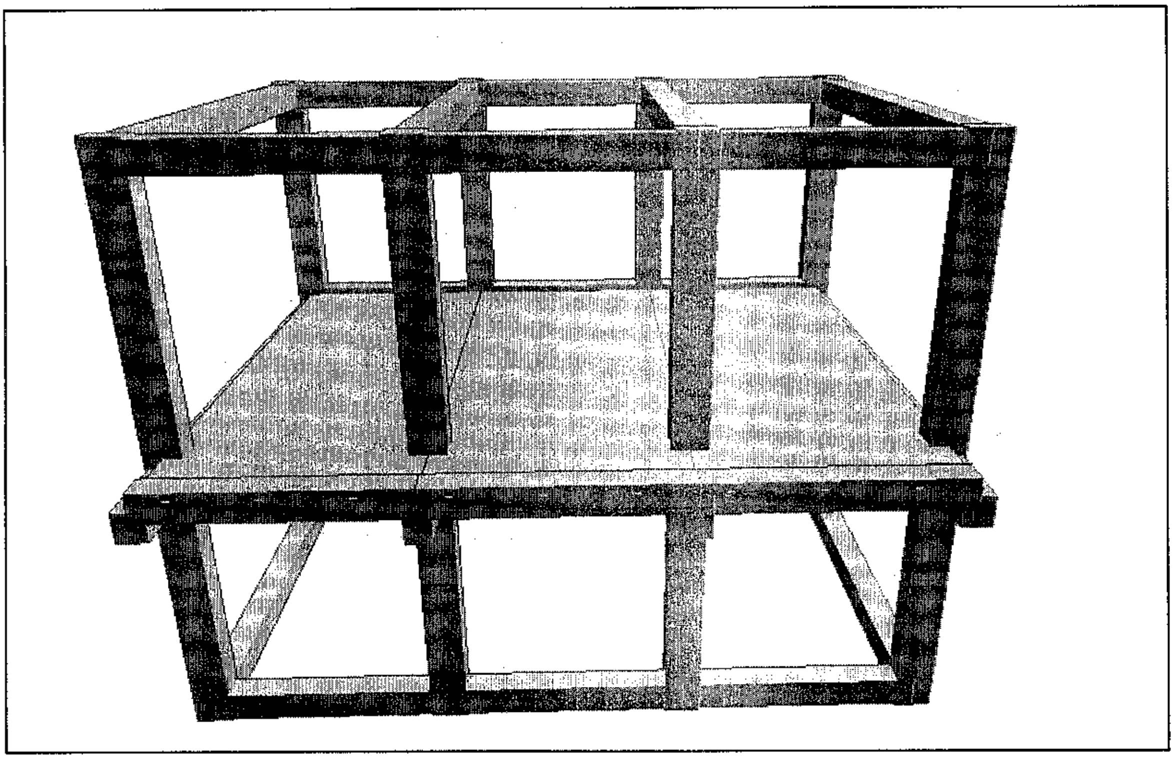

Figure 2.4, Sample model

2.2.2 Analyses and Design

After the modeling is completed, analysis and design of the building can be done. The programming can do static analyzing and designing by following the command during modeling. In the code, the program is commanded to analyze the structure and after that design the reinforcement of the beam by following the Code BS8110 followed by the design of column using the same Code. After finish the design of beam and column, the program will calculate the total amount of concrete for the design of beams and columns above and also the total weight of steel. The weight of each size of steel is also listed in the design section. The result of the analysis and the design are included in the appendix.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This study will incorporate in the methodology, the objectives and scope stated earlier to achieve the aims of this study. The methodology would involve certain processes such as defining the materials used for the construction, the load distribution.

3.2 Material

The material used for the construction is concrete grade C40 and steel bar grade Fy=460. This is the mail concrete grade and steel grade but other grade of concrete and steel will also used.

3.3 Building used for the study

The basic building is a 30 storeys building with fixed foundations and slabs, beams, columns without shear wall. This basic building is used to generate different buildings by adding shear wall at different locations and analyzed to determine the optimum location of the shear wall and the deflection of the building with and without shear wall are computed. Different shear walls will be tried to determine the effective shape of shear wall.

3.4 Loads acting on the building

The live load on the building is assumed to be 3.5 kN/m^2 and dead load from finishing is 1kN/m^2 excluding self weight of the members and wind load which varies with height.

3.5 Effective Location of shear wall

After the modeling of a 30 storey building without shear wall, analyze and design will be done to calculate the total amount of reinforcement bar for columns and beams. At the same time, the software also can be used to calculate the total deflection of the building.

After analyzing and designing the basic building, plane shear wall will be introduced at different locations in the building. The locations will start from one side of the building to the centre of the building and proceed to the other side of the building. The wind load direction will be considered to be parallel to the plane shear wall. For every locations of shear wall tried, total reinforcement bar for columns and beans; and the total deflection of the building is calculated. The results of total reinforcement and total deflection will be used to compare for the effective location of shear wall. Take note that in this step, the property of the building will not be changed or reduced except the addition plane shear wall because the purpose of this step is to determine the effective location of shear wall which produce minimum total reinforcement bar and minimum total deflection.

