COST COMPARISON BETWEEN CONVENTIONAL AND FLAT SLAB STRUCTURES

NilushiHewavitharana

(138737G)

Degree of Master of Engineering in Structural Engineering Design

Department of Civil Engineering

University of Moratuwa

Sri Lanka

December 2017

COST COMPARISON BETWEEN CONVENTIONAL AND FLAT SLAB STRUCTURES

NilushiHewavitharana

(138737G)

Thesis / Dissertation submitted in partial fulfilment of the requirements for the Degree Master of Engineering in Structural Engineering Design

Department of Civil Engineering

University of Moratuwa
Sri Lanka

December 2017

DECLARATION

I declarethat this is my own work and this thesis does not incorporate without acknowledgment any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books)

Signature:…………………………. Date: …………………

Eng.N.Hewavitharana

The above candidate has carried out research for the Masters under my supervision.

Signature of the supervisor:……………………………… Date:………………

Dr.K.Baskaran

ABSTRACT

In present era,conventional Reinforced Concrete(RC) frame buildings are commonly used for the construction. The use of flat slab building provides many advantages over conventional RC frame building in terms of architectural flexibility,use of space,easier form work and shorter construction time.

In the present work conventional and flat slab four story buildings are considered for cost comparison. In this research flat slab building andnormal symmetric RCframe buildings of different spans have been studied. The cost of construction for these buildings has also been compared. To find out the cost of reinforcement, formwork, concrete on structural elements slab,beam,columns are considered.For modeling and analysis of conventional and flat slabstructures,SAP 2000 software is used.The dead loads, live loads are considered as per British Standard.

The investigation shows that weight of flat slab structure is less compared to conventional slab structure. The cost of flat slab structure is less by around 12%-16% as compared to conventional slab. This study concludes that flat slab structures are the best suited for high rise buildings as compared to conventional slab structures,in terms of costof material.

Key words: Conventional slab, Flat slab,SAP2000,Cost Comparison

ACKNOWLEDGEMENT

My sincere thanks to the project supervisor Dr. K.Baskaran for devoting his valuable time in guiding me to complete thisresearch study. It is no doubt that without his interest and guidance, this would not have been a success. He not only provided direction and guidance through the course of this research, but also inspired me to really learn and understand structural engineering.

I wish to thank the Vice Chancellor, Dean of the Faculty of Engineering and Head of the Department of Civil Engineering of the University of Moratuwa, for the permission granted for this research work. Further, I wish to offer my thank to the Coordinator of the Post Graduate research work of Structural Engineering and all the lecturers and staff of the Department of Civil Engineering who helped me in numerous ways. Also, I wish to thank the librarian and the staff of the library for the co-operation extended to me for this research work.

I would like to take this opportunity to thank Department of buildings for its generosity in funding and approving duty leave while attending the lectures and also for the encouragement and support given to success this research work and to prepare this thesis during the period of research.

I would like to pay special thank unless, warmth and appreciation to my husband encouragement given from the beginning of the research and also my little children Nemika, Tharuki & Sithuka whose help & sympathetic attitude at every point during my research, without whom I was nothing.

The final acknowledgement is to all others helped in various ways to achieve this goal.

TABLE OF CONTENTS

Chapter 3

Structural arrangement & loads applied for case study

List of figures

List of tables

Chapter 1

INTRODUCTION

1.1 General

In this modern industrial era, we can see huge construction activities taking place everywhere, hence there will be a shortage of land space.So construction of tall structures has been triggered up to overcome this problem. High rise construction is a very good solution for need of housing and offices due to population increase. In Sri Lanka, high rise buildings of 20 to 40 stories are the present trend, in order to economize the investment in urban development. High rise buildings are designed primarily to serve the needs of an intended occupancy, whether residential, commercial or in some case a combination of the two for the structures.There are several elements modified to make work faster and economical also like introducing flat slab construction which reduces dead weight, and makes beams invisible, enhances floor area and also reduce cost of material.

Flat slabs are less labor intensive, simplify the installation of services and can accommodate more floors within restricted heights. However, the span influencing their design is the longest and they require more steel compared to two-way slabs. Other drawbacks of flat slabs are vulnerability to punching shear failure and higher deflections. To avoid punching shear failure drop panels, column heads or shear reinforcement are used. If span in flat slabs is reduced then both deflection and punching shear problems can be avoided. However, architects prefer to have few exposed columns in usable areas. This inevitably leads to columns in an irregular layout, hidden inside partitions or walls. Flat slab construction with columns in an irregular layout is a viable solution in constructing buildings that satisfy their functional requirements in urban environments.

The choice of type of slab for a particular floor depends on many factors. Economy of construction is obviously an important consideration, but this is a qualitative argument until specific cases are discussed, and is a geographical variable. The design loads, required spans, serviceability requirements, and strength requirements are all important. For beamless slabs, the choice between a flat slab and a flat plate is usually a matter of loading and span. Flat plate strength is often governed by shear strength at the columns, and for service live loads greater than perhaps (4.8 kN/m^2) and spans greater than about (7 to 8 m) the flat slab is often the better choice. If architectural or other requirements rule out capitals or drop panels, the shear strength can be improved by using metal shear heads or some other form of shear reinforcement, but the costs may be high.

Serviceability requirements must be considered, and deflections are sometimes difficult to control in reinforced concrete beamless slabs. Large live loads and small limits on permissible deflections may force the use of large column capitals. Negative-moment cracking around columns is sometimes a problem with flat plates, and again a column capital may be useful in its control.

Local customs among builders, designers, and users should not be overlooked when selecting the slab type. There is a natural human tendency to want to repeat what one has previously done successfully, and resistance to change can affect costs. However, old habits should not be allowed to dominate sound engineering decisions. If a flat plate or flat slab is otherwise suitable for a particular structure,it will be found that there is the additional benefit of minimizing the story height. In areas of absolute height restrictions, this may enable one to have an additional floorfor approximately each 10 floors, as compared with a two-way slab with the same clearstory heights. The savings in height lead to other economies for a given number of floors, since mechanical features such as elevator shafts and piping are shorter. There is less outside wall area,so wind loadings may be less severe and the building weighs less, which may bring cost reductions in foundations and other structural components. There are other cost savings when the ceiling finishes can be applied directly to the lower surfaces of the slabs.

In general normal frame construction utilizes columns, slabs and beams. However it may be possible to undertake construction without providing beams, in such a case frame system would consist of slab and column without beams.

This research is directed to find the cost comparison between conventional and flat slab structures. And compare the quantity and cost variation for conventional & flat &slab framed structures. SAP2000 ver. 14, which is a sophisticated structural software package, is used in this research.

1.2 Objectives

Main objectives of this research study presented are the following.

01. To compare quantity of concrete, steel, formwork variation on column,beam&slab separately.
02. To comparetotal concrete, steel, formwork material requirement variation for structure.
03. To compare overall cost for structure for concrete, steel, formwork.

1.3 Methodology

1. The modeling of the reinforcedconcrete structure has been done using commercially available structural software SAP2000 ver.14.Step by step procedure is adopted in SAP2000 to analyze the building for Dead & Imposed loads.Analysis of both types of slabs have been done by manually and for other member design (beam and column) software results have been taken.

2.A detailed literature review carried out on the modeling concepts, behaviors, and analysis aspects of both types of structures.

3.Detailed case study was carried out with varying spans3m,4m,5m,5.5m,6m,6.5m,7m,7.5mfour story buildings.Assume office building with perimeter brick loading.

4. Analysis of the results of the case study to obtain suitable guideline and conclusion.

1.4 Main findings

1. When compare the overall values of sixteen models (eight models for beam slab structure and other eight for flat slab), the cost of flat slab structure is less by around 12-16% as compared to conventional slab.

2.Total cost for flat slab structures is less than conventional slab structure. However this trendis reduced with the higher spans. For span more than 7.5m shear reinforcement to be provided or slab thickness to be increased to avoid punching shear. Then costs may be high for spans which are more than 7.5m.

3. Beamless slabs will be at a disadvantage if they are used in structures that must resist large horizontal loads by frame action rather than by shear walls or other lateral bracing. The transfer of moments between columns and a slab sets up high local moments, shears, and twisting moments that may be hard to reinforce. In this situation, the two-way slab is the more capable structure because of the relative ease with which its beams may be reinforced for these forces. In addition, it will provide greater lateral stiffness because of the presence of the beams and the greater efficiency of the beam-column connections.

1.5 An overview of the Thesis.

The second chapter of the thesis covers the literature review about flat slab and conventional beamslab. It also includes the advantages, disadvantages,failure methods and solutions of both type buildings.

The third chapter includes the selection of structural forms for both type of buildings andthe loads applied on them, for the detailed case study.

Chapter 4 explains the case study done on selected buildings with varying spans, including prepared models. Eight Models have been developed for conventional slab structures and another eight models have been developed for same structures by using flat slabs.

In 5th chapter, result of analysis anddiscussion are presented.

Chapter 6 includesthe conclusion and recommendation for future work.

Chapter 02

LITREATURE REVIEW

2.1 General

This research is mainly focused to find the more economical slab between conventional beam slab and flat slab.

INTRODUCTION

With rapid growth in population along with development of industrial and commercial activities, rapid urbanization has taken place which has resulted into continuous influx of rural people to metro cities. So, obviously the horizontal space constraint is reaching an alarming situation for metros. To cope with the situation maximum utilization of space vertically calls for the construction of multi – story buildings in large numbers. However the question of affordability of the target customers mainly the middle income group of our country necessitates efficient and cost effective design of such buildings. Flat slabs are preferred by both Architects and Clients because of their aesthetic and economicadvantages,also the floor height can be reduced in flat slabs as shown in figure 2.1. Though this form of reinforced concrete construction gives several advantages over frame structure, they also present some disadvantages because of brittle punching failure and large deformationas shown in fig.2.2.[15].

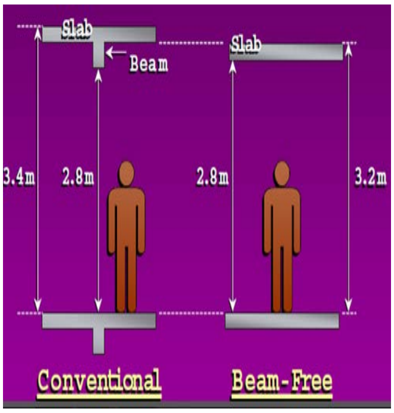


Figure 2.1-Floor height difference between flat slabs and conventional slabs.

Figure 2.2- Brittle punching failure in flat slabs

(source civildigital.com)

From the past history, it can be understood that the flat slab is very vulnerable in earthquake point of view. Figure 2.3 and 2.4 showthe failuresof buildings having flat slabs under different earthquakes.

Figure 2.3-Flat slab failure an earthquake

(Tropicana Casino Parking Garage)

Figure 2.4-Flat slab failure an earthquake
(Tropicana Casino Parking Garage)

The choice of slab for a particular floor depends on many factors. Economy of construction is obviously an important consideration,butthis is a qualitative argument until specific cases are discussed,and is a geographical variable. The design loads,required spans, serviceability requirements are all important.

2.2 Slabs

Slabsare constructed to provide flat surfaces, usually horizontal, in building floors, roofs, bridges, and other types of structures. The slab may be supported by walls, by reinforced concrete beams usually cast monolithically with the slab, by structural steel beams, by columns, or by the ground. Slabs are classified into 16 types. They are as follows.

- Flat Slab
- Conventional Slab
- Hollow core ribbed Slab
- Hardy Slab
- Waffle Slab
- Dome slab

- Pitch roof slab
- Slab with Arches
- Post tension slab
- Pre Tension Slab
- Cable suspension slab
- Low roof slab
- Projected slab
- Grabs slab
- Sunken Slab
- Miscellaneous Slab

This thesis mainly discussed about Flat slabs and Conventional slabs.[22].

2.3 Conventional beam slab

The System of Columns and Beams have been used in Construction since Ancient Egypt (Which lasted from about 3100BC until it was finally absorbed to the Roman Empire in 30 BC) ancient Greece and ancient Rome. In modern day construction, Column-Beam-Slab System is being used in all superstructures with new technology, and construction materials. Generally the load of the slab is transferred to the columns or walls through the beams, down to the foundation, and then to the supporting soil beneath.

A beam is a structural member which spans horizontally between supports and carries loads which act at right angles to the length of the beam. They are small in cross-section compared with their span. The width and depth of a typical beam are “small” compared with its span. Typically, the width and depth are less than span/10.

Generally, a beam is subjected to two sets of external forces and two types of internal forces. The external loads are the loads applied to the beam and reactions to the loads from the supports. The two types of internal force are bending moments and shear forces. The internal shear force and the internal bending moment can be represented as pairs of forces. The Figure below shows a Typical Beam with internal and external forces acting on it. [15].

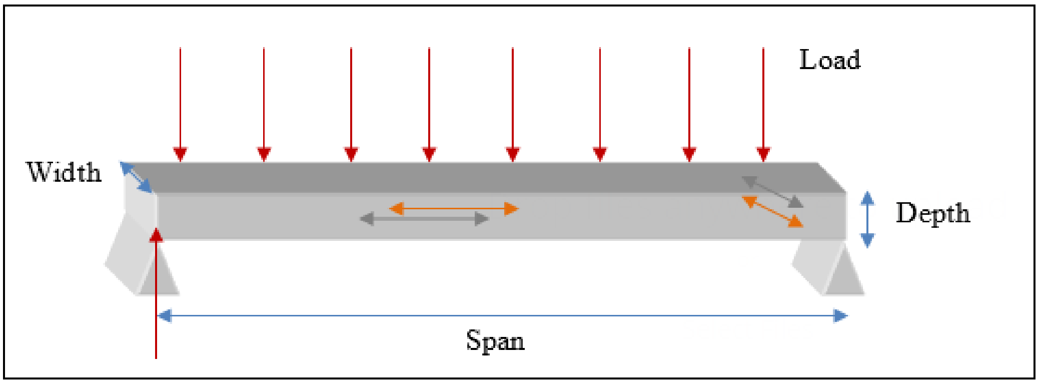


Figure 2.5-Beam with internal and external forces

There are several types of beams

- Simply supported Beam
- Fixed Beam
- Cantilever Beam
- Continuous Beam
- Overhanging Beam

The slab which is supported with beams and columns is called conventional slab. In this kind of slab the thickness of slab is small whereas depth of beam is large and load is transferred to beams and from beams to columns. It requires more formwork when compared with the flat slab. And there is no need of providing column caps in conventional slab. These types of slabs are used in constructing floors of multi story buildings.

Based on length and breadth, a conventional slab is classified into two types:

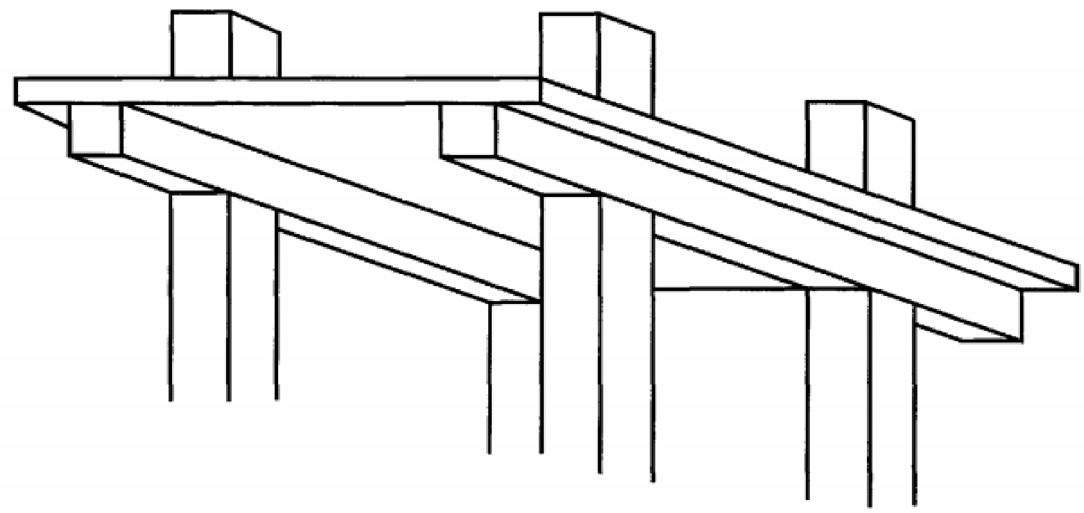
1. One-Way Slab
2. Two-Way Slab

2.3.1 One-Way Slab

One way slab is a slab which is supported by beams on the two opposite sides to carry the load along one direction. Slabs which the ratio of longer span (l) to shorter span (b) is equal or greater than 2, is considered as one way slab because this slab will bend in one direction i.e in the direction along its shorter span. However minimum reinforcement known as distribution steel is provided along the longer span above the main reinforcement to distribute the load uniformly and to resist temperature and shrinkage stresses.

$$\frac{\text{Longer span}}{\text{Shorter span}} > 2$$

In one way slab main reinforcement is provided in shorter span and distribution reinforcement is provided in longer span. Distribution bars are cranked to resist the formation of stresses.Example: Generally all the Cantilever slabs are one Way slab. Chajjas and verandahs are practical examples of one way slabs.



(a) one-way slab with beams

Figure 2.6–One- way slab with beams

2.3.2 Two-Way Slab

Two way slab is a slab supported by beams on all the four sides and the loads are carried by the supports along both directions, it is known as two way slab. In two way slab, the ratio of longer span (l) to shorter span (b) is less than 2.The slabs are likely to bend along the two spans, where the load is transferred in both directions to the four supporting edges and hence distribution reinforcement is provided in both directions.

$$\frac{\text{Longer span}}{\text{Shorter span}} < 2$$

Distribution bars are provided at both the ends in two way slab to resist the formation of stresses.

These types of slabs are used in constructing floors of multi story buildings.

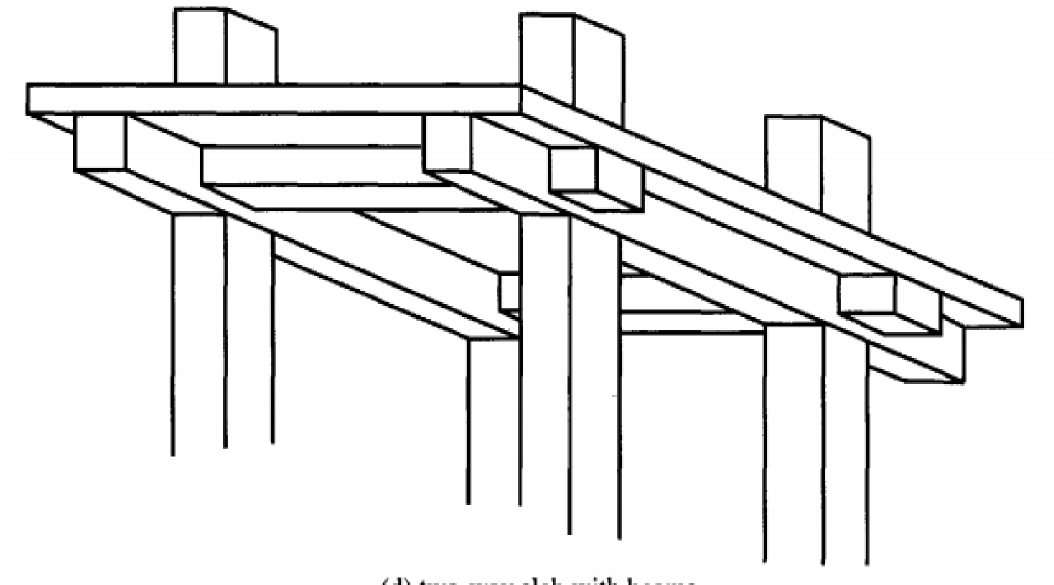

(d) two-way slab with beams

Figure 2.7- two-way slab with beams

When a slab is supported on all four sides, it effectively spans in both directions, and it is sometimes more economical to design the slab on this basis. The moment of bending in each direction will depend on the ratio of the two spans and the conditions of restraint at each support. If the slab is square and the restraint issimilar along the four sides, then the load will span equally in both directions. If the slab is rectangular, then more than half of the load will be carried in the shorter direction, and hence lesser load will be imposed on the longer direction.If a span is much longer than the other, a large portion of the load will be carried in the shorter direction and the slab may as well be designed as spanning in only onedirection.Moments in each direction of span are generally calculated using co-efficient which are tabulated in the code.The slab is reinforced with the bars in both directions parallel to the spans with the steel for the shorter span placed farthest from the neutral axis to form the greater effective depth.The deflectionis based on the shorter span and the percentage of the reinforcement in that direction. [8].

2.4 Flat slab

Flat slab is a reinforced concrete slab supported directly by concrete columns or caps. Flat slabs donot have beams. They are supported on columns themselves. Loads are directly transferred to columns. In this type of construction a plain ceiling is obtained thus giving attractive appearance from architectural point of view. The plain ceiling diffuses the light better and is considered less vulnerable in the case of fire than the usual beam slab construction.The flat slab is easier to construct and requires less formwork.

Figure 2.8 -Flat slab

Flat slabs are appropriate for most floor situations and also for irregular column layouts, curved floor shapes, ramps etc. The benefits of choosing flat slabs include a minimum depth solution, speed of construction, flexibility in the plan layout (both in terms of the shape and column layout), a flat soffit (clean finishes and freedom of layout of services) and scope and space for the use of flying forms.

Flat slabs are less labor intensive, simplify the installation of services and can accommodate more floors within restricted heights. However, the span influencing their design is the longest and they require more steel compared to two-way slabs. Other drawbacks of flat slabs are vulnerability to punching shear failure and higher deflections. To avoid punching shear failure drop panels, column heads or shear reinforcement are used. If span in flat slabs is reduced then both deflection and punching shear problems can be avoided. However, architects prefer to have few exposed columns in usable areas. This inevitably leads to columns in an irregular layout, hidden inside partitions or walls.Flat slab construction with columns in an irregular layout is a viable solution in constructing buildings that satisfy their functionalrequirements in urban environments.[8].

The flexibility of flat slab construction can lead to high economy and yet allow the architect great freedom of form.

Examples are; solid flat slab (figure 2.9), solid flat slab with drop panel, solid flat slab with column head, coffered flat slab(figure 2.10), coffered flat slab with solid panels, banded coffered flat slab,solid flat slab with drop panel(figure 2.11).

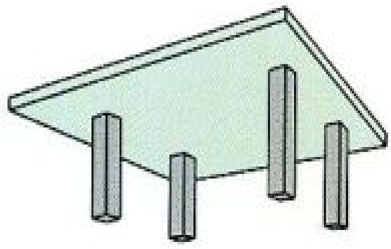


Figure 2.9 -Solid flat slab

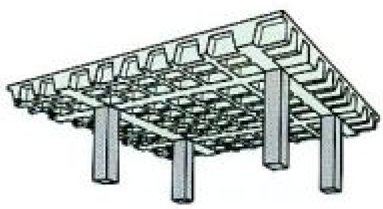


Figure 2.10- Coffered flat slab

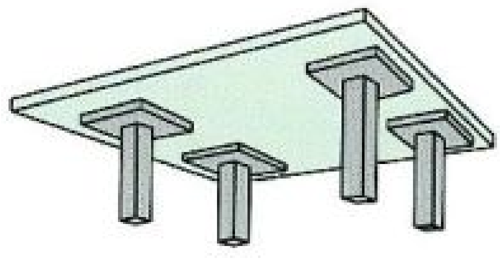


Figure 2.11-Solid flat slab with drop panel

Flat slab can be used where :[16].

1. To provide plain ceiling surface giving better diffusion of light
2. Easy constructability with economy in the formwork
3. Larger head room or shorter story height & pleasing appearance.
4. This kind of slabs are provided in parking
5. Flat slabs are generally used in parking decks, commercial buildings, hotels or places where beam projections are not desired.

Advantages:

1. Minimize the floor-to-floor heights when there is no requirement for a deep false ceiling. Building height can be reduced
2. Auto sprinkler is easier.
3. Less construction time.
4. Increases shear strength of slab
5. Reduces the moment in the slab by reducing the clear or effective span

Disadvantages:

1. In flat plate system, it is not possible to have large span.
2. Not suitable for supporting brittle (masonry) partitions.
3. Higher slab thickness.

