4

Chapter 4

Structural studies

4.1 Introduction:

After studying the project from the architectural point of view, it is necessary to move to the structural aspect to study the structural elements and describe them accurately. Where the loads acting on the building will be studied. To come out with a structural design that meets all safety and architectural requirements as well as taking into consideration the economic factor.

The structural design also requires the selection of the suitable structural elements for the project to be constructed. And to make sure of its possibility to be safely constructed on the ground, and keep the architectural design without any change.

4.2 The purpose of the structural design

Structural design is a complete process that depends on every deign steps, as it meets a set of goals and factors that will come out with an achieved the desired aim structure. These aims are as follows:

1- Safety: Where the building is safe in all cases and resist the various natural changes, through the selection of sections of the structural elements which can resist forces and stresses resulting from them.
2- Economic cost: achieving a structure with high safety and lowest economical cost.
3- Efficient use (Serviceability) : avoiding any defect in the building like cracks, some types of deflection which affect negatively on the architecture view and annoy the building users.
4- Keeping the architectural design of the building.

4.3 Stages of structural design.

Structural design can be divided into two basic stages:

Stage one: a primary study for the size and the nature of the project, In addition to understand the project in its all different aspects. And identify the materials that will be approved for the project, then the basic structural analysis of this system and the expected initial dimensions.

Stage two: It's the structural design of each part of the building, In a detailed manner according to the selected structural system and make the required structural detail ssuch as horizontal plans, vertical sections, and details of reinforcing steel.

4.4 Loads

Structural elements that are designed must be able to carry the loads acting on it without collapsing. The loads of the building are divided into different types as follows:

4.4.1 Dead loads

Are the loads resulting from the self-weight of the main elements that the building contains, Dead loads means the loads which acts on the structure since it is construct and remains constant in magnitude and fixed in its position throughout the lifetime of the structure. As well as additional parts, such as internal partitions, and any mechanical work or additions are carried out permanently and consistently in the building

This category can be calculated in a high range of accuracy using the design configuration, dimension of the structure and density of the materials, Table (4-1) shows several values of density for materials used in this project according to the Jordanian code.

Table 4.1 the densities for used materials

No.	Used materials	Density
1	Tiles	23 KN/ m^3
2	Reinforced concrete	25 KN/ m^3
3	Concrete block	15 KN/ m^3
4	Mortar and plaster	22 KN/ m^3
5	Sand	16 KN/ m^3

4.4.2 Live loads

Live loads are loads their magnitude and distribution at any given time are uncertain and their location can also be changed, and even their maximum intensities through the lifetime of the structure are not known with precision. These loads consist mainly of occupancy loads in building and traffic loads on bridges.

It’s a continuously changeable loads in amount and location, such as people, furniture, appliances, equipment. Its value depends on the use of the building and it is usually taken from special tables in different codes.

Table 4.2 The live load which was determined by the Jordanian code

No.	Used	Live
1	Parking	4 KN/ m2
2	Stores	3 KN/ m2
3	Stairs	4 KN/ m2
4	Ceilings	4 KN/ m2
5	Bedroom	2kN/m2

6	Bathrooms	2kN/m2
7	Living rooms ,Hall, Billiard	2kN/m2
8	Corridors, entrances, drawers, terraces, and high corridors that are connected between building	3 KN/ m2
9	Kitchens and laundry rooms	3 KN/ m2
10	Boilers, engines, fans and the like including weighing machines	7.5 KN/ m2

4.4.3 Environmental Loads

Loads come on the building that are caused by natural changes such as snow, wind and earthquake loads, also loads caused by soil pressure. The loads differ from one region to another. And these are :

4.4.3.1Wind loads

Horizontal forces affects building with more than 6 floors. These forces caused by the wind affects buildings. It may be positive if it's caused by compression or negative if it's caused by tension. Its unit is N/ m^2

Wind loads are determined depending on the speed and height of the building, the loads increasing by the increasing of height, also it depends on the height of the surrounding buildings in the location. Shear walls are designed according to wind pressure from the Jordanian code with a value of 0.4 KN/m^2

4.4.3.2 (Snow loads)

Loads that the building can be faced because of the accumulation of snow.These loads can be evaluated according to the following bases:

1- The height of the building above sea level.

2- The inclination of the surface faces the snowfall.

The ability of the roof to carry the snow can be determined by this equation: Sd = μi* So.

Where : So= the snow load on ground in KN/ m2

And μi= shape factor for snow load.