3.6 Effective shape of shear wall

The effective shape of shear wall will be determined by introducing different directions of wind load. According to literature review, there are 3 shapes of shear walls, plane shear wall, flanged shear wall and channel shear wall. Since plane shear wall was used in the first phase for determining the effective location, only flanged shear wall and channel shear wall will be used during this phase.

3.7 Final phase of project

The effective shape of shear walls will be designed for the effective location in the building. During this final phase of project, the size of the columns will be reduced to the minimum and if it is not necessary to keep any columns, those columns will be totally terminated from the building. The total reinforcement and the total deflection will be determined by STAAD software and this result will be used to compare with the result of the building without shear wall to check the reduction of deflection and the reduction of reinforcement. At the same time, the total usable area of every floor will be calculated manually. Since the size of the columns will be minimized and some of the columns will be totally terminated, the usable area of every floor is expected to increase compare to the building without shear wall. The flow chat of analyses is shown in figure 3.1.

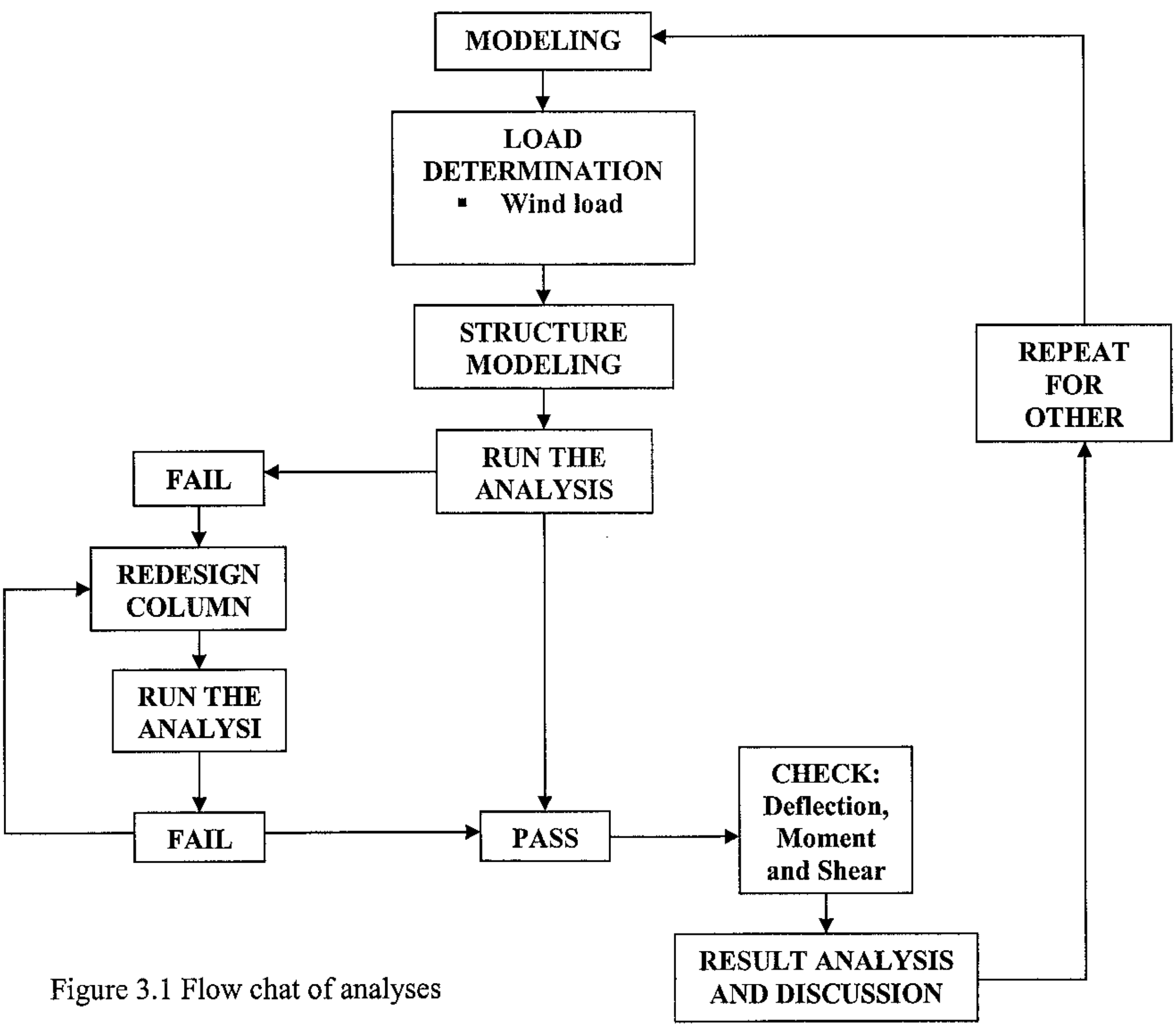

Figure 3.1 Flow chat of analyses

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this chapter, the design of the building will be differentiated by the location of the shear wall and also the shape of the shear wall. The first design is the basic design of the building without shear wall, in the second design; the shear wall will be placed at the side of the building and in the last design, the shear wall will be placed in the middle of the building. From the three designs, the author will find the economic and effective location of the shear wall which will require less reinforcement bar. The effective location above will be used to design building with different shape of shear wall for wind forces action in X and Z directions.