2.4.1 Types of flat slabs

Flat slabs can be classified as per the slab column junction. There are four types of flat slabs commonly used in buildings as shown in Fig.2.12. They are as follows.[19]

- Slab without drop and column without column head
- Slab with drop and column without column head
- Slab without drop and column with column head
- Slab with drop and column with column head

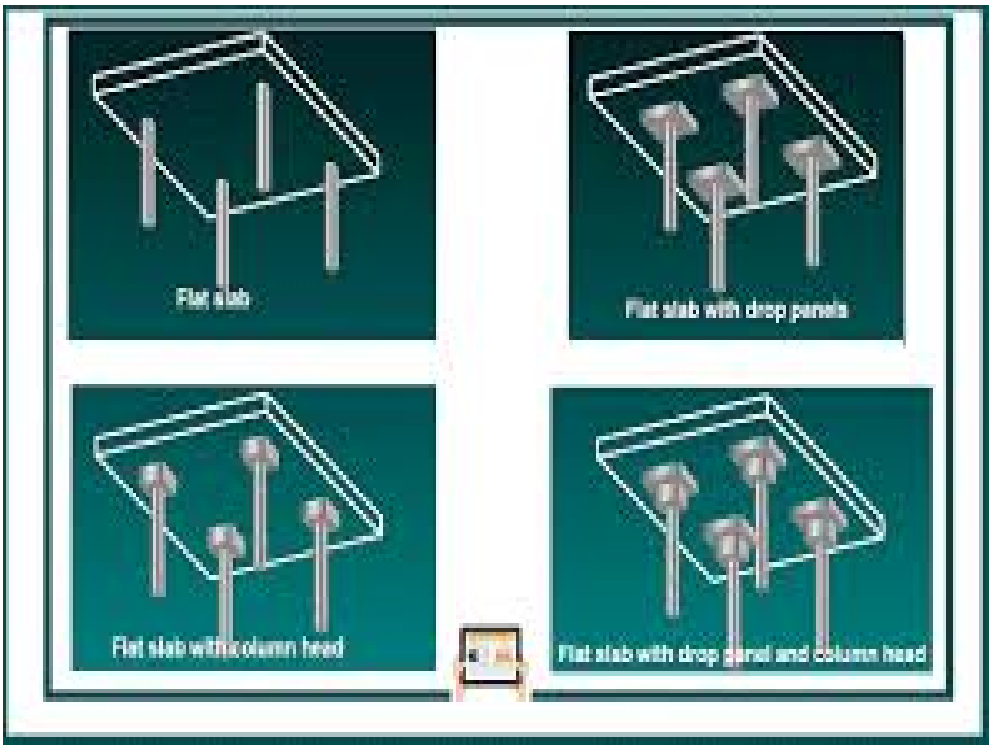


Figure 2.12-Types of flat slabs

2.4.2 Thickness of flat slab

The thickness of a flat slab is another important parameter because a thin slab provides the advantage of increased floor to ceiling height and lower cladding cost for the owner. However, there is profound lower limit to thickness of a slab, because extra reinforcements are needed to tackle design issues. Besides this, added margin must be provided to facilitate architectural alterations at later stages.

2.4.3 Types of Flat Slab Design

Multitudes of process and methods are involved in designing flat slabs and evaluating these slabs in flexures. Some of these methods are as following:

- The empirical method
- The sub-frame method
- The yield line method
- Finite –element analysis

For smaller frames, empirical methods are used, but sub-frame method is used in case of more irregular frames. The designs are conceptualized by employing appropriate software, but the use of sub-frame methods for very complicated design can be very expensive.[18]

The most cost effective and homogenous installation of reinforcements can be achieved by applying the yield line method. A thorough visualization in terms of complete examination of separate cracking and deflection is required since this procedure utilizes only collapse mechanism.

Structures having floors with irregular supports, large openings or bears heavy loads, application of finite- element analysis is supposed to be very advantageous. Great thought is put into choosing material properties or installing loads on the structures. Deflections and crack widths can also be calculated using Finite- element analysis.

2.4.4 Different components of flat slab

The main portion of interest in the flat slab building is the slab column junction. To ensure the safety, drop panels and column heads are provided.

2.4.4.1 Drop

To resist the punching shear predominant at the contact of slab and column support, the drop dimension should not be less than one- third of panel length in that direction.

2.4.4.2 Column Heads

Certain amount of negative moment is transferred from the slab to the column at the support. To resist this negative moment the area at the support needs to be increased. This is facilitated by providing column capital/heads.

2.4.4.3 Column Strip

Column strip means a design strip having a width of 0.25l, but not greater than 0.25l on each side of the column centre-line, where l, is the span in the direction moments are being determined, measured centre to centre of supports.

2.4.4.4 Middle Strip

Middle strip means a design strip bounded on each of its opposite sides by the column strips.

2.4.4.5 Panel

Panel means that part of a slab bounded on-each of its four sides by the centre-lines of a columns or centre-lines of adjacent-spans.

2.4.5 Use of column head

- Increases the punching shear strength between column and slab.
- Increases the moment capacity of the slab.
- Provides more thick supporting area.

2.4.6 Use of drop panel

- Enhances punching shear strength of a flat slab
- Increases negative moment carrying capacity of a flat slab
- Increases stiffness of the slab and hence reduces deflection

In a flat slabsystem, the floor consists of a concrete slab of uniform thickness which frames directly into columns. Two way flat slabs make use of either capitals in columns or drop panels in slab or both. This is the simplest and most logical structural form, which consists of uniform slabs from 125 to 200mm thickness, connected rigidly to supporting columns. This system, which is essentially of reinforced concrete, is very economical in having a flat soffit requiring simple formwork where the soffit can be used as the ceiling. [18]

2.5 Problems with flat slabs

Problems with flat slabs are mainly punching shear and deflection.

2.5.1 Punching shear of flat slabs

The punching shear is a failure mechanism in structural members like slabs and foundation by shear under the action of concentrated loads.

The action of concentrated loads is on a smaller area in the structural members. In most cases, this reaction is the one from the column acting against the slab. Eventually the slab will fail. One possible method of failure is that the load punches through the slab.

The punching shear strength is an extremely significant parameter for the design of flat slabs.Punching shear is a type of failure of reinforced concrete slabs subjected to high localized forces. In flat slab structures this occurs at column support points. The failure is due to shear. This type of failure is catastrophic because no visible signs are shown prior to failure. Punching shear failure disasters have occurred several times in this past decade. An example of punching shear failure can be seen in Figure 2.13. [13].

Piper's Row Car Park, Wolverhampton, UK, 1997 (built in 1965).

Figure 2.13-Flat Slab Failure due to Punching shear

A typical flat plate punching shear failure is characterized by the slab failing at the intersection point of the column. This results in the column breaking through the portion of the surrounding slab. This type of failure is one of the most critical problems to consider when determining the thickness of flat plates at the column-slab intersection. Accurate prediction of punching shear strengthis a major concern and absolutely necessary for engineers, so they can design a safe structure.

2.5.1.1 General Mechanism of Failure

Conventional wisdom does not apply when considering the mechanism of a punching shear failure; in a slab system with a concentrated load or at a slab column connection, the loaded area is not actually pushed through the slab as shown in Figure 2.14 Punching shear failures arises from the formation of diagonal tension cracks around the loaded area, which result in a conical failure surface as illustrated in Figure 2.15.[20]

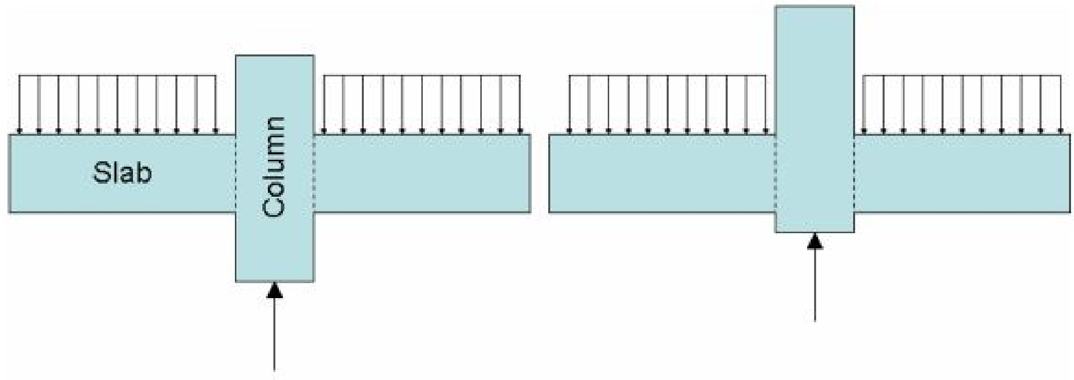


Figure 2.14-Punching shear failure near columns

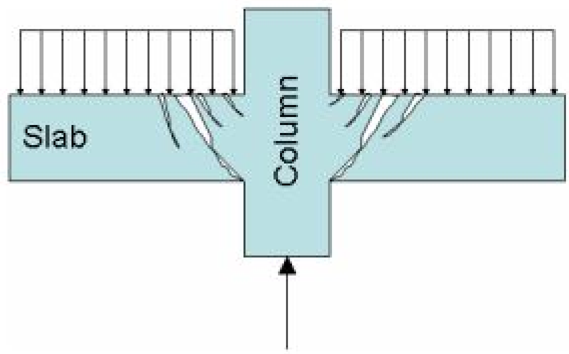


Figure 2.15- Conical failure surface of flat slabs

Punching shear is a phenomenon in flat slabs caused by concentrated support reactions inducing a cone shaped perforation starting from the top surface of the slab. Although generally preceded by flexural failure, punching shear is a brittle failure mode and the risk of progressive collapse requires a higher safety class in structural design.

2.5. 2 Deflection

Usually, at the center of each panel deflections are the maximum. Foreseeing deflections can be very tricky and will engage some form of elastic appraisal. While designing structure layout and during implementation using sub frame method, one way to evaluate mid-panel deflection is to use at least two parallel column strips.

Adequate control of deflections canusually be achieved for in-situ reinforcedconcrete beams and slabs by compliancewith specified span/depth ratios.However, as flat slab structures becomemore slender, serviceability is increasinglygoverning their design. The deflections are dependent on the moment distribution and the stiffness of the member.To control deflection of flat slabs slab thickness to be increased.

2.6 Behavior of Flat Slab Building during earthquake

The performance of flat slab building under seismic loading is poor as compare to frame structure due to lack of frame action which leads to excessive lateral deformation. In flat slab building the most vulnerable part is slab column joint. Extensive research has been done to find out the behavior of flat slab column connection. The failure mode depends upon the type and extent of loading. Punching shear strength of slab column connection is of importance which very much depends on the gravity shear ratio. Punching failure of flat slab can occur as a result of transfer of shearing force and unbalanced moment between slab and column. The behavior and design of flat slab structure for gravity loads are well established. Transfer of lateral displacement induces moment at slab column connection which is of complex three dimensional behaviors. Due to the flexibility of flat plate building, they must be combined with a stiffer lateral force resisting system in high seismic regions. When flat slab is used in combination with braced frames, shear wall for lateral load resistance, the column in building can be designed for only 25% of the design seismic force.[19].

2.7 Difference between flat slab and conventional slab – beams system.

There are so many differences between flat slab and beam slab system.

In two way slabs, the slab is supported by beams, the load of both slab and beams is conveyed to columns and footings.In flat slabs, the slab is supported by columns, no beams to be used.

In two way slabs,shear is critical in beams, but less critical for the slabs.In flat slabs, the shear is very critical at the area of connection of slab with column (called punching shear). Here the column due to load is trying to punch through the slab and we need the slab to be thickened (by using Caps)and/ or heavily reinforced to resist this shear.

In two way-slabs, due to (drop) beams, some of the floor heights is lost (we need more height for different piping installations.In flat slabs, we donot have this problem, because we donot have drop beams.

In flat slabs,less formwork is neededand formwork is simple and hence not costly. And also flat ceiling is available which gives attractive appearanceinbeam slabmore form work is needed.Form work is complicated and hence costly.Flat ceiling is not available for flat attractive appearance, you may have to do false ceiling.

It is easy to install sprinkler and piping and other utilities as beams are absent in flat slabs however, it is tricky to install those utilities in two way span slabs as beams interfere.[16]

2.8 Structural analysis by software SAP 2000 ver.14

SAP2000 is the most sophisticated and user – friendly release of the SAP series of computer program. SAP2000 had been used in the engineering industry for more than 30 years under various names. Initially, it began with SAP, SOLIDSAP or SAP IV and, followed by its personal computer versions, SAP 80, SAP 90 and finally

SAP2000. It is a stand – alone finite – element – based structural program for the analysis and design of civil engineering structures. It offers an intuitive, yet powerful user interface with many tools to aid in the quick and accurate construction of models, along with the sophisticated analytical techniques needed to do the most complex projects. SAP2000 is object based, meaning that the models are created using members that represent the physical reality. A beam with multiple members framing into it, is created as a single object, just as it exists in the real world, and the program handles the meshing needed to ensure that connectivity exists with the other members internally. Results for analysis and design are reported for the overall object and not for each sub- element that makes up the object, providing information that is both easier to interpret and more consistent with the physical structure. [4]

2.9 Verification of SAP 2000 software by modeling a four story frame And axial load calculation.

For two buildings with same layout has been followed and analyzed.

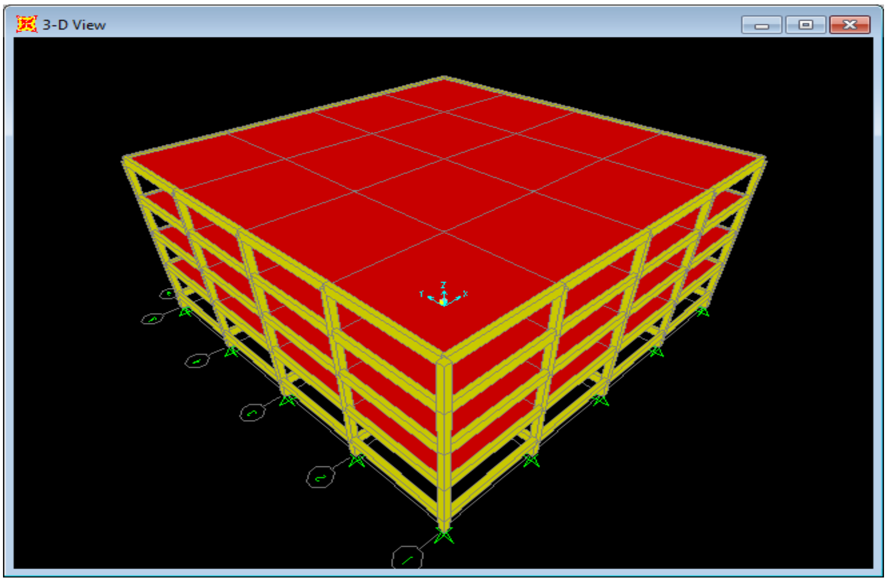


Figure 2.16-flat slab models with perimeter beams

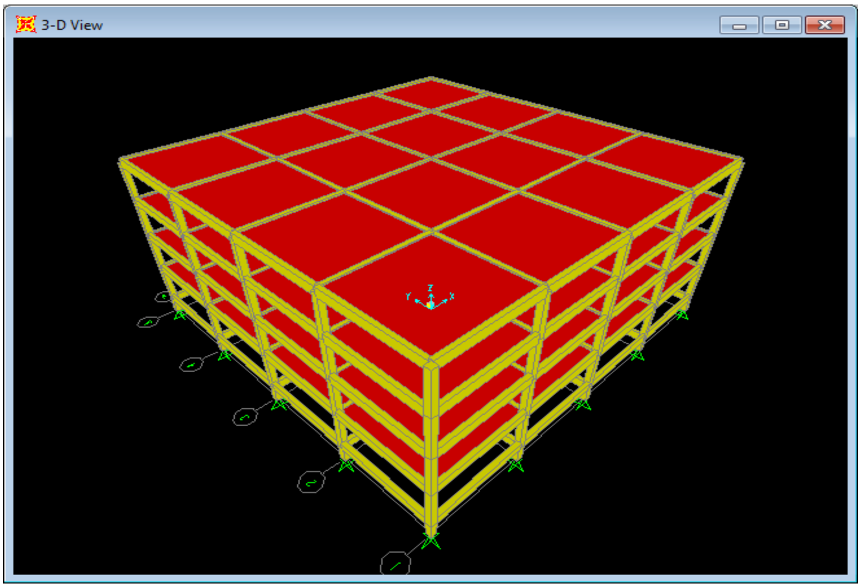


Figure 2.17-conventional beam slab model

A manual analysis is carried out for axial load of four story frame and the results obtained are compared with those obtained with analysis bySAP2000.

<u>A specimen calculation for interior column axial load-Conventional Slab</u>

Select, floor to floor height = 3.6 m

Considering a typical internal column loaded from a tributary area of 7.5m x 7.5 m

Slab thickness	= 250mm
Self weight of slab	= 7.5 x 7.5 x 0.25 x 24 = 337.5 kN
Weight of finishes and services (1.5 kN/m^2)	= 7.5 x 7.5 x 1.5 = 84.375 kN
Weight of partitions (1.0 kN/m^2)	= 7.5 x 7.5 x 1 = 56.25kN
Beam size	= 300 mmx750 mm
Height of beam	= (0.75-0.25)m
Weight of beams	= (7.5 + 7.5) x 0.50 x 0.3x24 =54kN
Total dead load	= 532.125kN

Imposed Loads (2.5 kN/m^2) = 7.5 x 7.5 x 2.5 = 140.625 kN

Load combination = $1.4G_k+1.6Q_k$

Design load per floor = 1.4 x 532.125 + 1.6 x 140.625 = 969.975kN

Ground to 4th floor

Trial column size from ground to 4th floor = 450 mm x 450 mm

Total column load at ground floor = 4 x 969.975 + 0.45x 0.45 x 3.6 x 4 x 24 x 1.4

= 3977.88kN

A specimen calculation for interior column axial load-Flat Slab

Select, floor to floor height = 3.6 m

Considering a typical internal column loaded from a tributary area of 7.5m x 7.5 m

Self weight of slab = 7.5 x 7.5 x 0.25 x 24 = 337.5 kN

Weight of finishes and services (1.5 kN/m^2) = 7.5 x 7.5 x 1.5 = 84.375 kN

Weight of partitions (1.0 kN/m^2) = 7.5 x 7.5 x 1 = 56.25 kN

Total dead load = 478.13 kN

Imposed Loads (2.5 kN/m^2) = 7.5 x 7.5 x 2.5 = 140.625 kN

Design load per floor = 1.4 x 564.125 + 1.6 x 140.625 = 894.38 kN

Ground to 4th floor

Trial column size from ground to 4th floor = 450 mm x 450 mm

Total column load at ground floor = 4 x 894.38 + 0.45x 0.45 x 3.6 x 4 x 24 x 1.4

= 3675.48kN

Table 2.1- Load comparison-Conventional slab

Span (m)	SAP 2000 results	Manual results
3.0	799.77kN	603.85 kN
4.0	1,265.12kN	991.26 kN
5.0	2,079.29kN	1,529.39 kN
5.5	2,510.26kN	1,944.36 kN
6.0	2,965.42kN	2,276.29 kN
6.5	3,449.39kN	2,776.95 kN
7.0	4,213.19kN	3,308.46kN
7.5	4,553.86kN	3977.88kN

Table 2.2- Load comparison -Flat slab

Span (m)	SAP 2000 results	Manual results
3.0	647.91 kN	584.41 kN
4.0	1,051.07 kN	965.34 kN
5.0	1,793.55 kN	1,496.99 kN
5.5	2,190.06 kN	1,896.84 kN
6.0	2,600.36kN	2,224.45 kN
6.5	3,055.54 kN	2,720.79 kN
7.0	3,744.36kN	3,232.86 kN
7.5	4,050.65 kN	3,675.48kN

According to the analysis of the data obtained, we can see the difference between the real load carried by columns and the load calculated by using the area method.

A column is one of the structural elements that carries loads chiefly in compression. Columns transmit loads from the upper floors to the lower levels, and then to the soil through the foundation. Since columns are compression elements, failure of one column in critical location can cause the progressive collapse of the adjoining floors and ultimately total collapse of the entire structure. Column load transfer frombeams and slabs by two methods: tributary area method and beams reaction method. Tributary area method is one of these methods which is being used to calculate the forces carried by columns in the building. This method depends oncomputing the forces on columns due to the load applied on the slab by calculating the surrounded area of columns and multiply this area by the load on the slab.The tributary area method is more suitable for masonry buildings and more widely used because of its suitability for hand calculation checks, and will also produce larger reactions in the walls and columns that terminate on a transfer level.

The using 3-D model is the most accurate estimation method to calculate the real loads effected on columns under different load cases and design these columns by considering the critical load combination. Area method is not always a suitable method to find axial loads on columns. [21].

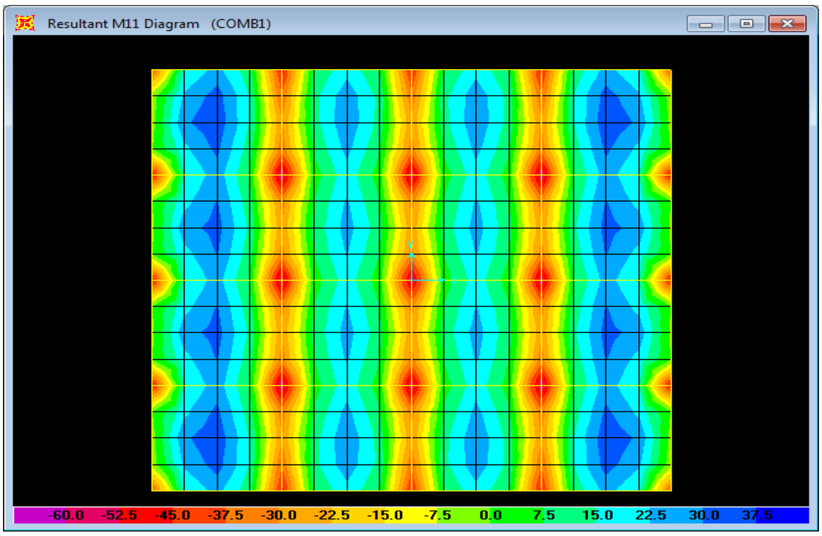


Figure 2.18- SAP analysis window of the slab moment of conventional slab

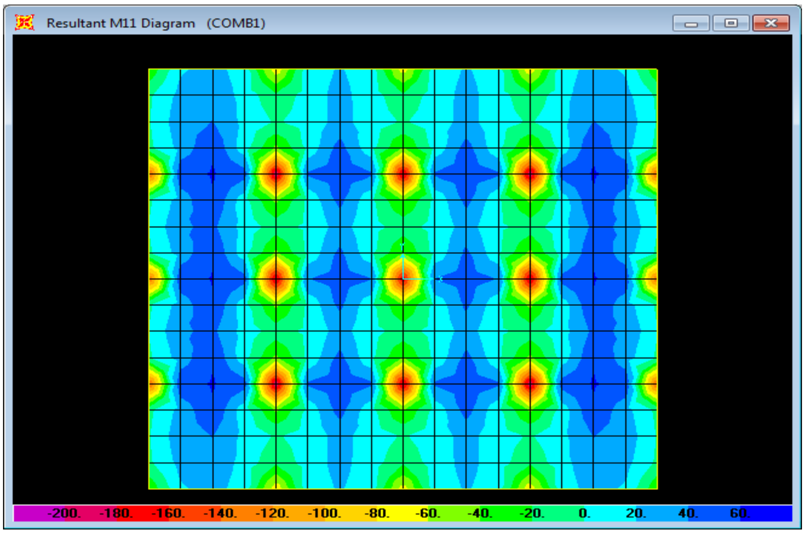


Figure 2.19 - SAP analysis window of the slab moment of flat slab

From Figure 2.18, it is clear that blue colors indicate sagging moment,while orange/yellow colors indicatehogging moments. Outer slab panels are having higher positive moments than internal panels. Along the supports negative moment values are close to each other for interior and outer supports.

From Figure 2.19 it is clear that moments are high around the column sections. These areas need heavy reinforcements than other areas. Negative moments at mid strips are low relative to the negative moments at the column strips.

Chapter 3

STRUCTURAL ARRANGEMENTS AND LOADS APPLIED FOR CASE STUDY

3.1 General

This case study is carried out with selected building layout of four story office building. A computer analysis is needed to carry out this case study. To develop a computer model, it is required to finalize the geometry of the structure, properties of elements and loading on the structure.

3.2 Layout of structure

For selecting the building layout for the case study, following factors were taken into account.

(i) Grid spacing was vary to 3.0m,4.0m,5.0m,5.5m,6m,6.5m,7.0m and 7.5 m

(ii) Eight structures were modeled for conventional beam slab buildings and other eight were modeled for flat slab building.

(iii) Floor to floor height was in the range of 3.6 m

Then, layout of the building was prepared based on the following.

(1) Initial member sizing

The building layout for 7.5m is shown below. In this study a symmetric building model was taken.

