Palestine Polytechnic University

College Of Technology And Engineering

Department Of Architectural And Civil Engineering

Project Title:

Architectural design of Palestine polytechnic hospital

Teamwork:

Mojahid Shalalda Qusai Taradeh
Salim Abu -Raiya Khaled Zabayna
Salama Arar

Supervisor:
Eng. Fahed Salahat

Hebron-Palestine

2017-2016م

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Supervisor Signature:
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Testing Committee Signature
....

Department Head Signature

....

الإهداء

إلى .... المعلم الأول.... رسولنا الكريم
سيد البشرية محمد بن عبدالله
إلى ....من هم أحق منا بالحياة
إلى....... الشهداء .
إلى .... الأسود الرابضة خلف القضبان
.... إلى من كسروا قيد السجان
....الأسرى .
إلى....أنشودة الصغر وقدوة الكبر
إلى....... أبي العزيز .
إلى....نبع العطاء وسيل الحنان
إلى....... أمي العزيزة .
إلى ....عنوان سعادتي إلى....... إخوتي
الأعزاء .
إلى.... هبة السماء .... أصدقائي
الأوفياء .
إلى .... الشموع التي احترقت لتنير الدرب
إلى...... **أساتذتي.**
إلى....من عرفتهم في هذا الصرح العلمي
...... زملائي وزميلاتي .
إلى....منهل العلم إلى.......جامعتي .
إلى....من أحبني وأحببته.

نقدم هذا البحث .

فريق **العمل**

الشكر والتقدير

إن الشكر والمنة لا تليق إلا لواهب العقول و منير الدروب لله عز وجل . **كما ونتقدم** بجزيل الشكر والامتنان إلى بانية الجيل الواعد **...جامعة** بوليتكنيك فلسطين .

إلى كلية الهندسة والتكنولوجيا.

إلى دائرة الهندسة المدنية والمعمارية ....بطاقمها التدريسي و الإداري.

إلى المشرف على هذا البحث المهندسة إيناس الشويكي.

والشكر واصل لكل من ساهم في انجاز هذا, البحث المتواضع .

فريق العمل

Project Abstract

Structural Design for Palestine Polytechnic University Hospital

WORKING TEAM:

MOJAHED SHALALDAH **QUSAI TARADAH**
KHALEED ZABAINAH **SALAMAH ARAR**
SALIM ABU-RAIYA

Palestine Polytechnic University -2017

SUPERVISOR:
ENG. FAHED SALAHAT

Structural design is the most important design of the building after the necessary of architectural design, the distribution of columns, loads, offer durability, the best prices and the highest degree of safety are the responsibility of the structural designer. In this project we will do the structural design of the Palestine Polytechnic University Hospital. The building consists of ten floors and the total area of 21342 m^2.

The architectural of the project is based on multiple steric blocks distributed consistently it terms of aesthetic and functional purposes, as well as it is designed in the form of distributing blocks that provide comfort, ease and speed of access for users.

It is important mentioning that we will use the Jordanian code to determine the live loads, and to determine the loads of earthquakes, for the analysis of the structural and design sections we will use the US Code (ACI_318_14), it must be noted that he will be relying on some computer programs such as: Autocad2007, Safe , Office2007, Atir, Etabs and others.

Expected after the completion of the project to be able to provide structural design of all structural elements with permission of Allah Almighty.

List of Abbreviations

- Ac = area of concrete section resisting shear transfer.
- As = area of non-prestressed tension reinforcement.
- A_S = area of non-prestressed compression reinforcement.

- Ag = gross area of section.
- Av = area of shear reinforcement within a distance (S).
- At = area of one leg of a closed stirrup resisting tension within a (S).
- b = width of compression face of member.
- bw = web width, or diameter of circular section.
- C_c = compression resultant of concrete section.
- C_s = compression resultant of compression steel.
- DL = dead loads.
- d = distance from extreme compression fiber to centroid of tension reinforcement.
- Ec = modulus of elasticity of concrete.
- fc' = compression strength of concrete .
- fy = specified yield strength of non-prestressed reinforcement.
- h = overall thickness of member.
- Ln = length of clear span in long direction of two- way construction, measured face-to-face of supports in slabs without beams and face to face of beam or other supports in other cases.
- LL = live loads.
- Lw = length of wall.
- M = bending moment.
- Mu = factored moment at section.
- Mn = nominal moment.
- Pn = nominal axial load.
- Pu = factored axial load
- S = Spacing of shear or in direction parallel to longitudinal reinforcement.
- Vc = nominal shear strength provided by concrete.
- Vn = nominal shear stress.
- Vs = nominal shear strength provided by shear reinforcement.
- Vu = factored shear force at section.
- Wc = weight of concrete. (Kg/m^3).
- W = width of beam or rib.

- Wu = factored load per unit area.
- Φ = strength reduction factor.
- ε_c = compression strain of concrete = 0.003mm/mm.
- ε_s = strain of tension steel.
- $\acute{\varepsilon}_s$ = strain of compression steel.
- ρ = ratio of steel area .

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CHAPTER

1

INTRODUCTION

1.1 INTRODUCTION.

1.2 RESEARCH PROBLEM.

1.3 THE OBJECTIVE OF THE PROJECT.

1.4 PROJECT STEPS.

1.5 REASONS TO CHOOSE PROJECT.

1.6 THE SCOPE OF THE PROJECT.

1.7 SCHEDULE.

1.1 Introduction:

Human nature needs to have places of worship in place of residence, and these places must have all the means to ensure comfort and safety. General design process requires the introduction of all aspects of the building to be created both in the architectural appearance of the building and how to distribute the spaces and areas within various service sections linked to each other, or structural terms dealing with structural system capable of carrying the loads affecting the building taking into account the minimum possible economical system construction as is compatible with the architectural design choice.

The objective of this project is to carry out the structural design of the building, which is a structural design for the Palestinian Polytechnic University Hospital which will be built in the future city of Dora.

1.2 Research Problem:

The problem centralized in the project analysis, architectural design and structural system of all sections of the buildings. Forces and loads of structural components, such as beams and columns, ribs, etc. will be analyzed in the project. Then the dimensions and the arming of various structural elements will be determined.

1.3 The Objective of the Project:

The objectives of the project are divided into two parts:

1. Architectural Goals:

In this project architectural design is not the main goal as civil and building engineers, however in this building it was necessary to achieve beauty, utility requirements, cost and durability, which are the basic architectural design requirements.

2. Structural Goals:

Structural design of the units will be done in this project with preparing all structural drawings for beams, slabs, columns, footings and shear walls to be ready for fulfillment on the location of the project.

1.4 Project Steps:

1. Architectural design (construction drawings, elevations, sections, public location).
2. Study of the units structurally to identify structural elements, loads on the buildings, and the selection of appropriate structural system.
3. Distributing of columns to the chosen structural system.
4. Structural analysis of all structural elements of the units.
5. Structural design of all structural elements.
6. Preparation of construction drawings of the building to remove the executable image.
7. Writing project in accordance with the requirements of the construction engineering.

1.5 Reasons to Choose the Project:

The reason of selecting the project back to several things, including the conquest of skill in design for structural elements in buildings, in addition to increasing knowledge of machine construction systems in our country and other countries, as well as the conquest of scientific knowledge and the process followed in the design and implementation of construction projects and the structural engineer after graduation in the work market in the future.

This research was done to submit it to the department of civil engineering and architecture at the College of engineering and technology at Palestine Polytechnic University to meet graduation requirements and a Bachelor's degree in civil engineering for building engineering.

1.6 The scope of the Project:

This project contains several chapters are detailed as follows:

- Chapter One: a general introduction to the project.
- Chapter Two: includes description of architectural project.
- Chapter Three: contains a description of the structural elements of the project.
- Chapter Four: Analysis and structural design of all structural elements.
- Chapter Five: The results that have been reached and recommendations.

1.7 Schedule:

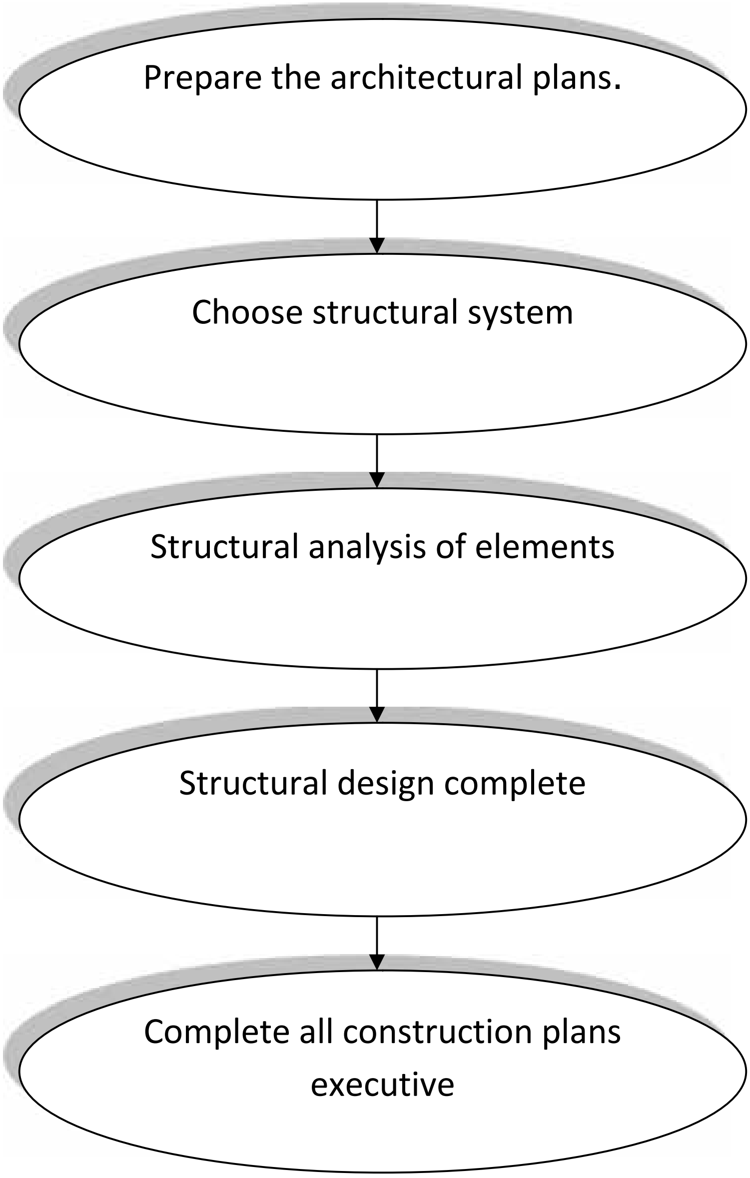

Figure (1-1): Shows the Stages of The Project.

CHAPTER

3

Structural Description

3.1 INTRODUCTION.

3.2 THE GOAL OF THE STRUCTURAL DESIGN.

3.3 SCIENTIFIC TESTS.

3.4 STAGES OF STRUCTURAL DESIGN.

3.5 LOADS ACTING ON THE BUILDING.

3.6 STRUCTURAL ELEMENTS OF THE BUILDING.

3.1 Introduction:

The main objective of the design process is to ensure the existence of necessary operating advantages with structural elements on the most suitable dimensions in terms of security and economic terms.

The knowledge of structural elements of any project is essential in the design of reinforced concrete structures to make comparisons between different types of these elements for the construction of safer system. So, the structural elements that go into the design of this project will be described.

3.2 The Goal of the Structural Design:

The structural design is an integrated and balanced structural system which is capable of carrying it and meets the established requirements and desires of users, and thus determines the structural elements from the following:

1- Factor of Safety: Is achieved by selecting sections for structural elements capable of withstanding the forces and resulting stresses.
2- Economy: Check by choosing the appropriate building materials and by choosing the perfect low-cost section.
3- Serviceability: To avoid excessive landing (deflection), fissures (cracks).
4- Preservation of architectural design.
5- Preserving the environment.

3.3 Scientific Tests:

Before the design of any construction project some tests must be done, tests of the soil to check the breaking strength, specifications, type, the underground water level and depth of the foundation layer. This is done through specific number of specified depths exploring holes done by the appropriate International Center for Geotechnical Engineering Studies (ICGES) in Bethlehem. Then the extracted samples were testedto measure the previous mentioned properties.

3.4 Stages for Structural Design:

We will divide the structural design of the project into two phases: -

1. The first stage: -
   In this stage, the appropriate structural system of the project construction and the analysis of this system will be determined.
2. The second stage: - The structural design of each element of the set is detailed and modified according to the chosen construction system and structural executing blueprints.

3.5 Loads Acting on the Building:

There is a group of forces that the building must be designed to endure, this group consists of several types of loads which must be calculated and selected carefully because any errors in identifying and calculating these loads can reflect negatively on the structural design of various structural elements.

3.5.1 Live Loads:

Includes the loads which effect on the building base on the usage of it, they can be classified into the following:

3.5.1.1 Dynamic Loads: like the machines that produce vibrations.

3.5.1.2 Static Loads: their location can be changed from time to time, like furniture, partitions, machines, and stored materials.

3.5.1.3 People Loads: depends on the usage of the building.

3.5.1.4 Execution Loads: acts on the building during the execution process, like cranes.

Jordan code loading :-

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الاشغال	كن/م²	كن
المباني الخاصة والسكنية.	**النوع الأول :** مباني الشقق السكنية التي لا يزيد ارتفاعها عن ثلاثة طوابق ولا يزيد عدد الشقق التي يمكن الوصول إليها من خلال درج مشترك عن أربع شقق للطابق الواحد.	جميع الغرف بما في ذلك غرف النوم والمطابخ وغرف الغسيل وما شابه ذلك (All Usages).	2.0	1.4
	النوع الثاني : المباني التي لا ينطبق عليها ما ورد في النوع الأول و البنسيونات والمباني المخصصة لاقامة الضيوف.	غرف النوم.	2.0	1.8
		الحمامات.	2.0	–
		الطعام وردهات الاستراحة والبلياردو.	2.0	2.7
		الممرات والمداخل والأدراج و مسطحات الأدراج والممرات المرتفعة الموصلة بين المباني.	3.0	4.5
		المطابخ وغرف الغسيل.	3.0	4.5

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الأشغال	كن/م^{2}	كن
تابع المباني الخاصة والسكنية.	تابع النوع الثاني:	المراحل والمحركات والمراوح وما شابه ذلك بما فيها أوزان الماكينات.	7.5	4.5
		الشرفات.	حمل الغرفة التي تؤدي إليها على أن لا يقل عن (3).	1.5 لكل متر طولي يؤثر عند الحافة الخارجية.
		الممرات الضيقة.	–	1.0 على مسافة متر واحد بين الحمل والآخر.
	النوع الثالث: الفنادق والموتيلات ومنازل الطلبة وماشابهها.	غرف النوم والمهاجع.	2.0	1.8
		الحمامات.	2.0	–
		الطعام وردهات الاستراحة والبلياردو.	2.0	2.7
		الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.	4.0	4.5
		المطابخ وغرف الغسيل.	3.0	4.5

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الأشغال	كن/م^2	كن
تابع المباني الخاصة والسكنية	تابع النوع الثالث:	المراحل والفركات والمراوح وماشابه ذلك.	7.5	4.5
		قاعات الرقص والساحات المشتركة دون مقاعد ثابتة.	5.0	3.6
		قاعات التجمع بمقاعد ثابتة.	4.0	-
		قاعات المشروبات.	5.0	-
		الشرفات.	حمل الغرفة التي تؤدي اليها على أن لا يقل عن (4) .	1.5لكل متر طولي يؤثر عند الحافة الخارجية.
		الممرات الضيقة.	كما في النوع الثاني.	
المباني التعليمية وماشابهها	السجون والمستشفيات والمدارس والكليات.	غرف المراحل والفركات والمراوح وغرف المشروبات والحمامات والشرفات والممرات وغرف الطعام وردهات الاستراحة والبلياردو.	كما ورد في النوع الثالث من المباني السكنية.	
		الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.	كما ورد في النوع الثاني من المباني السكنية.	

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الأشغال	كن/م²	كن
تابع المباني التعليمية وماشابهها.	تابع السجون والمستشفيات والمدارس والكليات.	أماكن التكديس الكثيف للكتب على عربات متحركة.	4.8 لكل متر من ارتفاع التخزين على أن لا يقل عن (10).	7.0
		غرف تكديس الكتب.	2.4 لكل متر من ارتفاع التخزين على أن لا يقل عن (6.5).	7.0
		مستودعات القرطاسية.	4 لكل متر من ارتفاع التخزين.	9.0
		الممرات والمداخل المعرضة لحركة المركبات والعربات المتحركة.	5.0	4.5
		غرف وقاعات التدريب.	5.0	9.0
		قاعات التجمع والمسارح والجمنازيوم دون مقاعد ثابتة.	5.0	3.6
		المختبرات بما فيها من أجهزة، والمطابخ وغرف الغسيل.	3.0	4.5
		الممرات والمداخل والأدراج وبسطات الأدراج الثانوية.	3.0	2.7

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الاشغال	كن/م^2	كن
تابع المباني التعليمية وماشابهها.	تابع السجون والمستشفيات والمدارس والكليات.	غرف التدريس.	3.0	2.7
		غرف المطالعة دون مستودع كتب.	2.5	4.5
		غرف المطالعة بمستودع كتب.	4.0	4.5
		قاعات المعدات.	2.0	1.8
		غرف الأشعة والعمليات والخدمات.	2.0	4.5
		غرف تبديل الملابس وغرف النوم في المستشفيات.	2.0	1.8
		المقصورات.	4.5 لكل متر طولي موزعا بانتظام على العرض.	-
مباني التجمعات العامة.	القاعات، قاعات الاجتماعات، المطاعم، المتاحف، المكتبات، النوادي، المسارح، ستوديوهات الاذاعة.	جميع الاشغالات عدا الاشغالات الواردة أدناه.	كما ورد في المباني التعليمية.	

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الاشغال	كن/م^2	كن
تابع مباني التجمعات العامة.	تابع القاعات، قاعات الاجتماعات، المطاعم، المتاحف، المكتبات، النوادي، المسارح، ستوديوهات الاذاعة.	الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.	4.0	4.5
		المنصات.	7.5	4.5
		أرضيات المتاحف وصالات عرض الفنون.	4.0	4.5
		أماكن العبادة (المساجد والكنائس).	3.0	2.7
مباني المكاتب.	المكاتب والبنوك.	مستودعات القرطاسية.	4 لكل متر من ارتفاع التخزين.	9.0
		غرف حفظ الملفات.	5.0	4.5
		قاعات البنوك.	3.0	-
		مكاتب للاستعمالات الخفيفة.	2.5	2.7
		الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني.	4.0	4.5

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الاشغال	كن/م²	كن
تابع مباني المكاتب.	تابع المكاتب والبنوك.	غرف المراحل والمراوح والحركات والممرات والمداخل المعرضة للتزاحم وحركة المركبات.	كما ورد في المباني التعليمية.	
		المطابخ وغرف الغسيل والحمامات والمشرفات والممرات الضيقة.	كما ورد في المباني التعليمية.	
المباني التجارية.		غرف المراحل والمراوح والحركات والممرات والمداخل المعرضة للتزاحم وحركة المركبات.	كما ورد في المباني التعليمية.	
	الدكاكين، المحلات التجارية الكبيرة، الأسواق المركزية.	المطابخ وغرف الغسيل والحمامات والمشرفات والممرات الضيقة.	كما ورد في المباني التعليمية.	
		الممرات والمداخل والأدراج ومسطحات الأدراج والممرات المرتفعة.	4.0	4.5
		مستودعات التبريد.	5 لكل متر من ارتفاع التخزين على أن لا يقل عن (15).	9.0
		مستودعات القرطاسية.	4 لكل متر من ارتفاع التخزين.	9.0

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الأشغال	كن/م۲	كن
تابع المباني التجارية.	تابع الدكاكين، المحلات التجارية، الكبيرة، الأسواق المركزية.	مستودعات أخرى.	2.4 لكل متر من ارتفاع التخزين.	7.0
		صالات البيع والشراء.	4.0	3.6
المباني الصناعية.	المشاغل والمصانع.	المسابك.	20.0	–
		مستودعات التبريد.	5.0 لكل متر من ارتفاع التخزين على أن لا يقل عن (15).	9.0
		مستودعات الورق في المطابع.	4.0 لكل متر من ارتفاع التخزين.	7.0
		مستودعات أخرى غير المذكورة أعلاه.	2.4 لكل متر من ارتفاع التخزين.	7.0
		مستودعات المواد المطبوعة والمساحات الأخرى في المطابع.	12.5	9.0
		الممرات والمداخل والأدراج وبسطات الأدراج.	4.0	4.5
		قاعات الماكينات والفراغات بينها.	4.0	4.5
		المشاغل والمصانع	5.0	4.5

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الإشغال	كن/م^2	كن
تابع المباني الصناعية.	توابع المشاغل والمصانع.	غرف المراجل والمراوح والمحركات والممرات والمداخل المعرضة للتزاحم وحركة المركبات.	كما ورد في المباني التعليمية.	
		المطابخ وغرف الغسيل والحمامات والشرفات والممرات الضيقة.	كما ورد في المباني التعليمية.	
مباني التخزين.		مخازن التبريد.	5.0 لكل متر من ارتفاع التخزين على أن لا يقل عن (15).	9.0
		أماكن التكديس الكثيف للكتب على شاحنات متنقلة.	4.8 لكل متر من ارتفاع التخزين على أن لا يقل عن (15).	7.0
		مخازن الورق في المطابع.	4.0 لكل متر من ارتفاع التخزين.	9.0
		مخازن القرطاسية.	4.0 لكل متر من ارتفاع التخزين.	9.0
		مخازن أخرى ومستودعات.	2.4 لكل متر من ارتفاع التخزين.	7.0
		غرف المحركات والمراوح وما شابه ذلك، شاملة وزن الماكينات.	7.5	4.5

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الأشغال	كن/م^2	كن
تابع مباني التخزين.		الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة المعرضة لأحمال تزيد عن أحمال التزاحم مثل حركة المركبات.	5.0	4.5
		الممرات الضيقة.	–	1.0 و المسافة بين مراكز الأحمال (1.0) م.
مباني المركبات.	المرائب (الكراجات)، مواقف السيارات، المنحدرات.	غرف المحركات والمراوح وما شابه ذلك شاملة وزن الماكينات.	7.5	4.5
		طرق المركبات والمنحدرات غير تلك الموجودة في المرائب المخصصة لوقوف سيارات نقل الركاب والشاحنات الخفيفة التي لا تزيد كتلتها الاجمالية عن (2500) كغ.	5.0	9.0
		مشاغل اصلاح جميع أنواع المركبات التي تزيد كتلتها الاجمالية عن (2500)كغ بما في ذلك الطرق والمنحدرات.	5.0	9.0

نوع المبنى		الاستعمال	الحمل الموزع	الحمل المركز البديل
عام	خاص	الأشغال	كن/م²	كن
تابع مباني المركبات.	توابع المرائب (الكراجات)، مواقف السيارات، المنحدرات.	ممرات المشاة العادية والمسقوفة والساحات التي يتم الوصول اليها من الطابق الأرضي دون عوائق لمرور المركبات، وكذلك الطرق المعبدة.	5.0	9.0
		الممرات والمداخل والأدراج وبسطات الأدراج والممرات المرتفعة الموصلة بين المباني والمعرضة للازدحام.	4.0	4.5
		ممرات المشاة العادية والمسقوفة والساحات التي يتم الوصول اليها من الطابق الأرضي والمخصصة لمرور المشاة فقط.	4.0	4.5
		مواقف السيارات المخصصة لسيارات نقل الركاب والشاحنات الخفيفة التي لا تزيد كتلتها الاجمالية عن (2500) كغ.	2.5	9.0

3.5.2 Dead Load:

The permanent forces resulting from gravity which are fixed in terms of amount and location and do not change during the age of the building, including the loads of the weight of structural elements and the weights of the permanent nonstructural elements like walls. It also includes the permanent lateral loads like the soil pressure on the basement walls.

