Chapter III

Structural description

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3-1 Introduction

The process of structural analysis and design of any building is integrated and indivisible, so after study the description of the architectural elements in our project, we started to Study the existing structural elements in constructions so we can choose the accurate structural system for the building which we are planning to design.

In this chapter, different structural elements will be discussed such as columns, beams, foundations and other structural elements, in addition to determine the value of the loads affecting on these elements, such as dead and live loads and other loads which will be mentioned later.

3-2 The purpose of structural analysis and design

Structural design is a connected process which depends on the structural elements that is supposed to act as one unit, so it is important to make the best design of the building to achieve these wanted aims:

1. **Safety:** it is supposed to do the design taking into consideration the safety of the building in every condition.
2. **Economical Coast:** Achieving the best level of safety with the least coast.
3. **Serviceability:** avoiding deflection and cracks which can make the building weak.
4. Save the architectural design of the building.

3-3 Structural analysis steps:

3-3-1 Soil investigation

The purpose of soil investigation is to explore and evaluate the subsurface conditions at various locations in the project site in order to develop geotechnical engineering recommendations for foundation design and construction.

Before the construction analysis of any building, geotechnical studies for the site must be done, it means every process to explore the site and study the soil, rocks and groundwater must be done, then analysis the previous study information and translate it, in order to predict the soil .behaviour .The most important thing is to get the soil bearing capacity in order to know how to design and execute the building.

3-3-2 primary structural design

In this stage, the appropriate structural system of project will be determined, according to the site of the project, its size, and the nature of the project.

3-3-3 final structural design

Final structural design of each element will be done with high accuracy according to the chosen construction system, in addition to make structural details appears in the structural drawings.

3-4 Loads classification

Loads which are directly affects the building classified into:

1. **Main loads (direct):** which include dead and live loads and environmental loads.
2. **Secondary loads (indirect):** These include shrinkage of concrete drought, heat impact and crawl and consolidation.

So, in structural calculation, we must consider the accuracy in the process of representation of loads on structural elements as the previous classification. Concrete, for example, has an expansion and shrinkage factor different than its reinforcement steel factor.

The designed structural elements must be able to carry loads without the occurrence of any failure, and these loads are:

1. **Dead loads.**
2. **Live loads.**
3. **Environmental loads.**

3-4-1-1 Dead loads

Loads resulting from the self-weight of building, which consists of the weights of the materials used in the building which include all the structural elements and fixtures weight. There is some of the specific density of the materials used as follows:

	Material	Density (KN/m³)
1	Mortar	22
2	Tiles	23
3	Reinforced concrete	25
4	Coarse sand	17
5	Plaster	22

Table 3-1: specific density of the used materials.

3-4-1-2 Live loads

Loads act on buildings and construction because of their different uses, including distributed and concentrated loads, which include:

1. **Dynamic loads:** such as the equipments which create vibrations affecting the entity.
2. **Static loads:** such as weights of people, the stored material and furniture. The table below shows the values of the live loads depending on the use of our building according to the Jordanian code.

So, in our project as a hospital building, we will take the live load in our calculations as 5KN/m according to Jordanian code.

تابع الأحمال الحية للأرضيات والعقدات

نوع المبنى		الاستعمال	الحمل الحي الموزع	الحمل المركز البديل
عام	خاص	الاشغال	كن/م²	كن
تابع للمباني التعليمية وملحقاتها.	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

Table 3-2: Live loads according to Jordanian code.

3-4-1-3 Environmental loads

loads caused by the environmental effects on the building.

3-4-1-4 Wind load

Horizontal forces affect the building which can clearly appears in the high ones, it has a positive value as a result of pressure and negative value as a result of tension, measured in kilo Newton per square meter (KN / m2). The determination of wind loads depending on the height of the building above ground level, and its location in compared with the surrounding buildings, whether higher or lower. Wind loads can be resisted through shear walls which are designed according to the loads acting over them.

3-4-1-5 Snow loads

loads affect the building due to snow accumulation, snow loads can be evaluated as the following:

1. The height of the building above sea level.
2. Slope of roof.

The following table shows the value of snow loads according to height above sea level by the Jordanian code.

Height of building above sea level (m)	**Snow load (KN /m^2)**
1. h < 250	0
2. 500 > h > 250	(800) /h-250
3. 1500 > h > 500	(h-400) / 320

Table 3-3: snow loads according to Jordanian code.