- Beam slab building
- Flat slab without drop and with peripheral beams

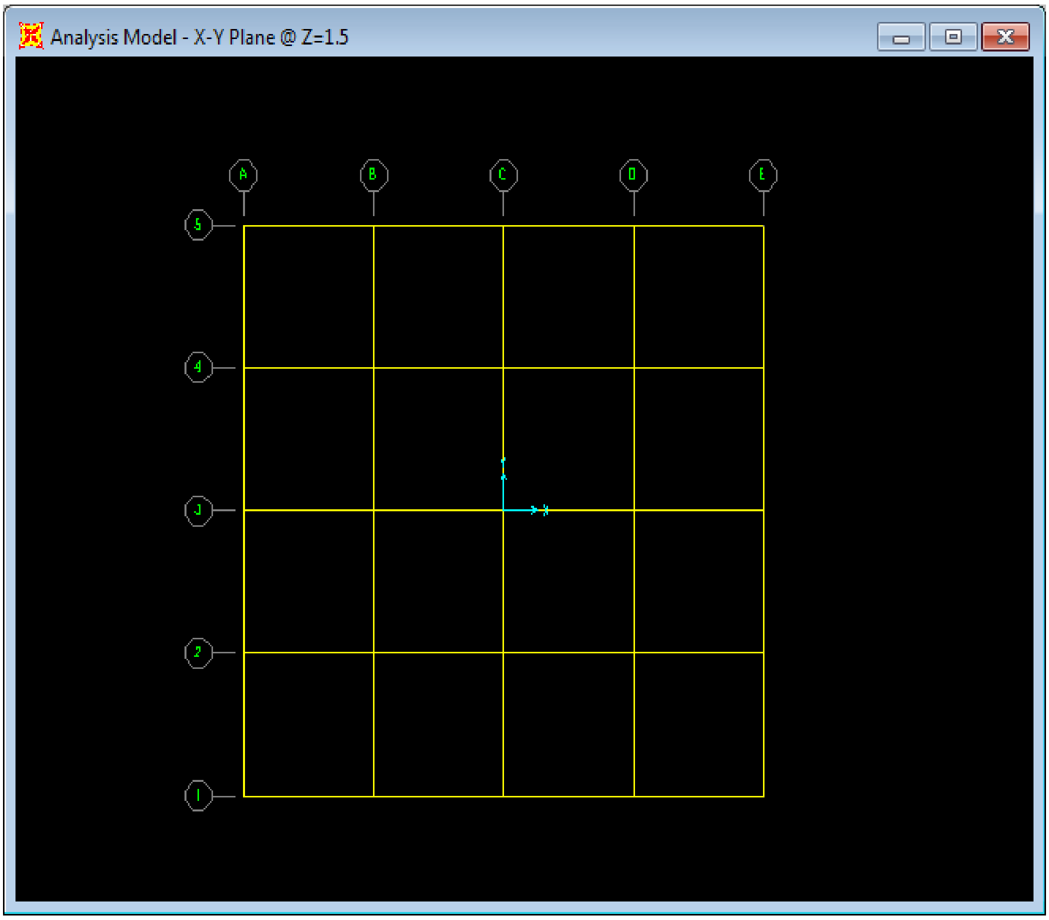


Figure 3.1- Layout plan for 7.5m span

3.2.1 Floor loads

The building selected in this study is assumed to be used as offices. The loads caused by the weight of the building, called dead loads, and its occupancy, called live loads represent gravity loads. The live loads are not permanent and they are variable and unpredictable. They not only change over time but also depend on location and building type. Floor live loads caused by the contents or objects are often called as occupancy loads. Codes provide values for live loads mostly in terms of equivalent uniform loads distributed over the floor area. Thus, imposed loads are obtained from BS 6399 : Part 1 : 1996.[2]

The dead loads are calculated from the approximate unit weights given in BS 648 or from the actual known weight of materials used.

As it is improbable that, in multi – story structures, every floor simultaneously carries the full live load, building codes of practice allow for use of load reduction factors for the design of columns, walls, beams, and their supports and foundations. Reduction in total distributed imposed floor loads with number of stories are given in the BS 6399: Part 1 : 1984 and according to the code the factor is 0.5 when it is more than 10 story. Reduction in imposed loads not consider for this project.

3.2.2. Initial member sizing

The member sizes are initially decided to complete the model. This was done according to British Standards BS 8110: Part 1: 1985 for each building. Initial member sizes are usually based on gravity loading. Selected member sizes are shown below.

Table 3.1 Initial member sizing of flat slabs and conventional slabs

Span (m)	3	4	5	5.5	6	6.5	7	7.5
Column size(mmxmm)	300x 300	300x 300	300x 300	350x 350	350x 350	350x 350	450x 450	450x 450
Beam width(mm)	300	300	300	300	300	300	300	300
Beam height (mm)	450	450	600	600	600	600	750	750
Slab thickness (mm)	150	150	175	175	175	200	225	250

3.3 Material properties of the structure

3.3.1 Concrete

For this case study the vertical load bearing elements (columns and the horizontal members (slabs and beams) are modeled with Grade 30 concrete. Concrete should be specified, produced, and tested for compliance with BS 5328. To specify concrete to meet strength, it is necessary to select its characteristic strength, commonly known as the Compressive Strength Grade of Concrete. Poisson's Ratio of Concrete = 0.2

3.3.2 Reinforcement

According to the codes of practice BS4449,BS4482 or BS 4483, the characteristic strength of high yield steel is 460 N / mm^2.

3.4 Loading to be applied on the structures

3.4.1 Dead and imposed (live) loads

As explained in clause 3.2.1 these represent the gravity loads on the structure, and following loads are applied to the building.

<u>Dead loads</u>

Density of reinforced concrete	= 24kN / m^3
225 mm thick brick masonry	= 5.0kN / m^2
Floor finishes and services	= 1.5 kN / m^2
General partition	=1.0 kN / m^2
Imposed loads	
All floors considered as office floors	
Floor loads	= 2.5kN / m^2

3.5 Structural forms for Case Study

3.5.1Flat slab building modeled with perimeter beam

For layouts of the building size is square shape in plan. Floor to floor height is 3.6m.The initial sizes are calculated in the Appendix A and building sizes are as follows.

- 12m X 12m
- 16m X 16m
- 20m X 20m
- 22m X 22m
- 24m X 24m
- 26m X 26m
- 28m X 28m
- 30m X 30m

3.5.2 Conventional slab building modeled with perimeter beam

The building layout is selected in such a way that it has a square shape in plan. Floor to floor height is 3.6m.The initial sizes are calculated in the Appendix A and building sizes are same as given above.

Chapter 4

COMPUTER MODELLING AND CASESTUDY

4.1 Computer modeling

The buildings were modeled by using SAP2000 version 14 by accounting for the linear analysis. The beams and columns are modeled with (line) elements. Slab is modeled with elements (thin shell).

4.2 Load cases and combination

Static vertical loads (Dead and Imposed) were applied to the 3- D model according to the british standard.

Load cases

Dead - represents all permanent dead loads (i. e . self – weight of elements, brick masonry , floor finishes, services and general partitions)

Live - represents imposed loads.

Load combinations

(1) 1.4 Dead + 1.6 live ($1.4\ G_k + 1.6\ Q_k$)

The sixteen models are analyzed, according to the above loads and load combinations. The outputs of the models are taken to find out the conclusion of research. The main output to be discussed in here is cost comparison between 16 different models.

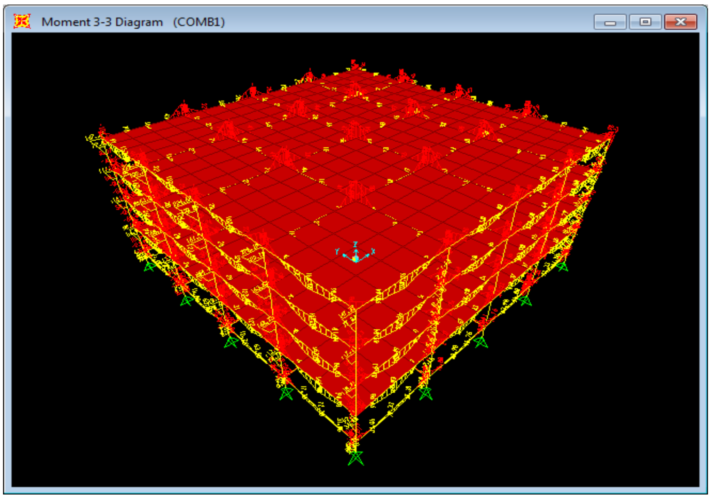


Figure 4.1-Bending moment variation in the beams of the building with conventional beam slab

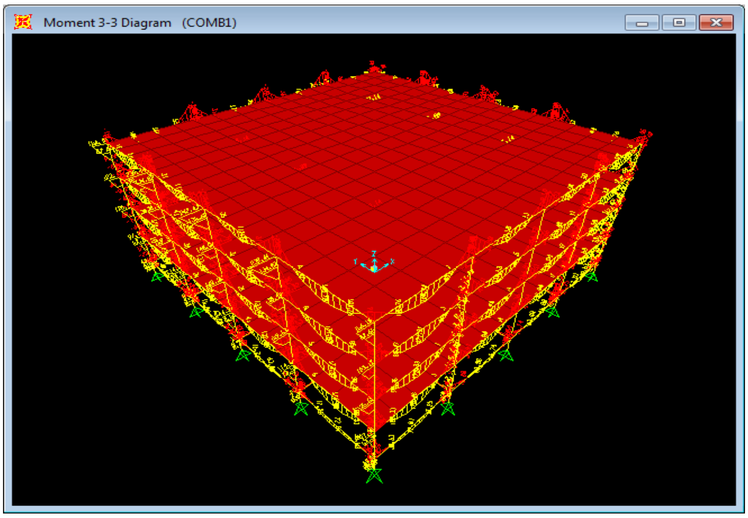


Figure 4.2-Bending moment variation in the beams of the building with flat slab

Chapter 4

COMPUTER MODELLING AND CASESTUDY

4.1 Computer modeling

The buildings were modeled by using SAP2000 version 14 by accounting for the linear analysis. The beams and columns are modeled with (line) elements. Slab is modeled with elements (thin shell).

4.2 Load cases and combination

Static vertical loads (Dead and Imposed) were applied to the 3- D model according to the british standard.

Load cases

Dead - represents all permanent dead loads (i. e . self – weight of elements, brick masonry , floor finishes, services and general partitions)

Live - represents imposed loads.

Load combinations

(1) 1.4 Dead + 1.6 live ($1.4\ G_k + 1.6\ Q_k$)

The sixteen models are analyzed, according to the above loads and load combinations. The outputs of the models are taken to find out the conclusion of research. The main output to be discussed in here is cost comparison between 16 different models.

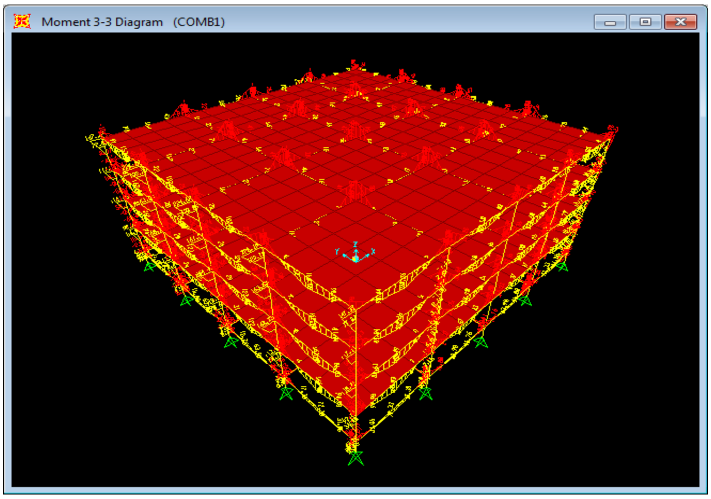


Figure 4.1-Bending moment variation in the beams of the building with conventional beam slab

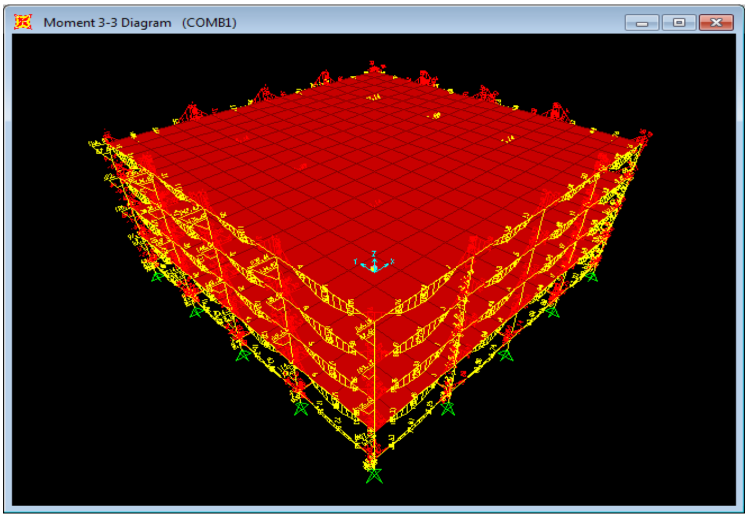


Figure 4.2-Bending moment variation in the beams of the building with flat slab

Chapter 5

5.1 RESULTS AND DISCUSSION

From the analysis of structures, bending moment and shear forces have been obtained. Based on bending moment and shear forces required area of reinforcement and then weight of the reinforcement have been determined.According to the member sizes selected, area of formwork and quantity of concrete have been obtained(ReferAnnex D).

Building schedule rates (BSR) has been used to find out the total cost of steel reinforcement,formwork and concrete used in slab, beam and column from ground floor level to top of structure.In the present study, to find out cost of structure, rates of steel, formwork and concrete were considered as Rs. 225,000 per Mt. of reinforcement, Rs. 3,000 per $m^2$of formwork and Rs.19,000 per $m^3$of concrete respectively. Rates include labor and material. (Refer Annex E)

From Fig. 5.1,5.2, 5.3 shows variation of the concrete,reinforcement and formwork requirement for slab,beam and columns in conventionalslabstructure and flat slab structure. Amount of concrete volumes of two separate slabs are shown on Table 5.1 and Table 5.2.

Table 5.1- Concrete requirement for conventional slab

Span	Concreting (m^3)		
	Slab	Beam	Column
3.00	90.77	43.20	30.60
4.00	159.41	57.60	30.60
5.00	288.46	102.00	29.25
5.50	349.67	112.20	39.81
6.00	415.05	122.40	39.81
6.50	555.46	124.80	39.81
7.00	728.46	176.40	62.78
7.50	973.56	180.00	62.78

Table 5.2- Concrete requirement for flat slab

Span	Concreting (m^3)		
	Slab	Beam	Column
3.00	90.77	17.28	30.76
4.00	159.41	23.04	30.76
5.00	288.46	40.80	29.82
5.50	349.67	44.88	40.58
6.00	415.05	48.96	40.58
6.50	555.46	49.92	40.47
7.00	728.46	70.56	64.78
7.50	973.56	72.00	64.60

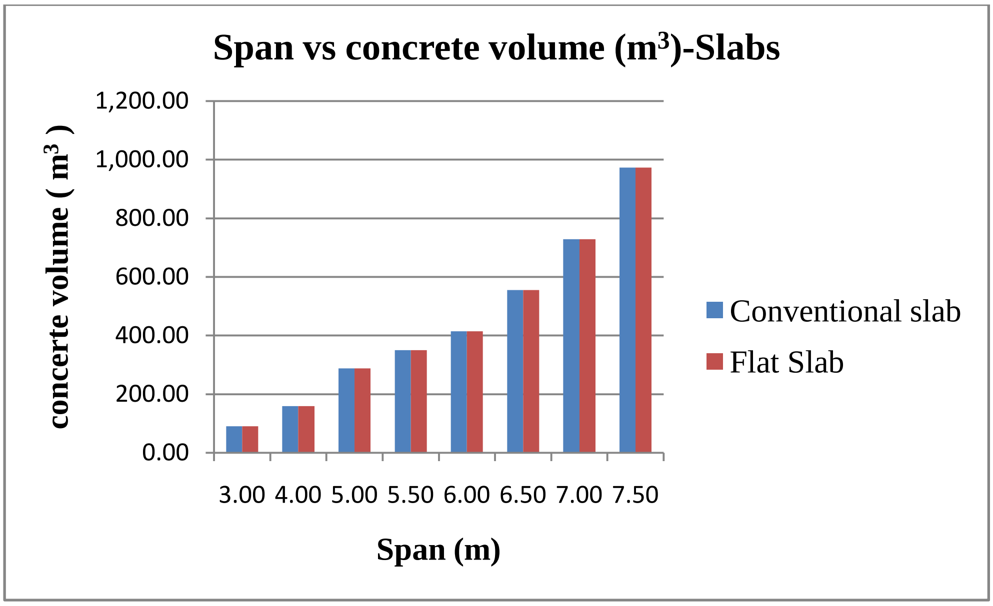


Figure 5.1- Span vs concrete volume (m^3)-Slabs

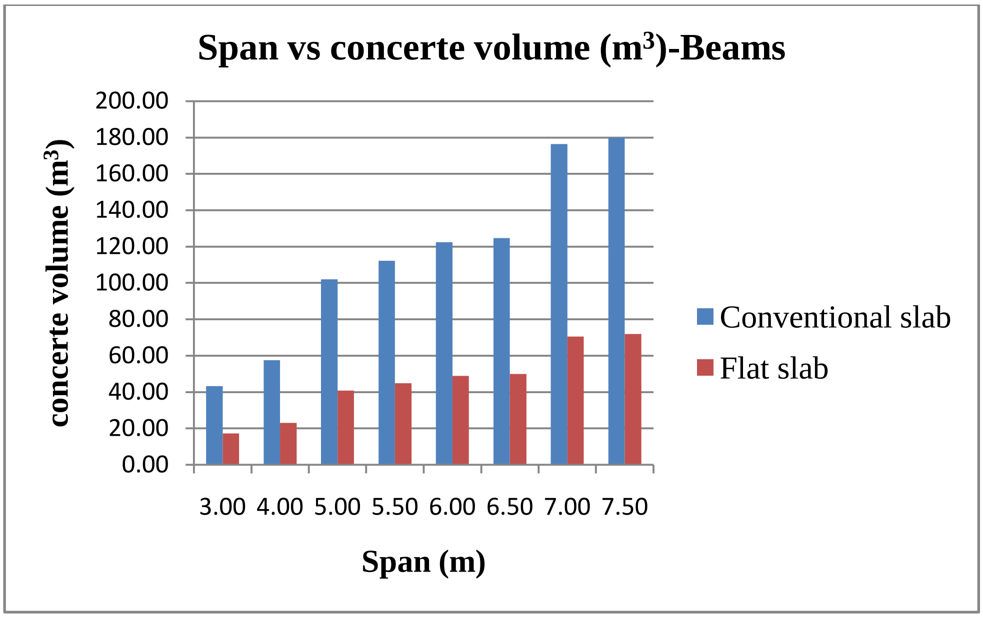


Figure 5.2 -Span vs concrete volume(m^3)-Beams

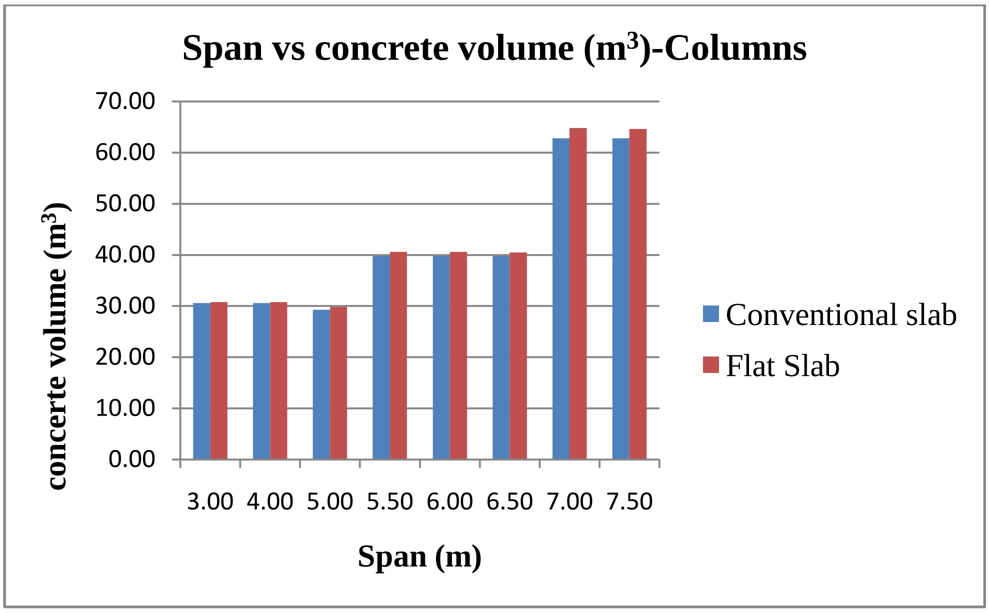


Figure 5.3-Span vs concrete volume(m^3)-Columns

Table 5.3- Percentage saving for concreting (m^3) with respect to conventional slab

Span	% saving for concreting (m^3) with respect to conventional slab		
	Slab	Beam	Column
3.00	0.00	60.00	-0.52
4.00	0.00	60.00	-0.52
5.00	0.00	60.00	-1.95
5.50	0.00	60.00	-1.93
6.00	0.00	60.00	-1.93
6.50	0.00	60.00	-1.66
7.00	0.00	60.00	-3.19
7.50	0.00	60.00	-2.90

It is clear that quantity of concrete for slab is identical for both structures. Quantity of concrete used for beams in flat slab structures is 60% less than conventional slab structuresirrespective of the span.For flat slabs volume of concreting has been considered up to slab bottom level at intermediate areas. Since small amount of concrete volume has increased for flat slabs. Quantity of concrete of column is 0.5%-3% higher than conventional slab structure with the span.

Table 5.4- Reinforcement requirement conventional slab

Span	Reinforcement (Mt)		
	Slab	Beam	Column
3.00	7.44	7.56	3.48
4.00	13.10	10.30	3.82
5.00	19.15	19.67	5.38
5.50	23.02	21.48	5.40
6.00	29.16	35.14	5.49
6.50	35.33	37.76	6.30
7.00	37.28	41.37	8.18
7.50	44.01	44.04	11.00

Table 5.5- Reinforcement requirement flat slab

Span	Reinforcement (Mt)		
	Slab	Beam	Column
3.00	8.96	2.30	3.06
4.00	15.83	3.10	3.27
5.00	26.41	6.30	4.58
5.50	32.59	6.87	4.61
6.00	42.44	11.24	4.67
6.50	51.07	12.08	5.36
7.00	58.85	13.24	6.95
7.50	64.61	13.39	9.35