The calculation of the loads requires the knowing of the dimensions of the structural elements and specific gravity of the materials used in the manufacturing of the structural elements.

Furthermore, falls within this definition the self-weight of the construction materials, like concrete, reinforcement rebar's, insulation materials, plaster, mortar, tiles, and electrical & sanitary installation.

Density KN/m^2	**Material**	#
23	Tiles	**1**
22	Mortar	**2**
25	Reinforced Concert	**3**
10	Hollow Block	**4**
22	Plaster	**5**
17	Sand	**6**

Table (3-1): Density of materials.

3.5.3 Environmental Loads:

result from environmental factors, including snow loads, earth quick loads, and soil loads. Theses loads vary in both magnitude and location, the wind load even varies in direction, and it depends on the unit of area exposed to the wind**.**

3.5.3.1 Snow Loads:

Snow loads can be calculated by knowing the altitude using the table below by Jordanian code.

SNOW LOAD KN/m^2	HEIGHT ABOVE SEA LEVEL(m)
0	H< 250
(H-150)/1000	500<200<H
(H-400)/400	1500<500<H
(H-812.5)/250	2500<1500<H

Table (3-2): Snow loads.

3.5.3.2 Earthquake Load:

Earthquakes produce horizontal and vertical vibrations due to the relative motion of the Earth rock layers, resulting in strong cut affects the origin and these loads must be taken into account in the design to ensure the resistance against earthquakes. This will be resisted by shear walls in a building on the construction accounts.

The load is determined based on location. (Dura south west of Hebron) so (zone is 2A and Z=0.15).

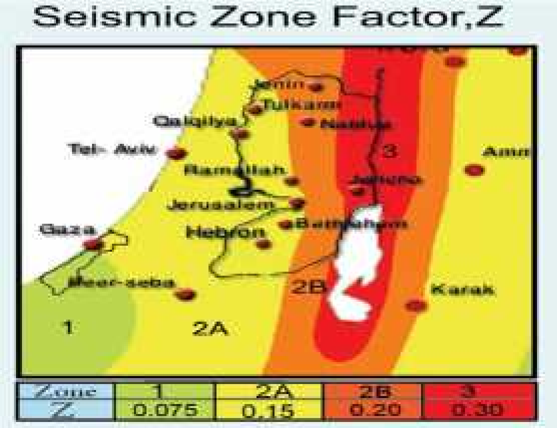

Figure (3-1): Earthquake map for Palestine.

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3.5.3.3 Wind Loads:

Wind loads produce horizontal forces on the building, and the wind load determination process depends on wind speed which changes with the height of the structure from the surface of the Earth and the location of the building itself, the surrounding buildings, and many other variables.

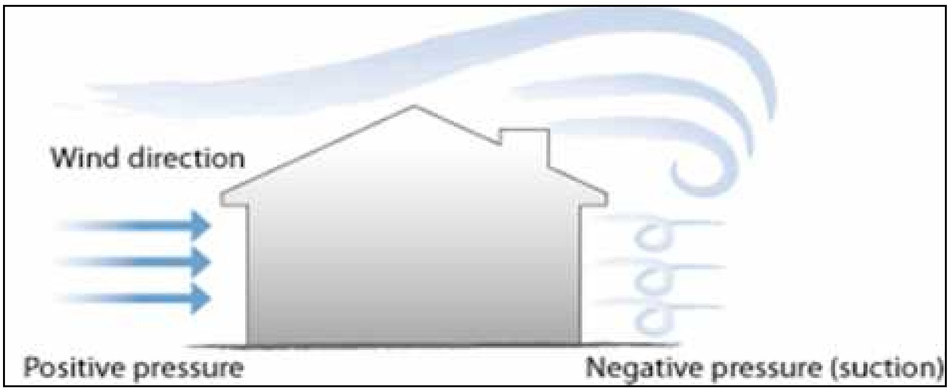


Figure (3-2): Wind Pressure on buildings.

3.6 Structural Elements of the Building:

All buildings are usually consisting of a set of structural elements that work together to maintain the continuity of a building and its suitability for human use, and the most important of these slabs and beams and columns and load-bearing walls, etc.

3.6.1 Slabs:

Structural elements are capable of delivering vertical forces due to the loads affecting the building's load-bearing structural elements such as beams, columns and walls, without distortions.

3.6.1.1 Ribbed Slabs:

In this project, two types of components both in its appropriate place, and which will clarify the structural design in the subsequent chapter, and below these types:

3.6.1.1.1 One Way Ribbed Slab:

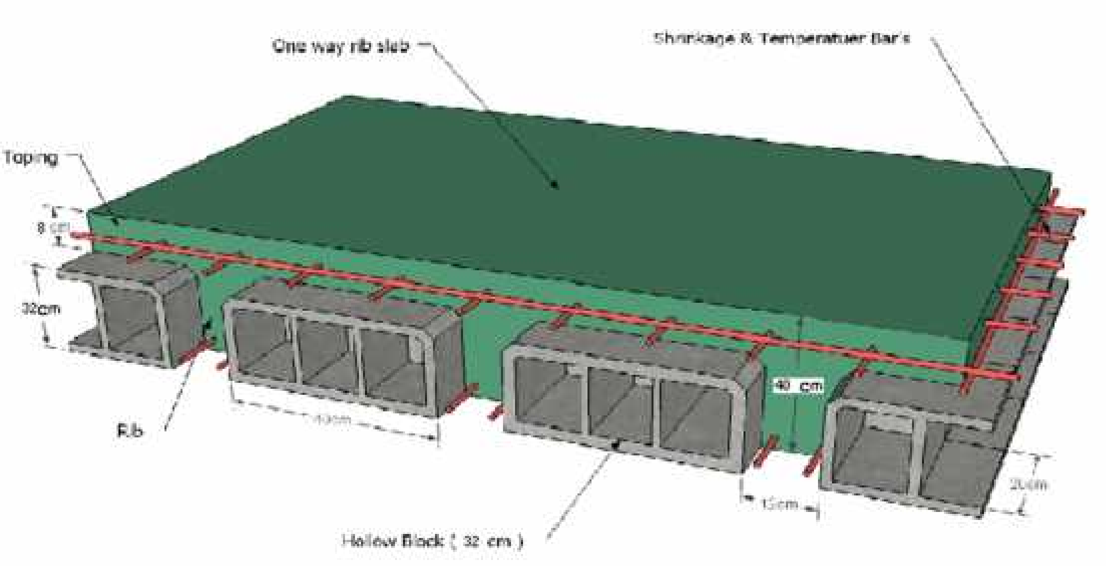


Figure (3-3): One Way Ribbed Slab.

3.6.1.1.2 Tow Way Ribbed Slab:

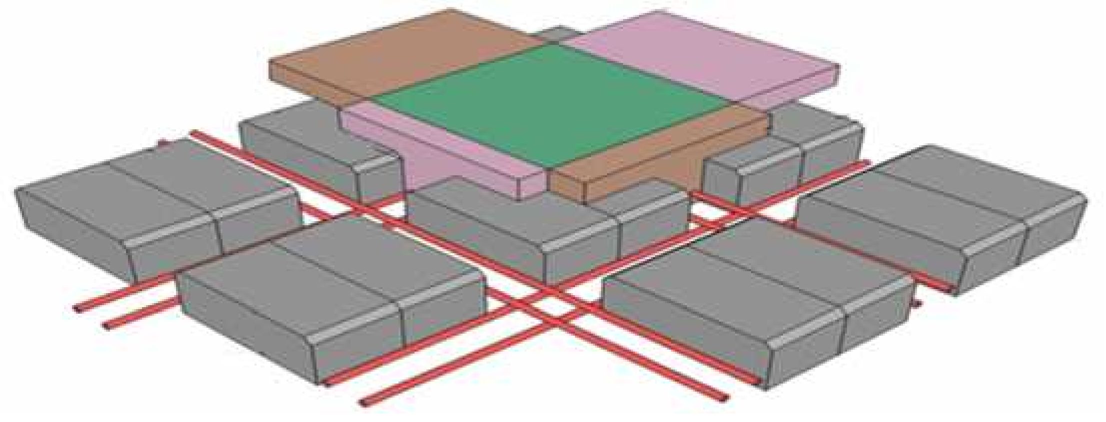


Figure (3-4): Tow Way Ribbed Slab.

3.6.1.2 Solid Slab:

3.6.1.2.1 One Way Solid Slab:

Figure (3-5): One Way solid Slab.

3.6.1.2.2 Tow Way Solid Slab:

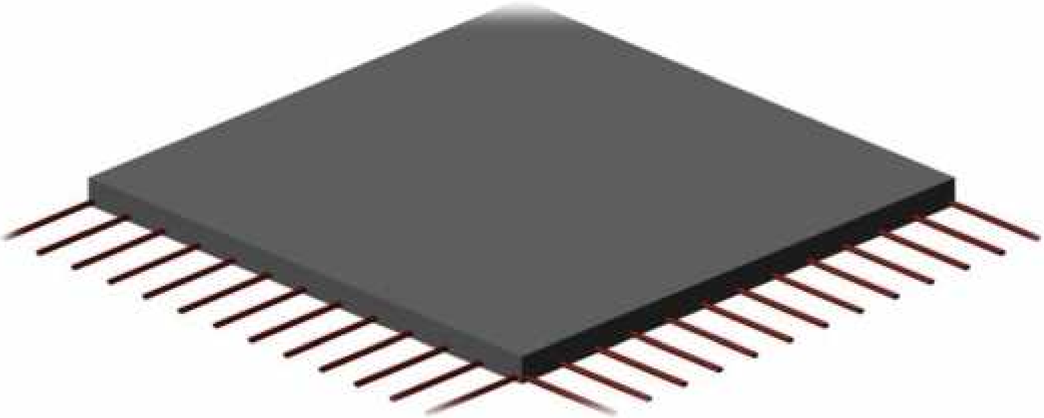


Figure (3-6): Two Way solid Slab.

3.6.2 **Beams**:

The basic structural elements in moving load of tiles into columns, and are of two types:

3.6.2.1 Hidden Beam(Hidden inside Slabs):

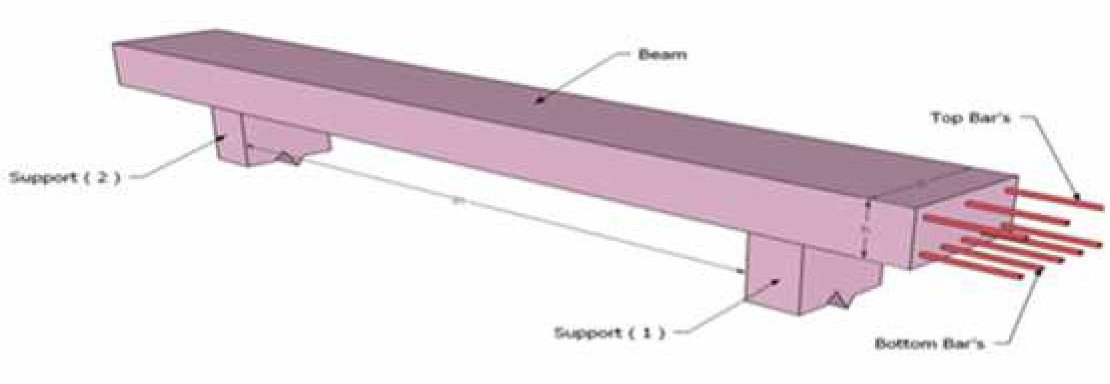


Figure (3-7): Hidden beam.

3.6.2.2 Dropped Beam: (Paneled Beam):

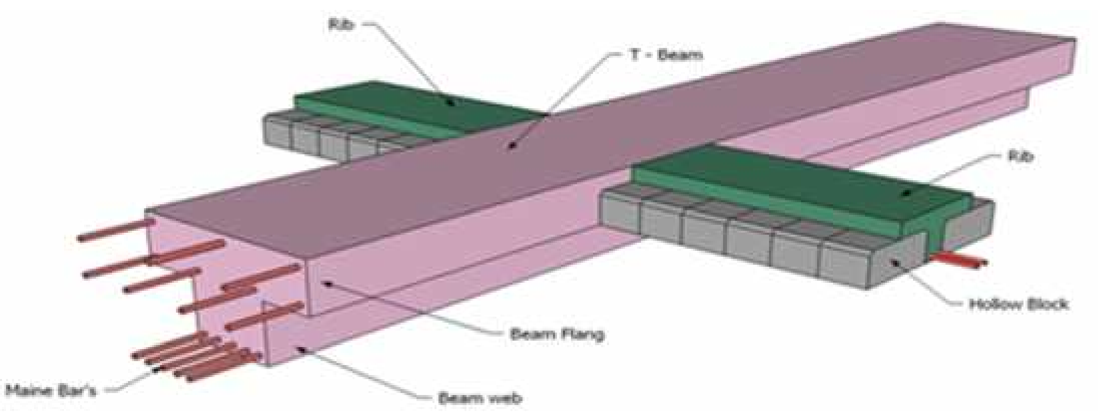


Figure (3-8): Dropped beam.

3.6.3 Stairs:

The architectural elements used for vertical transmission between the different levels of the lever through the building, and will be one of inclusion type design development.

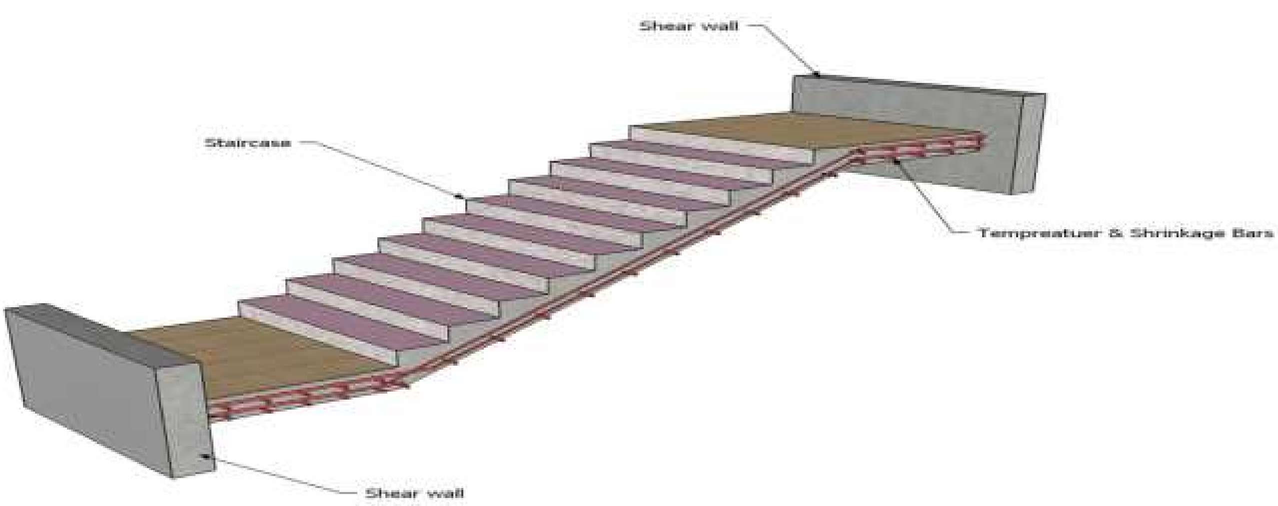


Figure (3-9): Stair.

3.6.4 Column:

The column is an important element in moving loads of bridges to the foundations, it is essential to transfer the loads and the building, and therefore must be designed so as to be able to download and load them, and two rectangular and square concrete columns.

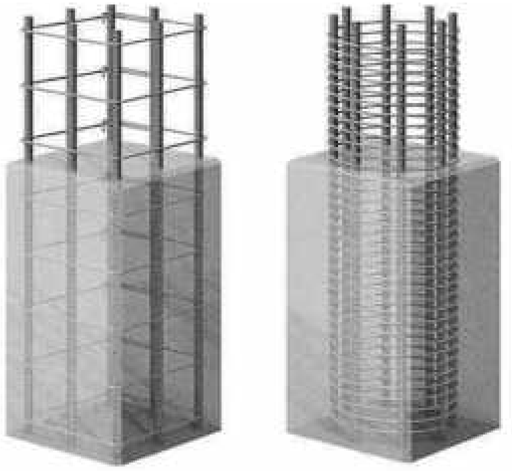


Figure (3-10): Columns.

3.6.5 Shear wall:

Is a structural system composed of braced panels (also known as shear panels) to counter the effects of lateral load acting on the building, the building contains a number of shear wall continued from Foundation to the end minaret.

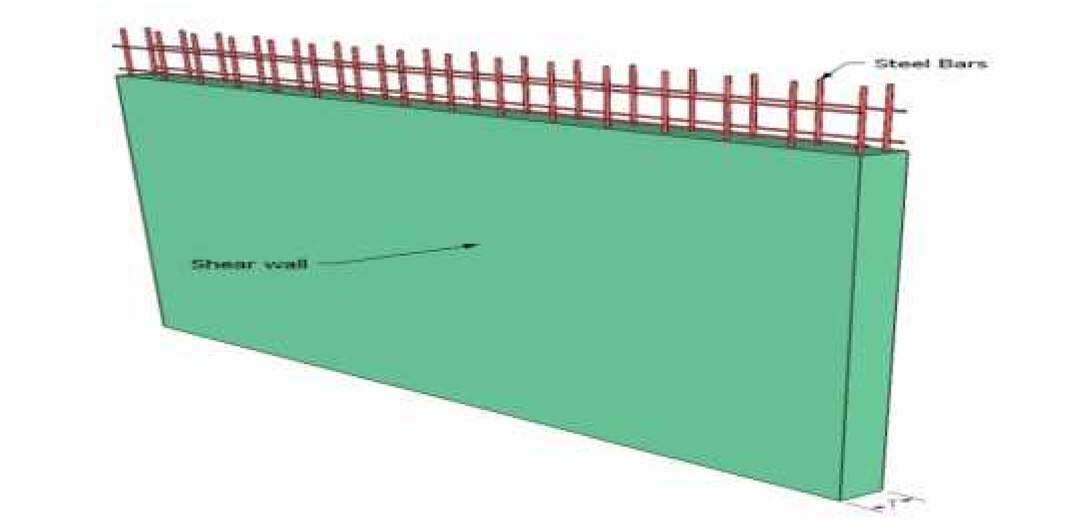


Figure (3-10): Shear wall.

