COMPARATIVE ANALYSIS AND DESIGN OF A TALL HOSTEL BUILDIING STRUCTURE USING THE COMPUTER AIDED DESIGN METHOD AND THE MANUALL METHOD

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SEPTEMBER, 2023.

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A PROJECT SUBMITTED TO THE DEPARTMENT OF STRUCTURAL ENGINEERING, FACULTY OF ENGINEERING, UNIVERSITY OF BENIN, BENIN CITY. IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.Eng.) DEGREE IN STRUCTURAL ENGINEERING.

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PLAGIARISM

This work "COMPARATIVE ANALYSIS AND DESIGN OF A TALL HOSTEL BUILDIING STRUCTURE USING THE COMPUTER AIDED DESIGN METHOD AND THE MANUALL METHOD" by ODIANOSEN, Paul Clinton with Mat. No. ENG1704117 of the Department of Structural Engineering, Faculty of Engineering, University of Benin City, Edo State, Nigeria, has PASSED the PLAGIARISM TEST.

PROJECT COORDINATOR: ENGR. E. ORIA-USIFO

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CERTIFICATION

This is to certify that this work was carried out by ODIANOSEN, Paul Clinton, MAT NO: ENG1704117, of the Department of Structural Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria.

SUPERVISOR: ENGR. U. UKEME

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HEAD OF DEPARTMENT: ENGR. DR. (MRS) N.I. IHIMEKPEN

Signature and date: ______________________________

DEDICATION

This project work is dedicated to God Almighty who is my protector and provider.

ACKNOWLEDGEMENT

I give all the glory to the Almighty God, who has been my strength throughout this project work. Words will not be enough to express my profound gratitude to my wonderful parents late Mr. Godday Odianosen and Mrs. Magdalene Odianosen for your support and love as well as my loving siblings.

Also, to my ever-supportive supervisor Engr. U. Ukeme for the rare privilege to be under his tutelage and to Engr. U. Ogbonna for his ever-loving guidance during the course of this project research and design.

I also want to appreciate the head of the department of civil and structural Engineering Dr. Mrs. N.I Ihimekpen. I will also like to thank Engr. Prof. Orie, Prof. H.A.P. Audu, Engr. E. Oria-Usifo and the entire staff of civil and structural Engineering department for their support and the knowledge impacted.

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ABSTRACT

This study compares the design method for a tall hostel building structure using computer aided design (CAD) with the traditional manual approach. This study examined the advantages and disadvantages of each technique in order to comprehend its efficacy, accuracy and relevance to contemporary building industry and building service engineers.

Given that this is a technological world, there are numerous software applications that can be used for complex and massive structural work in an economical way through saving time and people. Some applications are used in structural calculation of a civil engineering, where it is subjected to different types of loadings. In order to achieve this, ORION CSC18 software is used to analyze and design a multistory building and compare the results with the manual calculated values. Appropriate techniques are applied in creating geometry, columns cross sections as well as beams cross sections slabs and footings for analysis and design of multi-story building. .

Orion software is a reliable and efficient tool for structural design, simplifying analysis and creation. It determines reinforcement requirements for concrete segments and has a strong relationship with AutoCAD. However, caution is advised to avoid incorrect data input. Orion software is a reliable and efficient tool for structural design, simplifying analysis and creation. It determines reinforcement requirements for concrete segments and has a strong relationship with AutoCAD. However, caution is advised to avoid incorrect data input.

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CHAPTER ONE

INTRODUCTION

Building construction is the engineering that deals with the erection of building structures such as residential building on a chosen or selected site. In a simple term, a building can be said to be an enclosed space by walls with a roof overhead. In the ancient times of human development, humans lived in caves tree tops, under trees or any comfortable enclosed space as a form of shelter to protect themselves from wild animals and other adverse weather conditions. As time passed, with human development, better habitable abodes began to evolve such as huts made of mud, tree branches and timber. The shelter of those time have long been developed into magnificent houses and sophisticated structures even.

Building structures are important indicators of the social progress of a country and thus the technological advancement of such society can be assessed by the structural development overseen in such environment. Study has shown that humans spend about two-third of their life time in a house, therefore it is every individual's desire to own a comfortable home. this therefore explains the reason why people spend their hard-earned incomes in trying to own a house or make a home (Saif,2011).

As nowadays, building structures are one of the portrayals of social progress, new techniques are being developed daily for quickly construction processes and cheaper economic requirement. So, with ever growing population and increasing cost of lands in our urban areas, the need for matching accommodations are becoming overwhelming; thus tall building having several number of floors, thus creating lots of space for use to satisfy various human needs for building. That is, instead of having to erect several buildings in various land spaces and then adding more pressure to already scarce land space, a single tall building is erected to satisfy those related needs. Generally, such structures have prismatic sections and are the most obvious in developing countries to resist applied loads without any appreciable deformation of any part relative to another. it is the need for the structure to adequately receive loads acting on it (usually called service loads) which acts on certain points and safely transmit them to other points as required that prompts the designer to give life to the structure by effectively providing the member sections, selecting the right materials and properties for safety, stability,

strength, serviceability, feasibility and aesthetics requirements of the structure. And it is in the sight of these requirement that computer system is incorporated in design.

Computer based problem solving is a systematic process of designing, implementing and using programming tools. Final outcome of this process is software tools which is dedicated to solve the problem under consideration.

Software is just a collection of computer programs and programs are a set of instructions which guides computer’s hardware. And in this regard best known as computer aided designing software. It helps users creating designs in either 2D or 3D so that they can visualize the construction. CAD software includes a graphical user interface (GUI) that allows a user to create a digital model of physical items on their computer. CAD enables the development, modification, and optimization of the design process.

1.1 STATEMENT OF THE PROBLEM

With the growing quest for high rise buildings in urban areas and cities like Lagos, Abuja, Port Harcourt, Benin City, etc.it is imperative that the structural design for these structures are achieved in shortest possible time and accurately too.

Manual calculations method of structural design is not only cumbersome but is also prone to errors and takes quality time to be achieved. Sadly, this is the case in our country's educational system where students of Structural Engineering are taught the manual method of design. There is need for the structural designs to go beyond the manual method to computerized system of designing using certain structural software such as Orion, being studied in this project work to enable quicker and more accurate designs.

1.2 AIMS AND OBJECTIVES

The main aim of this work is to carry out a complete analysis and design of the main structural elements of a reinforced concrete ten floor storey hostel building using the structural software called Orion and comparing the results with that obtained by manual/hand calculations, where all design considerations are in accordance with the criteria of the Limit State Design and the British Standard for reinforced concrete design (B.S. 8110: Part l, 2 and 3).

To achieve this, the following are the specific objectives:

i. To see how designing manually differs with computerized system.

ii. To investigate the accuracy of design with Orion and manual Calculations.

iii. Acquiring efficiency with the structural software: Orion

iv. Establishing a good working experience with AutoCAD.

v. Gaining knowledge about the implementation of theoretical and practical design specifications of RCC materials.

1.3 SCOPE OF STUDY

This work will cover the following areas:

(i) The construction of a six-storey hostel building

(ii) Drafting of architectural design with the aid of AUTOCAD and the design and analysis with Orion.

(iii) Modelling of this reinforced structure with detailing and layouts.

1.4 JUSTIFICATION OF STUDY

Recent advances in technology have led to the development of computer programs that streamline various tasks across different fields. Civil engineering is no exception, with the emergence of software like STAAD Pro that significantly simplifies the analysis and design of RCC buildings. These programs can achieve tasks that would take days using manual calculations within a matter of hours.

Several other structural design software programs, such as Prota Structure, SAFE, ETABS, SA, etc., have also demonstrated their accuracy in replicating manual calculations for RCC buildings. Among these, Orion stands out for its user-friendliness and compatibility with the Nigerian building construction environment. This study aims to validate the use and adoption of Orion in the Nigerian building design and construction industry, as well as in academic settings to equip structural engineering students with the necessary skills.

However, like any software, Orion can be misused if proper analysis and design procedures are not followed. Erroneous procedures can lead to structural failures with significant consequences. Therefore, responsible use of the software is crucial.

To demonstrate the software's validity, hand calculations were performed on a series of critical structural elements, including a heavily loaded slab panel, beam, column, and footing, to confirm their accuracy.

CHAPTER TWO

LITERATURE REVIEW

2.1 OVERVIEW

This chapter show a comprehensive representation of previous related studies and work done in this research area (analysis and design of multi storey building using software and comparing these results with manual calculations).

Deevi Krishna Chaitanya and colleagues (January 2017): A (G+6) Multi-Storey Building: Analysis and Design employing STAAD Pro. To determine how many unknown forces there were, they used static indeterminacy methods. Distributing well-known fixed and moment values using the iteration method in order to meet the compatibility requirement. Moments were distributed using Kani's approach at successful junctions in the frame and continuous beam to ensure the stability of the building structure's members. They employed the design tool STADD Pro, which provided precision while cutting down on design time.

Another work to look at is the R. D. Deshpande et al. This work showed that checks for deflection was safe in their study (Analysis, Design and Estimation of Basement+G+2 Residential Building), published in June 2017. They used E-Tabs software to carry out the design and study of a G+2 residential building while estimating the size of the structure using the center line method. They used SP-16 to safely design the column and the interaction formula was tested.

Dotto Mkinga (February 2019) on his project of Modelling Reinforced Concrete Members for a Single Family Detached House using Prota structure, made the following remarks;

I. "The checks for a member's connectivity were successfully performed onto a location of interest such as column and beam joints, zooming the analytical model and rotating it into a different direction to view the connectivity more closely. The key was to examine whether the physical model that had been set up translated correctly and accurately into an analytical model".

II. "The results of load cases and load combinations from the model were justified by verifying that all beams had slab load values in them. The validity of these values was further examined by looking at the symmetry or by simple hand calculations".

III. "Animating the displacement, and displaying the resultant tab was crucial for analysing the analytical model. This helped to better visualize the model, and had any member disconnected within the model, it would have displayed separately. Furthermore, checking the exact magnitude of the displacement was fundamentally important, using the resultant tab of absolute displacement of a joint in 3D space. The resultant tab contains the values from the X, Y and Z components. The values showed a maximum number of 1mm which was reasonable".

IV. "The study also explained briefly how the Orion can exchange information with Autodesk Revit. The phenomenon is called bi-directional link, and, in many ways, it can significantly enhance project coordination and workflow. It is crystal clear; a bi-directional link with Revit is advantageous for project coordination and synchronization between structural engineers, project architects, owners and other stakeholders".

STAAD Pro was used by Kumar et al. (2018) to analyze, design, and calculate all of the reinforcements needed for the concrete portion of a G+20 residential constructions. All beams, columns, and slabs were examined for deflection and shear failure to determine whether the structure was secure.

Rashmi et al (2020) in comparing between manual calculations and STAAD Pro software analysis and design of G+4 RCC residential building, concluded that the analysis result is the same but the design is somewhat different, using the software made the design easier and faster to complete than the manual calculation method and that the building structure designed was able to sustain the loads acting on it.

Shaikh et al (2019), after analyzing the G+4 RCC storey building structure, concluded that the structure is safe in loading like dead load, live load, wind and seismic loads. Member dimensions are assigned by calculating the load type and its quantity applied on it. AutoCAD gives detailed information of the structure members' length, height, depth, size and numbers etc. STAAD Pro has the capacity to calculate the reinforcement needed for any

concrete section. The program contains a parameter which are designed as IS 456 (20(ÅJ). Beams are designed for flexure, shear and torsion and it gives the detail number, position, and spacing of reinforcements.

Robin (2016) portrayed that the results obtained by manual calculations and ETABS software design, though a bit differs, is within acceptable limit and can be considered successful. One good example was in the calculation of lateral loads effects, as he uses portal frame method for his analysis to convert lateral forces to vertical effects using manual calculation, ETABS program uses Finite Element Method thereby showing a significant variation. Also, his was based on BNBC code while he selected a code known as UBC 94 on the ETABS for his design. However, in the comparison of the results, it was found that approaches are applaudable.

2.2 STRUCTURAL DESIGN

Structural design is a methodological investigation of stability, strength and rigidity of the structure. The process of structural design is simple in concept but complex in detail. It involves the analysis of a proposed structure to show that its resistance or strength will meet or exceed a reasonable expectations load (Jumal et al, 2009). The basic objective in structural analysis and design is to produce a Structure that is capable of resisting all possible applied loads without failure in its intended lifetime. The structure is expected to transmit or support loads.

If the structure is improperly designed or fabricated, or if the actual applied load exceeds the design specifications, the structure will fail to perform its intended function with possible serious consequences. A well-designed structure greatly mitigates the possibilities of costly failures. In all, structural analysis and design should produce the structural elements of a system that can perform its function satisfactorily while being efficient and safe by choosing the right type of member sections and as well, not losing sight of economy.

2.2.1 REINFORCED CONCRETE (RC)

Also known as Reinforced Cement Concrete (RCC) is a composite material or a building construction system in which the concrete's relatively low tensile strength and ductility are compensated for by the inclusion of a reinforcement having higher tensile strength and or ductile property. The reinforcement is usually, though not limited to or necessarily, steel bars. It is usually embedded passively in the concrete before the concrete sets. By forming a strong bond together when the concrete sets, the two materials are able to resist a variety of applied force effectively as they act as a single element. Reinforced concrete is a versatile composite material and one

of the most widely used in modern construction (George et al, 2015). Concrete On its own is a relatively brittle material that is Strong under compression but less so under tension therefore, plain and unreinforced concrete is Unstable for many structures as it is relatively poor at withstanding many stresses induced by certain factors like vibrations, wind loading, tension and so on. Aside steel rods, other reinforcements that can be used are wires, mesh or cables, glass fiber and bamboo. These are known as rebar. For a strong, ductile and durable construction, the reinforcement needs to have the following properties at least:

i. High relative strength

ii. High toleration of tensile strain

iii. Good bond to the concrete irrespective of PH, moisture and similar factors.

iv. Thermal compatibility, not causing unacceptable stresses (such as Expansion or contraction) in response to changing temperature.

v. Durability in the concrete environment irrespective of corrosion or Sustained stress.

The revolutionary engineering of reinforcing the weak tensile zone of the concrete with steel bars were developed in mid-19th century. The early 20th century witnessed the development and use of reinforced concrete mainly due to the development of good quality concrete with improved strength and improved quality of steel with surface characteristics suitable to develop good bond with the concrete (Deween et al, 2012).

Large amount of concrete is used in the construction industry in Nigeria and in most countries of the world majorly due to its availability. Concrete is unarguably the most important building material playing a big role in the construction industry as it has the virtue of versatility, can be modelled into various shapes, durable and has good fire and corrosion resistance.

2.2.2 MULTI-STOREY BUILDING

A multi-storey building is one that has several floors. Though tallness of a building is relative and therefore cannot be defined by its height, multi-storey buildings are ones that are very tall of more than 15m high. From a structural engineer's point of view, a multi-storey building is one that by virtue of its height, is affected by lateral forces due to wind or earthquakes or both and the extent to which they play a role in the building's stability is an important consideration in the design of such a structure (Rashid et al, 2008).

Tall structure has fascinated mankind from the beginning of civilization. The Egyptian pyramid, one among the Seven Wonders of the World and constructed around 2600 B.C, are among such structures. These were built majorly for defense and to show off the extent of the region's civilization but in these modern times, the growth in the modern multi-storey building which began in the late 19th century is intended for residential and commercial purposes. The development of the multi-storey building has followed population growth, city developments, urbanization and industrialization. This causes people to migrate urban areas where job opportunities and better lives are significant. With these realities, available lands for housing and accommodation purposes are being exhausted and costly also.

2.3 STRUCTURAL ELEMENTS

The design of a multi-storey building involves the analysis and design of the various components that makes up such building. Each building structure consists of the following elements:

i. Slabs:

These are the horizontal plate elements that carry the dead and live loads of the building occupants. Slabs are designed either as one way spanning or two-way spanning. In one-way spanning, the longer edge is two or more times the shorter edge and the shorter edge direction is the direction loads are transferred to the beams. Hence the main reinforcement bars are provided along this direction; however, temperature, shrinkage and distribution steels are provided along the long edge. The two-way spanning is when the ratio of long edge to short edge is less than two and thus main reinforcements are provided in both directions. All permanent constructions of slab form the dead loads such as self-weight of the slab itself, partitions, floor finishes, partition walls, false ceiling or floor and other permanent construction of the building.

ii. Beams

These are horizontal members carrying the loads from slabs. It’s a structural member capable of withstanding loads primarily by resisting bending. Bending moments are induced in beams when they try to resist external loads on them, its own weight and other reactions acting on it.

