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DEPARTMENT OF CIVIL ENGINEERING
OPTION OF CONSTRUCTION TECHNOLOGY

STRUCTURAL DESIGN AND ARCHITECTURAL DRAWING OF TWO-STORY TECHNICAL VOCATIONAL TRAINING CLASSROOMS AT NGOMA DISTRICT

CASE STUDY: KIBUNGO SECTOR

Submitted in partial fulfilment of the requirement for the award of advanced diploma in construction technology

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Kigali October 2024

DECLARATION

I NIYONZIMA Ismael do hereby declare that the work presented in this dissertation is my own contribution to be the best of my knowledge. The same work has never been submitted to any other University or Institution. I, therefore, declare that this work is my own for the partial fulfilment of the requirements for the degree of Advanced diploma in
Civil Engineering department at ULK POLYTECHNIC INSTITUTE

NIYONZIMA Ismael

Signature ……………………………………………

Date of submission: ………………………………

CERTIFICATE

This is to certify that this dissertation work entitled "**Architectural and structural of two story technical Vocational training classrooms at NGOMA District case study KIBUNGO Sector**" is an original study conducted by Ismael NIYONZIMA under my supervision and guidance.

Eng. MUNYANEZA Jean Pierre ………………………………

Signature ……………………………………………

Date ………………… ……………………………….

DEDICATION

To God Almighty father

To my beloved my mother

To my brothers and sisters

To my relatives, friends and classmates

ABSTRACT

This project research was focused on the architectural and structural design of two multistory building of Technical Education Vocation Training school in NGOMA District, case study KIBUNGO Sector due to the lack of modern technical school at KIBUNGO sector. Several methods have been used during the conducted of the project like site observation to check the feasibility study and the appropriate placement of technical school. The main structural members/ elements such as foundation, beam, slab, column and stair and ramp have been designed to provide the safety of the structure.

To achieve this, EUROCODE 2-1992 has been used for analysis of different structural elements and soft-wares like Arch CAD to draw architectural plan view, elevations, and sections. For the structural elements analysis only beams are designed by PROKON software for computing beam details and steel reinforcement. The building members like slabs, columns, foundations and stair have been calculated by analytical method by using the basic knowledge in civil engineering.

The finding results showed the minimum steel reinforcements in the slab were in two ways direction at the top were (7Ø10/m) and bottom (6Ø8/m). For the beams the minimum steel bars were 5Φ16 at the top and 4Φ16 at bottom. In the column the steel bars were 4ϕ20 for ground floor part, 4ϕ16 for first floor, while for the second floor 4ϕ14. In pad foundation and stairs the steel bars were 6ϕ16mm/m and 6ϕ12 respectively while ground beam corresponded would have 4ϕ16 as minimum steel bars. The obtained results were analyzed in terms of safety. The bill of quantity revealed the amount of the whole building to be of six hundred and twenty-seven millions nine hundred and twenty thousand three hundred Rwandan francs. **(627,920,300 Rwf).**

The location of the building was well located at KIBUNGO sector, the load has been calculated and has been compared with bearing capacity and therefore the safety was insured after comparison. Perspective of the building has been established to illustrate different views and fattiness of the structure.

Finally, the proposed project has focused on design, geotechnical studies should be conducted before its implementation.

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First and foremost, special thanks are raised to the almighty God for his abundant blessing's knowledge, strength and protection granted me during my studies

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Without their support, my dream wouldn't be turned into reality.

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LIST OF SYMBOLS, ABBREVIATION AND ACRONYMS

Asw: is the cross section of two legs of stirrup

Φ: Diameter of steel reinforcement expressed in (mm)

Ab: Cross section area of the column

Ab: is average lateral area of the punching pyramid

Ab: The area of the column cross section ac: width of

column af: width of footing

As: Total cross section of steel reinforcement

As_{max}: Maximum bending moment (at the top and bottom) A_{sv}:

Shear force that use to calculate stirrup

b: The width of the compressive area

bc : breadth of the column bf: breadth

of footing bf: flange of the beam bw:

web of the beam C: Roller or Hinged

support d: short distance of The beam

Def max: Defection maximum

$d_{l:}$ waist

F: fixed support

Fcu: the characteristic concrete cube strength.

F_u: The ultimate deflection

Fy: is the characteristic strength of reinforcements

Fy: vertical force acts on the support of ramp

Fyv: is the characteristic strength of link reinforcements

G (Going or tread)

GK: Permanent loads h:

height of the beam

H: Height of column

H: Rise H=effective he:

Effective height Hf: Height

of footing hf: Thickness of

the slab ho: Effectiveheight

Lc: Difference of the distance between half of breadth and half of breadth of the column

Lx: Length of the short side of the panel

Ly: Length of the long side of the panel

Mx^-, My^-: Bending moment at the top Mx^+,

My^+: Bending moment at the bottom

N: Total loads of slab

Nc: loads from the column

Nf: Load transmitted by the column to the foundation

No: numeric number

P: Design pressure

P: Panel

Q: shear force acting on the cross section

Qf: Punching shear force QK:

Live loads

qsw: Total shear force carried by the all legs of the stirrup

Rb: Design concrete compression strength

Rbt: Concrete design tensile strength

Rbt: the concrete design tensile strength

Rs: Design steel tensile stress

Rsc: Area of steel compressive strength

Rsw: Design strength of the stirrups and the inclined bars

s: Distance between stirrups Um

average perimeter

Vmax: Maximum shear force αm, η: coefficient related to the design of members subjected to bending moment αsx : Long side of the panel αsy: short side of the panel γ: unite weight

Δl: Difference between long span and short span of the beam Δq:

balancing shear force

CHAPTER ONE: GENERAL INTRODUCTION

1.0. Introduction

This chapter summarize with background of study, problem statement, objectives of study the significance of study, scope and limitations of study, organization

1.1 Background

Technical and vocational education (TVET) is broadly defined as "Education which is mainly lead participants to acquire the practical skills, know-how and understanding, and necessary for employment in a particular occupation, trade or group of occupations. Such practical skills or know-how can be provided in a wide range of settings by multiple providers both in the public and private sector. The role of TVET in furnishing skills required to improve productivity, raise income levels and improve access to employment opportunities has been widely recognized (Nyerere, 2009).

TVET in Rwanda has been delivered by different providers at various qualification levels. Technical education is offered at upper secondary school level; both by public schools under the Ministry in charge of education and by private schools and those belonging to faith-based organizations. To achieve this goal, the Rwandan people must be provided opportunities to develop knowledge, skills and attitudes to compete in the labor market and contribute to the social and political life of their country. Reaching this objective will necessitate continued and significant investments in education at all levels to ensure universal access to educational opportunities characterized by their high quality and relevance to the rapidly development of country even the society especially NGOMA District (Nyerere, 2009).

1.2. Problem statement

The vision of the TVET policy is to develop human resources potential taking into consideration equal access to necessary competence acquisition without any discrimination to prepare the population to be productive and competitive and thus contribute to their welfare. Mindful of conditions for sustainable economic, environmental and social development, TVET allows people to use present and future opportunities for development as individuals, enterprises and society.

Normally, NGOMA District has 14 sectors, KIBUNGO sector is one of them, and Main problem of the sector has technical vocation school nowadays which is not modern and equitable to accommodate a great number of students and this effect on Sustainable development of the sector.

In this sector there is a lack of availability of TVET schools depends on the great number of youth population need to study technical skills,

It is in this regard to work on final year project comes to give contribution at NGOMA District development by designing a multi-story technical school.

1.3 Objectives of the study

1.3. 1.Main objective

The overall objectives of this research is architectural drawing and structural design of two stores building of technical vocational education training school in NGOMA district case study KIBUNGO sector.

1.3.2. Research questions and specific objectives

The research questions are written in the table below together with their specific objectives in other to achieve this research

Table 1.1: Outline of the specific objectives and research questions

Specific Objective	Research Questions
a. To do an architectural design of the building so as to illustrate different views of the building. technical school	✓ What are the importances of drawing this technical school?
b. To indicate the appropriate location of the proposed technical school in KIBUNGO sector	✓ Where this project would be localized?

c. To do the structural design of different reinforced concrete elements of this technical school.	✓ How was the building loaded?
To elaborate the bills of quantities	✓ How much cost for the whole project?

1.4. Significance of the study

1.4.1. Country Interest

To develop a regional and international TVET system that produces men and women quality graduates with employability skills that respond to the changing demands of employers and country's labor market.

1.4.2. Personal interest

It would help to increase knowledge and experience on this field from theory to practice then after conducting this research project, it would be possible to get degree in this career of civil engineering

1.4.3. Academic Interest

Student doing their research related to Structural and reinforced concrete design of a building may use this research as a good example for quick results.

1.5. Scope of the study

This study would deal with architectural drawings and structural design of technical school

It was not possible to calculate the bills of quantities and cost estimates of the building and conducting soil sample by different test based on financial means and time allocated on this research this is why the study area was limited to KIBUNGO sector.

1.6. Layout of the research

This work is organized into five chapters. Chapter one is the general introduction comprising the background, problem statement, overall and specific objectives, research questions, Significance of the study, Scope of the study and research layout. Chapter two reviews the general understanding of Technical education vocational training. School Chapter three describes materials and methods which shows the techniques, methodologies applied to meet the objectives. Chapter four presents result and discussions. Finally, chapter draws conclusion and recommendations formulated with respect to the predefined research objectives.

CHAPTER TWO: LITERATURE REVIEW

2.1. Definition of technical vocational education training (TVET)

'Technical and vocational education and training' (TVET) is understood as comprising education, training and skills development relating to a wide range of occupational fields, production, services and livelihoods (Hartl, 2009).

2.2. Government of Rwanda's policy for TVET

The Government of Rwanda is committed to investing in the development of human resources in order to meet the major objective of Vision 2020 which is to create a knowledge-based and technology-led economy. Comprehensive human resources development is considered to be one of the necessary pillars to reach the status of a middle income country Rwanda's economy is characterized by a serious lack of qualified people in the workforce, particularly in the technical sectors. The goal of education and TVET is therefore to fight ignorance and illiteracy so as to produce competent human resources for economic and social development (MINEDUC, 2008).

2.3. Architectural facilities of TVET

A classroom is a a room in which classes are held. Classrooms are found in educational institutions of all kinds, from preschools to universities, and may also be found in other places where education or training is provided, such as corporations and religious and humanitarian organizations. The classroom attempts to provide a space where learning can take place uninterrupted by outside distractions.

2.3.1. Size of the classroom

All most educational authorities agree that thirty is the ideal number of students in a class, but economic considerations stand in our way in achieving this ideal. Even in public schools, thirty-five is the average class strength. Analysis of data showed that 66.7% of schools have an average of 45 students per class. In the prevailing circumstances, it may be quite ideal to restrict the class size to forty-five (Sidhu, 1996).

2.3.2. Workshops

Workshops provide environments for learning to occur in a dynamic and a powerful manner. The workshop format can be used to promote personal growth, teach professionals skills, or create change within existing systems (Stock *et al*., 1999).

2.3.3. Laboratory

The area and accommodation of laboratories will depends on the average number of students taking sciences subjects. The number and area should, therefore be worked out in each case on the basis of actual requirements. Taking both educational and economic factors into considerations, an area of 20 square feet per student in laboratories was considered as essential (Sidhu, 1996).

2.3.4. Library

A separate room for library centrally located to all the teaching rooms should be a must in every school. But the standard for library accommodation should be rational and consistent with its utility. Considering the economy, utility and function, it is recommended that a library of 600 square feet would be adequate to meet the present education needs (Sidhu, 1996).

2.3.5. Administration

The area required for the school office will depend on the size of the school and number of staff members. Whereas it is necessary to reduce the non-teaching areas to absolute minimum it was felt that for efficient functioning of school, suitable accommodation for staff and office was necessary (Sidhu, 1996).

2.3.6. Storage

One of the most common complaints registered by the principals of school was the absence of inadequacy of storage space only 35.3% of the schools had a general store. Wherever provided, the accommodation for storage was generally considered insufficient (Sidhu, 1996).

2.3.7. Sanitary Facilities

It is universally agreed that the provisions of proper and adequate sanitary facilities is essential. But it is here only that there is a wide gap between the standard recommended by different authorities and actual conditions. The following scales of sanitary fittings are recommended:

1.Latrines or W.C one for every 100 students or part thereof

2.Urinals one for every 25 students or part thereof

3.Water taps with troughs one for every 50 students or part thereof (Sidhu, 1996).

2.4. Reinforced Concrete

Reinforced concrete is a strong durable building material that can be formed into many varied shapes and sizes ranging from simple rectangular columns, to curved domes and shells. Its utility and versatility is achieved by combining the best features of concrete and steel which are more or less complementary. Thus, when they are combined, the steel is able to provide the tensile strength and probably some of the shear strength while the concrete, strong in compression, protects the steel to give durability and fire resistance (Bungey, 1990).

Concrete can be used for all standard building both single story and multi-storey and for retain structures and bridges. Some of the common building structures are as follows:

1.The single-story portal supported on isolated footings

2.The medium-rise framed structure.

3.The tall multi-story frame and core structure where the core and rigid frames together resist wind loads

2.5. Material of Construction

2.5.1. Concrete

Portland cement is a composite material made by combining cement, supplementary cementing materials, aggregates, water and chemical admixtures in suitable proportions and allowing the resulting mixtures to set and harden over time (Nawy, 2008).

2.5.2. Water

Although the water itself is often not considered when dealing with materials that go into the production of concrete, it is an important ingredient, typically, 150 to 200kg/m^3 of water is used the old rule of thumb not difficult to identify, if you drink it, you can use it in the concrete, although good quality concrete can be made with water (Nawy, 2008).

2.5.3. Admixtures

Admixtures are chemical that are added during mixing concrete and significantly change its fresh, early age or hardened state to economic or physical advantage. They are usually defined as being added at rates of 5% by weight of the cement but the typical range for most types is only 0.3-1.5% (Peter & John , 2010)**.**

2.5.4. Aggregates

Aggregates makes up about 75% of the volume of the concrete, so their properties have a large influence on the properties of the concrete (Alexander & Mindes, 2005).

Aggregates are granular materials, most commonly natural gravels and sands or crushed stones, although occasionally synthetic materials such as slugs or expanded clays or shale's are used. Most aggregates have a specific gravity in the range of 2.6 to 2.7.

The role of aggregates is to provide much better dimensional stability and wear resistance, without aggregates large, castings of neat cements paste would essentially selfdestruct upon drying.

2.5.5. Concrete mix design

Concrete mixture design consists in selecting and proportioning the constituents to give the required strength, workability and durability.

There are two type of concrete mix:

Designed mix, where strength testing forms an essential part of the requirement for compliance.

Prescribed mix, in which proportions of the constituents to give the required strength and Workability are specified, strength testing is not required (Choo & Ginley, 1990).

2.5.6. Reinforcement

Reinforcement, usually in the form of steel bars, is placed in the concrete member, mainly in the tension zone, to resist the tensile forces resulting from external load on the member.

Reinforcement is also used to increase the member's compression resistance (Manaseer & Elias, 2008).

2.6. Properties of reinforced concrete

Composite action the tensile strength of concrete is only about 10 per cent of the compressive strength. Because of this, nearly all reinforced concrete structures are designed on the assumption that the concrete does not resist any tensile forces. Reinforcement is designed to carry these tensile forces, which is transferred by adequate bond between the Interfaces of the two materials. In the analysis and design of the composite reinforced concrete section, it is assumed that there is perfect bond, so that the strain in the reinforcement is identical to the strain in the adjacent concrete. For a simply supported beam subjected to downward transverse loading, the tension at the bottom is resisted by reinforcement whereas compression at top is resisted by concrete. The coefficients of thermal expansion for steel and for concrete are sufficiently close that problems with bond seldom arise from differential expansion between the two materials over normal temperature ranges

Wherever tension occurs it is likely that cracking of the concrete will take place. This cracking, however, does not detract from the safety of the structure provided there is good reinforcement bond to ensure that the cracks are restrained from opening so that the embedded steel continues to be protected from corrosion. When the compressive or shearing forces exceed the strength of the concrete, then steel reinforcement must again be provided, but in these cases it is only required to supplement the load-carrying capacity of the concrete (Bungey, 1990).

Stress-Strain Relations The loads on a structure cause distortion of its members with resulting stresses and strains in the concrete and the steel reinforcement. To carry out the analysis and design of a member, it is necessary to have knowledge of the relationship between these stresses and strains.

2.6.1. Concrete

The concrete is a very variable material, having a wide range of strengths and stress-strain curves. A typical curve for concrete in compression is shown in figure below. The ultimate strain 16 for most structural concretes tends to be a constant value of approximately 0.0035, irrespective of the strength of the concrete.

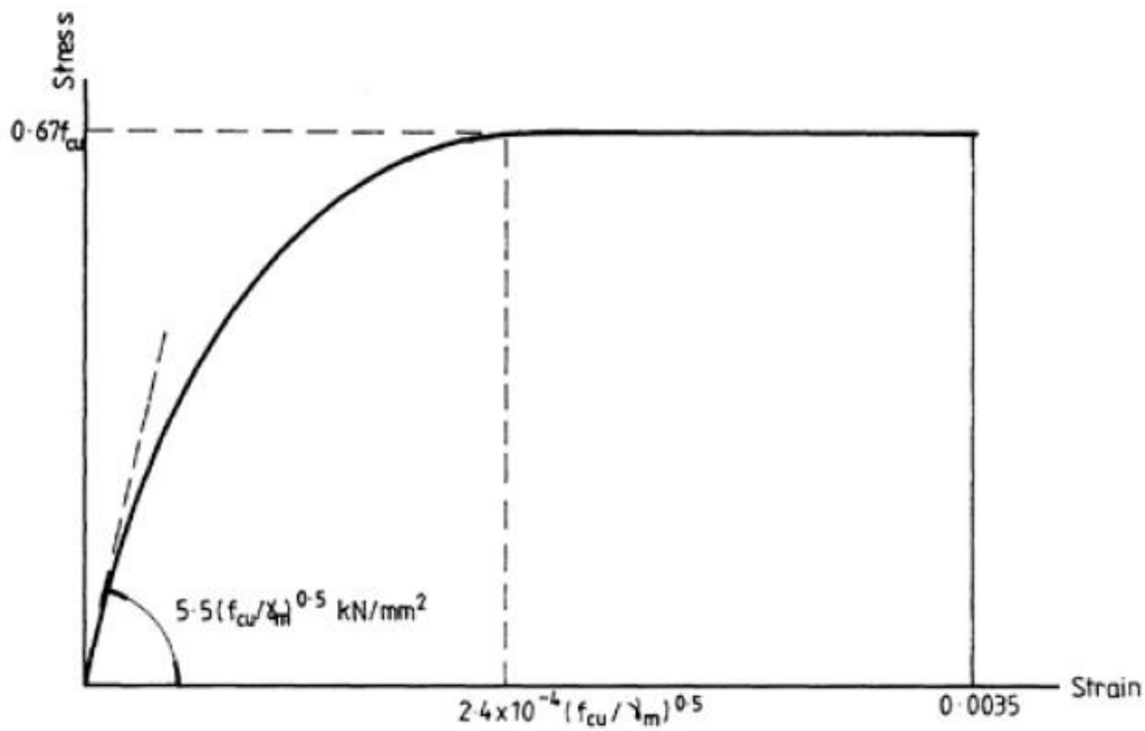


Figure 2.1: stress-strain curve for concrete in compression (Choo & Ginley, 1990)

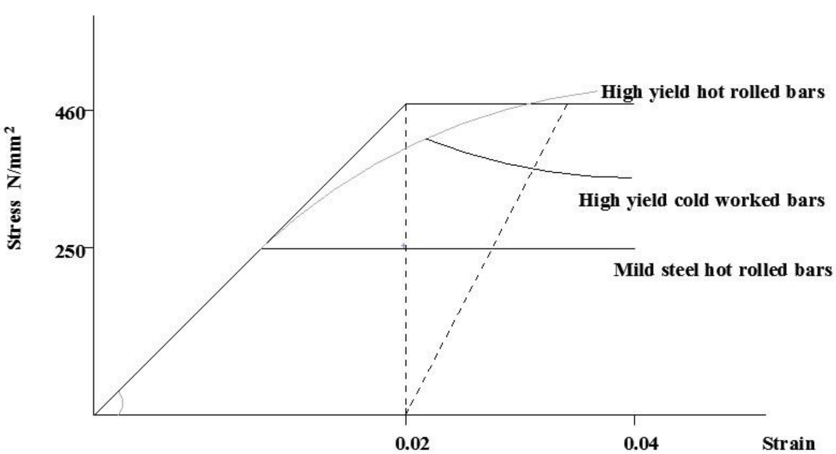


Figure 1.2: stress-strain curves for steel (Choo & Ginley, 1990).

2.6.2. Shrinkage

Shrinkage or dry shrinkage is the contraction that occurs in concrete when it dries and harens. Drying shrinkage is irreversible but alternative wetting and drying causes expansion and contraction of concrete (Choo & Ginley, 1990).

2.6.3. Creep

Creep in concrete is the gradual increase in strain with time in a member subjected to prolonged stress. The creep strain is much higher than the elastic stain on loading. If the specimen is unloaded there is an immediate elastic recovery and a slower recovery in the strain dues to creep. Both amounts of recovery are much less than the original strains under load.
The main factors affecting creep stain are the concrete mix and strength, the type of aggregate, curing, ambient relative humidity and magnitude and duration of sustained loading (Choo & Ginley, 1990).

2.6.4. Durability

Concrete structures, properly designed and constructed, are long lasting and should require little maintenance. The durability of the concrete is influenced by the exposure

Grade	**Lowest grade for use as specified**
C7 C10	Plain concrete
C15	Reinforced with light weight aggregate
C25	Reinforced concrete with dense aggregate
C30	Concrete with post-tensioned tendons

C40	Concrete with pre-tensioned tendons

Table 2.1: Grade of concrete (Bungey, 1990)

2.6.5. Concrete and reinforcement specification

The selection of the type of concrete is frequently governed by the strength required, which in turn depends on the intensity of loading and the form and size of the structural members. Table below shows a list of commonly used grades and also the lowest grade appropriate for various types of construction (Bungey, 1990).

Reinforcement: the table below lists the characteristic design strengths of several of the more common type of reinforcement**.**

Table 2.2: **characteristic design strengths of common reinforcement** (Bungey, 1990)**.**

Designation	**Nominal sizes(mm)**	**Specified characteristic strength Fy (N/mm^2)**
Hot-rolled mild steel (BS 4449) Hot-rolled high yield steel (BS 4449) Cold-worked high yield (BS 4461) Hard-drawn steel wire(BS 4482)	All sizes All sizes All sizes Up to and including 12	250 460 460 485

2.6.6. Bricks Materials

One of the oldest building material brick continues to be a most popular and leading construction material because of being cheap, durable and easy to handle and work with. Brick may be made of burnt clay or mixture of sand and lime or of Portland cement concrete. Clay bricks are used for building-up exterior and interior walls, partitions, piers, footings and other load bearing structures (Victoria, 2013).

2.6.7. Stone materials

Stone has been used in the construction of most of the important structures since prehistoric age such as pyramids of Egypt, Great Wall of China and etc. It has been defined as the natural, hard substance formed from minerals and earth material which are present in rocks. Stone can serve: to construct the foundation and wall items; to manufacture elements of stair, landings, parapets and guard rails; and it can also be used as flooring materials (Duggal, 2003).