The height of the project land=990m above sea level, so case (3) from the table above will be considered,and snow load will be equal to (990-400)/320=1.84KN/m^2

3-4-1-6 Earthquakes

One of the most important environmental loads affecting the building, consist of horizontal and vertical forces which create moments, including overturning and torque moments. It can be resisted using shear walls with a good thicknesses and enough reinforcement to assure the safety of the building. Earthquakes must be considered in the structural design to reduce its risk and improve the performance of the building. Code (UBC

1997) will be used in order to define and determine the seismic loads and shear forces according to it.

3-5 Construction elements

The building is a set of construction elements related for each other and acting as one unit. There are some of the construction elements used in the buildings like slabs, columns, stair, beams, and foundations. Here are some of the construction elements used in our project:

3-5-1 Slabs

Slabs are structural elements that transfer the vertical forces due to the loads affecting the structural elements of the building such as beams, walls and columns, without any distortions.

There are different types of commonly used reinforced concrete slabs, including the following:

1. **Solid slabs.**
2. **Ribbed slabs.**

But in our project only two types of slabs are suggested to be used:

3-5-1-1 One Way Solid Slabs: which have been used in some stairwall slabs.

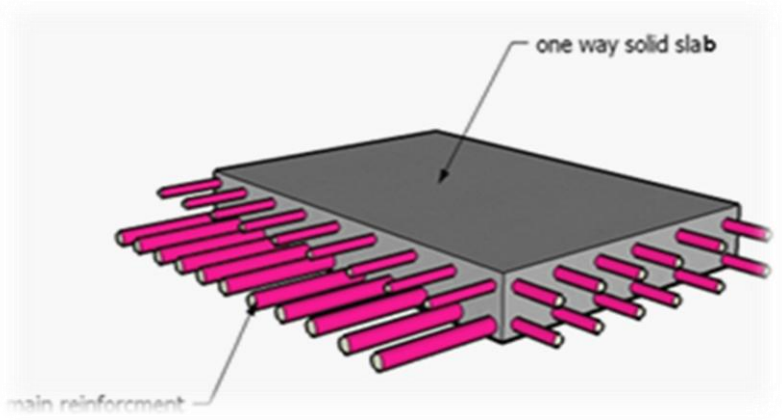

Figure 3-1: One way solid slab.

3-5-1-2 One way ribbed slabs: which consists of hollow slabs with total depth greater than solid slabs depth. This system is economical for buildings where superimposed loads are small and spans are relatively large, such as schools, hospitals, and hotels etc... .

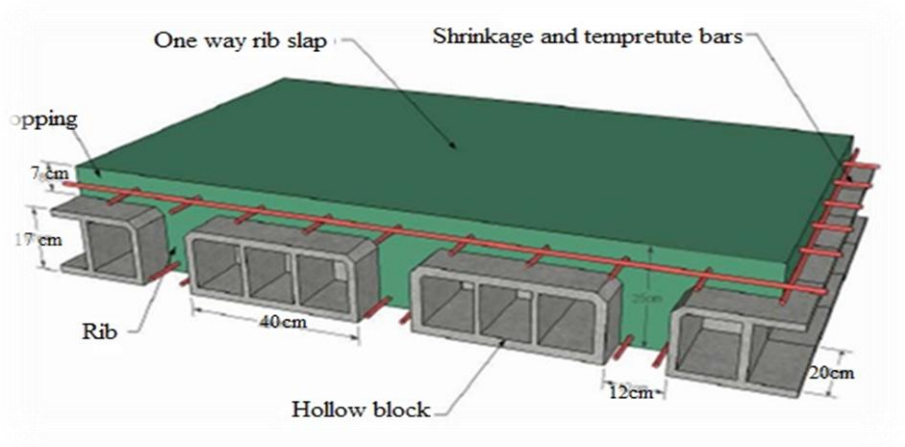

Figure 3-2: One way ribbed slab.

3-5-2 Columns

Columns are considered as the main component in the transfer of loads from slabs, beams and transferred it to the foundations, so it is an essential structural component of transfer the loads and the stability of the building. it must be designed to be able to carry and distribute all the loads act on it.

there are two types of columns, short and long columns. Columns sections have many forms, including rectangular, circular, polygon, box and the boat. Another classification of columns is according to the type of construction material used such as concrete, metal, and wood.

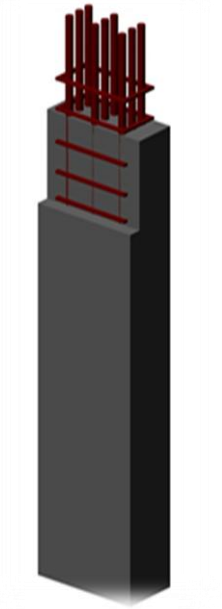

Figure 3-3: Rectangular column.