Beams are also subjected to shear and thus both bending and shear in the beam induces tensile stresses. Thus, steel reinforcing tremendously increases the beam strength. Depending on the situation, beam can be designed singly or doubly reinforced (section with both tension and compression reinforcement). In practice, most beams are designs for tension reinforcement only (singly reinforced); however, situations may exist whereby it is necessary to design for both tension and compression reinforcement. For example, where beam section is limited due to architectural considerations, it may happen that the concrete cannot develop the needed compression to resist the resulting bending. In some other situations, it may happen that if a section is designed for tension reinforcement only, it would be over reinforced in that region and this is neither desirable nor acceptable in most codes of practices. Thus, such section is recommended to be designed for both compression and tension reinforcement.

iii. Columns:

These are the vertical members carrying axial loads in the case of interior columns or axial loads and moments in the case of exterior columns. They receive loads from beams and carry it chiefly in compression. They are very important aspect of a building as its failure can result to total collapse of the building. Through columns, loads are transferred to the foundations.

iv. Foundation Base:

These transfer the loads and weight from the structure to the supporting soil. They distribute the load applied to larger areas thereby reducing the stress on the soil. This is the lower part of a building helping to transfer the gravity load of the building to the earth. Foundation are generally categorized into two: shallow foundation and deep foundations and for tall building, a strong foundation is a must if it should sustain the Structure for its entire lifetime. To establish a foundation, trench is dug deep enough till a less compressible and more stable stratum is reached. After the foundation is done, the construction of the building's superstructure can now begin

These components provide access or movement from one floor to another in a structure. The stairs comprise of steps with landings at suitable intervals to provide comfort and safety of users.

2.4 DESIGN PHILOSOPHY

Engineering is a profession in which the knowledge of mathematical and natural science gained by study, practice and experience is applied with judgment to develop ways to economically utilize the materials and forces of nature for the benefits of mankind (Khumir et al, 2018)

The structural design of any structure involves the establishment of the loading and other design conditions which must be supported by the structure and therefore must be considered in its design and then selecting the proper materials and proportioned elements of the structure according to art, engineering science and technology in order to fulfill its purpose and meet the conditions of safety, serviceability, economy and functionality. This is followed by the analysis and computation of the internal gross forces (thrust, shear, bending moment and torsion) as well as stress intensities, strain, deflection and reactions produced by the loads, changes in temperature, shrinkage, creep and other design condition.

Design philosophy therefore is the set of principles, assumptions and procedure which are used to meet the conditions of serviceability, safety, economy and functionality of the structure. Several design philosophies have been introduced from different parts of the world. Some of the design philosophies that has been used by the engineers are: J. Ultimate Load Method: Also known as load factor method or the Ultimate strength methods is one that is based on the ultimate strength of the Structural members assuming a failure condition whether due to the crushing of the Concrete or due to the yield of reinforced steel bars. In this method, actual loads or working loads are multiplied by a load factor to obtain the ultimate design loads. The load factor represents a high percentage of factor for safety required in the design.

II. Working stress method: Also called allowable stress design is based on elastic theory, the actual working loads acting on a structure are estimated and members of the Structure are proportioned based on certain

allowable stresses in concrete and steel. The allowable stresses are fractions of the crushing strength of concrete and the yield strength of the steel.

Ill. Limit State Design: This philosophy is an advancement on the traditional design methods; an extension of the Working stress method and Ultimate load method. It considers safety at the Ultimate load and serviceability at the working load.

The Limit State is the state of impending failure, beyond which a structure ceases to perform its intended function satisfactorily, in terms of either safety or serviceability therefore all actions likely to occur during a structure's design life are considered here in this type of design philosophy to ensure that the structure remains fit for use with appropriate levels of reliability (Hamad el al., 2007). The Limit State Design involves estimating the subjected loads on a structure, choosing the sizes of members to resist the loads and selecting the appropriate design criteria. This method requires two principal criteria to be satisfied: - The Ultimate Limit State (ULS) - The Serviceability Limit State (SLS).

The Ultimate Limit State is the design for the safety of a structure and its users by limiting the stress that the materials experience. In order to comply with the engineering demands for strength and stability under design loads, ULS must be fulfilled as an established condition. The ULS is a purely elastic condition, usually located at the upper part of its elastic zone (approximately 15% lower than the elastic limit). If all factored bending stresses, shear and tensile/compressive stresses are below the calculated resistance, then a structure will satisfy the ULS criterion. Safety and reliability can be assumed as long as this criterion is fulfilled since the structure will behave in the same way under repetitive loadings (Alldurah et al, 2007).

Serviceability Limit State is the design to ensure a structure is comfortable and usable. This includes checks for deflections, vibrations, fire resistance, cracking as well as durability. These are the conditions that are not strength based but can still render the structure Unusable for its intended use. Serviceability is a condition in building design under which the building is still considered useful. If these limits be exceeded, the structure may still be structurally sound but nevertheless be considered unfit. SLS might also involve limits to non-structural issues such as acoustics and heat transmission. A structure is expected to remain functional for its intended use subject to routine loading in order to satisfy SLS criterion (Alldurah et a", 2007).

Not losing sight of economy and aesthetics, the design of any building structure is ensured that the requirements of safety, stability and serviceability were satisfied. Hence, the Limit State Design method is the philosophy on which modern design of most structures are based and thus is the framework of this project.

2.5 DESIGN CODE

The design of any structure requires many detailed computations, and some of these are repetitive in nature. Standard construction and assembly methods have evolved through experience and need for uniformity in the construction industry. These have resulted in standard details and in some cases, standard components for building construction published in handbooks or guides. One of such is the design code of practice and for a reinforced concrete, many countries have their own structural design codes or technical documents which give such needed signs. It necessary, therefore, for a designer to be guidelines for successful design. It is necessary, therefore, for a designer to be familiar and efficient with the local requirements/recommendations where the structure is to be situated in regards to correct practice. In Nigeria, the British Standard (B.S. 81 10: Part l, Part 2 and Part 3) which is the basis for this project work and the Euro Code (EC 2) is commonly used and acceptable for the design of reinforced concrete buildings. Other design codes around the countries of the world are: IS 456 (India), ACI 318 (United States of America), TS 500 (Turkey), BNBC (Bangladesh), GB 50010 (China) and so on.

CHAPTER THREE

METHODOLOGY

The following methods were used in the analysis and design of a tall administrative building:

i. Computer Aided Design Software Method and

ii. Manual Method

3.1 Computer Aided Design Method

There are a lot of software available for the structural design of building, but we will be taking a look at Orion Csc 18 software in the design and analysis of the building. First step,

i. Panelling = General Arrangement

ii. Drawing showing beam, layout, columns slab.

iii. We remove the elements not needed span of two column ≤ six meters.

iv. Also, we consider stability before economy.

v. Place columns at every edge where needed

vi. After this, we superimpose on a copy of a floor plan.

vii. Next, we ray (Ray helps to put our construction line)

viii. Next we pick a column and put it on other columns too.

ix. Copy the whole work to your clipboard

x. Open another sheet and paste

xi. Save the file as ‘dxf 2004’

xii. Go to Orion csc18

3.1.1 On Orion Csc

Here, the sheet is called workspace, below are the procedures involved on using Orion Csc18 for the analysis

A. SLAB CREATION

i. Click on the Slab icon and the slab properties dialog will appear.

ii. Click on the Type box

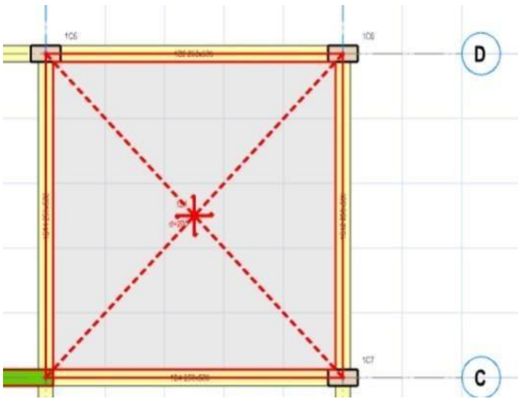
iii. Select Slab Type as 1

iv. Enter the slab thickness

v. In the Loads tab, enter Service Dead Load.

vi. Position the cursor in the region bounded by beams @GL 3, 4, C, D, and left-click to create a slab

vii. Create more slabs to give the layout desired.



B. BEAM CREATION

i. Click on the Beam icon & the beam properties will appear

ii. In the beam properties, use the defaults values b = 250 mm & h = 500 mm

iii. To create a beam, pick the start and the endpoints by clicking on the intersection of axes

iv. Right-click to end the beam insertion after inserting the two beams as shown above

Multiple beams can also be inserted by dragging a box enclosing the area you want to insert beams. Beams will automatically be created between columns and walls.

v. Click and drag box enclosing the columns & walls shown above

vi. Insert the rest of the beams by any method as shown below

vii. Click on the curve beam insertion icon in the Beam Properties dialog

viii. Click on the intersection of axes A/3 and then the intersection of axes B/4 (i.e., start & end of the beam)

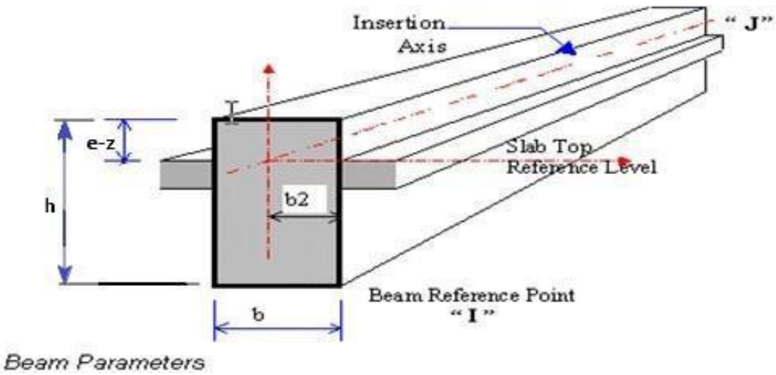
ix. Press F2 to define the apex.

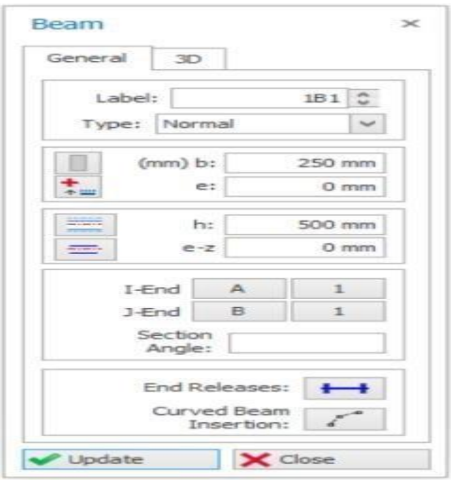
Before creating slabs, we need to define the load cases & combinations

i. Go to the Loading tab, click Load Cases and Combinations

ii. Pick Loading Generator

iii. Pick OK to save & close the Load Combination Editor





C. COLUMN CREATION

i. Define geometry

ii. Pick specific material property

iii. Specify the load and boundary conditions acting on the column

iv. Pick RC Column icon

v. Use the default size b1 & b2 and eccentricity e2 & e2

vi. Insert columns by clicking on the intersection of axes

vii. Multiple columns can be inserted by dragging a box around the intersection of axes

viii. Check for bending moment axial load and shear

ix. Check for the design reinforcements

D. Foundation creation; Based on the analysis results, proceed with designing the foundation. This process may involve the following sub-steps:

i. Size and Type Selection: Determine the appropriate size and type of foundation (e.g., spread footing, pile foundation) based on the analysis and soil properties.

ii. Reinforcement (if applicable): If the foundation includes reinforced concrete elements, design the reinforcement, specifying the type, size, and spacing of rebar.

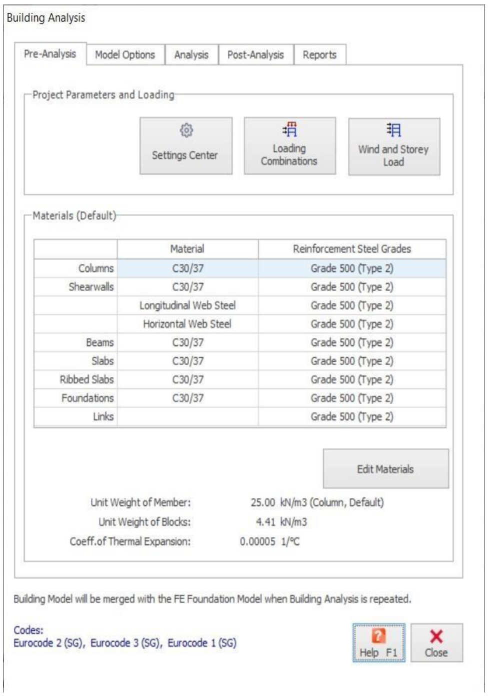
iii. Check for Bearing Capacity: Ensure that the foundation's bearing capacity is not exceeded under the applied loads.

iv. Check for Settlement: Assess the foundation's settlement to ensure it meets acceptable limits.

v. Foundation Detailing: Generate detailed construction drawings and specifications for the foundation design.

E. BUILDING ANALYSIS

Go to the Analysis tab →click Building Analysis → Pre-Analysis tab

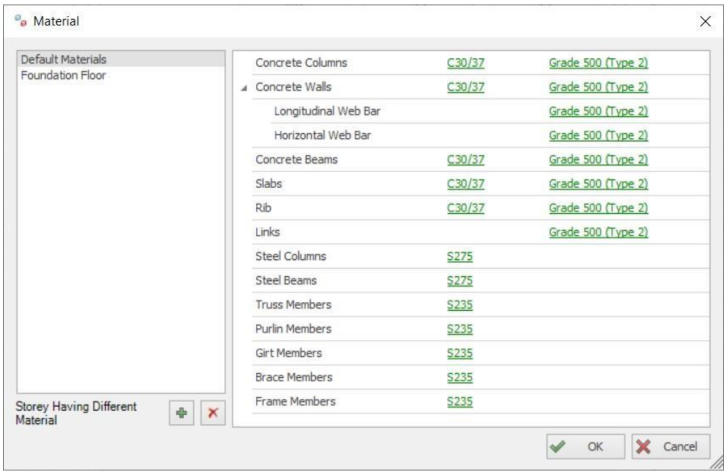


The initial configuration stage, known as the Pre-Analysis setup, provides the opportunity to establish the fundamental assumptions underpinning the analysis:

1. **Settings Centre:** Within the settings centre, you can access and subsequently revise key analysis parameters, such as the design code and notional horizontal load.
2. **Load Combination:** This section enables the generation, addition, or modification of various load cases or load combination sets.
3. **Wind and Storey Load:** Automatic wind load calculations are generated, and you have the option to review and input any lateral loads as needed. Notably, automatically generated lateral loads, including the notional horizontal loads, will only be computed and displayed following the completion of the analysis.
4. **Edit Materials:** Here, you can review, add, or make alterations to the materials used in the analysis.

Materials

We will now critically define the materials for this construction via Building analysis> Pre-Analysis dialogue.