2.6.8. Mortar materials

Mortar is a mixture of sand and lime or a mixture of sand and cement with or without lime. The mortar used in brickwork transfers the tensile, compressive and shear stresses uniformly between adjacent bricks (Chudley & Greeno, 2005). The mortar can also be used to join stone block and etc.

2.7. Structural element and limit states design

2.7.1. Structure design

The first function in design is the planning carried out by the architects to determine the arrangement and layout of the building to meet the client's requirements. The structural engineering determines the best structural system to bring the architect's concept into being. Construction in different materials and with different arrangement and systems may require investigation to determine the most economical answer. That is why the engineering and architect should work together for this conceptual design (Choo & Ginley, 1990).

Once the building form and structural arrangement have been finalized the design problem consists of the following:

a. Idealization of the structure into load bearing frames and elements for analysis and design.
b. Analysis to determine the maximum moments, thrusts and shears for design
c. Production of arrangement and detail drawings and schedules

The complete building structure can be broken down into the following elements:

Beams: horizontal members carrying lateral loads

Slabs: horizontal plate elements carrying lateral loads. They may be simply supported or continuous over one or more supports and are classified according to the method of support as follows: Spanning one way between beams or walls, spanning two ways between the support beams or walls, and Flat slabs carried on columns and edge beams or walls.

Columns: vertical members carrying primarily axial load but generally subjected to axial load and moment

Walls: vertical plate elements resisting vertical, lateral or in-planeloads

Bases and foundations pads or strips supported directly on the ground that spread the loads from columns or walls so that they can be supported by the ground without excessive settlement. Alternatively, the bases may be supported on piles (Choo & Ginley, 1990).

2.8. Limit state design

Limit state design in the engineering structure must ensure that under the least loading the structure is safe, during normal working conditions of the deformation members does not detract from the appearance, durability or performance of the structure

Three basic methods using factors of safety to achieve safe, workable structure despite of difficult in assessing the precise loading and the variation in the strength of the concrete and the steel, which are:

a. The permissible stress method in which ultimate strength of the strength of the materials are divided by a factor of safety to provide design stresses which are usually within the elastically range.
b. The load factor method in which the working loads are multiplied by safe of factor

c. The limit state which multiplies working loads by the partial factor of safety and also divided the materials ultimate strength by further partial factors of safety. In the load factor method, the ultimate strength of the materials should be used in the calculation, where doesn't take account into materials and also doesn't be used in the calculation of deflection and cracking at the working loads.

The benefits of using those safeties are coming from developing of improved concrete and steel properties (Mosley *et al*., 2007).

2.8.1. Criteria for a safe design limit states

The criterion for a safe design is that the structure should not become unfit for use, i.e. That it should not reach a limit state during state its design life. This is achieved, in particular, by designing the structure to ensure that it does not reach (Nawy, 2008).

2.8.2. Serviceability Limit States

Generally, the most important serviceability limit states are: deflection, cracking and durability. Other limit states that may be reached include: excessive vibration, fatigue, fire resistance and special circumstances such as earthquake resistance.

The relative importance of each limit state will vary according to the nature of the structure. In assessing a particular limit state for a structure, it is necessary to consider all the possible variable parameter such as the load, material strengths and constructional tolerances (Paik & Thayamballi, 2003).

2.8.3. Partial Factor of Safety

Other possible variations such as constructional tolerances are allowed for by partial factors of safety applied to the strength of the materials and to the loadings. In practice these values adopted are based on experience and simplified calculations.

Partial factors of safety for materials(γm)

Design strength $= \dfrac{\text{characteristic strength (fk)}}{\text{partial factor of safety } (\gamma m)}$

With fk =fm -64s, where fk = characteristic strength, f m = mean strength and s =standard deviation.

The factors considered when selecting a suitable value for Partial Factors of Safety for Materials are: the strength of the material in an actual member; and the severity of the limit state being considered. The recommended values for partial factors of safety for materials are given in table below although it should be noted that for precast factory conditions it may be possible to reduce the value for concrete at the ultimate limit state (Mosley, 2007).

Table 2.3: Values of partial factors of safety applied to materials γ_m (Bill Mosley, 2007)

Limit state	Materials	
	Concrete	Steel
Ultimate		
flexure	1.5	1.115
Shear	1.25	1.115
Bond	1.4	
Serviceability	1.0	1.0

2.8.5. Partial factors of safety for loads (γf)

Errors and inaccuracies may be due to a number of causes such as design assumptions and inaccuracy of calculation; possible unusual load increases; unforeseen stress redistributions and constructional inaccuracy. These cannot be ignored, and are taken into account by applying a partial factor of safety on the loadings, so that

Design load = characteristic load x partial factor of safety (γf)

Where characteristic load = mean load ± 1.64 standard deviations

The value of this factor should also take into account the importance of the limit state under consideration and reflect to some extent the accuracy with which different types of loading can be predicted; and the probability of particular load combinations occurring. Recommended values are given in table below. It should be noted that design errors and constructional inaccuracies have similar effects and are thus sensibly grouped together

Table 2.4: values of partial factor of safety for loadings (γ_f) (Mosley, 2007).

Load combination	Ultimate				Serviceability
	Dead(γ_G)	Imposed(γ_Q)	Earth and Water(γ_Q)	Wind(γ_W)	all ((γ_G, γ_Q ,γ_W)
Dead and imposed(+Earth and water	1.4(or1.0)	1.6 (or 0.0)	1.4	-	1.0
Dead and wind(+Earth and water	1.4 (or 1.0)	-	1.4	1.4	1.0
Dead , imposed and water (+Earth and water	1.2	1.2	1.2	1.2	1.0

The lower values in brackets applied to dead loads or imposed load at the ultimate limit state should be used when minimum loading is critical.

2.9. Analysis of the structure

The object of analysis of the structure is to determine the axial forces, shears and moments throughout the structure. A reinforced concrete structure is a combination of beams, columns, slabs and walls, rigidly connected together to form a monolithic frame**.** Each individual member must be capable of resisting the forces acting on it, so that the determination of these forces is an essential part of the design process.

The full analysis of a rigid concrete frame is rarely simple; but simplified calculations of adequate precision can often be made if the basic action of the structure is understood. The analysis must begin with an evaluation of all the loads carried by the structure, including its own weight. First the structure itself is rationalized into simplified forms that represent the load-carrying action of the prototype. The forces in each member can then be determined by one of the following methods: Applying moment and shear coefficients, Manual calculations and Computer methods. In this project computer methods are used.

2.9.1. Load

Structure member must be designed to support specific loads.
Loads are those forces which a given structure should be proportioned. In general, load may be classified as dead and live or imposed (Nelson, 2005).

2.9.2. Dead load

Dead loads are loads of constant magnitude that remain in one position. They include the weight of the structure under consideration. As well as fixtures those are permanently attached to it. For a reinforced concrete building some dead loads are the frames, walls, floor, ceiling, stairways, roofs and plumbing. To design a structure, it is necessary for the weights or dead loads of the various part to be estimated for use in the analysis (Nelson, 2005).

2.9.3. Live and imposed loads

Which are movable or actually moving loads; these include snow on the roof, people, temporary partition and so on. Wind loads are loads but their effects are considered separately because they are affected by the location, size and shape of a structure. In the BS8110 code of practice specify values of the above loads which must be used in design. These values, however, are usually multiplied by a factor of safety to allow for uncertainties; generally, the factor of safety used for live loads tend to be greater than those applied to dead loads because live loads are more difficult to determine accurately Recommended values of safety factors of safety are given in table2.2. It should be noted that design errors and constructional inaccuracies have similar effects and are thus sensibly grouped together (Nelson, 2005).

2.9.4. Wind loads

Wind pressure on a building surface depends primarily on its velocity, the shape and surface Structure of the building, the protection from wind offered by surrounding natural terrain or man-made structures, and to a smaller degree, the density of air which decreases with altitude and temperature. All other factors remaining the same, the pressure due to wind is proportionate to the square of the velocity:

$p = 0.00256V^2$

Where

P is the pressure, in psf

V is the velocity of wind, in miles per second (Taranath, 2010).

2.9.5. Seismic loads

Although structural design for seismic loading is primarily concerned with structural safety during major earthquakes, serviceability and the potential for economic loss are also of concern. As such, seismic design requires an understanding of the structural behavior under large inelastic, cyclic deformations. Behavior under this loading is fundamentally different from wind or gravity loading. It requires a more detailed analysis, and the application of a number of stringent detailing requirements to assure acceptable seismic performance beyond the elastic range. Some structural damage can be expected when the building experiences design ground motions because almost all building codes allow inelastic energy dissipation in structural systems (Taranath, 2010).

Thermal Load

Thermal load is defined as the temperature that causes the effect on buildings, such as outdoor air temperature, solar radiation, underground temperature, indoor air temperature and the heat source equipment inside the building. The change of the temperature in the Structural and non-structural member causes thermal stress and is defined as the effect of thermal load.

The basic thermal load is the 100-year-return period of the change in outdoor air temperature, solar radiation, underground temperature or equivalent value. The basic thermal load of outdoor air temperature is based on the 100-year-return period value of the annual highest and lowest temperature (Nicol & Humphreys, 2002).

CHAPTER THREE: RESEARCH METHODOLOGY

3.1.1. Site description

The site is located in Eastern Province, NGOMA district, KIBUNGO sector, CYASEMAKAMBA cell due to the population census of 2012-2013 this sector has the growth of population of 28.338. This site has access to water and electricity.

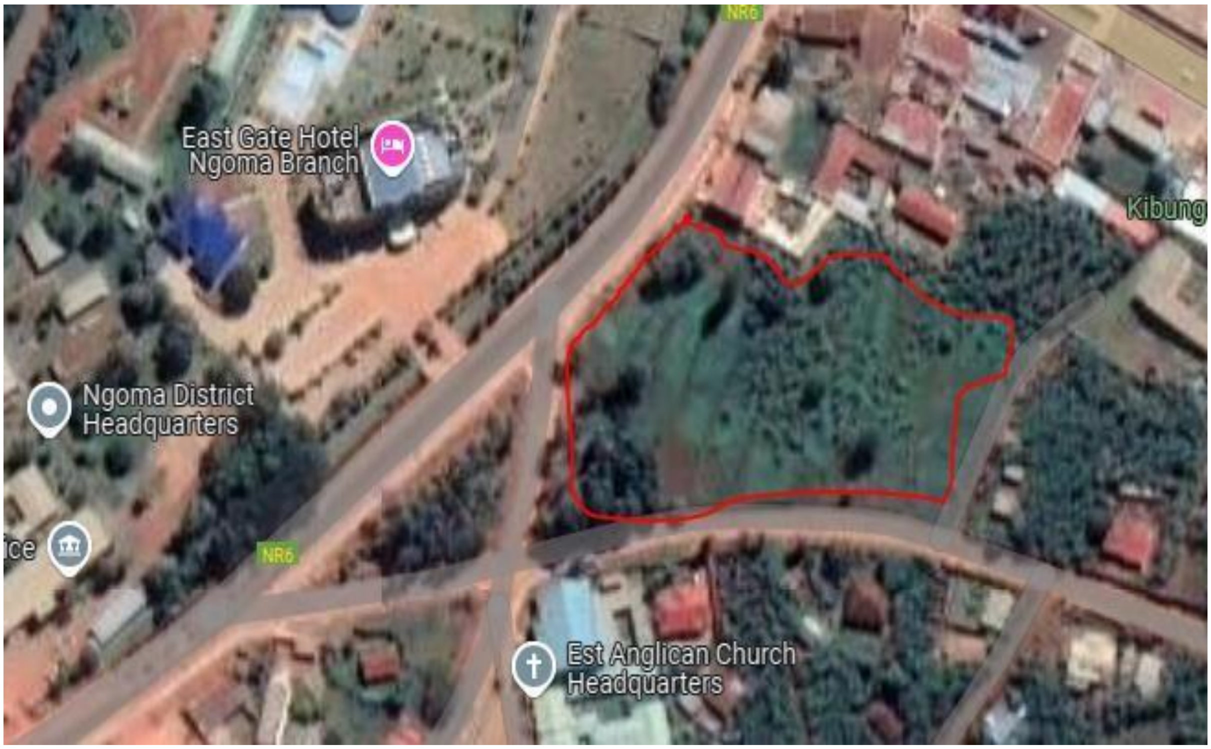


Figure 2.1: study area

3.2. Architectural drawings

3.2.1. Building description

This technical vocation education training school has the capacity of accommodating 600students. The number of each class is 25/classroom. This house is divided into two parts the first for administration and the second for classrooms and workshops this will be built on 4435.20 $m^{2.}$ It has two stories 20 classrooms, meeting rooms, 2computer labs, administration offices, sanitary facilities and workshops.

For the part of ground floor are reserved for workshops, other stories are reserved for classrooms the first floor of classrooms are similar to the second floor. The overall height of the building is 11m and the structure will be in reinforced concrete.

3.2. 2. Contribution of architectural drawings

Architectural Drawings are the backbones of the building designs and play a critical role in translating a design to feasible structure in the context of designer, the client's intentions are mainly restraints into three main categories includes:

- ✓ The intended use of the structure
- ✓ Quality and time of project completion
- ✓ Budget cost limits

They show to the designer all information and dimensions of the structure such as door, windows, and elevations in consideration of the structure.

3.2.3. The components of architectural drawings

Conceptual design is a function of choosing a suitable form of system or arrangement to meet a given architectural appearance. Some of the architectural elements are: Site plan, floor plans, elevations, sections, roof plan, foundation plan, perspective and some elements of structure and its details.

Site plan: it contains the following information: dimensions of the site, direction of true north, name of the street upon which the site adjoins, position of the proposed building, plan of the roof and the scale has to be: 1/200; 1/500; 1/1000; 1/2000, or more. (Rwanda building Control regulations, 2009).

Floor plan: they show the general set out of the building, give the details of arrangements in the floor, thus showing the positions of beams, columns, walls and openings like doors, windows, etc.

The scale has to be: 1/200; 1/100; 1/50 (Rwanda building Control regulations, 2009).

Elevations: they give the general outlook of the building; they reveal much the nature of cladding on the building. Elevations are drawn in three categories: front elevation, rear elevation, side elevations (left side and right side). The scale has to be: 1/200; 1/100; 1/50 (Rwanda building Control regulations, 2009).

Sections: they contain the following information: inside elevations, vertical dimensions, materials used, roof slope, etc. The scale has to be: 1/100; 1/50 (Rwanda building Control regulations, 2009).

Foundation plan

Every structure needs a foundation. The function of a foundation is to provide a level and uniformly distributed support for the structure. The foundation must be strong enough to support and distribute the load of the structure and sufficiently level to prevent the walls from cracking and the doors and windows from sticking. The foundation also helps to prevent cold or warm air and dampness from entering the structure from beneath. The footing distributes the weight of the structure over a large area. The footing is usually always made from concrete because it can withstand heavy weights and is virtually decay-proof. They are generally two types of foundation a concrete slab foundation and a raised foundation made from piers and columns.

Roof plan

The roof design is not simply a finishing touch to cover the home, but a protective barrier from sun, wind, rain, run off, snow buildup and more. Often, the roof can present a larger visible surface area than the walls, so adequate planning must be undertaken. Drawing a suitable roof design will take a mastery of measurements and facts that pertain specifically to the properties location, weather and size. It shall contain the following information:

- Show the roof drains.
- Indicate the building and wall-section lines.
- Indicate the roof slope
  Indicate the type of roofing and insulation, etc.
-

3.3. Structural design

Table 3.1: showing design information

Information	Meaning
Euro code2: The structural use of concrete 1992	Building regulations and design codes
Floor: - Imposed load (Maximum) = 4 KN / m^2 -Partition = 1 KN / m^2 Stairs: -Imposed =4 KN / m^2 Finishes = 1 KN / m2 classroom live loads:3 KN / m^2	General load conditions
Safe bearing pressure : 300 KN / m^2	Sub soil conditions
Concrete grade: fcu = 24kN / m^2 for Reinforcement: fy = 460 N/ mm^2 For stirrup = 250 N/mm^2 Self- weight: -Reinforced concrete = 24 KN /m^3 Masonry = 19 KN / m^3	Data corresponding to given materials
1.4 for dead load and 1.6 for live load	Partial safety factors

3.3.1: Formula used for design

- 3.3.1.1 Slab

- The thickness of the slab lies between $\frac{lx}{20}$ and $\frac{lx}{40}$ where lx is the shorter side of the panel, using the biggest panel among others. (Mosley,W.H., Hulse, R., & Bungey, J. H, 2007).

The effective height (ho) = thickness of the slab (Hf) – the clear cover

-

- 3.3.1.2: Type of slab
- $\lambda = \frac{ly}{lx}$ Where λ =ration of long side and short side ly=long side lx= short side
- 3.3.1.3: bending moment
- $Mx = \alpha s\ x \times N \times lx^2$
- $My = \alpha s\ y \times N \times lx^2$
- 3.3.1.4: Required steel reinforcements

$\alpha m = \frac{M}{Rb.ho^2.b}$

- $As = \frac{M}{\eta.Rs.ho.}$ (Bungey, 1990)
- 3.3.2 Beam
- 3.3.2.1 Computation of the depth of the beam
- $\frac{Lmax}{12} \leq h \leq \frac{Lmax}{8} =$ Where Lmax is the largest span between two consecutive beams
- 3.3.2.2 Computation of web of flange of the beam (bw)
- $0.5 \leq \frac{bW}{h} \leq 1$ where bw is the web of flange of the beam, h is height of the beam
- 3.3.2.3 Computation of width flange of beam (bf)
-

$$Bf = \leq \begin{cases} 12hf + bw \\ \frac{l}{3} \\ \frac{D}{2} \end{cases}$$

(Bungey, 1990) where:

- Bf: is the width flange of the beam
- Hf: thickness of the slab
- D: short distance of the beam, BW is the web of flange of the beam

- 3.3.2.3 Load on the beam computed by the software but non-factored)

- Non- factored own weight of the beam $= \gamma * (bf * hf) + (bw * h)$

- 3.3.3 Column

- Cross section: length * width

- 3.3.3.1. Load on column

- 3.3.3.2. Calculation of dead load

- Load from the slab= total dead load of slab * influence area from the slab
- Self-load of the column=safety factor * area of column * height of column * unite weight
- Load from the beam=safety factor * width of the beam * height of the beam * (length +width of influence area) *unit weight
- Masonry walls=safety factor * thickness of slab * height of slab * (length +width of influence area * unit weight
-

- Plaster on the wall=safety * thickness of finishes * height of finishes * (length +width of influence area * unit weight)
- 3.3.3.3. Live load

Live load=live load of slab * iinfluence area from the slab

-

3.3.3.4. Load applied on the floor of the column

- 3.3.3.5. Ground floor part of the column up to footing

- -self-load of the underground column= safety factor * area of column * height of underground column * unit weight
- loads= (load from the slab+ load from the beam+ masonry load+ plaster on the wall+ live load from the slab) * number of story+ ((self-weight of the column * number floor) + self-load of the underground column) + (load from the slab+ load from the beam+ live load from the slab)

3.3.3.6. Floor part of the column

- loads= (load from the slab+ load from the beam+ masonry load+ plaster on the wall+ live load from the slab)*number of story+ ((self-weight of the column * number floor) + self-load of the underground column) + (load from the slab+ load from the beam+ live load from the slab)

3.3.3.7 Steel reinforcements on the column

- Slenderness ratio ($\lambda)=\frac{0.7H}{a}$ (Bungey, 1990).
- Where:
- [illegible]= slenderness ratio
- h=effective height of the column
- a= width of column

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1. Architectural design

This technical vocation education training school had the capacity of accommodating 600 students. The number of each class is 30/classroom. The total number of classrooms were 20classrooms. This technical school should be built on 4435.20 m^2, meeting rooms, 2computer labs, administration offices, sanitary facilities and workshops were included. The overall height of the building is 1050m and the structure will be in reinforced concrete. The table below shows the dimensions and types of each room.

Table 4.1: types of rooms with their dimensions

Rooms			**persons**	
types	**Dimensions (m^2)/room**	**Total of number rooms**	**Persons per room**	**Total of number persons**
Classrooms	54	20	30	600
Meeting hall	244.80	1	600	600
library	244.80	1	148	148
Computer lab	54	4	30	120
workshops	108	5	60	300
Secretary room	12.25	1	3	3
Headmaster office	36	1	6	6
Animation room	30	1	3	3
Headteacher office	48	1	3	3
Teacher's room	36	7	8	56
Registration room	12.25	1	4	4
Student's Toilets + urines	1.5	14	17	238
Staff's toilets	1.5	8	12	12
Total		45		2093

Sanitary Facilities

It is universally agreed that the provisions of proper and adequate sanitary facilities are essential. But it is here only that there is a wide gap between the standard recommended by different authorities and actual conditions. The following scales of sanitary fittings are recommended:

a) Latrines or W.C one for every 100 students or part thereof
b) Urinals one for every 25 students or part thereof
c) Water taps with troughs one for every 50 students or part thereof (Sidhu, 1996).

A separate room for library centrally located to all the teaching rooms should be a must in every school. But the standard for library accommodation should be rational and consistent with its utility. Considering the economy, utility and function, it is recommended that a library of 600 square feet would be adequate to meet the present education needs (Sidhu, 1996).

All most educational authorities agree that thirty is the ideal number of students in a class but economic considerations stand in our way in achieving this ideal. Even in public schools, 35 is the average class strength. Analysis of data showed that 66.7% of schools have an average of 45 students per class. In the prevailing circumstances, it may be quite ideal to restrict the class size to 45 (Sidhu, 1996).

Note: Architectural results corresponding with Architectural drawings (see appendices)

4.2. Structural elements design

The Complete of our design building structure can be broken down into the following elements:

Beams: horizontal members carrying lateral loads

Slab: horizontal plate elements carrying lateral loads

Columns: vertical members carrying primarily axial load but generally subjected to axial load and moment walls vertical plate elements resisting vertical, lateral or in plane loads **Bases and**

foundations: pads or strips supported directly on the ground that spread the loads from columns or walls so that they can be supported by the ground without excessive settlement.

Stair: it is a support consisting of a place to rest the foot while ascending or descending a stairway.

Ramp: is concave bend of a handrail where a sharp change in level or direction occurs, as at a stair landing.

4.3. Design considerations

a. The strains in concrete and reinforcement are derived assuming that plane sections remain plane
b. The tensile strength of the concrete is ignored
c. For a slab design, the consideration is taken according to the large panel. Slab is the same at all levels in the building.
d. For beam design, is to the overloaded beam which are the beam of long span is the design beam
e. Colum is the most overloaded
f. Foundation is the one that support the designed column.
g. Stairs are the same type at all levels. We have to design one of those stairs
h. Cover to reinforcement considerations are: beams are 30mm column is 30mm foundation is 50mm
i. Compressive strength of concrete is 24N/mm^2 and tensile strength of the steel 460N/mm^2

4.4. Slab design

4.4.1. Introduction

Concrete slabs are similar to beams in the way they span horizontally between supports and may be simply supported, continuously supported or cantilevered. Unlike beams, slabs are relatively thin structural members which are normally used as floors and occasionally as roof systems in multi-stores buildings.