3.6.6 Foundations:

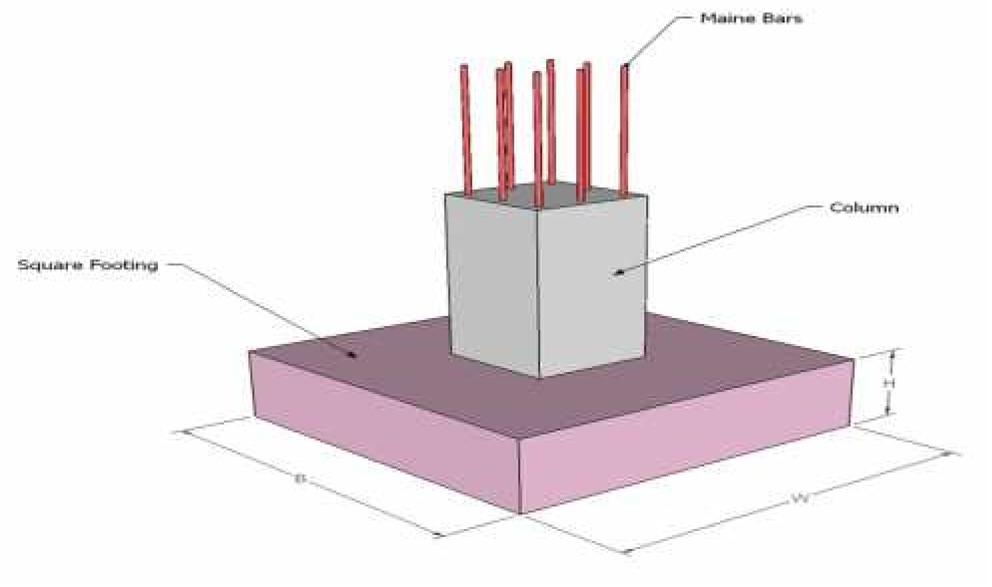


Figure (3-11): Isolating footing.

CHAPTER

4

DESIGN OF STRUCTURAL MEMBERS

4-1 Introduction.

4-2 Design Method and Requirements.

4-3 Check of Minimum Thickness of Structural Member.

4-4 Design of Topping.

4-5 Design of One Way Rib Slab.

4.6 Design of Beam.

4.7 Design of Two Way Rib Slab.

4.8 Design of Column.

4.9 Design of Basement Wall.

4.10 Design of Stair.

4.11 Design of Isolating Footing.

4.1 Introduction:

Many structures are built of reinforced concrete: bridges, buildings, retaining walls, tunnels and others.

Reinforced concrete is logical union of two materials: plain concrete, which possesses high compressive strength but little tensile strength, and steel bars embedded in the concrete, which can provide the needed strength in tension.

Plain concrete is made by mixing cement, fine aggregate, coarse aggregate, water, and frequently admixtures.

Understanding of reinforced concrete behavior is still far from complete, building codes and specifications that give design procedures are continually changing to reflect latest knowledge.

Structural concrete can be classified into: -

Lightweight concrete with unit weight from about 1350 to 1850 kg/m3.

Normal weight concrete with unit weight from about 1800 to 2400 kg/m3.

Heavyweight concrete with unit weight from about 3200 to 5600 kg/m3.

4.2 Design Method and Requirements:

The design strength provided by a member is calculated in accordance with the requirements and assumptions of **ACI_code (318_08)**.

✓ **Strength design method: -**

In ultimate strength design method, the service loads are increased by factors to obtain the load at which failure is considered to be occurring.

This load called factored load or factored service load. The structure or structural element is then proportioned such that the strength is reached when factored load is acting.

The computation of this strength takes into account the nonlinear stress-strain behavior of concrete.

The strength design method is expressed by the following, Strength provided ≥ strength required to carry factored loads.

NOTE: -

The statically calculation and the key plans dependent on the architectural plans.

- Code: -
  ACI 2008
  UBC
- Material: -
  Concrete: -B300

$fc' = 30N/mm^2(MPa)$ For circular section

but for rectangular section ($fc' = 30 * 0.8 = 24MPa$).

Reinforcement steel: -

The specified yield strength of the reinforcement {fy = 420 N/mm² (MPa).

✓ **Factored loads: -**

The factored loads for members in our project are determined by: -

$W_u = 1.2\ D_L + 1.6\ L_L$ ACI-code-318-08(9.2.1)

4.3 Check Thickness of Structural Member:

Minimum thickness (h)				
Member	Simply supported	One end continuous	Both end continuous	Cantilever
solid one way slabs	L/20	L/24	L/28	L/10
Beams or ribbed one way slabs	L/16	L/18.5	L/21	L/8

Table (4-1): Check of Minimum Thickness of Structural Member.

For Rib: -

$h_{min}$for (one end continuous) = L/18.5 = 5.85/18.5 = 31.6 cm .

$h_{min}$for (both end continuous) = L/21 = 6.21/21 = 29.5 cm .

$h_{min}$for (both end continuous) = L/21= 4.49/21 = 21.3 cm .

$h_{min}$for (one end continuous) =L/18.5 = 4.75/18.5 = 25.6 cm .

Take h = 35 cm

27 cm block + 8 cm topping = 35cm

For Beam: -

$h_{min}$for (one end continuous) = L/18.5 = 4.57/18.5 = 24.7 cm .

$h_{min}$for (one end continuous) =L/18.5=7.29/18.5=39.4cm . control.

Take h = 50 cm

4.4 Design of Topping:

- ✓ **Statically System For Topping:-**

Consider the topping as strip of (1m) width, and span of mold length with both end fixed in the ribs.

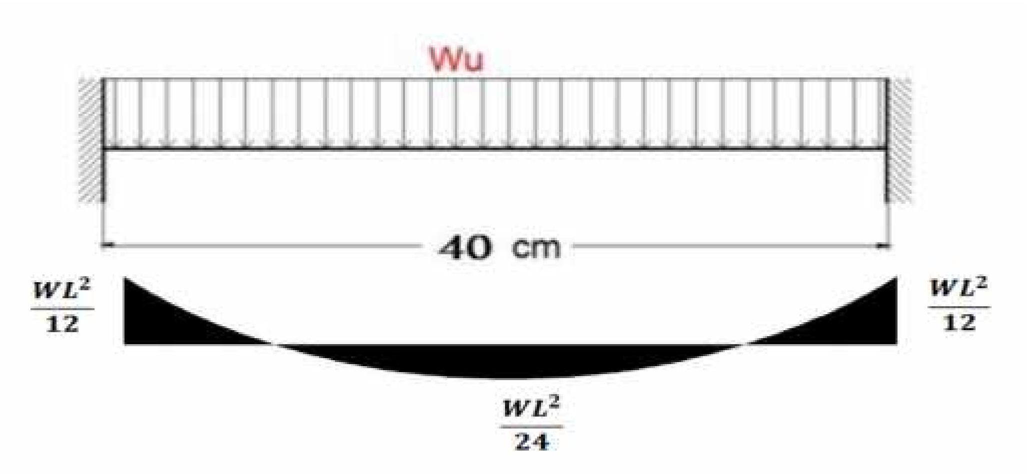


Fig (4-1): Topping Load.

- ✓ **Load Calculations:**

Dead Load: -

No.	**Parts of Rib**	**Calculation**
1	**Tiles**	**0.03*23*1 = 0.69 KN/m**
2	**Mortar**	**0.03*22*1 = 0.66 KN/m**
3	**Coarse Sand**	**0.07*17*1 = 1.19 KN/m**
4	**Topping**	**0.08*25*1 = 2 KN/m**
5	**Partitions**	**1*1=1 KN/m**
		Sum= 5.54 KN/m

Table (4-2): Dead Load Calculation of Topping.

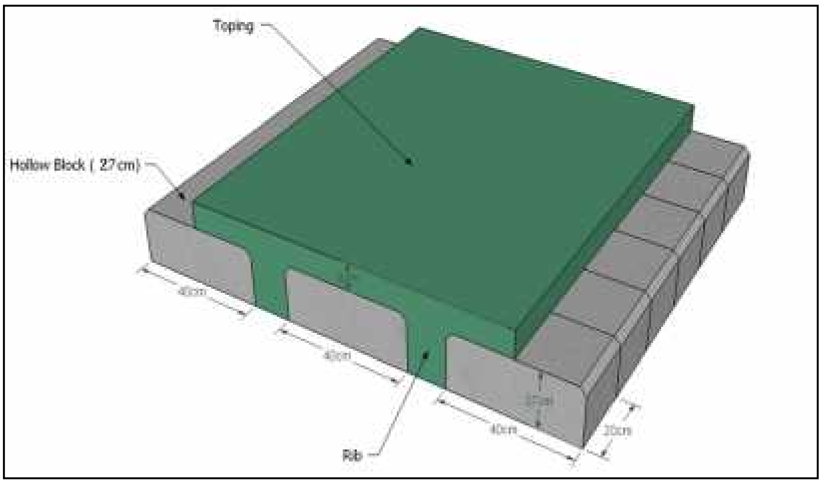


Fig (4-2): Detailing of topping .

Live Load: -

Nominal total live load = 5 KN/m^2.

Live load calculation = 5*1=5 KN/m.

W_u = 1.2×D+1.6×L= 1.2*5.54 + a.6*5 = 14.468 KN/m. (total factored load).

$$M_u = \frac{W_u * l^2}{12} = 0.192\ \text{KN.m}$$

$$\emptyset M_n = 0.55 * 0.42 * \sqrt{24} * 1000 * \frac{80^2}{6} = 1.21\ \text{KN.m}$$

$$\emptyset M_n = 1.21\ \text{KN.m} > M_u = 0.192\ \text{KN.m}$$

No structural reinforcement is needed. Therefore, shrinkage and temperature reinforcement must be provided.

For the shrinkage and temperature reinforcement :-

$\rho = 0.0018$

$A_s = \rho * b * h = 0.0018 * 1000 * 80 = 144$ mm2/ m strip.

A_s Ø8 = 50.24 mm^2 , 144/50.24=2.8=3 bars , S=1000/4=25 cm.

Take 3Ø/m with As=150.8mm^2/m strip or Ø8 @ 300 mm in both directions.

Step (S) is the smallest of :

1. 3h = 3×80 =240 mm *control* ACI 10.5.4 .
2. 450mm.
3. $S = 380\ \frac{280}{f_s} - 2.5C_c = 380\ \frac{280}{\frac{2}{3}420} - 2.5 * 20 = 330$ mm

$S = 380\ \frac{280}{f_s} = 380\ \frac{280}{\frac{2}{3}420} = 380$ mm

Use 8 @ 20 cm in both directions , 20 cm < 24 cm , OK.

Check shear strength :

$$V_u = \frac{W_u * L}{2} = 2.89\ \text{KN.m}$$

$$\emptyset * Vc = \frac{0.75}{6} * \sqrt{24} * 1 * 100 = 61.25\ \text{KN}$$

61.25 > 2.88

∴ No shear reinforcement is requirement .

4.5 Design of One Way Rib Slab(Rib3(28)):

For the one-way ribbed slabs, the total dead load to be used in the analysis and design is calculated as follows.

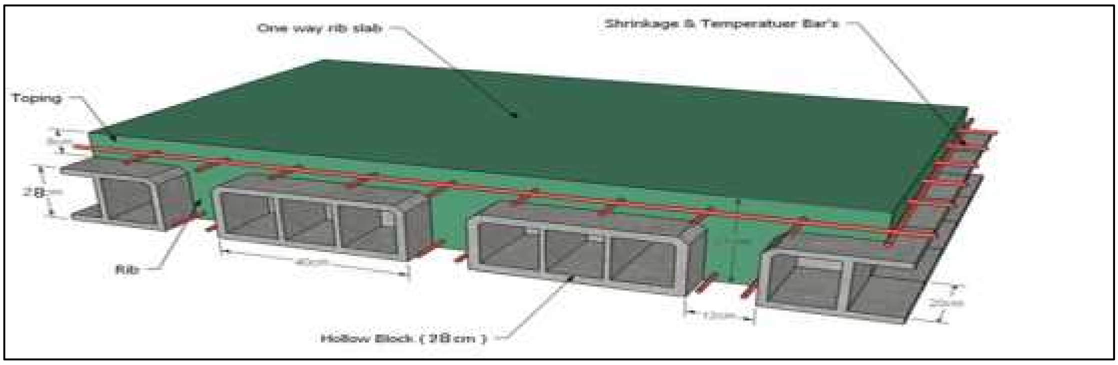


Fig (4-3): Detailing One Way Rib Slab (Rib3(28)).

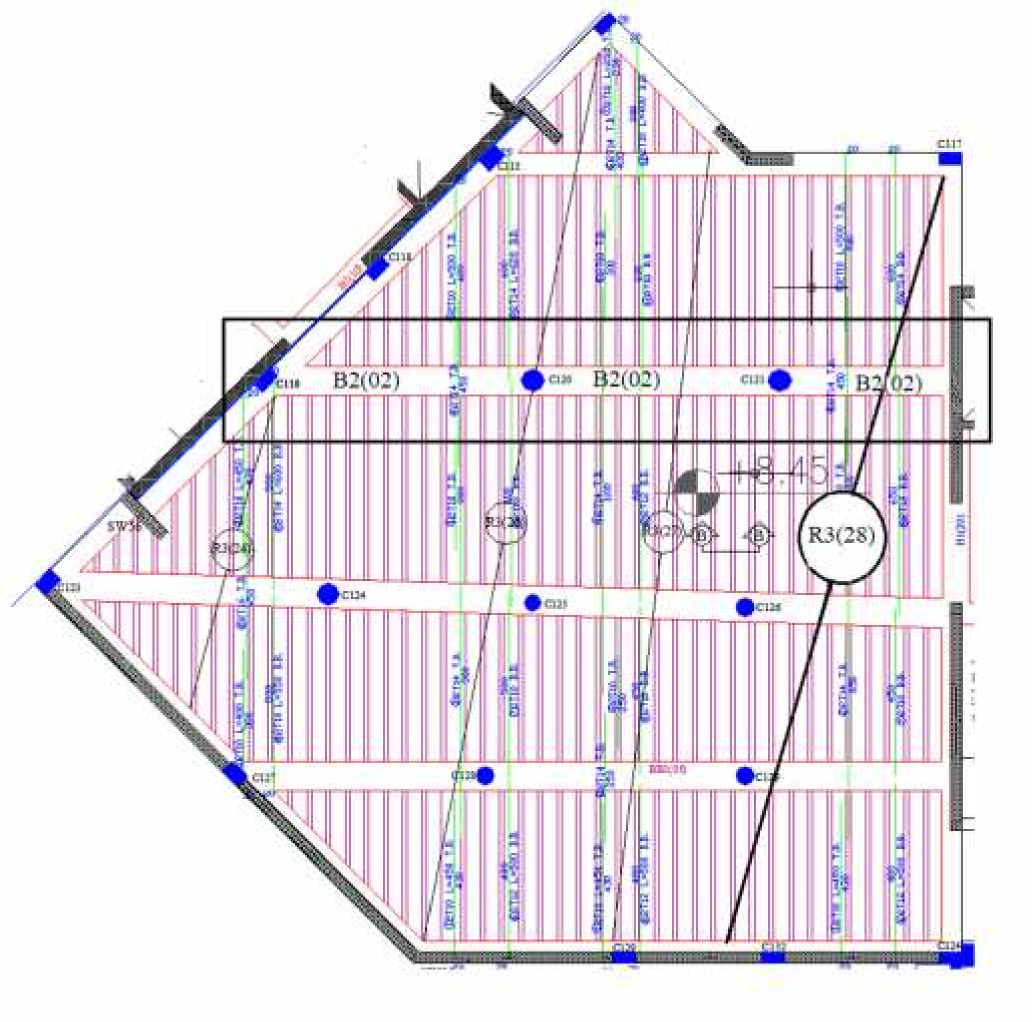


Fig (4-4): Statically System of (Rib3(28)).

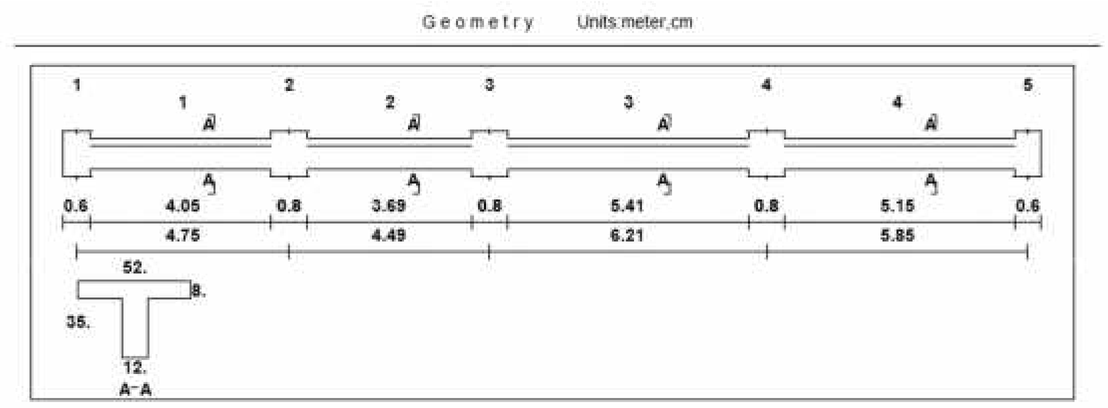


Fig (4-4): Geometry of (Rib3(28)).

- ✓ **Load Calculation: -**

Dead Load: -

No.	Parts of Rib	Calculation
1	**Tiles**	0.03*23*0.52 = 0.359 KN/m/rib
2	**Mortar**	0.03*22*0.52 = 0.343 KN/m/rib
3	**Coarse Sand**	0.07*17*0.52 = 0.620 KN/m/rib
4	**Topping**	0.08*25*0.52 = 1.04 KN/m/rib
5	**RC. Rib**	0.27*25*0.12 = 0.81 KN/m/rib
6	**Hollow Block**	0.27*10*0.4 = 1.08 KN/m/rib
7	**plaster**	0.03*22*.52= 0.343 KN/m/rib
8	**partions**	1*0.52= 0.52 KN/m/rib
		Sum = 5.1 KN/m/rib

Table (4-3): Dead Load Calculation of (Rib3(28)).

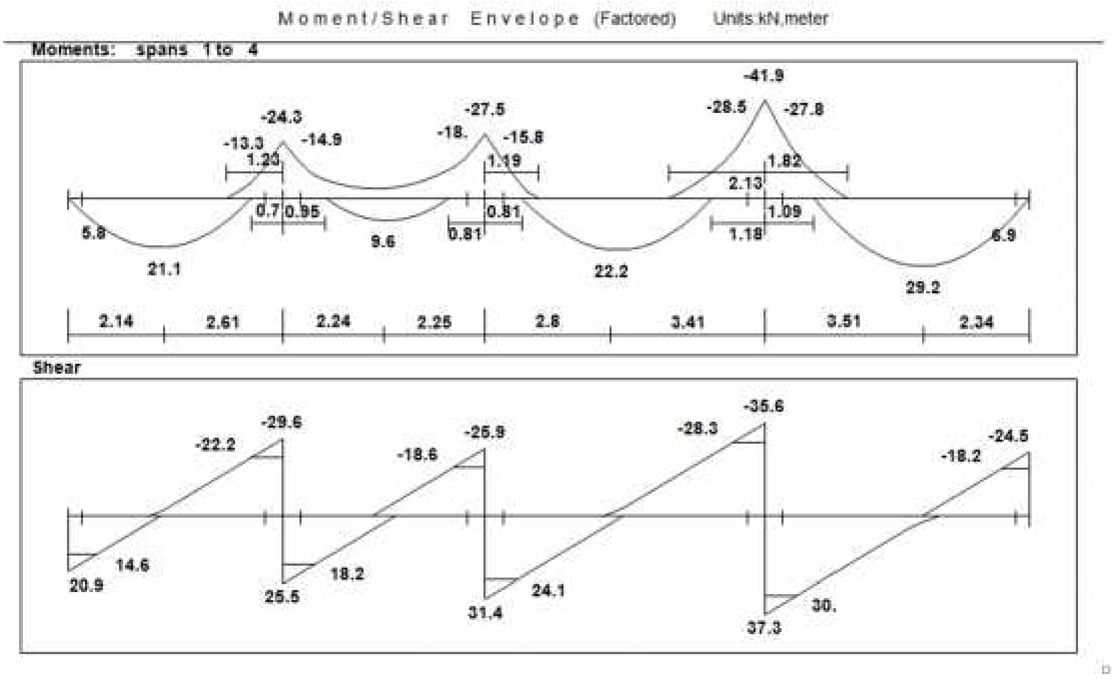


Fig (4-5): Shear and Moment Diagram of (Rib3(28)) .