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

Table 4.3 snow loads according height of sea level.

(KN/m^2)snow loads	(M)the height above sea level
0	h < 250
(h-250)/1000	500 > h > 250
(h-400) / 400	1500 > h > 500
(h – 812.5)/ 250	2500 > h > 1500

4.4.3.3 Earthquake loads

One of the most important environmental loads that affect the building, it's a horizontal and vertical forces cause moments such as torque moment, Due to the relative movement of the rocky earth layers, resulting cutting forces affecting the building. In design , this loads should be taken in consideration and it must be designed according to horizontal forces to make sure that the building is resisting the earthquakes in case it happen. thus minimizing of earthquake damage.

These loads will be dealt through shear walls, which will be distributed in this project according to its' structural calculations.

4.5 Geotechnical studies:

Before studying of building, a geotechnical studies for the location should be done. It means all the works related to the exploration of the site and the study of soil, rocks and groundwater, also analysis for the information to predict how the soil behaves when building constructed. The civil engineer looks for the bearing capacity of soil, which is needed to design the footings.

4.6 Structural elements of the building

Buildings usually consist of a set of structural elements that intersect with each another to resist loads on the building, this includes: slabs, beams, columns, shear walls, stairs and footings.

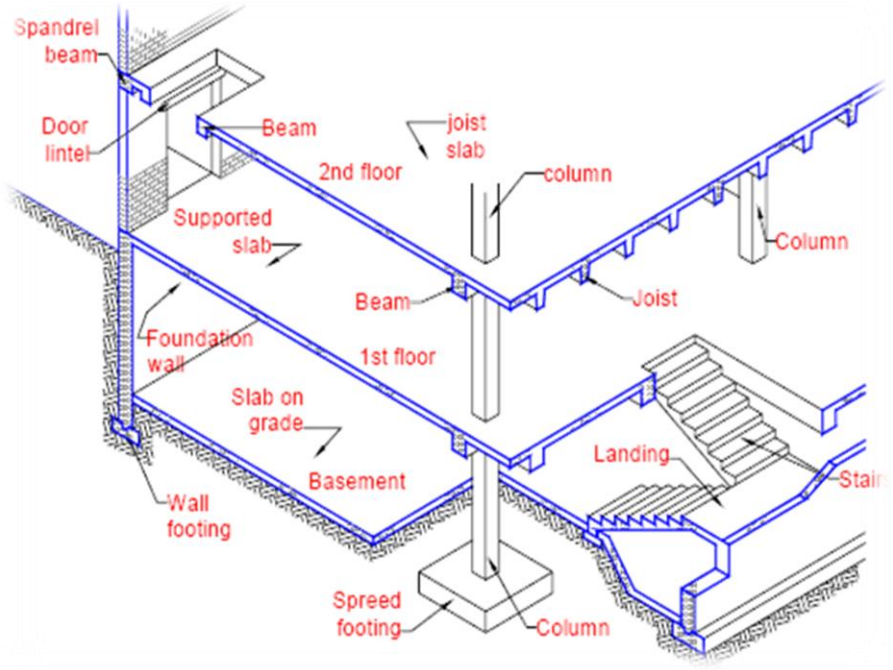

Figure 4.1 some of the structural elements of the building

The project contains the following elements:

4.6.1 Slabs

A slab is a structural element whose thickness is small compared to its own length and width. According to the way loads are transferred to supporting beams and columns, without being deformed, slabs are classified into several types:

1- Solid slabs, divided into:
   a. One way solid slab.
   b. Two way solid slab.
2- Ribbed slab, divided into:
   a. One way ribbed slab.
   b. Two way ribbed slab.

One way solid slab:

Where the ratio of the longer to the shorter side (L/S) of the slab is less or equal to 2.0. They are used in areas that face heavy live loads, in order to avoid vibration due to low thickness.

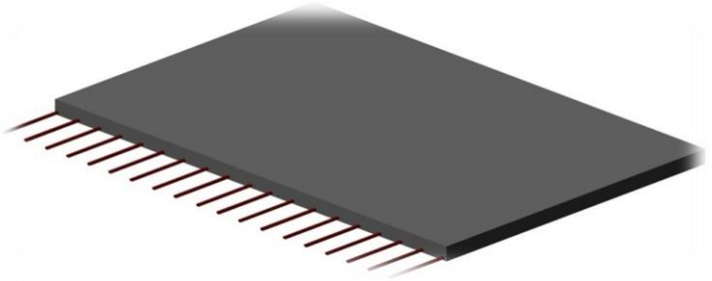

Figure 4.2 One way solid slab

Two way solid slab:

Where the ratio of the longer to the shorter side (L/S) of the slab is larger than 2.0. it is used in case the loads affecting the slab are more than the one way solid slab can take. It has a larger resistant for loads where the reinforcement distribution is in two directions.