Figure 3-4: Circular column.

3-5-3 Beams

They are essential structural elements transport loads of ribs and solid slabs to columns. Concrete beams divided into two types:-

1. **Hidden beams:** beams hidden inside the slab so that its height equals to the height of the slab.
2. **Drop beams:** beams with height greater than the height of the slap, the excess part of the beam is in both directions, lower one (Down Stand Beam) or upper (Up stand Beam),so these parts are called L –section and T-section.

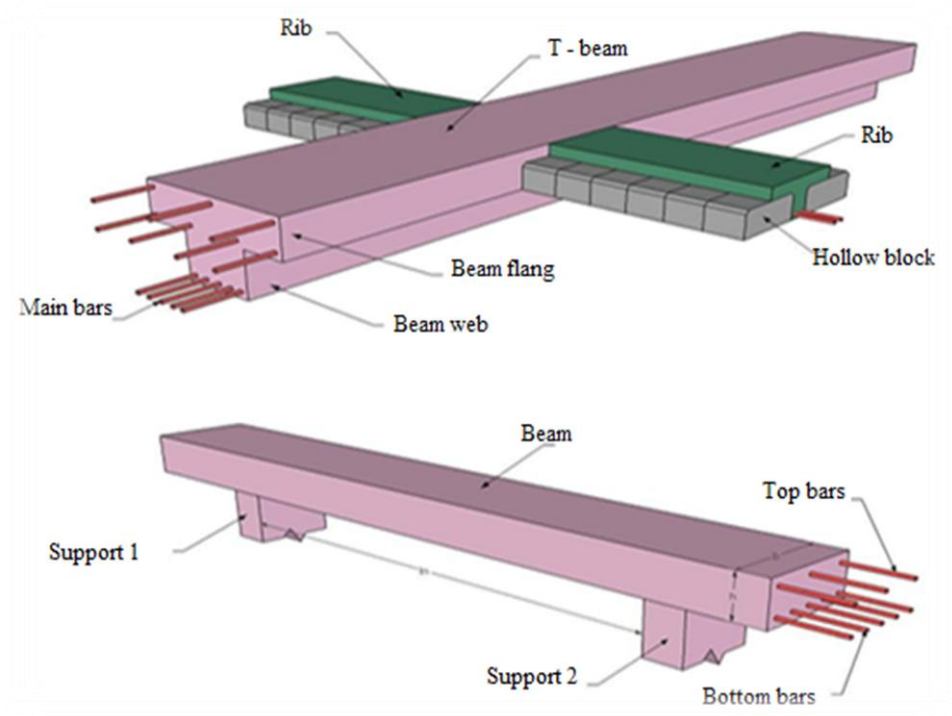

Figure 3-5: Beams.

3-5-4 Shear walls

Structural elements resist the vertical and horizontal forces which affecting the building, such as strong winds and earthquakes.

These walls resisting the vertical loads transferred to them, and resist the horizontal forces that affecting the building, so they must be available in both directions, taking into account that the distance between the centre of rigidity where the shear walls should be built and the centre of gravity of the building must be as less as it possible, and be enough to reduce the torques and their effects on the building walls that resist the horizontal forces.

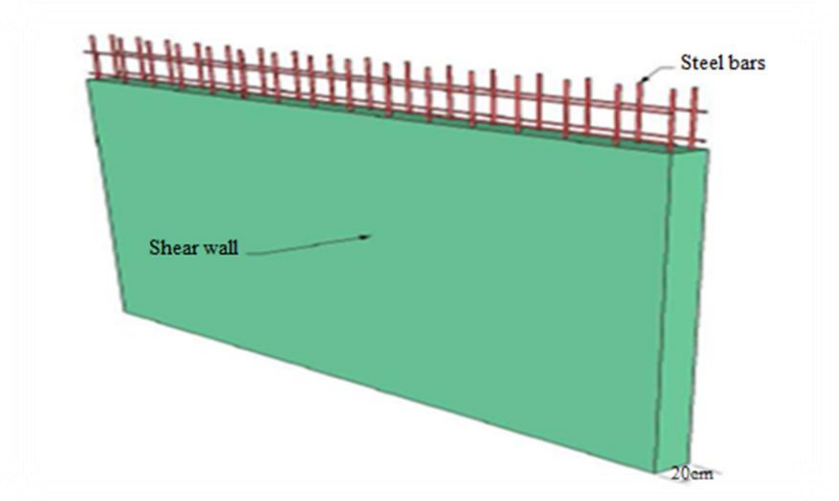

Figure 3-6: Shear wall.