4.2 Basic Building without Shear Wall

In this design, the columns resist gravity load and the lateral wind load as shown in the model (Figure 4.1); there is no shear wall in this design. The column size for this building is 800mm*800mm and the beams size is 600mm*400mm. The top view of the building is shown in (Figure 4.1).

The analyses shown that the maximum displacement occurs at the top node of the building which deflects parallel to wind direction z which is d = 218.735mm.

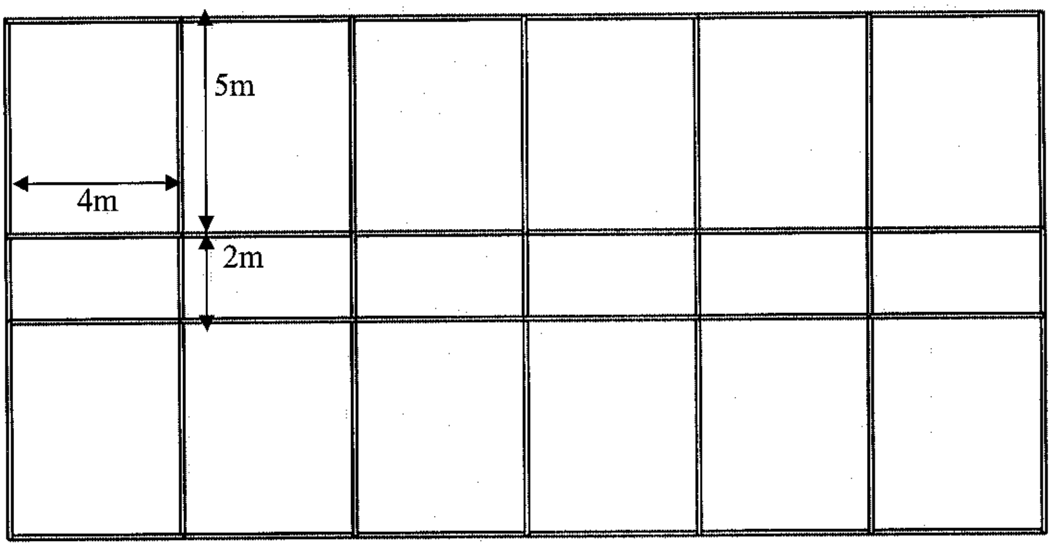

Figure 4.1 Top view of the basic building

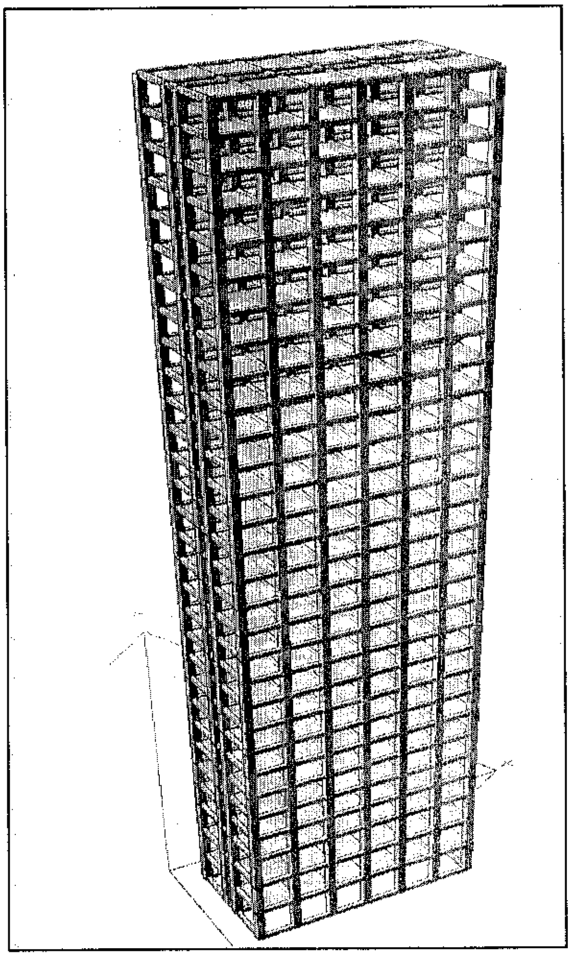

Figure 4.2, Basic building without shear wall

4.3 Basic building with shear wall at the side

Instead of using the columns to resist the lateral wind load, the author introduces the shear wall at the side of the building to help the columns against wind load (Figure 4.3). From STAAD programming analysis, the maximum deflection of the tope node of the building is 224.319mm, which is greater than the maximum deflection of the first case. This is because of twisting due to unsymmetrical shear wall at only one side of the building.