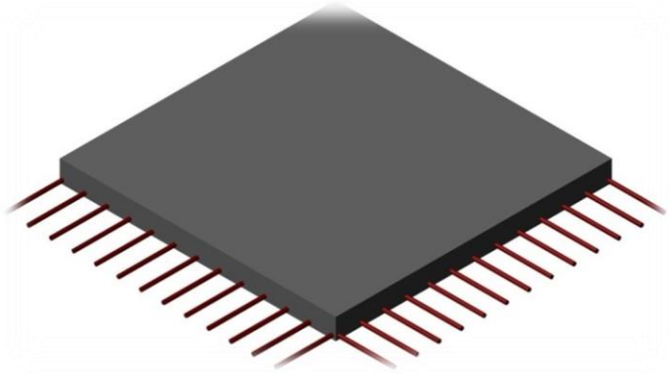

Figure 4. 3 Two way solid slab.

One way ribbed slab:

One of the most famous methods used in the design of slabs in Palestine , the rib is provided in one way only, since resistance of concrete in tension is too small compared with that in compression, concrete in the tension zone may be gathered in regularly spaced ribs cast monolithically with topping slab on top of these ribs. Hollow blocks are arranged between the ribs. The use of these blocks makes it possible to have smooth ceiling which is often required for architectural considerations and have a good sound and temperature insulating. These slabs are most economical for buildings such as hospitals, schools and hotels. The reinforcement bars are in one direction and we used this type in most of the slabs.

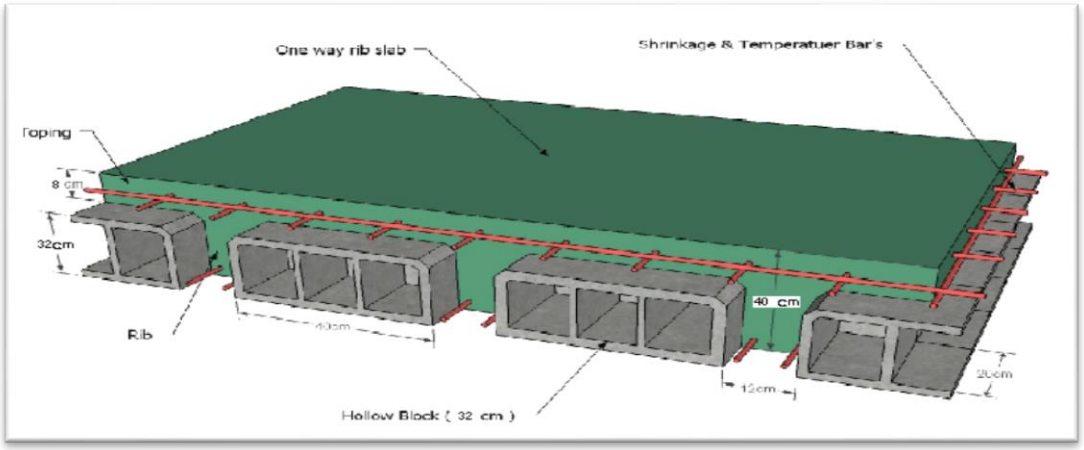

Figure 4. 4 One way ribbed slab

Two way ribbed slab:

It resemble in contents the previous type of slab, but the difference here that the reinforcement bars are in two directions including the rib, also the load distribution is in all directions. This of slabs was used in the project.