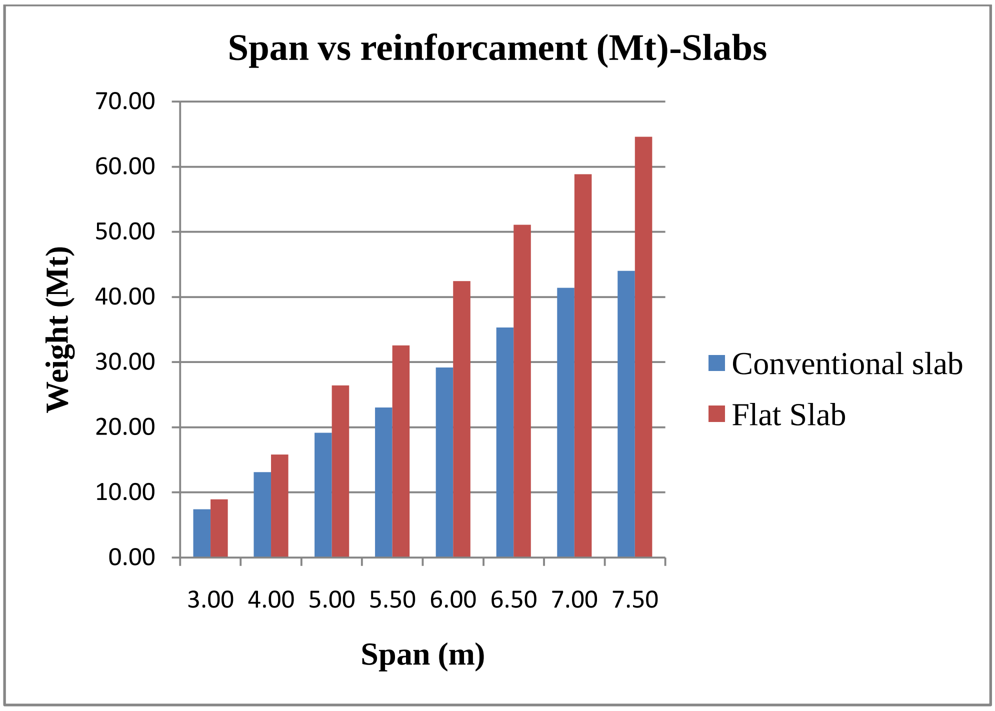


Figure 5.4 Span vsreinforcement (Mt)-Slabs

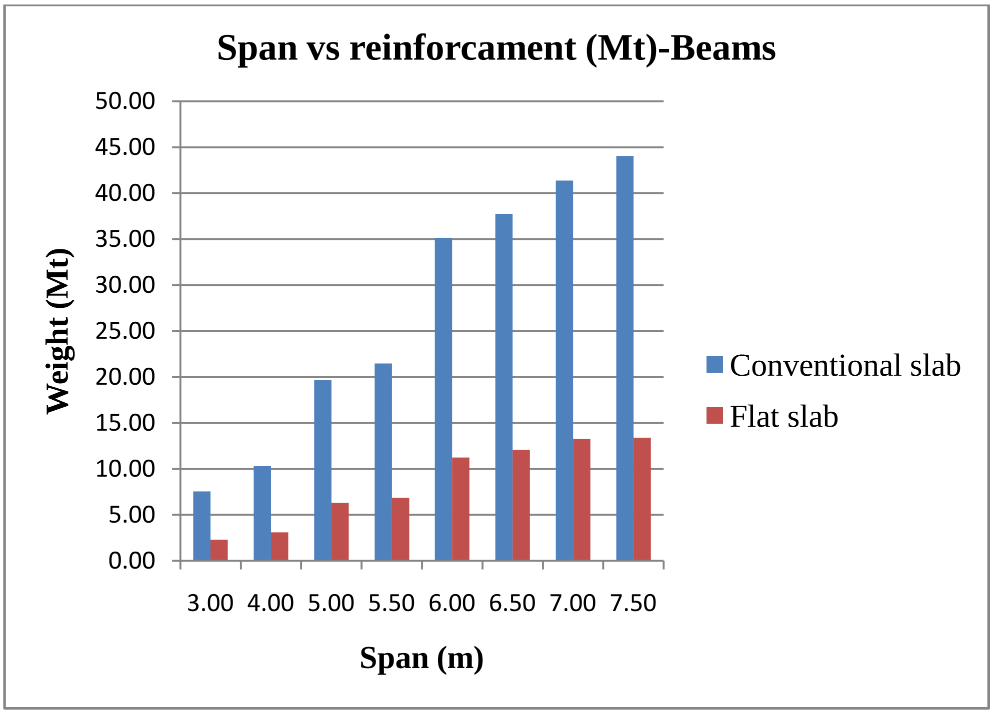


Figure 5.5-Span vsreinforcement (Mt)-Beams

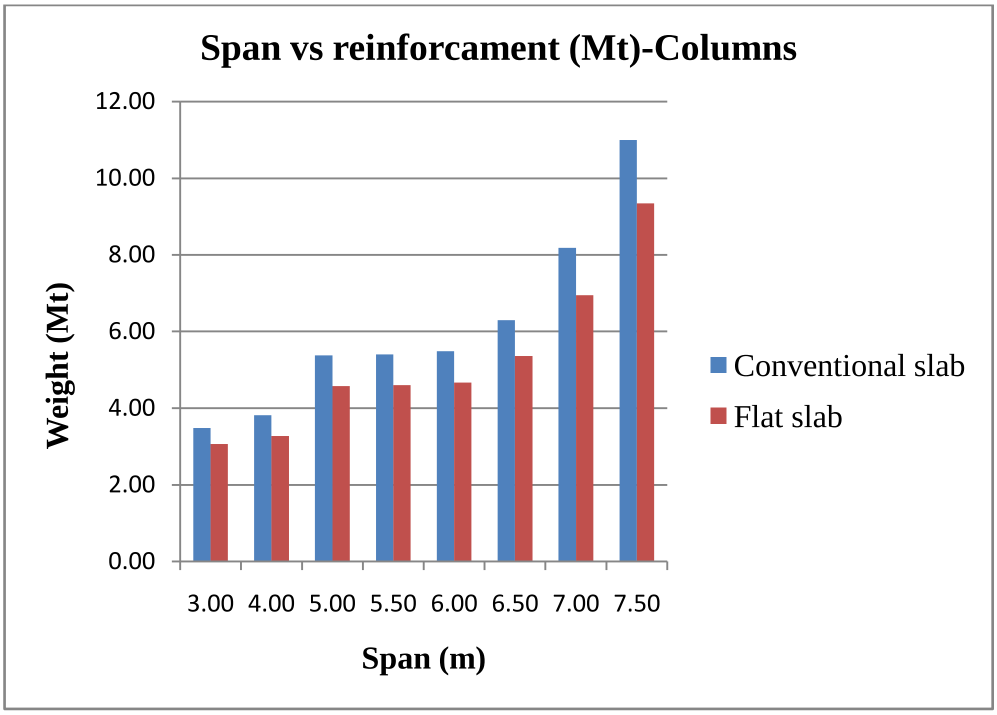


Figure 5.6-Span vsreinforcement (Mt)-Columns

Table 5.6 -Percentage saving for Reinforcement(Mt.) respect to conventional slab

Span	% saving for Reinforcement(Mt.) respect to conventional slab		
	Slab	Beam	Column
3.00	-20.47	69.58	12.04
4.00	-20.84	69.88	14.29
5.00	-37.91	67.97	14.87
5.50	-41.57	68.02	14.72
6.00	-45.54	68.01	15.00
6.50	-44.55	68.01	14.93
7.00	-42.07	68.00	15.05
7.50	-46.80	69.61	14.99

It shows that quantity of steel for flat slab is higher than conventional slab. For higher spans steel requirement for flat slab is high. Quantity of steel of beam is around 69% less than conventional slab structure with the span.Quantity of steel of column is around 15% less than conventional slab structure with the span.

Table5.7- Formwork requirement conventional slab

Span	Formwork (m^2)		
	Slab	Beam	Column
3.00	496.08	442.80	378.00
4.00	915.28	601.47	378.00
5.00	1,470.60	980.49	360.00
5.50	1,793.00	1,102.74	420.00
6.00	2,147.40	1,229.58	420.00
6.50	2,544.32	1,301.85	420.00
7.00	2,974.84	1,757.43	513.00
7.50	3438.96	1,851.33	513.00

Table 5.8- Formwork requirement flat slab

Span	Formwork (m^2)		
	Slab	Beam	Column
3.00	577.08	177.12	414.00
4.00	1,025.08	249.39	414.00
5.00	1,609.20	420.21	411.00
5.50	1,946.00	487.26	479.50
6.00	2,314.80	558.90	479.50
6.50	2,726.12	607.53	476.00
7.00	3,171.04	840.51	607.50
7.50	3,649.56	905.97	603.00

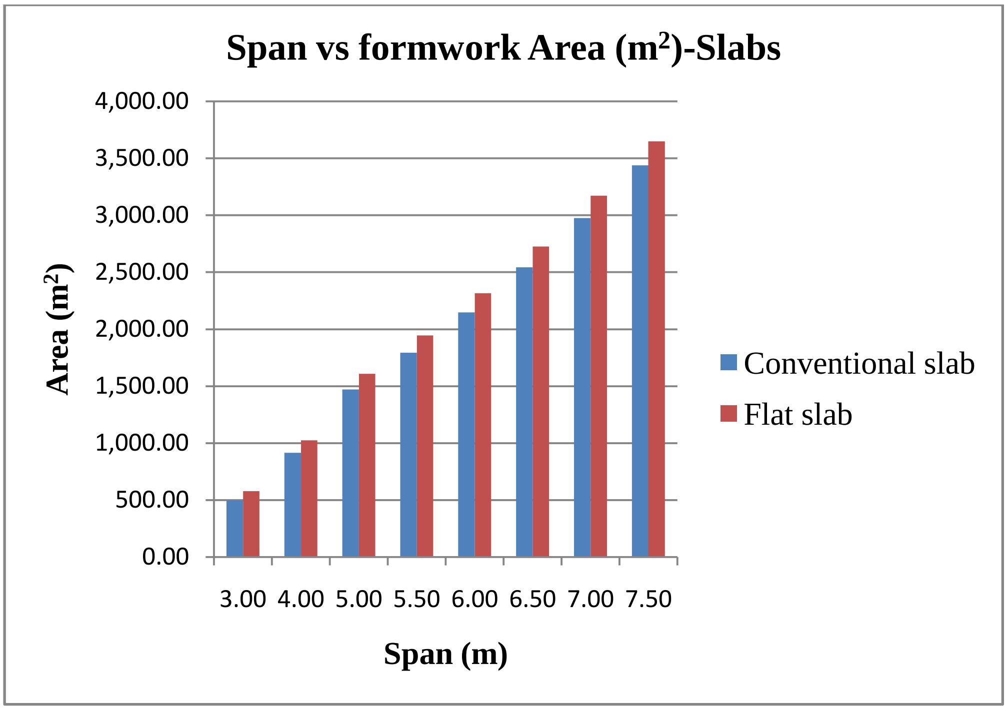


Figure 5.7-Span vsformwork area (m^2)-Slabs

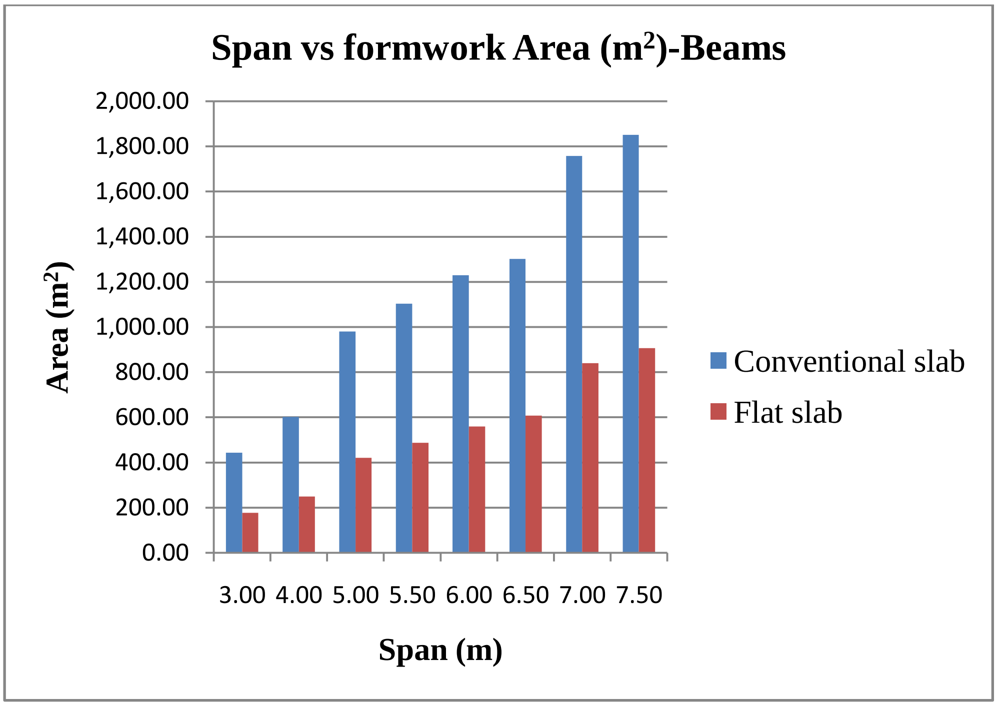


Figure 5.8 -Span vsformwork area (m^2)-Beams

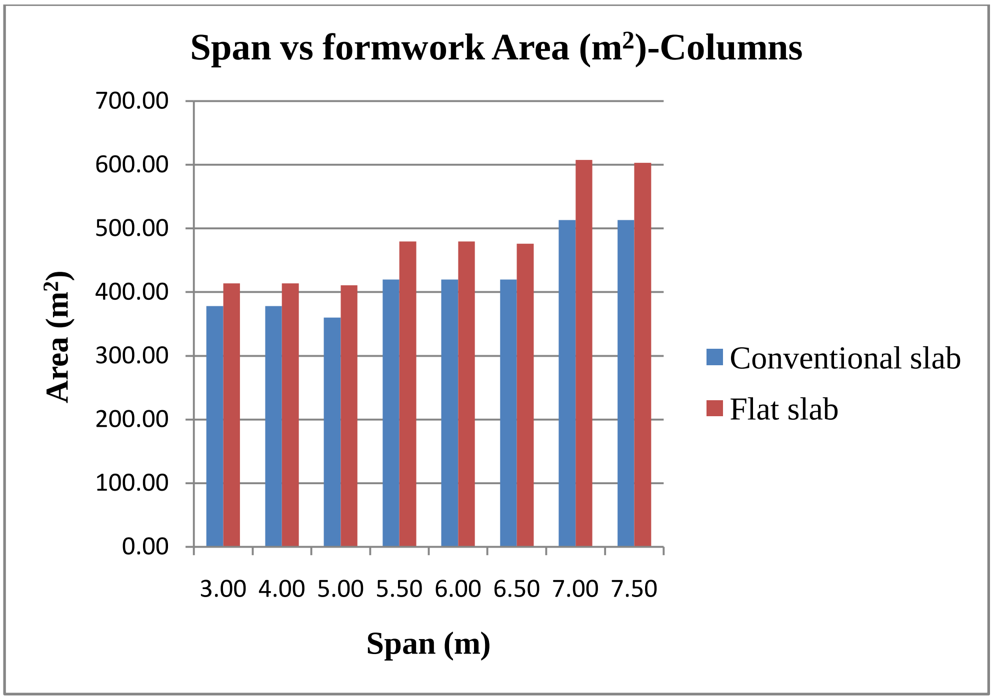


Figure 5.9-Span vsformwork area (m^2)-Columns

Table 5.9- Percentage saving for formwork(m^2) respect to conventional slab

Span	% saving for formwork(m^2) respect to conventional slab		
	Slab	Beam	Column
3.00	-16.33	60.00	-9.52
4.00	-12.00	58.54	-9.52
5.00	-9.42	57.14	-14.17
5.50	-8.53	55.81	-14.17
6.00	-7.80	54.55	-14.17
6.50	-7.15	53.33	-13.33
7.00	-6.60	52.17	-18.42
7.50	-6.12	51.06	-17.54

It shows that quantity of formwork for flat slab is 6%-16% higher than conventional slab. Quantity of formwork of beam for flat slab is 51%-60% less than conventional slab structure with the span.Quantity of formwork of column for flat slab is 9%-18% higher than conventional slab structure with the span.

Table 5.10 -Total Material requirement for conventional slab and flat slab

Span (m)	Conventional slab			Flat slab		
	Concrete	R/F	Formwork	Concrete	R/F	Formwork
3.00	164.57	18.48	1,316.88	138.82	14.32	1,168.20
4.00	247.61	27.21	1,894.75	213.22	22.20	1,688.47
5.00	419.71	44.20	2,811.09	359.08	37.28	2,440.41
5.50	501.68	49.90	3,315.74	435.13	43.75	2,912.76
6.00	577.26	69.78	3,796.98	504.59	58.35	3,353.20
6.50	720.07	79.39	4,266.17	645.85	68.51	3,809.65
7.00	967.64	86.82	5,245.27	863.80	79.03	4,619.05
7.50	1,216.34	99.05	5,803.29	1,110.16	87.34	5158.53

Table 5.11- Total cost for conventional slab and flat slab

Span(m)	Floor Area(m^2)	Conventional slab	Flat slab	% saving of cost of labour and material over conventional slab
		Total cost for concrete,f/w,r/f (Rs)	Total cost for concrete,f/w,r/f (Rs)	
3.00	144.00	11,236,116.66	9,364,977.67	16.65
4.00	256.00	16,511,565.10	14,111,470.45	14.54
5.00	400.00	26,353,267.68	22,532,293.82	14.50
5.50	484.00	32,241,248.33	27,654,001.23	14.23
6.00	576.00	38,440,834.11	33,103,239.29	13.89
6.50	676.00	45,229,901.54	39,115,542.60	13.52
7.00	784.00	53,655,856.94	47,090,752.93	12.24
7.50	900.00	62,805,654.34	56,220,495.65	10.48

Table 5.12 -Total cost per m^2 for conventional slab and flat slab

Span(m)	Floor Area(m^2)	Conventional slab	Flat slab	% saving of cost of labour and material over conventional slab
		Total cost per $m^2$for concrete,f/w,r/f (Rs)	Total cost per m^2 for concrete,f/w,r/f (Rs)	
3.00	144.00	78,028.59	65,034.57	16.65
4.00	256.00	64,498.30	55,122.93	14.54
5.00	400.00	65,883.17	56,330.73	14.50
5.50	484.00	66,614.15	57,136.37	14.23
6.00	576.00	66,737.56	57,470.90	13.89
6.50	676.00	66,908.14	57,863.23	13.52
7.00	784.00	68,438.59	60,064.74	12.24
7.50	900.00	69,784.06	62,467.22	10.48

It shows that total cost difference for flat slab structure and beam slab structure decreases when the span increases. Around 10%-16% less than conventional slab structure.But for 8.0m span for flat slab shear check is marginaly ok and for 8.5m span flat slab shear check is not satisfactory and shear reinforcement to be provided.(refer Table 5.13). Then the slab reinforcement cost for flat slab increases and further more it is not econmical.

However for other advantages disscussed in Chapter 2 can be raised for flat slab for higher spans.

Table 5.13- shear check for 8.0m span and 8.5m span

Span (m)	Shear stress v (N/mm^2)	Shear capacity v_c (N/mm^2)
8.0	0.52	0.53
8.5	0..54	0.51

Table 5.14 –Comparisonof axial load on columns

Span (m)	SAP2000 results for conventional slab (A)	SAP2000 results For flat slab (B)	((A)-(B))*100/A %
3.00	799.77 kN	647.91 kN	18.99
4.00	1,265.12kN	1,051.07 kN	16.92
5.00	2,079.29 kN	1,793.55 kN	13.74
5.50	2,510.26kN	2,190.06 kN	12.75
6.00	2,965.42 kN	2,600.36kN	12.31
6.50	3,449.39kN	3,055.54 kN	11.42
7.00	4,213.19kN	3,744.36kN	11.13
7.50	4,553.86 kN	4,050.65 kN	11.05

Weight of flat slab structure is 11% to 19% lower than conventional slab structure.

According to this case study, when considering various spans 3m,4m,5m,5.5m,6m,6.5m,7m,7.5m it can be summarized as below.

- Quantity of concrete for beams is about 60%-69% less in flat slab structures than the conventional slab structures with the span. Quantity of concrete of column is 0.5%-3% higher in flat slab structures than the conventional slab structures with the span.
- Quantity of steel for flat slab is more than 35%-45% higher than conventional slab for larger spans.
- Quantity of steel for beams is 69% less than conventional slab structures with the span. Quantity of steel for columns is around 15% less than conventional slab structure with the span.
- Quantity of formwork for flat slab is 6%-16% higher than conventional slab. Quantity of formwork for beamsin flat slab structures is 51%-60% less than conventional slab structures with the span.
- Quantity of formwork for columnsin flat slab structures is 9%-18% higher than conventional slab structures with the span.
- Total cost for flat slab structures is 10%-16% less than conventional slab structures.When span increases, % saving is decreases. For more than 7.5m span, shear is critical and shear reinforcements should be provided to safeguard against punching.Then overall cost of flat slab structures is not much more economical than beam slab structures.

5.2 Comparison between previous studies

Cost comparison between conventional and flat slab structures has been done previously and it was done for Ground level+ 3 slab building model having floor plan of 30m x 30m in square.The floor plan is devided into 7.5m x 7.5m bays with dead load on floors finishing 1.5 $kN/m^2$and live load on floor 3 kN/m^2. In that research, only the steel and concrete variations were compared. It was assumed that grade 25 concrete was used for concreting.

Table 5.15- results comparison

Item	Previous research results for 7.5m span	Results regarding this thesis for 7.5m span
Quantity and cost of concrete of beam for flat slab is less than conventional slab	68.00%	60.00%
Quantity and cost of steel of beam for flat slab is less than conventional slab	84.48%	66.57%
Quantity and cost of steel of column for flat slab is less than conventional slab	15.48%	14.99%
Cost of concrete and steel for conventional slab is less than flat slab	42.42%	31.88%
Cost of concrete and steel for flat slab structure is less than conventional slab	15.80%	10.25%

It is difficult to compare the both results because material properties,member dimensions and loadings are different with this research.

Some other similar topics has been done for flat slab and conventional slabs.

- Comparative study of flat slab and conventional slab structure using ETABS for different earthquake zones of India.

- Comparative study of flat slabs and conventional RC slabs in high seismic zone.

- Comparative study of flat slab with old traditional two way slab.

Chapter 6

RESULTS AND CONCLUSION

6.1 Conclusion

Based on the analysis results the following conclusions are drawn. Weight of flat slab structure is quite low as compared to conventional slab structure.Flat slab structure is more economical than that of conventional slab structure for spans smaller than 8m.However, flat slab structuresenhance the aesthetic view and yet allow the architect to have great freedom of form works, the ease of placement of flexural reinforcement, the ease of casting concrete, the free space for water, air pipes, etc. between slab and a possible furred ceiling, the reduction of building height in multi-story structures by saving one story height, etc. flat slab structures are the best solution for high rise structures as compared to conventional slab structures.

When considering the results of this case study, following conclusions can be made.

- Quantity of concrete for beams is 60% less than conventional slab structure with the span.
- Quantity of concrete for columns is 0.5%-3% higher than conventional slab structures with the span.
- Quantity of steel for flat slab is more than 35%-45% higher than conventional slab.
- Quantity of steel for beam is 69% less than conventional slab structuresfor higher spans.
- Quantity of steel for column is 15% less than conventional slab structure with the span.
- Quantity of formwork for flat slab is 6%-16% higher than conventional slab.
- Quantity of formwork of beam for flat slab is 51%-60% less than conventional slab structure with the span.
- Quantity of formwork of column for flat slab is 9%-18% higher than conventional slab structure with the span.

- Total cost for flat slab structure is 10%-16% less than conventional slab structure.

6.2 Recommendations for future works

The performance of flat slab building under seismic loading is poor as compared to frame structures due to lack of frame action which leads to excessive lateral deformation. In flat slab building the most vulnerable part is slab column joint. The failure mode depends upon the type and extent of loading.Punching failure of flat slab can occur as a result of transfer of shearing force and unbalanced moment between slab and column.

Buildings with flat plate design is generally less rigid. Lateral stiffness depends largely on the configuration of lift core position, layout of walls and columns. Frame action is normally insufficient to resist lateral loads in high rise buildings, it needs to act in tendon with walls and lift cores to achieve the required stiffness.Hence it is necessary to do research to find out the behavior of flat slab for seismic conditions.

REFERENCES

[1]. British Standard, BS 8110: part 1: 1985 "Code of practice for Structural use of concrete". Amendment no.03, published and effective from March 1993.

[2]. British Standard, BS 6399: part 1:1996: "Code of practice for dead and imposed loads". Publishe September 1996.

[3].W.P.Dias “Graded Examples in reinforced concrete Design”.Example-16 flat slabs. Published in 1995 by Society of Structural Engineers Sri Lanka.

[4].Sap 2000 version 14.0, integrated software for structured Analysis and Design. Analysis Reference Manual, Computers and structures.

[5].W.H.Mosley and J.H.Bungey“Reinforced concrete design”.

[6].Charles E.Reynolds and James C Steedman “Reinforced concrete designer’s hand book”. Published by E and F.N. Spon Ltd. in 1988, 10th edition.

[7].International Research Journal of Engineering and Technology(IRJET) Volume:02 Issue:03,june -2015.

[8].Robert Park William L.Gamble “Reinforced concrete slabs .”,2nd edition.

[9].The constructor-Civil Engineering Home “Flat slabs-Type of flat slab design and its advantages.”

[10].Civil Digital.com “Flat Slab Floor System. Advantages and Disadvantages of Flat Slabs.”

[11].A.H.Allen “Reinforced Concrete Design to BS 8110 simply explained.”,Flat slab consruction. Published by E and F.N. Spon Ltd. in 1988.

[12].British Standard BS 648:1964 “Schedule of weights of building materials”.

[13].Comparative Study of Flat Slab with Old Traditional Two Way Slab. Vol. 4 Issue 2 July 2014.

[14].Cost Comparison Between flat slab with drop and without drop in four story lateral load building. B.V.M.Engineering College, V.V.Nagar, Gujarat, India, 13-14 May 2011.

[15].Cost Comparison between conventional and flat slab structures. International Research Journal of Engineering and Technology.Volume: 02 Issue: 03 | June-2015

[16].Difference between Flat slab and Conventional slab beam system. Gharedia.com/website.

[17].Cost comparison between conventional and flat slab structures. IRJET journal.

[18].Types of flat slab design. http://theconstructor.org

[19].Types of flat slabs. www,dailycivil.com.

[20].General Mechanism of flat slab failures. http://civildigital.com

[21].Comparison of calculation of axial loads on columns by tributary area method and 3D modeling by SAP2000Article (PDF Available) *in* Journal of Civil and Structural Engineering VOLUME 3(NO.2): November 2012.

[22].Types of slabs. http://civilread.com

Appendix A

A.1 Calculation - Selection of section dimensions of 4 storied building 7.5m span

The section dimension of slabs and beams are selected so that the deflection criterion could be satisfied. It is assumed that the flexural and shear resistance required will be provided by using sufficient amount of reinforcement.

<u>Slab thickness</u>

Select thickness as 250 mm

Clear cover to r/f	= 20 mm
Effective depth (Assuming r/f bars of 12 mm Φ)	= 250 - 20 - 10/2
	= 225 mm
Span / Effective depth	= 7500 / 225
	= 33.33
Basic (Span/ Eff depth) for continuous slabs	= 26
Required modification factor for tension r/f	= 33.33/26
	= 1.28

This can be easily achieved. Therefore, use slab thickness of 250 mm

<u>Beam dimensions</u>

Select depth as 750 mm

Clear cover to r/f = 25 mm

Effective depth (assuming r/f bars and links of 20 mm Φ and 10 mm Φ)

	= 750 - 25 - 10 - 20/2
	= 705 mm
Long span / effective depth	= 7500 / 705 = 10.63

This is a reasonable value.