3-5-5 Foundations

Foundations are the link between the structural elements of the building and the land, the weights and loads which have been carried by foundations come from the loads located on slabs moves into beams then to columns and finally to footings into the soil. The foundation must be responsible for carrying the dead loads of the building and also dynamic loads resulting from wind ,snow, earthquakes and also live loads within the building.

it is expected in our project to use different types of foundations depending on soil bearing capacity and loads along each foundation.

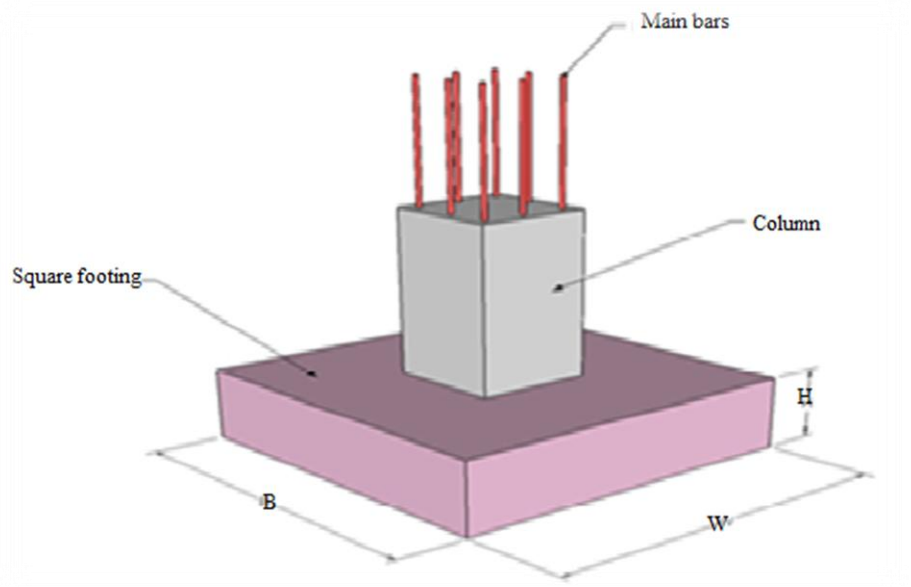

Figure 3-7: Isolated footing.

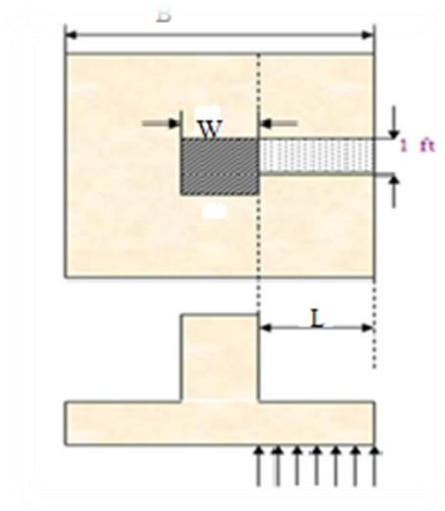

Figure 3-8: isolated footing plan.

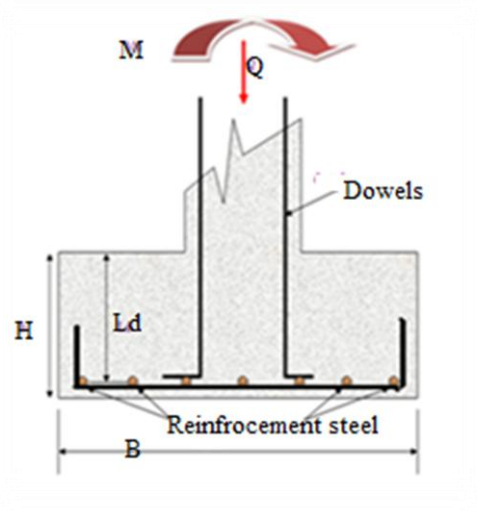

Figure 3-9: isolated footing section.

3-5-6 Stairs

Structural element responsible for vertical movement between floors in the building. Staircase design is structurally as a solid slab in one direction.