Those are the criteria has been considered during design critical panel

1. high live load/dead load ratios
2. Serviceability of a floor system could not maintained through deflection control and crack control

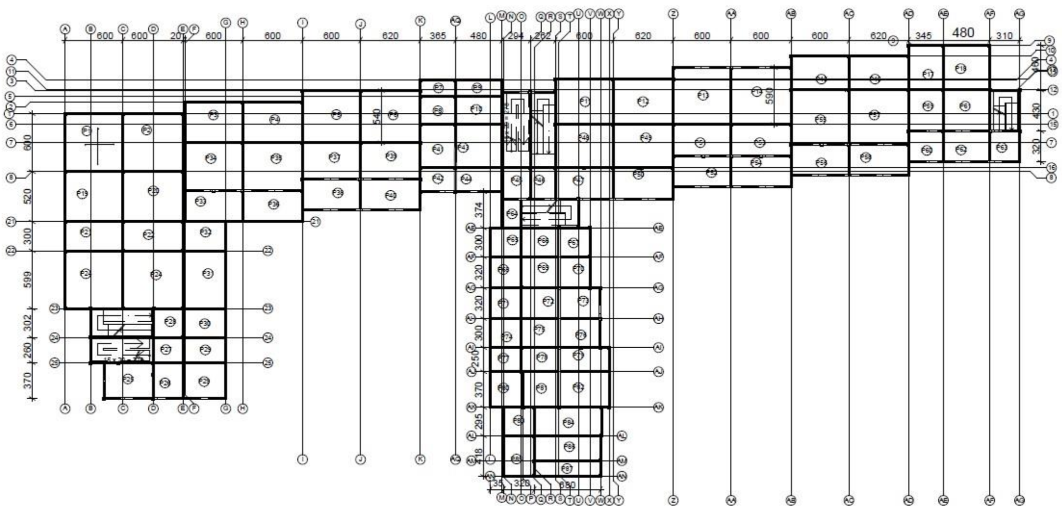


Figure 3.1: Critical panels

For cleared figure see in appendices the most critical panel

4.4.2. Calculation of the depth of slab

The thickness of the slab lies between Lx/20 and Lx/40where Lx is the shorter side of the panel, using the biggest panel among others here is a panel (P1) of 6.0*6.0m

Slab thickness then equals = Hf= 30cm and comparing to = 15cm

Then with this difference we are going to take the slab thickness of Hf=17cm.

The effective height (ho) = thickness of the slab – the clear cover= 17-2.5= 14.5cm

The effective height of our slab (ho) =14.5cm

4.4.2.1. Load on slab

a. Calculation of dead load

Self –load= 1.4*1*1*0.17*24 + (1.4*1*1*1.5*24) KN/ m^2=7.812 KN/m^2

Dead load =5.712 KN/m +2.1KN/m = 7.812KN/m2

b. Calculation of live load

The weight of live load for classroom is equal to 3.0KN/m^2

Live load=1.6*1*1*3KN/m=4.8KN/m^2

Total load on slab = (7.812+4.8) KN/m^2 =12.612KN/m^2

Ly=6.0m

Lx=6.0m

ly 6,0

— □ — □1. □ 2Two-way slab

lx 6,0

Typical panel

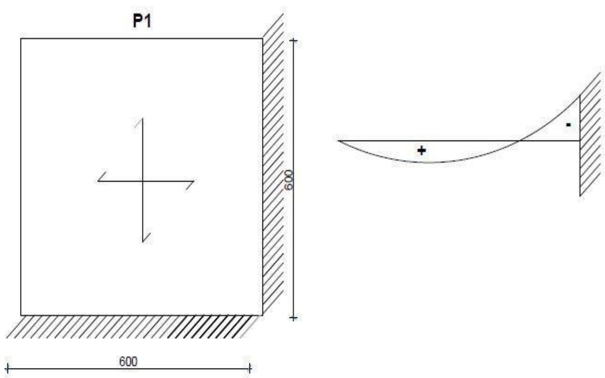


Figure4.2: Typical panel

4.4.2.2. Bending moment

Mx=αsx*n*Lx2

My=αsy*n*Lx2

Mx-= $0.063*12.612*6.0^2$=28.60KNm

Mx+= $0.027*12.612*6.0^2$=12.25KNm

My-=0.063 *$12.612*6.0^2$=28.60KNm

My+= $0.027*12.612*6.0^2$=12.25KNm

4.4.2.3. Steel bars calculation

For concrete c25/30

$\xi R = 0.393$ $Rb = 1.3 KN/cm^2$

$Rs = 40 KN/cm^2$

$M^- max = 28.60 KNm$

$M^+ max = 12.25 KNm$

4.4.2.4. Steel reinforcement

a. Required steel reinforcements at the top

$$\alpha m = \frac{M}{Rb*ho^2*b} = \frac{(28.60*100)}{1.3*(14.5)^2*100)} = 0.104$$

We use 0.104; ξ=0.11; η=0.945

$$As = \frac{M}{\eta.Rs.ho} = \frac{(28.60*100)}{0.945*(14.5)*40)} = 5.218\ cm^2/m$$

We take the required As = 5.50cm^2/m

We use 7ϕ10mm/m

b. Required steel reinforcements at the bottom

$$\alpha m = \frac{M}{Rb*ho^2*b} = \frac{12.25*100)}{(1.3*(14.5)^2*100)} = 0.044$$

We take αm= 0.049 ξ = 0.05; < ξ R =0.393; η= 0.975

$$As = \frac{M}{\eta.Rs.ho} = \frac{(12.25*100)}{(0.975*(14.5)*40)} = 2.166\ cm^2/m$$

We take the required As is the minimum=3.02 cm^2/m

We use 6ϕ8mm/m

4.4.2.5. Steel arrangement in slab

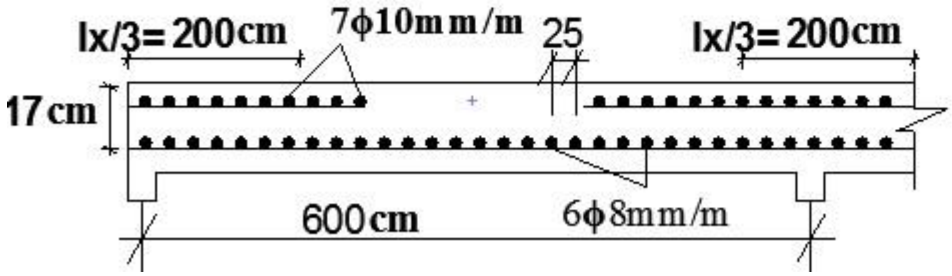


Figure 4.3: Steel arrangement in slab

The Area that was found 2.166 cm^2/m for bottom steel requirement was not reach to the design steel required (Mosley *et al*., 2007). Minimum steel required in slab is 6Φ8 /m with corresponding As = 3.02cm^2/m for this steel reinforcement slab was able to carry the load that applied on it

Note: the other chosen critical panel was computed as the same as this one were presented in appendices

4.5. Design of beam

4.5.1. Introduction

A beam is generally considered to be any member subjected principally to transverse gravity or vertical loadings. Beams carry load from slab to column. They are generally classified according to their geometry and the manner in which they are supported.

Sections used in concrete beam design are two types:

a. Flanged sections of either T or L shape with tension steel and with or without compression steel
b. Rectangular section with tension and compression steel

4.5.2.1 Tributary areas and influence of the beam to be designed

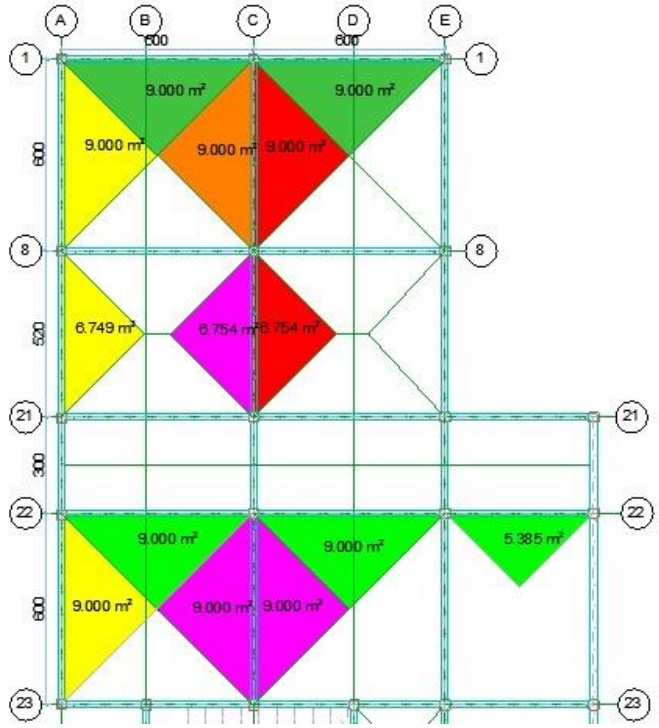


Figure4.4: Tributary areas and influence of the beam to be designed

4.5.2.2. Longitudinal beam design c-c

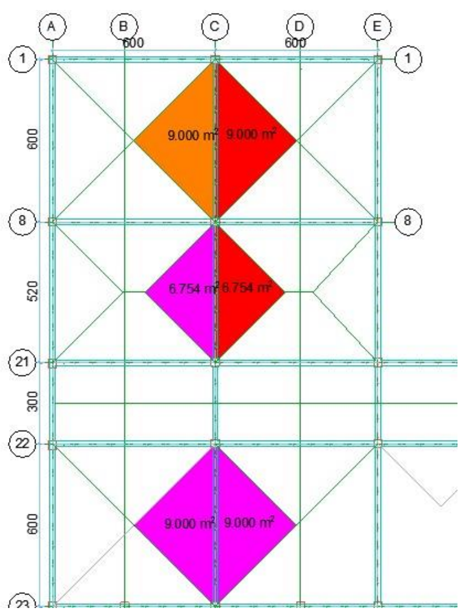


Figure4.5: beam with their influenced areas

Note: As the span lengths of this beam are equals, i.e.: the span difference is 0% which means that for this case $\Delta l = 0\% \leq 20\%$, the beam can be analyzed and designed using coefficients method or Prokon software can be used.

a. Beam sizes computation

Thickness (h) of the beam

Computation for the overall depth of the beam (h) Thickness (h) of the beam lies in the range between $\frac{L}{8}$ *and* $\frac{L}{12}$ where L (600cm) is the largest between two consecutive beams

the range is between 50cm and 75cm. Let us take 75cm as the thickness of the Beam Note:

The height of the masonry wall =3.0m-0.75m=2.25m

The height of the area of the plaster=3.0m-0.17m=2.83m

Computation for the web of the beam (bw)

The strength of a beam is affected considerably more by its depth than its breath. A suitable breath may be a third to half of the depth, but it may be much less for deep beam and at other times wide shallow beams are used to conserve headroom, the beam should not be too narrow; if it is much less than 200mm wide there may be difficulty in providing adequate side cover and space for the reinforcing bars. $\frac{h}{3} \le bw \le \frac{h}{2}$ For this beam the breath is ranging in the interval of $\frac{75}{3}$ and $\frac{75}{2}$ which is from 25cm to 37.5cm.

In line with the above assumption, let’s take bw = 30cm

Computation for the breath of the flange (b_f)

Flanged beams occur where beams are cast integral with and support a continuous floor slab. Part of the slab adjacent to the beam is counted as acting in compression to form T and L beams (MacGinley, 2003).

Bf for T-beam is equal to the smallest value of the following:

- A third of the beam span = $\frac{600}{3}$ = 200cm
- The half of the distance between beams = $\frac{600}{2}$ = 300cm
- $12h_f$ +bw=12*17cm+30cm =234 cm

So, the b_f of the beam is equal to 200cm

4.5.2.2. Load on the beam

a. Load from the slab

Dead load from the slab=5.712+2.1=7.812 KN/m^2

Uniformly distributed Live loads (KN/m) = 1.6*1*1*3= 4.8 KN/m^2

Table 4.2: Dead load and live load from slab

Span	Tributary area(m^2)	Dead load from the slab(KN/m)	Live load from the slab(KN/m)
1	18	$\frac{18*7.812}{6}$ =23.436	$\frac{18*4.8}{6}$ =14.4
2	13.52	$\frac{13.52*7.812}{5.2}$ =20.311	$\frac{13.52*4.8}{5.2}$ =12.48
3	0	0	0
4	18	$\frac{18*7.812}{6}$ =23.436	$\frac{18*4.8}{6}$ =14.4

Masonry wall:1.4x0.20x2.250x1x19=11.97KN/m

Wall finishes=1.4x0.03x2.83x20x2=4.754KN/m

Additional loadings on the beam (self-weight is computed by the software but nonfactored)

Non- factored own weight of the beam = $\gamma\{(bf*hf)$ + (bw*h)} = {24*[(2*0.17) + (0.3*0.58)]} = 12.336 KN/m

Factored own weight of the beam = 1.4*12.336 = 17.27KN/m

Beam own weight difference = Factored own weight of the beam - Non- factored own weight of the beam: 17.27KN/m – 12.336 KN/m = 4.934KN/m

Deduction =1.4*(bf-bw)*hf*$\gamma = 1.4*(2-0.3)0.17*24 = 9.71 KN/m$

Subtotal dead load: (11.97+4.754 +4.934-9.71) =11.948KN/m

b. Dead load and live load of each span

Span1 G1=23.436+11.948=35.384KN/m

Q1=14.4KN/m

Span2 G2=20.311+11.948=32.259KN/m

Q2=12.48KN/m

Span3 G3=11.948=11.948KN/m

Q3=0KN/m

Span4 G4=23.436+11.948=35.384KN/m

Q4=14.4KN/m

Table 4.3: showing the design parameters of the beam

Fcu (Mpa)	25
Fy(Mpa)	460
Fyv(Mpa)	250
%redistribution	0
Downward/optimized redistribution	D
Cover to center top steel (mm)	35
Cover to center bottom steel(mm)	35
Dead load factor	1.4
Live load factor	1.6
Density of concrete	24
%live load permanent	25
Creep coefficient	2
Ecs shrinkage strain (KN/m^3)	$300E*10^{-6}$

Table 4.4: Beam Section dimensions

Sec No	Bw (mm)	D (mm)	Bf-top (mm)	Hftop (mm)

1	300	750	2000	170

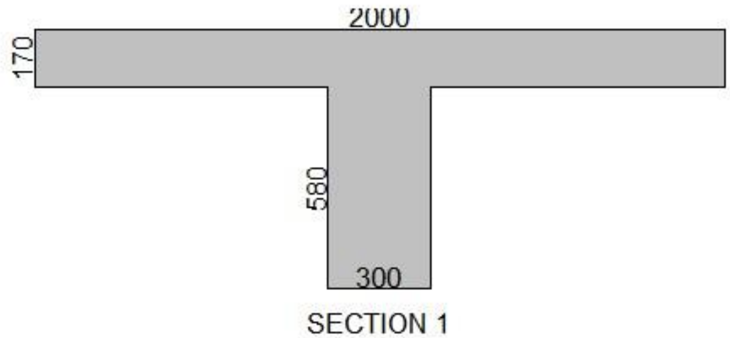


Figure4.6: Designed beam section

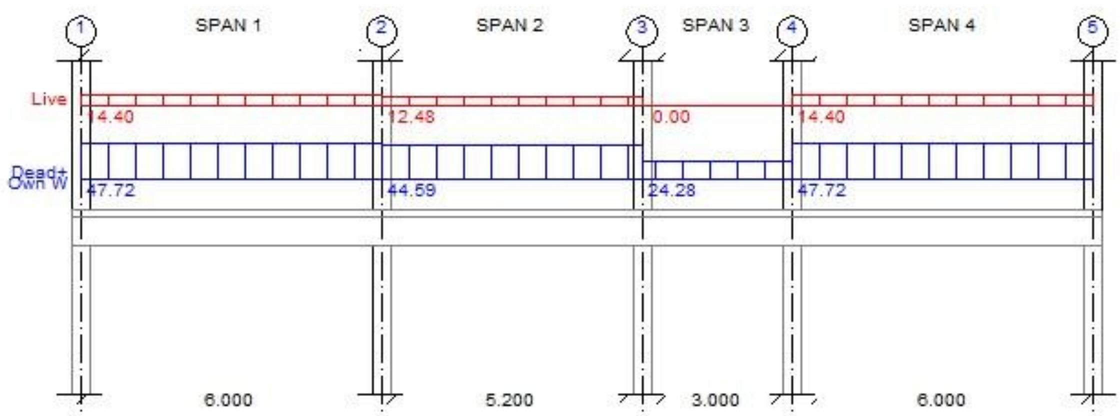


Figure4.7: Beam elevation and their loadings

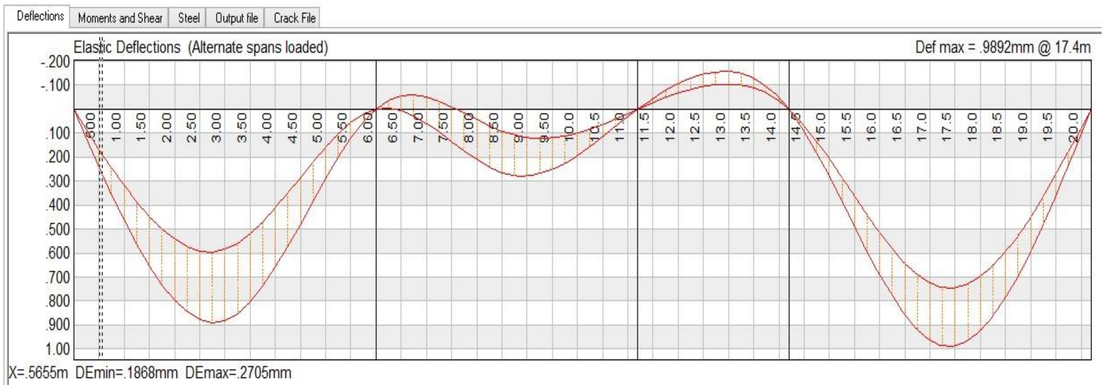


Figure4.8: Elastic deflection

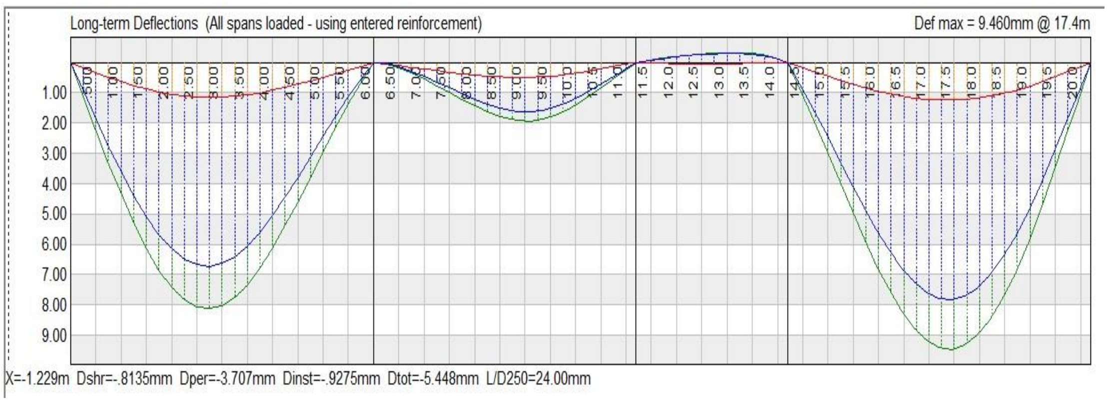


Figure4.9: Long-term deflection

c. Deflection checking

The ultimate deflection $f_u = \frac{Lmax}{500}$

$f_u = \frac{6000}{500} = 12mm$

The maximum long- term deflection should be lesser than the ultimate deflection for suitable beam; otherwise the depth of the beam can be changed.

For the beam C-C the maximum long-term deflection is 9.46mm which is lesser than the ultimate deflection fu=12mm thus the beam cross sectional dimensions are suitable

Figure4.10: Shear force diagram

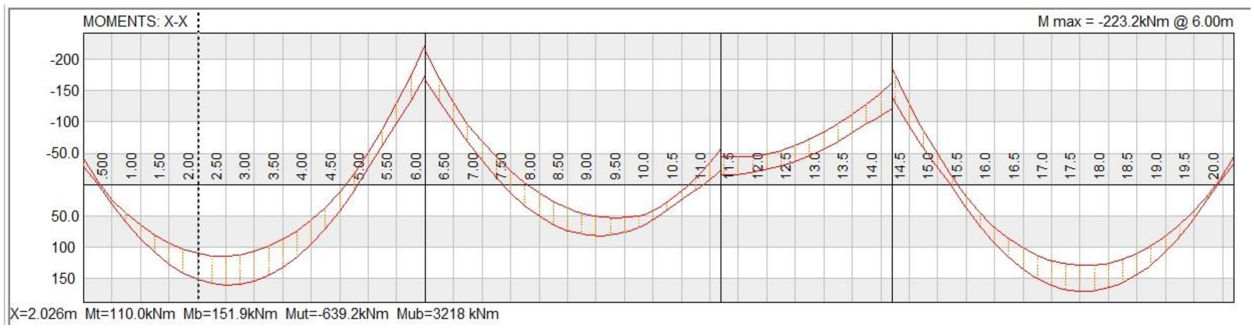


Figure4.11: Moment diagram

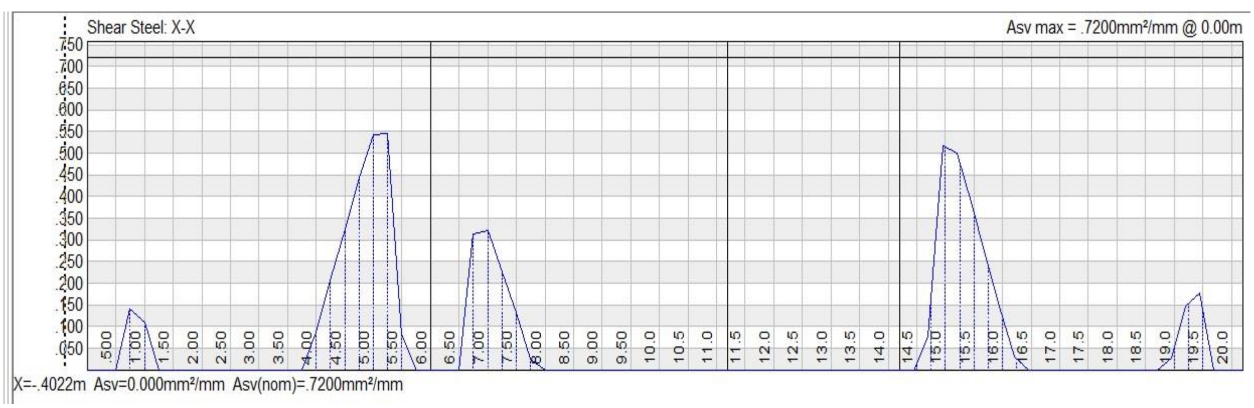


Figure4.12: Stirrups diagram

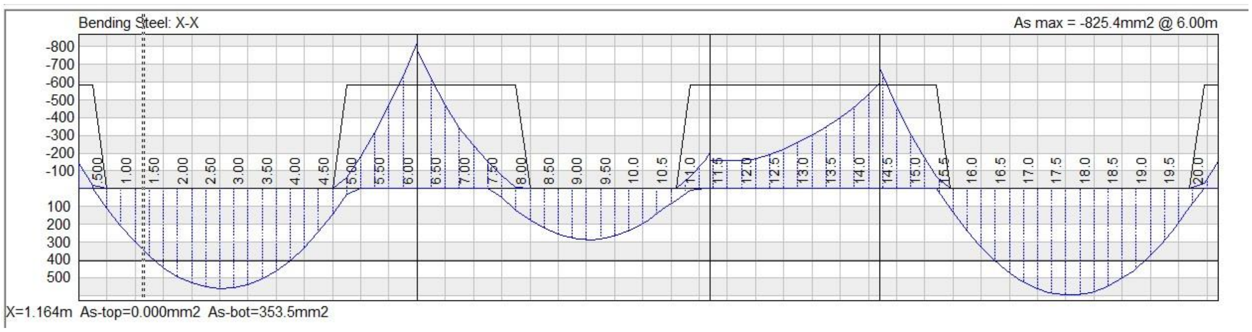


Figure4.13: Top and bottom steel reinforcement diagram

4.5.2.3. Steel reinforcement in a beam

a. Stirrups Requirement

The A_{SV} = 0.544mm^2/mm = 5.44mm^2/cm which gives the use of links of minimum AS_V = 50.3 mm^2/cm of Φ8.