Also select beam width as 300 mm

Therefore, use beam dimensions of 750mm x 300mm

Column dimensions

Select, floor to floor height = 3.6 m

Considering a typical internal column loaded from a tributary area of 7.5m x 7.5 m

Self weight of slab = 7.5 x 7.5 x 0.25 x 24 = 337.5 kN

Weight of finishes and services (1.5 kN/m^2) = 7.5 x 7.5 x 1.5 = 84.375 kN

Weight of partitions (1.0 kN/m^2) = 7.5 x 7.5 x 1 = 56.25kN

Weight of beams = (7.5 + 7.5) x (0.75-0.25) x 24 x 0.3 =54kN

Total dead load = 532.125 kN

Imposed Loads (2.5 kN/m^2) = 7.5 x 7.5 x 2.5 = 140.625 kN

Design load per floor = 1.4 x 532.125 + 1.6 x 140.625 = 969.975kN

Ground to 4th floor

Trial column size from ground to 4th floor = 450 mm x 450 mm

Total column load at groundfloor = 4 x 969.975 + 0.45x 0.45 x 3.6 x 4 x 24 x 1.4

= 3,977.88kN

Assuming columns are axially loaded primarily and Grade 30 concrete with tor steel reinforcement (fy = 460 N/mm2) percentage of 2.0% of gross cross section,

$N = 0.35\ A_c f_{cu} + 0.67\ A_{sc} f_y$

$N = 0.35\ Ac \times 30 + 0.67 \times 0.02\ A_c \times 460$

$N = 16.66\ Ac$

$A_c = N/16.66$

$= 3,977.88 \times 1000 / 16.66$

$= 238,769.31 mm^2$

Assumed size of 450 mm x 450 mm is approximately satisfactory.

A.2 Calculation-A specimen calculation for interior slab panel for conventional slab beam.

Shorter span BM coefficient	=	0.024
Longer span BM coefficient	=	0.24
Interior support BM coefficient	=	0.032
Dead load	=	$0.25 \times 24 + 1.5 + 1$
	=	8.5 kN / m^2
Imposed load (office building)	=	2.5 kN / m^2
Design Load	=	$1.4 \times 8.5 + 1.6 \times 2.5$
	=	15.9 kN / m^2

BM for shorter span (before distribution)	= 0.024 (15.9) $(7.5)^{2}$
	=21.46kNm/m
BM for shorter span (after distribution)	=20.84kNm/m
K	$=M/bd^2*f_{cu}$
	$= 20.84*10^6/(1000*225^2*30)$
	=0.014
Hence compression r/f not required.)	
Z	$=d*(0.5+(0.25-k/0.9)^{0.5}$
	=0.98d<0.95d
Z	=0.95d
	=213.75mm
Area of reinforcement required	=M/0.87fyZ
	=243.62mm^2
Minimum r/f requirement	=325mm^2

Provide T10 200mm spacing

Check for deflection[1]-Table 3.11.

f_s	=	$(5*f_y*A_s$ required)/(8*A_s provided)
	=	178.28
f_1	=	2
Allowable deflection	=	f1*(span/effective depth)
	=	2*26 (interior panel)
Actual deflection	=	Actual span/Actual effective depth
	=	7500/225
	=	33.33
Actual deflection	<	Allowable deflection

Hence deflection ok.

T10 200mm spacing satisfactory.

BM for Longer span (BM before dis.) = 0.024 (15.9) $(7.5)^2$

=21.46kNm/m

BM for Longer span (BM after dis.) =20.71kNm/m

Similarly T10 @200mm c/c

BM for Interior support (BM before dis.) = 0.032 (15.9) $(7.5)^2$

= 28.62kNm/m

BM for Interior support (BM after dis.) = 31.17kNm/m

Similarly T10 @200mm c/c

A.3 Calculation-A Specimen calculation for interior slab panel for flat slab.

It will be assumed that the slab is without drops, and the maximum value of effective diameter will be employed for column heads.[3].-Example 16

Slab thickness	
Maximum value of h_C	=(1/4)(7.5) = 1.875 ^{m}
Assuming trial ${}^{span}/_{depth}$ of 32	
Effective depth	= ${}^{7500}/_{32}$= 234.375
H	= 234 .375 + 20 + 5
	= 259. 375
	Assumed depth as 250mm
d_{long}	= 250 – 20 - ${}^{10}/_{2}$ = 225mm
d_{short}	= 225-10 = 215 mm
d_{av}	= 220 mm
Panel Area	= 7.5 ^{m}× 7.5^{m} = 56 .26 ^{m2}
Self load	= 0.25× 56 .25 × 24
	= 337. 5 kN
Finishes	= 1.5 × 56. 25
	= 84 . 375 kN
Partition	= 1.0 × 56. 25
	= 56. 25 kN
Total dead load	= 478.125kN
Total Imposed Load	= 2.5×56 .25
	= 140.625 kN
Design load	= 1.4 × 478 .125
	+ 1.6 ×140 . 625
	= 894. 375 kN

BM long way [1]-Table 3.19.

Effective span	=7.5-(2/3)*1.875m
	=6.25m
Span moment	= (0.071) (894.375) 6.25
	= 396.88kNm

Check for deflection

Total span moment	=396.88kN/m
M/bd^2	$=396.88x10^6/(7500)(225^2)$
	=1.04

If $A_{s,required}=A_{s,provided}$, $f_s=288N/mm^2$

Modification factor for tension r/f	=1.38
Allowable span/effective depth	=26*1.38=35.88
Actual span/effective depth	=7500/225=33.33

Allowable span/effective depth>Actual span/effective depth

Hence ok.

[1]-Table 3.20.

Column Strip (3.75^m)	= (0.55) ×396.88
	= 218.28kNm
Column Strip per m	=58.2kNm

Similarly T12 @150mm c/c

Mid Strip (3.75^m)	= (0.45) ×396.88
	= 178.6kNm
Mid Strip per m	=47.63kNm

Similarly T12 @200mm c/c

Support moment	=(0.055)(894.375) (6.25)
	= 307.44kNm

Column Strip (3.75^m) = 0.75 × (307.44)

= 230.58kNm

Total reinforcement requirement = $2695mm^2$

As per BS code clause3.7.3.1

Total reinforcement requirement for Central half of the column strip } =2695*2/3

=$1796mm^2$

Reinforcement requirement per m =1796/1.875

=$957.87mm^2$

Similarly T12 @100mm c/c for central half of column strip and edges T12 @ 200mmc/c

Mid Strip (3.75^m) = 0.25× (307.44)

= 76.86kNm

Mid Strip per m =20.45kNm

Similarly T12 @250mm c/c

<u>Check for shear</u>

If square columns are used size of column head $=(\pi(1.875/2)^2)^{0.5}$

=1.66m

Perimeter of column head =1.66*4

=6.64m

1st critical perimeter =(2*1.5*0.22+1.66)*4

=2.32*4m

Area within perimeter =2.32*2.32

=$5.38m^2$

V_t =894.375Kn

$V_{effective}$ =(1.15)*894.375kN

=1028.53kN

v_{max} =V/bd

=1028.53*10^3/(6.64*10^3*220)

=0.7

Load on 1st perimeter =(894.375/56.25)*(56.25-5.38)

=808.8kN

v =(1.15*808.8*10^3)/2.32*4*10^3*220

=0.45N/mm^2

Reinforcement provided at the support for 3.75m length Longer direction } =3394.3mm^2

Reinforcement provided at the support for 3.75m length Shorter direction } =3394.3mm^2

Reinforcement provided at the support for 3.75m length (Average) } =3394.35mm^2

V_c=0.79*(100*A_s/bd)$^{1/3}$*(400/d)$^{1/4}$/1.25

V_c=0.79*(100*3394.3/3750*220)$^{1/3}$*(400/220)$^{1/4}$/1.25

V_c=0.79*(0.74)*(1.16)/1.25=0.68/1.25=0.54

v <v_c

Hence shear r/f not required.

Similar calculation has been done for 8.0m and 8.5m span flat slabs.

For 8.0m span v =0.52N/mm^2

v_c =0.53N/mm^2

Shear r/f marginally ok.

For 8.5m span v =0.54N/mm^2

v_c =0.51N/mm^2

Shear not satisfactory.

Shear reinforcement to be provided.

APPENDIX B.1

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
1	0	COMB1	Combination	-1,746.90	-28.67	-28.67	0.00	0.00
1	0.375	COMB1	Combination	-1,744.35	-28.67	-28.67	10.75	10.75
1	0.375	COMB1	Combination	-1,744.35	-28.67	-28.67	10.75	10.75
1	0.75	COMB1	Combination	-1,741.80	-28.67	-28.67	21.51	21.51
1	0.75	COMB1	Combination	-1,741.80	-28.67	-28.67	21.51	21.51
1	1.125	COMB1	Combination	-1,739.25	-28.67	-28.67	32.26	32.26
1	1.125	COMB1	Combination	-1,739.25	-28.67	-28.67	32.26	32.26
1	1.5	COMB1	Combination	-1,736.70	-28.67	-28.67	43.01	43.01
2	0	COMB1	Combination	-1,538.69	-42.83	-42.83	-61.56	-61.56
2	0.9	COMB1	Combination	-1,532.57	-42.83	-42.83	-23.01	-23.01
2	0.9	COMB1	Combination	-1,532.57	-42.83	-42.83	-23.01	-23.01
2	1.8	COMB1	Combination	-1,526.44	-42.83	-42.83	15.54	15.54
2	1.8	COMB1	Combination	-1,526.44	-42.83	-42.83	15.54	15.54
2	2.7	COMB1	Combination	-1,520.32	-42.83	-42.83	54.08	54.08
2	2.7	COMB1	Combination	-1,520.32	-42.83	-42.83	54.08	54.08
2	3.6	COMB1	Combination	-1,514.20	-42.83	-42.83	92.63	92.63
3	0	COMB1	Combination	-1,136.32	-66.32	-66.32	-120.30	-120.30
3	0.9	COMB1	Combination	-1,130.20	-66.32	-66.32	-60.61	-60.61
3	0.9	COMB1	Combination	-1,130.20	-66.32	-66.32	-60.61	-60.61
3	1.8	COMB1	Combination	-1,124.07	-66.32	-66.32	-0.92	-0.92
3	1.8	COMB1	Combination	-1,124.07	-66.32	-66.32	-0.92	-0.92
3	2.7	COMB1	Combination	-1,117.95	-66.32	-66.32	58.76	58.76

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
3	2.7	COMB1	Combination	-1,117.95	-66.32	-66.32	58.76	58.76
3	3.6	COMB1	Combination	-1,111.83	-66.32	-66.32	118.45	118.45
4	0	COMB1	Combination	-724.39	-65.11	-65.11	-117.30	-117.30
4	0.9	COMB1	Combination	-718.26	-65.11	-65.11	-58.70	-58.70
4	0.9	COMB1	Combination	-718.26	-65.11	-65.11	-58.70	-58.70
4	1.8	COMB1	Combination	-712.14	-65.11	-65.11	-0.09	-0.09
4	1.8	COMB1	Combination	-712.14	-65.11	-65.11	-0.09	-0.09
4	2.7	COMB1	Combination	-706.02	-65.11	-65.11	58.51	58.51
4	2.7	COMB1	Combination	-706.02	-65.11	-65.11	58.51	58.51
4	3.6	COMB1	Combination	-699.89	-65.11	-65.11	117.11	117.11
5	0	COMB1	Combination	-307.23	-77.22	-77.22	-130.63	-130.63
5	0.9	COMB1	Combination	-301.10	-77.22	-77.22	-61.13	-61.13
5	0.9	COMB1	Combination	-301.10	-77.22	-77.22	-61.13	-61.13
5	1.8	COMB1	Combination	-294.98	-77.22	-77.22	8.37	8.37
5	1.8	COMB1	Combination	-294.98	-77.22	-77.22	8.37	8.37
5	2.7	COMB1	Combination	-288.86	-77.22	-77.22	77.87	77.87
5	2.7	COMB1	Combination	-288.86	-77.22	-77.22	77.87	77.87
5	3.6	COMB1	Combination	-282.73	-77.22	-77.22	147.37	147.37
6	0	COMB1	Combination	-2,909.71	-2.38	-0.18	0.00	0.00
6	0.375	COMB1	Combination	-2,907.16	-2.38	-0.18	0.07	0.89
6	0.375	COMB1	Combination	-2,907.16	-2.38	-0.18	0.07	0.89
6	0.75	COMB1	Combination	-2,904.61	-2.38	-0.18	0.14	1.78
6	0.75	COMB1	Combination	-2,904.61	-2.38	-0.18	0.14	1.78
6	1.125	COMB1	Combination	-2,902.06	-2.38	-0.18	0.20	2.67
6	1.125	COMB1	Combination	-2,902.06	-2.38	-0.18	0.20	2.67

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
6	1.5	COMB1	Combination	-2,899.51	-2.38	-0.18	0.27	3.56
7	0	COMB1	Combination	-2,659.05	-45.34	4.07	5.27	-49.63
7	0.9	COMB1	Combination	-2,652.93	-45.34	4.07	1.61	-8.83
7	0.9	COMB1	Combination	-2,652.93	-45.34	4.07	1.61	-8.83
7	1.8	COMB1	Combination	-2,646.81	-45.34	4.07	-2.05	31.98
7	1.8	COMB1	Combination	-2,646.81	-45.34	4.07	-2.05	31.98
7	2.7	COMB1	Combination	-2,640.68	-45.34	4.07	-5.70	72.78
7	2.7	COMB1	Combination	-2,640.68	-45.34	4.07	-5.70	72.78
7	3.6	COMB1	Combination	-2,634.56	-45.34	4.07	-9.36	113.59
8	0	COMB1	Combination	-1,971.43	-94.61	5.58	11.07	-172.36
8	0.9	COMB1	Combination	-1,965.31	-94.61	5.58	6.05	-87.21
8	0.9	COMB1	Combination	-1,965.31	-94.61	5.58	6.05	-87.21
8	1.8	COMB1	Combination	-1,959.19	-94.61	5.58	1.03	-2.06
8	1.8	COMB1	Combination	-1,959.19	-94.61	5.58	1.03	-2.06
8	2.7	COMB1	Combination	-1,953.06	-94.61	5.58	-3.99	83.09
8	2.7	COMB1	Combination	-1,953.06	-94.61	5.58	-3.99	83.09
8	3.6	COMB1	Combination	-1,946.94	-94.61	5.58	-9.01	168.23
9	0	COMB1	Combination	-1,279.65	-91.24	2.83	5.71	-164.62
9	0.9	COMB1	Combination	-1,273.52	-91.24	2.83	3.16	-82.51
9	0.9	COMB1	Combination	-1,273.52	-91.24	2.83	3.16	-82.51
9	1.8	COMB1	Combination	-1,267.40	-91.24	2.83	0.60	-0.40
9	1.8	COMB1	Combination	-1,267.40	-91.24	2.83	0.60	-0.40
9	2.7	COMB1	Combination	-1,261.28	-91.24	2.83	-1.95	81.72
9	2.7	COMB1	Combination	-1,261.28	-91.24	2.83	-1.95	81.72
9	3.6	COMB1	Combination	-1,255.15	-91.24	2.83	-4.50	163.83

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
10	0	COMB1	Combination	-585.48	-117.11	4.69	6.91	-193.42
10	0.9	COMB1	Combination	-579.36	-117.11	4.69	2.69	-88.01
10	0.9	COMB1	Combination	-579.36	-117.11	4.69	2.69	-88.01
10	1.8	COMB1	Combination	-573.23	-117.11	4.69	-1.53	17.39
10	1.8	COMB1	Combination	-573.23	-117.11	4.69	-1.53	17.39
10	2.7	COMB1	Combination	-567.11	-117.11	4.69	-5.76	122.79
10	2.7	COMB1	Combination	-567.11	-117.11	4.69	-5.76	122.79
10	3.6	COMB1	Combination	-560.99	-117.11	4.69	-9.98	228.19
11	0	COMB1	Combination	-2,803.35	-2.05	0.00	0.00	0.00
11	0.375	COMB1	Combination	-2,800.80	-2.05	0.00	0.00	0.77
11	0.375	COMB1	Combination	-2,800.80	-2.05	0.00	0.00	0.77
11	0.75	COMB1	Combination	-2,798.24	-2.05	0.00	0.00	1.54
11	0.75	COMB1	Combination	-2,798.24	-2.05	0.00	0.00	1.54
11	1.125	COMB1	Combination	-2,795.69	-2.05	0.00	0.00	2.30
11	1.125	COMB1	Combination	-2,795.69	-2.05	0.00	0.00	2.30
11	1.5	COMB1	Combination	-2,793.14	-2.05	0.00	0.00	3.07
12	0	COMB1	Combination	-2,556.38	-43.95	0.00	0.00	-47.98
12	0.9	COMB1	Combination	-2,550.26	-43.95	0.00	0.00	-8.42
12	0.9	COMB1	Combination	-2,550.26	-43.95	0.00	0.00	-8.42
12	1.8	COMB1	Combination	-2,544.14	-43.95	0.00	0.00	31.13
12	1.8	COMB1	Combination	-2,544.14	-43.95	0.00	0.00	31.13
12	2.7	COMB1	Combination	-2,538.01	-43.95	0.00	0.00	70.69
12	2.7	COMB1	Combination	-2,538.01	-43.95	0.00	0.00	70.69
12	3.6	COMB1	Combination	-2,531.89	-43.95	0.00	0.00	110.25
13	0	COMB1	Combination	-1,902.41	-92.35	0.00	0.00	-167.96

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
13	0.9	COMB1	Combination	-1,896.29	-92.35	0.00	0.00	-84.85
13	0.9	COMB1	Combination	-1,896.29	-92.35	0.00	0.00	-84.85
13	1.8	COMB1	Combination	-1,890.16	-92.35	0.00	0.00	-1.74
13	1.8	COMB1	Combination	-1,890.16	-92.35	0.00	0.00	-1.74
13	2.7	COMB1	Combination	-1,884.04	-92.35	0.00	0.00	81.38
13	2.7	COMB1	Combination	-1,884.04	-92.35	0.00	0.00	81.38
13	3.6	COMB1	Combination	-1,877.92	-92.35	0.00	0.00	164.49
14	0	COMB1	Combination	-1,233.47	-89.72	0.00	0.00	-161.74
14	0.9	COMB1	Combination	-1,227.35	-89.72	0.00	0.00	-80.99
14	0.9	COMB1	Combination	-1,227.35	-89.72	0.00	0.00	-80.99
14	1.8	COMB1	Combination	-1,221.22	-89.72	0.00	0.00	-0.25
14	1.8	COMB1	Combination	-1,221.22	-89.72	0.00	0.00	-0.25
14	2.7	COMB1	Combination	-1,215.10	-89.72	0.00	0.00	80.50
14	2.7	COMB1	Combination	-1,215.10	-89.72	0.00	0.00	80.50
14	3.6	COMB1	Combination	-1,208.97	-89.72	0.00	0.00	161.24
15	0	COMB1	Combination	-555.85	-115.34	0.00	0.00	-190.55
15	0.9	COMB1	Combination	-549.73	-115.34	0.00	0.00	-86.74
15	0.9	COMB1	Combination	-549.73	-115.34	0.00	0.00	-86.74
15	1.8	COMB1	Combination	-543.61	-115.34	0.00	0.00	17.06
15	1.8	COMB1	Combination	-543.61	-115.34	0.00	0.00	17.06
15	2.7	COMB1	Combination	-537.48	-115.34	0.00	0.00	120.86
15	2.7	COMB1	Combination	-537.48	-115.34	0.00	0.00	120.86
15	3.6	COMB1	Combination	-531.36	-115.34	0.00	0.00	224.67
16	0	COMB1	Combination	-2,909.71	-2.38	0.18	0.00	0.00
16	0.375	COMB1	Combination	-2,907.16	-2.38	0.18	-0.07	0.89

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
16	0.375	COMB1	Combination	-2,907.16	-2.38	0.18	-0.07	0.89
16	0.75	COMB1	Combination	-2,904.61	-2.38	0.18	-0.14	1.78
16	0.75	COMB1	Combination	-2,904.61	-2.38	0.18	-0.14	1.78
16	1.125	COMB1	Combination	-2,902.06	-2.38	0.18	-0.20	2.67
16	1.125	COMB1	Combination	-2,902.06	-2.38	0.18	-0.20	2.67
16	1.5	COMB1	Combination	-2,899.51	-2.38	0.18	-0.27	3.56
17	0	COMB1	Combination	-2,659.05	-45.34	-4.07	-5.27	-49.63
17	0.9	COMB1	Combination	-2,652.93	-45.34	-4.07	-1.61	-8.83
17	0.9	COMB1	Combination	-2,652.93	-45.34	-4.07	-1.61	-8.83
17	1.8	COMB1	Combination	-2,646.81	-45.34	-4.07	2.05	31.98
17	1.8	COMB1	Combination	-2,646.81	-45.34	-4.07	2.05	31.98
17	2.7	COMB1	Combination	-2,640.68	-45.34	-4.07	5.70	72.78
17	2.7	COMB1	Combination	-2,640.68	-45.34	-4.07	5.70	72.78
17	3.6	COMB1	Combination	-2,634.56	-45.34	-4.07	9.36	113.59
18	0	COMB1	Combination	-1,971.43	-94.61	-5.58	-11.07	-172.36
18	0.9	COMB1	Combination	-1,965.31	-94.61	-5.58	-6.05	-87.21
18	0.9	COMB1	Combination	-1,965.31	-94.61	-5.58	-6.05	-87.21
18	1.8	COMB1	Combination	-1,959.19	-94.61	-5.58	-1.03	-2.06
18	1.8	COMB1	Combination	-1,959.19	-94.61	-5.58	-1.03	-2.06
18	2.7	COMB1	Combination	-1,953.06	-94.61	-5.58	3.99	83.09
18	2.7	COMB1	Combination	-1,953.06	-94.61	-5.58	3.99	83.09
18	3.6	COMB1	Combination	-1,946.94	-94.61	-5.58	9.01	168.23
19	0	COMB1	Combination	-1,279.65	-91.24	-2.83	-5.71	-164.62
19	0.9	COMB1	Combination	-1,273.52	-91.24	-2.83	-3.16	-82.51
19	0.9	COMB1	Combination	-1,273.52	-91.24	-2.83	-3.16	-82.51

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
19	1.8	COMB1	Combination	-1,267.40	-91.24	-2.83	-0.60	-0.40
19	1.8	COMB1	Combination	-1,267.40	-91.24	-2.83	-0.60	-0.40
19	2.7	COMB1	Combination	-1,261.28	-91.24	-2.83	1.95	81.72
19	2.7	COMB1	Combination	-1,261.28	-91.24	-2.83	1.95	81.72
19	3.6	COMB1	Combination	-1,255.15	-91.24	-2.83	4.50	163.83
20	0	COMB1	Combination	-585.48	-117.11	-4.69	-6.91	-193.42
20	0.9	COMB1	Combination	-579.36	-117.11	-4.69	-2.69	-88.01
20	0.9	COMB1	Combination	-579.36	-117.11	-4.69	-2.69	-88.01
20	1.8	COMB1	Combination	-573.23	-117.11	-4.69	1.53	17.39
20	1.8	COMB1	Combination	-573.23	-117.11	-4.69	1.53	17.39
20	2.7	COMB1	Combination	-567.11	-117.11	-4.69	5.76	122.79
20	2.7	COMB1	Combination	-567.11	-117.11	-4.69	5.76	122.79
20	3.6	COMB1	Combination	-560.99	-117.11	-4.69	9.98	228.19
21	0	COMB1	Combination	-1,746.90	-28.67	28.67	0.00	0.00
21	0.375	COMB1	Combination	-1,744.35	-28.67	28.67	-10.75	10.75
21	0.375	COMB1	Combination	-1,744.35	-28.67	28.67	-10.75	10.75
21	0.75	COMB1	Combination	-1,741.80	-28.67	28.67	-21.51	21.51
21	0.75	COMB1	Combination	-1,741.80	-28.67	28.67	-21.51	21.51
21	1.125	COMB1	Combination	-1,739.25	-28.67	28.67	-32.26	32.26
21	1.125	COMB1	Combination	-1,739.25	-28.67	28.67	-32.26	32.26
21	1.5	COMB1	Combination	-1,736.70	-28.67	28.67	-43.01	43.01
22	0	COMB1	Combination	-1,538.69	-42.83	42.83	61.56	-61.56
22	0.9	COMB1	Combination	-1,532.57	-42.83	42.83	23.01	-23.01
22	0.9	COMB1	Combination	-1,532.57	-42.83	42.83	23.01	-23.01
22	1.8	COMB1	Combination	-1,526.44	-42.83	42.83	-15.54	15.54