Dead Load /rib = 5.1 KN/m

Live Load: -

Live load = 5 KN/m^2

Live load /rib = 5 KN/m^2 × 0.52m = 2.6 KN/m.

- Effective Flange Width (b_E): - **ACI-318-11 (8.10.2)**

b_E For T- section is the smallest of the following: -

b_E = L / 4 = 369/ 4 =92.2cm

b_E = 12 + 16 t = 12 + 16 (8) = 140 cm

b_E = $b_e \leq$ center to center spacing between adjacent beams = 52 cm *Control* .

b_E For T-section = 52cm.

- ✓ **Moment Design for (R3(28)):-**

Design of Positive Moment for Rib :-(Mu=21.1 KN.m)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$.

Check if $a > h_f$ to determine whether the section will act as rectangular or T- section.

$M_{nf} = 0.85. f_c'. b_e. h_f. (d - \frac{h_f}{2})$

$= 0.85 \times 24 \times 520 \times 80 \times \;\; 314 - \frac{80}{2} \;\; \times 10^{-6} = 232.5$ KN. m

$M_n \gg \frac{M_u}{\varphi} = \frac{21.1}{0.9} = 23.\ 55$ KN.m, the section will be designed as rectangular section with $b_e = 520$ mm.

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{21.1 \times 10^6}{0.9 \times 520 \times 314^2} = 0.459 Mpa$

$m = \frac{fy}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.6$

$\rho = \frac{1}{m} \;\; 1 - \;\; \sqrt{1 - \frac{2.m.R_n}{420}} \;\; = \frac{1}{20.6} \;\; 1 - \;\; \sqrt{1 - \frac{2 \times 20.6 \times 0.459}{420}} \;\; = 0.0011065$

$A_{s,req} = \rho.b.d = 0.0011065 \times 520 \times 314 = 180.67 \ mm^2$.

Check for As min: -

$A s \min = \frac{\sqrt{fc'}}{4(fy)} (bw)(d)$ ACI-318 (10.5.1)

$A s \min = \frac{\sqrt{24}}{4(420)} (120)(314) = 110 mm^2$.

$A s \min = \frac{1.4}{(fy)} (bw)(d)$

$A s \min = \frac{1.4}{420} (120)(314) = 125.6 mm^2$ controls

$As_{req} = 180.7 \ mm^2 > As_{min} = 125.6 \ mm^2$ OK

Use 2 ø 12, $A_{s,provided} = 226 \ mm^2 > A_{s,required} = 180.7 \ mm^2$ Ok

$S = \frac{120-40-20-(2 \times 12)}{1} = 36$ mm $> d_b = 12 > 25$ mm OK

Check for strain: -

$a = \frac{As.fy}{0.85 b f_c'} = \frac{226 \times 420}{0.85 \times 520 \times 24} = 8.94 \ mm$

$x = \frac{a}{\beta_1} = \frac{8.94}{0.85} = 10.53\ mm$

$\varepsilon_s = 0.003\ \ \frac{d-x}{x}\ \ = 0.003\ \ \frac{314\ -10.53}{10.53}\ \ = 0.0864 > 0.005$ **$0k$**

Design of Positive Moment for Rib: - (Mu=9.6 KN.m)

$d = h - cover - d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{9.6\times10^6}{0.9\times520\times314^2} = 0.208 Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\ \ 1 - \ \ \overline{1-\frac{2.m.R_n}{420}}\ \ = \frac{1}{20.6}\ \ 1 - \ \ \overline{1-\frac{2\times20.6\times0.208}{420}}\ \ = 0.0004977\ .$

$A_{s,req} = \rho.b.d = 0.0004997\times520\times314 = 81.26\ mm^2$.

Check for As min: -

$A s\ \min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ ACI-318 (10.5.1)

$A s\ \min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110 mm^2$

$A s\ \min = \frac{1.4}{(fy)}(bw)(d)$

$A s\ \min = \frac{1.4}{420}(120)(314) = 125.6 mm^2$ controls

$A_{s,required} = 82.26\ mm^2 < A_{s\ min} = 125.6\ mm^2$.

Provided $A_{s\ min} = 125.6\ mm^2$.

Use 2 ø 12 , $A_{s,provided} = 226.2\ mm^2 > A_{s,min} = 125.6\ mm^2$ … Ok

$S = \frac{120-40-20-(2\times12)}{1} = 36\ mm > d_b = 12 > 25\ mm$ OK

Check for strain: -

$a = \frac{A_s f_y}{0.85 b\ f_c'} = \frac{226.2\times420}{0.85\times520\times24} = 8.95\ mm$

$x = \frac{a}{\beta_1} = \frac{8.95}{0.85} = 10.53\ mm$

$\varepsilon_s = 0.003\ \frac{d-x}{x} = 0.003\ \frac{314-10.53}{7.31} = 0.086 > 0.005$ 0k

Design of Positive Moment for Rib :-(Mu=21.2 KN.m)

Assume bar diameter ø 12 for main positive reinforcement

$d = h - \text{cover} - d_{\text{stirrups}} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$.

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{21.2\times10^6}{0.9\times520\times314^2} = 0.459 Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2\times20.6\times0.459}{420}}\right) = 0.0011065$

$A_{s,req} = \rho.b.d = 0.0011065\times520\times314 = 180.67\ mm^2$.

Check for As min: -

$As\ \min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ ACI-318 (10.5.1)

$As\ \min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110 mm^2$.

$As\ \min = \frac{1.4}{(fy)}(bw)(d)$

$As\ \min = \frac{1.4}{420}(120)(314) = 125.6 mm^2$ controls

$As_{req} = 180.7\ mm^2 > As_{min} = 125.6\ mm^2$ OK

Use 2 ø 12, $A_{s,provided} = 226\ mm^2 > A_{s,required} = 180.7\ mm^2$ Ok

$S = \frac{120-40-20-(2\times12)}{1} = 36\ \text{mm} > d_b = 12 > 25\ \text{mm}$ OK

Check for strain: -

$a = \frac{A_s.f_y}{0.85 b\, f_c'} = \frac{226\times420}{0.85\times520\times24} = 8.94\ mm$

x$=\frac{a}{\beta_1}=\frac{8.94}{0.85}=10.53\ mm$

$\varepsilon_s=0.003\ \ \frac{d-x}{x}\ \ =0.003\ \ \frac{314\ -10.53}{10.53}\ \ =0.0864>0.005$ **0k**

Design of Positive Moment for Rib: - (Mu=29.2 KN.m)

Assume bar diameter ø 14 for main positive reinforcement

d =h- cover - d$_{stirrups}-\frac{d_b}{2}=350-20-10-\frac{14}{2}=315\ mm$

R$_n=\frac{M_u}{\emptyset b d^2}=\frac{29.2\times10^6}{0.9\times520\times315^2}=0.632\ Mpa$

m$=\frac{f_y}{0.85f_c'},=\frac{420}{0.85\times24}=20.6$

ρ$=\frac{1}{m}\ \ 1-\ \ \sqrt{1-\frac{2.m.R_n}{420}}\ \ =\frac{1}{20.6}\ \ 1-\ \ \sqrt{1-\frac{2\times20.6\times0.632}{420}}\ \ =0.00153$

A$_{s,req}$ = ρ.b.d = 0.00153×520×314 = 250 mm^2

Check for As min: -

$$A\,s\ \min=\frac{\sqrt{fc'}}{4(fy)}(bw)(d)$$ ACI-318 (10.5.1)

$$A\,s\ \min=\frac{\sqrt{24}}{4(420)}(120)(314)=110mm^2$$

$$A\,s\ \min=\frac{1.4}{(fy)}(bw)(d)$$

$A\,s\ \min=\frac{1.4}{420}(120)(314)=125.6mm^2$ **controls**

As$_{req}$ = 250 mm^2 > As$_{min}$= 125.6 mm^2 OK

Use 2 ø 14, As$_{,provided}$= 307.87 mm^2>A$_{s,required}$= 250 mm^2 … Ok

S $=\frac{120-40-20-(2\times14)}{1}=32\ mm>d_b=14>25$ mm OK

Check for strain: -

a $=\frac{A_s.f_y}{0.85b\,f_c'}=\frac{307.87\times420}{0.85\times120\times24}=52.82\ mm$

$x=\frac{a}{\beta_1}=\frac{52.82}{0.85}=62.14\ mm$

$\varepsilon_s=0.003\ \ \frac{d-x}{x}\ \ =0.003\ \ \frac{315-62.14}{62.14}\ \ =0.002408>0.005$ **$0k$**

Design of Negative Moment for Rib: - (Mu=-13.3 KN.m)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $d_{stirrups}-\frac{d_b}{2}=350-20-10-\frac{12}{2}=314\ mm$

$R_n=\frac{M_u}{\emptyset bd^2}=\frac{13.3\times10^6}{0.9\times120\times314^2}=1.25\ Mpa$

$m=\frac{fy}{0.85f_c'}=\frac{420}{0.85\times24}=20.6$

$\rho=\frac{1}{m}\ \ 1-\ \sqrt{1-\frac{2.m.R_n}{420}}\ =\frac{1}{20.6}\ \ 1-\ \sqrt{1-\frac{2\times20.6\times1.25}{420}}\ =0.00307$

$A_{s,req}$ = ρ.b.d = 0.00307 ×120×314 = 115.71 mm^2

Check for As min: -

$A s\ \min=\frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ **ACI-318 (10.5.1)**

$A s\ \min=\frac{\sqrt{24}}{4(420)}(120)(314)=110m^2$

$A s\ \min=\frac{1.4}{(fy)}(bw)(d)$

$A s\ \min=\frac{1.4}{420}(120)(314)=125.6mm^2$ controls

As_{req} = 115.71 mm^2 < As_{min}= 125.6 mm^2

As_{req} = 125.6 mm^2

Use 2 ø10, $As_{,provided}$ = 157.07 mm^2> $A_{s,required}$ = 125.6mm^2… Ok

$S=\frac{120-40-20-(2\times10)}{1}=40\ mm>d_b=12>25\ \ mm$ OK

Check for strain: -

$a = \frac{A_s.f_y}{0.85b\,f_c'} = \frac{157.07\times420}{0.85\times120\times24} = 26.94\ mm$

$x = \frac{a}{\beta_1} = \frac{26.94}{0.85} = 31.7mm$

$\varepsilon_s = 0.003\ \ \frac{d-x}{x}\ \ = 0.003\ \ \frac{314-31.7}{31.7}\ \ = 0.0267 > 0.005$ **Ok**

Design of Negative Moment for Rib: - (Mu=-18 KN.m)

Assume bar diameter ø 12 for main positive reinforcement

$d = h\text{- cover - } d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{12}{2} = 314\ mm$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{18\times10^6}{0.9\times120\times314^2} = 1.7\ Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\ \ 1 - \sqrt{1 - \frac{2.m.R_n}{420}}\ \ = \frac{1}{20.6}\ \ 1 - \sqrt{1 - \frac{2\times20.6\times1.7}{420}}\ \ = 0.0042$

$A_{s,req} = \rho.b.d = 0.0042 \times120\times314 = 158.5\ \ mm^2$

Check for As min: -

$A s\ \min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ ACI-318 (10.5.1)

$A s\ \min = \frac{\sqrt{24}}{4(420)}(120)(314) = 110m^2$

$A s\ \min = \frac{1.4}{(fy)}(bw)(d)$

$A s\ \min = \frac{1.4}{420}(120)(314) = 125.6mm^2$ controls

$As_{req} = 158.5\ mm^2 > As_{min} = 125.6\ mm^2$

$As_{req} = 158.5\ mm^2$

Use 2 ø12, $As_{,provided} = 226.19\ \ mm^2 > A_{s,required} = 158.5\ mm^2$… Ok

$S = \frac{120-40-20-(2\times12)}{1} = 36\ mm > d_b = 12 > 25\ \ mm$ **OK**

Check for strain: -

a =$\frac{A_s.f_y}{0.85b\,f_c'} = \frac{226.19\times420}{0.85\times120\times24} = 38.8\ mm$

x$= \frac{a}{B_1} = \frac{38.8}{0.85} = 45.65\,mm$

$\varepsilon_s = 0.003\ \ \frac{d-x}{x}\ \ = 0.003\ \ \frac{314-45.65}{45.65}\ \ = 0.0176 > 0.005$ **0k**

Design of Negative Moment for Rib: - (Mu=-28.5KN.m)

Assume bar diameter ø 14 for main positive reinforcement

d =h- cover - d$_{\text{stirrups}} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{14}{2} = 313\,mm$

R$_n = \frac{M_u}{\emptyset b d^2} = \frac{28.5\times10^6}{0.9\times120\times313^2} = 2.7\ Mpa$

m$= \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

ρ$= \frac{1}{m}\ \ 1-\ \ \overline{1-\frac{2.m.R_n}{420}}\ \ = \frac{1}{20.6}\ \ 1-\ \ \overline{1-\frac{2\times20.6\times2.7}{420}}\ \ = 0.0069$

A$_{s,req}$ = ρ.b.d = 0.0069 ×120×313 = 259.16 mm^2

Check for As min: -

$A s\ \min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ ACI-318 (10.5.1)

$A s\ \min = \frac{\sqrt{24}}{4(420)}(120)(313) = 109.5m^2$

$A s\ \min = \frac{1.4}{(fy)}(bw)(d)$

$A s\ \min = \frac{1.4}{420}(120)(313) = 125.2mm^2$ **controls**

As$_{req}$ = 259.16 mm^2 >As$_{min}$= 125.2 mm^2

As$_{req}$ = 259.16 mm^2

Use 2 ø14, As$_{,provided}$ = 307.9 mm^2> A$_{s,required}$ = 259.16 mm^2… Ok

S $= \frac{120-40-20-(2\times14)}{1} = 32\ mm > d_b = 14 > 25\ mm$ ***OK***

Check for strain: -

a $=\frac{A_s f_y}{0.85 b f_c'} = \frac{307.9\times420}{0.85\times120\times24} = 15.1\ mm$

x$=\frac{a}{\beta_1} = \frac{15.1}{0.85} = 17.76\,mm$

$$\varepsilon_s = 0.003\ \frac{d-x}{x}\ = 0.003\ \frac{315-17.76}{17.76}\ = 0.0502 > 0.005 \qquad \mathbf{0k}$$

- ✓ **Shear Design for (Rib3(28)) : -**

V_u at distance d from support = 30 KN

Shear strength V_c, provided by concrete for the joists may be taken 10% greater than for beams. This is mainly due to the interaction between the slab and closely spaced ribs. **(ACI, 8.13.8).**

Assume bar diameter ø 10 for shear reinforcement.

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 350 - 20 - 10 - \frac{10}{2} = 315\ mm$

$V_c = \frac{1.1}{6}\ \sqrt{f_c'} b_w d = \frac{1.1}{6}\sqrt{24}\ \times 120 \times 315 \times 10^{-3} = 33.95\ KN$

øV_c =0.75×33.95 =25.46 KN

0.5 ø V_c =0.5×25.46 =12.73 KN

V_u> ø V_c

for shear design, shear reinforcement is required ($A_{v,}$),

$Vs_{min} = \frac{1}{16}\ \sqrt{f_c'} bw\ d \geq \frac{1}{3}\ bw\ d$

Vs min$=\frac{1}{16}\sqrt{24} * 120 * 315 = 11.57\ KN$

$Vs_{min} = \frac{1}{3}\ bw\ d = \frac{1}{3} * 120 * 315 = 12.6\ KN$

ø(V_c+Vs_{min}) = 0.75(33.84+12.56) =34.8kn

øV_c<Vu <ø (V_c+Vs_{min})

25.38 < 27 <34.8

for shear design minimum shear reinforcement is required ($A_{v,min}$), Reinforcement.

Use stirrups (2 leg stirrups) ø 8@150 mm, $A_v = 2 \times 50.24 = 100.5\ mm^2$

$Av_{min} = \frac{1}{16}\ \overline{f_c'}\frac{b_w s}{fyt} \geq \frac{1}{3}\frac{b_w s}{fyt}$

$Av_{min} = 100.5 = \frac{1}{16}\sqrt{24}\frac{120s}{420} \rightarrow s = 1.145m$

$100.5 = \frac{1}{3}\frac{120s}{420} \rightarrow s = 1.055m$

S max = $\frac{d}{2} = 157mm$

S max →≤600mm

Take (2 leg stirrups) ø 8 @ 150 mm

$A_v = \frac{2*50.3}{0.15} = 670.67\ mm^2/m$ strip

4.6 Design of Beam B2(02):

- ❖ Material: -
  - ⇒ concrete B300 Fc' = 24 N/mm^2
  - ⇒ Reinforcement Steel fy = 420 N/mm^2
- ❖ Section: -
  - ⇒ B = 80 cm
  - ⇒ h= 500 cm
  - ⇒ d=500-40-10-20/2= 440 mm

✓ Statically System and Dimensions: -

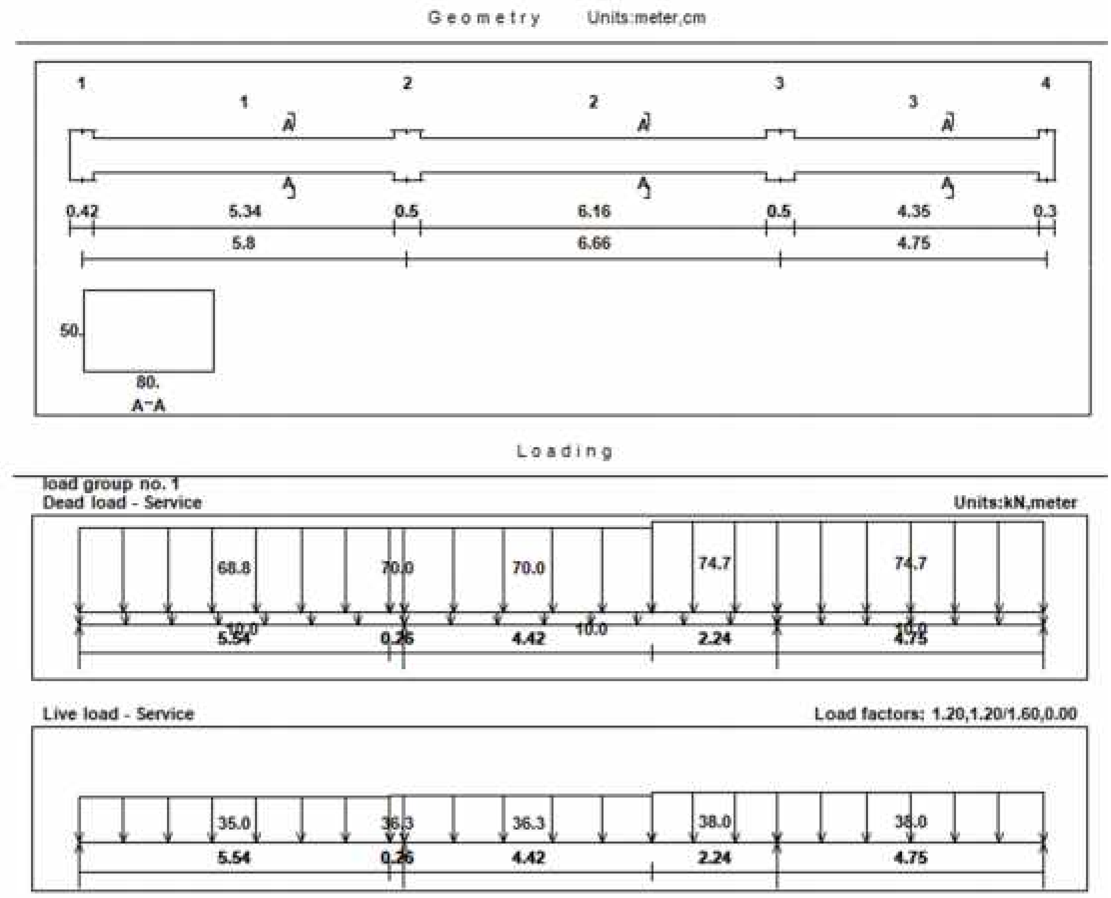


Fig (4-6): Statically System and Loads Distribution of B2(02) .

✓ Load Calculations: -

Dead Load Calculations for Beam (B2(02)): -

The distributed Dead and Live loads acting upon B2(02) can be defined from the support reactions of the R3(28).