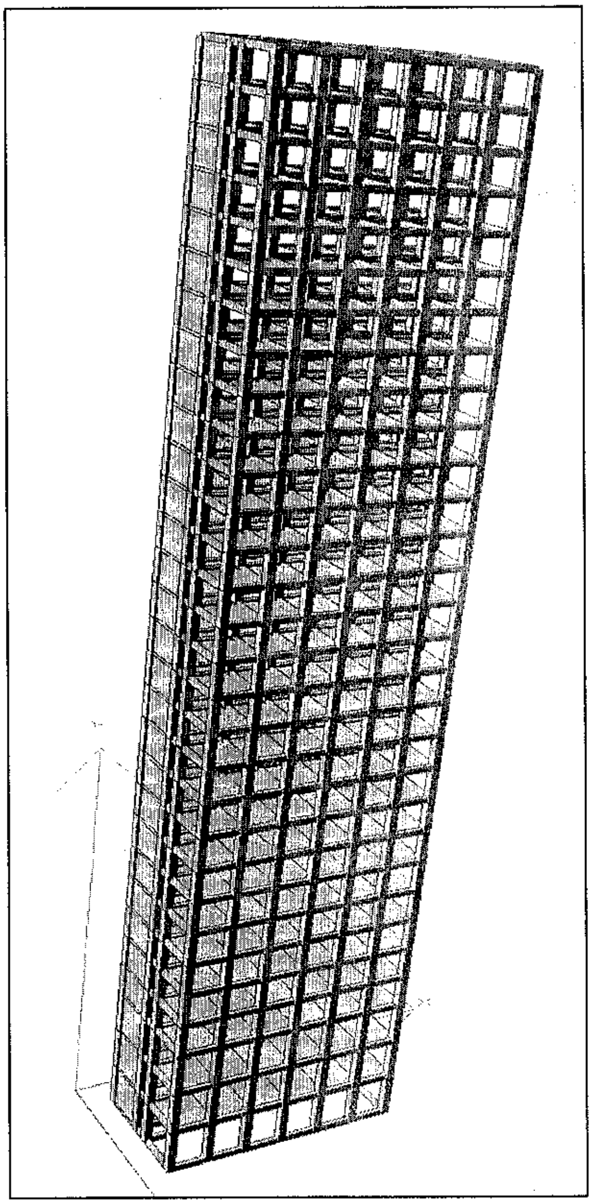

Figure 4.3, Basic building with shear wall at the side

4.4 Basic building with shear wall in the middle

In this case, the shear wall with the same thickness and the same property as presented in case 2 but located in the middle of the building is modeled. The purpose of introducing shear wall in the middle of the building is to stop twisting which was occurred in case 2 (Figure 4.4).

From the analysis of STAAD programming, the maximum deflection of the top node of the building is d = 181.86mm. With shear wall in the middle of the building, it produces the smallest deflection of the top node compared to the two cases above.

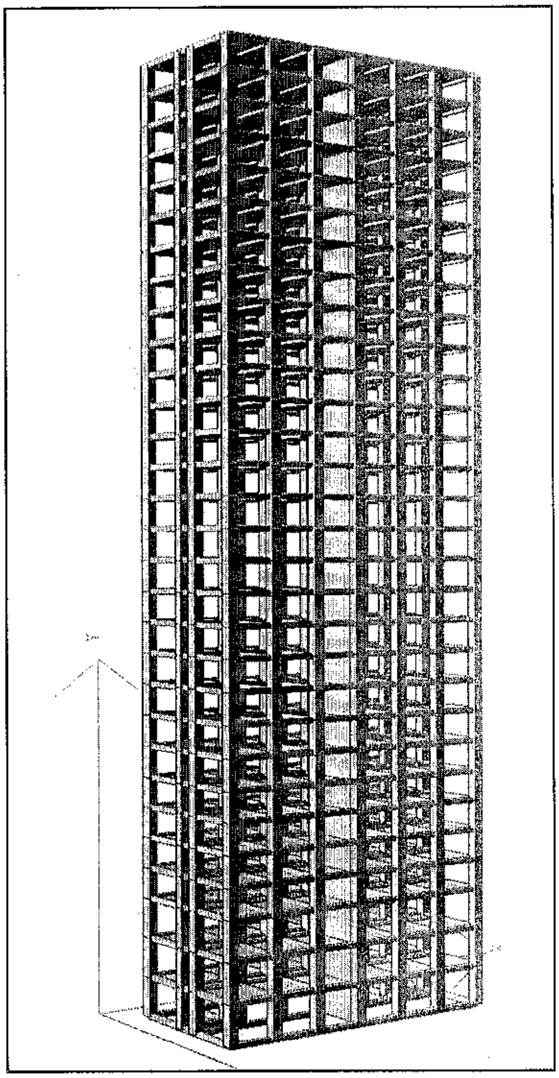

Figure 4.4, Basic building with shear wall in the middle

4.5 Design of building with flanged and channel shear wall

From the above analyses and design, the author has found that the effective location of shear wall is in the middle of the building. The other 30 stories building is design with different characteristic as describe below:

The beam span = 7m and 8m with 600mm depth and 400mm width

The wind speed comes from two directions, z direction and x direction.