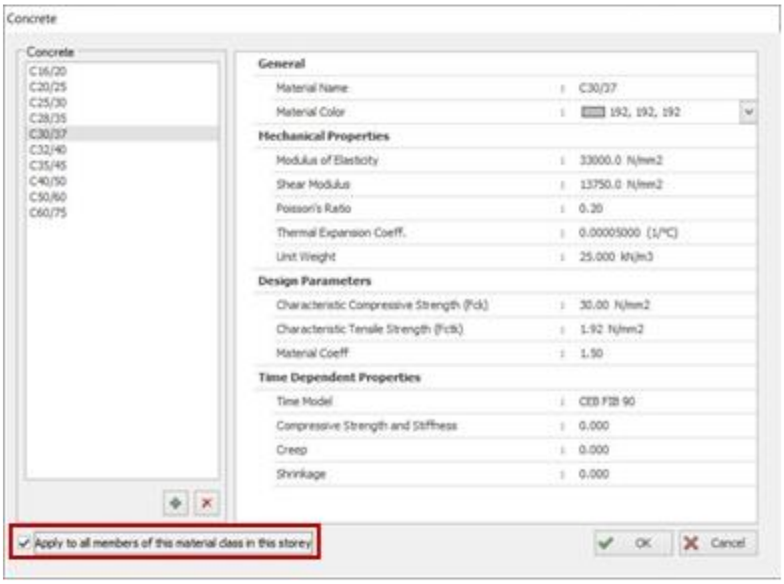


Pick Edit Materials

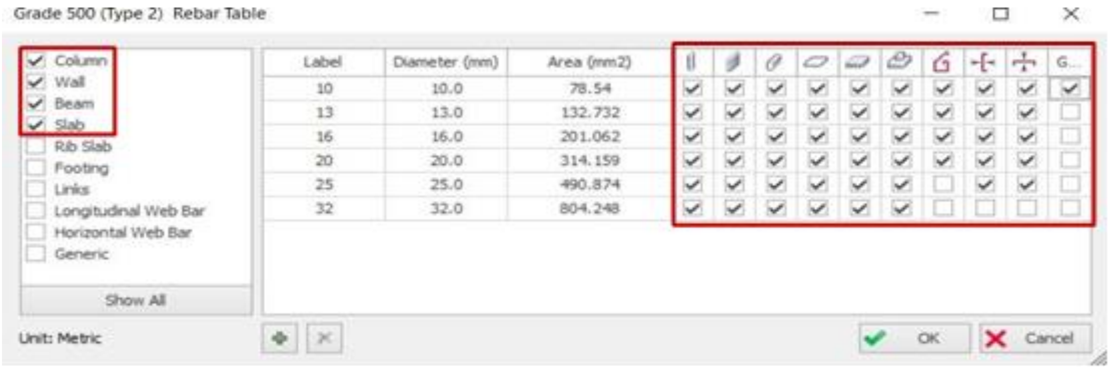
The materials and reinforcement steel grades are shown for all member types. Default Material is used for super-structure floors.

If a different material is required for a particular storey, a separate material set can be added by picking the icon. Steel reinforcement grades and diameters are also defined here.

Pick Column Concrete Grade → select C20/25 → Apply to all members in this storey → OK



Pick Steel Grade and ensure that Grade 410 (Type 2) is selected and applied to all member type. Click “Edit…” next to Rebar Diameter & the rebar table will pop up



Load Combinations

No	Combination	LL Red	R/C	Steel	G	Q	Qp11	Qp12	Qp21	Qp22	Qp31	Qp32	Qp41	Qp42	NGx	NQx	NGy	NQy
1	G+Q	✓	✓	✓	1.35	1.50	0	0	0	0	0	0	0	0	0	0	0	0
2	G+Qp1	✓	✓	✓	1.35	0	1.50	0	0	0	0	0	0	0	0	0	0	0
3	G+Qp2	✓	✓	✓	1.35	0	0	0	1.50	0	0	0	0	0	0	0	0	0
4	G+Qp3	✓	✓	✓	1.35	0	0	0	0	0	1.50	0	0	0	0	0	0	0
5	G+Qp4	✓	✓	✓	1.35	0	0	0	0	0	0	0	1.50	0	0	0	0	0
6	G+Q+Nx	✓	✓	✓	1.35	1.50	0	0	0	0	0	0	0	0	1.00	1.00	0	0
7	G+Nx+Q	✓	✓	✓	1.35	1.05	0	0	0	0	0	0	0	0	1.00	1.00	0	0
8	G+Q-Nx	✓	✓	✓	1.35	1.50	0	0	0	0	0	0	0	0	-1.00	-1.00	0	0
9	G-Nx+Q	✓	✓	✓	1.35	1.05	0	0	0	0	0	0	0	0	-1.00	-1.00	0	0
10	G+Q+Ny	✓	✓	✓	1.35	1.50	0	0	0	0	0	0	0	0	0	0	1.00	1.00
11	G+Ny+Q	✓	✓	✓	1.35	1.05	0	0	0	0	0	0	0	0	0	0	1.00	1.00
12	G+Q-Ny	✓	✓	✓	1.35	1.50	0	0	0	0	0	0	0	0	0	0	-1.00	-1.00
13	G-Ny+Q	✓	✓	✓	1.35	1.05	0	0	0	0	0	0	0	0	0	0	-1.00	-1.00

We have already generated the cases and load combinations previously, as shown above.

SLAB ANALYSIS & DESIGN

In beam/slab models, you can obtain slab reinforcement by inserting slab strips in both the X and Y directions. This process utilizes the moment coefficient method as outlined in the tables in the BS8110 code. It's important to note that this slab reinforcement procedure is independent of the general building analysis and can be performed either before or after the building analysis.

To effectively use the moment coefficient method, it is crucial to ensure that all the Slab Types are correctly set according to the guidelines provided in the BS8110 code. You have the option to automate this process in batch mode by following these steps:

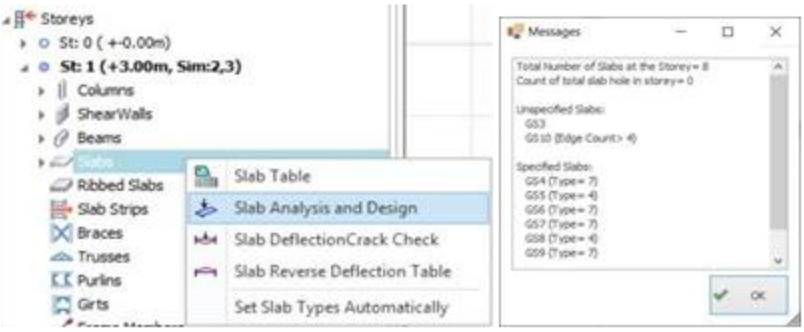
1. In the structure tree, locate and right-click on the slab icon.

2. From the context menu that appears, select the option "Set Slab Types Automatically."

By choosing this option, the software will automatically set the Slab Types based on the relevant criteria from the BS8110 code. This can streamline the process and help ensure that your slab reinforcement is configured correctly for your structural analysis and design.

From the Structure Tree, double click on storey St: 1 to return to the 1st Storey plan view.

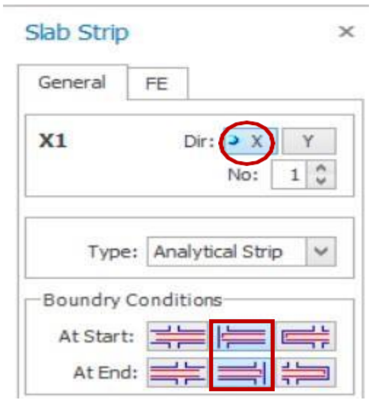
Right-click on Slab → Set Slab Types Automatically → Choose defaults options OK



Click OK to close the Messages dialog.

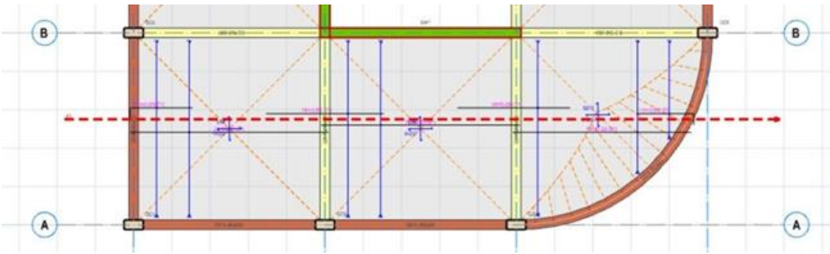
- Go to the Modelling tab & click on the Slab Strip the Slab Strip Properties will be displayed:
- Slab Strip Type: Analytical Strip is used for design based on the Code Method. FE Strip is used for innovation based on Finite Element Analysis results. Manual strip is used to manually input rebars without any analysis & design.

Set To configure the Slab Strip in accordance with the provided instructions, follow these steps:

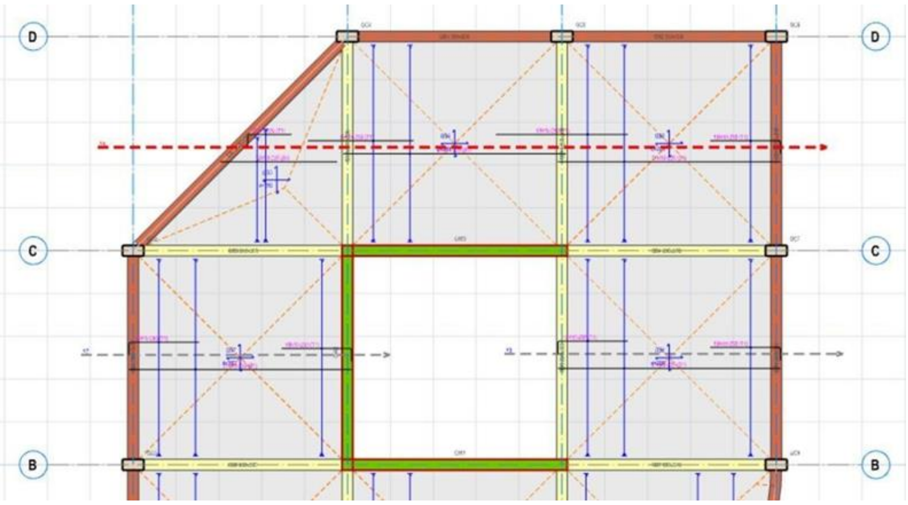


1. Set the Dir (Direction) to X.
2. Set the No (Number) to '1' so that the strip label is X1.
3. Set the Type to Analytical Strip.
4. Set the At Start condition to Bob.
5. Set the At End condition to Bob as well.
6. Now, you'll need to pick the slab strip's start and end points:

These steps will correctly configure the Slab Strip with the specified properties and conditions in your modelling software.



- Draw another similar slab strip X2 to obtain the design for the slabs between Axis B-C/1-2



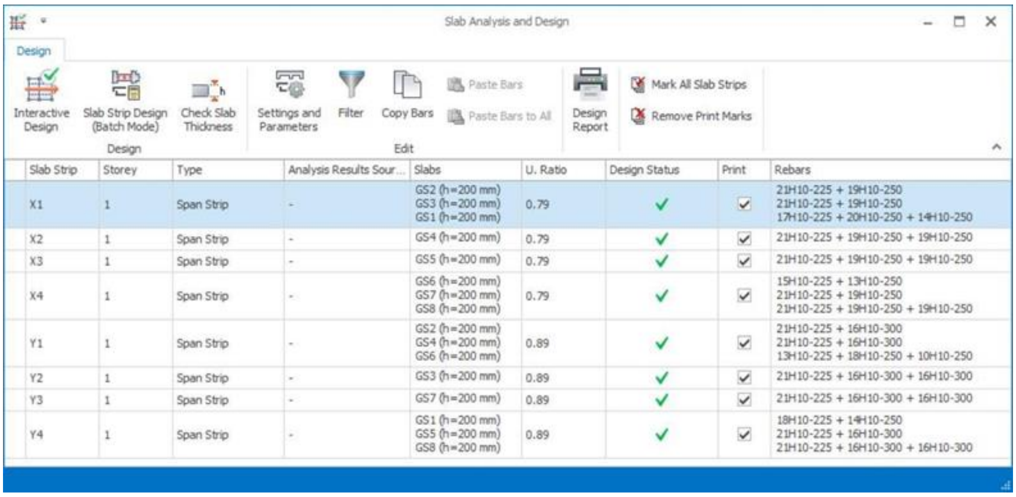
- Draw similar slab strip X3 to obtain the design for the slabs between Axis B-C/3-4
- Draw slab strip X4 to obtain the design for the slabs between Axis C-D/1-4

Now draw the vertical strips to design Y-direction rebar for the slabs.

Begin by selecting the starting point for the first vertical strip, and then draw it vertically through all the slabs. Repeat this process three more times, creating a total of four vertical strips, each extending through all of the slabs.

Your final layout should consist of these four vertical strips and the slab reinforcements as indicated in your reference or software interface.

We can now re-check the strips as a batch and create a slab analysis & design report.



Go to the Design tab → choose Slab Analysis and Design

In the slab analysis and design dialog, you will find several functions in the top menu bar for managing and reviewing the slab design.

These functions provide a comprehensive set of tools for managing, customizing, and analyzing the design of slab strips in your structural model.

- **Click Design Report**

The Slab Reinforcement Design report will be displayed. Options are available to configure and then print it. Any failure in the design will be highlighted in the Notifications pane at the left.

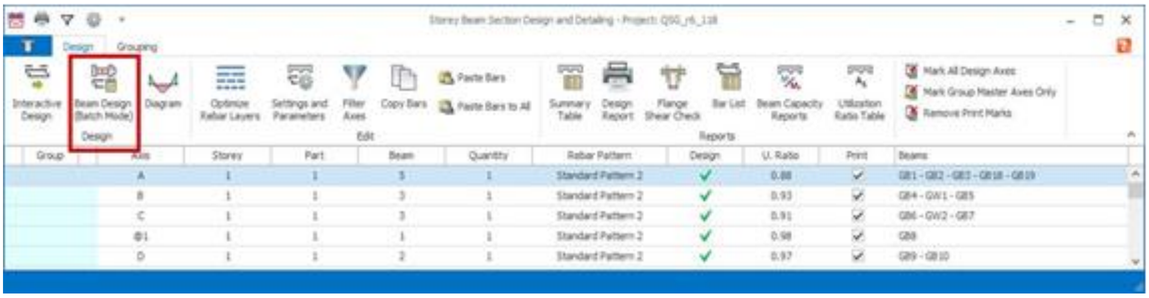
- Review the report and then Exit

BEAM DESIGN

Go to Design tab → pick Storey Beams

Since we have selected beam reinforcement design as part of Building Analysis, all the

beams are already designed as indicated by green ticks.



If they are not designed, you can choose Beam Design (*Batch Mode*) to design all beams at one go.

To customize the content of your report for beams:

In your report or configuration interface, you should see a column labelled "Print" alongside the list of beams.

To include a particular beam in your report, check the box in the "Print" column corresponding to that specific beam.

Conversely, if you want to exclude a beam from the report, uncheck the "Print" checkbox for that beam. By using the "Print" column and checking/unchecking the boxes, you can easily

Control which beams are included or excluded from your report, allowing you to tailor the report to your specific needs.

Choose Design Report

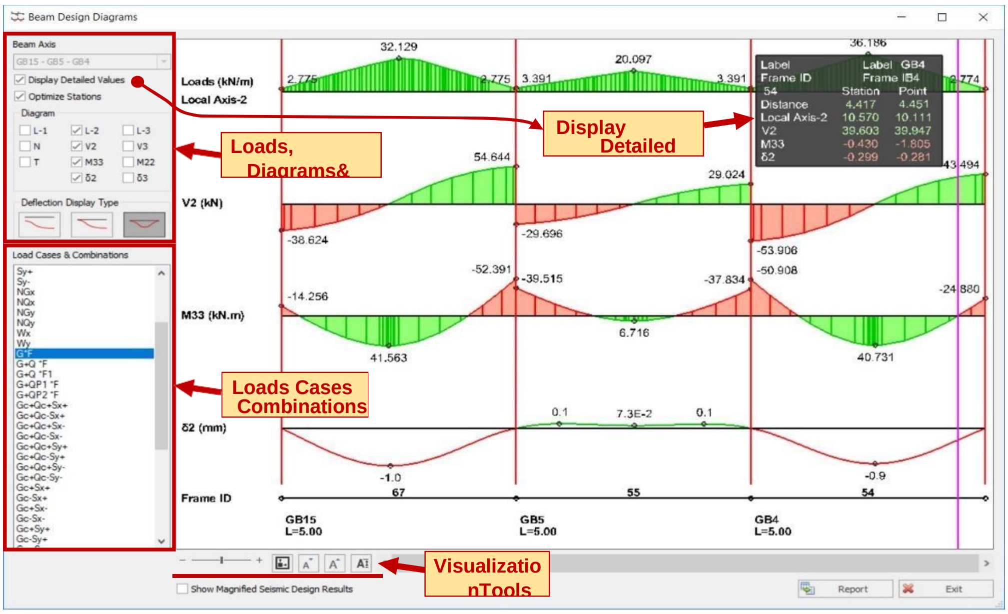
Beam Design Report is in rich text format. Choose the preferred Report Options to include the various force diagrams.