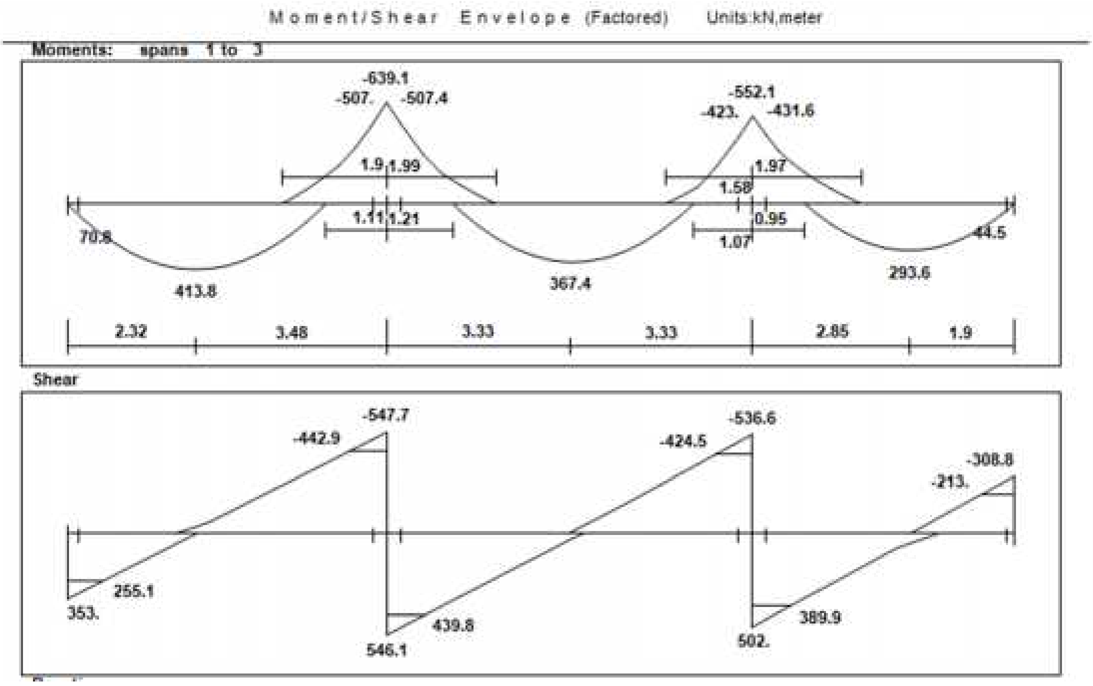


Fig (4-7): Shear and Moment Diagram of B2(02)

- ✓ **Moment Design for (B2(02)): -**

Flexural Design of Positive Moment of Beam :-(Mu=413.8 KN.m)

Determine of $M_{n,max}$

d=500-40-10-20/2= 440 mm

$$x = \frac{3}{7}d = \frac{3}{7}.440 = 188.6\,mm$$

$$a = \mathcal{B}.x = 188.6 * 0.85 = 160.28\,mm$$

Mn_{max}= 0.85∗ f_c' ∗a *b (d - $\frac{a}{2}$)=0.85*24*160.28*800*(440-160.28/2) *10^{-6}= 941.31KN.m

∅ Mn_{max} = 0.82* 941.3 = 771.87 KN.m > 413.8 KN.m.

Design as singly reinforcement:

$$Rn = \frac{M_u}{\emptyset bd^2} = \frac{413.8 \times 10^6}{0.9 \times 800 \times 440^2} = 2.97\ Mpa$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.6$$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times2.96}{420}}\right) = 0.00776$

$A_s = \rho.b.d = 0.00767\times800\times440 = 2701.53\ mm^2$

Check for $A_{s,min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*440 = 1026.45\ mm^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*440 = 1173.34\ mm^2$ Controls

$A_{smin} = 1173.34\ mm^2 < A_{sreq} = 2701.53\ mm^2$

Use 9ø20 Bottom, $A_{s,provided}= 2827.43\ mm^2 > A_{s,required} = 2701.53\ mm^2$ Ok

Check spacing: -

$S = \frac{800-40*2-20-(9\times20)}{8} = 65\ mm > d_b = 20 > 25\ mm$ OK

Check for strain: -

$a = \frac{A_s.f_y}{0.85b\,f_c'} = \frac{2827.43\ \times420}{0.85\times800\times24} = 72.76\ mm$

$x = \frac{a}{B_1} = \frac{72.76}{0.85} = 85.6\ mm$

$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{440-85.6}{85.6}\right) = 0.0124 > 0.005$ 0k

Flexural Design of Positive Moment of Beam : - (Mu=367.4 KN.m)

$R_n = \frac{M_u}{\phi bd^2} = \frac{367.4\times10^6}{0.9\times800\times440^2} = 2.64\ Mpa.$

$m = \frac{f_y}{0.85f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times2.64}{420}}\right) = 0.00674$

$A_s = \rho.b.d = 0.00674\times800\times440 = 2373.9\ mm^2.$

Check for $A_{s,min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*440 = 1026.45\ mm^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*440 = 1173.34\ mm^2$ Controls

$A_{smin} = 1173.34\ mm^2 < A_{sreq} = 2373.9\ mm^2$

Use 8ø20 Bottom, $A_{s,provided}$= 2513.27 mm^2>$A_{s,required}$= 2373.9 mm^2 Ok

Check spacing: -

$S = \frac{800-40*2-20-(8\times20)}{7} = 77.14\ mm > d_b = 20 > 25\ mm$ OK

Check for strain: -

$a = \frac{A_s.f_y}{0.85b\,f_c'} = \frac{2513.27\times420}{0.85\times800\times24} = 64.68\ mm$

$x = \frac{a}{\beta_1} = \frac{64.68}{0.85} = 76.1\ mm$

$\varepsilon_s = 0.003\ \frac{d-x}{x} = 0.003\ \frac{440-76.1}{76.1} = 0.0143 > 0.005$ 0k

Flexural Design of Positive Moment of Beam :-(Mu=293.6KN.m)

$R_n = \frac{M_u}{\emptyset bd^2} = \frac{293.6\times10^6}{0.9\times800\times440^2} = 2.1\ Mpa.$

$m = \frac{fy}{0.85f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\ 1-\ \sqrt{1-\frac{2.m.R_n}{420}} = \frac{1}{20.6}\ 1-\ \sqrt{1-\frac{2\times20.6\times2.1}{420}} = 0.0053$

$A_s = \rho.b.d = 0.0053\times800\times440 = 1867.3\ mm^2$.

Check for $A_{s,min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*440 = 1026.45\ mm^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*440 = 1173.34 \text{ mm}^2$ Controls

$A_{smin} = 1173.34 \text{ mm}^2 < A_{sreq} = 1867.3 \text{ mm}^2$

Use 6ø20 Bottom, $A_{s,provided}$= 1884.95 mm^2>$A_{s,required}$= 1867.3 mm^2 Ok

Check spacing: -

$S = \frac{800-40*2-20-(6\times20)}{5} = 116\ mm > d_b = 20 > 25\ mm$ OK

Check for strain: -

$a = \frac{A_s.f_y}{0.85b\ f_c'} = \frac{1884.95\times420}{0.85\times800\times24} = 48.5\ mm$

$x = \frac{a}{\beta_1} = \frac{48.5}{0.85} = 57.07\ mm$

$\varepsilon_s = 0.003\ \frac{d-x}{x} = 0.003\ \frac{440-57.07}{57.07} = 0.0201 > 0.005$ 0k

Flexural Design of Negative Moment of Beam :-(Mu=507.4 KN.m)

$R_n = \frac{M_u}{\phi bd^2} = \frac{507.4\times10^6}{0.9\times800\times440^2} = 3.64\ Mpa.$

$m = \frac{fy}{0.85f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\left(1 - \sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times3.64}{420}}\right) = 0.00962$

$A_s = \rho.b.d = 0.00962\times800\times440 = 3386.3 \text{ mm}^2.$

Check for $A_{s,min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*440 = 1026.45 \text{ mm}^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*440 = 1173.34 \text{ mm}^2$ Controls

$A_{smin} = 1173.34 \text{ mm}^2 < A_{sreq} = 3386.3 \text{ mm}^2$

Use 11ø20 Bottom, $A_{s,provided}$= 3455.75 mm^2>$A_{s,required}$= 3386.3 mm^2 Ok

Check spacing: -

S $= \frac{800-40*2-20-(11\times20)}{10} = 48\ mm > d_b = 20 > 25\ mm$ OK

Check for strain: -

a $= \frac{A_s.f_y}{0.85b\,f_c'} = \frac{3455.75\times420}{0.85\times800\times24} = 88.93\ mm$

x$= \frac{a}{\beta_1} = \frac{88.93}{0.85} = 104.63\ mm$

$\varepsilon_s = 0.003\ \frac{d-x}{x} = 0.003\ \frac{440-104.63}{104.63} = 0.00962 > 0.005$ 0k

Flexural Design of Negative Moment for Beam :-(Mu=431.6 KN.m)

R$_n$$= \frac{M_u}{\emptyset b d^2} = \frac{431.6\times10^6}{0.9\times800\times440^2} = 3.1\ Mpa.$

m$= \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

ρ$= \frac{1}{m}\ 1-\sqrt{1-\frac{2.m.R_n}{420}} = \frac{1}{20.6}\ 1-\sqrt{1-\frac{2\times20.6\times3.1}{420}} = 0.00804$

A_s = ρ.b.d = 0.00804×800×440 = 2827.22 mm^2.

Check for $A_{s,min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*800*440$ = 1026.45 mm^2

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*800*440$= 1173.34 mm^2 Controls

A_{smin} = 1173.34 mm^2 < A_{sreq} = 2827.22 mm^2

Use 9ø20 Bottom, $A_{s,provided}$= 2827.43 mm^2>$A_{s,required}$= 2827.22 mm^2 Ok

Check spacing: -

S $= \frac{800-40*2-20-(9\times20)}{8} = 65\ mm > d_b = 20 > 25\ mm$ OK

Check for strain: -

a =$\frac{A_s f_y}{0.85b\,f_c'}=\frac{2827.43\times420}{0.85\times800\times24}=72.76\ mm$

x=$\frac{a}{\beta_1}=\frac{72.76}{0.85}=85.6\ mm$

$\varepsilon_s=0.003\ \frac{d-x}{x}\ =0.003\ \frac{440-85.6}{85.6}\ =0.0124>0.005$ 0k

- ✓ **Shear Design for (B2(02)): -**

1. Case 3: -

for shear design, minimum shear reinforcement is required ($A_{v,min}$), Reinforcement.

Use stirrups (2 leg stirrups) ø 10/ 150 mm, $A_v = 2\times78.54 = 157.08\ mm^2$

V_u = 442.9 KN

$V_c=\frac{1}{6}\sqrt{fc'}b_w\,d==\ \frac{1}{6}\sqrt{24}*800*440*10^{-3}=287.40$KN

Φ V_c= 0.75*287.40=215.56 KN

Φ Vsmin≥ $0.75\ (\frac{1}{3})$ * bw * d = 0 .75* $(\frac{1}{3})$*800*440*10^{-3} = 88 KN Controls

Φ Vsmin ≥ $0.75\ (\frac{\sqrt{fc'}}{16})$ * bw * d = 0.75*$(\frac{\sqrt{24}}{16})$ * 800 * 440*10^{-3} = 80.83 KN

Φ Vc<Vu ≤ Φ Vc + Φ Vsmin

215.56<442.9 ≤ 303.56…… not satisfied

Cases 1&2&3 is not suitable

4. Case 4: -

$v_{s'}=\frac{1}{3}\ \sqrt{fc'}b_w\,d=\frac{1}{3}\sqrt{24}*\ 800*440$ = 574.81 KN

$\emptyset(v_c+\ v_{s,\min})<v_u\ \le\ \emptyset(v_c+\ v_{s'})$

$0.75(287.4 + 88) < 442.9 < 0.75(287.40 + 574.51)$

$281.55 < 442.9 < 646.45$

shear reinforcement is required

As =157.08 mm^2

$V_s = V_n - V_c = \frac{442.9}{0.75} - 287.40 = 303.14$ KN

$S = \frac{A_v f_{yt}\, d}{v_s} = \frac{157.08 * 420 * 440}{303.14 * 1000} = 95.76\ mm$ control

$s_{max} \leq \frac{d}{2} = \frac{440}{2} = 220\ mm \qquad or \qquad s_{max} \leq 600\ mm$

Use 4 leg Φ 10 @100mm.

4.7 Design of two way ribbed slab:

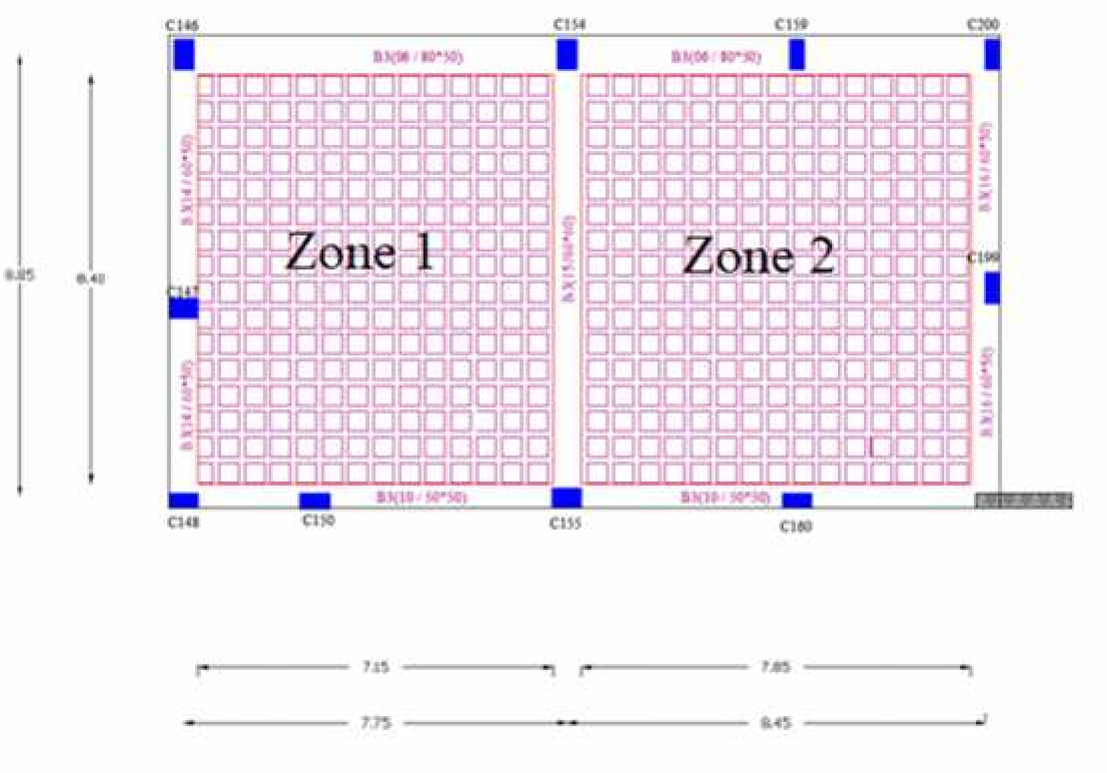


Fig (4-8): Statically system of tow way rib slab .

LL =5 KN/m^2 Fc' = 24 N/mm^2 Fy = 420 N/mm^2

- Tiles, 3 cm .
- Mortar,3 cm .
- Sand,7 cm .
- Plaster 2 cm, .
- Partitions, 1 KN/m^2 .

Minimum thickness (deflection requirements): Assume the thickness for the shown ribbed slab , h = 35 cm.

Check for the minimum thickness of the slab:

$$I_{B3(06)} = \frac{bh^3}{12} = \frac{80*50^3}{12} = 833333.33 \text{ cm}^4$$

$$I_{B3(14\&16)} = \frac{bh^3}{12} = \frac{60*50^3}{12} = 625\,000 \text{ cm}^4$$

$I_{B3(10)} = \frac{bh^3}{12} = \frac{50*50^3}{12}$ = 520833.33 cm^4

$I_{B3(15)} = \frac{bh^3}{12} = \frac{60*60^3}{12}$ = 625 000 cm^4

The moment of inertia for the ribbed slab is the sum of moment of inertia of T-section ribs within a distance (L/2 + bw)

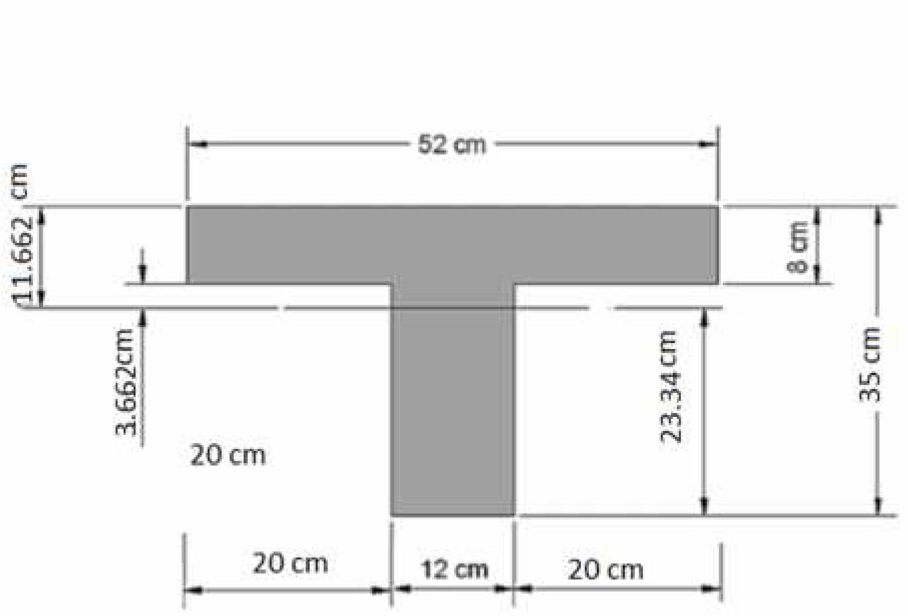


Fig (4-9): Detailing of section in two way rib slab .

be $= 52\ cm$

$$yc = \frac{40*8*4+12*35*17.5}{8*40+12*35} = 1280*\frac{7350}{740} = 11.662 \text{ cm}$$

$$I_{RIB} = \frac{52*11.66^3}{3} - \frac{2*20*3.66^3}{3} + \frac{12*23.34^3}{3} =$$

=27477.53 – 653.705 +50858.38

=77682.205 cm^4

Short direction , L=7.15 m =715 cm

$$I_s = \frac{I\ RIB*(\frac{L}{2}+bw)}{bf} = 77682.205*(814/2+60)/52 \quad = 623698.48\ cm^4$$

Long direction , L=8.4 m =840 cm

$$I_s = \frac{I\,RIB*(\frac{L}{2}+b\,w)}{bf} = 77682.205*(840/2+50)/52 \quad = 702127.622\ \text{cm}^4$$

Long direction , L=8.4 m =840 cm , b_w=80

$$I_s = \frac{I\,RIB*(\frac{L}{2}+b\,w)}{bf} = 77682.205*(840/2+80)/52 \quad = 746944.28\ \text{cm}^4$$

Short direction mid span L=715/2 + 60 +810 +785/2 =810 cm

$$Is = \frac{I\,RIB*L}{be} = 77682.205*810/52 = 1210049.73\ \text{cm}^4$$

$$\alpha_{f1} = \frac{I_{b(B3(14))}}{I_s\,\text{sh0rt}} = \frac{625000}{623698.48} = 1.002$$

$$\alpha_{f2} = \frac{I_{b(B3(11))}}{I_s\,\text{sh0rt}} = \frac{520833.33}{702127.622} = 0.742$$

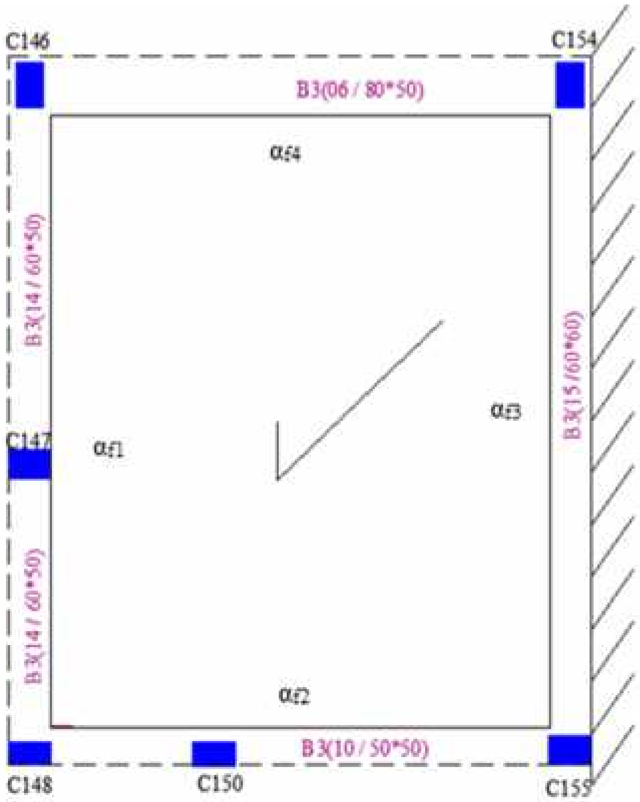
$$\alpha_{f3} = \frac{I_{b(B3(14))}}{I_s\,\text{sh0rt}} = \frac{10800000}{1210049.73} = 0.893$$

$$\alpha_{f4} = \frac{I_{b(B3(14))}}{I_s\,\text{sh0rt}} = \frac{833333.33}{746944.28} = 1.116$$

$$\alpha_{fm} = \alpha_{f1} + \alpha_{f2} + \alpha_{f3} + \alpha_{f4}/4$$

$$= 3.753/4 = 0.938$$

$$2 > 0.938 > 0.2$$



$$h = \frac{\text{Ln}(0.8+\frac{fy}{1400})}{36+5\beta(\alpha\text{fm}-0.2)} \geq 125$$

$$\beta = \frac{ln,long}{ln,short} = \frac{8.4}{17.15} = 1.175$$

$$h = \frac{8400(0.8+\frac{420}{1400})}{36+5*1.175(0.938-0.2)} = \frac{9240}{40.336} = 22.908\ cm < 35\ \text{cm} \quad \text{ok}$$

take slab thickness h slab = 35 cm

Topping = 8 cm

Hollow block = 27 cm

Load calculation:

Material	Quality Density KN/m3	
Tiles	23	0.03*0.52*0.52*23 =0.1866
mortar	22	0.03*0.52*0.52*22 =0.1785
Sand	17	0.07*0.52*0.52*17 =0.3218
Reinforced Concrete Topping	25	0.08*0.52*0.52*25 =0.541
Reinforced Concrete Rib	25	0.12*0.27*0.92*25 =0.7452
Concrete Block	10	0.4*0.4*0.0.27*10 =0.432
Plaster 1 KN/m2	22	0.02*0.4*0.0.27*10 =0.0.119
Partitions		1*052*052 = 0.2704
Total Dead Load,		2.795KN

Table (4-4): Dead Load calculation for two way rib slab.