The column size = 600mm*800mm with 3.5m high for ground floor to fifth floor.

The size of the column reduces by 50mm*50mm for every 5 story.

The shear wall thickness = 400mm

Below is top view of the building (Figure 4.5) and the model of the building (Figure 4.6)

After analyze and design of the building, the maximum deflect of the top node = 259.055mm (note: this building is different from the building above, this build is more economic) and the total volume of concrete take off for column and beam = 2949.66 cu.meter with the total weight of reinforcement = 1299901.00 Newton

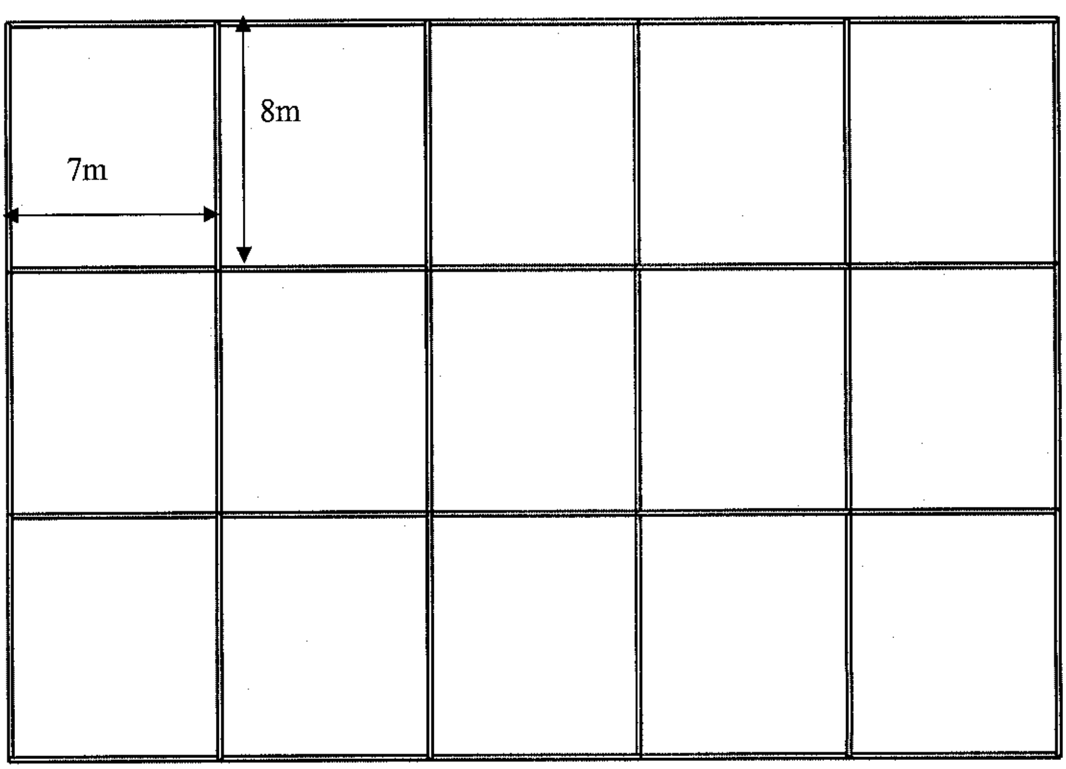

Figure 4.5: Top view of the building

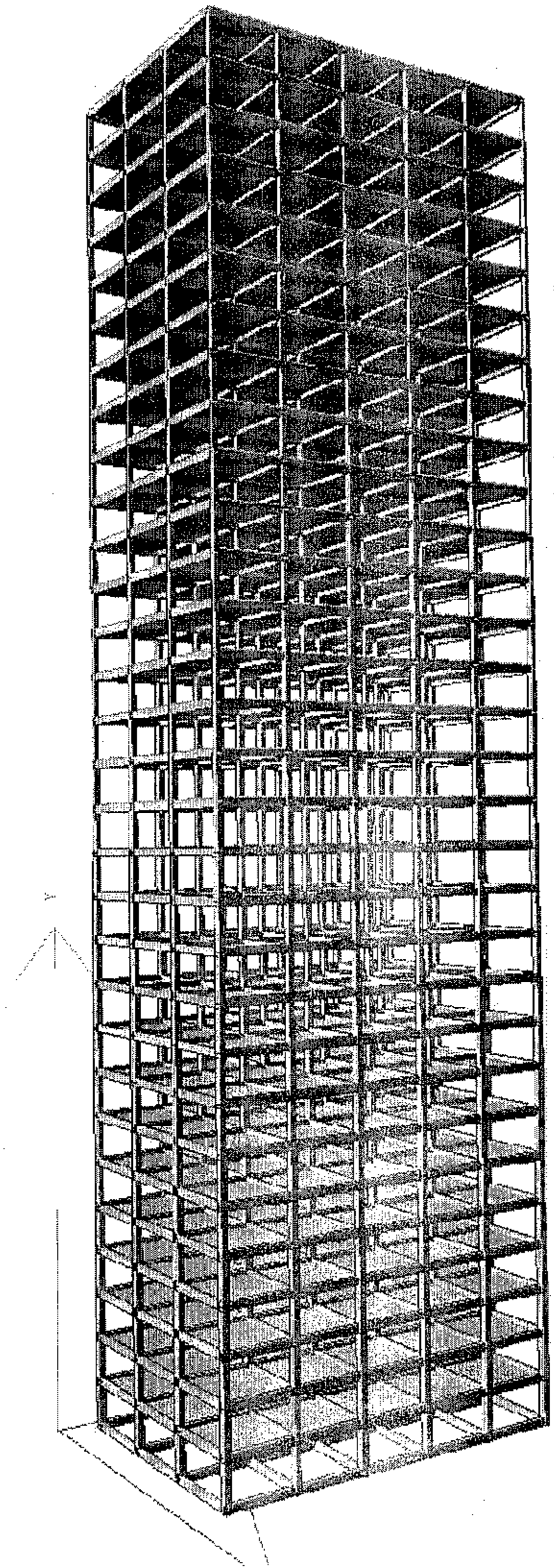

Figure 4.6: More economical building

4.6 Final design of the building with combination of shear wall

This is the final stage of the project; a channel shear wall will be placed in the middle of the building, the location of the elevator. Every corner of the building will be designed with flanged wall of "L" shape. When the shear wall is present, the columns of that area are totally terminated. So there are no columns at the four corners of the building or the center of the building. Figure 4.7 shows the building from the side view and figure 4.8 shows the building from the front view. After analysis and design of the building, the maximum deflection of the top node = 72.244mm and the total volume of concrete take off for column and beam = 2496.95 cu.meter with the total weight of reinforcement = 975157.81 Newton.