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
22	1.8	COMB1	Combination	-1,526.44	-42.83	42.83	-15.54	15.54
22	2.7	COMB1	Combination	-1,520.32	-42.83	42.83	-54.08	54.08
22	2.7	COMB1	Combination	-1,520.32	-42.83	42.83	-54.08	54.08
22	3.6	COMB1	Combination	-1,514.20	-42.83	42.83	-92.63	92.63
23	0	COMB1	Combination	-1,136.32	-66.32	66.32	120.30	-120.30
23	0.9	COMB1	Combination	-1,130.20	-66.32	66.32	60.61	-60.61
23	0.9	COMB1	Combination	-1,130.20	-66.32	66.32	60.61	-60.61
23	1.8	COMB1	Combination	-1,124.07	-66.32	66.32	0.92	-0.92
23	1.8	COMB1	Combination	-1,124.07	-66.32	66.32	0.92	-0.92
23	2.7	COMB1	Combination	-1,117.95	-66.32	66.32	-58.76	58.76
23	2.7	COMB1	Combination	-1,117.95	-66.32	66.32	-58.76	58.76
23	3.6	COMB1	Combination	-1,111.83	-66.32	66.32	-118.45	118.45
24	0	COMB1	Combination	-724.39	-65.11	65.11	117.30	-117.30
24	0.9	COMB1	Combination	-718.26	-65.11	65.11	58.70	-58.70
24	0.9	COMB1	Combination	-718.26	-65.11	65.11	58.70	-58.70
24	1.8	COMB1	Combination	-712.14	-65.11	65.11	0.09	-0.09
24	1.8	COMB1	Combination	-712.14	-65.11	65.11	0.09	-0.09
24	2.7	COMB1	Combination	-706.02	-65.11	65.11	-58.51	58.51
24	2.7	COMB1	Combination	-706.02	-65.11	65.11	-58.51	58.51
24	3.6	COMB1	Combination	-699.89	-65.11	65.11	-117.11	117.11
25	0	COMB1	Combination	-307.23	-77.22	77.22	130.63	-130.63
25	0.9	COMB1	Combination	-301.10	-77.22	77.22	61.13	-61.13
25	0.9	COMB1	Combination	-301.10	-77.22	77.22	61.13	-61.13
25	1.8	COMB1	Combination	-294.98	-77.22	77.22	-8.37	8.37
25	1.8	COMB1	Combination	-294.98	-77.22	77.22	-8.37	8.37

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
25	2.7	COMB1	Combination	-288.86	-77.22	77.22	-77.87	77.87
25	2.7	COMB1	Combination	-288.86	-77.22	77.22	-77.87	77.87
25	3.6	COMB1	Combination	-282.73	-77.22	77.22	-147.37	147.37
26	0	COMB1	Combination	-2,909.71	-0.18	-2.38	0.00	0.00
26	0.375	COMB1	Combination	-2,907.16	-0.18	-2.38	0.89	0.07
26	0.375	COMB1	Combination	-2,907.16	-0.18	-2.38	0.89	0.07
26	0.75	COMB1	Combination	-2,904.61	-0.18	-2.38	1.78	0.14
26	0.75	COMB1	Combination	-2,904.61	-0.18	-2.38	1.78	0.14
26	1.125	COMB1	Combination	-2,902.06	-0.18	-2.38	2.67	0.20
26	1.125	COMB1	Combination	-2,902.06	-0.18	-2.38	2.67	0.20
26	1.5	COMB1	Combination	-2,899.51	-0.18	-2.38	3.56	0.27
27	0	COMB1	Combination	-2,659.05	4.07	-45.34	-49.63	5.27
27	0.9	COMB1	Combination	-2,652.93	4.07	-45.34	-8.83	1.61
27	0.9	COMB1	Combination	-2,652.93	4.07	-45.34	-8.83	1.61
27	1.8	COMB1	Combination	-2,646.81	4.07	-45.34	31.98	-2.05
27	1.8	COMB1	Combination	-2,646.81	4.07	-45.34	31.98	-2.05
27	2.7	COMB1	Combination	-2,640.68	4.07	-45.34	72.78	-5.70
27	2.7	COMB1	Combination	-2,640.68	4.07	-45.34	72.78	-5.70
27	3.6	COMB1	Combination	-2,634.56	4.07	-45.34	113.59	-9.36
28	0	COMB1	Combination	-1,971.43	5.58	-94.61	-172.36	11.07
28	0.9	COMB1	Combination	-1,965.31	5.58	-94.61	-87.21	6.05
28	0.9	COMB1	Combination	-1,965.31	5.58	-94.61	-87.21	6.05
28	1.8	COMB1	Combination	-1,959.19	5.58	-94.61	-2.06	1.03
28	1.8	COMB1	Combination	-1,959.19	5.58	-94.61	-2.06	1.03
28	2.7	COMB1	Combination	-1,953.06	5.58	-94.61	83.09	-3.99

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
28	2.7	COMB1	Combination	-1,953.06	5.58	-94.61	83.09	-3.99
28	3.6	COMB1	Combination	-1,946.94	5.58	-94.61	168.23	-9.01
29	0	COMB1	Combination	-1,279.65	2.83	-91.24	-164.62	5.71
29	0.9	COMB1	Combination	-1,273.52	2.83	-91.24	-82.51	3.16
29	0.9	COMB1	Combination	-1,273.52	2.83	-91.24	-82.51	3.16
29	1.8	COMB1	Combination	-1,267.40	2.83	-91.24	-0.40	0.60
29	1.8	COMB1	Combination	-1,267.40	2.83	-91.24	-0.40	0.60
29	2.7	COMB1	Combination	-1,261.28	2.83	-91.24	81.72	-1.95
29	2.7	COMB1	Combination	-1,261.28	2.83	-91.24	81.72	-1.95
29	3.6	COMB1	Combination	-1,255.15	2.83	-91.24	163.83	-4.50
30	0	COMB1	Combination	-585.48	4.69	-117.11	-193.42	6.91
30	0.9	COMB1	Combination	-579.36	4.69	-117.11	-88.01	2.69
30	0.9	COMB1	Combination	-579.36	4.69	-117.11	-88.01	2.69
30	1.8	COMB1	Combination	-573.23	4.69	-117.11	17.39	-1.53
30	1.8	COMB1	Combination	-573.23	4.69	-117.11	17.39	-1.53
30	2.7	COMB1	Combination	-567.11	4.69	-117.11	122.79	-5.76
30	2.7	COMB1	Combination	-567.11	4.69	-117.11	122.79	-5.76
30	3.6	COMB1	Combination	-560.99	4.69	-117.11	228.19	-9.98
31	0	COMB1	Combination	-4,553.86	-6.74	-6.74	0.00	0.00
31	0.375	COMB1	Combination	-4,551.31	-6.74	-6.74	2.53	2.53
31	0.375	COMB1	Combination	-4,551.31	-6.74	-6.74	2.53	2.53
31	0.75	COMB1	Combination	-4,548.76	-6.74	-6.74	5.05	5.05
31	0.75	COMB1	Combination	-4,548.76	-6.74	-6.74	5.05	5.05
31	1.125	COMB1	Combination	-4,546.21	-6.74	-6.74	7.58	7.58
31	1.125	COMB1	Combination	-4,546.21	-6.74	-6.74	7.58	7.58

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
31	1.5	COMB1	Combination	-4,543.66	-6.74	-6.74	10.10	10.10
32	0	COMB1	Combination	-4,441.99	4.71	4.71	4.51	4.51
32	0.9	COMB1	Combination	-4,435.87	4.71	4.71	0.27	0.27
32	0.9	COMB1	Combination	-4,435.87	4.71	4.71	0.27	0.27
32	1.8	COMB1	Combination	-4,429.74	4.71	4.71	-3.97	-3.97
32	1.8	COMB1	Combination	-4,429.74	4.71	4.71	-3.97	-3.97
32	2.7	COMB1	Combination	-4,423.62	4.71	4.71	-8.21	-8.21
32	2.7	COMB1	Combination	-4,423.62	4.71	4.71	-8.21	-8.21
32	3.6	COMB1	Combination	-4,417.49	4.71	4.71	-12.45	-12.45
33	0	COMB1	Combination	-3,310.37	7.58	7.58	15.35	15.35
33	0.9	COMB1	Combination	-3,304.25	7.58	7.58	8.52	8.52
33	0.9	COMB1	Combination	-3,304.25	7.58	7.58	8.52	8.52
33	1.8	COMB1	Combination	-3,298.13	7.58	7.58	1.70	1.70
33	1.8	COMB1	Combination	-3,298.13	7.58	7.58	1.70	1.70
33	2.7	COMB1	Combination	-3,292.00	7.58	7.58	-5.12	-5.12
33	2.7	COMB1	Combination	-3,292.00	7.58	7.58	-5.12	-5.12
33	3.6	COMB1	Combination	-3,285.88	7.58	7.58	-11.94	-11.94
34	0	COMB1	Combination	-2,210.80	3.10	3.10	6.60	6.60
34	0.9	COMB1	Combination	-2,204.68	3.10	3.10	3.81	3.81
34	0.9	COMB1	Combination	-2,204.68	3.10	3.10	3.81	3.81
34	1.8	COMB1	Combination	-2,198.55	3.10	3.10	1.01	1.01
34	1.8	COMB1	Combination	-2,198.55	3.10	3.10	1.01	1.01
34	2.7	COMB1	Combination	-2,192.43	3.10	3.10	-1.78	-1.78
34	2.7	COMB1	Combination	-2,192.43	3.10	3.10	-1.78	-1.78
34	3.6	COMB1	Combination	-2,186.31	3.10	3.10	-4.57	-4.57

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
35	0	COMB1	Combination	-1,129.90	5.74	5.74	7.90	7.90
35	0.9	COMB1	Combination	-1,123.78	5.74	5.74	2.74	2.74
35	0.9	COMB1	Combination	-1,123.78	5.74	5.74	2.74	2.74
35	1.8	COMB1	Combination	-1,117.66	5.74	5.74	-2.42	-2.42
35	1.8	COMB1	Combination	-1,117.66	5.74	5.74	-2.42	-2.42
35	2.7	COMB1	Combination	-1,111.53	5.74	5.74	-7.59	-7.59
35	2.7	COMB1	Combination	-1,111.53	5.74	5.74	-7.59	-7.59
35	3.6	COMB1	Combination	-1,105.41	5.74	5.74	-12.75	-12.75
36	0	COMB1	Combination	-4,393.88	-6.67	0.00	0.00	0.00
36	0.375	COMB1	Combination	-4,391.33	-6.67	0.00	0.00	2.50
36	0.375	COMB1	Combination	-4,391.33	-6.67	0.00	0.00	2.50
36	0.75	COMB1	Combination	-4,388.78	-6.67	0.00	0.00	5.00
36	0.75	COMB1	Combination	-4,388.78	-6.67	0.00	0.00	5.00
36	1.125	COMB1	Combination	-4,386.23	-6.67	0.00	0.00	7.50
36	1.125	COMB1	Combination	-4,386.23	-6.67	0.00	0.00	7.50
36	1.5	COMB1	Combination	-4,383.67	-6.67	0.00	0.00	10.00
37	0	COMB1	Combination	-4,274.83	4.83	0.00	0.00	4.61
37	0.9	COMB1	Combination	-4,268.71	4.83	0.00	0.00	0.27
37	0.9	COMB1	Combination	-4,268.71	4.83	0.00	0.00	0.27
37	1.8	COMB1	Combination	-4,262.59	4.83	0.00	0.00	-4.08
37	1.8	COMB1	Combination	-4,262.59	4.83	0.00	0.00	-4.08
37	2.7	COMB1	Combination	-4,256.46	4.83	0.00	0.00	-8.42
37	2.7	COMB1	Combination	-4,256.46	4.83	0.00	0.00	-8.42
37	3.6	COMB1	Combination	-4,250.34	4.83	0.00	0.00	-12.76
38	0	COMB1	Combination	-3,204.40	7.90	0.00	0.00	15.91

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
38	0.9	COMB1	Combination	-3,198.27	7.90	0.00	0.00	8.81
38	0.9	COMB1	Combination	-3,198.27	7.90	0.00	0.00	8.81
38	1.8	COMB1	Combination	-3,192.15	7.90	0.00	0.00	1.70
38	1.8	COMB1	Combination	-3,192.15	7.90	0.00	0.00	1.70
38	2.7	COMB1	Combination	-3,186.03	7.90	0.00	0.00	-5.41
38	2.7	COMB1	Combination	-3,186.03	7.90	0.00	0.00	-5.41
38	3.6	COMB1	Combination	-3,179.90	7.90	0.00	0.00	-12.52
39	0	COMB1	Combination	-2,139.78	3.42	0.00	0.00	7.17
39	0.9	COMB1	Combination	-2,133.66	3.42	0.00	0.00	4.10
39	0.9	COMB1	Combination	-2,133.66	3.42	0.00	0.00	4.10
39	1.8	COMB1	Combination	-2,127.54	3.42	0.00	0.00	1.02
39	1.8	COMB1	Combination	-2,127.54	3.42	0.00	0.00	1.02
39	2.7	COMB1	Combination	-2,121.41	3.42	0.00	0.00	-2.05
39	2.7	COMB1	Combination	-2,121.41	3.42	0.00	0.00	-2.05
39	3.6	COMB1	Combination	-2,115.29	3.42	0.00	0.00	-5.13
40	0	COMB1	Combination	-1,078.27	6.52	0.00	0.00	8.99
40	0.9	COMB1	Combination	-1,072.14	6.52	0.00	0.00	3.13
40	0.9	COMB1	Combination	-1,072.14	6.52	0.00	0.00	3.13
40	1.8	COMB1	Combination	-1,066.02	6.52	0.00	0.00	-2.74
40	1.8	COMB1	Combination	-1,066.02	6.52	0.00	0.00	-2.74
40	2.7	COMB1	Combination	-1,059.90	6.52	0.00	0.00	-8.60
40	2.7	COMB1	Combination	-1,059.90	6.52	0.00	0.00	-8.60
40	3.6	COMB1	Combination	-1,053.77	6.52	0.00	0.00	-14.46
41	0	COMB1	Combination	-4,553.86	-6.74	6.74	0.00	0.00
41	0.375	COMB1	Combination	-4,551.31	-6.74	6.74	-2.53	2.53

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
41	0.375	COMB1	Combination	-4,551.31	-6.74	6.74	-2.53	2.53
41	0.75	COMB1	Combination	-4,548.76	-6.74	6.74	-5.05	5.05
41	0.75	COMB1	Combination	-4,548.76	-6.74	6.74	-5.05	5.05
41	1.125	COMB1	Combination	-4,546.21	-6.74	6.74	-7.58	7.58
41	1.125	COMB1	Combination	-4,546.21	-6.74	6.74	-7.58	7.58
41	1.5	COMB1	Combination	-4,543.66	-6.74	6.74	-10.10	10.10
42	0	COMB1	Combination	-4,441.99	4.71	-4.71	-4.51	4.51
42	0.9	COMB1	Combination	-4,435.87	4.71	-4.71	-0.27	0.27
42	0.9	COMB1	Combination	-4,435.87	4.71	-4.71	-0.27	0.27
42	1.8	COMB1	Combination	-4,429.74	4.71	-4.71	3.97	-3.97
42	1.8	COMB1	Combination	-4,429.74	4.71	-4.71	3.97	-3.97
42	2.7	COMB1	Combination	-4,423.62	4.71	-4.71	8.21	-8.21
42	2.7	COMB1	Combination	-4,423.62	4.71	-4.71	8.21	-8.21
42	3.6	COMB1	Combination	-4,417.49	4.71	-4.71	12.45	-12.45
43	0	COMB1	Combination	-3,310.37	7.58	-7.58	-15.35	15.35
43	0.9	COMB1	Combination	-3,304.25	7.58	-7.58	-8.52	8.52
43	0.9	COMB1	Combination	-3,304.25	7.58	-7.58	-8.52	8.52
43	1.8	COMB1	Combination	-3,298.13	7.58	-7.58	-1.70	1.70
43	1.8	COMB1	Combination	-3,298.13	7.58	-7.58	-1.70	1.70
43	2.7	COMB1	Combination	-3,292.00	7.58	-7.58	5.12	-5.12
43	2.7	COMB1	Combination	-3,292.00	7.58	-7.58	5.12	-5.12
43	3.6	COMB1	Combination	-3,285.88	7.58	-7.58	11.94	-11.94
44	0	COMB1	Combination	-2,210.80	3.10	-3.10	-6.60	6.60
44	0.9	COMB1	Combination	-2,204.68	3.10	-3.10	-3.81	3.81
44	0.9	COMB1	Combination	-2,204.68	3.10	-3.10	-3.81	3.81

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
44	1.8	COMB1	Combination	-2,198.55	3.10	-3.10	-1.01	1.01
44	1.8	COMB1	Combination	-2,198.55	3.10	-3.10	-1.01	1.01
44	2.7	COMB1	Combination	-2,192.43	3.10	-3.10	1.78	-1.78
44	2.7	COMB1	Combination	-2,192.43	3.10	-3.10	1.78	-1.78
44	3.6	COMB1	Combination	-2,186.31	3.10	-3.10	4.57	-4.57
45	0	COMB1	Combination	-1,129.90	5.74	-5.74	-7.90	7.90
45	0.9	COMB1	Combination	-1,123.78	5.74	-5.74	-2.74	2.74
45	0.9	COMB1	Combination	-1,123.78	5.74	-5.74	-2.74	2.74
45	1.8	COMB1	Combination	-1,117.66	5.74	-5.74	2.42	-2.42
45	1.8	COMB1	Combination	-1,117.66	5.74	-5.74	2.42	-2.42
45	2.7	COMB1	Combination	-1,111.53	5.74	-5.74	7.59	-7.59
45	2.7	COMB1	Combination	-1,111.53	5.74	-5.74	7.59	-7.59
45	3.6	COMB1	Combination	-1,105.41	5.74	-5.74	12.75	-12.75
46	0	COMB1	Combination	-2,909.71	-0.18	2.38	0.00	0.00
46	0.375	COMB1	Combination	-2,907.16	-0.18	2.38	-0.89	0.07
46	0.375	COMB1	Combination	-2,907.16	-0.18	2.38	-0.89	0.07
46	0.75	COMB1	Combination	-2,904.61	-0.18	2.38	-1.78	0.14
46	0.75	COMB1	Combination	-2,904.61	-0.18	2.38	-1.78	0.14
46	1.125	COMB1	Combination	-2,902.06	-0.18	2.38	-2.67	0.20
46	1.125	COMB1	Combination	-2,902.06	-0.18	2.38	-2.67	0.20
46	1.5	COMB1	Combination	-2,899.51	-0.18	2.38	-3.56	0.27
47	0	COMB1	Combination	-2,659.05	4.07	45.34	49.63	5.27
47	0.9	COMB1	Combination	-2,652.93	4.07	45.34	8.83	1.61
47	0.9	COMB1	Combination	-2,652.93	4.07	45.34	8.83	1.61
47	1.8	COMB1	Combination	-2,646.81	4.07	45.34	-31.98	-2.05

Element Forces - Frames for 7.5m conventional slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
47	1.8	COMB1	Combination	-2,646.81	4.07	45.34	-31.98	-2.05
47	2.7	COMB1	Combination	-2,640.68	4.07	45.34	-72.78	-5.70
47	2.7	COMB1	Combination	-2,640.68	4.07	45.34	-72.78	-5.70
47	3.6	COMB1	Combination	-2,634.56	4.07	45.34	-113.59	-9.36
48	0	COMB1	Combination	-1,971.43	5.58	94.61	172.36	11.07
48	0.9	COMB1	Combination	-1,965.31	5.58	94.61	87.21	6.05
48	0.9	COMB1	Combination	-1,965.31	5.58	94.61	87.21	6.05
48	1.8	COMB1	Combination	-1,959.19	5.58	94.61	2.06	1.03
48	1.8	COMB1	Combination	-1,959.19	5.58	94.61	2.06	1.03
48	2.7	COMB1	Combination	-1,953.06	5.58	94.61	-83.09	-3.99
48	2.7	COMB1	Combination	-1,953.06	5.58	94.61	-83.09	-3.99
48	3.6	COMB1	Combination	-1,946.94	5.58	94.61	-168.23	-9.01
49	0	COMB1	Combination	-1,279.65	2.83	91.24	164.62	5.71
49	0.9	COMB1	Combination	-1,273.52	2.83	91.24	82.51	3.16
49	0.9	COMB1	Combination	-1,273.52	2.83	91.24	82.51	3.16
49	1.8	COMB1	Combination	-1,267.40	2.83	91.24	0.40	0.60
49	1.8	COMB1	Combination	-1,267.40	2.83	91.24	0.40	0.60
49	2.7	COMB1	Combination	-1,261.28	2.83	91.24	-81.72	-1.95
49	2.7	COMB1	Combination	-1,261.28	2.83	91.24	-81.72	-1.95
49	3.6	COMB1	Combination	-1,255.15	2.83	91.24	-163.83	-4.50
50	0	COMB1	Combination	-585.48	4.69	117.11	193.42	6.91
50	0.9	COMB1	Combination	-579.36	4.69	117.11	88.01	2.69
50	0.9	COMB1	Combination	-579.36	4.69	117.11	88.01	2.69
50	1.8	COMB1	Combination	-573.23	4.69	117.11	-17.39	-1.53
50	1.8	COMB1	Combination	-573.23	4.69	117.11	-17.39	-1.53

APPENDIX B.2

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
1	0	COMB1	Combination	-1,745.88	-28.05	-28.05	0.00	0.00
1	0.375	COMB1	Combination	-1,743.33	-28.05	-28.05	10.52	10.52
1	0.375	COMB1	Combination	-1,743.33	-28.05	-28.05	10.52	10.52
1	0.75	COMB1	Combination	-1,740.78	-28.05	-28.05	21.04	21.04
1	0.75	COMB1	Combination	-1,740.78	-28.05	-28.05	21.04	21.04
1	1.125	COMB1	Combination	-1,738.23	-28.05	-28.05	31.55	31.55
1	1.125	COMB1	Combination	-1,738.23	-28.05	-28.05	31.55	31.55
1	1.5	COMB1	Combination	-1,735.68	-28.05	-28.05	42.07	42.07
2	0	COMB1	Combination	-1,537.46	-44.73	-44.73	-63.22	-63.22
2	0.9	COMB1	Combination	-1,531.34	-44.73	-44.73	-22.96	-22.96
2	0.9	COMB1	Combination	-1,531.34	-44.73	-44.73	-22.96	-22.96
2	1.8	COMB1	Combination	-1,525.22	-44.73	-44.73	17.29	17.29
2	1.8	COMB1	Combination	-1,525.22	-44.73	-44.73	17.29	17.29
2	2.7	COMB1	Combination	-1,519.09	-44.73	-44.73	57.55	57.55
2	2.7	COMB1	Combination	-1,519.09	-44.73	-44.73	57.55	57.55
2	3.6	COMB1	Combination	-1,512.97	-44.73	-44.73	97.80	97.80
3	0	COMB1	Combination	-1,135.16	-70.54	-70.54	-128.24	-128.24
3	0.9	COMB1	Combination	-1,129.04	-70.54	-70.54	-64.76	-64.76
3	0.9	COMB1	Combination	-1,129.04	-70.54	-70.54	-64.76	-64.76
3	1.8	COMB1	Combination	-1,122.91	-70.54	-70.54	-1.28	-1.28
3	1.8	COMB1	Combination	-1,122.91	-70.54	-70.54	-1.28	-1.28
3	2.7	COMB1	Combination	-1,116.79	-70.54	-70.54	62.21	62.21

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
3	2.7	COMB1	Combination	-1,116.79	-70.54	-70.54	62.21	62.21
3	3.6	COMB1	Combination	-1,110.66	-70.54	-70.54	125.69	125.69
4	0	COMB1	Combination	-723.00	-68.58	-68.58	-123.73	-123.73
4	0.9	COMB1	Combination	-716.88	-68.58	-68.58	-62.00	-62.00
4	0.9	COMB1	Combination	-716.88	-68.58	-68.58	-62.00	-62.00
4	1.8	COMB1	Combination	-710.76	-68.58	-68.58	-0.28	-0.28
4	1.8	COMB1	Combination	-710.76	-68.58	-68.58	-0.28	-0.28
4	2.7	COMB1	Combination	-704.63	-68.58	-68.58	61.45	61.45
4	2.7	COMB1	Combination	-704.63	-68.58	-68.58	61.45	61.45
4	3.6	COMB1	Combination	-698.51	-68.58	-68.58	123.17	123.17
5	0	COMB1	Combination	-305.74	-81.60	-81.60	-137.66	-137.66
5	0.9	COMB1	Combination	-299.62	-81.60	-81.60	-64.22	-64.22
5	0.9	COMB1	Combination	-299.62	-81.60	-81.60	-64.22	-64.22
5	1.8	COMB1	Combination	-293.50	-81.60	-81.60	9.22	9.22
5	1.8	COMB1	Combination	-293.50	-81.60	-81.60	9.22	9.22
5	2.7	COMB1	Combination	-287.37	-81.60	-81.60	82.66	82.66
5	2.7	COMB1	Combination	-287.37	-81.60	-81.60	82.66	82.66
5	3.6	COMB1	Combination	-281.25	-81.60	-81.60	156.10	156.10
6	0	COMB1	Combination	-2,825.43	-1.78	-0.37	0.00	0.00
6	0.375	COMB1	Combination	-2,822.88	-1.78	-0.37	0.14	0.67
6	0.375	COMB1	Combination	-2,822.88	-1.78	-0.37	0.14	0.67
6	0.75	COMB1	Combination	-2,820.33	-1.78	-0.37	0.27	1.33
6	0.75	COMB1	Combination	-2,820.33	-1.78	-0.37	0.27	1.33
6	1.125	COMB1	Combination	-2,817.77	-1.78	-0.37	0.41	2.00
6	1.125	COMB1	Combination	-2,817.77	-1.78	-0.37	0.41	2.00