Pick OK to generate the report

Exit & this report will automatically be saved & made available for compilation in Report Manager.

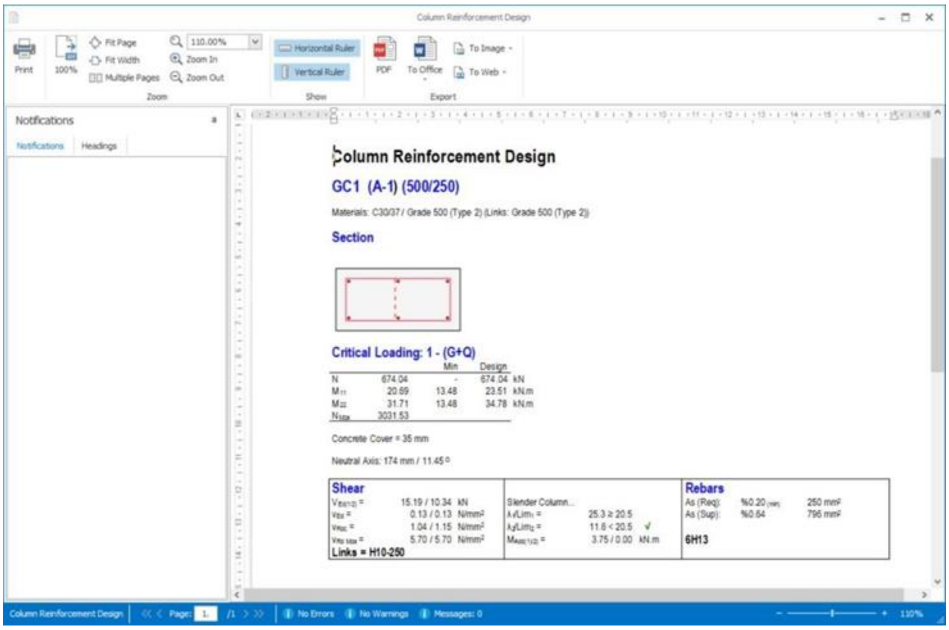
Any figures in red indicate a failure to meet the design criteria and should be investigated.

Click on the Diagrams button to see the loading and design forces.



COLUMN DESIGN

1. Navigate to the Column Section Design under the Design tab. Since we have selected to run column reinforcement design as part of Building Analysis, all the columns and walls are already designed as indicated by a green tick.
2. Go to the Reports tab Choose Design Report. To customize the content of your report, in the Load Combination table, you'll see a column labeled "Print." Check the box in the "Print" column for each column you want to include in the report. You can add or remove columns from the report by checking or unchecking the "Print" checkbox accordingly.
3. Check "Include Column/Wall Sections in the Report" to draw the column section detail.
4. Pick OK to generate the report.



5. Exit & this report will automatically be saved & made available for compilation in Report Manager.
6. Double click on GC1 in the list of columns in the Column Design screen.

7. Click Column Analysis to inspect the Interaction Diagrams (capacity curves

- ➢ *Select Interaction Diagram (N-M)*

For rectangular columns, there will be 2 capacity curves in direction 1 and direction 2 respectively.

The governing design will be the smaller curve; for this column in will be along dir-2, the shorter dimension & hence weaker capacity.

- ➢ *Select Dir-2 (N-M11)*

To confirm the adequacy of this column's design with the chosen reinforcement, it's essential that all the design combination pointsfall within the curve. This is particularly critical ifyou have made manual adjustments or modifications to the design parameters. In other words, the column's performance must align with the design criteria throughout all considered load combinations and conditions.

For this column, it is braced in both directions, the calculatedeffective lengths β are less than 1 &hence M-add is zero or minimal.

You can change the bracing condition manually.

- ➢ *Untick both Dir-1-Braced & Dir-2 Braced*
- ➢ *Click Interactive Design to refresh the design*
- ➢ *Go back to Slenderness tab to review*
- ➢ When the column is in an unbraced condition, it leads to effective lengths greater than 1. Consequently, an additional moment due to slenderness, denoted as M-add, is computed and automatically included in the initial design moment,resulting in the final design moment.

3.2 MANUAL DESIGN METHOD

Architectural plans of buildings come with different internal spaces representing rooms and other service spaces. During the preparation of General Arrangement (GA) for the manual structural design of the building, one or combination of these spaces form panels. The panels come in different sizes depending on the size of the different rooms or spaces. The panels can also be two-way slab panel or one way slab panel depending on the ratio of the longer span (Ly) to the shorter span (Lx). Generally,

If $\frac{L_y}{L_x} \leq 2$, the slab panel is two-way spanning.

If $\frac{L_y}{L_x} < 2$, the panel is one-way spanning.

The following steps were used in the design of a two-storeyed building

A. SLAB DESIGN.

i. Define Design Parameters

Determine the loads, including dead loads (DL), live loads (LL), and any other imposed loads on the slab. Consider material properties such as concrete strength (f_{ck}), reinforcement yield strength (f_y), and other material specifications. Specify support conditions, including the span length (L), width (b), and slab thickness (d).

ii. Calculate Design Loads Compute the design loads acting on the slab.

iii. Determine Moment and Shear Force Calculate the maximum moment (M) and shear force (V) at critical sections of the slab, typically near the supports, using the following formulas: Maximum moment at support (M_{max}) = (W_{total} x L^2)/8 Maximum shear force at support (V_{max}) = (W_{total} x L)/2

iv. Design for Flexural Reinforcement Calculate the required area of flexural reinforcement (As) using the formula: As = (M_{max} x 10^6) / (0.87 x f_y x (d - 0.4 x x)) Where:

v. M_{max} = Maximum moment at support (N_{mm}) f_y = Yield strength of reinforcement (N/mm^2) d = Effective depth of the slab (mm)

vi. x = Lever arm, typically assumed as 0.95d for simply supported slabs.

vii. Shear Assessment Determine the shear force (V_s) at a distance d from the support face using the formula: V_s

viii. = (V_{max} x L)/ (2 x d) Check if Vs is less than the shear capacity of the concrete (V_c) at that section. If Vs exceeds V_c, additional shear reinforcement (stirrups) may be needed.

ix. Deflection Check Verify the slab's deflection against allowable limits specified in BS 8110.

x. Shear Reinforcement Design If required, design shear reinforcement (typically stirrups) to withstand the computed shear force. The specific design equations for stirrups will depend on your project's details and can be found in the BS 8110 code.

B. COLUMN DESIGN

i. Establish Design Parameters. Identify the required axial load (N_{ed}) and bending moment (M_{ed}) to be supported by the column. Specify the concrete strength (f_{ck}) and the yield strength of reinforcement (f_y).

ii. Compute Axial Load and Bending Moment Calculate the design axial load (N_{ed}) and moment (M_{ed}) considering applied loads and reactions from adjacent elements.

iii. Select Column Dimensions. Choose appropriate column dimensions, including the cross-sectional area (A_c) and the effective depth (d).

iv. Verify Axial Load Capacity

Compute the axial load capacity (N_{rd}) of the column using the formula: N_{rd} = (Ac x f_{ck}) /γ_c

Where:

Ac = Cross-sectional area of the column

f_{ck} = Characteristic compressive strength of concrete γc = Partial safety factor for concrete

Compare N_{ed} to N_{rd} to ensure the column can safely carry the axial load.

v. Check Bending Moment Capacity. Calculate the moment capacity (M_{rd}) of the column with the formula: $M_{rd} = (Ac \times f_{ck} \times (d - a/2))/\gamma_c$

Where:

a = Depth to the centroid of the longitudinal tension reinforcement.

Compare M_{ed} to M_{rd} to verify that the column can withstand the bending moment.

vi. Assess Combined Axial Load and Bending

Consider the interaction between axial load and bending moment using the interaction formula:

$(N_{ed} / N_{rd}) + (M_{ed}/M_{rd}) \leq 1.0$

Ensure that the combined effects are within the column's capacity limits.

vii. Design Longitudinal Reinforcement

Determine the required area of longitudinal reinforcement (A_s) using this formula: As = (Ned - N_{rd}) / ((f_y / γs))

Where: N_{rd} = Axial load capacity of the column

γs = Partial safety factor for steel

viii. Design Shear Reinforcement (if applicable). If the column experiences shear forces, design the shear reinforcement (commonly links or stirrups) according to the relevant BS 8110 specifications.

ix. Create Detailed Drawings

C. BEAM DESIGN

i. Establish Design Parameters. Identify the anticipated loads and moments the beam will bear, encompassing dead loads, live loads, and other pertinent forces. 1.2. Determine the beam's span length and its support conditions, which could be simply supported, continuous, or cantilevered. 1.3. Specify the concrete grade (e.g., C25/30) and the type of reinforcement (e.g., T12).

ii. Compute Design Moments 2.1. Calculate the maximum bending moments and shear forces at critical segments of the beam. You may employ structural analysis software or manual calculations for this phase.

iii. Choose an Appropriate Section Shape 3.1. Select a suitable section shape, such as rectangular, T-beam, or I-beam, based on the computed moments and shear forces.

iv. Verify Serviceability Requirements 4.1. Scrutinize deflection limits to ensure compliance with the beam's serviceability criteria. BS 8110 presents deflection limits for various structure types.

v. Determine Reinforcement 5.1. Compute the required area of tensile reinforcement (As) using the design moments and the specified concrete and steel grades. 5.2. Establish the spacing and diameter of longitudinal bars (primary reinforcement) to meet design specifications. 5.3. Calculate the minimum shear reinforcement (links or stirrups) needed based on design shear forces and determine the spacing and diameter of this shear reinforcement.

vi. Detailing and Arrangement of Bars 7.1. Develop a detailed reinforcement layout, outlining the positioning of longitudinal bars and shear reinforcement. 7.2. Confirm that the reinforcement adheres to specified cover requirements and spacing.

vii. Confirm Development Length and Anchorage 8.1. Validate that the reinforcement bars have adequate development length to transfer calculated forces to the concrete. 8.2. Ensure proper anchorage is provided at the beam ends.

viii. Check for Minimum and Maximum Reinforcement 9.1. Confirm that the calculated amount of reinforcement aligns with BS 8110's minimum and maximum limits.

D. FOUNDATION DESIGN

i. Determine Design Loads: Assess the required support for the foundation, considering both permanent (dead loads) and temporary (live loads) structures. Permanent loads entail the structure's weight and permanent fixtures, while live loads encompass transient factors like people and furnishings.

ii. Soil Investigation: Conduct a geotechnical assessment to ascertain the soil characteristics at the construction site. This includes an analysis of soil type, bearing capacity, settlement properties, and groundwater levels.

iii. Foundation Type Selection: Choose the most suitable foundation type based on the specific soil conditions and building prerequisites. Common options encompass shallow foundations like spread footings and deep foundations such as piles or caissons.

iv. Determine the Foundation Dimensions: Calculate the foundation's size and shape based on factors like design loads, soil bearing capacity, and structural needs. Ensure that the foundation dimensions are adequate for distributing loads to the soil without causing excessive settlement or instability.

v. Load Combination: Combine various load scenarios (dead loads, live loads, wind loads, etc.) in accordance with BS 8110 to determine the design loads that the foundation must accommodate. This process involves considering different load combinations to account for simultaneous loading conditions.

vi. Design for Soil Bearing Capacity: Verify that the soil's bearing capacity can support the calculated loads without excessive settlement. Ensure that the foundation's base area is sufficient to evenly distribute the loads within the permissible bearing capacity limits.

vii. Structural Analysis: Conduct a structural analysis to determine the internal forces and moments within foundation elements (e.g., beams, slabs, columns) that transmit loads to the foundation. Ensure that these structural elements are designed to withstand these loads effectively.

viii. Reinforcement Design: Calculate the necessary reinforcement for foundation elements using appropriate design guidelines, including those specified in BS 8110. Design reinforcement for bending, shear, and torsion as needed.

ix. Detailing: Generate comprehensive drawings and specifications for the foundation, outlining the layout, reinforcement specifics, and concrete mix design. Ensure strict adherence to design requirements and safety margins.

x. for Stability and Settlement: Perform rigorous checks for stability against overturning, sliding, and uplift to confirm the foundation's overall stability. Monitor settlement to remain within permissible limits to prevent structural damage.

xi. Construction Considerations: Take construction methods into account, including formwork, concrete placement, curing, and quality control, to guarantee that the foundation is constructed in accordance with the design specifications.

xii. Documentation: Prepare an exhaustive set of design documentation, encompassing drawings, calculations, and specifications, necessary for construction and regulatory approval.

CHAPTER FOUR

ANALYSIS, CALCULATION AND DISCUSSION OF RESULTS.

The following are analysis of results generated from the design of a tall hostel building using the following methods:

i. CADs Method for Computer Aided Design Software.

ii. Manual Method

Reference	Calculation	Solution
	Design information Project: Six storeys: Six Storey Building Design Stresses: f_{cu} = N/mm^2 F_y= 410N/mm^2 Weight of Concrete =25KN/m^2 Fire Resistance = 1 hr. Exposure + mild Loading: Imposed = 1.5KN/m^2 Finishes = 1.0 KN/m^2 Screeding = 20KN/m^2 Soil condition: Laterite soil Bearing capacity = 200kn/m^2 **SLAB DESIGN** INITIAL PROPORTIONING Basic span/ d ratio = 20 Modification factor (m) = 1.30 Minimum effective depth (d) = (span/Basic ratio) x m = (3275/20) x 1.30 = 210mm Table 3.3 Mild exposure @ c30 Nominal cover = 25mm 1 hr fire resistance Nominal cover = 20mm Therefore, nominal cover = 25mm Overall depth h = d + cover + Ø/2 = 210 + 25 +12/2 = 241mm Effective depth D = h - cover – Ø/2 241 – 25 -12/2 =210mm.	