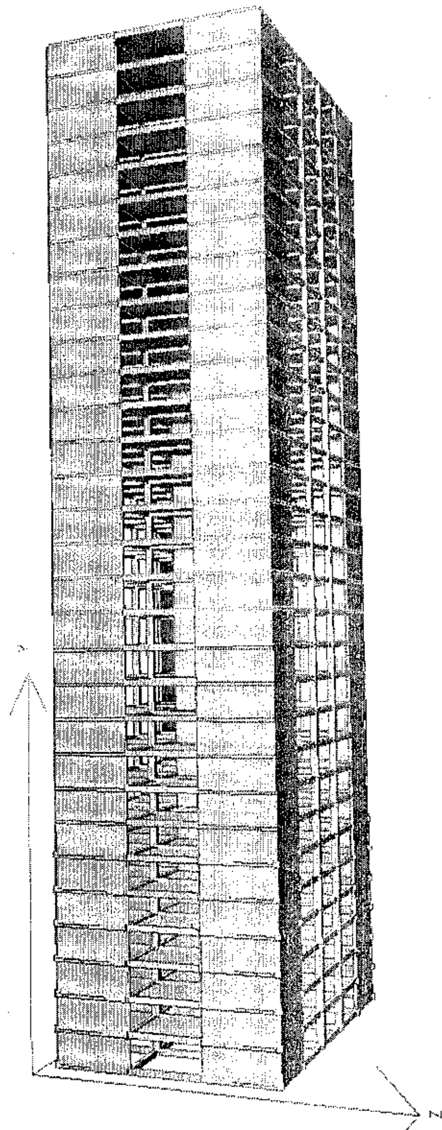

Figure 4.7 Side view of the building

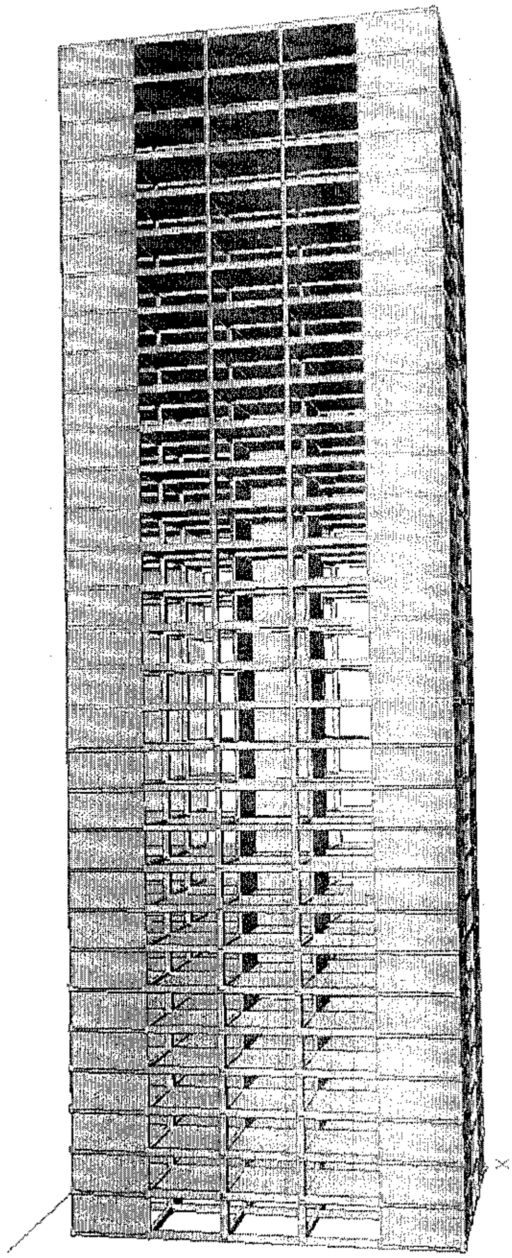

Figure 4.8 Front view of the building

Table 4.1 the percentage different between building with and without shear walls

	Without shear wall	With shear wall	Percentage
Total reinforcement	1299.90kN	975.16kN	25%
Total Concrete	2949.66m^3	2496.95m^3	15.35%
Useable Place	828.48m^2/floor	838.43m^2/floor	1.2%
Max deflection	259mm	72mm	72.2%

CHAPTER 5

CONCLUSIONS AND SCOPE FOR FURTHER STUDIES

5.1 CONCLUSIONS

The objective of this research was to study the use of shear wall to restrain the lateral wind loading in the design of tall building. STAAD software was used for analysis and design of the building structure and also to reduce the complication of complex calculation. Different shapes of shear walls and locations were tried and analyzed. The following conclusions were arrived based on the study.

1. The plane shear walls alone are not effective enough to sustain the lateral wind load acting from different directions toward the building. Flanged walls and channel walls are recommended for the tall buildings located in the area where the wind direction varies.
2. The results from the research also show that the effective location of shear walls is in the middle half of the building which is suitable for the staircase and the lift.
3. However, to have a better distribution of shear walls against gravity load and to reduce the thickness of the channel shear walls which located in the middle half of the building, flanged walls should be provided at the corners and at the sides of the building.
4. When different combinations of effective shapes of shear walls and effective locations of shear walls were analyzed, the project shows that that shear walls are economically effective for tall buildings by providing higher safety factor and less lateral deflection
5. Buildings with shear wall have extra usable space in every floor according to the percentage of reduction of column size.

5.2 SCOPE FOR FURTHER STUDIES

However, there are weakness and lacking in this project since all the rooms at the corner of the building which directly contact with shear walls do not have windows. This project can be improved further by modeling shear walls with opening by using finite element method.