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
6	1.5	COMB1	Combination	-2,815.22	-1.78	-0.37	0.55	2.67
7	0	COMB1	Combination	-2,575.19	-45.49	4.27	5.57	-49.29
7	0.9	COMB1	Combination	-2,569.07	-45.49	4.27	1.72	-8.35
7	0.9	COMB1	Combination	-2,569.07	-45.49	4.27	1.72	-8.35
7	1.8	COMB1	Combination	-2,562.95	-45.49	4.27	-2.12	32.59
7	1.8	COMB1	Combination	-2,562.95	-45.49	4.27	-2.12	32.59
7	2.7	COMB1	Combination	-2,556.82	-45.49	4.27	-5.97	73.53
7	2.7	COMB1	Combination	-2,556.82	-45.49	4.27	-5.97	73.53
7	3.6	COMB1	Combination	-2,550.70	-45.49	4.27	-9.81	114.46
8	0	COMB1	Combination	-1,904.68	-91.30	5.93	11.67	-169.15
8	0.9	COMB1	Combination	-1,898.56	-91.30	5.93	6.33	-86.98
8	0.9	COMB1	Combination	-1,898.56	-91.30	5.93	6.33	-86.98
8	1.8	COMB1	Combination	-1,892.44	-91.30	5.93	1.00	-4.81
8	1.8	COMB1	Combination	-1,892.44	-91.30	5.93	1.00	-4.81
8	2.7	COMB1	Combination	-1,886.31	-91.30	5.93	-4.34	77.36
8	2.7	COMB1	Combination	-1,886.31	-91.30	5.93	-4.34	77.36
8	3.6	COMB1	Combination	-1,880.19	-91.30	5.93	-9.68	159.53
9	0	COMB1	Combination	-1,236.27	-78.88	3.17	6.31	-145.53
9	0.9	COMB1	Combination	-1,230.15	-78.88	3.17	3.46	-74.53
9	0.9	COMB1	Combination	-1,230.15	-78.88	3.17	3.46	-74.53
9	1.8	COMB1	Combination	-1,224.03	-78.88	3.17	0.61	-3.53
9	1.8	COMB1	Combination	-1,224.03	-78.88	3.17	0.61	-3.53
9	2.7	COMB1	Combination	-1,217.90	-78.88	3.17	-2.24	67.46
9	2.7	COMB1	Combination	-1,217.90	-78.88	3.17	-2.24	67.46
9	3.6	COMB1	Combination	-1,211.78	-78.88	3.17	-5.09	138.46

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
10	0	COMB1	Combination	-568.30	-117.13	5.53	8.15	-182.22
10	0.9	COMB1	Combination	-562.18	-117.13	5.53	3.17	-76.80
10	0.9	COMB1	Combination	-562.18	-117.13	5.53	3.17	-76.80
10	1.8	COMB1	Combination	-556.05	-117.13	5.53	-1.80	28.61
10	1.8	COMB1	Combination	-556.05	-117.13	5.53	-1.80	28.61
10	2.7	COMB1	Combination	-549.93	-117.13	5.53	-6.78	134.02
10	2.7	COMB1	Combination	-549.93	-117.13	5.53	-6.78	134.02
10	3.6	COMB1	Combination	-543.81	-117.13	5.53	-11.75	239.44
11	0	COMB1	Combination	-2,711.57	-1.22	0.00	0.00	0.00
11	0.375	COMB1	Combination	-2,709.02	-1.22	0.00	0.00	0.46
11	0.375	COMB1	Combination	-2,709.02	-1.22	0.00	0.00	0.46
11	0.75	COMB1	Combination	-2,706.46	-1.22	0.00	0.00	0.91
11	0.75	COMB1	Combination	-2,706.46	-1.22	0.00	0.00	0.91
11	1.125	COMB1	Combination	-2,703.91	-1.22	0.00	0.00	1.37
11	1.125	COMB1	Combination	-2,703.91	-1.22	0.00	0.00	1.37
11	1.5	COMB1	Combination	-2,701.36	-1.22	0.00	0.00	1.83
12	0	COMB1	Combination	-2,464.75	-45.32	0.00	0.00	-48.85
12	0.9	COMB1	Combination	-2,458.63	-45.32	0.00	0.00	-8.05
12	0.9	COMB1	Combination	-2,458.63	-45.32	0.00	0.00	-8.05
12	1.8	COMB1	Combination	-2,452.50	-45.32	0.00	0.00	32.74
12	1.8	COMB1	Combination	-2,452.50	-45.32	0.00	0.00	32.74
12	2.7	COMB1	Combination	-2,446.38	-45.32	0.00	0.00	73.53
12	2.7	COMB1	Combination	-2,446.38	-45.32	0.00	0.00	73.53
12	3.6	COMB1	Combination	-2,440.26	-45.32	0.00	0.00	114.32
13	0	COMB1	Combination	-1,829.75	-91.72	0.00	0.00	-169.69

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
13	0.9	COMB1	Combination	-1,823.63	-91.72	0.00	0.00	-87.14
13	0.9	COMB1	Combination	-1,823.63	-91.72	0.00	0.00	-87.14
13	1.8	COMB1	Combination	-1,817.50	-91.72	0.00	0.00	-4.59
13	1.8	COMB1	Combination	-1,817.50	-91.72	0.00	0.00	-4.59
13	2.7	COMB1	Combination	-1,811.38	-91.72	0.00	0.00	77.95
13	2.7	COMB1	Combination	-1,811.38	-91.72	0.00	0.00	77.95
13	3.6	COMB1	Combination	-1,805.26	-91.72	0.00	0.00	160.50
14	0	COMB1	Combination	-1,185.55	-79.75	0.00	0.00	-147.03
14	0.9	COMB1	Combination	-1,179.42	-79.75	0.00	0.00	-75.25
14	0.9	COMB1	Combination	-1,179.42	-79.75	0.00	0.00	-75.25
14	1.8	COMB1	Combination	-1,173.30	-79.75	0.00	0.00	-3.48
14	1.8	COMB1	Combination	-1,173.30	-79.75	0.00	0.00	-3.48
14	2.7	COMB1	Combination	-1,167.18	-79.75	0.00	0.00	68.30
14	2.7	COMB1	Combination	-1,167.18	-79.75	0.00	0.00	68.30
14	3.6	COMB1	Combination	-1,161.05	-79.75	0.00	0.00	140.07
15	0	COMB1	Combination	-535.15	-118.60	0.00	0.00	-184.54
15	0.9	COMB1	Combination	-529.02	-118.60	0.00	0.00	-77.80
15	0.9	COMB1	Combination	-529.02	-118.60	0.00	0.00	-77.80
15	1.8	COMB1	Combination	-522.90	-118.60	0.00	0.00	28.95
15	1.8	COMB1	Combination	-522.90	-118.60	0.00	0.00	28.95
15	2.7	COMB1	Combination	-516.77	-118.60	0.00	0.00	135.69
15	2.7	COMB1	Combination	-516.77	-118.60	0.00	0.00	135.69
15	3.6	COMB1	Combination	-510.65	-118.60	0.00	0.00	242.43
16	0	COMB1	Combination	-2,825.43	-1.78	0.37	0.00	0.00
16	0.375	COMB1	Combination	-2,822.88	-1.78	0.37	-0.14	0.67

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
16	0.375	COMB1	Combination	-2,822.88	-1.78	0.37	-0.14	0.67
16	0.75	COMB1	Combination	-2,820.33	-1.78	0.37	-0.27	1.33
16	0.75	COMB1	Combination	-2,820.33	-1.78	0.37	-0.27	1.33
16	1.125	COMB1	Combination	-2,817.77	-1.78	0.37	-0.41	2.00
16	1.125	COMB1	Combination	-2,817.77	-1.78	0.37	-0.41	2.00
16	1.5	COMB1	Combination	-2,815.22	-1.78	0.37	-0.55	2.67
17	0	COMB1	Combination	-2,575.19	-45.49	-4.27	-5.57	-49.29
17	0.9	COMB1	Combination	-2,569.07	-45.49	-4.27	-1.72	-8.35
17	0.9	COMB1	Combination	-2,569.07	-45.49	-4.27	-1.72	-8.35
17	1.8	COMB1	Combination	-2,562.95	-45.49	-4.27	2.12	32.59
17	1.8	COMB1	Combination	-2,562.95	-45.49	-4.27	2.12	32.59
17	2.7	COMB1	Combination	-2,556.82	-45.49	-4.27	5.97	73.53
17	2.7	COMB1	Combination	-2,556.82	-45.49	-4.27	5.97	73.53
17	3.6	COMB1	Combination	-2,550.70	-45.49	-4.27	9.81	114.46
18	0	COMB1	Combination	-1,904.68	-91.30	-5.93	-11.67	-169.15
18	0.9	COMB1	Combination	-1,898.56	-91.30	-5.93	-6.33	-86.98
18	0.9	COMB1	Combination	-1,898.56	-91.30	-5.93	-6.33	-86.98
18	1.8	COMB1	Combination	-1,892.44	-91.30	-5.93	-1.00	-4.81
18	1.8	COMB1	Combination	-1,892.44	-91.30	-5.93	-1.00	-4.81
18	2.7	COMB1	Combination	-1,886.31	-91.30	-5.93	4.34	77.36
18	2.7	COMB1	Combination	-1,886.31	-91.30	-5.93	4.34	77.36
18	3.6	COMB1	Combination	-1,880.19	-91.30	-5.93	9.68	159.53
19	0	COMB1	Combination	-1,236.27	-78.88	-3.17	-6.31	-145.53
19	0.9	COMB1	Combination	-1,230.15	-78.88	-3.17	-3.46	-74.53
19	0.9	COMB1	Combination	-1,230.15	-78.88	-3.17	-3.46	-74.53

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
19	1.8	COMB1	Combination	-1,224.03	-78.88	-3.17	-0.61	-3.53
19	1.8	COMB1	Combination	-1,224.03	-78.88	-3.17	-0.61	-3.53
19	2.7	COMB1	Combination	-1,217.90	-78.88	-3.17	2.24	67.46
19	2.7	COMB1	Combination	-1,217.90	-78.88	-3.17	2.24	67.46
19	3.6	COMB1	Combination	-1,211.78	-78.88	-3.17	5.09	138.46
20	0	COMB1	Combination	-568.30	-117.13	-5.53	-8.15	-182.22
20	0.9	COMB1	Combination	-562.18	-117.13	-5.53	-3.17	-76.80
20	0.9	COMB1	Combination	-562.18	-117.13	-5.53	-3.17	-76.80
20	1.8	COMB1	Combination	-556.05	-117.13	-5.53	1.80	28.61
20	1.8	COMB1	Combination	-556.05	-117.13	-5.53	1.80	28.61
20	2.7	COMB1	Combination	-549.93	-117.13	-5.53	6.78	134.02
20	2.7	COMB1	Combination	-549.93	-117.13	-5.53	6.78	134.02
20	3.6	COMB1	Combination	-543.81	-117.13	-5.53	11.75	239.44
21	0	COMB1	Combination	-1,745.88	-28.05	28.05	0.00	0.00
21	0.375	COMB1	Combination	-1,743.33	-28.05	28.05	-10.52	10.52
21	0.375	COMB1	Combination	-1,743.33	-28.05	28.05	-10.52	10.52
21	0.75	COMB1	Combination	-1,740.78	-28.05	28.05	-21.04	21.04
21	0.75	COMB1	Combination	-1,740.78	-28.05	28.05	-21.04	21.04
21	1.125	COMB1	Combination	-1,738.23	-28.05	28.05	-31.55	31.55
21	1.125	COMB1	Combination	-1,738.23	-28.05	28.05	-31.55	31.55
21	1.5	COMB1	Combination	-1,735.68	-28.05	28.05	-42.07	42.07
22	0	COMB1	Combination	-1,537.46	-44.73	44.73	63.22	-63.22
22	0.9	COMB1	Combination	-1,531.34	-44.73	44.73	22.96	-22.96
22	0.9	COMB1	Combination	-1,531.34	-44.73	44.73	22.96	-22.96
22	1.8	COMB1	Combination	-1,525.22	-44.73	44.73	-17.29	17.29

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
22	1.8	COMB1	Combination	-1,525.22	-44.73	44.73	-17.29	17.29
22	2.7	COMB1	Combination	-1,519.09	-44.73	44.73	-57.55	57.55
22	2.7	COMB1	Combination	-1,519.09	-44.73	44.73	-57.55	57.55
22	3.6	COMB1	Combination	-1,512.97	-44.73	44.73	-97.80	97.80
23	0	COMB1	Combination	-1,135.16	-70.54	70.54	128.24	-128.24
23	0.9	COMB1	Combination	-1,129.04	-70.54	70.54	64.76	-64.76
23	0.9	COMB1	Combination	-1,129.04	-70.54	70.54	64.76	-64.76
23	1.8	COMB1	Combination	-1,122.91	-70.54	70.54	1.28	-1.28
23	1.8	COMB1	Combination	-1,122.91	-70.54	70.54	1.28	-1.28
23	2.7	COMB1	Combination	-1,116.79	-70.54	70.54	-62.21	62.21
23	2.7	COMB1	Combination	-1,116.79	-70.54	70.54	-62.21	62.21
23	3.6	COMB1	Combination	-1,110.66	-70.54	70.54	-125.69	125.69
24	0	COMB1	Combination	-723.00	-68.58	68.58	123.73	-123.73
24	0.9	COMB1	Combination	-716.88	-68.58	68.58	62.00	-62.00
24	0.9	COMB1	Combination	-716.88	-68.58	68.58	62.00	-62.00
24	1.8	COMB1	Combination	-710.76	-68.58	68.58	0.28	-0.28
24	1.8	COMB1	Combination	-710.76	-68.58	68.58	0.28	-0.28
24	2.7	COMB1	Combination	-704.63	-68.58	68.58	-61.45	61.45
24	2.7	COMB1	Combination	-704.63	-68.58	68.58	-61.45	61.45
24	3.6	COMB1	Combination	-698.51	-68.58	68.58	-123.17	123.17
25	0	COMB1	Combination	-305.74	-81.60	81.60	137.66	-137.66
25	0.9	COMB1	Combination	-299.62	-81.60	81.60	64.22	-64.22
25	0.9	COMB1	Combination	-299.62	-81.60	81.60	64.22	-64.22
25	1.8	COMB1	Combination	-293.50	-81.60	81.60	-9.22	9.22
25	1.8	COMB1	Combination	-293.50	-81.60	81.60	-9.22	9.22

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
25	2.7	COMB1	Combination	-287.37	-81.60	81.60	-82.66	82.66
25	2.7	COMB1	Combination	-287.37	-81.60	81.60	-82.66	82.66
25	3.6	COMB1	Combination	-281.25	-81.60	81.60	-156.10	156.10
26	0	COMB1	Combination	-2,825.43	-0.37	-1.78	0.00	0.00
26	0.375	COMB1	Combination	-2,822.88	-0.37	-1.78	0.67	0.14
26	0.375	COMB1	Combination	-2,822.88	-0.37	-1.78	0.67	0.14
26	0.75	COMB1	Combination	-2,820.33	-0.37	-1.78	1.33	0.27
26	0.75	COMB1	Combination	-2,820.33	-0.37	-1.78	1.33	0.27
26	1.125	COMB1	Combination	-2,817.77	-0.37	-1.78	2.00	0.41
26	1.125	COMB1	Combination	-2,817.77	-0.37	-1.78	2.00	0.41
26	1.5	COMB1	Combination	-2,815.22	-0.37	-1.78	2.67	0.55
27	0	COMB1	Combination	-2,575.19	4.27	-45.49	-49.29	5.57
27	0.9	COMB1	Combination	-2,569.07	4.27	-45.49	-8.35	1.72
27	0.9	COMB1	Combination	-2,569.07	4.27	-45.49	-8.35	1.72
27	1.8	COMB1	Combination	-2,562.95	4.27	-45.49	32.59	-2.12
27	1.8	COMB1	Combination	-2,562.95	4.27	-45.49	32.59	-2.12
27	2.7	COMB1	Combination	-2,556.82	4.27	-45.49	73.53	-5.97
27	2.7	COMB1	Combination	-2,556.82	4.27	-45.49	73.53	-5.97
27	3.6	COMB1	Combination	-2,550.70	4.27	-45.49	114.46	-9.81
28	0	COMB1	Combination	-1,904.68	5.93	-91.30	-169.15	11.67
28	0.9	COMB1	Combination	-1,898.56	5.93	-91.30	-86.98	6.33
28	0.9	COMB1	Combination	-1,898.56	5.93	-91.30	-86.98	6.33
28	1.8	COMB1	Combination	-1,892.44	5.93	-91.30	-4.81	1.00
28	1.8	COMB1	Combination	-1,892.44	5.93	-91.30	-4.81	1.00
28	2.7	COMB1	Combination	-1,886.31	5.93	-91.30	77.36	-4.34

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
28	2.7	COMB1	Combination	-1,886.31	5.93	-91.30	77.36	-4.34
28	3.6	COMB1	Combination	-1,880.19	5.93	-91.30	159.53	-9.68
29	0	COMB1	Combination	-1,236.27	3.17	-78.88	-145.53	6.31
29	0.9	COMB1	Combination	-1,230.15	3.17	-78.88	-74.53	3.46
29	0.9	COMB1	Combination	-1,230.15	3.17	-78.88	-74.53	3.46
29	1.8	COMB1	Combination	-1,224.03	3.17	-78.88	-3.53	0.61
29	1.8	COMB1	Combination	-1,224.03	3.17	-78.88	-3.53	0.61
29	2.7	COMB1	Combination	-1,217.90	3.17	-78.88	67.46	-2.24
29	2.7	COMB1	Combination	-1,217.90	3.17	-78.88	67.46	-2.24
29	3.6	COMB1	Combination	-1,211.78	3.17	-78.88	138.46	-5.09
30	0	COMB1	Combination	-568.30	5.53	-117.13	-182.22	8.15
30	0.9	COMB1	Combination	-562.18	5.53	-117.13	-76.80	3.17
30	0.9	COMB1	Combination	-562.18	5.53	-117.13	-76.80	3.17
30	1.8	COMB1	Combination	-556.05	5.53	-117.13	28.61	-1.80
30	1.8	COMB1	Combination	-556.05	5.53	-117.13	28.61	-1.80
30	2.7	COMB1	Combination	-549.93	5.53	-117.13	134.02	-6.78
30	2.7	COMB1	Combination	-549.93	5.53	-117.13	134.02	-6.78
30	3.6	COMB1	Combination	-543.81	5.53	-117.13	239.44	-11.75
31	0	COMB1	Combination	-4,050.65	-5.95	-5.95	0.00	0.00
31	0.375	COMB1	Combination	-4,048.10	-5.95	-5.95	2.23	2.23
31	0.375	COMB1	Combination	-4,048.10	-5.95	-5.95	2.23	2.23
31	0.75	COMB1	Combination	-4,045.55	-5.95	-5.95	4.46	4.46
31	0.75	COMB1	Combination	-4,045.55	-5.95	-5.95	4.46	4.46
31	1.125	COMB1	Combination	-4,043.00	-5.95	-5.95	6.69	6.69
31	1.125	COMB1	Combination	-4,043.00	-5.95	-5.95	6.69	6.69

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
31	1.5	COMB1	Combination	-4,040.45	-5.95	-5.95	8.92	8.92
32	0	COMB1	Combination	-3,937.43	2.66	2.66	2.68	2.68
32	0.9	COMB1	Combination	-3,931.31	2.66	2.66	0.29	0.29
32	0.9	COMB1	Combination	-3,931.31	2.66	2.66	0.29	0.29
32	1.8	COMB1	Combination	-3,925.18	2.66	2.66	-2.10	-2.10
32	1.8	COMB1	Combination	-3,925.18	2.66	2.66	-2.10	-2.10
32	2.7	COMB1	Combination	-3,919.06	2.66	2.66	-4.49	-4.49
32	2.7	COMB1	Combination	-3,919.06	2.66	2.66	-4.49	-4.49
32	3.6	COMB1	Combination	-3,912.94	2.66	2.66	-6.88	-6.88
33	0	COMB1	Combination	-2,945.33	4.06	4.06	8.02	8.02
33	0.9	COMB1	Combination	-2,939.20	4.06	4.06	4.36	4.36
33	0.9	COMB1	Combination	-2,939.20	4.06	4.06	4.36	4.36
33	1.8	COMB1	Combination	-2,933.08	4.06	4.06	0.71	0.71
33	1.8	COMB1	Combination	-2,933.08	4.06	4.06	0.71	0.71
33	2.7	COMB1	Combination	-2,926.96	4.06	4.06	-2.95	-2.95
33	2.7	COMB1	Combination	-2,926.96	4.06	4.06	-2.95	-2.95
33	3.6	COMB1	Combination	-2,920.83	4.06	4.06	-6.60	-6.60
34	0	COMB1	Combination	-1,966.71	1.55	1.55	3.52	3.52
34	0.9	COMB1	Combination	-1,960.59	1.55	1.55	2.13	2.13
34	0.9	COMB1	Combination	-1,960.59	1.55	1.55	2.13	2.13
34	1.8	COMB1	Combination	-1,954.46	1.55	1.55	0.73	0.73
34	1.8	COMB1	Combination	-1,954.46	1.55	1.55	0.73	0.73
34	2.7	COMB1	Combination	-1,948.34	1.55	1.55	-0.66	-0.66
34	2.7	COMB1	Combination	-1,948.34	1.55	1.55	-0.66	-0.66
34	3.6	COMB1	Combination	-1,942.22	1.55	1.55	-2.05	-2.05

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
35	0	COMB1	Combination	-997.67	4.40	4.40	5.69	5.69
35	0.9	COMB1	Combination	-991.55	4.40	4.40	1.73	1.73
35	0.9	COMB1	Combination	-991.55	4.40	4.40	1.73	1.73
35	1.8	COMB1	Combination	-985.42	4.40	4.40	-2.22	-2.22
35	1.8	COMB1	Combination	-985.42	4.40	4.40	-2.22	-2.22
35	2.7	COMB1	Combination	-979.30	4.40	4.40	-6.18	-6.18
35	2.7	COMB1	Combination	-979.30	4.40	4.40	-6.18	-6.18
35	3.6	COMB1	Combination	-973.18	4.40	4.40	-10.14	-10.14
36	0	COMB1	Combination	-3,934.41	-6.15	0.00	0.00	0.00
36	0.375	COMB1	Combination	-3,931.86	-6.15	0.00	0.00	2.31
36	0.375	COMB1	Combination	-3,931.86	-6.15	0.00	0.00	2.31
36	0.75	COMB1	Combination	-3,929.31	-6.15	0.00	0.00	4.61
36	0.75	COMB1	Combination	-3,929.31	-6.15	0.00	0.00	4.61
36	1.125	COMB1	Combination	-3,926.75	-6.15	0.00	0.00	6.92
36	1.125	COMB1	Combination	-3,926.75	-6.15	0.00	0.00	6.92
36	1.5	COMB1	Combination	-3,924.20	-6.15	0.00	0.00	9.23
37	0	COMB1	Combination	-3,815.68	3.39	0.00	0.00	3.42
37	0.9	COMB1	Combination	-3,809.56	3.39	0.00	0.00	0.37
37	0.9	COMB1	Combination	-3,809.56	3.39	0.00	0.00	0.37
37	1.8	COMB1	Combination	-3,803.43	3.39	0.00	0.00	-2.68
37	1.8	COMB1	Combination	-3,803.43	3.39	0.00	0.00	-2.68
37	2.7	COMB1	Combination	-3,797.31	3.39	0.00	0.00	-5.73
37	2.7	COMB1	Combination	-3,797.31	3.39	0.00	0.00	-5.73
37	3.6	COMB1	Combination	-3,791.18	3.39	0.00	0.00	-8.78
38	0	COMB1	Combination	-2,860.97	5.58	0.00	0.00	10.85