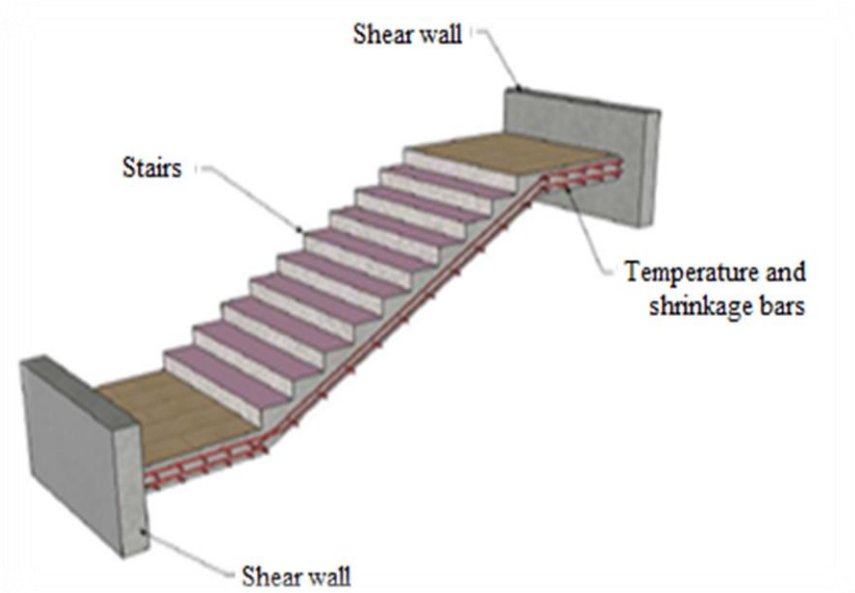

Figure 3-10: Stair diagram.

3-5-7 Expansion Joints

It can be used in buildings with large horizontal dimensions or special shapes and situations. Expansion joints have some requirements and recommendations as follows:

- From 40 to 45 m in normal regions like Palestine.
- From 30 to 35 m in warm regions.
- We can increase these distances by consider the effect of creep and shrinkage.
- In retaining walls we must decrease distances between expansion joints.
- Expansion joint width should not be less than (3cm).

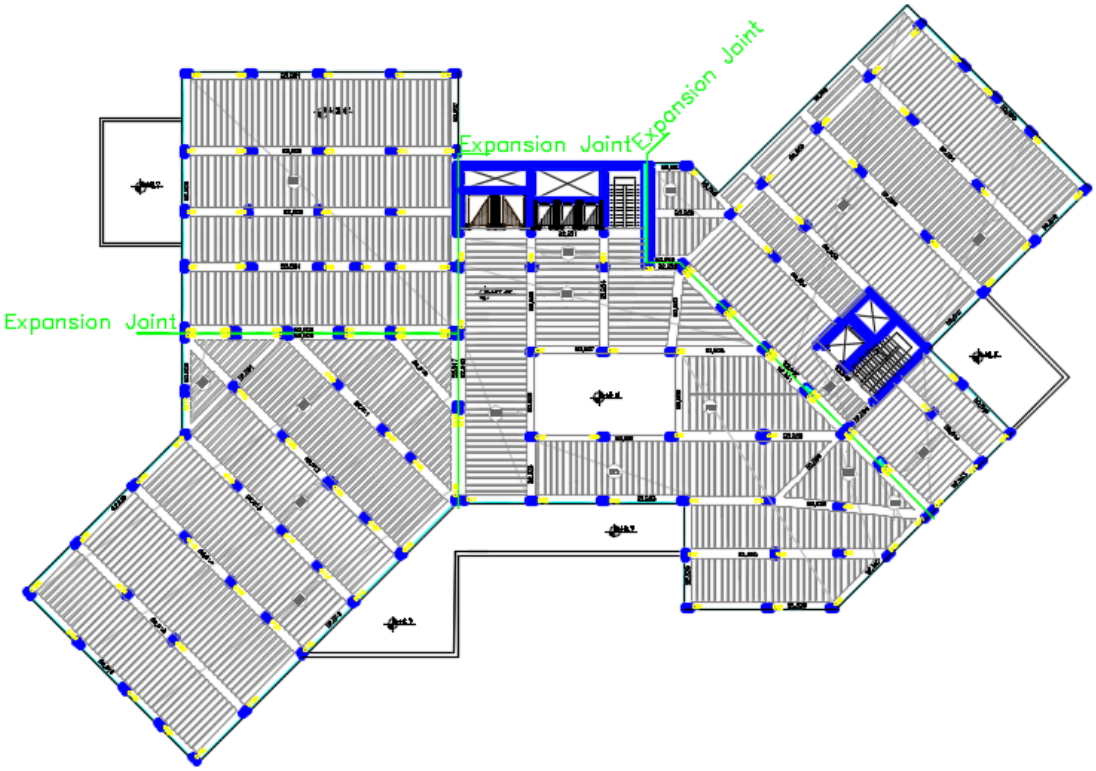

Figure 3-11: Expansion joint.