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APPENDIX

STAAD SPACE
START JOB INFORMATION
ENGINEER DATE 21-Mar-08
END JOB INFORMATION
INPUT WIDTH 79
UNIT METER KN
JOINT COORDINATES
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0 1; 21 32 0 25;
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ELEMENT
_SHEARWALL 2367 TO 2606
END GROUP DEFINITION
ELEMENT PROPERTY
1917 TO 2366 THICKNESS 0.15
2367 TO 2696 THICKNESS 0.4
DEFINE MATERIAL START
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POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
END DEFINE MATERIAL
CONSTANTS
MATERIAL CONCRETE MEMB 1 TO 1898 1917 TO 2696
MEMBER PROPERTY BRITISH
40 43 48 52 53 55 TO 57 102 105 110 114 115 117 TO 119 164 167 172 176 177 -
179 TO 181 226 229 234 238 239 241 TO 243 288 291 296 300 301 303 TO 304 -
305 PRIS YD 0.35 ZD 0.55
MEMBER PROPERTY BRITISH
1 TO 38 63 TO 100 125 TO 162 187 TO 224 249 TO 286 311 TO 348 373 TO 410 435 -
436 TO 472 497 TO 534 559 TO 596 621 TO 658 683 TO 720 745 TO 782 807 TO 844 -
869 TO 906 931 TO 968 993 TO 1030 1055 TO 1092 1117 TO 1154 1179 TO 1216 -
1241 TO 1278 1303 TO 1340 1365 TO 1402 1427 TO 1464 1489 TO 1526 -
1551 TO 1588 1613 TO 1650 1675 TO 1712 1737 TO 1774 1799 TO 1836 -
1861 TO 1898 PRIS YD 0.6 ZD 0.4
350 353 358 362 363 365 TO 367 412 415 420 424 425 427 TO 429 474 477 482 -
486 487 489 TO 491 536 539 544 548 549 551 TO 553 598 601 606 610 611 613 -
614 TO 615 PRIS YD 0.35 ZD 0.55
660 663 668 672 673 675 TO 677 722 725 730 734 735 737 TO 739 784 787 792 -
796 797 799 TO 801 846 849 854 858 859 861 TO 863 908 911 916 920 921 923 -
924 TO 925 PRIS YD 0.35 ZD 0.55
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1788 1789 1791 TO 1793 -
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0.55
MEMBER PROPERTY BRITISH
39 41 42 44 TO 47 49 TO 51 54 58 TO 62 101 103 104 106
TO 109 111 TO 113 116 -
120 TO 124 163 165 166 168 TO 171 173 TO 175 178 182
TO 186 225 227 228 230 -
231 TO 233 235 TO 237 240 244 TO 248 287 289 290 292
TO 295 297 TO 299 302 -
306 TO 310 349 351 352 354 TO 357 359 TO 361 364 368
TO 372 411 413 414 416 -
417 TO 419 421 TO 423 426 430 TO 434 473 475 476 478
TO 481 483 TO 485 488 -
492 TO 496 535 537 538 540 TO 543 545 TO 547 550 554
TO 558 597 599 600 602 -
603 TO 605 607 TO 609 612 616 TO 620 659 661 662 664
TO 667 669 TO 671 674 -
678 TO 682 721 723 724 726 TO 729 731 TO 733 736 740
TO 744 783 785 786 788 -
789 TO 791 793 TO 795 798 802 TO 806 845 847 848 850
TO 853 855 TO 857 860 -
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TO 930 969 971 972 974 -