b. steel reinforcement at the top

The area of required steel reinforcement at the top As max = 825.4mm^2 which gives the use of 5Φ16 of As = 1005mm^2

c. Requirement Steel Reinforcement at the Bottom

The area of required steel reinforcement at the bottom As max = 589.6mm^2 which gives the minimum of 4Φ16 of As = 804mm^2

4.5.2.4. Steel arrangement in the beam

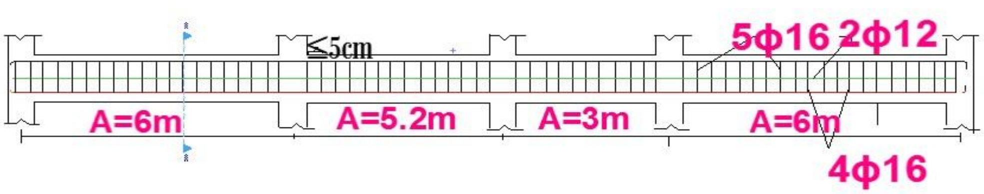


Figure4.14: Longitudinal cross section of the beam

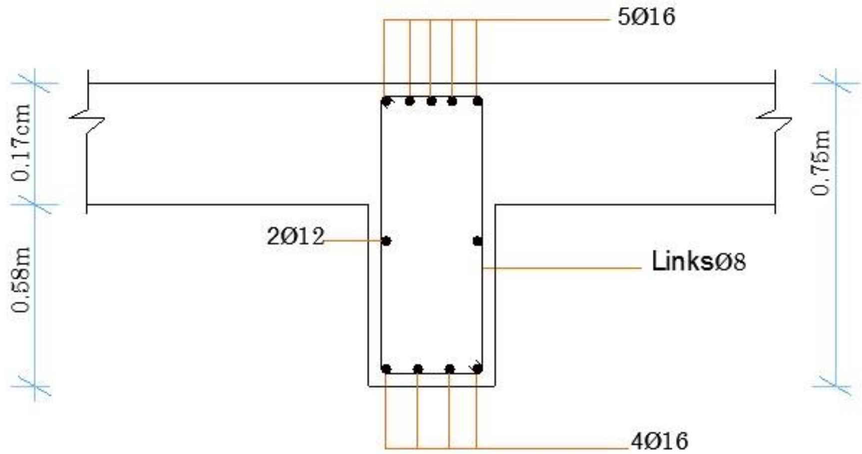


Figure4.15: Transversal section of the beam

4.5.3. Design of beam 22-22 (most loaded transverse internal beam

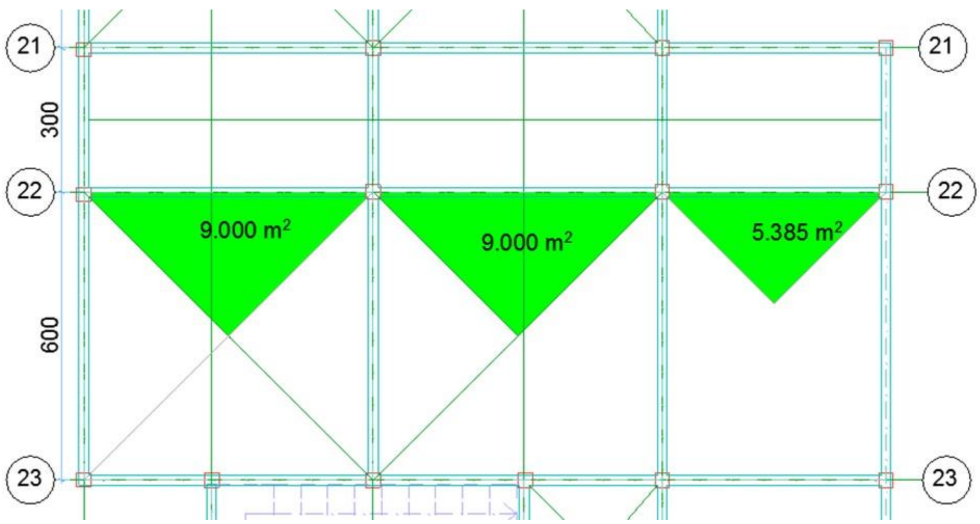


Figure4.16: most loaded transverse internal beam

4.5.3.1. Design parameters

The b_f =200cm

Hf of slab=170cm

Height of the beam=75cm

Dead load from the slab=5.712+2.1=7.812 KN/m^2

Uniformly distributed Live loads (KN/m) = 1.6*1*1*3= 4.8 KN/m^2

Table4.5: Dead load and live load from slab

Span	Tributary area(m^2)	Dead load from the slab(KN/m)	Live load from the slab(KN/m)
1	18	$\frac{18*7.812}{6}$ =23.436	$\frac{18*4.8}{6}$ =14.4
2	18	$\frac{18*7.812}{6}$ =23.436	$\frac{18*4.8}{6}$ =14.4
3	12.369	$\frac{12.369*7.812}{4.64}$ =20.825	$\frac{12.369*4.8}{4.64}$ =12.795

4.5.3.2. Load on the beam

Masonry wall:1.4x0.20x2.25x1x19=11.97KN/m

Wall finishes=1.4x0.03x2.83x20x2=4.7544KN/m

Additional loadings on the beam (self-weight is computed by the software but nonfactored)

Non- factored own weight of the beam =$\gamma\{(bf * hf$) + (bw*h)} = {24*[(2*0.17) + (0.3*0.58)]} = 12.336 KN/m

Factored own weight of the beam = 1.4*12.336 = 17.27KN/m

Beam own weight difference = Factored own weight of the beam - Non- factored own weight of the beam: 17.27KN/m – 12.336 KN/m = 4.934KN/m

Deduction =1.4*(bf-bw)*hf*$\gamma = 1.4 * (2 - 0.3)0.17 * 24 = 9.71\text{KN/m}$

Subtotal dead load: (11.97+4.7544 +4.934-9.71) =11.9484KN/m

a. Dead load and live load of each span

Span1 G1=23.436+11.9484=35.3844KN/m

Q1=14.4KN/m

Span2 G2=23.436+11.9484=35.3844KN/m

Q2=14.4KN/m

Span3 G3=20.825+11.9484=32.7734KN/m

Q3=12.795KN/m

Table 4.6: input parameters for computing beams

Fcu (Mpa)	25
Fy(Mpa)	460
Fyv(Mpa)	250
%redistribution	0
Downward/optimized redistribution	D
Cover to center top steel (mm)	35
Cover to center bottom steel(mm)	35
Dead load factor	1.4
Live load factor	1.6
Density of concrete	24
%live load permanent	25
Creep coefficient	2
Ecs shrinkage strain (KN/m^3)	$300E*10^{-6}$

Table 4.7: input measure computing beam

Sec No	Bw (mm)	D (mm)	Bf-top (mm)	Hf-top (mm)
1	300	750	2000	170

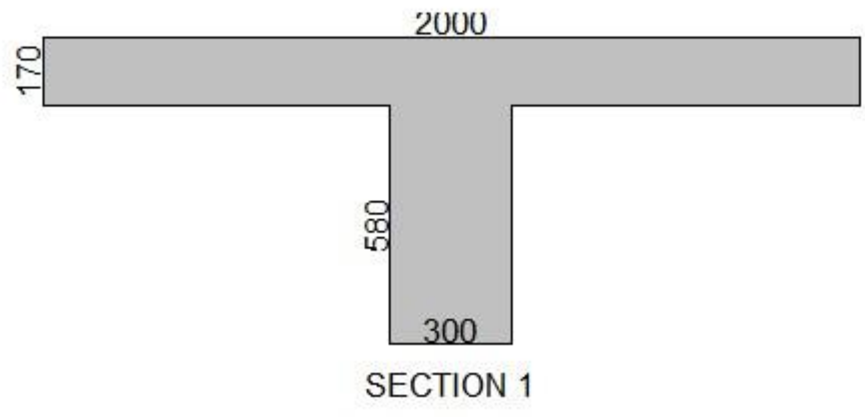


Figure4.17: beam Section

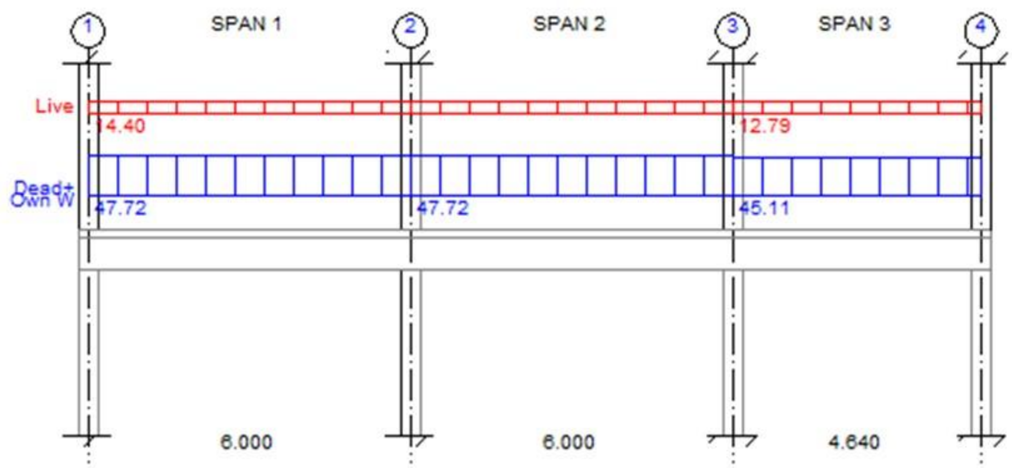


Figure4.18: Beam elevation and their loadings

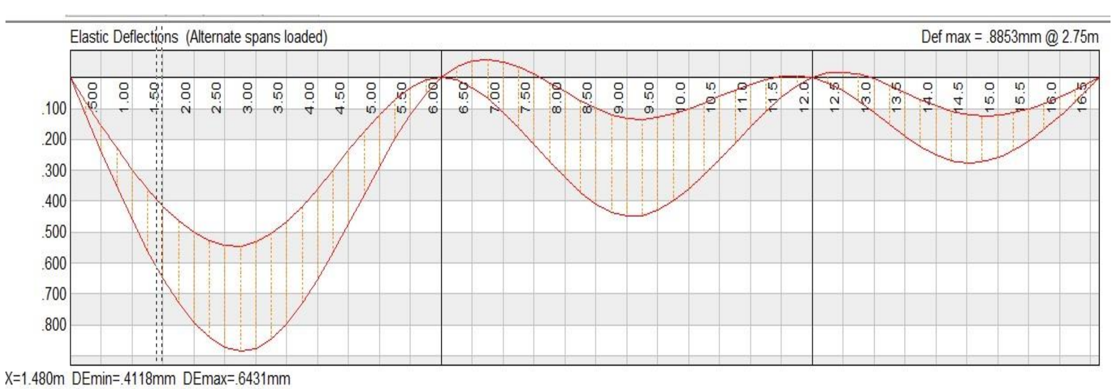


Figure4.19: Elastic deflection

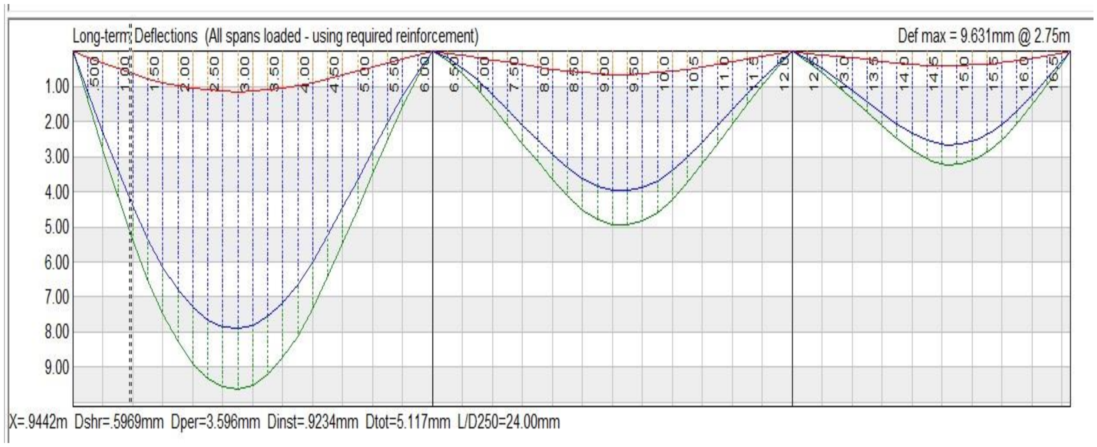


Figure4.20: Long-term deflection

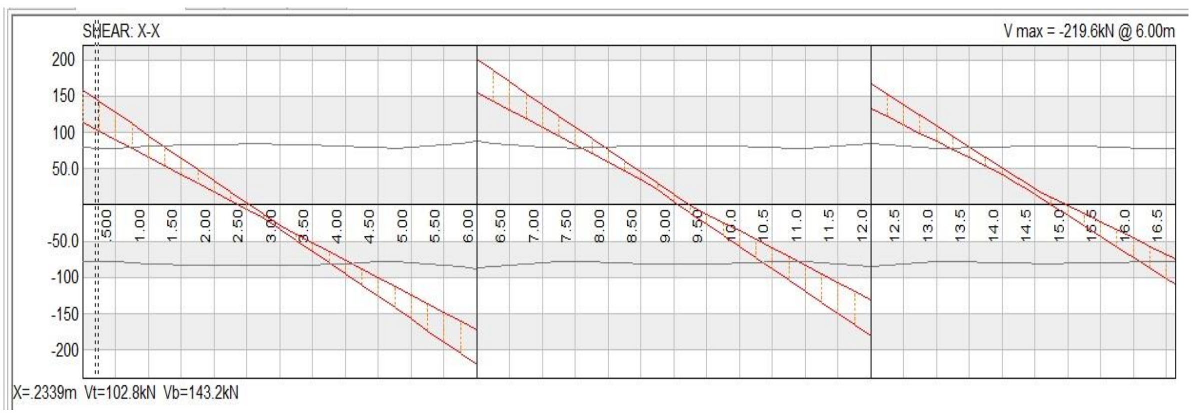


Figure4.21: Shear force diagram

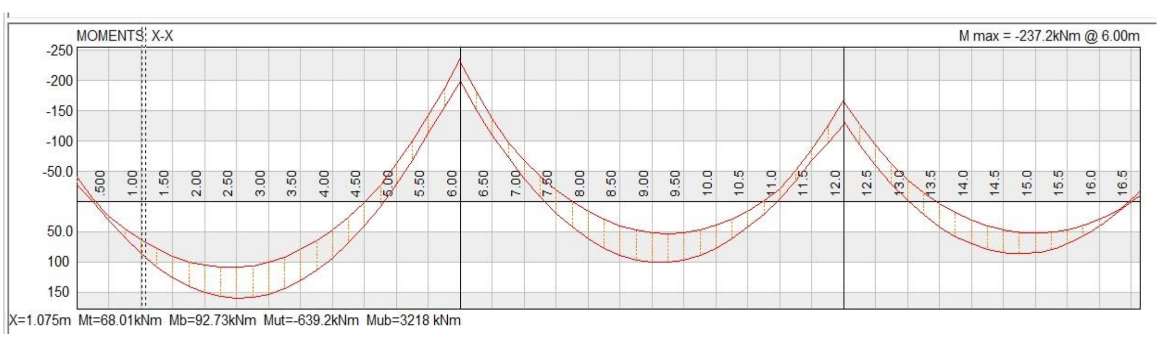


Figure4.22: Bending moment diagram

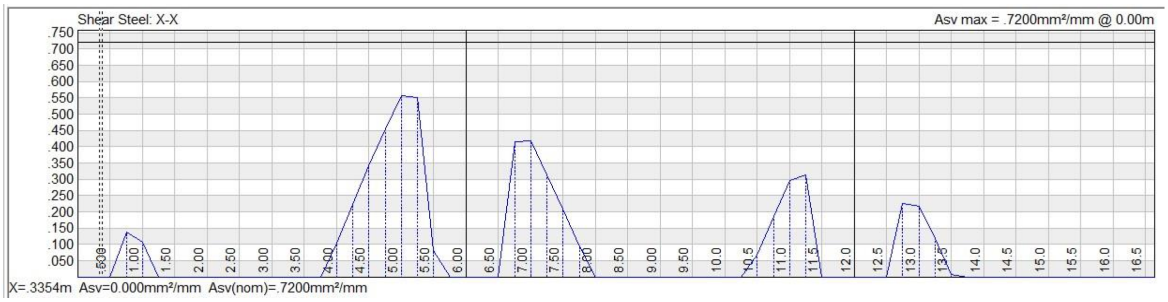


Figure4.23: Stirrup diagram

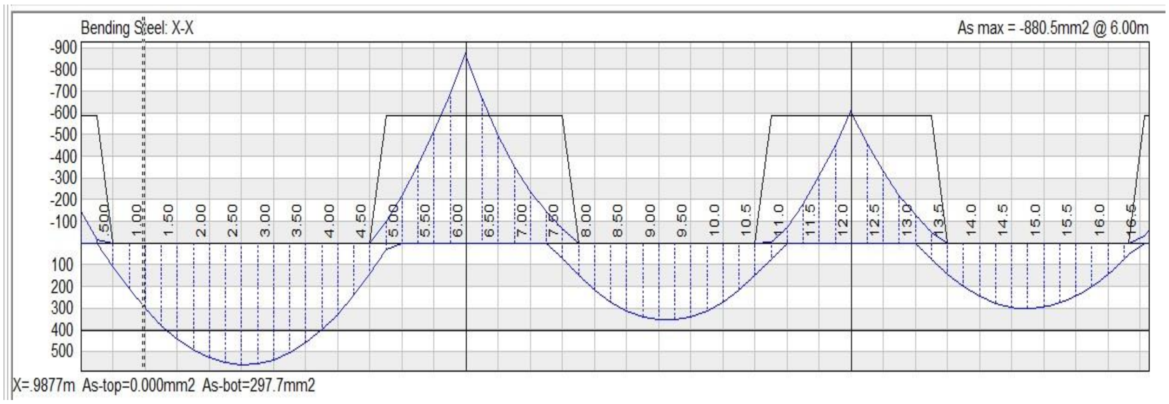


Figure4.24: Top and bottom steel diagram

4.5.3.3. Steel reinforcement in beam

a. Stirrup's requirement in beam

The A_{SV} = 0.8928mm^2/mm = 8.928mm^2/cm which gives the use of links of minimum ASV = 50.3mm^2/cm of Φ8. with spacing of 200 mm

b. Requirement steel reinforcement at the top

The area of required steel reinforcement at the top A_S max = 880.5mm^2 which gives the use of 5Φ16 of A_S = 1005mm^2

c. Requirement steel reinforcement at the bottom

The area of required steel reinforcement at the bottom A_S max = 561.4mm^2 which gives the use of 4Φ16 of A_S = 804mm^2

4.5.3.4. Steel arrangement in the beam

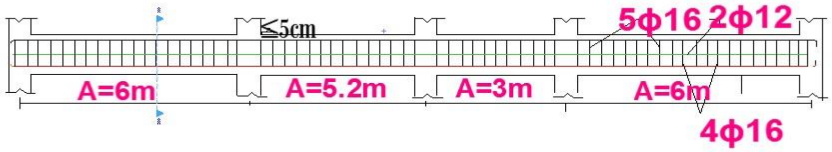


Figure4.25: Longitudinal cross section of the beam

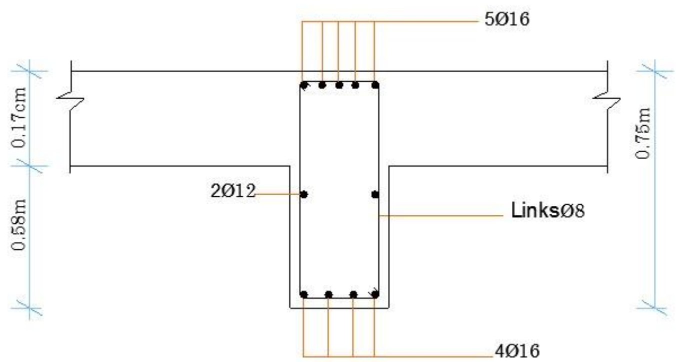


Figure4.26: Transversal Section of the beam

i. For stirrups the area 0.8928mm^2/cm obtained didn't achieve to the designed steel required (Mosley *et al.*, 2007). The minimum steel area required of stirrup is Asv = 50.2 mm^2/cm of Φ8.

ii. At the top of the beam the area obtained A_s max = 880.5cm^2 didn't match with the required steel reinforcement (Mosley *et al.*, 2007). The corresponding area of steel reinforcement is A_s = 1005cm ^{2} with steel reinforcement of 5Φ16.

iii. The provision of additional steel reinforcements of 2Φ12 to minimize the spacing which is between top reinforcement and bottom reinforcement, to make it lesser than 40cm because the spacing is restrictedly limited to 40 cm.

If the result found is lesser than the required steel reinforcements, the Minimum design steel required in beam is 4Φ12 with As = 452 mm^2 (Mosley *et al.*, 2007).It should be better if height of the beam is same at all structure.

4.6. Design of reinforced concrete column

4.6.1. Definition

A column is designed to resist mainly axial loadings in compression. It is a structure carrying loads from the beams and slabs down to the foundations, and therefore it is primarily compressive members, although it may also have to resist bending forces due to the continuity of the structure. Based on the slenderness ratio, columns are categorized into short and slender.

4.6.2. Analysis and Design of Columns

On this project we will design four columns: one internal most loaded column and three external (edge) columns.