Dead Load of slab:

DL = 2.795/0.52*0.52 = 10.338 KN/m^2

W_D = 1.2*10.338 = 12.406 KN/m^2

Live Load of slab:

LL = 5 KN/m^2

W_L = 1.6*5 = 8 KN/m^2

W_u = W_L+ W_D = 12.41+8 = 20.41 KN/m^2

Moment calculation:

Ma = Ca*W*L^2a*be , Mb = Cb*W*L^2b*be

La = 7.15 m , Lb = 8.4 m

La/Lb = 0.85

Case 6 :

Ca negative = 0.083 , Ca positive $_D$ = 0.042

Ca positive $_L$ = 0.046

Cb positive $_D$ = 0.017

Cb positive $_L$ = 0.022

Ma negative = Ca negative*W*L^{2}a*be

= 0.083*20.41*7.15^2*0.52 = 45.034 KN.m

Ma positive $_D$ = 0.042*12.41*7.15^2*0.52 = 13.86 KN.m

Ma positive $_L$ = 0.046*8*7.15^2*0.52 = 9.78 KN.m

Mb positive =13.86+9.78 = 23.64 KN.m

Mb positive $_D$ = 0.017*12.41*8.4^2*0.52 = 7.74 KN.m

Mb positive $_L$ = 0.022*8*8.4^2*0.52 = 6.46 KN.m

Mb positive = 7.74+6.46 = 14.2 KN.m

Ca negative (Zone 2)

m = 7.85/8.4 = 0.93 , Case 6

0.9 ----- 0.079
0.93 ----- Ca negative
0.95 ----- 0.075

$$\frac{Ca\ negative - 0.079}{0.93 - 0.9} = \frac{0.075 - 0.079}{0.95 - 0.9}$$

Ca negative = 0.0766

Ma negative=Ca negative*Wu*L^{2}a*be=0.0766*20.41*7.85^2*0.5 =50.1KN.m

Slab reinforcement :

Design of Negative Moment(Mu=50.1 KN.m):

Assume bar diameter Ø18 For main reinforcment

d = h – C – $d_{stirups}$ – d_{bar}/2 = 350 – 20 – 8 – 18/2 = 313 mm.

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{50.1\times10^6}{0.9\times120\times313^2} = 4.73\ Mpa.$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times4.73}{420}}\right) = 0.013$

$A_s = \rho.b.d = 0.013\times120\times313 = 488.28\ mm^2.$

Check for $A_{s,min}$:-

$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*120*313 = 109.5\ mm^2$

$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*120*313 = 125.2\ mm^2$ Controls

$A_{smin} = 125.2mm^2 < A_{sreq} = 488.28\ mm^2$

Use 2ø18 Bottom, $A_{s,provided}$= 508.68 mm^2>$A_{s,required}$= 488.28 mm^2 Ok

Check for strain: -

$a = \frac{A_s.f_y}{0.85 b f_c'} = \frac{508.68\times420}{0.85\times120\times24} = 87.3\ mm$

$x = \frac{a}{\beta_1} = \frac{87.3}{0.85} = 102.7\ mm$

$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{313-102.7}{102.7}\right) = 0.0061 > 0.005$ 0k

Design of positive Moment(Mu=23.64 KN.m):

Assume bar diameter Ø14 For main reinforcment

$d = h - C - d_{stirups} - d_{bar}/2 = 350 - 20 - 8 - 14/2 = 315\ mm$

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{23.64\times10^6}{0.9\times520\times315^2} = 0.51\ Mpa.$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.6$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times0.51}{420}}\right) = 0.00123$$

$A_s = \rho.b.d = 0.00123\times520\times315 = 201.5\ mm^2$.

Check for $A_{s,min}$:-

$$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*120*315 = 110.23\ mm^2$$

$$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*120*315 = 126\ mm^2 \qquad \text{Controls}$$

$A_{smin} = 126\ mm^2 > A_{sreq} = 201.5\ mm^2$

Use 2ø12 Bottom, $A_{s,provided}$= 226.1 mm^2> A_{smin} = 201.5x mm^2 Ok

Check for strain: -

$$a = \frac{A_s.f_y}{0.85b\ f_c'} = \frac{226.1\times420}{0.85\times520\times24} = 8.95\ mm$$

$$x = \frac{a}{\beta_1} = \frac{8.95}{0.85} = 10.53mm$$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{315-10.53}{10.53}\right) = 0.0867 > 0.005 \qquad 0k$$

Design of positive Moment(Mu=14.2 KN.m):

Assume bar diameter Ø14 For main reinforcment

$d = h - C - d_{stirups} - d_{bar}/2 = 350 - 20 - 8 - 14/2 = 315$ mm

$$R_n = \frac{M_u}{\phi bd^2} = \frac{14.2\times10^6}{0.9\times520\times315^2} = 0.306Mpa.$$

$$m = \frac{f_y}{0.85f_c'} = \frac{420}{0.85\times24} = 20.6$$

$$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.6}\left(1-\sqrt{1-\frac{2\times20.6\times0.306}{420}}\right) = 0.000734$$

$A_s = \rho.b.d = 0.000734\times520\times315 = 120.25\ mm^2$.

Check for $A_{s,min}$:-

$$As_{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420}*120*315 = 110.23 \text{ mm}^2$$

$$As_{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420}*120*315 = 126 \text{ mm}^2 \qquad \text{Controls}$$

$A_{smin} = 126$ mm^2 > $A_{sreq} = 120.25$ mm^2

Provide $A_{smin} = 126$ mm^2

Use 2ø12Bottom, $A_{s,provided}$= 226.1 mm^2> A_{smin} = 126 mm^2 Ok

Check for strain: -

$$a = \frac{A_s f_y}{0.85 b f_c'} = \frac{226.1\times420}{0.85\times520\times24} = 8.95\ mm$$

$$x = \frac{a}{\beta_1} = \frac{8.95}{0.85} = 10.53mm$$

$$\varepsilon_s = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{315-10.53}{10.53}\right) = 0.0867 > 0.005 \qquad 0k$$

Design for shear:

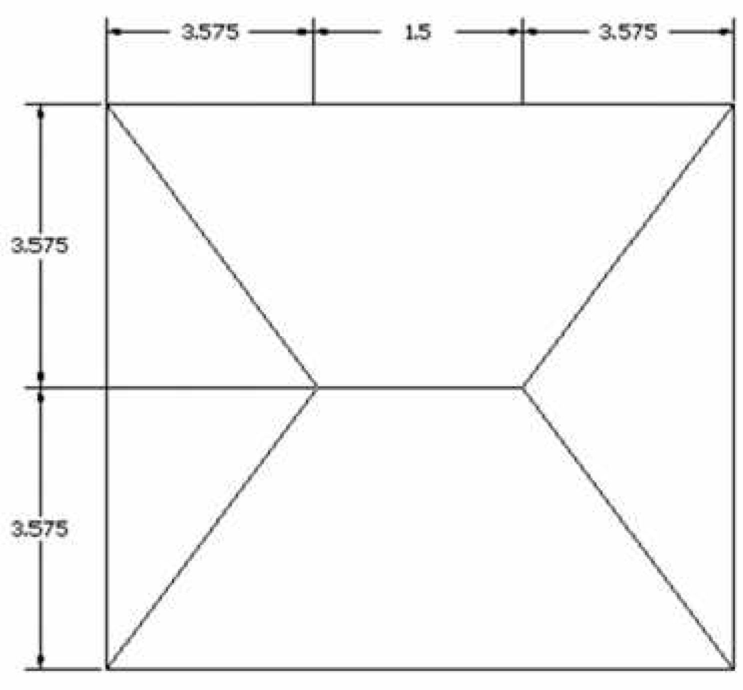


Fig (4-10): Load distribution .

The shear in the slab can be Calculated using tributary area for shear (as simply supported 1m strip)

Vu_d = Wu*be((Ln/2)-d) = 20.41*0.52((7.15/2)-0.315) = 34.6 KN

$øVc = \frac{1.1}{6}\ \overline{f'c}*bw*d = 0.75*\frac{1.1}{6}*\sqrt{24}*120*315*10^{-3} = 25.46$ KN

øVc = 25.46 KN < Vu_d = 34.6 KN

$Vsmin \geq \ (\frac{1}{3}) * bw * d = (\frac{1}{3})*120*315*10^{-3} = 12.6$ KN   Controls

$Vsmin \ \geq \ (\frac{\sqrt{fc'}}{16}) * bw * d = (\frac{\sqrt{24}}{16}) * 120 * 315*10^{-3} = 11.57$ KN

Φ Vc = 25.46 KN <Vu = 34.6 KN ≤ (Φ Vc + Φ Vsmin) = 34.91 KN

Use 2 leg Φ8

As =157.08 mm^2

$$\frac{Av\ min}{s} = \frac{1}{3}*\frac{bw}{fy} = \frac{1}{3}*\frac{120}{420} = \frac{2*50}{s}\ mm$$

S = 1050 mm

$$s_{max} \leq \frac{d}{2} = \frac{315}{2} = 157.5\ mm \qquad or \qquad s_{max} \leq 600\ mm$$

Use 2Φ8 @ 12.5 cm   c/c .

4.8 Design of column:

DL = 3862.8 KN   Fy = 420 MPa

Ll = 1731.KN $F'c$ = 28 MPa

Length of columm = 3.7 m

Check Tybe Of Column

$$\frac{K\,Lu}{r} = \frac{1 * 3.7}{0.3 * 0.60} = 20.55 < 22 \quad \text{Short column}$$

Pu = 1.2*3862.8 + 1.6*1731.5 = 4653.36 + 2770.4 = 7405.7 KN

Assume $0.01 \leq \rho g = \frac{Ast}{Ag} \leq 0.08$, $\rho g = 0.0$, $Ast = \rho g * Ag = 0.02\, Ag$

Selecting column dimension

$\Phi Pn = Pu = \Phi*0.8*(0.85*F'c*(Ag-Ast)+Ast*Fy)$, $\Phi = 0.65$ for tied column

$= 7405.76 = 0.65*0.8*(0.85*28(Ag- 0.02*Ag)+0.02Ag*420)$

$Ag = \frac{7405.76}{17.526} = 422558.48\ mm^2$, $Ag = 500 * b = 422558.48$

b = 845.12 mm^2

Try   a = 500 mm , b = 800 mm

A = 500*800 = 400000 mm^2

Selecting longitudinal bars

$7405.76*10^{-3} = 0.65*0.8(0.85*28(400000-Ast)+A_{st}*420)$

$A_{st} = 11917.83\ mm^2$

Use 20Φ28 with $A_{st} = 12315.04\ mm^2 > A_{st\ req} = 11917.83\ mm^2$

$\rho g = A_{st}/A_g = 12315.04/500*800 = 0.03$

Design of ties :

Use ties Φ10 with spacing shall not exceed the smallest of

1. $48d_{sirips}$ = 48*10 = 480 mm
2. $16d_{bar}$ = 16*28 = 448 mm control
3. Smallest dimension of column = 500 mm

Use Φ10 @ 400 mm .

Check for code required :

Clear space :

1. Clear spacing in X direction:

$$\frac{800 - 40.2 - 10.2 - 28 * 7}{6} = 84\ mm$$

84 mm > 40 mm > $1.5d_{bar}$ = 1.5*28 = 28 mm ok

2. Clear spacing in Y direction:

$$\frac{500 - 40.2 - 10.2 - 28 * 5}{4} = 66\ mm$$

66 mm > 40 mm > $1.5d_{bar}$ = 1.5*28 = 28 mm ok

3.Cross Reinforcement Ratio :

$0.01 < \rho g\ 0.03 < 0.08$ ok

4. Number of bar 20 > 4 for rectangular section

5. Minimum tie diameter Φ10 for Φ28 bars ok

6. Spacing of ties S = 400 ok

7. Arrangement of ties 84 mm

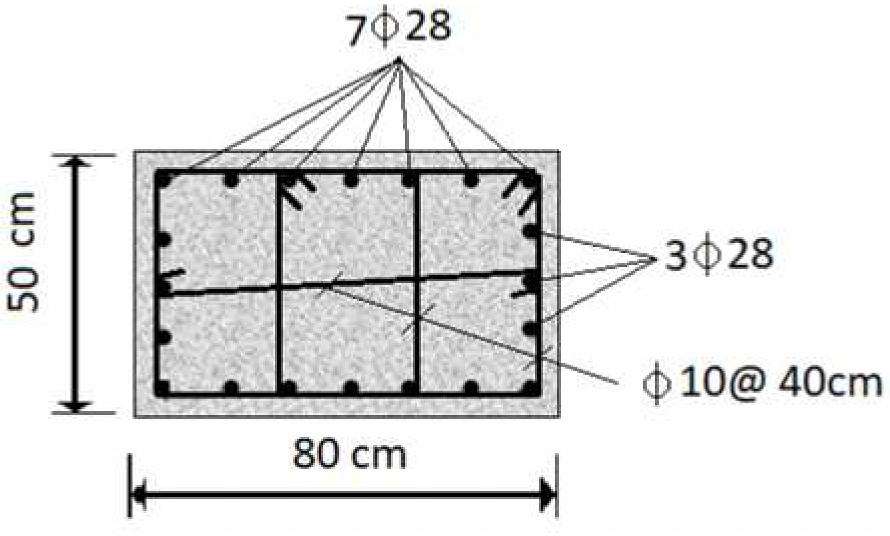


Fig (4-11): Reinforcement and detailing of column .

4.9 Design of Basement Wall:

Fc’ = 24 Mpa

Fy = 420 Mpa

$\emptyset = 35°$ $\gamma = 19 \mathrm{KN/m^3}$

$\mathrm{Ko} = 1 - \sin \emptyset$

$= 1 - \sin 35 = 0.426$

Load on basement wall:

For 1m length of wall.

* Weight of backfill:

Due to soil pressure at rest , p. = C.* W * h = 0.426 * 19 * 4 = 32.37 $\mathrm{KN/m^2}$

And H.= p. * h / 2 = 32.37 * 4 / 2 = 64.47 $\mathrm{KN/m^2}$.

Due to surcharge P_s=C.* W_s = 0.426 * 5 = 2.13 $\mathrm{KN/m^2}$

And H_s= p_h * h = 32.37 * 4 = 8.52 $\mathrm{KN/m^2}$.

H. : is due to a rectangular loading , whereas H_s is due to uniform loading .

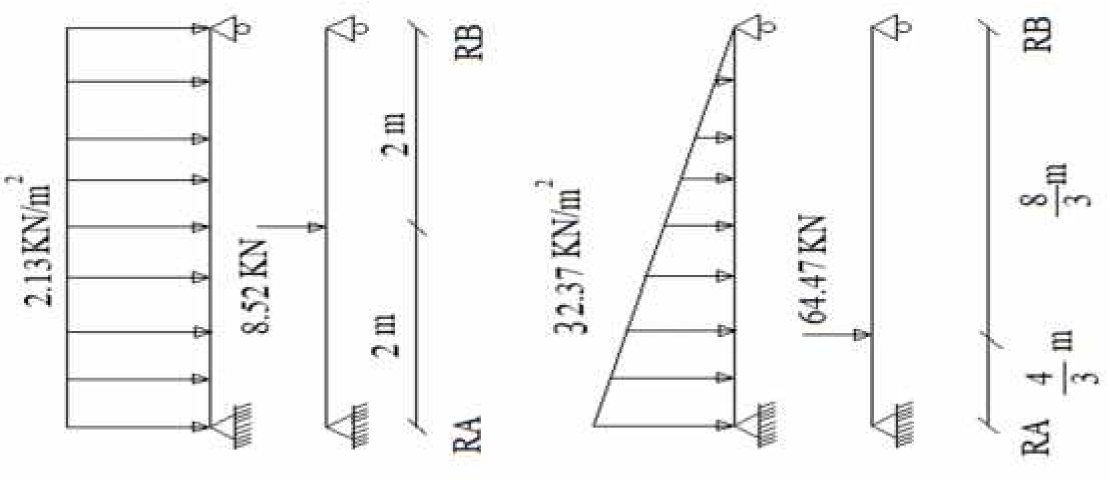


Figure (4-12): Load of basement wall .

Factored reactions:

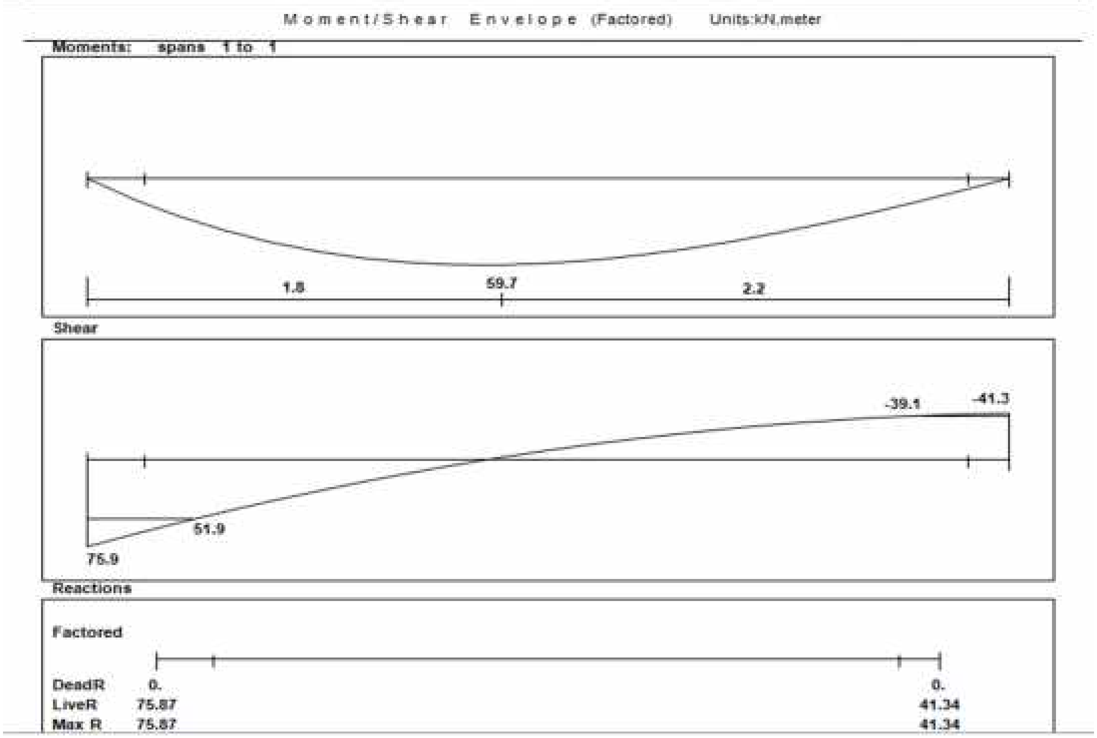


Fig (4-13): Shear and Moment Diagram of basement wall.

RA=1.6((8.52/2)+(2*64.47/3))=75.58 KN

RB=1.6((8.52/2)+(64.47/3))=41.2 KN

Max positive bending moment within the span accurse at the section of zero shear .

Vu=41.2-1.6(2.13*X)-1.6*0.5*32.37*X*X/4 =0

$6.47X^2 + 3.41X - 41.2 = 0$

$$X = \frac{-3.41 \pm \sqrt{3.41^2 - 4*6.47*-41.2}}{2*6.47}$$

X = 2.73 , X=2.8

Design of bending moment:

$Mu = 41.2*2.24 – 3.41*2.27*0.5 – 2.27^2*6.47/3 = 59.51$ KN.m.

