Loads :

Structures must be designed to support specific loads.

Loads are those forces for which a given structure should be proportioned. In general, loads divided into three categories; live loads, dead loads, and environmental loads.

1- Dead loads :

Are those constant in magnitude and fixed in location throughout the life time of the structure. Include the weight of the structure (self-weight) and any permanent material placed on the structure, such as tiles, roofing materials, and walls. Dead loads can be determined with a high degree of accuracy from the dimensions of the elements and the unit weight of materials.

2- Live loads :

Consisting chiefly of occupancy loads in buildings and traffic loads on bridges. In general, Live loads include the following:

* occupancy loads caused by the weight of the people, furnature, and goods.
* The weight of the traffic on a bridge.

3- Environmental loads :

These loads consist mainly of snow load, wind pressure, temperature changes, pressure of liquids, and earthquakes.

Note:

live and environmental loads may be steady or unsteady, movable or moving; they may be applied slowly, suddenly, vertically or laterally. In addition their magnitudes may fluctuate with time.

Tables (1) and (2) shown the unit weight and uniformly distributed live load of some materials and occupancy.

Table (1) Density of various materials

Material	Density (kg/m^3)
Bricks	1900
Cement	1400
Earth, dry, packed	1500
Sand or gravel	1800
Steel	7800
Concrete	2400

Table (2) Typical U.D.L.L.

Occupancy	Contents	Design L.L. (kN/m^2)
Assembly Hall	Fixed seat	3
	Movable seat	5
Hotel	private room	2
	Balconies	5

Table (2) Followed

Occupancy	Contents	Design L.L. (kN/m^2)
Housing	Private room	2
	Public room	5
Library	Reading rooms	3
	Stack rooms	7
Office building	offices	2.5
	Lobbies	5
Stairs	Light	5
ware houses	Heavy	12

Serviceability, Strength, and Structural Safety:

A structure must be safe against collapse and serviceable in use. Serviceability requires that deflections be adequately small, cracks, if any, be kept to tolerable limits. Safety requires that the strength of the structure be adequate for all loads. A factor of safety is necessary for a number of reasons, may be listed as follows:

1- Actual loads may differ from those assumed.
2- Actual loads may be distributed in a manner different from that assumed.
3- The actual structural behaviour may differ from that assumed

4- Actual member dimensions may differ from those specified.

5- Reinforcement may not be in its proper position.

6- Actual material strength may be different from that specified.

Safety provisions of the ACI code :

The ACI code recommeds by using strength reduction factors and load factors. These factors are based to some extent on statistical information but to a larger degree on experience. The design strength (ϕS_n) of a structure or member must be at least equal to the required strength (U) calculated from the factored loads.

$$\text{Design Strength} \geq \text{required Strength}$$

$$\phi S_n \geq U$$

The required strength (U) is calculated by applying load factors to the respective service loads : dead load (D.L) , live load (L.L.) , wind load (W) , ...etc. The load factors specified in ACI code, to be applied to calculated dead loads and those live and environmental loads shown in ACI (9.2). Required strength for dead and live load only, the code specifies that ,

$$U = 1.4\ D.L. + 1.7\ L.L \quad \ldots \text{ACI } 9.2$$

Strength reduction factors (ϕ):

The ACI code are given different valuse of ϕ depending on the state of Knowledge and the accuracy with which various strengths can be calculated. Thus, the value for bending is higher than that for shear or bearing.

The ϕ factors are less than unity and the code provides ϕ factors for the several strengths. The ϕ factor is multiplied by nominal strength to obtain ultimate strength.