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
38	0.9	COMB1	Combination	-2,854.85	5.58	0.00	0.00	5.82
38	0.9	COMB1	Combination	-2,854.85	5.58	0.00	0.00	5.82
38	1.8	COMB1	Combination	-2,848.73	5.58	0.00	0.00	0.80
38	1.8	COMB1	Combination	-2,848.73	5.58	0.00	0.00	0.80
38	2.7	COMB1	Combination	-2,842.60	5.58	0.00	0.00	-4.23
38	2.7	COMB1	Combination	-2,842.60	5.58	0.00	0.00	-4.23
38	3.6	COMB1	Combination	-2,836.48	5.58	0.00	0.00	-9.25
39	0	COMB1	Combination	-1,909.66	2.66	0.00	0.00	5.68
39	0.9	COMB1	Combination	-1,903.53	2.66	0.00	0.00	3.29
39	0.9	COMB1	Combination	-1,903.53	2.66	0.00	0.00	3.29
39	1.8	COMB1	Combination	-1,897.41	2.66	0.00	0.00	0.90
39	1.8	COMB1	Combination	-1,897.41	2.66	0.00	0.00	0.90
39	2.7	COMB1	Combination	-1,891.29	2.66	0.00	0.00	-1.50
39	2.7	COMB1	Combination	-1,891.29	2.66	0.00	0.00	-1.50
39	3.6	COMB1	Combination	-1,885.16	2.66	0.00	0.00	-3.89
40	0	COMB1	Combination	-960.74	6.66	0.00	0.00	8.87
40	0.9	COMB1	Combination	-954.62	6.66	0.00	0.00	2.88
40	0.9	COMB1	Combination	-954.62	6.66	0.00	0.00	2.88
40	1.8	COMB1	Combination	-948.50	6.66	0.00	0.00	-3.11
40	1.8	COMB1	Combination	-948.50	6.66	0.00	0.00	-3.11
40	2.7	COMB1	Combination	-942.37	6.66	0.00	0.00	-9.10
40	2.7	COMB1	Combination	-942.37	6.66	0.00	0.00	-9.10
40	3.6	COMB1	Combination	-936.25	6.66	0.00	0.00	-15.09
41	0	COMB1	Combination	-4,050.65	-5.95	5.95	0.00	0.00
41	0.375	COMB1	Combination	-4,048.10	-5.95	5.95	-2.23	2.23

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
41	0.375	COMB1	Combination	-4,048.10	-5.95	5.95	-2.23	2.23
41	0.75	COMB1	Combination	-4,045.55	-5.95	5.95	-4.46	4.46
41	0.75	COMB1	Combination	-4,045.55	-5.95	5.95	-4.46	4.46
41	1.125	COMB1	Combination	-4,043.00	-5.95	5.95	-6.69	6.69
41	1.125	COMB1	Combination	-4,043.00	-5.95	5.95	-6.69	6.69
41	1.5	COMB1	Combination	-4,040.45	-5.95	5.95	-8.92	8.92
42	0	COMB1	Combination	-3,937.43	2.66	-2.66	-2.68	2.68
42	0.9	COMB1	Combination	-3,931.31	2.66	-2.66	-0.29	0.29
42	0.9	COMB1	Combination	-3,931.31	2.66	-2.66	-0.29	0.29
42	1.8	COMB1	Combination	-3,925.18	2.66	-2.66	2.10	-2.10
42	1.8	COMB1	Combination	-3,925.18	2.66	-2.66	2.10	-2.10
42	2.7	COMB1	Combination	-3,919.06	2.66	-2.66	4.49	-4.49
42	2.7	COMB1	Combination	-3,919.06	2.66	-2.66	4.49	-4.49
42	3.6	COMB1	Combination	-3,912.94	2.66	-2.66	6.88	-6.88
43	0	COMB1	Combination	-2,945.33	4.06	-4.06	-8.02	8.02
43	0.9	COMB1	Combination	-2,939.20	4.06	-4.06	-4.36	4.36
43	0.9	COMB1	Combination	-2,939.20	4.06	-4.06	-4.36	4.36
43	1.8	COMB1	Combination	-2,933.08	4.06	-4.06	-0.71	0.71
43	1.8	COMB1	Combination	-2,933.08	4.06	-4.06	-0.71	0.71
43	2.7	COMB1	Combination	-2,926.96	4.06	-4.06	2.95	-2.95
43	2.7	COMB1	Combination	-2,926.96	4.06	-4.06	2.95	-2.95
43	3.6	COMB1	Combination	-2,920.83	4.06	-4.06	6.60	-6.60
44	0	COMB1	Combination	-1,966.71	1.55	-1.55	-3.52	3.52
44	0.9	COMB1	Combination	-1,960.59	1.55	-1.55	-2.13	2.13
44	0.9	COMB1	Combination	-1,960.59	1.55	-1.55	-2.13	2.13

Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
44	1.8	COMB1	Combination	-1,954.46	1.55	-1.55	-0.73	0.73
44	1.8	COMB1	Combination	-1,954.46	1.55	-1.55	-0.73	0.73
44	2.7	COMB1	Combination	-1,948.34	1.55	-1.55	0.66	-0.66
44	2.7	COMB1	Combination	-1,948.34	1.55	-1.55	0.66	-0.66
44	3.6	COMB1	Combination	-1,942.22	1.55	-1.55	2.05	-2.05
45	0	COMB1	Combination	-997.67	4.40	-4.40	-5.69	5.69
45	0.9	COMB1	Combination	-991.55	4.40	-4.40	-1.73	1.73
45	0.9	COMB1	Combination	-991.55	4.40	-4.40	-1.73	1.73
45	1.8	COMB1	Combination	-985.42	4.40	-4.40	2.22	-2.22
45	1.8	COMB1	Combination	-985.42	4.40	-4.40	2.22	-2.22
45	2.7	COMB1	Combination	-979.30	4.40	-4.40	6.18	-6.18
45	2.7	COMB1	Combination	-979.30	4.40	-4.40	6.18	-6.18
45	3.6	COMB1	Combination	-973.18	4.40	-4.40	10.14	-10.14
46	0	COMB1	Combination	-2,825.43	-0.37	1.78	0.00	0.00
46	0.375	COMB1	Combination	-2,822.88	-0.37	1.78	-0.67	0.14
46	0.375	COMB1	Combination	-2,822.88	-0.37	1.78	-0.67	0.14
46	0.75	COMB1	Combination	-2,820.33	-0.37	1.78	-1.33	0.27
46	0.75	COMB1	Combination	-2,820.33	-0.37	1.78	-1.33	0.27
46	1.125	COMB1	Combination	-2,817.77	-0.37	1.78	-2.00	0.41
46	1.125	COMB1	Combination	-2,817.77	-0.37	1.78	-2.00	0.41
46	1.5	COMB1	Combination	-2,815.22	-0.37	1.78	-2.67	0.55
47	0	COMB1	Combination	-2,575.19	4.27	45.49	49.29	5.57
47	0.9	COMB1	Combination	-2,569.07	4.27	45.49	8.35	1.72
47	0.9	COMB1	Combination	-2,569.07	4.27	45.49	8.35	1.72
47	1.8	COMB1	Combination	-2,562.95	4.27	45.49	-32.59	-2.12

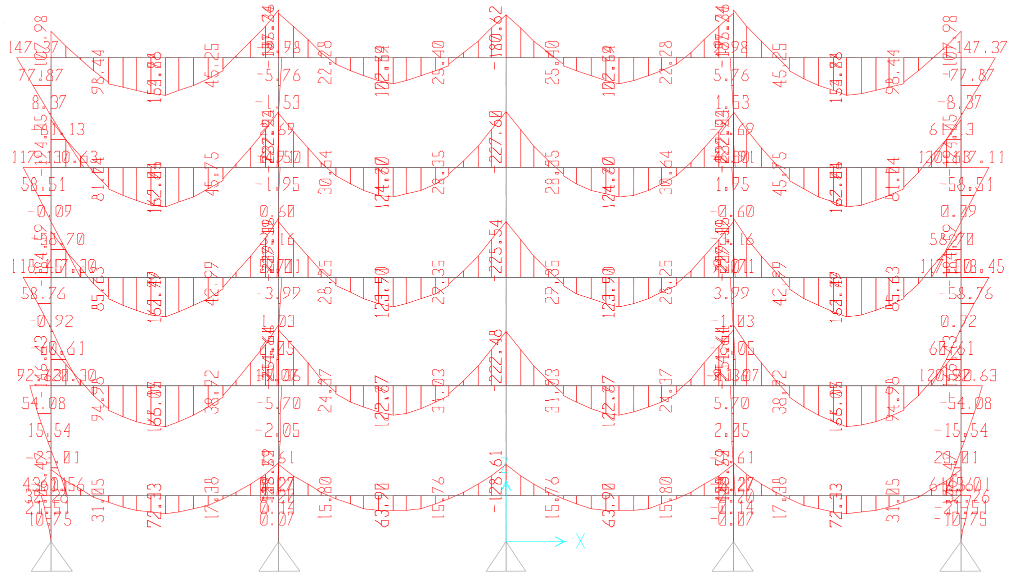
Element Forces - Frames for 7.5m Flat slab								
Frame	**Station**	**OutputCase**	**CaseType**	**P**	**V2**	**V3**	**M2**	**M3**
Text	m	Text	Text	KN	KN	KN	KN-m	KN-m
47	1.8	COMB1	Combination	-2,562.95	4.27	45.49	-32.59	-2.12
47	2.7	COMB1	Combination	-2,556.82	4.27	45.49	-73.53	-5.97
47	2.7	COMB1	Combination	-2,556.82	4.27	45.49	-73.53	-5.97
47	3.6	COMB1	Combination	-2,550.70	4.27	45.49	-114.46	-9.81
48	0	COMB1	Combination	-1,904.68	5.93	91.30	169.15	11.67
48	0.9	COMB1	Combination	-1,898.56	5.93	91.30	86.98	6.33
48	0.9	COMB1	Combination	-1,898.56	5.93	91.30	86.98	6.33
48	1.8	COMB1	Combination	-1,892.44	5.93	91.30	4.81	1.00
48	1.8	COMB1	Combination	-1,892.44	5.93	91.30	4.81	1.00
48	2.7	COMB1	Combination	-1,886.31	5.93	91.30	-77.36	-4.34
48	2.7	COMB1	Combination	-1,886.31	5.93	91.30	-77.36	-4.34
48	3.6	COMB1	Combination	-1,880.19	5.93	91.30	-159.53	-9.68
49	0	COMB1	Combination	-1,236.27	3.17	78.88	145.53	6.31
49	0.9	COMB1	Combination	-1,230.15	3.17	78.88	74.53	3.46
49	0.9	COMB1	Combination	-1,230.15	3.17	78.88	74.53	3.46
49	1.8	COMB1	Combination	-1,224.03	3.17	78.88	3.53	0.61
49	1.8	COMB1	Combination	-1,224.03	3.17	78.88	3.53	0.61
49	2.7	COMB1	Combination	-1,217.90	3.17	78.88	-67.46	-2.24
49	2.7	COMB1	Combination	-1,217.90	3.17	78.88	-67.46	-2.24
49	3.6	COMB1	Combination	-1,211.78	3.17	78.88	-138.46	-5.09
50	0	COMB1	Combination	-568.30	5.53	117.13	182.22	8.15
50	0.9	COMB1	Combination	-562.18	5.53	117.13	76.80	3.17
50	0.9	COMB1	Combination	-562.18	5.53	117.13	76.80	3.17
50	1.8	COMB1	Combination	-556.05	5.53	117.13	-28.61	-1.80
50	1.8	COMB1	Combination	-556.05	5.53	117.13	-28.61	-1.80

APPENDIX C.1-BEAM SLAB-MATERIAL REQUIREMENT

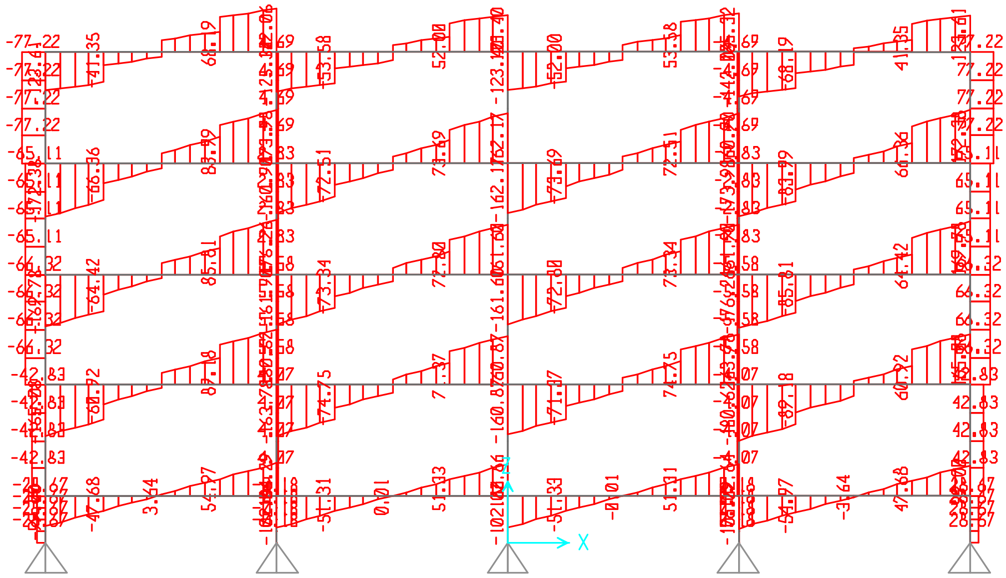
span		3.00	4.00	5.00	5.50	6.00	6.50	7.00	7.50
Concreting	slab	90.77	159.41	288.46	349.67	415.05	555.46	728.46	973.56
	beam	43.20	57.60	102.00	112.20	122.40	124.80	176.40	180.00
	column	30.60	30.60	29.25	39.81	39.81	39.81	62.78	62.78
Total		**164.57**	**247.61**	**419.71**	**501.68**	**577.26**	**720.07**	**967.64**	**1,216.34**
R/F	slab	7.44	13.10	19.15	23.02	29.16	35.33	37.28	44.01
	beam	7.56	10.30	19.67	21.48	35.14	37.76	41.37	44.04
	column	3.48	3.82	5.38	5.40	5.49	6.30	8.18	11.00
Total		**18.48**	**27.21**	**44.20**	**49.90**	**69.78**	**79.39**	**86.82**	**99.05**
Formwork	slab	496.08	915.28	1,470.60	1,793.00	2,147.40	2,544.32	2,974.84	3,438.96
	beam	442.80	601.47	980.49	1,102.74	1,229.58	1,301.85	1,757.43	1,851.33
	column	378.00	378.00	360.00	420.00	420.00	420.00	513.00	513.00
Total		**1,316.88**	**1,894.75**	**2,811.09**	**3,315.74**	**3,796.98**	**4,266.17**	**5,245.27**	**5,803.29**

APPENDIX C.2-FLAT SLAB- MATERIAL REQUIREMENT									
span		**3.00**	**4.00**	**5.00**	**5.50**	**6.00**	**6.50**	**7.00**	**7.50**
Concreting	slab	90.77	159.41	288.46	349.67	415.05	555.46	728.46	973.56
	beam	17.28	23.04	40.80	44.88	48.96	49.92	70.56	72.00
	column	30.76	30.76	29.82	40.58	40.58	40.47	64.78	64.60
Total		**138.82**	**213.22**	**359.08**	**435.13**	**504.59**	**645.85**	**863.80**	**1,110.16**
R/F	slab	8.96	15.83	26.41	32.59	42.44	51.07	58.85	64.61
	beam	2.30	3.10	6.30	6.87	11.24	12.08	13.24	13.39
	column	3.06	3.27	4.58	4.61	4.67	5.36	6.95	9.35
Total		**14.32**	**22.2**	**37.28**	**44.01**	**58.35**	**68.51**	**79.03**	**87.34**
Formwork	slab	577.08	1,025.08	1,609.2	1946.00	2314.80	2726.12	3171.04	3649.56
	beam	177.12	249.39	420.21	487.26	558.90	607.53	840.51	905.97
	column	414.00	414.00	411.00	479.50	479.50	476.00	607.50	603.00
Total		**1,168.20**	**1,688.47**	**2,440.41**	**2,912.76**	**3,353.20**	**3,809.65**	**4,619.05**	**5,158.53**

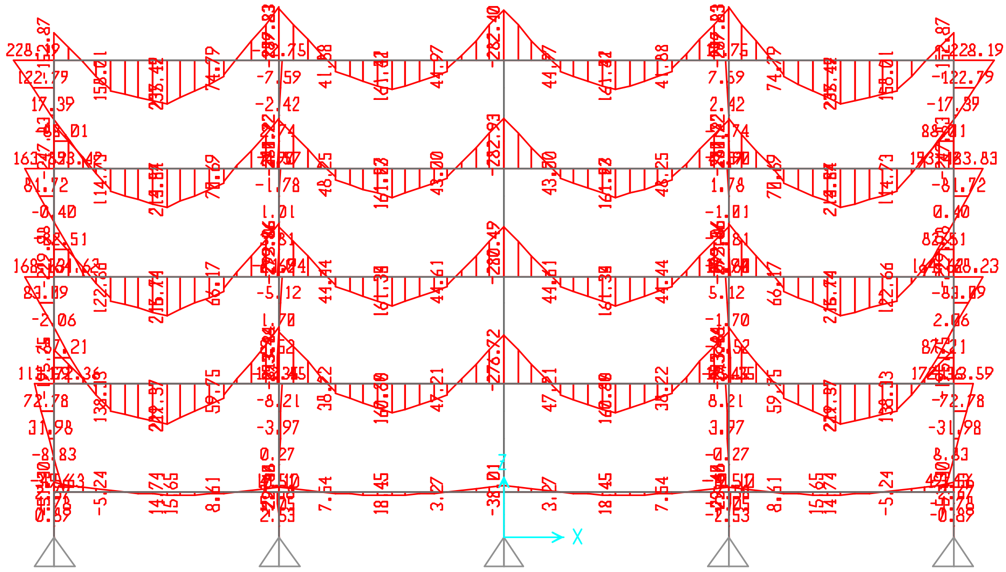
APPENDIX- D



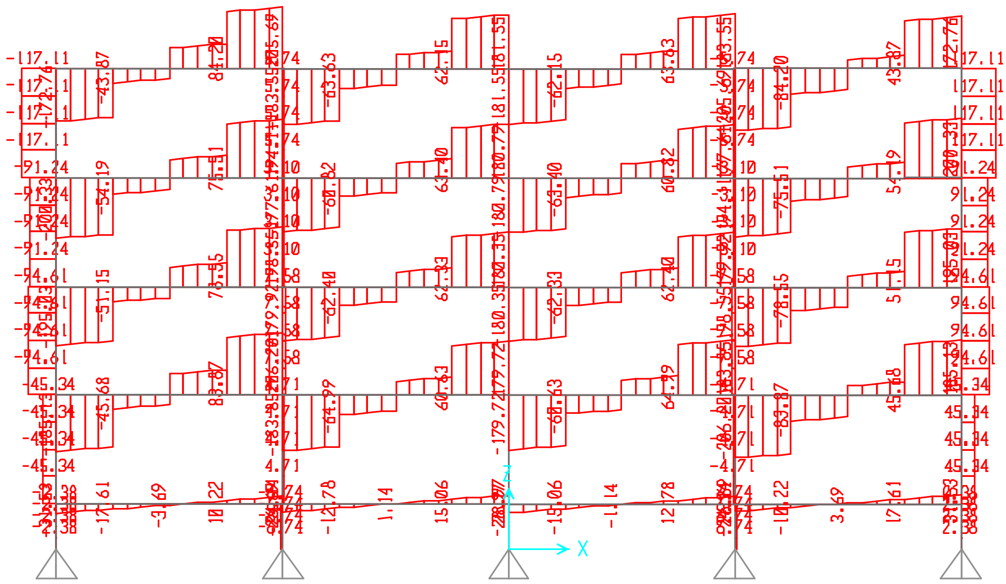
D.1 Bending moment diagram for perimeter frame for 7.5m-conventional slab



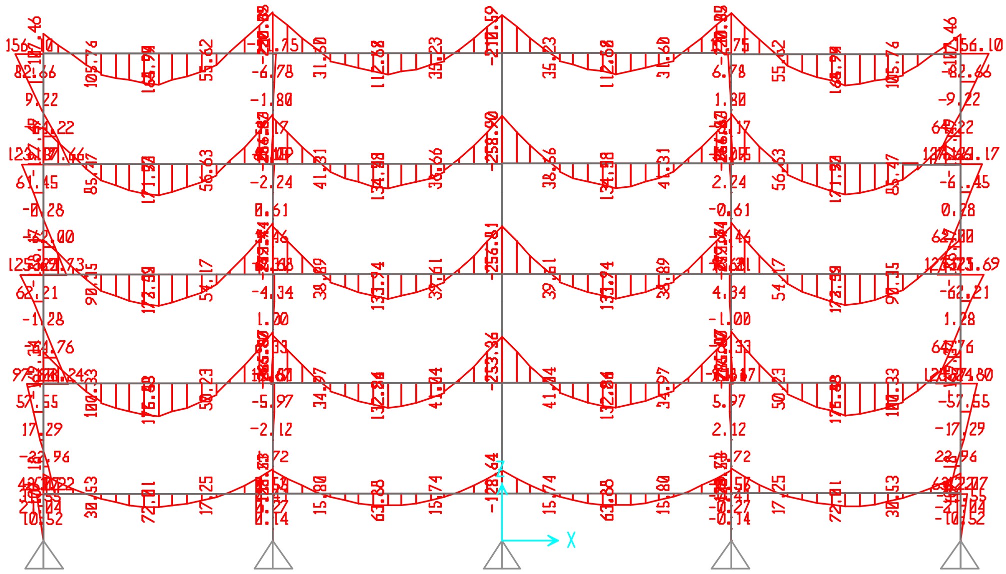
D.2 Shear force diagram for perimeter framefor 7.5m-conventional slab



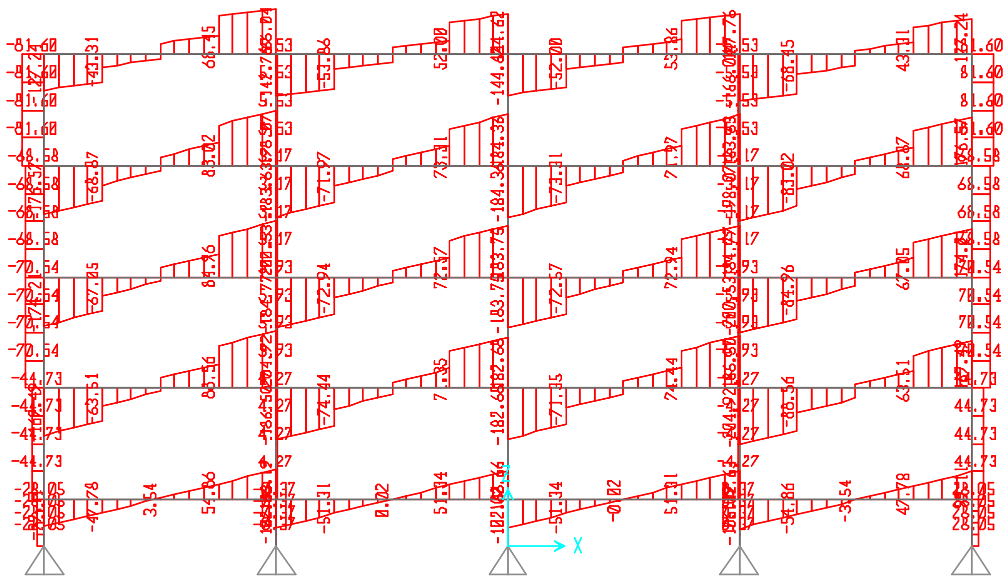
D.3Bending moment diagram for internal framefor 7.5m-conventional slab



D.4Shear Force diagram for internal framefor 7.5m-conventional slab



D.5Bending moment diagram for perimeter framefor 7.5m-flat slab



D.6Shear force diagram for perimeter frame for 7.5m-flat slab

APPENDIX-E

E.1-Mixing concrete Grade 30				
	UNIT	**QTY**	**RATE**	**AMOUNT**
Cement	Bags	31.00	1,100.00	34,100.00
Hire of mixture, vibrator, operator, fuel etc.	Days	0.33	7,800.00	2,600.00
skill labourer	Days	0.33	1,200.00	400.00
Water	L	600.00	2.00	1,200.00
Sand	Cubes	0.42	18,900.00	7,938.00
Un Skilled Labourer	Days	2.00	850.00	1,700.00
metal ¾"	Cubes	0.82	7,500.00	6,150.00
Rate for cube				54,088.00
Rate for m^3				19,112.37
Say				**19,000.00**

E.2-Mild steel/Tor steel reinforcement to lintols slab beams or columns bent to shape laid in position and tied with G I wire as directed				
	UNIT	**QTY**	**RATE**	**AMOUNT**
Smith	Day	20.00	1,500.00	30,000.00
Binding wire 16 BWG	kg	14.00	276.00	3,864.00
Tor steel	Mt	1.00	175,000.00	175,000.00
Un Skilled Labourer	Day	20.00	850.00	17,000.00
				225,864.00
Say				**225,000.00**

E.3-Sawn timber form work for Moulding,Assembling,Dismantling,Cleaning and labour				
	UNIT	**QTY**	**RATE**	**AMOUNT**
Un Skilled Labourer	Day	6.00	850.00	5,100.00
Timber class 2 joists (4"x2")	m	10.00	400.00	4,000.00
Timber class 2 (2"x1")	m	8.00	56.00	448.00
Timber class 2 planks (1")	m^2	6.00	1500.00	9,000.00
nail 1"	Kg	1.20	264.00	316.80
Timber class 2 battens 2"x2"	m	14.00	156.00	2,184.00
Carpenter (Skilled Labourer)	Day	3.00	1200.00	3,600.00
2"x2" bracing for props	m	39.00	101.00	3,939.00
Rate for square				28,587.80
Rate for m^2				3,077.27
Say				**3,000.00**