Wall thickness is 25 cm , assuming Ø18 for bar diameter.

d = 165 mm

Take Ø = 0.9 for flexure

For Mu = 59.1 KN/m

$$R_n = \frac{59.51*10^6}{0.9*1000*165^2} = 2.4MPa.$$

$$m \;\; = \frac{fy}{0.85\times fc'} = 20.59$$

$$\circ \; = \frac{1}{m}\left(1-\sqrt{1-\frac{2mM_n}{f_y}}\right) = \frac{1}{20.59}\left(1-\sqrt{1-\frac{2*20.59*2.4}{420}}\right) = 0.00609$$

As_{req} = 0.006.9*1000*166 = 1011.9 mm^2/m

$As\,\mathrm{min} = \frac{0.25\sqrt{f_c'}}{fy}.bw.d = 550$ mm^2/m

$As\,\mathrm{min} = \frac{1.4}{fy}.bw.d = 481.5$ mm^2/m

$Asreq \;\; > \;\; As\,\mathrm{min}$, ok

$$m \;\; = \frac{Asreq}{As20mm} = \frac{1011.9}{254.47} = 3.97$$

S = 0.251

Try Ø18 @ 25 $cm\ or$ 4Ø18/m.

Check if thickness is equate enough

Assume initial thickness = 25 cm

Vu = 75.58 KN

Ø = 0.75 $reduction\ factor\ of\ shear$

$$¤Vc = \frac{¤\sqrt{f_c'}*b_w*d}{6}$$

Assume reinforcement bars are Ø20

$$\mathrm{d} = 200 - 75 - \frac{20}{2} = 115\ \mathrm{mm}$$

$$¤Vc = \frac{0.75\sqrt{24} * 1000 * 115}{6} = 70.422\ \mathrm{KN}$$

Vu <¤Vc , Thickness is not enough

Try 25 cm thickness

$$\mathrm{d} = 250 - 75 - \frac{20}{2} = 166\ \mathrm{mm}$$

$$¤Vc = \frac{0.75\sqrt{24} * 1000 * 166}{6} = 101.04\ \mathrm{KN}$$

¤Vc > Vu , ok

¤$Vc / 2 = 50.52KN$

Design of the horizontal reinforcement:

Longitudinal reinforcement : use a minimum steel ration of 0.002 (ACI code , section 14.3) or use Ø12 bars spaced at 25 cm for each side of the wall.

Asmin $= 0.002 * \mathrm{b} * \mathrm{h} = 0.002 * 1000 * 250 = 500\mathrm{mm}^2/\mathrm{m}$

SelectØ12@250mm/m in two layer.

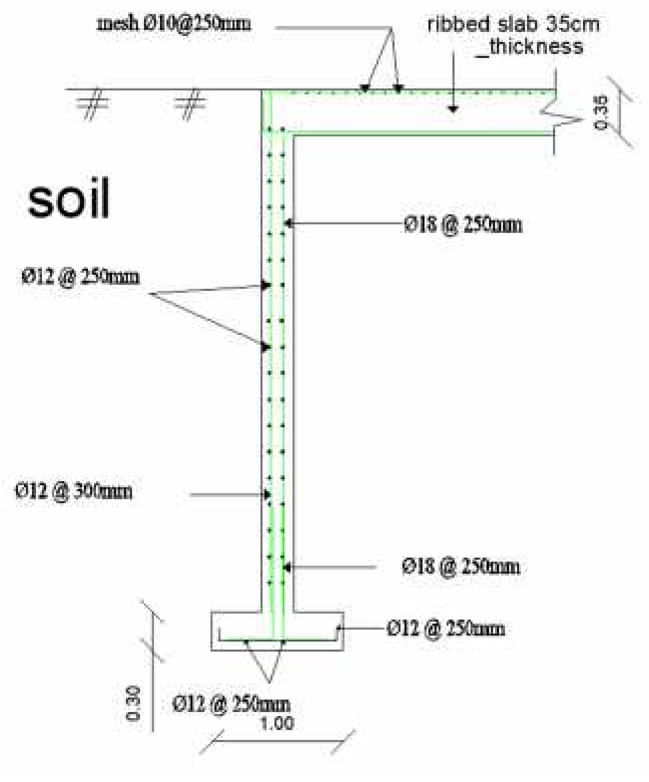


Fig (4-14): Reinforcement of Basement wall.

4.10 Design of stair:

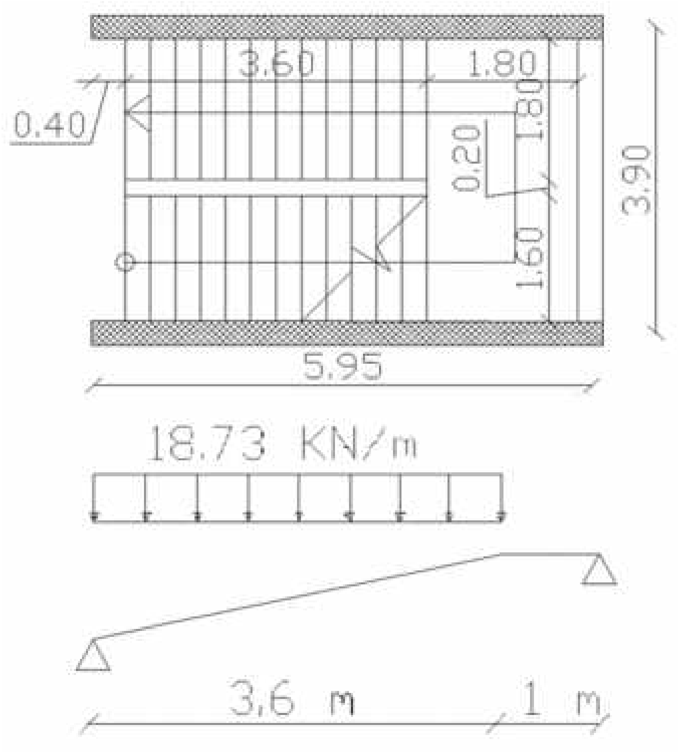


Figure (4-15): Top view of stair and static system.

Determination of Slab Thickness:

L = 4.6m.

h_{req} = 4.6/ 20 = 23

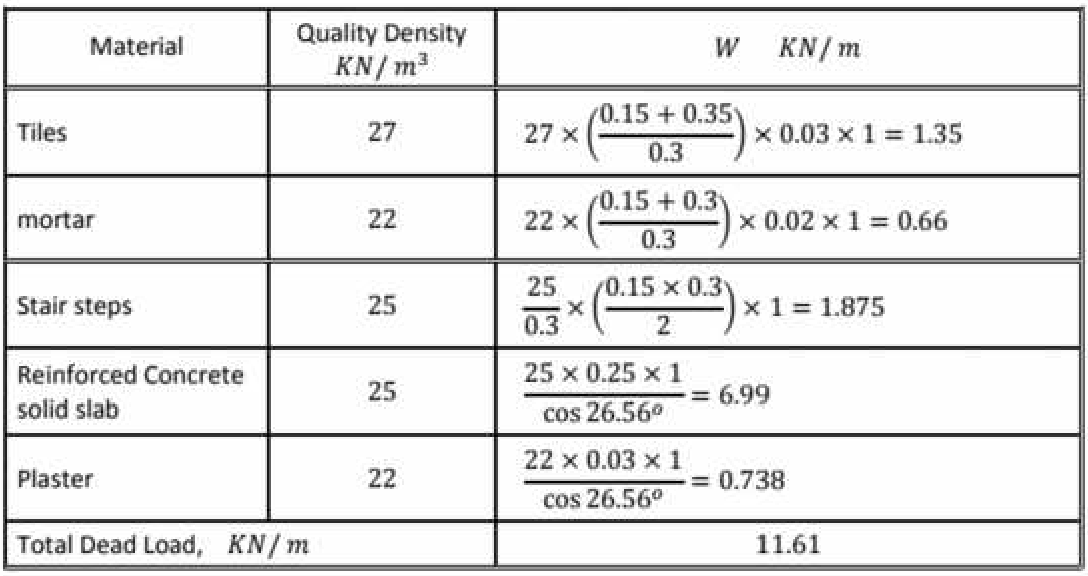
Use h = 25cm.

$\theta = \tan^{-1}(150/ 300) = 26.565$

Load Calculations at section :

Load on Flight:

Dead Load for 1m strip:

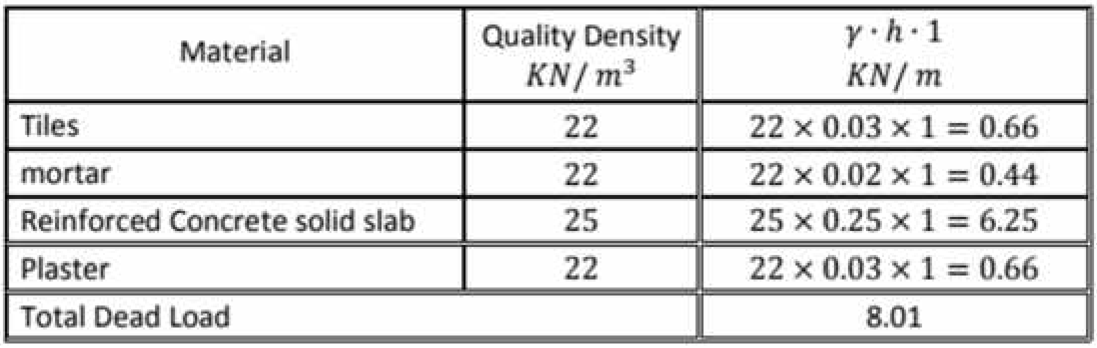


Material	Quality Density KN/m^3	$W \quad KN/m$
Tiles	27	$27 \times \left(\frac{0.15+0.35}{0.3}\right) \times 0.03 \times 1 = 1.35$
mortar	22	$22 \times \left(\frac{0.15+0.3}{0.3}\right) \times 0.02 \times 1 = 0.66$
Stair steps	25	$\frac{25}{0.3} \times \left(\frac{0.15 \times 0.3}{2}\right) \times 1 = 1.875$
Reinforced Concrete solid slab	25	$\frac{25 \times 0.25 \times 1}{\cos 26.56^o} = 6.99$
Plaster	22	$\frac{22 \times 0.03 \times 1}{\cos 26.56^o} = 0.738$
Total Dead Load, KN/m		11.61

Table (4-5): Load calculation for flight.

Load on landing:

Dead Load:



Material	Quality Density KN/m^3	$\gamma \cdot h \cdot 1$ KN/m
Tiles	22	$22 \times 0.03 \times 1 = 0.66$
mortar	22	$22 \times 0.02 \times 1 = 0.44$
Reinforced Concrete solid slab	25	$25 \times 0.25 \times 1 = 6.25$
Plaster	22	$22 \times 0.03 \times 1 = 0.66$
Total Dead Load		8.01

Table (4-6): Load calculation for landing.

Live load:

Live load for stairs = 3 KN/ m^2 , from Jordan code of loads .

Factor Loads:

W= 1.2*11.61+1.6*3*1= 18.73 KN/ m.

W= 1.2*8.01+1.6*3*1= 14.41 KN/ m.

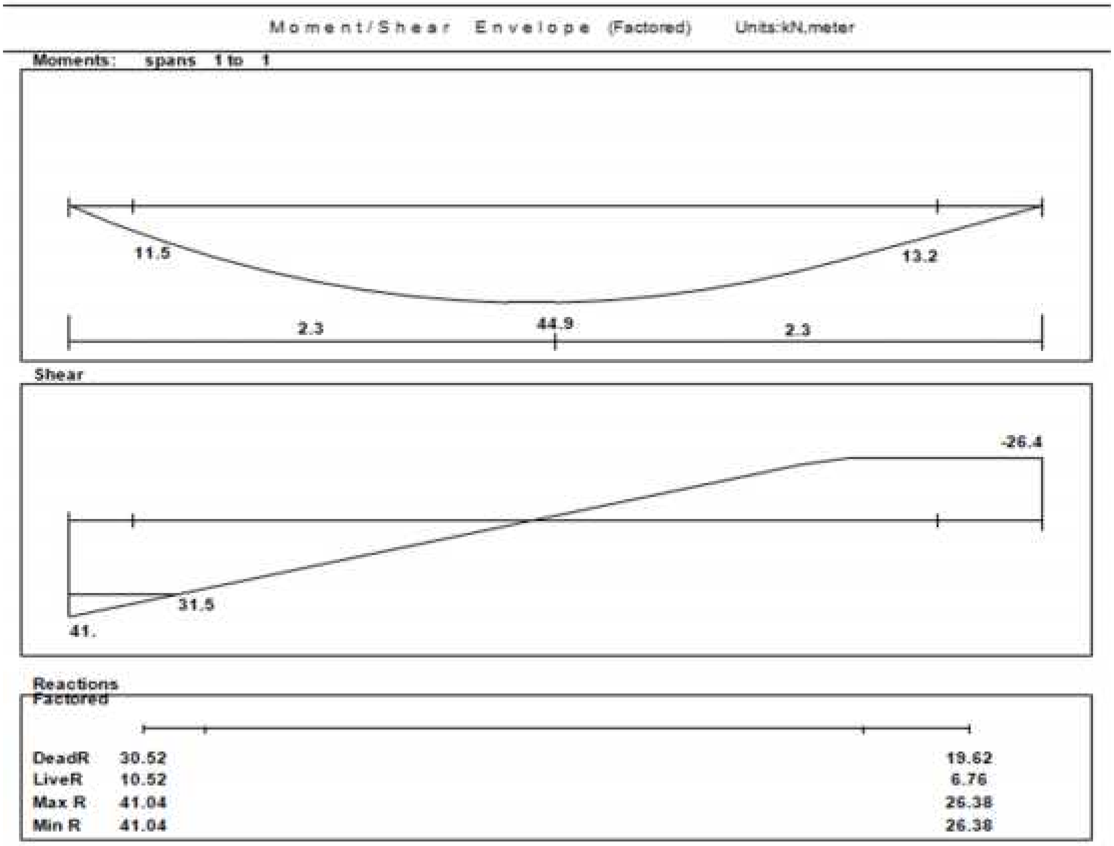


Fig (4-16): Shear and Moment Diagram of stair.

Design of Shear:

Assume Ø 14 for main reinforcement: -

d = 250-20 -14\2 = 223 mm

Take max shear as the support reaction

Vu = 41.04 KN

$$\text{¤}Vc = \frac{\text{¤}\sqrt{f_c'} * b_w * d}{6}$$

$$\text{¤}Vc = \frac{0.75 * \sqrt{24} * 1000 * 223}{6} = 136.56 KN / m$$

Vu = 41.04 KN<¤Vc /2 = 68.3 KN.

No shear Reinforcement is required. So the depth of the stair is OK.

Design of Bending Moment:

Max Mu = $18.73*(\frac{2.19*2.19}{2}) - 41.04 * 2.19 = 44.9$ KN.m.

Mn= $\frac{Mu}{0.9} = \frac{44.9}{0.9} = 49.9 KN.m/m$

Assume Ø 14 for main reinforcement: -

d = 250-20 -14\2 =223 mm

$$K_n = \frac{Mn}{b \cdot d^2}$$

$$Kn = \frac{49.9*10^6}{1000*223^2} = 1MPa \ .$$

$$m = \frac{fy}{0.85 \times fc'}$$

$$m = \frac{420}{0.85 \times 24} = 20.6$$

$$\circ = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mk_n}{f_y}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2*20.6*1}{420}}\right) = 0.00244$$

As_{req} = 0.00244*1000*223 = 544.6 mm^2/m

$$As_{\min} = 0.0018 * b * h = 0.0018 * 1000 * 250 = 450 mm^2$$

$As_{\min}$ = 450mm $\leq As_{req}$ = 544 mm^2

Use Φ 14@ 25 cm

As provided = 616 mm^2 > As req.

Step smallest of :

1. 3h = 3*250 = 750 mm

2. 450 mm

3. $S = 380*\frac{280}{fs} – 2.5Cc = 380*\frac{280}{\frac{2}{3}*420} – 2.5*20 = 330$ mm   Control

$S = 380*\frac{280}{fs} = 380$ mm

S = 250 mm < Smax = 330 mm

Shrinkage and temperature reinforcement

As = 0.0018*250*1000 = 450 mm^2

$n = \frac{450}{113.1} = 3.98$

$S = \frac{1}{n} = \frac{1}{3.98} = 0.251$ m

Take 4 Φ 12 /m , As = 452.4 mm^2/m

Step for shrinkage :

1. S = 5h = 5*250 = 1250 mm

2. S = 450 mm   Control

S = 300 mm < S = 450 mm , ok

Design of landing:

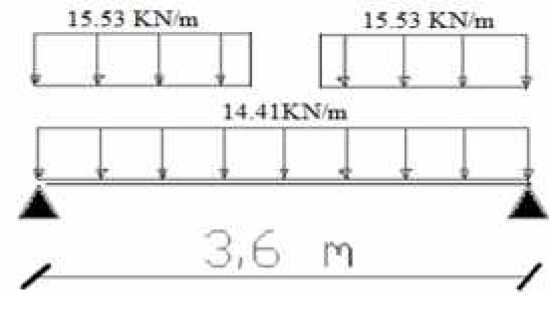


Fig (4-17): Landing load.

Design of Shear:

Reaction at each support

R = (14.412*3.6/2) + (16.5*1.7) = 54 KN

Check for shear strength

Assume Φ 14 for main reinforcement

d = 250-20-14/2 = 223 mm

Tack max shear as the support reaction

Vu = 54 KN

$$¤Vc = \frac{0.75 * \sqrt{24} * 1000 * 223}{6} = 136.56 KN/m$$

Vu max = 54 KN <¤*Vc* /2 = 68.3 KN.