Table (3) Strength reduction factors (ϕ) in the ACI code

Strength condition	ϕ
Tension - controlled sections	0.90
Compression controlled sections	
- Members with spiral reinforcement	0.70
- other reinforced members	0.65
Bearing on concrete	0.65
Shear and torsion	0.85

Quality control :

- Concrete : The main measure of the structural quality of concrete is its compressive strength. Compressive strength (f'_c or f_{cu}) is based on Standard 150 mm dia. x 300 mm height cylinders or 150 x 150 x 150 mm cubes, cured under standard conditions, and tested at specified rate of loading at 28 days of age or as specified.
The ACI code specifies that a pair of cylinders sets shall be tested for each 110 m^3 of concrete or each 460 m^2 of surface area (slabs or walls) actually placed. ACI code also specified the followings to consider the concrete strength acceptable :
1- Every arithmetic average of any three consecutive strength tests equals or exceeds (f'_c).
2 - No individual strength test falls below the specified (f'_c) by more than 3.5 MPa if f'_c is 35 MPa or less, or falls below f'_c by more than 10 % if f'_c is over 35 MPa.
- Required average strength :
Required average compressive strength for used as the basis for selection of concrete proportions, using sample standard deviation (S_s), but when data are not available to establish a sample standard deviation, the code recommend to use table (4).

Table (4) Required average compressive strength when data are not available to establish a sample standard deviation.

Specified compressive strength (MPa)	Required average compressive strength (MPa)
$f'_c < 21$	$f'_{cr} = f'_c + 7.0$
$21 \leq f'_c \leq 35$	$f'_{cr} = f'_c + 8.3$
$f'_c > 35$	$f'_{cr} = 1.10 f'_c + 5.0$

- Grades of concrete :-

Many grades of concrete are used in concrete works, the grade number generally refers to its characteristic strength in N/mm^2 (MPa).

Lowest appropriate grade	MPa	Appropriate use
C7.5	7.5	blinding concrete
C 10	10.0	filling holes in weak ground
C 15	15.0	general mass concrete
C 20	20.0	reasonable quality reinforced concrete
C 25	25.0	good quality reinforced concrete
C 30	30.0	good quality reinforced concrete
C 35	35.0	good quality reinforced concrete
C 40	40.0	good quality reinforced concrete
C 45	45.0	good quality reinforced concrete
C 50	50.0	High strength concrete
C 60	60.0	High strength concrete

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C 30	30.0	
C 35	35.0	
C 40	40.0	
C 45	45.0	
C 50	50.0	High strength concrete
C 60	60.0	

- Steel bars :

Reinforcing steel is a high strength material compared with concrete. The specification for test of steel bars issued in ASTM A 615M, for deformed and plain steel bars for concrete reinforcement. Bars are of three grades of three minimum yield levels, namely 40 (280 MPa), 60 (420 MPa), and grade 75 (520 MPa) respectively.

Table (5) Deformed bar designation.

Bar No. or (mm)	Nominal mass (Kg/m)	Diameter (mm)	Area (mm^2)	Perimeter (mm)
3 (10)	0.560	9.5	71	29.9
4 (13)	0.994	12.7	129	39.9
5 (16)	1.552	15.9	199	49.9
6 (19)	2.235	19.1	284	59.8
7 (22)	3.042	22.2	387	69.8
8 (25)	3.973	25.4	510	79.8
9 (29)	5.060	28.7	645	90.0
10 (32)	6.404	32.3	819	101.3
11 (36)	7.907	35.8	1006	112.5
14 (43)	11.38	43.0	1452	135.1
18 (57)	20.24	57.3	2581	180.1

- Tensile requirments of bars :

The steel bars shall conform to the ASTM A 615 M requirements for tensile properties prescribed in table (6)

Table (6) Tensile requirements :

	Grade 40 (280)[A]	Grade 60 (420)	Grade 75 (520)[B]
Tensile Strength (MPa), Min.	420	620	690
Yield Strength (MPa), Min.	280	420	520
Elongation in (203 mm), Min.%			
Bar designation No. (mm)			
3 (10)	11	9	---
4, 5, (13, 16)	12	9	---
6 (19)	12	9	7
7, 8 (22, 25)	---	8	7
9, 10, 11 (29, 32, 36)	---	7	6
14, 18 (43, 57)	---	7	6

[A] Grade 40 (280) bars are furnished only in sizes 3 through 6.
[B] Grade 75 (520) bars are furnished only in sizes 6 through 18.

The most common type of reinforcing steel is in the form of round bars, some times called rebars, available in a large range of diameters from about (10 - 35) mm.