4.6.3. Design of interior column C8 (the most loaded)

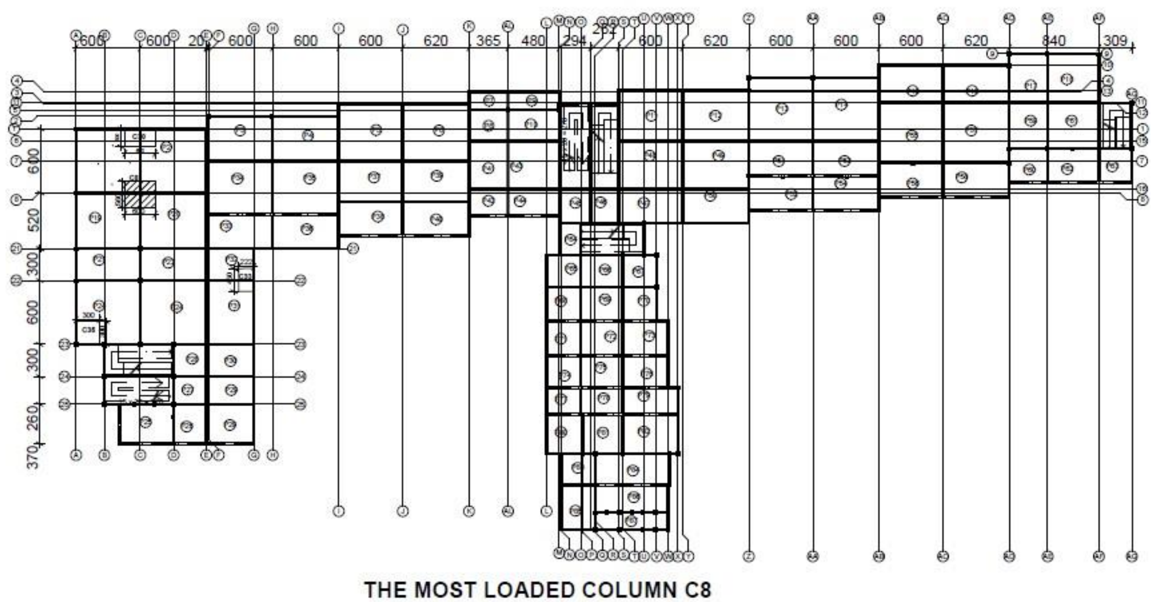


Figure4.27: layout plan of the columns

Cross section: 35cm*35cm

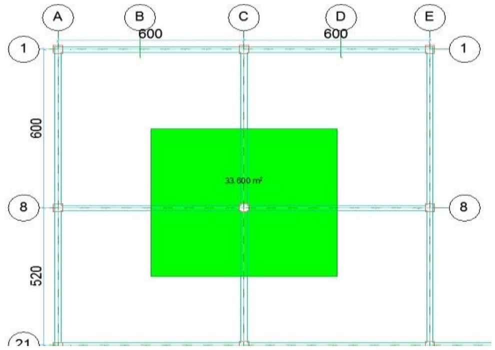


Figure 4.28: column with their influences

4.6.3.1. Load on column

a. Dead load

Load from the slab= 7.812*6.0*5.60=262.48KN

Self-load of the column=1.4*0.35*0.35*3*24KN/m=12.348KN/m

Load from the beam=1.4*0.3*0.58*(6.0+5.60) *24KN/m=67.818KN/m

Masonry walls=1.4*0.2*2.25*(5.6+6.0) *19KN/m=138.852KN/m

Plaster on the wall=1.4*0.03*2.83*(5.60+6.0) *2*20KN/m=55.15KN/m

b. Live load

Live load=4.8*6.0*5.60=161.28KN

4.6.3.2. Load on floor of the column

c. Ground floor part of the column (up to footing)

Self-load of the underground column= 1.4*0.35*0.35*1.5*24=6.174KN/m Loads=
(262.48+138.852+67.818+55.15+161.2)*82+ (12.348*3) +6.174+262.48+67.818+161.28
N1=1905.956KN

a. First floor part of the column

Loads=

(262.48+138.852+67.818+55.15+161.28) *1+ (12.348*2) + (262.48+67.818+161.28)

N2= 1201.854KN

b. Second floor part of the column

Loads= (161.28+67.818+262.48+12.348*1)

N3=503.926KN

4.3.3.3. Steel Reinforcement in Columns

Slenderness ratio (□) □□ $\frac{Lo}{a}$

Where Lo is the effective height of the column and is the smallest side of the cross

	6	8	10	12	14	16	18	20
φ	0.92	0.91	0.89	0.86	0.82	0.77	0.71	0.64

section. Here we use 0.7H for the interior column, table shows the values of φ

(□) $\frac{7*300}{35}$ 0.
□□□ 6<14.3 means that our column is short

With $\lambda = 6$ φ=0.92 then

a. Ground floor part of the column (up to footing)

$$As=\frac{\frac{1905.956}{0.92}-1.3*35*35}{40}=11.97\ cm^2$$

We take 4 Φ20mm with As = 12.57cm^2

b. First floor column

$$As=\frac{\frac{1201.854}{0.92}-1.3*35*35}{40}=-7.153cm^2$$

$$As_{\min}=\frac{0.4}{100}*Ab=\frac{0.4*35*35}{100}=4.9cm^2$$

We take 4Φ16mm with As =12.06 cm^2

c. Second floor part of the column

We take 4Φ14mm with As = 616 cm^2

The minus sign means that the column on the second floor is able to carry the rest of the building without steel reinforcement (Bungey, 1990). But we have to put minimum steel reinforcements. Here we take the minimum steel cross section of the column for second floor4Φ14The minimum steel required in column 4Φ12 .

4.6.3.4. Steel Arrangement in column

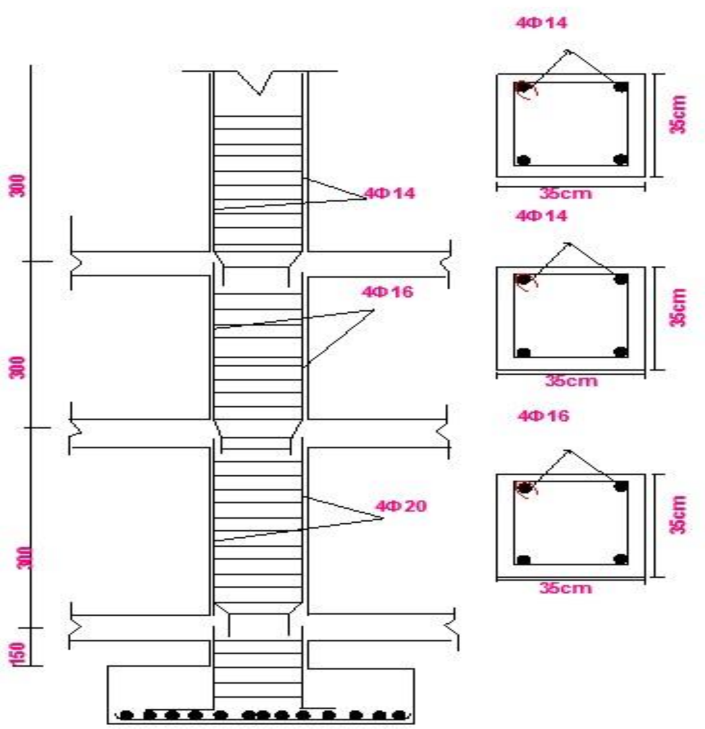


Figure4.29: column reinforcement

4.7. Design of foundation

4.7.1. Introduction

Foundation is a sub-structure element which interfaces the superstructure and supporting ground.

There six types of foundations: pad footings, combined footings, strap footings, strip footings, raft foundations and piled foundations

We have used the pad footing in our design for reason that is simple to calculate, and it is efficient, the bearing capacity of soil is assumed to be equal 300KN/m^2.

4.7.1.1 Design of interior pad foundation of the column C8

Column C8 design load=1905.956KN

Total design live load==75.952KN

Total design permanent load =1905.956-75.952=1830.004KN

Total characteristic live load= $\frac{75.952}{1.6}$ =47.47KN

Total characteristic permanent load= $\frac{1830.004KN}{1.4}$ =1307.145KN

Total characteristic load=47.47+1307.145=1354.615KN

Estimate foundation weight +soil unit=10% total characteristics= $\frac{10*1354.615}{100}$ =135.4615KN

Total load on the soil=1354.615 +135.4615 =1490.0765KN

Let as assume soil design bearing capacity =300KN/m^2 = 300*10^{-4}KN/cm^2

a. The require area of foundation

Af= $\frac{\text{Total load on the soil}}{\text{Design bearing capacity}} = \frac{1905.956}{0.030}$ =63531.8667cm^2

af= $\sqrt{63531.8667}$ =252.0552cm let take af=255cm and bf=255cm

4.1.4.3. Design pressure

P= $\frac{N}{Af} = \frac{1905.956}{255*255}$ =0.0293KN/cm^2=293KN/m^2

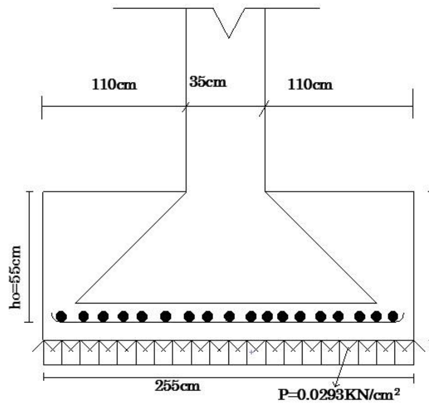


Figure4.30: Checking shear force

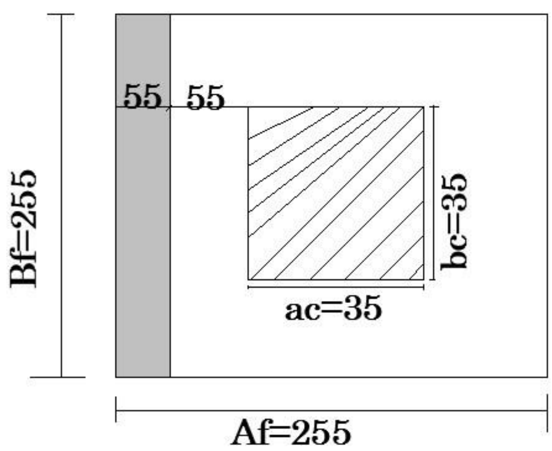


Figure4.31: Area of the foundation

B. ***Checking of shear force***

The shear force Q≤0.54*Rbt*Ab

Where Ab=af*ho

Q=P*bf (lc-ho)

ho=H-5 let take H=60cm Q=P*bf (lc-ho) ho=60-5=55cm

Shear: Q ≤ 0.54*Rbt*Ab $P * bf(lc - ho) \leq$ 0.54*Rbt*Ab

lc= $\frac{bf}{2}$-$\frac{bc}{2}$=$\frac{255}{2}$-$\frac{35}{2}$- =110cm

Ab=af*ho=255*55=14025cm

0.0293*255(110−55)≤0.54*0.09*14025

410.9325KN$\leq$ 681.615KN OK

c. Checking for punching shear

Qf=Nf-∇q $\leq$Rbt*Ab

Where Ab=Um*ho, Um=2(ac+bc+2ho), $\nabla q = P(ac + 2ho)^2$

Um=2(35+35+2*55) =360cm   Ab=360*55=19800cm^2

$\nabla q = 0.0293(35 + 2 * 55)^2$=616.85KN

Qf=1905.956 -616.85 $\leq$ 0.09*19800

1289.106 KN $\leq$ 1782KN OK

Moment calculation

Mmax=$\left(\frac{Paf}{2}\right)\left(\frac{bf-bc}{2}\right)^2=\frac{0.0293*255}{2}\left(\frac{255-35}{2}\right)^2$=45202.575KN

As=$\frac{M}{0.9*ho*Rs}=\frac{45202.575}{0.9*55*40}$=22.829cm^2 let take 5Φ25 with As=24.54cm^2

4.7.1. 2. Arrangement of steel in foundation

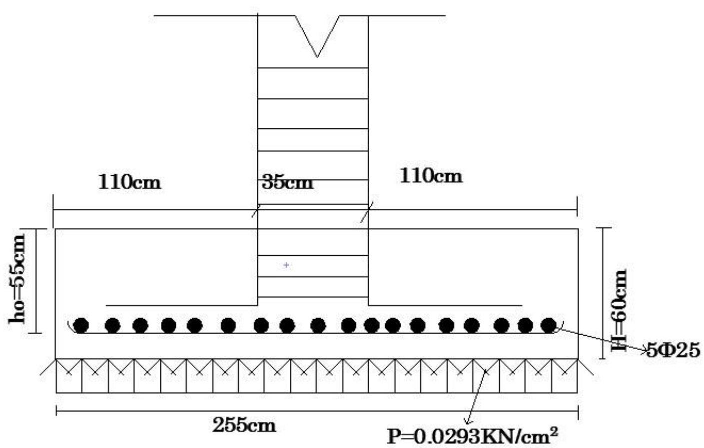


Figure4.32: Steel Arrangement in foundation

Maximum area of foundation was found As = 22.829cm^2 this area had not any correspond steel bar in table of Sectional areas of groups of bars (Mosley *et al.*, 2007). The chosen area to be used had As = 24.54cm^2 with corresponding steel bar

$5^{\Phi 25}$ this steel was safely to be used in foundation because it was more loaded structure that would carry the superstructure.

4.8. Design of stair

4.8.1. Computation of equivalent thickness (he)

Dl =17cm

Rise (H) =17cm

Going (G) =28cm

$\theta = \tan^{-1}(\frac{rise}{going})$ $\theta = \tan^{-1}\frac{H}{G} = \tan^{-1}\frac{17}{28} = 31.26° \approx 32°$

he= $\frac{H}{2}$ $\frac{dl}{\cos\alpha} = \frac{17}{2} + \frac{17}{\cos 32} = 28.55cm \approx 29cm_{+}$

Effective height (ho) =equivalent thickness-concrete caver=29-2.5=26.5cm

4.8.2. Load on stair

Dead load =1.4*0.29*1*1*24==9.744KN/m

Finishes=1.4*1.5=2.1 KN/m

Live load=1.6*3=4.8KN/m

Total load= 8.904+2.1+4.8=16.644KN/m

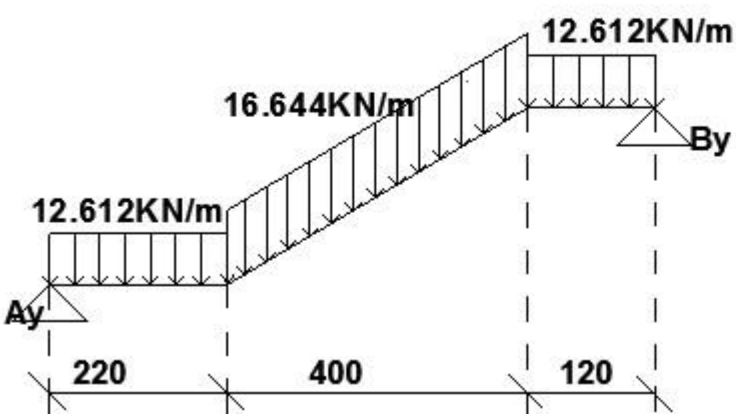


Figure4.33: Loads on stair

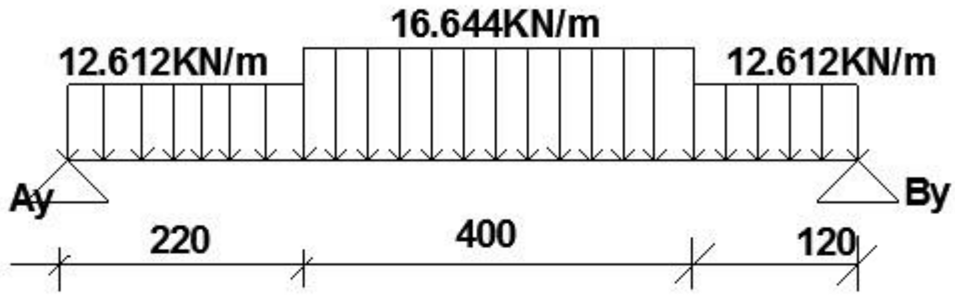


Figure4.34: Load combination on stair

$A_{Y+}B_{Y=}$12.612*2.2+16.644*4+12.612*1.2=109.457KN

$\sum$ MA=0 $\frac{12.612*2.2^2}{2}$+16.644*4 ($\frac{4}{2}+2.2$) +12.612*1.2*($\frac{1.2}{2}+6.2$) -7.4B_Y=0

7.4B_Y=407.757KN

B_Y=55.102KN

AY=109.457-B_Y=106.097-55.102=54.355KN

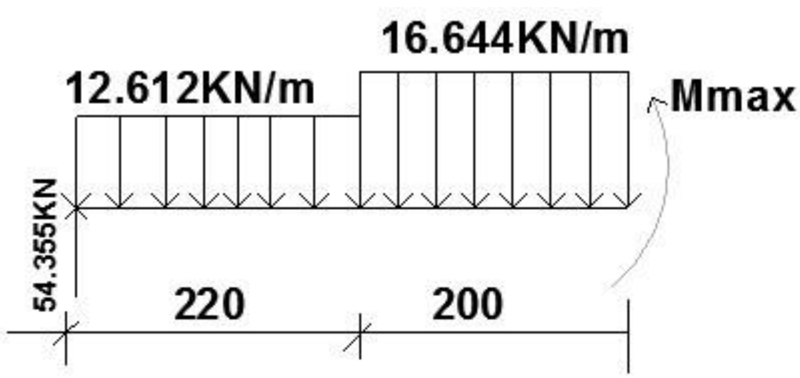


Figure4.35: Moment calculation

Mmax=54.355*4.2-12.612*2.2*($\frac{2.2}{2}$+2) -16.644*($\frac{2^2}{2}$)

Mmax=108.989KNm

4.1.5.4 Required steel reinforcement in the stair

$\alpha m=\frac{M}{Rb*b*ho^2}=\frac{108.989*100}{1.3*100*26.5^2}$=0.119$\approx$0.122

ξ=0.13 η=0.935

As=$\frac{M}{\eta.Rs.ho.} = \frac{108.989*100}{0.935*40*26.5}$ = 10.996cm^2/m

With this cross section we are going to use 6Φ16/m with As =12.06cm^2/m

4. 8.3, Arrangement of steel bar

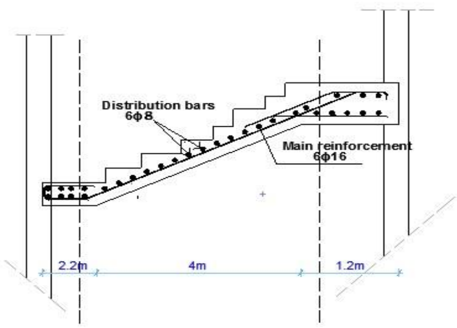


Figure4.36: Steel Reinforcement

Area that was found as = 10.996cm^2/m cm^2/m doesn't have any corresponding value in table of Sectional areas of groups of bars (Mosley *et al.*, 2007). The area has been chosen was as = 12.06cm^2/m with corresponding steel reinforcement 6Φ16 /m stair was designed likes slab

4.8. Design of ramp

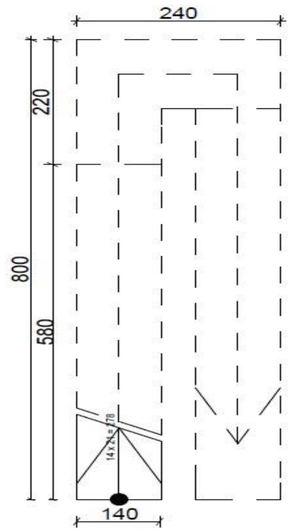


Figure4.37: Ramp designed

4.9.1. Size of ramp

Dl= 300 $(\frac{1}{20},\frac{1}{30})$

Dl=300 $\frac{1}{20}$ = 15cm and Dl =300$\frac{1}{30}$ = 10cm the average between these two distance gives us the value of Dl = 15 cm and Dl = 10cm

For the ramp h is zero because it hasn't risers but only going.

α = arc tan $(\frac{1.5}{8})$ = 10.62°

The ramp that will be designed is supported by two inclined parallel beams supported by two parallel columns and between these columns there is another small beam that connects them.

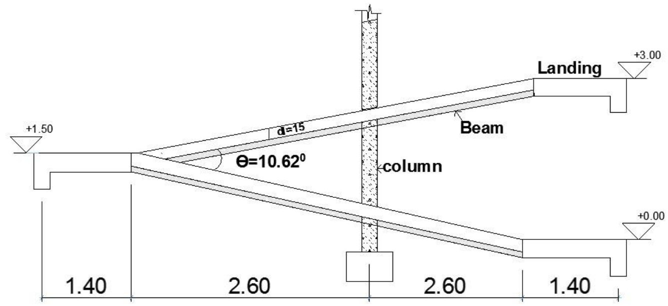


Figure4.38: Ramp dimensions

We have to design one part of ramp because all the two parts are similar hl= $\frac{dl}{\cos\alpha}=\frac{15}{\cos 10.62}=$ 15.26cm

4.1.6 .2 Load on ramp ho= hl-concrete clear cover= 15.26-2.5= 12.76cm Dead loads= 1.4*0.1526*1*1*24= 5.127KN/m

Load from finishes = 1.4*1.5= 2.1 KN/m2

Live load= 1.6*3= 4.8 KN/m2

Total load= 5.127+2.1+4.8= 12.027 KN/m

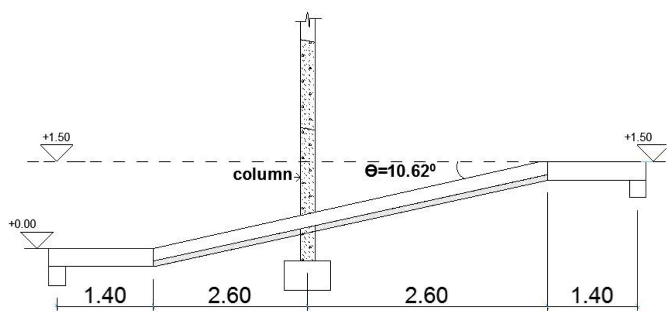


Figure4.39: Longitudinal cross section of the ramp

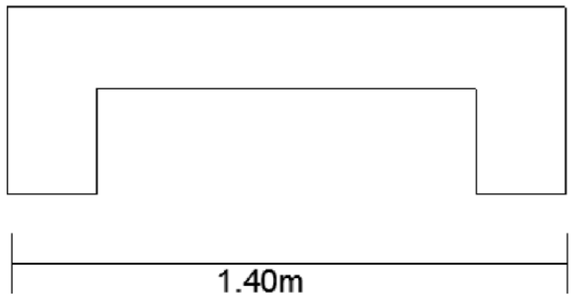


Figure4.40: Transversal Section

The total distributed load that is applied on the slab of the ramp including Permanent load calculated based on the ramp thickness, finishes and live load in total it is 12.03KN/m

Figure4.41: Free body diagram

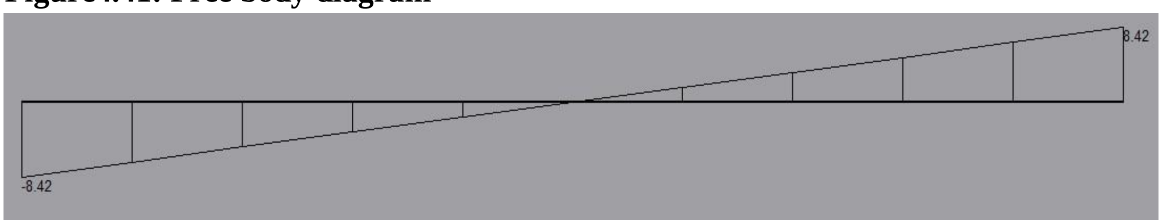


Figure4.42: Shear force diagram (KN)