975 TO 977 979 TO 981 984 988 TO 992 1031 1033 1034
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1105 1108 1112 TO 1116 -
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PRIS YD 0.2 ZD 0.2
MEMBER OFFSET
1 6 TO 8 63 68 TO 70 125 130 TO 132 187 192 TO 194 249
254 TO 256 311 316 -
317 TO 318 373 378 TO 380 START -0.3 0 0
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START -0.1 0 0
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0.1 0 0
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207 210 213 216 -
219 222 269 272 275 278 281 284 331 334 337 340 343 346
393 396 399 402 405 -
408 START 0 0 -0.4
23 26 29 32 35 38 85 88 91 94 97 100 147 150 153 156 159
162 209 212 215 218 -
221 224 271 274 277 280 283 286 333 336 339 342 345 348
395 398 401 404 407 -
410 END 0 0 0.4
5 18 TO 20 67 80 TO 82 129 142 TO 144 191 204 TO 206
253 266 TO 268 315 328 -
329 TO 330 377 390 TO 392 END 0.3 0 0
SUPPORTS
1 TO 24 FIXED
DEFINE WIND LOAD
TYPE 1
INT 0.9 1 1.1 1.2 1.3 HEIG 20 40 60 80 105
LOAD 1 DEADLOAD
SELFWEIGHT Y -1
FLOOR LOAD
YRANGE 0 105 FLOAD -1
LOAD 2 LIVELOAD
FLOOR LOAD
YRANGE 0 105 FLOAD -3.5
LOAD 3 WINDLOAD
WIND LOAD -X 1 TYPE 1
WIND LOAD -Z 1 TYPE 1
PERFORM ANALYSIS PRINT ALL
START CONCRETE DESIGN
CODE BS8110
DESIGN BEAM 1 TO 38 63 TO 100 125 TO 162 187 TO
224 249 TO 286 311 TO 348 -
373 TO 410 435 TO 472 497 TO 534 559 TO 596 621 TO
658 683 TO 720 -
745 TO 782 807 TO 844 869 TO 906 931 TO 968 993 TO
1030 1055 TO 1092 1117 -
1118 TO 1154 1179 TO 1216 1241 TO 1278 1303 TO 1340
1365 TO 1402 1427 TO 1464 -
1489 TO 1526 1551 TO 1588 1613 TO 1650 1675 TO 1712
1737 TO 1774 -
1799 TO 1836 1861 TO 1898
FYMAIN 413688 MEMB 1 TO 38 63 TO 100 125 TO 162
187 TO 224 249 TO 286 311 -
312 TO 348 373 TO 410 435 TO 472 497 TO 534 559 TO
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1737 TO 1774 -
1799 TO 1836 1861 TO 1898
DESIGN COLUMN 39 TO 62 101 TO 124 163 TO 186 225
TO 248 287 TO 310 -
349 TO 372 411 TO 434 473 TO 496 535 TO 558 597 TO
620 659 TO 682 -
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1713 TO 1736 -
1775 TO 1798 1837 TO 1860
BRACE 0 MEMB 39 TO 62 101 TO 124 163 TO 186 225
TO 248 287 TO 310 349 TO 372 -
411 TO 434 473 TO 496 535 TO 558 597 TO 620 659 TO
682 721 TO 744 -
783 TO 806 845 TO 868 907 TO 930 969 TO 992 1031 TO
1054 1093 TO 1116 1155 -
1156 TO 1178 1217 TO 1240 1279 TO 1302 1341 TO 1364
1403 TO 1426 1465 TO 1488 -
1527 TO 1550 1589 TO 1612 1651 TO 1674 1713 TO 1736
1775 TO 1798 -
1837 TO 1860
DESIGN ELEMENT 1917 TO 2696
CONCRETE TAKE
END CONCRETE DESIGN
FINISH
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