Ly/lx = (3275 / 3275) = 1
Ly/lx = 1 < 2.0

Design as a two-way spanning slab
Cl3.5.3.4
$Msx = Bsx\ nlx^2$
$Msy = Bsy\ nlx^2$
Table 3.14
Taking ly/lx = 1.0
Bsx + = 0.024
Bsx - =0.031
Bsy + = 0.024
Bsy - = 0.032

Short Span / mid span
Cl 3.5.3.4
$Msx = = Bsx \times n \times lx^2$
= 0.024 x 12.55 x 3.2752 = 3.986 kN/m
$K = Msx^2/Farbd^2$
$3.986.X\ 106/30 \times 1000 \times 210^2$
= 0,003 <0.156
Therefore, Design for tension reinforcement only
Cl 3.4.4.4
z= d (0.5 + √ 0.25-14/0.9)
= d (0.5+ √0.25-0.03/0.9)
= 0.997d
Since z = 0.997 d > 0.95d, take;
z=0.95d
= 0.95 x 210
= 199.5mm
A_s – M/0.95fy Z = 3.986 x 106/(0.95×350×199.5) = $60.09m^2$

Table 3.25
Minimal As= 0.13bh/100
= 0.13 x 1000 x 241/ 100 = $313.3mm^2$
A_s req = $314mm^2$
Provide Y12@ 250 c/c
As prov =$566mm^2$
Cl 3.5.3.4
M_{sx}- = B_{sx} x n_x lx2= 0.13 x 12.55 x 3.2752 = 4.173KN/m
K= M_{sx}-/$f_{cu}bd^2$
4.1731 x 106 x 30 x 1000 x 2102 =0.003 < 0.156
Cl 3.4.4.4

Z = d (0.5 +√ o.25- k/0.9) = d Co.5+ √0-25-0.03/0.9
= 0.997 d
Since z = 0.997d > 0.95; take
Z =0.95d = 0.95x 210 = 199.5mm
Cl 3.4.4.4
As = M/ 0.95fyZ = 4.173 x 106/ 0.95 x 350 x 199.5 = 62.91mm^2
Recall, As min = 313.3mm^2
Provide Y 12 @ 250mm c/c
As prov = 566mm^2

Long Span
D = 210 – 12 = 198mm
Cl 3.5.3.4
M_{sy} + = B_{sy} x n x lx2
= 0.024 x 12.55 x 3.2752= 3.231KN/m
K= M_{sy}+/fcubd^2 = 3.231 x 106/ 30 x 1000 1982 = 0.003< 0.0156

Design for tension reinforcement only
z = d(0.5 + √ 0.25 –k/0.9) = d(0.5 + √ 0.25 –0.003/0.9) = 0.997d
Since z 0.997d >095d, take
Z = 0.95d = 0.95x 210= 199.5mm
Cl 3.4.4.4
As = M/ 0.95fyZ = 3.231 x 106/ (0.95 x 350x 199.5) = 48.71mm_2
Recall, As min = 313.3mm_2
As req = 314mm2
Provide Y12 @250mm c/c
As prov = 56mm_2
Cl 3.5.3.4
M_{sy} = B_{sy} x n x lx 2 = 0.032 x 12.55 x 3.2752 = 4.31mm_2
Still provide Y12@ 250mm spacing

DEFLECTION CHECK
Table 3.10
M_{sx}+ / bd2 = 3.986x 106/1000 x 2102 =0.09
Fs= (2fyAsreq/ 3As prov) x 1/Bb

= (2 x 350 x 314/ 3 x 566) x 1/1 = 129.45N/mm_2

M_f = 0.55 + 477-fs/120(0.9+M/bd2) = 3.48 > 2.0

	Take mf = 2.0 Basic span / effective depth ratio= 20 Limiting Span / effective depth = 20 x mf = 20 x 20 = 40 Actual span / effective depth = 3275 / 210 Actual span/ effective depth < limiting span / effective depth = okay CRACK CHECK Cl 3.12.11.2.7 Spacing between bars < 3d or 750mm 3d =n 3 x 210 = 630mm Spacing = 250mm < 630mm Therefore, crack is controlled BEAM DESIGN INITIAL PROPORTIONING Table 3.9 Basic span /d ratio = 20 (Simply supported) D = 10000/ basic span / depth ratio = 500mm Table 3.3 Mild exposure @ c30 = 25mm Fire resistance cover = 20mm Nominal cover = 25mm Take 20 diameter bar Ø Take 12mm diameter strips $Ø_l$ Overall depth h = d + cover+ Ø + $Ø_l$ 500 + 25 12 + 20/2 = 547mm Revised effective depth, d = h – cover – Ø – Ø/2= 547 – 25 - 8 - 12/2= 508mm… B_w = h/3 = 547/3= 183mm B_{eff} = b_w + lx/3 = 183 +3275/5= 838mm Volume = L x w x h = 3.275 x 3.275 x 0.542= 5.87m^3 Mass = v x 24= 5.87 x 24= 140.8g Self-weight of beam= (h–hf) b_yl= 140.8 x 9.81= 1381.31N=1.38KN Dead load from Slab = 1.0 x 10.73= 10.73 KN Wall load = 3.47 x (0.5547-0.21) x 3275 = 3.83KN Total Dead load = 1.38 +10.73.3.83= 15.94KN Live load from slab =1.5 x 10.73= 16.095KN Table 2.2 Ultimate load (F) = 1.4Gk + 1.6 Qk = 1.4(15.94) + 1.6(16.095) = 48.1KN/m2 Design Ultimate load = 48.1/ 10= 4.81KN/m	

BENDING MOMENT AND SHEAR FORCE

$M = wl^2/8$; F = Wl/8

= 4.81 x 3.833/ 8 = 8.82; 4.01 x 3.83/8 = 2.1

REINFORCEMENT

Cl 3.4.4.4

K = M /bd2fcu = 8.82 x 106/ 1000 x 30 = 0.001 < 0.95

Singly reinforced section, so there's need for compression reinforcement

Z = d(0.5 + √ 0.25 –k/0.9)= d(0.5 + √ 0.25 –0.001/0.9)

Since Z = 0.99d > 0.95, take Z= 0.95d

= 0.95 x 508= 482.6mm

A_s= M/ 0.95fyZ = 8.82 x 106/0.95 x 350 x 482.6 = 54.97mm^2

Table 3.25 Minimum As = 0.13%bh= 0.13bh/100

=0.13 x 1000 x 547 / 100 = 711.1mm^2

$A_s$prov = 925mm^2

DEFLECTION CHECK

Table 3.10

M/bd2 = 8.82 x 10^{65} / 1000 x 2.1 x 508^2 = 0.02

F_s = (2fy Asreq / 3 A_s prov)/ 1/B_b = 2 x 350 x 711.1/ 3 x 925mm^2

= 179.4 N/mm2

Mf = 0.55 + 477- 174.4/100 (0.9 + 0.02) < 2 = 3

.25>2.0

Taking mf as 2.0

Basic span / effective depth ratio = 20

Limiting span / effective depth = 20 x 2 = 40

Actual span / effective depth = 3275/508= 6.5

6.5 < 40 (deflection is satisfied)

SHEAR CHECK

At face of support: V_{face} = 179.4 – 48.1 x 0.45/2 = 168.6KN

V= v/ bwd= 168.6 x 10^3 / 183 x 508 = 1.8N/mm^2

CRACK CHECK

Table 3.25

Area of steel provided bw/b = 183/3275 =0.1

Min; 0.13bwh/100 = 0.13 x 547 / 100 = 130mm 2/m Cl 3.126

max = 4 x 183 x 547 / 100 = 4004

Provided 6925

130<925<4004 ok

Table 3.28 spacing of bars = 183- 2 x 25- 2 x 6 – 3 x 20/2 = 30.5 >
25 ok < 155 okay

ANCHORAGE

Table 3.27 lap length = 40 x 25 = 1000mm= anchorage length
Coordinate of bars
Fig 3.25 cut 3925 @ 0.08L = 0.08 x 1000 = 80mm from center of column

End anchorage
3.12.9.4 End anchorage length = 12 Ø = 12 x 20 = 240mm; beyond centre line of support.
Since column is 450mm, there is a provision for this length.

COLUMN DESIGN

SUPPORT LOADS

Floor area supported by columns = 3.275 x (3.275 + 2.825)/2 = $10m^2$ (0.75fy- 0.35fcu) Asl = N – 0.35fcuAc
Asc = N – 0.3Fcu Ac / 0.75fy – 0.3Fcu
Total beam length
Spanning in to column = 3.275/2 + 3.275/2 + 3.275/2 + 2.825/2= 6.325m

Slab load = 12.55KN/m2
Beam load = 0.183 x 25x 0.45 = 2.1KN/m
Wall load = 3.47 x 3.6 = 12.5KN Beam/ wall load =m 2.1 + 12.5 = 14.6

LOADING

5th to 6th floor
Slab load = 12.55 x 10 = 125.5
Beam /wall load = 14.6 x 6.325 = 92.345KN
Column self-weight = 0.45 x 0.45 x 25 x 3.6 = 18.225KN
Total load = 236.07KN

4th – 5th floor
Loading from above = 236.07KN
Overall = 236.07
Total = 472.14KN

3rd – 4th floor

From above = 472.14
Overall = 236.07
Total = 708.21KN

2^{nd} – 3^{rd} floor
From above = 708.21
Overall = 236.07
Total = 944.28KN

1^{st} – 2^{nd}
From above, = 944.28
Overall = 236.07
Total = 1180.35KN

FOUNDATION DESIGN
Column axial load = 1180.38KN
Column size = 450 x 450
Foundation column load = m0.45 x 0.45 x 3.6 x 25 = 25.73KN
Total axial load in pad = 1180.35 + 25.73= 1206.1KN
Soil bearing capacity = 200KN/m^2
FOOTING DEPTH
Vu = lesser (0.8 + √ 35, 5N/mm2) = 4.7N/mm^2
Perimeter of column, U = 4 x 450 =1800mm
Shear stress @ face of column
U + N/ column perimeter x d Vu/2 = 1206.1 x 103/ 1800 x d
D = 1206.1 x 103 x 2 / 1800 x 4.7 = 285mm
Assume using a blinding concrete layer; cover 50mm
Assume 20mm diameter bars
H = 285 + 50 +20 = 355 say 360mm
D= 360 – 50 -20 = 290mm

FOOTING AREA
N_s = total axial load x hy_cA = 1206.1 + 0.36 x 24 x A = 1206.1+8.64 A
Soil bearing pressure at service; (200KN/m^2) = 8.64A/ A
A = 1206.1/ 191.36 = 6.3m2 required base area
Provide a square base of 2.51m D =B = 2.51
Area = 6.3m^2
Earth pressure @ Ultimate Limit State
Earth pressure (P) = 1206.1/ 6.3 = 191.4 KN/m^2
Reinforcement:

Moment at face of column M = P x BL (l/2)
= 191.4 x 2.51 x 1.03 (1.03/2) = 254.8KN/m
K = M/Fcubd2 = 254.8 x 106/ 35 x 2510 x 2902 = 0.034 < 0.156 ok
z/d = 0.5 + √ 0.25 –0.034/0.9 = 0.98>0.95
Therefore Z = 0.95d = 0.95 x 290 = 275.5mm
As = M/ 0.95fyZ = 254.8 x 106/0.95 x 350 x 275.5 = 2781.5mm2
Provide 8T20 @ spacing = 2510/8 = 313.75mm
centers Asp = 3100mm2
Minimum reinforcement:
Asmin = 0.13bh/100= 0.13 x 2510 x 360/100 = 1174.68< Asp (OK)
Spacing (313.75mm) < 750 (ok)
SHEAR CHECK
Checking shear at 1.0d from face of column, V = P x BL
= 191.4 x 2.51 x 0.53 = 254.62KN
V=v/bd= 254.62 x 103/2510 x 290 =0.35N/mm2
Table 3.8; 100As/bd = 100 x 3100/2510 x 290 = 0.43 450/d = 450/290 =1.6>1
Therefore (0.79 x 0.431/3 x 1.6 x35/25)1/3/ 1.75 = 0.5N/mm2
Since V-Vc == shear is okay

PUNCHIING SHEAR @ 1.5D FROM SURFACE OF COLUMN

Critical perimeter for shear = column perimeter + 8 x 1.5d=4 x 400
+8 x 1.5 x 290= 5280mm

Area within the perimeter (Ap)=(0.45 + 3d)^2 = 1.74m^2
Punching shear force Vp, = 191.4 (A –Ap) = 672.78KN
Punching shear stress = Vp /(w) = 0.439N/mm^2
Since Vc = 0.95N/mm^2 (v<vc), punching shear is ok
(v<vc),
punching shear is ok

4.2 SOFTWARE ANALYSIS RESULTS

Slab Reinforcement Design
LEGEND:
d/h = Slab Effective/Total
Depths (d=h-cover) g/q
Dead/Live Loads (not factored)
L1 = Width of the Slab Along the Strip Direction
L2 = Width of the Slab Perpendicular to the Strip Direction
C = Moment Coefficient M=C p / L^2
M-span = Ultimate Span Moment
M-sup = Ultimate Support Moment
Mc = Balanced Support Moment
As = Steel Area (Required/Supplied)

Slab Strip: X1 -- Storey: 1
Materials: C20/25 / Grade 410 (Type 2)

	Type	g	L1	C-sup	C-span	As	
Slab	d/h	q	L2	M-sup	M-span		Req/Sup
	(mm)	(kN/m2)		(mm)	(kN.m)	(kN.m)	(mm2)

S T E E L B A R S

250(T1) Support Mc = 0.4Support As =254.40/452 .39
SupTop: Y12-
1S6 1 8.441 3824.90 0.0320 0.0240 254.4/452. 39
107/150 2.500 3231.40 3.7 2.7 StrBot: Y12-
250(B2)
250(T1) Support Mc = 3.7Support As =254.40/452 .39
SupTop: Y12-
1S8 1 8.441 3824.90 0.0320 0.0240 254.4/452. 39
107/150 2.500 3231.40 3.7 2.7 StrBot: Y12-
250(B2)
250(T1) Support Mc = 3.7Support As =254.40/452 .39
SupTop: Y12-
1S7 1 8.441 3824.90 0.0320 0.0240 254.4/452. 39
107/150 2.500 3231.40 3.7 2.7 StrBot: Y12-
250(B2)
250(T1) Support Mc = 3.7Support As =254.40/452 .39
SupTop: Y12-
1S13 1 8.441 3824.90 0.0320 0.0240 254.4/452. 39
107/150 2.500 3231.40 3.7 2.7 StrBot: Y12-
250(B2)
250(T1) Support Mc = 3.7Support As =254.40/452 .39
SupTop: Y12-
1S17 1 8.441 3825.00 0.0320 0.0240 254.4/452. 39
107/150 2.500 3231.40 3.7 2.7 StrBot: Y12-
250(B2)
250(T1) Support Mc = 3.7Support As =254.40/452 .39
SupTop: Y12-
1S16 1 8.441 3801.20 0.0320 0.0240 254.4/452. 39

250(B2) 107/150 2.500 3231.40 3.7 2.7 StrBot: Y12-
250(T1) Support Mc = 3.7Support As = 254.40/452 .39
SupTop: Y12-
1S18 1 8.441 3824.90 0.0320 0. 0240 254.4/452. 39
107/150 2.500 3231.40 3.7 2.7 StrBot: Y12-
250(B2)
250(T1) Support Mc = 3.7Support As = 254.40/452 .39
SupTop: Y12-
1S22 1 8.441 5605.40 0.0320 0. 0240 254.4/452. 39
107/150 2.500 3231.40 3.7 2.7 StrBot: Y12-
250(B2)
250(T1) Support Mc = 0.4Support As = 254.40/452 .39
SupTop: Y12-

Slab Strip: X11 -- Storey: 1
Materials: C20/25 / Grade 410 (Type 2)
Slab Type d/h (mm) g
q
(kN/m2) L1
L2 (mm) C-sup
M-sup (kN.m) C-span
M-span
(kN.m) As
Req/Sup
(mm2) S T E E L B A R S
Support Mc = 0.4Support As =254.40/452.39 SupTop: Y12-
250(T1)
1S1 1 8.441 3824.90 0.0320 0.0240 254.4/452.39
107/150 2.500 3225.10 3.6 2.7 StrBot: Y12-
250(B2)
Support Mc = 3.6Support As =254.40/452.39 SupTop: Y12-
250(T1)
1S2 1 8.441 3824.90 0.0320 0.0240 254.4/452.39
107/150 2.500 3225.10 3.6 2.7 StrBot: Y12-
250(B2)
Support Mc = 6.6Support As =254.40/452.39 SupTop: Y12-
250(T1)
1S10 1 8.441 3824.90 0.0507 0.0377 254.4/452.39
119/150 2.500 5443.70 8.1 6.0 StrBot: Y12-
250(B1)
Deflection Check L/d = 32.14 < 52.0 *** Sufficient ***
Support Mc = 8.1Support As =254.40/452.39 SupTop: Y12-
250(T1)
1S9 1 8.441 3824.90 0.0507 0.0377 254.4/452.39
119/150 2.500 5443.70 8.1 6.0 StrBot: Y12-
250(B1)
Slab Strip: X12 Storey: 1
Materials: C20/25 / Grade 410 (Type 2)
Slab Type d/h (mm) g
q

(kN/m2) L1
L2 (mm) C-sup
M-sup (kN.m) C-span
M-span
(kN.m) As
Req/Sup
(mm2) STEELBARS
Support Mc = 1.0Support As =254.40/452.39 SupTop:
Y12-
250(T1)
1S15 1 8.441 3556.50 0.0000 0.0458 254.4/452.39
119/150 2.500 6617.00 1.0 6.3 StrBot: Y12-
250(B1)

Slab Strip: X12 Storey: 1
Materials: C20/25 / Grade 410 (Type 2)
Slab Type d/h (mm) g
q
(kN/m2) L1
L2 (mm) C-sup
M-sup (kN.m) C-span
M-span
(kN.m) As
Req/Sup
(mm2) STEELBARS
Support Mc = 1.0Support As =254.40/452.39 SupTop:
Y12-
250(T1)
1S15 1 8.441 3556.50 0.0000 0.0458 254.4/452.39
119/150 2.500 6617.00 1.0 6.3 StrBot: Y12-
250(B1)