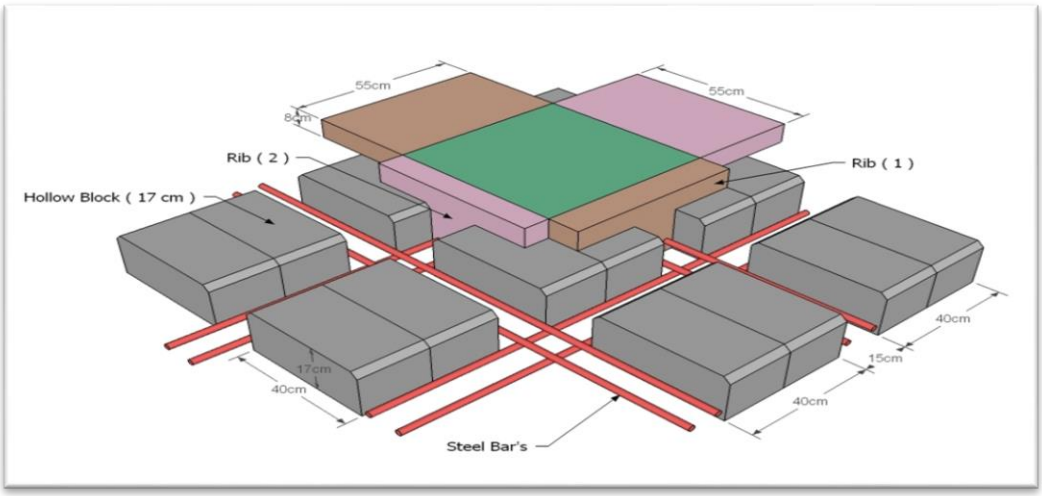

Figure 4. 5 Two way ribbed slab

4.6.2 Stairs

Stairs an architectural element is found in buildings to move between two levels on the same floor or between a number of floors through the building. There are usually designed as one way solid slab and that's obvious in our project. Also taking into consideration in structural design the loads caused by elevators.

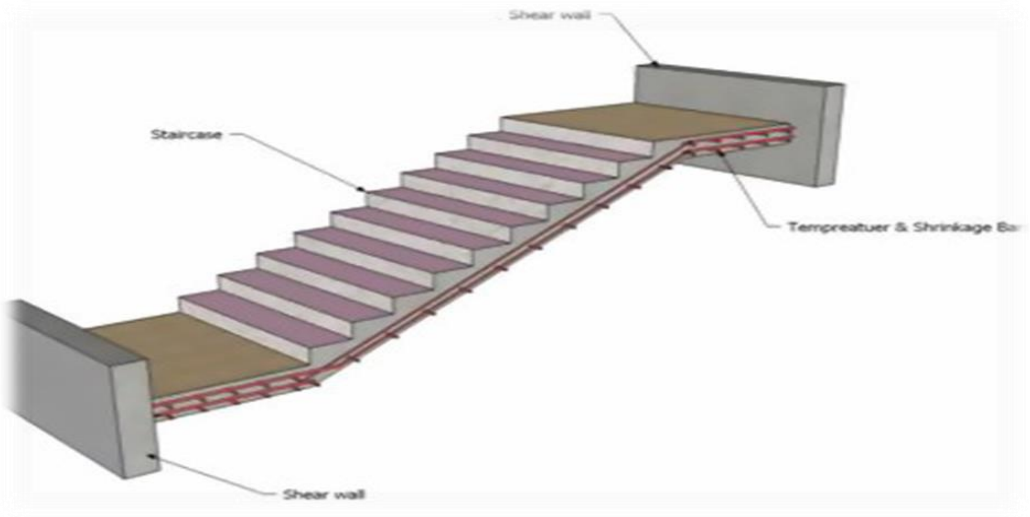

Figure 4. 6 Stair

4.6.3 Beams

Horizontal or inclined structural member spanning a distance between one or more supports and carrying vertical loads across its longitudinal axis, as a girder, joist or rafter. Three basics types of beams are: Simply supported beam (supported at both ends), Continuous (supported at more than two points) and Cantilever (supported at one end with the other end overhanging and free).

Also, beams are divided into:

1- Hidden beams: its height equals the height of slab.
2- Drop beams: its height is larger than the height of slab, the extra part of the beam is shown in one of the up (up stand beam) or down (down stand beam) directions, where these bridges called T-section and L-section.

Due to the different distances between columns in the building in this project including the loads acting on it, beams that will be used in the slab will be hidden beams and other drop. The horizontal reinforcement bars to resist the moment acting on it. And using stirrups to resist shear forces.