Design of Bending Moment:

Mu = 54*1.8-14.41*$\frac{1.8*1.8}{2}$-16.5*1.7*$\frac{1.7}{2}$ + 0.1 = 47.12 KN.m/m

Mn = Mu / 0.9 =47.12 / 0.9 = 52.36 KN.m.

d = 223 mm.

$$K_n = \frac{Mn}{b \cdot d^2}$$

$$k_n = \frac{52.36 * 10^6}{1000 * 223^2} = 1.05 MPa \ .$$

$$m = \frac{fy}{0.85 \times fc'}$$

$$m = \frac{420}{0.85 \times 24} = 20.6$$

$$° = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2mM_n}{f_y}}\right) = \frac{1}{20.6}\left(1 - \sqrt{1 - \frac{2 * 20.6 * 1.05}{420}}\right) = 0.00257$$

As_{req} = 0.00257*1000*223 = 572.64 mm^2

$$As_{\min} = 0.0018 * b * h = 0.0018 * 100 * 250 = 450 \, mm^2$$

$As_{\min}$ = 450 $mm^2 <$ As_{req} = 572.64 mm^2

Use Φ 12

$n = \frac{As}{As\Phi 12} = \frac{572.64}{113.1} = 4.6$

$S = \frac{1}{n} = \frac{1}{4.6} = 0.217$ m

Use Φ 12@ 20 cm

$As_{provided} = 565.5\ mm^2 > As = 572.64\ mm^2$

Step smallest of :

1. 3h = 3*250 = 750 mm

2. 450 mm

3. $S = 380*\frac{280}{fs} - 2.5Cc = 380*\frac{280}{\frac{2}{3}*420} - 2.5*20 = 330$ mm   Control

$S = 380*\frac{280}{fs} = 380$ mm

S = 250 mm < Smax = 330 mm

Shrinkage and temperature reinforcement

As = 0.0018*250*1000 = 450 mm2

n = 450/113.1 = 3.98

S = 1/n = 1/3.98 = 0.251 m

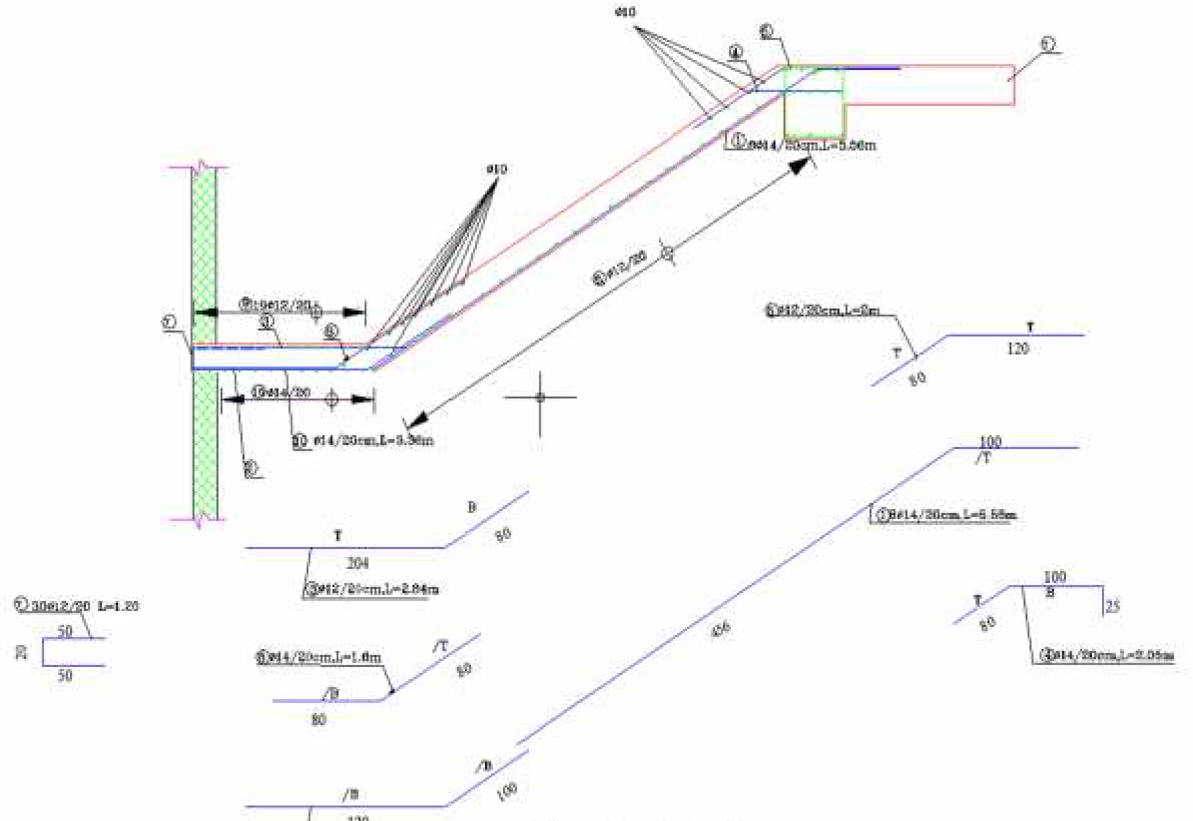
Take 4 Φ 12 /m , As = 452.4 mm2/m

Step for shrinkage :

1. S = 5h = 5*250 = 1250 mm

2. S = 450 mm   Control

S = 300 mm < S = 450 mm   , ok



Section (A-A)

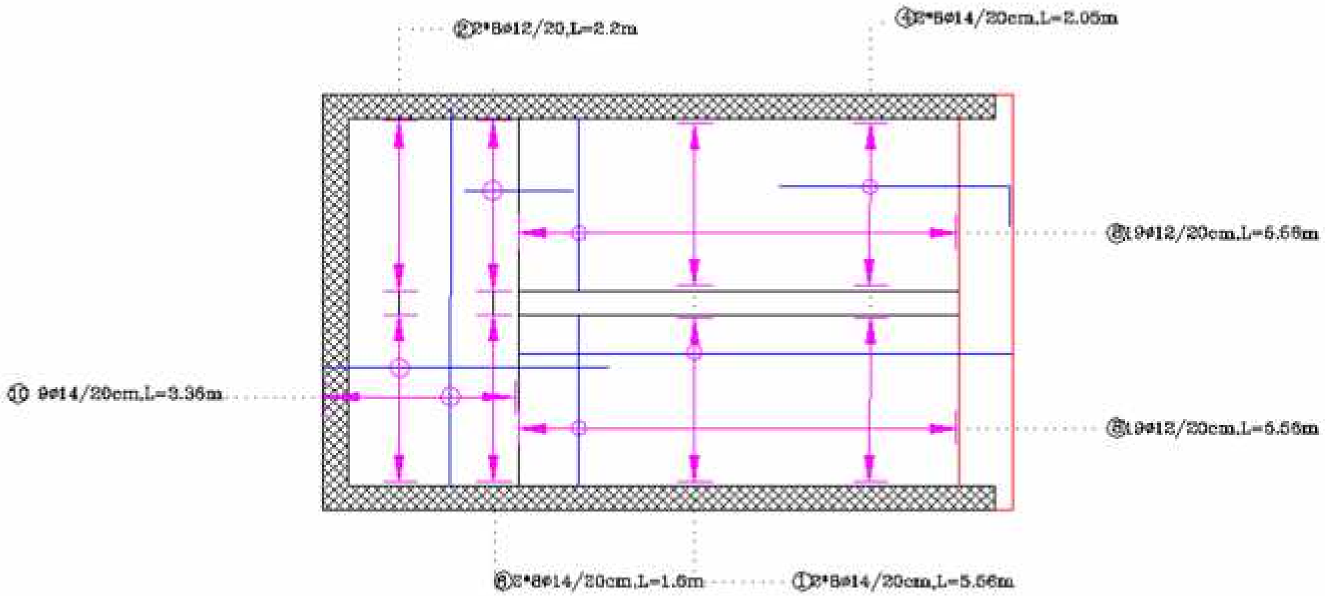


Figure (4-18): Reinforcement for stairs.

4.10 Design of isolated footing :

Service dead load = 3863.8 KN

Service live load = 1731.5 KN

Service surcharge = 5 KN

Permissible (allowable) soil pressure = 300 KN/m^2

Soil density = 19 KN/^{3}

Assume h of footing = 40 cm

$q_{a\ net}$ = 300 – 1.2*19 – 0.4*25 – 5 = 262.2 KN/m^2

A = $\frac{Pn}{\text{qa net}} = \frac{2862.8+1731.5}{262.2} = 17.52$ m^2

A = L^2 , L = $\sqrt{A}$ = $\sqrt{17.52}$ = 4.18 m

Take L = 4.2 m

Depth of footing and shear:

Pn = 7405.76 KN

q_u = 7405.76/4.2*4.2 = 419.83 KN/m^2

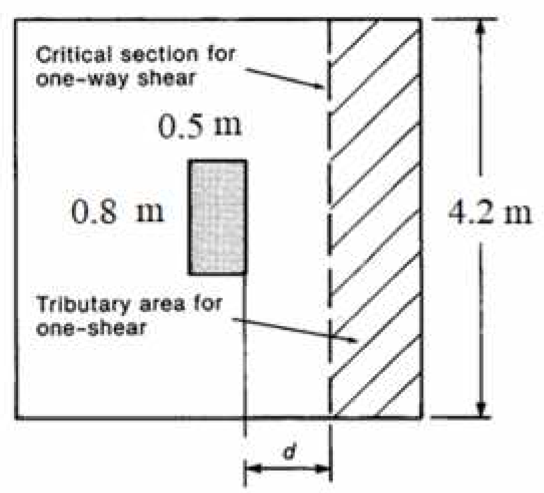
One way shear :

Vu at distance d from face of support

Vu = qu*b(L/2 -a/2 -d)= 419.83*4.2(4.2/2 -0.8/2 - d)

Let Vu = $\emptyset Vc$ ($\emptyset = 0.75$)

$$V_c = \frac{1}{6}\sqrt{f_c'}bw\,d = \frac{1}{6}\sqrt{24} * 4200 * d$$



(419.83*4.2)/(0.75)*(4.2/2 -0.8\2 –d) =3704.05*d

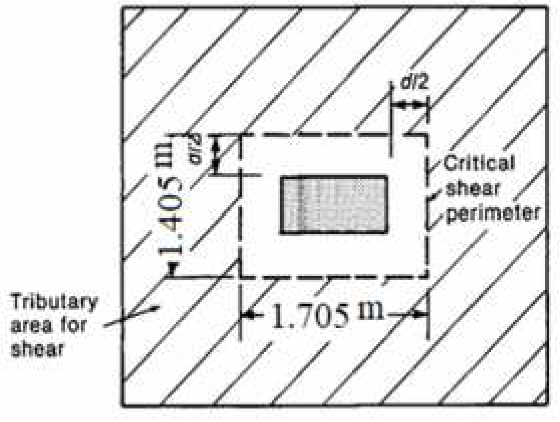
2351.78 (2.1 – 0.4 - d)= 3704.05*d

d = 3996.78/6055.1 = 0.66 m

Assume cover 75 mm, and steel bars of $\emptyset 20$

The d average will be used

h = 660 + 75 + 20 = 665 mm



Two way shear:

Let Vu = $\emptyset Vc$ ($\emptyset = 0.75$)

Vu = 419.83 (4.2*4.2 –(05+d)*(0.8+d)

= 419.83(17.64 – (1.165 * 1.465))

Vu = 6689.27 KN

β = 800/500 = 1.6

b_0 = 2(0.8+0.665) + 2(0.5 + 0.665) = 2.39 + 2.33 = 5.26 m

α_s = 40 - interior column

Vc = 1/6 (1 + 2/β) 1/6(1+ 2/1.6)

Vc = 1/12 ($\alpha_{s\,*\,d}$ / b_0) 1/12 (40 * 0.665/ 5.26 + 2) = 0.588

Vc = 1/3 $\sqrt{f'c}$ * b_0 * d 1/3 = 0.3333 - control

Take Vc = 1/3 $\sqrt{f'c}$ * b_0 * d

Vc = 1/3 *$\sqrt{28}$ * 5260 *665*10 $^{\wedge 3}$ = 6169.7 KN

$\emptyset Vc$ = 4627.28 < Vu = 6689.27 KN NOT OK

Take h = 1000 mm

d = 1000 – 75 -20 =905 mm

b_0 = 2(0.8+0.905) + 2(0.5 + 0.905) = 3.41 + 2.81 = 6.22 m

α_s = 40 - interior column

Vc = 1/6 (1 + 2/β) 1/6(1+ 2/1.6) = 0.375

Vc = 1/12 ($\alpha_{s\,*\,d}$ / b_0) 1/12 (40 * 0.905/ 5.26 + 2) = 0.567

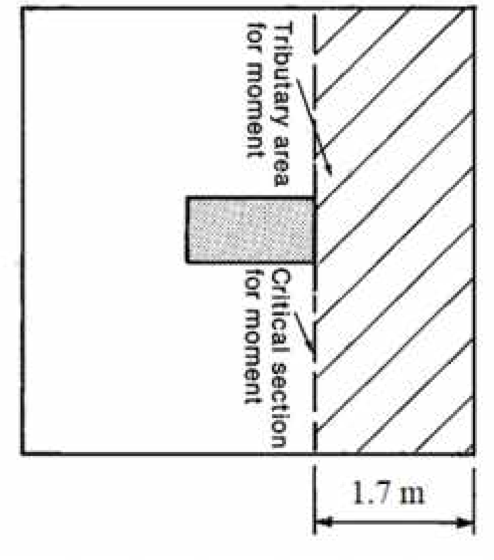
Vc = 1/3 $\sqrt{f'c}$ * b_0 * d 1/3 = 0.3333 - control

Take Vc = 1/3 $\sqrt{f'c}$ * b_0 * d

Vc = 1/3 *$\sqrt{28}$ * 6220 *905*10 $^{\wedge 3}$ = 10567.3 KN

$\emptyset Vc$ = 7925.48 KN > Vu = 6689.27 KN OK

Design for flexure in short direction:



Take steel bars of $\emptyset 20$

d = 1000 -75 -20 = 905 mm

Mu = 419.83 * 4.2 *1.7 *1.7/2 = 2547.95 KN. M

$$Rn = \frac{M_u}{\emptyset bd^2} = \frac{2547.95 \times 10^6}{0.9 \times 4200 \times 905^2} = 0.823\ Mpa$$

$$m = \frac{fy}{0.85 f_c'} = \frac{420}{0.85 \times 28} = 17.64$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) =$$

$$\frac{1}{17.64}\left(1 - \sqrt{1 - \frac{2 \times 17.64 \times .823}{420}}\right) = 0.001995$$

$A_s = \rho.b.d = 0.001995 \times 4200 \times 905 = 7584.61\ mm^2$

$As_{\min} = 0.0018 * b * h = 0.0018 * 4200 * 1000 = 7560\ mm^2$

$As_{\min}$ = 7560 mm^2 < As_{req} = 7584.61 mm^2

Use 25 Φ 20 with A_s = 7853.98 mm^2

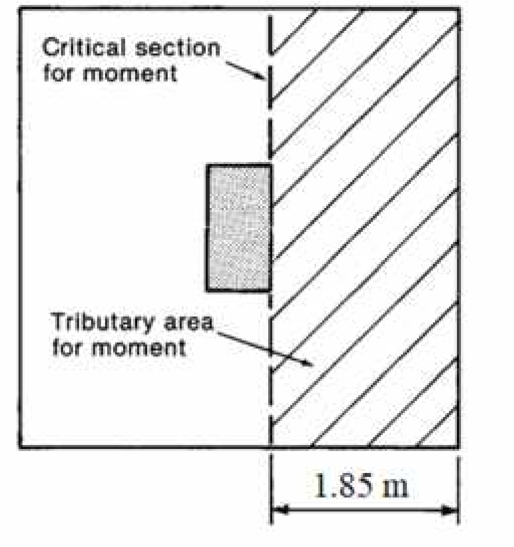
S = 4200 – 75*2 -25*20 /24 = 147.91 mm

Step is the smallest of :

1. 3h = 3*1000 = 3000 mm
2. 450 mm - control

S = 147.91mm < Smax = 450 mm ok

Design for flexure in long direction:



Take steel bars of Ø20

d = 1000 -75 -20 = 905 mm

Mu = 419.83 * 4.2 *1.85 *1.85/2 = 3017.42KN. M

$$Rn = \frac{M_u}{\emptyset b d^2} = \frac{3017.42 \times 10^6}{0.9 \times 4200 \times 905^2} = 0.0974\ Mpa$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 28} = 17.64$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{17.64}\left(1 - \sqrt{1 - \frac{2 \times 17.64 \times 0.974}{420}}\right) = 0.00237$$

$A_s = \rho.b.d = 0.00237 \times 4200 \times 905 = 9008.9\ mm^2$

$As_{min} = 0.0018 * b * h = 0.0018 * 4200 * 1000 = 7560\ mm^2$

$As_{min} = 7560\ mm^2 < As_{req} = 9008.9\ mm^2$

Use 19 Φ 25 with A_s = 9326.6 mm^2 > As_{min} =7560 mm^2

S = 4200 – 75*2 -19*25 /18 = 198.61 mm

$As_{provided} = 9326.6\ mm^2 > As = 9008.9\ mm^2$

Step is the smallest of :

1. 3h = 3*1000 = 3000 mm
2. 450 mm - control

S = 198.61mm < Smax = 450 mm ok

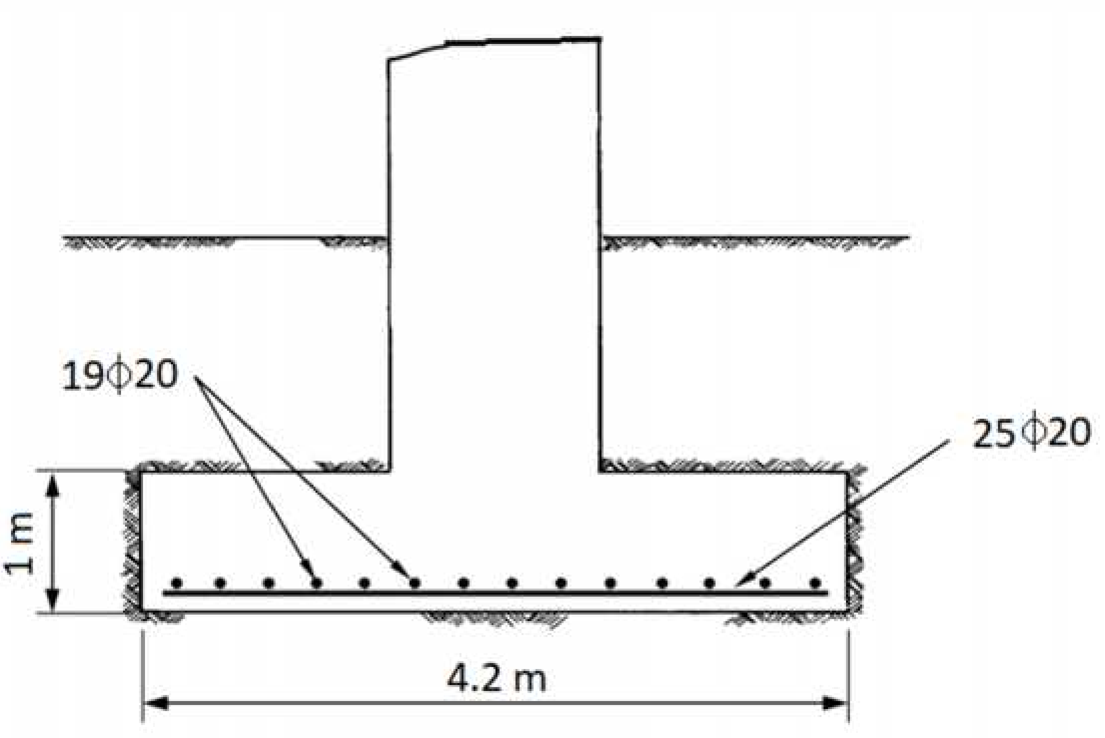


Fig (4-19): Section in footing.

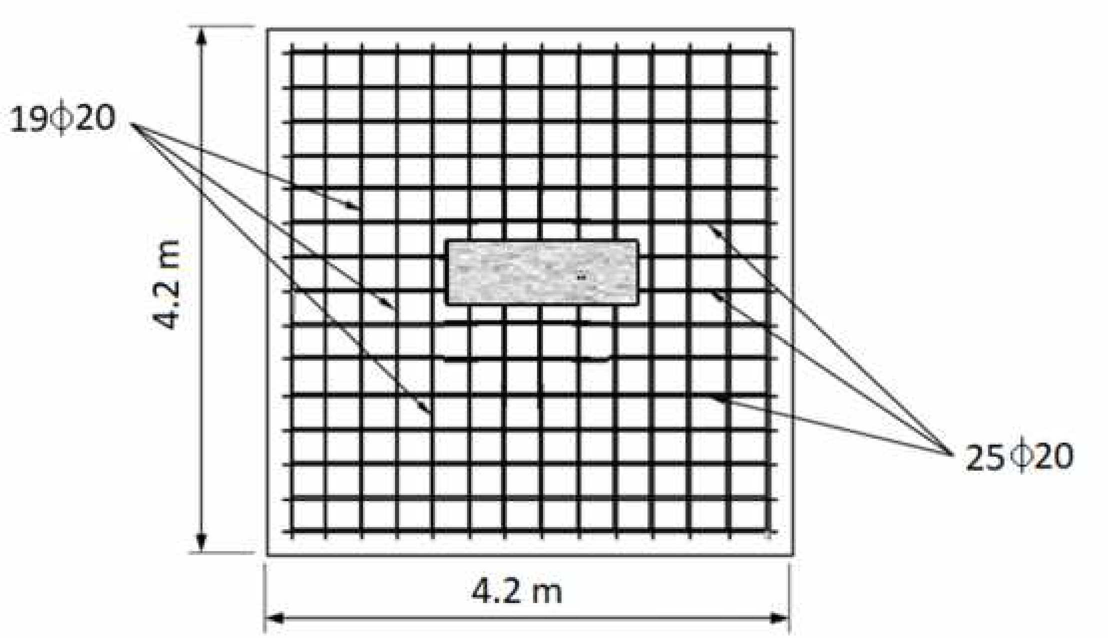


Fig (4-20): Top view of footing.

CHAPTER

5

RESULTS AND RECOMMENDATIONS

5.1 RESULTS .

5.2 RECOMMENDATIONS.

5.3 REFERENCES.

5.1 Results:

1) إن فهم المخططات المعمارية له دور كبير في إيجاد الحلول الإنشائية الملائمة لنوع الاستخدام في المبنى.

2) إن القدرة على الحل اليدوي ضرورية للمصمم الإنشائي للتأكيد على حل البرامج المحوسبة وفهم طريقة عملها.

3)التعرف على العناصر الإنشائية، وكيفية التعامل معها، ومع آلية عملها، وذلك ليتم تصميمها تصميما جيدا يحقق الأمان والقوة الإنشائية.

5.2 Recommendations:

1) يجب أن يكون هنالك تنسيق بين المصمم المعماري والإنشائي خلال عملية التصميم حتى ينتج مبنى متكاملاً إنشائياً ومعمارياً.

2)يوصى بتنفيذ المشروع حسب المخططات المرفقة بالمشروع بأقل تغييرات ممكنة.

3)ينصح بوجود مهندس مشرف للإشراف على التنفيذ وأن يلتزم بالمخططات والشروط لضمان التنفيذ الأفضل للمشروع.

4)يجب استكمال التصميم الكهربائي والميكانيكي للمشروع قبل المباشرة في التنفيذ لإدخال أي تعديلات محتملة عليه من الناحية الإنشائية.

5.3 References

1.Building code requirements for structural concrete (ACI-318-14), USA, 2014.
2.Uniform Building Code (UBC).
3.كود البناء الأردني, كود الأحمال والقوى, مجلس البناء الوطني الأردني, عمان,الأردن, 2006م