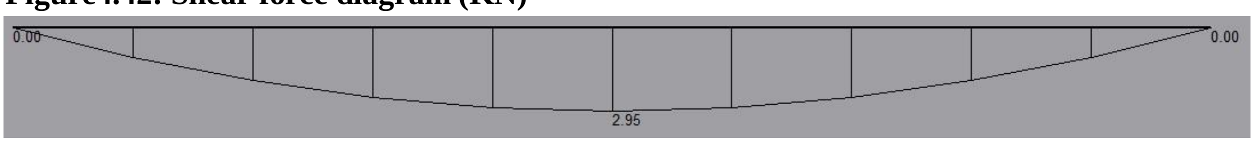


Figure4.43: Bending moment (KN/m)

The maximum bending moment of the ramp is M_{max}= 2.95KNm

4.9.2. Calculation of steel reinforcement in the ramp

$\alpha m = \frac{M}{Rb*b*ho^2} = = \frac{2.95*100}{1.3*100*12.76^2} = 0.014$

From the table of Coefficients related to the design of members subjected to bending moment we have:

ζ= 0.02; < R =0.393 (Case of singly reinforcements) η= 0.990

$AS = \frac{M}{\eta * Rs * ho} = = \frac{2.95*100}{0.990*40*12.76}$ =0.584cm^2/m

With this cross section we are going to use the minimum steel cross section Using 6Φ 8mm/m with As =3.02cm^2/m

4.8.3. Beams design

a. Design of the two parallel beams

Hf =17cm ho= 17-
3.5cm= 13.5cm

The load from the slab that will be applied on one beam is the load from the half of the slab because the other load from the other half of the slab will be applied the load on the other beam, and then the half of the slab is 0.7m

As the maximum length of the panel to be supported equal 2.6m

Height of the beam lies in range between $\frac{lmax}{12}$ and $\frac{lmax}{8}$ = $\frac{2.6}{12} = 21.67\text{cm}$ and $\frac{2.6}{8}$ =32.5cm

h=30cm

Let take the height of the beam which is equal to 30cm and the width of 25cm

b. Loads on the beam

Permanent loads

Self-load = 1.4*0.3*0.25*1*24= 2.52KN/m

Load from the slab= 7.812*0.7= 5.468KN/m

Live loads

4.8*0.7=3.36KN/m

The total load that is applied on the beam supporting the ramp is P= (2.52+5.468+3.36) = 11.348KN/m

The load applied on the landing of the ramp is the same as the load on the actual slab which is P= 12.612 KN/m

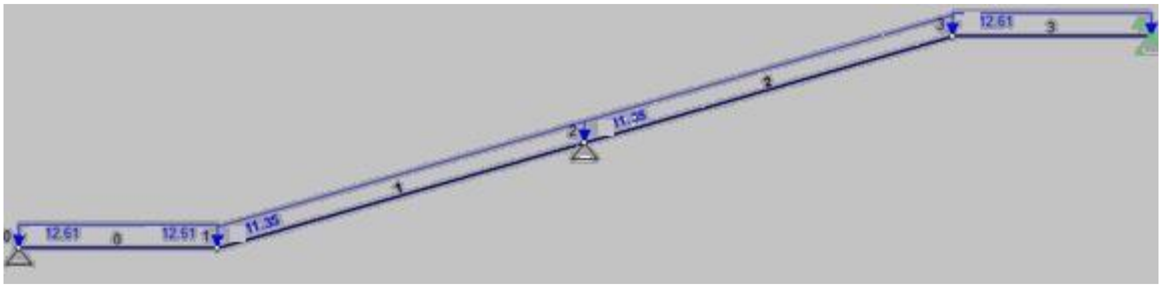


Figure4.44: Free body diagram

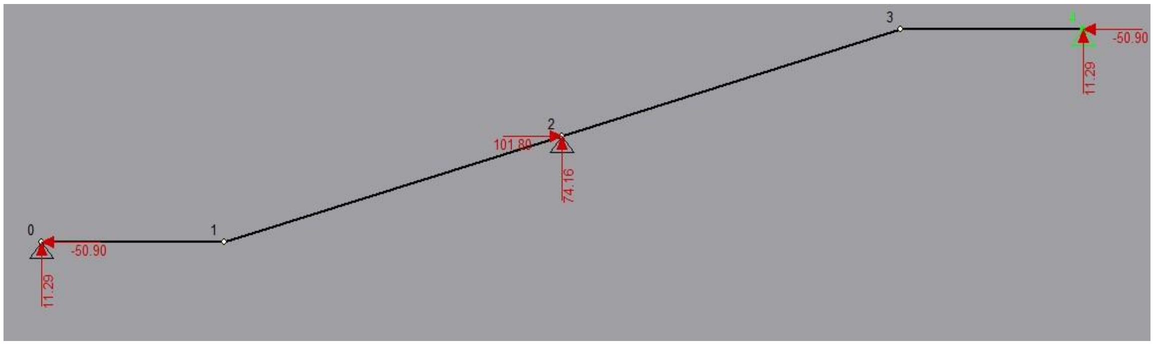


Figure4.45: Reaction at support

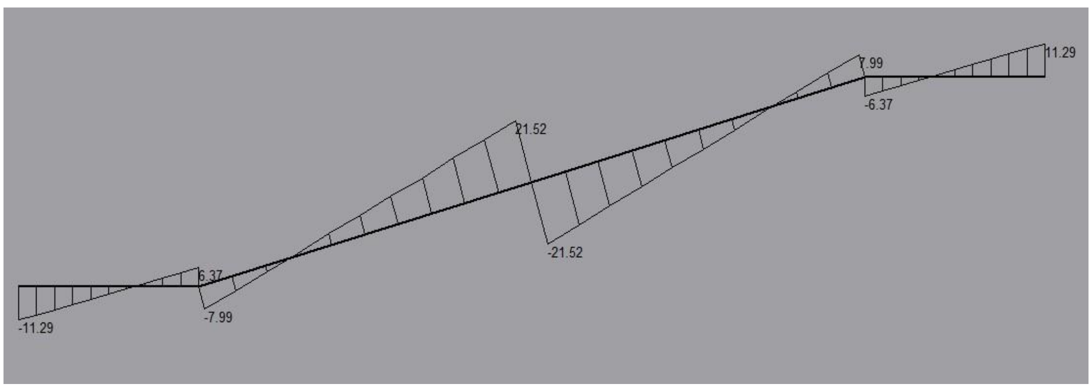


Figure4.46: Shear force diagram

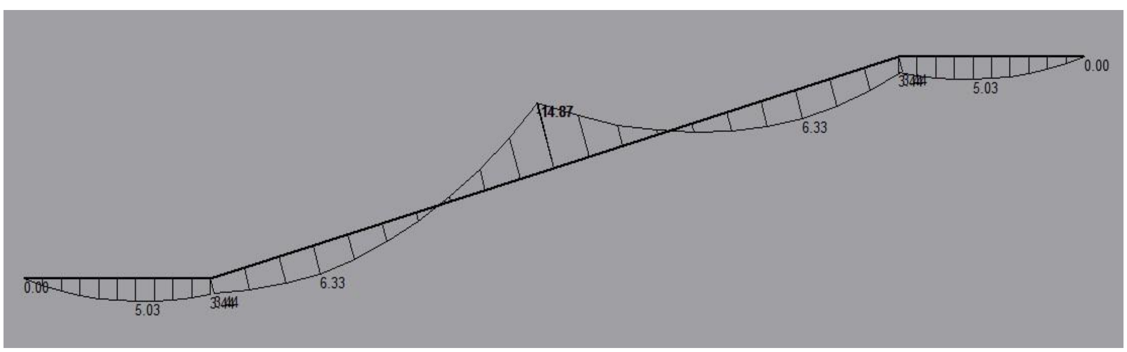


Figure4.47: Bending moment diagram

c. The maximum shear force

Vmax= 21.52KN

The maximum bending moment

M^{-}_{max}= 14.87KNm

M^{+}_{max}= 6.33KNm

4.9.3. Steel reinforcement calculation

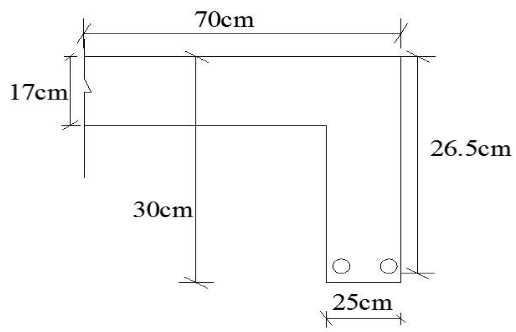


Figure4.48: Steel Reinforcement in Beam

hf=17cm ho=H-3.5=30-3.5=26.5cm

$$bf\begin{cases} 6hf + b = 6*17 + 25 = 127cm \\ \frac{l}{3} = \frac{260}{3} = 86.67cm \\ \frac{d}{2} = \frac{140}{2} = 70cm \end{cases}$$

bf=70cm

4.9.4. Required steel reinforcement

a. Required steel at the top

M^{-}max=14.84KNm

$\alpha m = \frac{M}{Rb*bf*ho^2} = \frac{14.84*100}{1.3*70*26.5^2} = 0.023 \approx 0.03$

From the table of Coefficients related to the design of members subjected to bending moment we have:

$\xi = 0.03$ η=0.985   Rs=40KN/cm^2

X=ξ*ho=0.03*36.5=1.095cm

In case x$\leq$ hf

As=$\frac{M}{\eta * Rs * ho} = \frac{14.84*100}{0.985*40*26.5}$=1.42$cm^2$

With this cross section we are going to use the steel cross section Using 2 Φ14mm with As = 3.08cm^2

b. Required steel reinforcement at the bottom

M+ max= 6.33KNm

αm=$\frac{M}{Rb*bf*ho^2} = \frac{6.33*100}{1.3*70*26.5^2} = 0.01$

$\xi = 0.01$ η=0.995

X=ξ*ho=0.01*36.5=0.365cm

In case x$\leq$ hf

As=$\frac{M}{\eta * Rs * ho} = \frac{6.33*100}{0.995*40*26.5}$=0.60$cm^2$

With this cross section we are going to use the steel cross section Using 2 Φ12mm with As = 2.26cm^2

4.9.5. Stirrups

Vmax= 21.52KN $\varphi bf = 1.5$

Rbt=0.09KN/cm^2 b=25cm

$$qsw = \frac{Q^2}{4\varphi bf * Rbt * b * ho^2} = \frac{(21.52)^2}{4 * 1.5 * 0.09 * 25 * (26.5)^2} = 0.049cm^2/cm$$

Taken Φ8 with Asw=0.503 cm^2

Rsw=0.8*RS

$$S = \frac{Rsw * Asw * n}{qsw} = \frac{0.8 * 40 * 0.503 * 2}{0.049} 656.98cm$$

S must be less than the three following values:

$$\begin{cases} Smax = \frac{0.75\varphi bf * Rbt * b * ho^2}{Q} = \frac{0.75 * 1.5 * 0.09 * 25 * 26.5^2}{21.52} = 82.6cm \\ \text{width of the beam(b)} = 25cm \\ 30cm \end{cases}$$

Let take S=25cm

4.9.6. Steel reinforcement arrangement in the beam

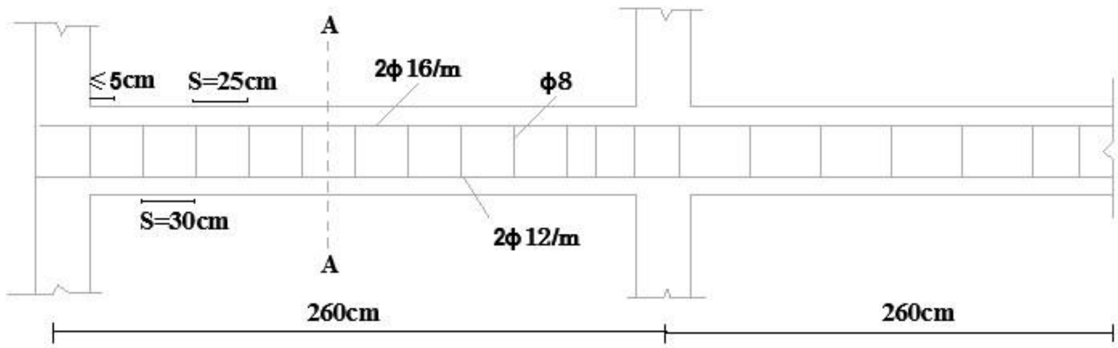


Figure4.49: Steel reinforcement in a beam

Design of the beam that connects two parallel columns hf =17cm ho = 30-3.5cm= 26.5cm

Table 4.8: force acts on the support

Support	direction	Reaction(KN)
2	Fy	74.16

The total force that acts on the support 2 where there is beam connecting these two parallel columns F=74.16KN

The length of the ramp is 1.40m and the total force obtained above is acting in the half of the ramp which means it acting on 70cm. we are going to calculate the load which will be applied in 1m.

Uniformly distributed load on 1m P = $\frac{74.16}{0.7}$ = 105.94KN/m

Self-load of the beam = 1.4*0.3*0.25*1*24= 2.52KN/m

The total load applied on the beam =105.94KN/m + 2.52KN/m = 108.46KN/m

Figure4.50: free body diagram

a. Total distributed load on the beam

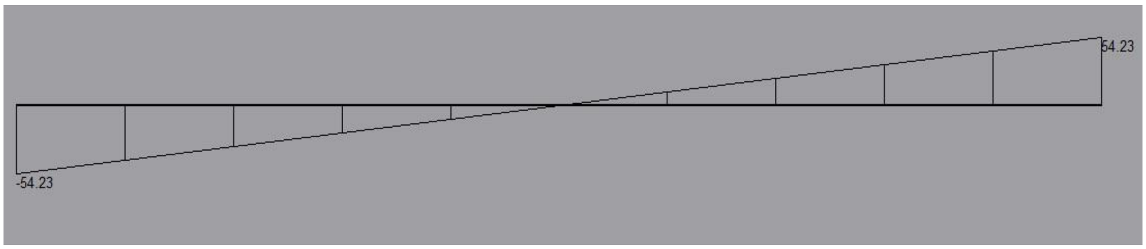


Figure4.51: Shear force diagram (KN)

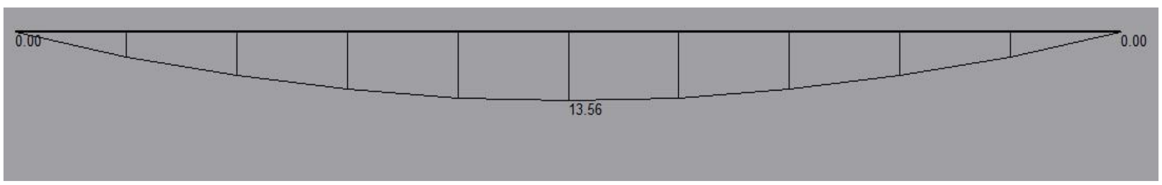


Figure4.52: Bending moment diagram (KN/m)

4.9.7. Steel reinforcement calculation in the beam of ramp

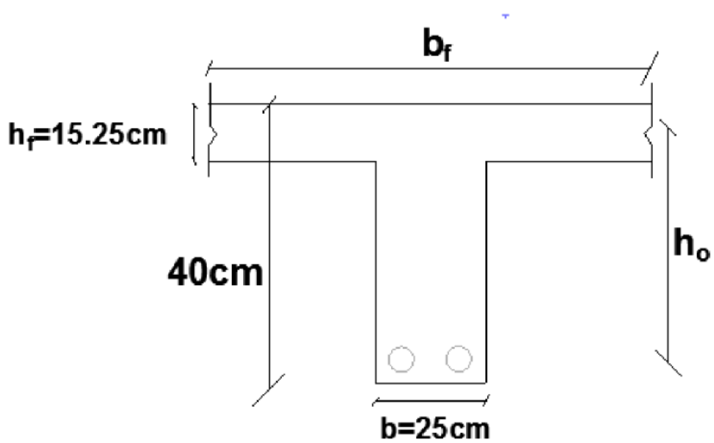


Figure4.53: section of the beam

hf =17cm ho = H-3.5cm=30-3.5=26.5cm

$$bf\begin{cases} 12hf + b = 12 * 17 + 25 = 229cm \\ \frac{l}{3} = \frac{140}{3} = 46.7cm \\ \frac{d}{2} = \frac{260}{2} = 130cm \end{cases}$$

Then bf= 46.7cm

4.1.6 .12 required steel reinforcement at the bottom of the beam

$M^{+}max$=13.56KNm

$\alpha m = \frac{M}{Rb*bf*ho^2} = \frac{13.56*100}{1.3*30*26.5^2} = 0.0495 \approx 0.058$

From the table of Coefficients related to the design of members subjected to bending moment we have:

$\xi = 0.06$ η=0.970 Rs=40KN/cm^2

X=ξ*ho=0.06*26.5=1.59cm

In case x$\leq$ hf

$As = \frac{M}{\eta*Rs*ho} = \frac{13.56*100}{0.970*30*26.5}$=1.758$cm^2$

With this cross section we are going to use the steel cross section Using 2 Φ12mm with As = 2.26cm^2

Stirrups

Vmax= 54.52KN $\varphi bf = 1.5$

Rbt=0.09KN/cm^2

b=30cm

$$qsw = \frac{Q^2}{4\varphi bf * Rbt * b * ho^2} = \frac{(52.54)^2}{4 * 1.5 * 0.09 * 30 * (26.5)^2} = 0.242cm^2/cm$$

Taken Φ8 with Asw=0.503 cm^2

Rsw=0.8*RS

$$S = \frac{Rsw * Asw * n}{qsw} = \frac{0.8 * 40 * 0.503 * 2}{0.242} = 133.0247cm$$

S must be less than the three following values:

$$\begin{cases} Smax = \frac{0.75\varphi bf * Rbt * b * ho^2}{Q} = \frac{0.75 * 1.5 * 0.09 * 30 * 26.5^2}{52.54} = 40.599cm \\ \text{width of the beam(b)} = 30cm \\ 30cm \end{cases}$$

Let take S=30cm

4.9.8. Steel arrangement in the beam

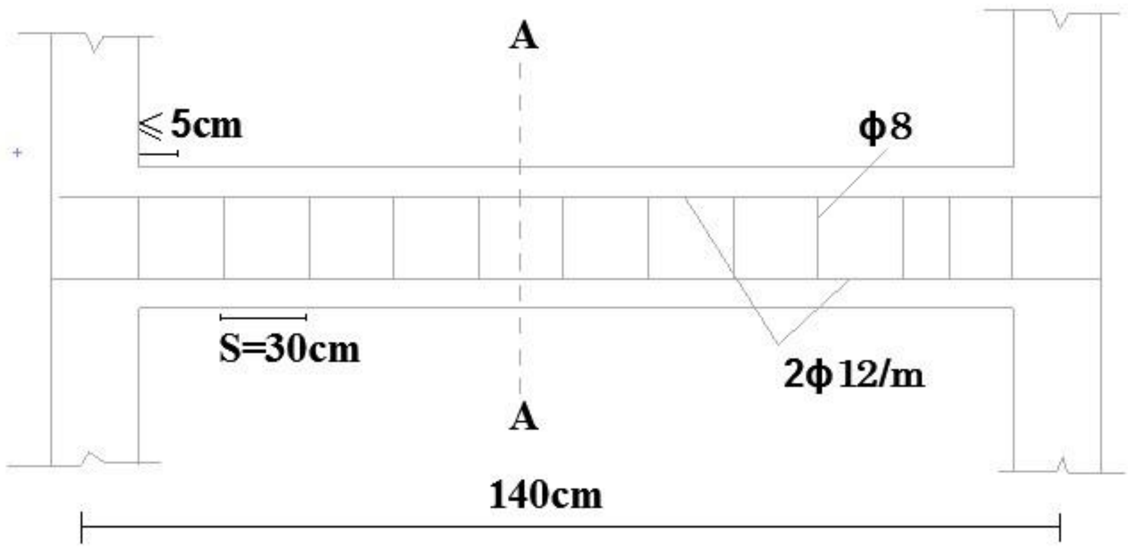


Figure4.54: Steel Reinforcement that connect two parallel beam longitudinal section

4.8.9. Steel reinforcement calculation

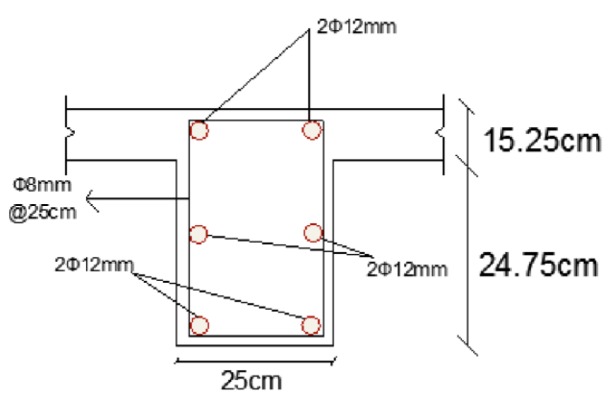


Figure4.55: Steel Reinforcement that connect two parallel beam transversal section

4.9.10. Steel arrangement

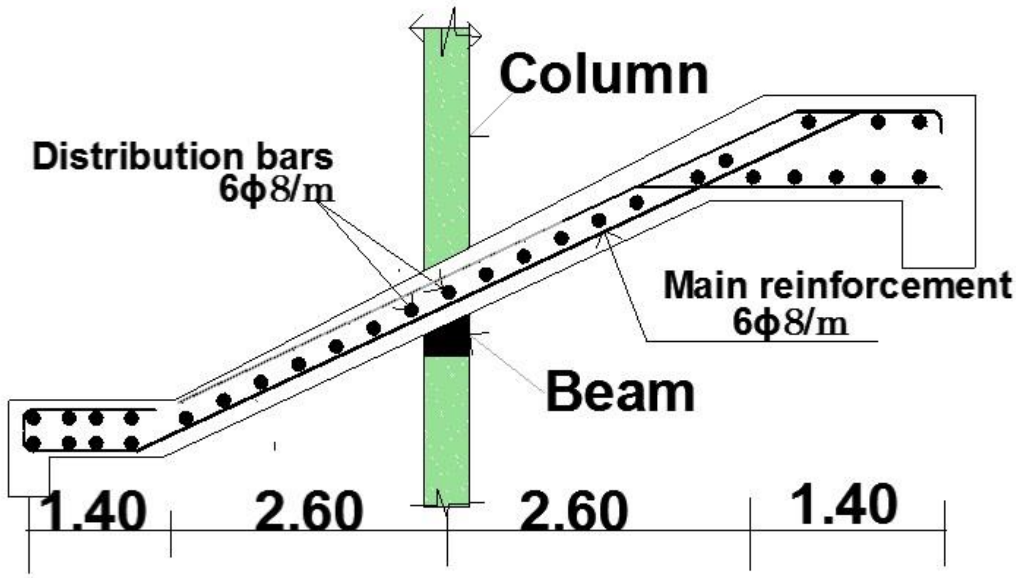


Figure4.56: Steel Reinforcement in whole ramp

Ramp need beam to support it. The designed beam had an area of 1.787 cm^2 which was not required to support ramp (Mosley et al., 2007). That why was chosen to use As = 2.26 cm^2 with correspond steel reinforcement 2 Φ12 mm this is able to support ramp.