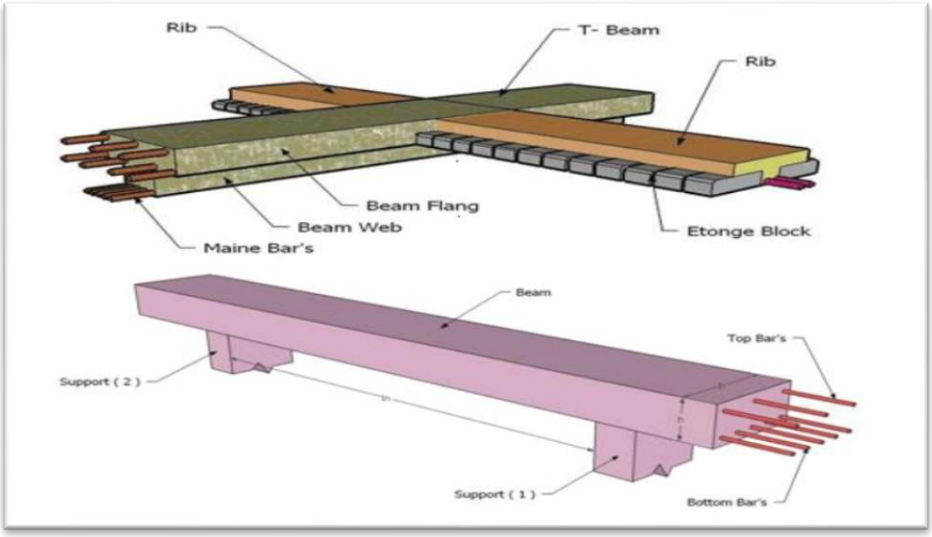

Figure 4. 7 Types of beams.

4.6.4 Columns

Columns are basic elements in the structure, where the loads transferred from the slab to the beams, which in turn transferred them into columns, then to the footings, therefore, columns are an important elements in the building, and must be design to be able to transfer and distribute the loads acting on it. So, columns are divided into two types according to deal with it in structural design:

1- Long columns.

2- Short columns.

And according to of architectural form or geometry: there are rectangular, circular and square columns. The project contains two shapes of columns, rectangular and circular ones.

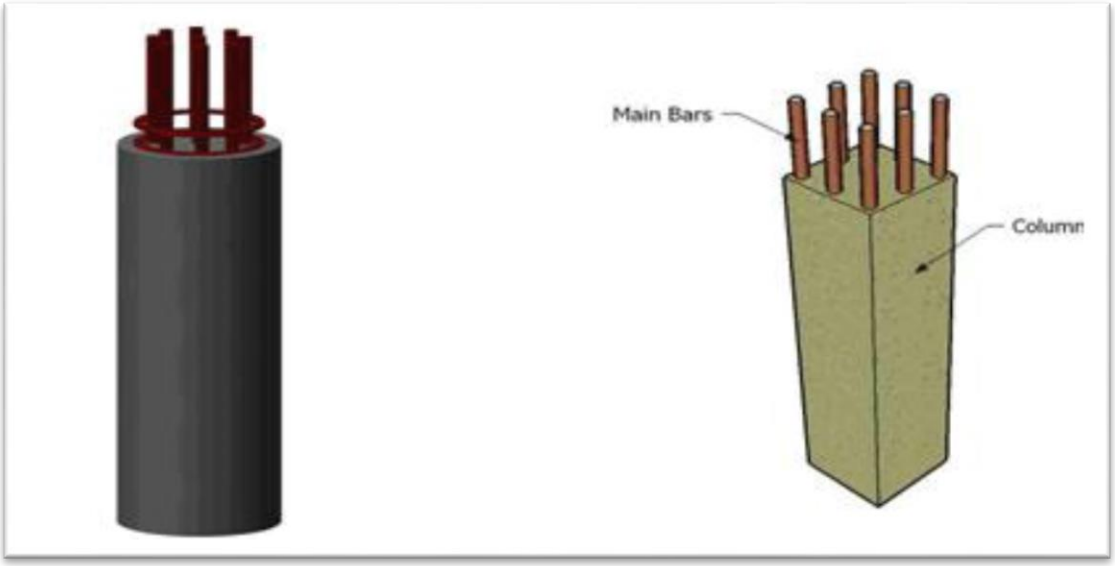

Figure 4. 8 Types of column

4.6.5 Shear walls

Walls surrounds the stairs and elevators, including some areas of the building as necessary. the function of the shear walls, is to resist horizontal shear forces that face the building as a result of the loads of earthquakes and winds. These walls also considered as carrier walls. It is provided in two perpendicular directions in the building so that the distance between the resistance center formed by the shear walls in each direction and the center of gravity of the building as little as possible, to provide full stability of the building, the following figure shows a reinforced shear wall.