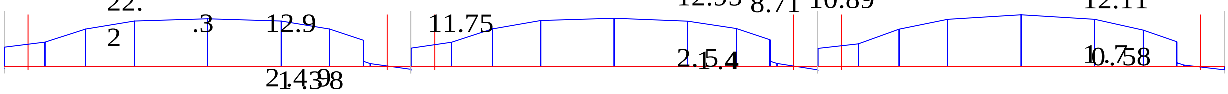
Slab Strip: X13 -- Storey: 1
Materials: C20/25 / Grade 410 (Type 2)
Slab Type d/h (mm) g
q
(kN/m2) L1
L2 (mm) C-sup
M-sup (kN.m) C-span
M-span
(kN.m) As
Req/Sup
(mm2) STEELBARS
Support Mc = 0.4Support As =254.40/452.39 SupTop:
Y12-
250(T1)
1S20 1 8.441 2224.70 0.0000 0.0447 254.4/452.39

119/150 2.500 3984.50 0.4 2.4 StrBot: Y12-250(B1)

Axis: X2 Storey: 1 Etriyeler: C20/25 / Grade 410 (Type 2) (Links: Grade 250 (Plain))

	1B1 L=3824.9mm	1B2 L=3824.9mm	1B3 L=3824.9mm
BwxH (mm)	225 x 450	225 x 450	225 x 450
Flange BfxHf	---	---	---
	C20/25 / Grade 410 (Type 2)	C20/25 / Grade 410 (Type 2)	C20/25 / Grade 410 (Type 2)

9.29 11.81



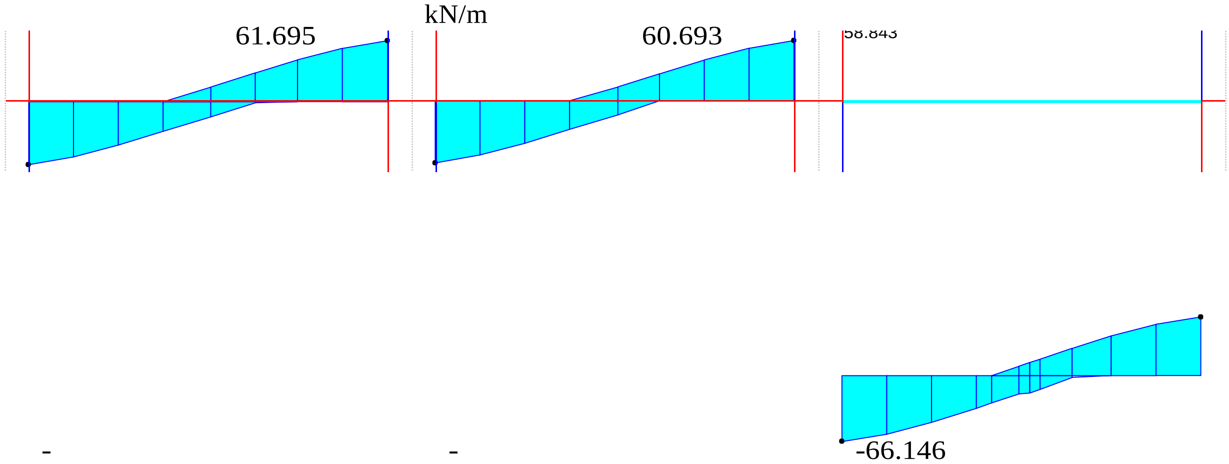
Loads

0.38 0.77 1.22 1.91 2.6 3.06 3.83 0.38 0.77 1.22 1.91 2.6 3.06 3.83 0.38 0.77 1.22 1.91 2.6 3.06 3.83

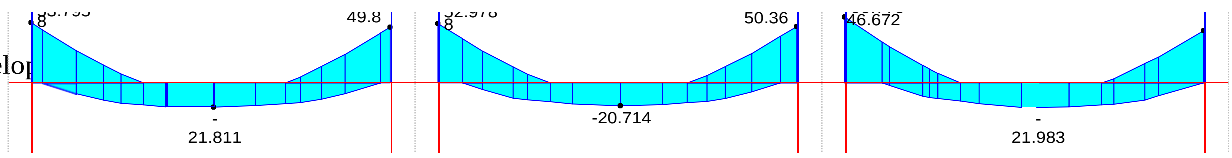
G=1-.1.213 -1.488 -1.771 -1.69

UDL G=2.04 Q=0 kN/m UDL G=2.04 Q=0 kN/m UDL G=2.03 Q=0 kN/m

Shear Force (Envelope)



Moment (Envelope)



Bending (Top Edge) ...

M (kN.m)	53.8	7.8	49.9	53.0	7.6	50.4	58.8	9.9	46.7
d (mm)	407.0	407.0	407.0	407.0	407.0	405.0	405.0	407.0	407.0
K/K'	0.37	0.05	0.34	0.36	0.05	0.35	0.41	0.07	0.32
x (mm)	62.31	45.22	57.44	61.29	45.22	58.38	68.99	45.22	53.50
As (mm2)	398.16	56.77	367.06	391.64	55.36	373.03	440.83	71.50	341.87

As' (mm2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
As-min	171.72	171.72	171.72	171.72	171.72	171.72	171.72	171.72	171.72

Bending (Bottom Edge) ...

M (kN.m)	11.6	21.8	11.6	8.3	20.7	10.1	5.0	22.0	14.0
d (mm)	407.0	407.0	390.0	390.0	407.0	390.0	390.0	407.0	390.0
K/K'	0.08	0.15	0.09	0.06	0.14	0.08	0.04	0.15	0.10
x (mm)	45.22	45.22	43.33	43.33	45.22	43.33	43.33	45.22	43.33
As (mm2)	84.09	158.22	87.63	63.10	150.26	76.65	38.03	159.47	105.80
As' (mm2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
As-min	171.72	171.72	171.72	171.72	171.72	171.72	171.72	171.72	171.72

Shear and Bending Design ...

Vd (kN)	63.1		61.7	62.3		60.7	66.1		58.8
v (N/mm2)	0.69		0.67	0.68		0.67	0.73		0.64
vc (N/mm2)	0.47	0.47	0.47	0.47	0.47	0.54	0.54	0.47	0.47
v-max (N/mm2)	4.00		4.00	4.00		4.00	4.00		4.00
Vnom (kN)		93.0			93.0			93.0	
Td (kN.m)		0.1			0.0			0.6	
vt (N/mm2)		0.00			0.00			0.00	
vt-min(N/mm2)		0.00			0.00			0.00	
b-sup (mm)	0.0		0.0	0.0		0.0	0.0		0.0
Links	R10-300	R10-300	R10-300	R10-300	R10-300	R10-300	R10-300	R10-300	R10-300

Deflection Check ...

L/d 9.4 < 58.64 OK 9.4 < 58.64 OK 9.4 < 58.64 OK

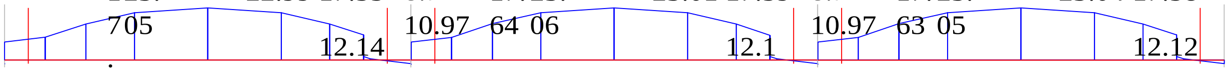
Supplied Steel Areas (mm2)

Top Edge	402.12	402.12	402.12	402.12	402.12	628.32	628.32	402.12	402.12
Bot Edge	402.12	402.12	402.12	402.12	402.12	402.12	402.12	402.12	402.12

Steel Bars ...

Top.Bars	2Y16		2Y16		2Y16	
Top.Sup.	2Y16		2Y16	2Y20	2Y20	2Y16
Top.Sup.						
Bot.Bars	2Y16		2Y16		2Y16	
Bot.Bars						
Bot.Sup						

BwxH (mm)	1B4 L=3824.9mm 225 x 450	1B5 L=3824.9mm 225 x 450	1B6 L=3824.9mm 225 x 450
Flange BfxHf	--- C20/25 / Grade 410 (Type 2)	--- C20/25 / Grade 410 (Type 2)	--- C20/25 / Grade 410 (Type 2)



Loads

0.38 0.77 1.2 2 1.91 2.6 3.06 3.83 0.38 0.77 -1.712 1.22 1.91 2.6 3.06 3.83 0.38 0.77 -1.722 1.22 1.91 2.6 3.06 3.83 -1.73

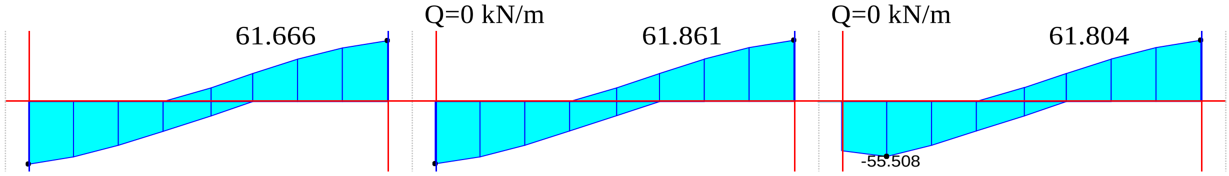
G=-1.16.869

UDL G=2.03 Q=0 kN/m

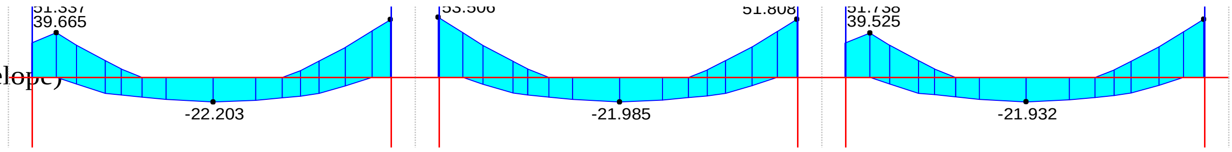
UDL G=2.03 Q=0 kN/m

UDL G=2.03 Q=0 kN/m

Shear Force (Envelope)



Moment (Envelope)



Bending (Top Edge) ...

M (kN.m)	53.7	7.3	51.3	53.5	7.3	51.8	53.6	7.4	51.7
d (mm)	407.0	407.0	407.0	407.0	407.0	407.0	407.0	407.0	405.0
K/K'	0.37	0.05	0.35	0.37	0.05	0.36	0.37	0.05	0.36
x (mm)	62.16	45.22	59.25	61.95	45.22	59.83	62.02	45.22	60.09
As (mm2)	397.20	52.90	378.60	395.86	52.70	382.33	396.32	53.37	383.95
As' (mm2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

As-min	171.72	171.72	171.72	171.72	171.72	171.72	171.72	171.72	171.72

Bending (Bottom Edge) ...

M (kN.m)	8.6	22.2	10.0	8.5	22.0	9.8	8.6	21.9	9.4
d (mm)	390.0	407.0	390.0	390.0	407.0	390.0	390.0	407.0	390.0
K/K'	0.06	0.15	0.08	0.06	0.15	0.07	0.06	0.15	0.07
x (mm)	43.33	45.22	43.33	43.33	45.22	43.33	43.33	45.22	43.33
As (mm2)	65.12	161.07	75.97	64.34	159.49	74.24	65.03	159.10	71.42
As' (mm2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
As-min	171.72	171.72	171.72	171.72	171.72	171.72	171.72	171.72	171.72

Shear and Bending Design ...

Vd (kN)	63.1		61.7	62.9		61.9	55.5		61.8
v (N/mm2)	0.69		0.67	0.69		0.68	0.61		0.68
vc (N/mm2)	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.54
v-max (N/mm2)	4.00		4.00	4.00		4.00	4.00		4.00
Vnom (kN)		93.0			93.0			93.0	
Td (kN.m)		0.0			0.0			0.0	
vt (N/mm2)		0.00			0.00			0.00	
vt-min(N/mm2)		0.00			0.00			0.00	
b-sup (mm)	0.0		0.0	0.0		0.0	0.0		0.0
Links	R10-300	R10-300	R10-300	R10-300	R10-300	R10-300	R10-300	R10-300	R10-300

Deflection Check ...

L/d 9.4 < 58.64 OK 9.4 < 58.64 OK 9.4 < 58.64 OK

Supplied Steel Areas (mm2)

Top Edge	402.12	402.12	402.12	402.12	402.12	402.12	402.12	402.12	628.32
Bot Edge	402.12	402.12	402.12	402.12	402.12	402.12	402.12	402.12	402.12

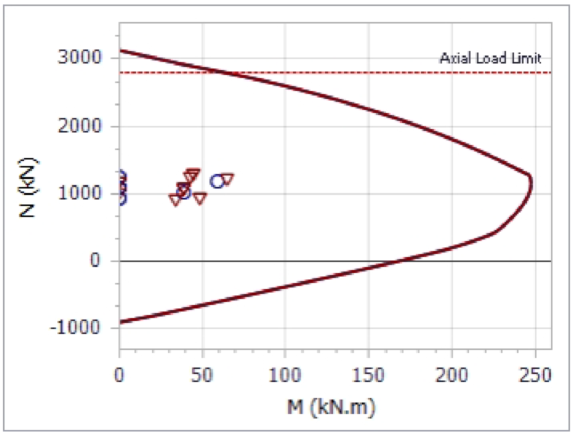
Steel Bars ...

Top.Bars		2Y16			2Y16			2Y16	
Top.Sup.	2Y16		2Y16	2Y16		2Y16	2Y16		2Y20
Top.Sup.									
Bot.Bars		2Y16			2Y16			2Y16	
Bot.Bars									

Column Reinforcement Design

1C1 (X2-Y1) (450/450)

(C20/25 / Grade 410 (Type 2))

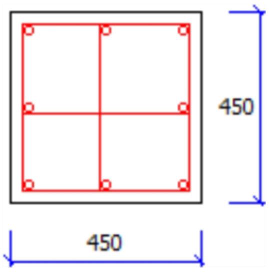


No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	1282.6, 1300.0	-11.8, 8.1	17.1, -11.2
2	1230.3, 1247.6	-12.1, 7.9	16.9, -11.2
3	921.5, 938.8	-7.0, 5.1	10.8, -6.9
4	1005.4, 1020.3	-9.8, 6.9	7.7, 23.1
5	1163.2, 1178.1	-10.0, 6.7	21.2, -42.0
6	1227.8, 1242.6	-18.9, 46.9	14.3, -9.0
7	940.9, 955.8	-1.0, -33.4	14.5, -9.9
8	1084.3, 1099.2	-9.9, 6.8	14.4, -9.4
9	1084.3, 1099.2	-9.9, 6.8	14.4, -9.4
10	1084.3, 1099.2	-9.9, 6.8	14.4, -9.4
11	1084.3, 1099.2	-9.9, 6.8	14.4, -9.4

Critical Loading: 1 - (G*F)

	min		Design
N	1300.0	-	1300.0 kN
M_{11}	-11.8	-26.0	-44.2 kN.m
M_{22}	17.1	26.0	0.0 kN.m
N_{max}	2025.0		

Concrete Cover = 25.0 mm



BS8110- Cl.3.8.4.5

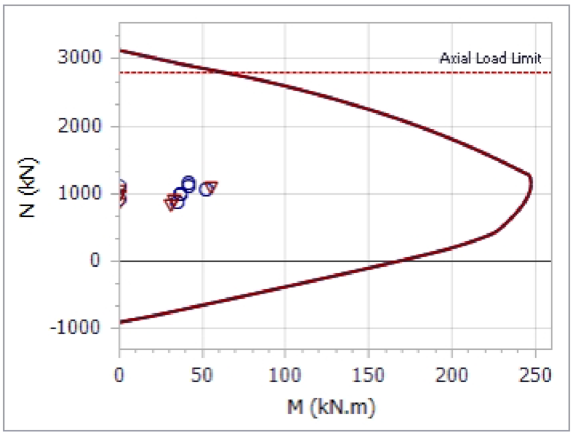
N/bhFcu = 0.257

Beta = 0.70

$V_{d(1/2)}$ = 6.0 / 12.7 kN $v_{c'(1/2)}$ = 0.88 / 1.00 N/mm2 $v_{(1/2)}$ = 0.03 / 0.07 N/mm2 Links = R10-225	Short Column... L_{e1}/b_1 = L_{e2}/b_2 = Madd(1/2) =	5.1 < 15.0 √ 5.1 < 15.0 √ 0.0 / 0.0 kN.m	As (Req): %0.40 (min) As (Sup): %1.24 8Y20	810.00 mm2 2513.27 mm2

2C1 (X2-Y1) (450/450)