4.10. Ground beam

4.10.1. Introduction

Ground beam is a reinforced concrete beam for supporting walls, joints, etc.at or near ground level, it self either resting directly upon the ground

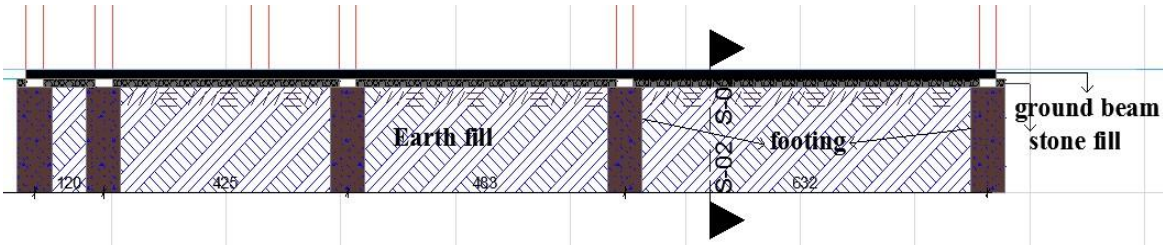


Figure4.57: Ground beam longitudinal cross section

a. Determination the depth of the Ground beam

We have a continuous ground beam, and the effective height of the ground beam lies in the range between

$$\frac{Lmax}{15} \leq h \leq \frac{Lmax}{10} = \frac{600cm}{15} \leq h \leq \frac{600cm}{10}$$

Where L max (600cm) is the largest span between two Consecutive ground beams The range is between 40 cm and 60cm.

Let's take h= 50cm and bw = 30cm like breath of beam

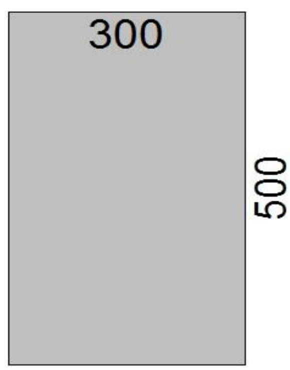


Figure4.58: cross section of ground beam

Area of section=(300*500)=150000mm^2=1500cm^2

b. Design of steel reinforcement on the ground beam

Area of steel required at the top and bottom should be equal area of section*0.5%

As at top = $\frac{150000*0.5}{100}$ =750mm^2

The area of required steel reinforcement at the top A_s max = 750mm^2 which gives the use of 4Φ16of A_s = 804mm^2

As at bottom= $\frac{1500*0.5}{100}$ =7.5cm^2

The area of required steel reinforcement at the bottom A_s max = 750mm^2 which gives the use of 4Φ16of A_s = 804mm^2

Steel arrangement ground beam

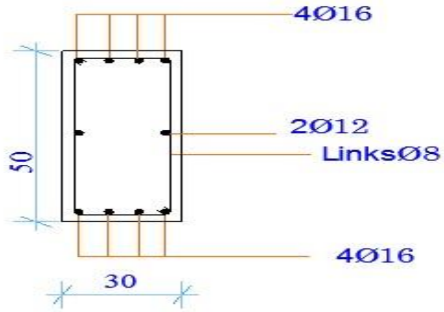


Figure4.59: transversal steel arrangement ground beam

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

During this project, Architectural and structural design of a two-storey building for Ngoma technical vocation education training school have been designed according to Euro code 2. The designed school and its facilities occupy a small surface area. This shows the realisation of the land use management objective. Within this project the structural design was done and detailing of reinforcements bars in beam, slab, column and were presented. This showed how the class theories learnt during the undergraduate studies should be applied in the field for the best structure design and analysis. Throughout the entire design process, different useful parameters were found. Among them, the safe bearing capacity of soil about 300 KN/m^2 (at 2.0m) was used. The uses of Lin pro software and Prokon to Euro code were found as fast and powerful tool to be used in this work. For architectural design, the Arch cad 15 software had been used.

The bill of quantity revealed the amount of the whole building to be of six hundred and twenty-seven million, nine hundred and twenty thousand, three hundred Rwandan francs. (**627,920,300** Rwf).

5.2. Recommendations

For this project to be feasible, the following recommendations should be considered important:

- ✓ Ngoma district and stakeholders are recommended to implement this project which can be considered as sustainable solution of the existing problem of technical school.
- ✓ Department of Civil Engineering was recommended to improve software for facilitating students during dissertation projects.

REFERENCES

Alexander, M., & Mindes, S. (2005). *Aggregates in concrete.*Washington: Taylor & Francis e-Library. pp 234-246

Al-Manaseer, A. & Elias, N. (2008). *Placement of mass concrete for cast-in-place concrete piling: The Effects of Heat of Hydration of Mass Concrete for Cast-In-Place Piles.* Washington: John Wiley & Son. pp 123

Bungey, W. H. (1990). *Reinforced concrete design* (4th ed.). Liverpool: John Wiley & Son. pp 43-45

Choo, B.S., & MacGinley, T.J. (1990). *Reinforced concrete design theory and examples*. Singapore: Taylor & Francis. pp 67

Chudley, R., & Greeno, R. (2005). *Construction technology.* New York: Pearson Education. pp 45

Duggal, S. K. (2003). *Building materials, new age international publishers.* New Delhi: Sterling publishers. pp 123-125

Hartl, M. (2009). *Technical and vocational education and training (TVET) and skills development for poverty reduction–do rural women benefit. Retrieved.* New York: Taylor & Francis. pp 234

Rwanda housing. (2009). *Rwanda building Regulation Code.* pp 1-4

MacGinley, T. J.(2003). *Reinforced concrete design theory and examples.* New York: Taylor & Francis. pp 45-46

Mineduc. (2008). *Technical and vocational education and training (tvet) policy in Rwanda.* Kigali: Rwanda education board. pp 67-69

Mosley,W.H., Hulse, R., & Bungey, J. H. (2007). *Reinforced concrete design to euro code 2* (6th ed.). New York: Pargrave Macmillan. pp 89-90

Nawy, E. G. (2008). *Concrete construction engineering handbook* (2nd ed.). New York: Taylor & Francis pp 32-35

Nelson, J. K. (2005). *Design of reinforced concrete.* New Jersey: Pargrave Macmillan. pp. 67-68

Nyerere, J. (2009). *Technical and vocational education and training (TVET) sector mapping in Kenya.* Nairobi: Sector mapping in Kenya. pp 67

Paik, J. K., & Thayamballi, A. K. (2003). *Ultimate limit state design of steel-plated structures.* Washington: John Wiley & Sons. pp 45

Peter, D., & John, I. (2010). *Construction materials their nature and behavior* (4th ed.). Washington: Taylor & Francis. pp 78-79

Sidhu, K. S. (1996). *School organisation & administration.* New Delhi: Sterling Publishers Pvt. Ltd .pp 57-58

Stock-ward, R., Jeff, E., Brooks, H., & Susan, M. (1999). *Designing and facilitating experiential learning.* New York: Taylor & Francis. pp 34

Victoria, A. N. (2013). Characterization and performance evaluation of water works sludge as bricks material. *International Journal of Engineering, 3* (2) pp 1-4.

APPENDICES

Appendix A: Costing and Estimating

GROUND LEVEL					
	DESCRIPTION	**UNIT**	**QUANTITY**	**RATE/RWF**	**TOTAL**
I	**SETTING OUT**				
I.1	**Site clearance**				
1.1.		m³	4000	3,640	14,560,000
	S/total				**14,560,000**
I	**FOUNDATION EXCAVATION**				
1	Trench excavation	m³	695	2,500	1,737,500
	excavation of footing	m³	95	2,500	225,000
	bases concrete	m^2	1344	7,000	8,393,000
	damp proof	Ml	196	5,000	980,000
2	Back filling	m³	990	2,500	2,475,000
	S/total				**13,810,500**
III	**FOUNDATION WALLING**				
1	Reinforced concrete to column and bases.	m³	23	400,000	9,076,000
2	Ground beam	m³	37	400,000	14,844,000
3	Damp proof course	m²	600	200,000	120,000,000
	S/total				**143,920,000**

IV	**SUPER STRUCTURE**				
1	20cm thick masonry in baked bricks	m^3	130	70,000	9,134,300
	S/total				**9,134,300**
V	**REINFORCED CONCRETE**				
1	Column	m^3	23	400,000	9,200,000
2	Beam	m^3	37	400,000	14,800,000
3	Reinforced concrete staircases	m^3	4	400,000	1,736,000
4	Reinforced concrete ramp	m^3	4	400,000	1,712,000
5	Reinforced concrete slab	m^3	118	400,000	47,240,000
	S/total				**74,688,000**
VI	**PLASTERING**				
1	Hardcore filling to under walkways and ground floor slab.	m^2	**800**	4000	3,200,000
2	Sand and cement mortar rendering to walkways and ground floor slab.	m^2	**800**	4000	3,200,000
3	Sand and cement mortar rendering to slab soffit.(ceiling)	m^2	**800**	4000	3,200,000
	S/total III				**9,600,000**
VII	**DOORS AND CURTAIN WALL**				
4	Flash single door 90/210	pcs	31	90,000	2,790,000
5	Windows	pcs	33	70,000	2,310,000
	S/total				**5,100,000**

X	**PAINTING**				
1	Emulsion painting to interior and exterior walls.	m^2	1,798.00	4,000	7,192,000
2	Emulsion painting to ceiling	m^2	**1500**	4,000	6,000,000
3	High gloss painting to all windows	Ltr	**33**	3,000	99,000
4	Varnish painting to all wooden doors	pcs	31	6,000	186,000
	S/Total				**13,477,000**
	GROUND FLOOR TOTAL				
	FIRST STORY				
	DESCRIPTION	**UNIT**	**QUANTITY**	**RATE**	**SUM**
IV	**SUPER STRUCTURE**				
1	20cm thick masonry Baked bricks	m^3	130	70,000	9,100,000
	S/total				**9,100,000**
V	**REINFORCED CONCRETE**				
1	Reinforced concrete columns	m^3	21	400,000	8,588,000
2	Reinforced beam	m^3	36	400,000	14,460,000
3	Reinforced concrete staircases	m^3	4	400,000	1,600,000
4	Reinforced ramp	m^3	4	400,000	1,600,000
5	Reinforced concrete slab	m^3	118	400,000	47,200,000
	S/total				**73,448,000**
VI	**PLASTERING**				

1	Hardcore filling to under walkways and ground floor slab.	m²	**800**	4000	3,200,000
2	Sand and cement mortar rendering to	m²	**800**	4000	3,200,000
	walkways and ground floor slab.				
3	Sand and cement mortar rendering to slab soffit.(ceiling)	m²	**800**	4000	3,200,000
	S/total III				**9,600,000**
VII	**DOORS AND CURTAIN WALL**				
1	Flash single door 90/210	pcs	31	90,000	2,790,000
4	Windows	pcs	33	70,000	2,310,000
	S/total				**5,100,000**
X	**PAINTING**				
1	Emulsion painting to interior and exterior walls.	m^2	1,798.00	4,000	7,192,000
2	Emulsion painting to ceiling	m^2	**1500**	4,000	6,000,000
3	High gloss painting to all windows	Ltr	**33**	3,000	99,000
4	Varnish painting to all wooden doors	pcs	31	6,000	186,000
	S/Total				**13,477,000**
	FIRST FLOOR TOTAL				**#REF!**
	SECOND STORY				
	DESCRIPTION	**UNIT**	**NUMBER**	**RATE**	**SUM**
IV	**SUPER STRUCTURE**				

1	20cm thick masonry blocks	m^3	130	70,000	9,100,000
	S/total				**9,100,000**
V	**REINFORCED CONCRETE**				

1	Reinforced concrete columns	m^3	30	400,000	12,000,000
2	Reinforced concrete beams	m^3	36	400,000	14,460,000
3	Reinforced concrete stairs case	m^3	8	400,000	3,200,000
5	Reinforced concrete slab	m^3	118	400,000	47,200,000
	S/total				**81,260,000**
VI	**PLASTERING**				
1	Hardcore filling to under walkways and ground floor slab.	m^2	**800**	4000	3,200,000
2	Sand and cement mortar rendering to walkways and ground floor slab.	m^2	**800**	4000	3,200,000
3	Sand and cement mortar rendering to slab soffit.(ceiling)	m^2	**800**	4000	3,200,000
	S/total III				**9,600,000**
VII	**DOORS AND CURTAIN WALL**				
1	Flash single door 90/210	pcs	31	90,000	2,790,000
4	Windows	pcs	33	70,000	2,310,000
	S/total				**5,100,000**
	THIRD STORY				
	DESCRIPTION	**UNIT**	**QNTY**	**RATE**	**SUM**

XI	**SUPER STRUCTURE**				
1	20cm thick masonry wall	m^3	130.00	70,000	9,100,000
2	**S/total**				**9,100,000**
XII	**REINFORCED CONCRETE**				
1	Reinforced concrete Columns	m^3	42.67	400,000	17,068,000
2	Reinforced concrete beams	m^3	71.00	400,000	28,400,000
3	Reinforced concrete stairs	m^3	4.00	400,000	1,600,000
4	reinforced concrete ramp	m^3	4.00	400,000	1,600,000
5	reinforced concrete slab	m^3	126.00	400,000	50,400,000
6	**S/Total**				**99,068,000**
XIII	**PLASTERING**				
1	Hardcore filling to under walkways and ground floor slab.	m^2	800	4000	3,200,000
2	Sand and cement mortar rendering to walkways and ground floor slab.	m^2	800	4000	3,200,000
3	Sand and cement mortar rendering to slab soffit.(ceiling)	m^2	800	4000	3,200,000
	S/total III				**9,600,000**
XIV	**DOORS AND CURTAIN WALL**				
1	Flash single door 90/210	pcs	31	90000	2790000
4	Windows	pcs	33	70000	2310000

	S/total				**5,100,000**
XV II	**<u>PAINTING</u>**				
1	Emulsion painting to interior and exterior walls.	m^2	1,798.00	4,000	7,192,000
2	Emulsion painting to ceiling	m^2	**1500**	4,000	6,000,000
3	High gloss painting to all windows	Ltr	**33**	3,000	99,000
4	Varnish painting to all wooden doors	pcs	52	6,000	312,000
	S/total				**13,603,000**
		FINISHING SLAB			
XV III	**FINISHING TOP SLAB**				
1	**asphalt filling**	m^2	**1300**	**35000**	45,500,000
2	**gravel filling**	m^3	**70**	**60000**	4,200,000
	FINISHING SLAB TOTAL				**95,000**
	GRAND TOTAL				
	TOTAL COST: 627,920,300FRW				

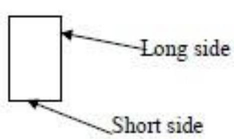
Appendix B: Coefficients related to the design of slabs

Panel	coefficients		$\lambda = \frac{L_y}{L_x}$							
			1.0	1.1	1.2	1.3	1.4	1.5	1.7	2.0
	Short side	M^-	-	-	-	-	-	-	-	-
	α_{sx}	M^+	0.037	0.044	0.051	0.059	0.066	0.072	0.083	0.095
	Long side	M^-	-	-	-	-	-	-	-	-
	α_{sy}	M^+	0.037	0.036	0.036	0.035	0.034	0.032	0.029	0.024
	Short side	M^-	0.089	0.098	0.105	0.110	0.113	0.116	0.119	0.122
	α_{sx}	M^+	0.033	0.038	0.043	0.047	0.050	0.053	0.057	0.061
	Long side	M^-	-	-	-	-	-	-	-	-
	α_{sy}	M^+	0.027	0.025	0.024	0.022	0.020	0.018	0.015	0.011
	Short side	M^-	-	-	-	-	-	-	-	-
	α_{sx}	M^+	0.027	0.034	0.042	0.049	0.055	0.062	0.074	0.089
	Long side	M^-	0.089	0.096	0.098	0.099	0.098	0.094	0.084	0.068
	α_{sy}	M^+	0.033	0.035	0.035	0.035	0.035	0.034	0.032	0.028
	Short side	M^-	0.069	0.073	0.076	0.078	0.079	0.080	0.081	0.082
	α_{sx}	M^+	0.027	0.027	0.031	0.033	0.034	0.035	0.036	0.038
	Long side	M^-	-	-	-	-	-	-	-	-
	α_{sy}	M^+	0.018	0.016	0.014	0.013	0.011	0.010	0.009	0.006
	Short side	M^-	-	-	-	-	-	-	-	-
	α_{sx}	M^+	0.018	0.024	0.031	0.037	0.043	0.051	0.064	0.080
	Long side	M^-	0.069	0.076	0.084	0.090	0.093	0.094	0.091	0.079
	α_{sy}	M^+	0.027	0.029	0.030	0.031	0.032	0.032	0.032	0.029
	Short side	M^-	0.063	0.074	0.084	0.093	0.099	0.104	0.112	0.118
	α_{sx}	M^+	0.027	0.032	0.037	0.041	0.045	0.049	0.054	0.059
	Long side	M^-	0.063	0.061	0.059	0.055	0.051	0.046	0.039	0.029
	α_{sy}	M^+	0.027	0.027	0.026	0.025	0.023	0.022	0.019	0.015
	Short side	M^-	0.056	0.062	0.067	0.071	0.074	0.076	0.079	0.081
	α_{sx}	M^+	0.023	0.026	0.028	0.031	0.032	0.034	0.036	0.038
	Long side	M^-	0.042	0.039	0.035	0.032	0.028	0.025	0.020	0.015
	α_{sy}	M^+	0.020	0.019	0.017	0.016	0.014	0.013	0.011	0.008
	Short side	M^-	0.042	0.053	0.064	0.073	0.081	0.089	0.101	0.111
	α_{sx}	M^+	0.020	0.025	0.030	0.035	0.038	0.043	0.049	0.056
	Long side	M^-	0.056	0.058	0.059	0.058	0.057	0.054	0.047	0.037
	α_{sy}	M^+	0.023	0.023	0.023	0.023	0.023	0.022	0.019	0.016
	Short side	M^-	0.042	0.050	0.056	0.062	0.066	0.070	0.074	0.078
	α_{sx}	M^+	0.018	0.021	0.024	0.027	0.029	0.031	0.034	0.037
	Long side	M^-	0.042	0.041	0.039	0.037	0.034	0.031	0.026	0.020
	α_{sy}	M^+	0.018	0.018	0.017	0.016	0.015	0.013	0.012	0.009

$$M_{sx} = \alpha_{sx} . n . lx^2$$
$$M_{sy} = \alpha_{sy} . n . lx^2$$

Fixed side

Pined side



Appendix A: sectional area of group

Sectional areas of groups of bars (mm^2)

Bar size (mm)	Number of bars													Weight (Kg/m)
	1	2	3	4	5	6	7	8	9	10	11	12	14	
6	28.3	56.5	85	113	141	170	198	226	254	283	311	339	396	0.222
8	50.3	101	151	201	251	302	352	402	452	503	553	603	704	0.395
10	79	157	236	314	393	471	550	628	707	785	864	942	1100	0.617
12	113	226	339	452	565	679	792	905	1018	1131	1244	1357	1583	0.888
14	154	308	462	616	770	924	1078	1232	1385	1539	1693	1847	2155	1.208
16	201	402	603	804	1005	1206	1407	1608	1810	2011	2212	2413	2815	1.578
18	254	509	763	1018	1272	1527	1781	2036	2290	2545	2799	3054	3563	1.998
20	314	628	942	1257	1571	1885	2199	2513	2827	3142	3456	3770	4398	2.466
22	380	760	1140	1521	1901	2281	2661	3041	3421	3801	4181	4562	5322	2.984
24	452	905	1357	1810	2262	2714	3167	3619	4072	4524	4976	5429	6333	3.551
25	491	982	1473	1963	2454	2945	3436	3927	4418	4909	5400	5890	6872	3.853
26	531	1062	1593	2124	2655	3186	3717	4247	4778	5309	5840	6371	7433	4.168
28	616	1232	1847	2463	3079	3695	4310	4926	5542	6158	6773	7389	8621	4.834
30	707	1414	2121	2827	3534	4241	4948	5655	6362	7069	7775	8482	9896	5.549
32	804	1608	2413	3217	4021	4825	5630	6434	7238	8042	8847	9651	11259	6.313
34	908	1816	2724	3632	4540	5448	6355	7263	8171	9079	9987	10895	12711	7.127
36	1018	2036	3054	4072	5089	6107	7125	8143	9161	10179	11197	12215	14250	7.990
38	1134	2268	3402	4536	5671	6805	7939	9073	10207	11341	12475	13609	15878	8.903
40	1257	2513	3770	5027	6283	7540	8796	10053	11310	12566	13823	15080	17593	9.865

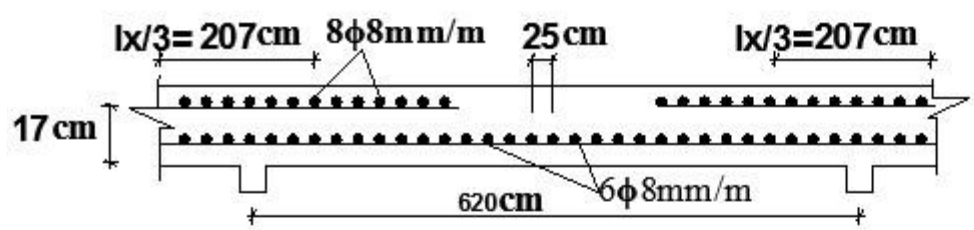
Appendix B: Table of Coefficients related to the design of members subjected to bending moment

ξ	$\alpha_m = \frac{M}{Rb * ho^2 * b}$	η		ξ	$\alpha_m = \frac{M}{Rb * ho^2 * b}$	η
0.01	0.010	0.995		0.37	0.302	0.815
0.02	0.020	0.990		0.38	0.308	0.810
0.03	0.030	0.985		0.39	0.314	0.805
0.04	0.039	0.980		0.40	0.320	0.800
0.05	0.049	0.975		0.41	0.326	0.795
0.06	0.058	0.970		0.42	0.332	0.790
0.07	0.068	0.965		0.43	0.338	0.785
0.08	0.077	0.960		0.44	0.343	0.780
0.09	0.086	0.955		0.45	0.349	0.775
0.10	0.095	0.950		0.46	0.354	0.770
0.11	0.104	0.945		0.47	0.360	0.765
0.12	0.113	0.940		0.48	0.365	0.760
0.13	0.122	0.935		0.49	0.370	0.755
0.14	0.130	0.930		0.50	0.375	0.750
0.15	0.139	0.925		0.51	0.380	0.745
0.16	0.147	0.920		0.52	0.385	0.740
0.17	0.156	0.915		0.53	0.390	0.735
0.18	0.164	0.910		0.54	0.394	0.730
0.19	0.172	0.905		0.55	0.399	0.725
0.20	0.180	0.900		0.56	0.403	0.720
0.21	0.188	0.895		0.57	0.408	0.715
0.22	0.196	0.890		0.58	0.412	0.710
0.23	0.204	0.885		0.59	0.416	0.705
0.24	0.211	0.880		0.60	0.420	0.700
0.25	0.219	0.875		0.61	0.424	0.695
0.26	0.226	0.870		0.62	0.428	0.690
0.27	0.234	0.865		0.63	0.432	0.685
0.28	0.241	0.860		0.64	0.435	0.680
0.29	0.248	0.855		0.65	0.439	0.675
0.30	0.255	0.850		0.66	0.442	0.670
0.31	0.262	0.845		0.67	0.446	0.665
0.32	0.269	0.840		0.68	0.449	0.660
0.33	0.276	0.835		0.69	0.452	0.655
0.34	0.282	0.830		0.70	0.455	0.650
0.35	0.289	0.825				
0.36	0.295	0.820				