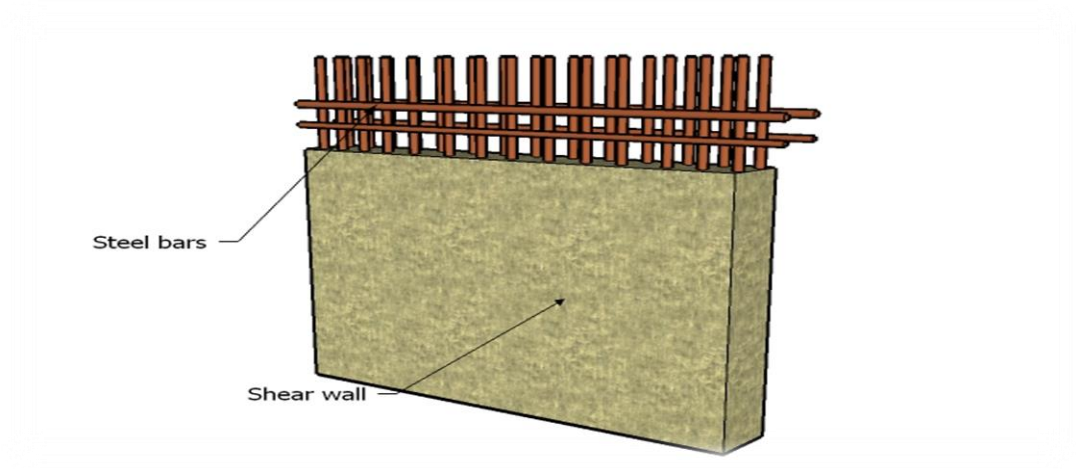

Figure 4. 9 Shear wall.

4.6.6 Footings

Footings are the first to be constructed in the building, while its design is completed after the design of all the structural elements in the building. It is the link between the structural elements of the building and the ground, it transferred the loads from columns and carrier walls to the soil as a pressure, and on several types as follows:

1- **Isolated footings.**
2- **Strip (wall) footings.**
3- **Raft footings.**
4- **Combined footings.**

A different types of footings will be used depending on the type of soil, the carrying capacity and the loads.

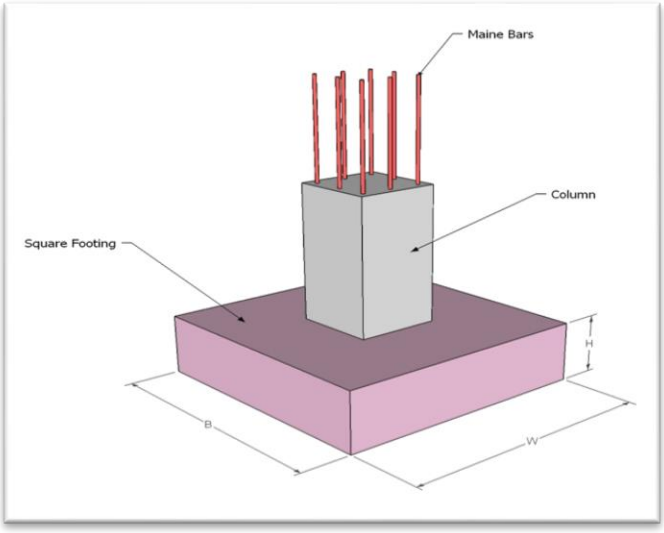

Figure 4. 10 Footings

4.6.7 Piles

Piles are a thin, large length elements compared to the dimensions of its section, piles are used for many purposes, the most important one is receiving columns and walls loads and transferring them to the soil. Piles extend within the soil with its full length or a part of it, to perform the task of transferring loads, stabilizing the soil, controlling the settlement, reducing the effects of dynamic loads and increasing the resistance of horizontal forces,, etc.

Piles are classified according to the type of soil into: (Bearing piles) or (Friction piles).

4.6.8 Expansion separators

Are constructed in building with large horizontal dimensions or shapes and special conditions, including thermal expansion joints or landing joints, or it's may be for the both purposes. When analyzing the structures for studying as a resistant to earthquakes, these intervals are called seismic separators. These separators have some specific requirements and recommendations as follows:

Thermal expansion joints should be used in the building according to the approved code, These joints must reach the top of the foundations face without penetrating them. The maximum distances of the building are considered as follows:

1- (40m) in regions with high moisture.
2- (36m) in regions with average, normal moisture.
3- (32m) in region with moderate moisture.
4- (28m) in dry regions.

Also, the width of the separator must be at least (3cm) or larger.