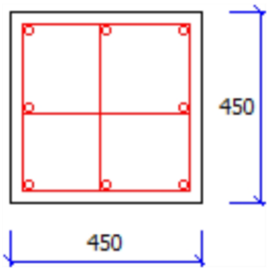
(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	1157.0, 1174.4	-14.4, 18.2	21.2, -24.8
2	1105.2, 1122.5	-14.2, 17.0	20.3, -24.5
3	834.7, 852.0	-9.2, 12.5	14.0, -15.6
4	913.6, 928.4	-12.3, 15.7	5.1, -6.0
5	1042.6, 1057.5	-12.0, 15.1	30.6, -35.7
6	1097.5, 1112.4	-30.9, 38.6	17.5, -20.6
7	858.6, 873.5	6.5, -7.9	18.1, -21.2
8	978.1, 992.9	-12.2, 15.4	17.8, -20.9
9	978.1, 992.9	-12.2, 15.4	17.8, -20.9
10	978.1, 992.9	-12.2, 15.4	17.8, -20.9
11	978.1, 992.9	-12.2, 15.4	17.8, -20.9

Critical Loading: 1 - (G*F)

		min	Design	
N	1174.4	-	1174.4	kN
M_{11}	18.2	23.5	0.0	kN.m
M_{22}	-24.8	-23.5	-42.0	kN.m



N_{max} 2025.0 Concrete Cover = 25.0 mm

BS8110- Cl.3.8.4.5

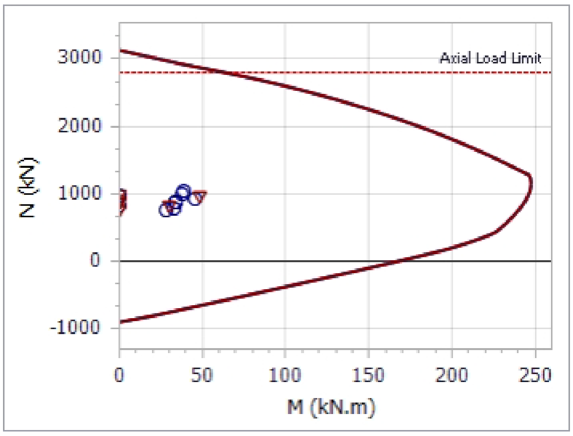
N/bhFcu = 0.232

Beta = 0.73

$V_{d(1/2)}$ = 15.4 / 8.5 kN $v_{c'(1/2)}$ = 1.34 / 1.26 N/mm2 N/mm2 $v_{(1/2)}$ = 0.08 / 0.04 Links = R10-225	Short Column... L_{e1}/b_1 = 5.7 < 15.0 √ L_{e2}/b_2 = 5.7 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm^2 As (Sup): %1.24 2513.27 mm^2 8Y20

3C1 (X2-Y1) (450/450)

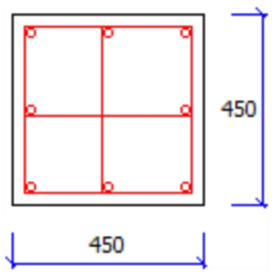
(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	1025.3, 1042.7	-15.9, 18.2	22.2, -23.2
2	976.0, 993.3	-14.7, 15.9	20.9, -22.3
3	742.2, 759.6	-11.0, 13.4	15.0, -15.3
4	816.8, 831.7	-13.5, 15.5	6.1, -8.0
5	916.5, 931.4	-13.2, 15.1	31.2, -31.1
6	959.9, 974.8	-32.1, 33.6	18.3, -19.3
7	773.4, 788.3	5.4, -3.0	19.0, -19.8
8	866.7, 881.5	-13.4, 15.3	18.7, -19.6
9	866.7, 881.5	-13.4, 15.3	18.7, -19.6
10	866.7, 881.5	-13.4, 15.3	18.7, -19.6
11	866.7, 881.5	-13.4, 15.3	18.7, -19.6

Critical Loading: 1 - (G*F)

	min	Design	
N	1042.7	-	1042.7 kN
M_{11}	18.2	20.9	0.0 kN.m
M_{22}	-23.2	-20.9	-39.1 kN.m
N_{max}	2025.0		



Concrete Cover = 25.0 mm

BS8110- Cl.3.8.4.5

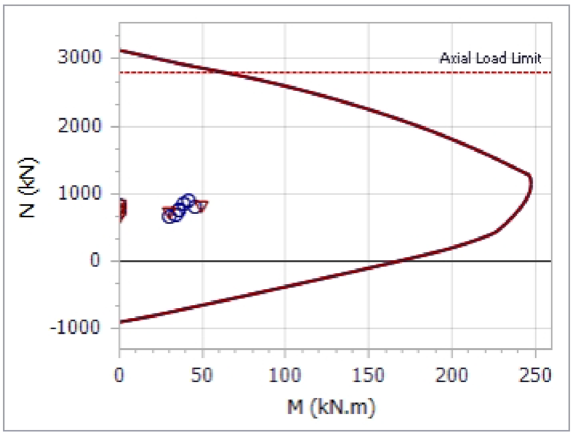
N/bhFcu = 0.206

Beta = 0.76

$V_{d(1/2)}$ = 11.8 / 3.3 kN $v_{c'(1/2)}$ = 1.28 / 1.13 N/mm2 N/mm2 $v_{(1/2)}$ = 0.06 / 0.02 Links = R10-225	Short Column... L_{e1}/b_1 = 5.7 < 15.0 √ L_{e2}/b_2 = 5.7 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm2 As (Sup): %1.24 2513.27 mm2 8Y20

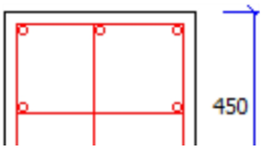
4C1 (X2-Y1) (450/450)

(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	889.2, 906.5	-17.8, 20.8	23.6, -25.5
2	843.9, 861.3	-15.9, 17.9	21.9, -24.1
3	645.5, 662.9	-12.7, 15.5	16.2, -17.1
4	714.7, 729.6	-15.1, 17.6	8.7, -12.3
5	788.4, 803.3	-14.8, 17.3	31.0, -30.7
6	821.0, 835.8	-31.8, 32.5	19.5, -21.3
7	682.1, 697.0	1.9, 2.5	20.2, -21.7
8	751.5, 766.4	-15.0, 17.5	19.9, -21.5
9	751.5, 766.4	-15.0, 17.5	19.9, -21.5
10	751.5, 766.4	-15.0, 17.5	19.9, -21.5
11	751.5, 766.4	-15.0, 17.5	19.9, -21.5

Critical Loading: 1 - (G*F)



		min	Design	
N	906.5	-	906.5	kN
M_{11}	20.8	18.1	0.0	kN.m
M_{22}	-25.5	-18.1	-42.0	kN.m

N_{max}	2025.0	Concrete Cover = 25.0 mm

BS8110- Cl.3.8.4.5

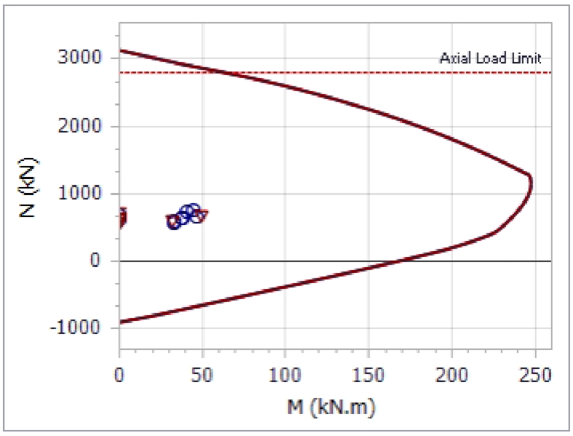
N/bhFcu = 0.179

Beta = 0.79

$V_{d(1/2)}$ = 13.0 / 0.2 kN $v_{c'(1/2)}$ = 1.18 / 0.63 N/mm^2 N/mm^2 $v_{(1/2)}$ = 0.07 / 0.00 Links = R10-225	Short Column... L_{e1}/b_1 = 5.7 < 15.0 √ L_{e2}/b_2 = 5.7 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm^2 As (Sup): %1.24 2513.27 mm^2 8Y20

5C1 (X2-Y1) (450/450)

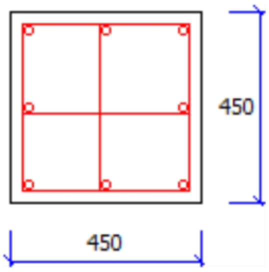
(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	749.0, 766.3	-19.3, 22.1	24.6, -26.5
2	709.2, 726.5	-16.8, 18.7	22.7, -24.8
3	545.1, 562.4	-14.2, 16.8	17.1, -18.1
4	607.3, 622.1	-16.3, 18.7	11.2, -15.0
5	658.8, 673.7	-16.1, 18.5	30.3, -29.7
6	682.0, 696.8	-30.8, 30.7	20.5, -22.1
7	584.1, 598.9	-1.7, 6.4	21.1, -22.6
8	633.0, 647.9	-16.2, 18.6	20.8, -22.4
9	633.0, 647.9	-16.2, 18.6	20.8, -22.4
10	633.0, 647.9	-16.2, 18.6	20.8, -22.4
11	633.0, 647.9	-16.2, 18.6	20.8, -22.4

Critical Loading: 1 - (G*F)

	min	Design		
N	766.3	-	766.3	kN
M_{11}	22.1	15.3	0.0	kN.m
M_{22}	-26.5	-15.3	-44.7	kN.m



N_{max}	2025.0	Concrete Cover = 25.0 mm

BS8110- Cl.3.8.4.5

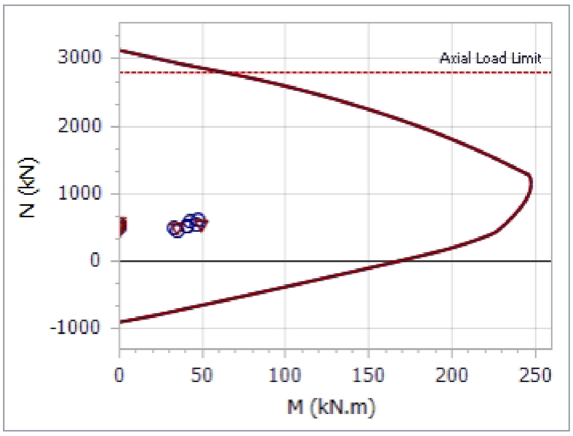
N/bhFcu = 0.151

Beta = 0.82

$V_{d(1/2)}$ = 13.8 / 3.2 kN $v_{c'(1/2)}$ = 1.08 / 0.91 N/mm2 $v_{(1/2)}$ = 0.07 / 0.02 N/mm2 Links = R10-225	Short Column... L_{e1}/b_1 = 5.7 < 15.0 √ L_{e2}/b_2 = 5.7 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm2 As (Sup): %1.24 2513.27 mm2 8Y20

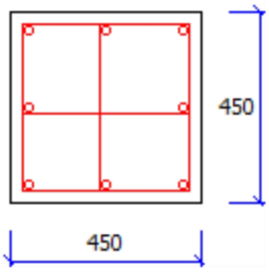
6C1 (X2-Y1) (450/450)

(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	605.6, 622.9	-20.4, 23.2	25.3, -27.5
2	572.3, 589.7	-17.5, 19.5	23.2, -25.4
3	441.6, 459.0	-15.4, 17.9	17.7, -19.0
4	495.1, 510.0	-17.2, 19.6	13.3, -17.7
5	528.5, 543.4	-17.1, 19.5	29.3, -28.6
6	543.9, 558.8	-29.3, 28.8	21.0, -22.9
7	479.7, 494.6	-5.1, 10.2	21.6, -23.4
8	511.8, 526.7	-17.2, 19.5	21.3, -23.2
9	511.8, 526.7	-17.2, 19.5	21.3, -23.2
10	511.8, 526.7	-17.2, 19.5	21.3, -23.2
11	511.8, 526.7	-17.2, 19.5	21.3, -23.2

Critical Loading: 1 - (G*F)



	min	Design		
N	622.9	-	622.9	kN
M_{11}	23.2	12.5	0.0	kN.m
M_{22}	-27.5	-12.5	-47.4	kN.m
N_{max}	2025.0			

Concrete Cover = 25.0 mm

BS8110- Cl.3.8.4.5

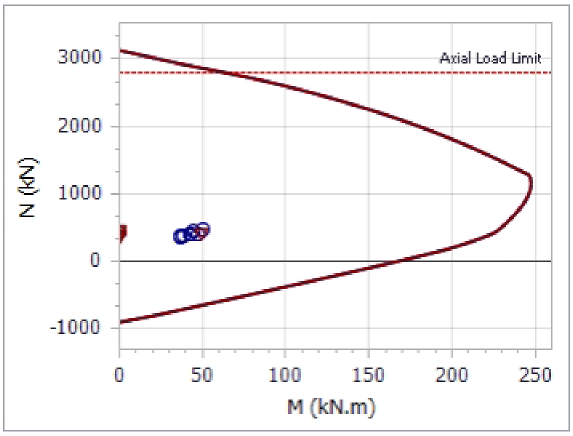
N/bhFcu = 0.123

Beta = 0.85

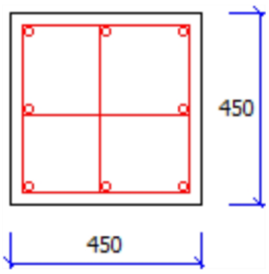
$V_{d(1/2)}$ = 14.4 / 6.0 kN $v_{c'(1/2)}$ = 0.98 / 0.91 N/mm^2 $v_{(1/2)}$ = 0.07 / 0.03 N/mm^2 Links = R10-225	Short Column... L_{e1}/b_1 = 5.7 < 15.0 √ L_{e2}/b_2 = 5.7 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm^2 As (Sup): %1.24 2513.27 mm^2 8Y20

7C1 (X2-Y1) (450/450)

(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	459.6, 476.9	-21.8, 24.2	26.7, -28.6
2	433.8, 451.2	-18.3, 20.1	24.3, -26.2
3	335.8, 353.1	-16.7, 18.8	18.8, -19.9
4	378.9, 393.7	-18.3, 20.3	16.1, -20.4
5	398.0, 412.9	-18.3, 20.4	28.9, -27.7
6	407.3, 422.2	-28.0, 26.8	22.2, -23.8
7	369.5, 384.4	-8.7, 13.8	22.8, -24.3
8	388.4, 403.3	-18.3, 20.3	22.5, -24.1
9	388.4, 403.3	-18.3, 20.3	22.5, -24.1
10	388.4, 403.3	-18.3, 20.3	22.5, -24.1
11	388.4, 403.3	-18.3, 20.3	22.5, -24.1



Critical Loading: 1 - (G*F)

	min	Design		
N	476.9	-	476.9	kN

M_{11}	24.2	9.5	0.0	kN.m
M_{22}	-28.6	-9.5	-50.0	kN.m
N_{max}	2025.0			

Concrete Cover = 25.0 mm

BS8110- Cl.3.8.4.5

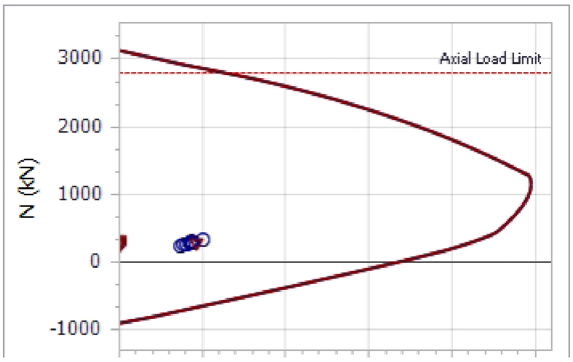
N/bhFcu = 0.094

Beta = 0.89

$V_{d(1/2)}$ = 15.2 / 13.9 kN $v_{c'(1/2)}$ = 0.88 / 0.87 N/mm^2 $v_{(1/2)}$ = 0.08 / 0.07 N/mm^2 Links = R10-225	Short Column... L_{e1}/b_1 = 5.7 < 15.0 √ L_{e2}/b_2 = 5.7 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm^2 As (Sup): %1.24 2513.27 mm^2 8Y20

8C1 (X2-Y1) (450/450)

(C20/25 / Grade 410 (Type 2))