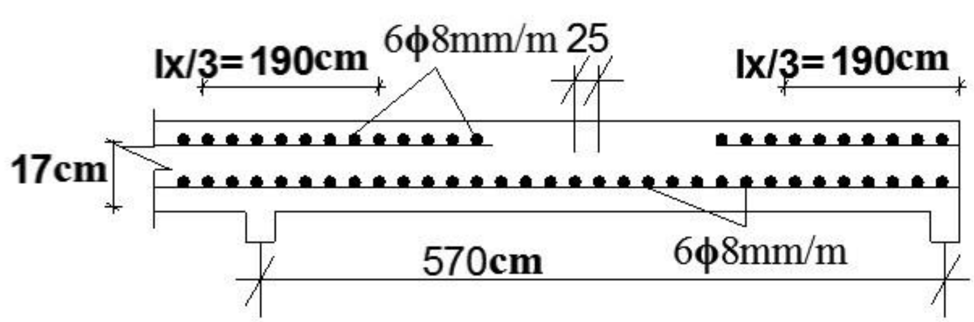
Appendix C: table showing Slab results

Slab panel No	Hf cm	Ly m	Lx m	M- kNm	M+ kNm	Steel reinforcement	
57	17	6.2	5.9	20.41	8.57	At the top	At the bottom
						8ϕ8mm/m @250	6ϕ8mm/m@250
82	17	5.7	3.7	11.97	5.17	6ϕ8mm/m @250	6ϕ8mm/m@250

Appendix D: Slab steel arrangement panel



Appendix E: Slab steel arrangement panel 82

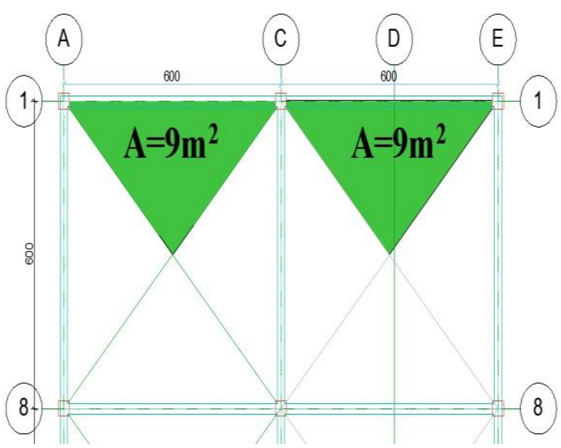


Slab steel arrangement panel 57

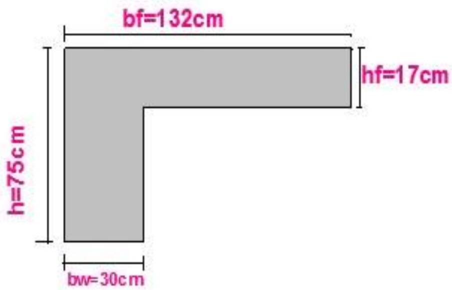
Appendix F: Beams results

beam No	description	Hf cm	H cm	Bw cm	Bf m	M- KN/m	Asv KN	Steel reinforcement		
1-1	transversal	17	75	30	1.32	191	155.3	At the top	At the bottom	Stirrups
								4Φ16@200	4Φ16@200	Φ8
								2Φ12@200	2Φ12@200	
A-A	longitudinal	17	75	30	1.32	142.2	139.6	4Φ16@200	4Φ16@200	Φ8
								2Φ12@200	2Φ12@200	

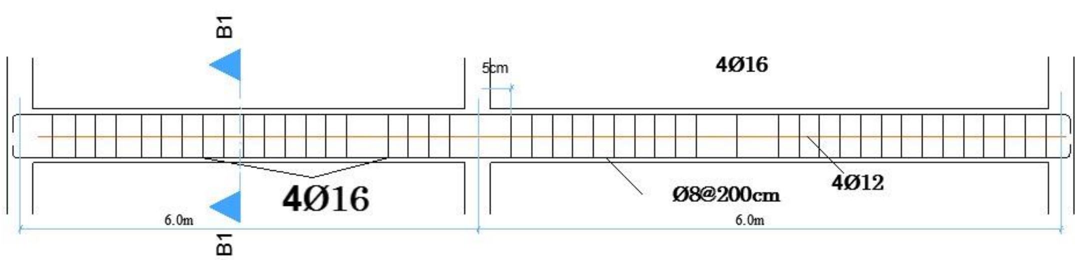
Appendix G: Influence area of transversal edge-beam 1-1



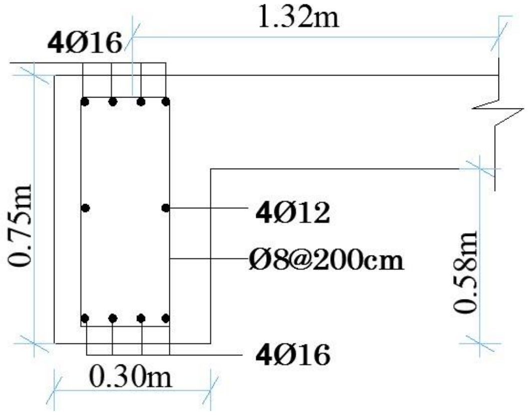
Appendix H: Cross-section of transversal edge-beam 1-1



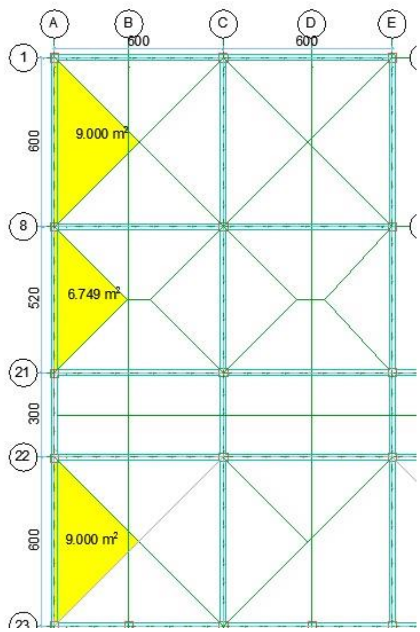
Appendix I: Steel arrangement in Beams



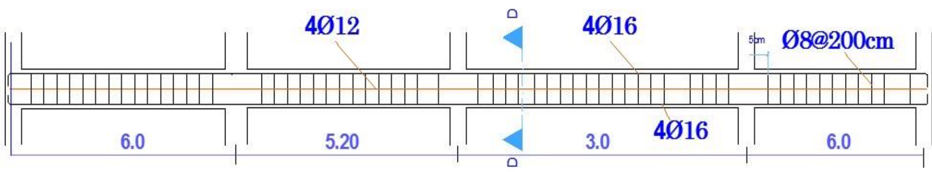
Appendix J: Longitudinal section steel reinforcement edge-beam 1-1



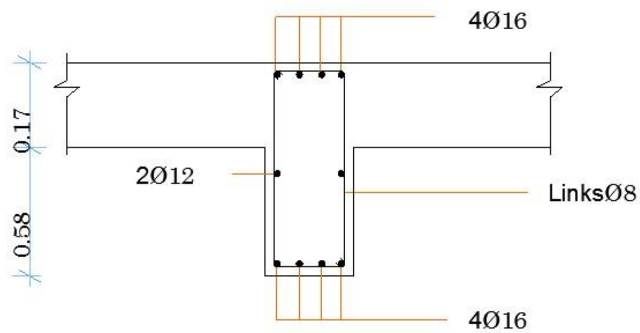
Appendix K: Transversal steel reinforcement edge beam 1-1



Appendix L: Influence area of longitudinal edge-beam A-A



Appendix M: Transversal steel reinforcement beam A-A



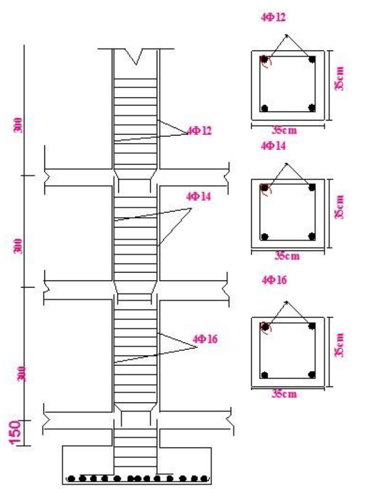
Appendix N: Longitudinal Steel reinforcement in beam A-A

Appendix O: Column results

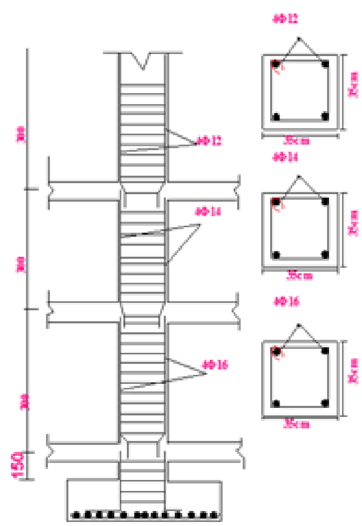
Column No	Description	H M	Area of column m^2	Loads KN	Area of steel cm^2	Steel reinforcement
33	Ground floor		9	690.142	-20.85	4Φ16
	First floor	3		422.532	4.9	4Φ14
	Second floor			161.132	4.9	4Φ12
35	Ground floor		18	1183.155	-7.3	4Φ16
	First floor	3		734.481	4.9	4Φ14
	Second floor			291.981	4.9	4Φ12

30	Ground floor	3	13.5	934.414	-14.14	4Φ12
	First floor			578.349	-23.92	4Φ12
	Second floor			226.458	-33.58	4Φ12

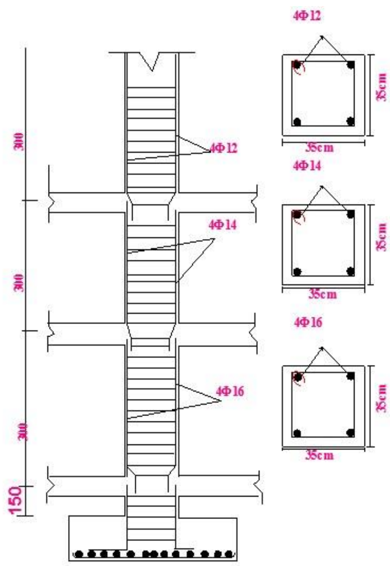
Appendix P: Steel arrangement in column C33



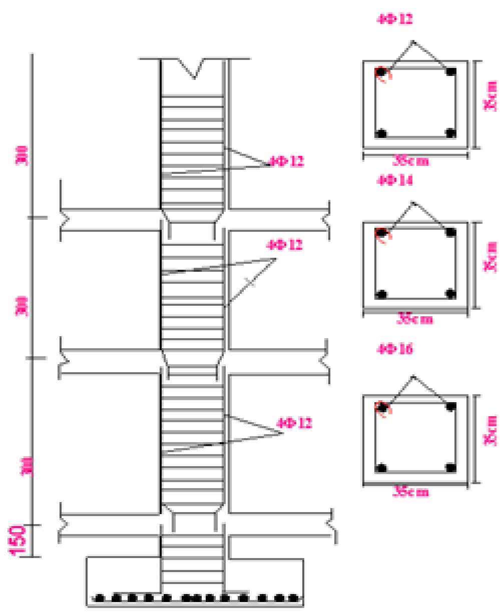
Appendix R: Steel reinforcement column C30



Appendix Q: Steel reinforcement column C35



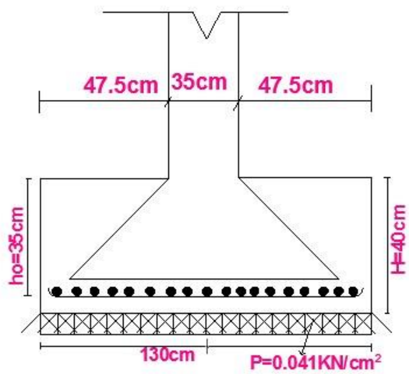
Appendix R: Steel reinforcement column C30



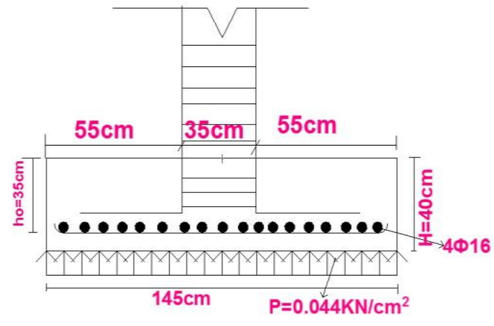
Appendix R: Footing results

Footing No	Af cm	Bf cm	H cm	Column section cm	Ho cm	Mmax KN/m	$P=\frac{N}{Af}$ KN/m^2	Area of steel cm^2	Steel reinforcement
33	130	130	40	35	35	60.129	41	12.57	4Φ20
35	170	170	40	35	35	158.785	41	15.71	5Φ20
30	145	145	40	35	35	96.497	44	8.04	4Φ16

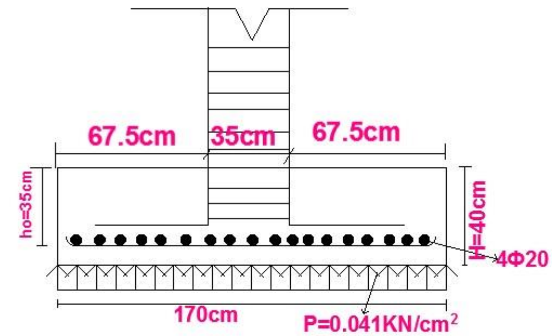
Appendix S: footing

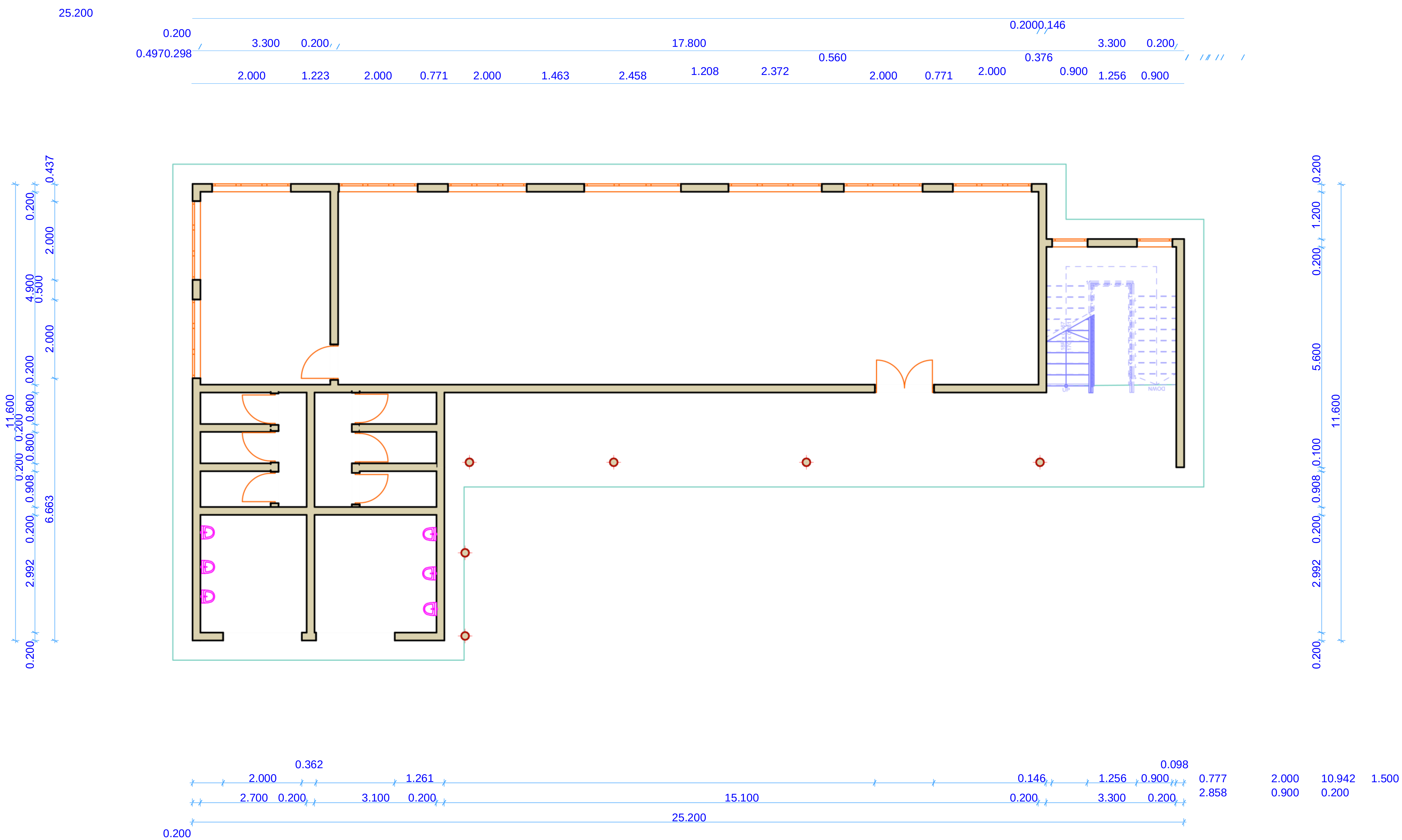


Appendix T: Steel reinforcement in Footing C30



Appendix U: Footing 33


67.5cm
35cm
67.5cm
ho=35cm
H=40cm
4Φ20
170cm
P=0.041KN/cm2


25.200
0.200
0.4970.298
3.300
0.200
17.800
0.2000.146
3.300
0.200
0.560
0.376
2.000
1.223
2.000
0.771
2.000
1.463
2.458
1.208
2.372
2.000
0.771
2.000
0.900
1.256
0.900
0.437
0.200
2.000
4.900
0.500
2.000
0.200
11.600
0.200
0.800
0.200
0.800
0.908
6.663
0.200
2.992
0.200
0.200
1.200
0.200
5.600
11.600
0.100
0.908
0.200
2.992
0.200
0.362
2.000
1.261
0.098
0.146
1.256
0.900
0.777
2.858
2.000
0.900
10.942
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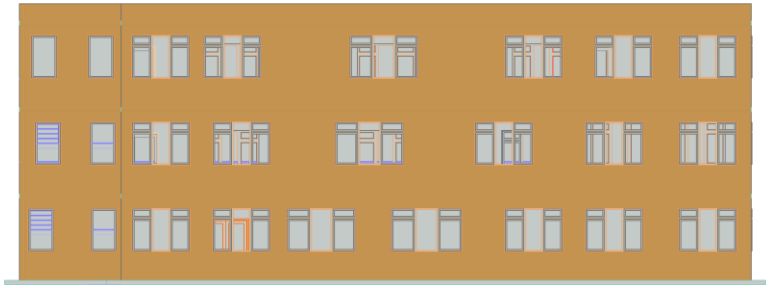
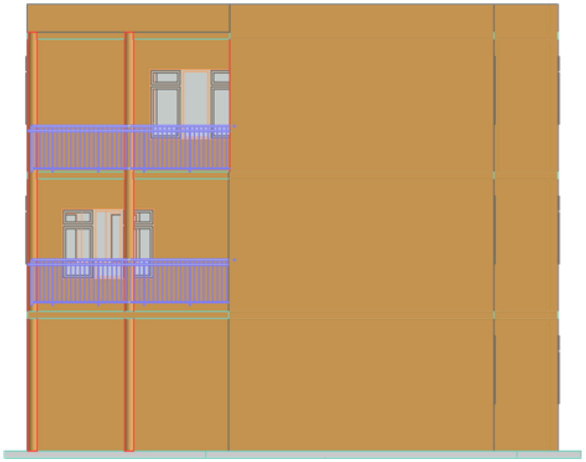
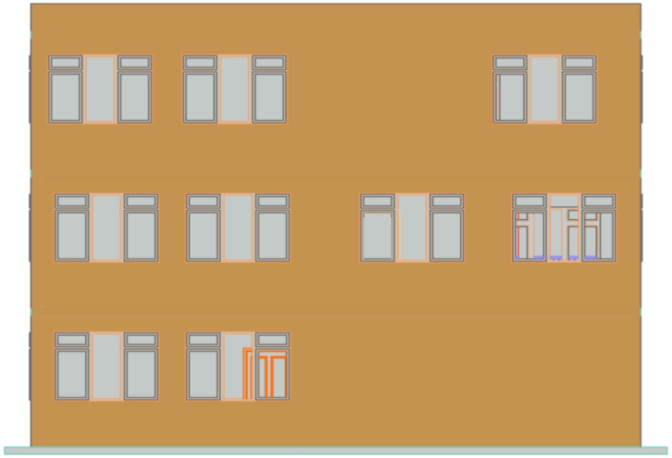
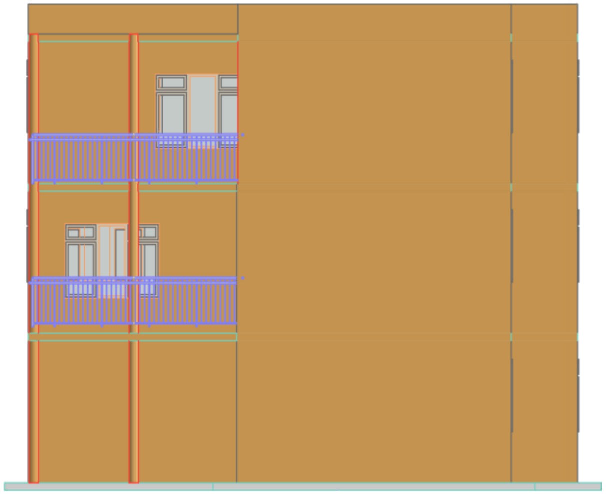
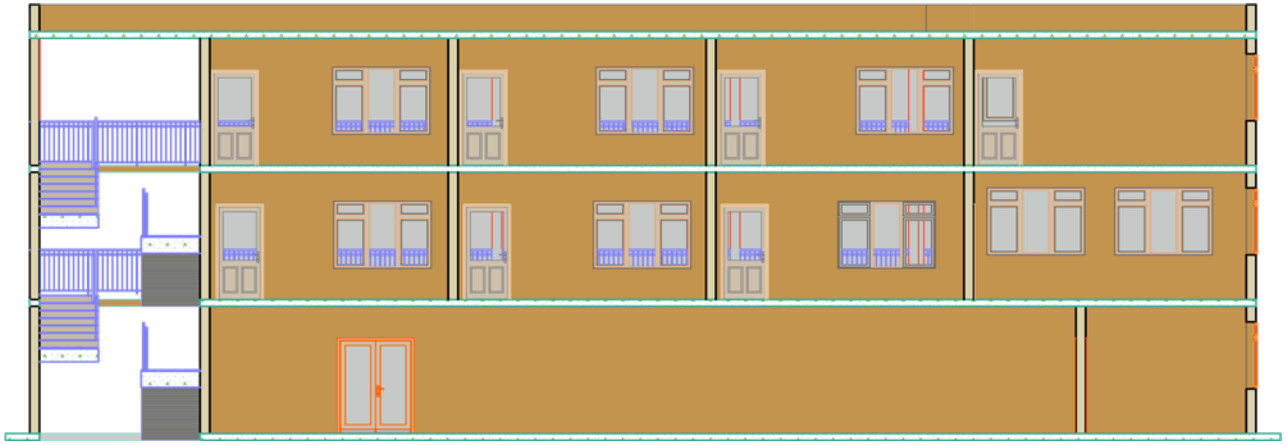
0.200
15.100
0.200
3.300
0.200
25.200
0.200





SECTIONS