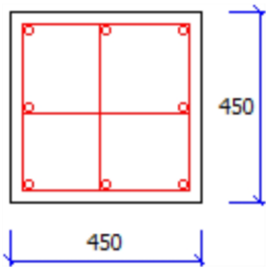
No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	312.0, 329.3	-20.6, 24.0	24.0, -27.8
2	294.3, 311.6	-17.4, 20.0	21.8, -25.4
3	228.4, 245.8	-15.7, 18.6	17.0, -19.5
4	259.3, 274.1	-17.3, 20.2	15.6, -21.5
5	268.2, 283.0	-17.3, 20.3	24.9, -25.3
6	273.1, 288.0	-24.5, 24.0	20.0, -23.2
7	254.3, 269.2	-10.2, 16.5	20.5, -23.6

8	263.7, 278.6	-17.3, 20.2	20.2, -23.4
9	263.7, 278.6	-17.3, 20.2	20.2, -23.4
10	263.7, 278.6	-17.3, 20.2	20.2, -23.4
11	263.7, 278.6	-17.3, 20.2	20.2, -23.4

Critical Loading: 1 - (G*F)

		min	Design	
N	329.3	-	329.3	kN
M_{11}	24.0	6.6	0.0	kN.m
M_{22}	-27.8	-6.6	-50.0	kN.m
N_{max}	2025.0			

Concrete Cover = 25.0 mm



BS8110- Cl.3.8.4.5

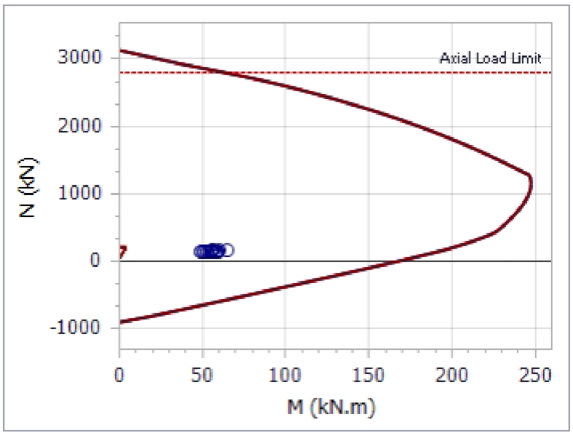
N/bhFcu = 0.065

Beta = 0.92

$V_{d(1/2)}$ = 14.3 / 13.5 kN $v_{c'(1/2)}$ = 0.78 / 0.77 N/mm² $v_{(1/2)}$ = 0.07 / 0.07 N/mm² Links = R10-225	Short Column... L_{e1}/b_1 = 5.7 < 15.0 √ L_{e2}/b_2 = 5.7 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm² As (Sup): %1.24 2513.27 mm² 8Y20

9C1 (X2-Y1) (450/450)

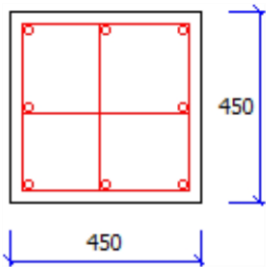
(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	162.0, 179.4	-28.9, 27.6	37.3, -33.6
2	153.1, 170.5	-22.9, 22.4	33.6, -30.4
3	118.8, 136.2	-23.6, 22.0	26.3, -23.8
4	135.8, 150.6	-24.1, 23.1	28.1, -27.9
5	138.2, 153.1	-24.6, 23.4	34.6, -28.6

6	140.4, 155.3	-28.8, 24.4	31.0, -28.1
7	133.6, 148.4	-19.9, 22.0	31.7, -28.5
8	137.0, 151.9	-24.3, 23.2	31.4, -28.3
9	137.0, 151.9	-24.3, 23.2	31.4, -28.3
10	137.0, 151.9	-24.3, 23.2	31.4, -28.3
11	137.0, 151.9	-24.3, 23.2	31.4, -28.3

Critical Loading: 1 - (G*F)



	min	Design		
N	179.4	-	179.4	kN
M_{11}	-28.9	-3.6	0.0	kN.m
M_{22}	37.3	3.6	65.0	kN.m
N_{max}	2025.0	Concrete Cover = 25.0 mm		

BS8110- Cl.3.8.4.5

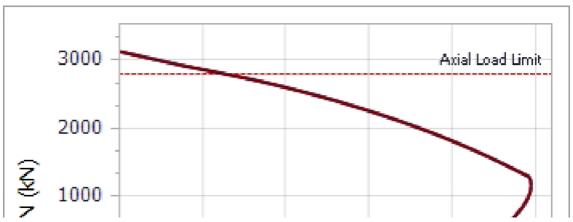
N/bhFcu = 0.035

Beta = 0.96

$V_{d(1/2)}$ = 24.8 / 20.9 kN $v_{c'(1/2)}$ = 0.68 / 0.68 N/mm2 $v_{(1/2)}$ = 0.13 / 0.11 N/mm2 Links = R10-225	Short Column... L_{e1}/b_1 = 5.7 < 15.0 √ L_{e2}/b_2 = 5.7 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm2 As (Sup): %1.24 2513.27 mm2 8Y20	

10C1 (X2-Y1) (450/450)

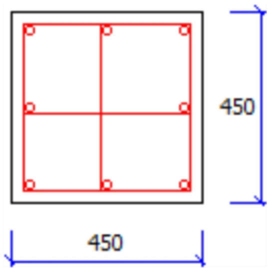
(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	15.9, 34.3	-7.2, 13.4	5.5, -10.5
2	14.0, 32.4	-5.6, 13.6	4.0, -10.3

3	13.1, 31.4	-5.9, 7.8	5.0, -6.9
4	13.5, 29.3	-6.1, 11.5	4.4, -10.4
5	13.5, 29.3	-6.0, 11.1	4.9, -7.4
6	14.1, 29.8	-6.9, 10.9	4.6, -8.9
7	13.0, 28.7	-5.2, 11.7	4.7, -8.8
8	13.5, 29.3	-6.0, 11.3	4.6, -8.9
9	13.5, 29.3	-6.0, 11.3	4.6, -8.9
10	13.5, 29.3	-6.0, 11.3	4.6, -8.9
11	13.5, 29.3	-6.0, 11.3	4.6, -8.9

Critical Loading: 2 - (G+Q *F)



	min	Design	
N	32.4	-	32.4 kN
M_{11}	13.6	0.6	23.9 kN.m
M_{22}	-10.3	-0.6	0.0 kN.m
N_{max}	2025.0	Concrete Cover = 25.0 mm	

BS8110- Cl.3.8.4.5

N/bhFcu = 0.006

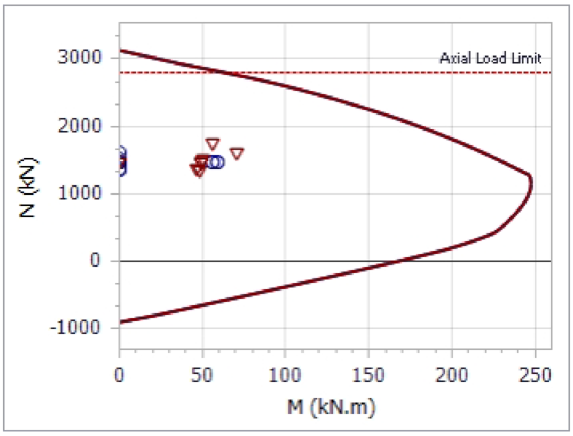
Beta = 0.99

$V_{d(1/2)}$ = 5.9 / 7.6 kN $v_{c'(1/2)}$ = 0.57 / 0.58 N/mm2 N/mm2	Short Column... L_{e1}/b_1 = 6.0 < 15.0 √ L_{e2}/b_2 = 6.0 < 15.0 √	As (Req): %0.40 (min) 810.00 mm2 As (Sup): %1.24 2513.27 mm2

V(1/2) = 0.03 / 0.04 Links = R10-225	Madd(1/2) = 0.0 / 0.0 kN.m	8Y20

1C2 (X2-Y13) (450/450)

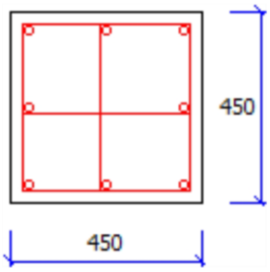
(C20/25 / Grade 410 (Type 2))



No	NTop/Bot (kN)	M11 Top/Bot (kN.m)	M22 Top/Bot (kN.m)
1	1735.2, 1752.5	-19.6, 12.7	1.1, -1.7
2	1512.2, 1529.6	-19.6, 12.5	-5.3, 1.9
3	1367.8, 1385.2	-11.4, 7.6	7.0, -4.6
4	1463.7, 1478.6	-16.3, 10.7	-14.9, 36.4
5	1466.5, 1481.4	-16.5, 10.6	16.7, -39.3
6	1601.7, 1616.6	-25.9, 50.7	0.7, -0.9
7	1328.6, 1343.4	-7.0, -29.4	1.1, -2.0
8	1465.1, 1480.0	-16.4, 10.6	0.9, -1.4
9	1465.1, 1480.0	-16.4, 10.6	0.9, -1.4
10	1465.1, 1480.0	-16.4, 10.6	0.9, -1.4
11	1465.1, 1480.0	-16.4, 10.6	0.9, -1.4

Critical Loading: 1 - (G*F)

	min		Design	
N	1752.5	-	1752.5	kN
M_{11}	-19.6	-35.1	-55.9	kN.m



M_{22} -1.7 -35.1 0.0 kN.m

N_{max} 2025.0 Concrete Cover = 25.0 mm

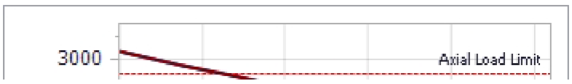
BS8110- Cl.3.8.4.5

N/bhFcu = 0.346

Beta = 0.59

$V_{d(1/2)}$ = 20.1 / 8.8 kN N/mm^2 $v_{c'(1/2)}$ = 1.56 / 1.04 N/mm^2 $v_{(1/2)}$ = 0.10 / 0.05 Links = R10-225	Short Column... L_{e1}/b_1 = 5.1 < 15.0 √ L_{e2}/b_2 = 5.0 < 15.0 √ Madd(1/2) = 0.0 / 0.0 kN.m	As (Req): %0.40 (min) 810.00 mm^2 As (Sup): %1.24 2513.27 mm^2 8Y20

2C2 (X2-Y13) (450/450)



(C20/25 / Grade 410 (Type 2))

M1

Stairs With a Simply Supported Landing By Outer Longer Edge

Stair Parameters:

Section Forces

Left Support	35.2	kN/
Right Support	5	m

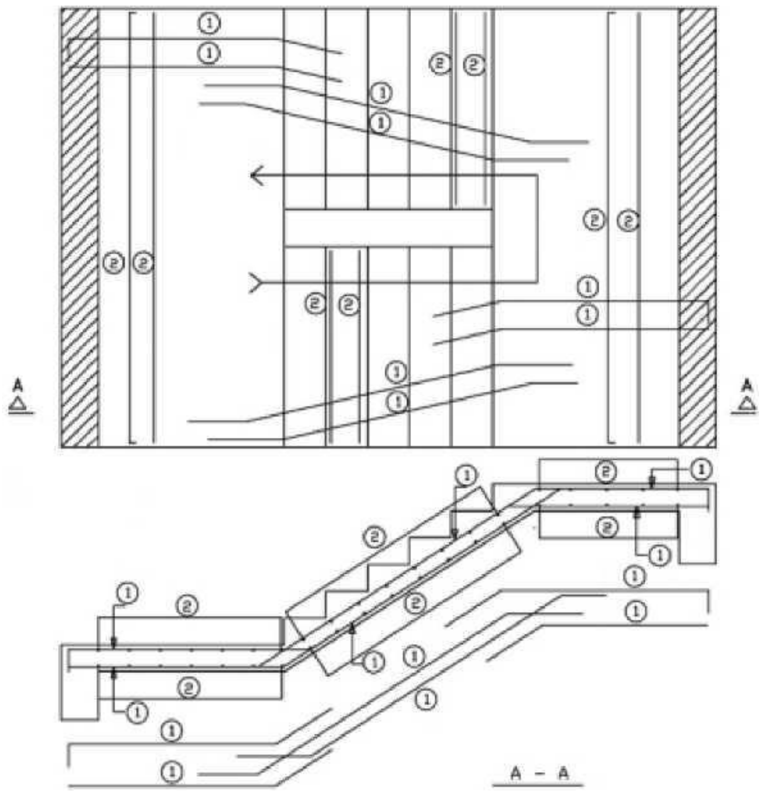
Storey Height (h):	3000.0		mm
Stair Width (b):		1200.0	mm
Storey Landing Width (bSK):		1484.0	mm
Intermediate Landing Width (bSA):		479.0	mm
Number of Steps (n):		18	
Step Width (a):		280.0	mm
Step Height (Rise) (s):		150.0	mm
Stair Hole Width (bK):		100.0	mm
Plate Thickness (Stair) (dK):		200.0	mm
Plate Thickness (Landing) (dS):		180.0	mm
Stair Plate Angle		28.18	deg
Support Width (bM):		300.0	mm
Concrete Cover		30.0	mm
Deflection Check:			
Span	(L)	4483.0	mm
Section Depth	(d)	170.0	mm
L/d		26.37	
Loads			
At The Stair Arms:	5.445	1.500	3.500
At The Landings: 4.320		1.500	3.500

Bending Moment

Bending Moment 42.4

Reinforcement Design

#		Moment	Steel Area	Selected Steel Bars
1	1st Sloped Plate - Primary Rebar (Top)	42.4	823.10	10Y12-120
1	1st Sloped Plate - Primary Rebar	42.4	823.10	10Y12-120
2	1st Sloped Plate - Distribution Rebar	0.0	164.62	15Y8-290
2	1st Sloped Plate - Distribution Rebar	0.0	164.62	15Y8-290
2	Landing Plate Lateral Rebar (Top)	0.0	164.62	6Y8-290
2	Landing Plate Lateral Rebar (Bot)	0.0	164.62	6Y8-290



4.3 DISCUSSION

Orion 18 not only provides calculation sheets for structural elements but also generates detailed drawings and rebar bending schedules, facilitating construction planning. Comparing the software's results with my manual calculations revealed some discrepancies. The software consistently yielded higher load calculations, shear forces, and bending moments than my manual calculations. However, this discrepancy can actually be beneficial as the design based on Orion's higher values automatically fulfills the requirements of the manual calculations.

The primary explanation for this difference likely lies in the distinct analysis methods employed by the software and manual calculations. For example, my manual calculations used the coefficient method from BS8110-1 Table 3.5 for shear force and bending moment, assuming the beam satisfied clause 3.4.3. However, the software's method remains unknown, potentially involving more analytical approaches like slope deflection, matrix methods, or other complex techniques for analyzing statically indeterminate structures.

Additionally, subtle human errors, possibly unidentified during manual calculations, could also contribute to the observed variations in analysis results.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The purpose of this project effort is to make comparison between Orion as a design tool and software and manual method in designing and analyzing a structure. The following conclusion was reached after a number of members were manually calculated to compare with the outcomes produced by the software.

a. The software is effective for structural design because the manual design's level of agreement with it is acceptable.
b. Designing with the software facilitates less labor and makes it less taxing, especially when designing multi-story buildings where several lengthy calculations are necessary.
c. For any concrete segment, Orion has the ability to determine how much reinforcement is required that can basically withstand the load on that segment.
d. It is simpler to use software to analyze and create the entire structure because it takes less time to do so than it does to do so manually.
e. The relationship between the program and AutoCAD is fantastic since it allows one to import general arrangement drawings created in AutoCAD into the program and then export the structural detailing back to AutoCAD.
f. It is important to use the software carefully to avoid entering incorrect data that would provide inaccurate results because the accuracy of the results depends on the correctness of the parameters entered.
g. Even a novice user will find the program to be incredibly user-friendly and simple to comprehend and utilize. It permits dynamic parameter inputs and member structural modelling.

5.2 RECOMMENDATION

Professional designers frequently employ software to produce design results and they do it with good judgment because they have much knowledge in the subject. In order to understand and effectively use the software, structural engineering students and young professionals must be proficient in its use as well as efficient in the philosophy, principles, and art of structural design. I therefore suggest the following:

a. That the students of the school be thought the use Of the software as part of their course Work in other to put them up-to-date with What is Obtainable in the outside world and the construction industry. But not withstanding that basic knowledge of manual designing should be acquired.
b. That computer Aided Designed should be appreciated more often in designing as it is more efficient and productive.

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