Cement Mortar:

Mortar is a mixture of cementitious material, aggregate generally with a grain size of less than 4 mm, water and possibly additives and/or admixtures. Mortar can be classified as cement-lime mortar, cement mortar, lime mortar or masonry cement mortar. Mortar is used for the following functions:

- To bind materials together (e. g. masonry mortar and tile adhesive mortar, either nonreinforced or reinforced)
- To serve as a seating and levelling material for the masonry units
- To provide aesthetic quality of the structure and a level or smooth finish (e. g. floor screed mortar, internal plastering)
- To protect against weathering (e. g. external rendering)
- To improve thermal insulation of walls (e. g. external thermal insulation composite systems, thermal insulation rendering mortar, lightweight masonry mortar)
- To repair and renovate constructions (e. g. concrete repair mortar, damproofing mortar, or renovation mortar)

Figure (1): Examples of mortars use.

The currently most common types of mortar are:

- Masonry mortar which is divided into general purpose mortar, lightweight mortar, and thin layer mortar

- Rendering mortar which is used to protect buildings against weathering and to give them a decorative look. Thermal insulating renders are part of this group.
- Plastering mortar to finish inside walls
- Floor screed mortar; mainly self-levelling
- High-technology dry mortars (tile adhesive, concrete repair etc.)
- External Thermal Insulating Composite Systems (ETICS) 11 Portland Cement Association, Masonry Information.

Mortar types:

The mortars are generally classified according to their composition, application, requirements, their production method, and their supply method.

Mortars classified according to their composition:

(a) Cement mortars

(b) Hydraulic lime mortars

(c) Air lime mortars: they are mortars produced with hydrated air lime and sand which are used for internal and external coatings

(d) Composite mortars made from cement and hydraulic lime

(e) Composite mortars made from cement and air lime: these limes can be mixed with different amounts of cement (common or white).

Mortars defined by their application:

(a) Mortars for masonry construction

(b) Mortars for coatings

(c) Mortars for paving

(d) Adhesive mortars

(e) Mortars for repair work

(f) Waterproofing mortars.

Mortars defined by their requirements:

(a) Mortars made with recipes or prescriptions: They are normally known based on their declared components. For example: Cement:Lime:Sand mortars, Lime:Sand mortars or Cement:Sand mortars.

(b) Designed mortars: A mortar which is required to have a certain characteristic, which can be a particular strength, adherence or water resistance. For example: an M-5 masonry mortar should achieve a compression strength after 28 days of 5 N/mm^2 in accordance with the EN 998-2(14) regulation.

Mortars defined by their production method

(a) Masonry mortar produced on site: a mortar composed of the individual components measured and mixed on site.

(b) Semi-finished factory produced masonry mortar:

(i) - Pre-dosed masonry mortar: a mortar whose components are completely factory dosed and is supplied to the place where they will be used and where they are mixed in accordance with the manufacturer's specifications and conditions.

(ii) - A premixed lime and sand masonry mortar: a mortar whose components have been completely factory dosed and mixed and are supplied to its place of use where other factory specified or supplied components are added: (i.e.: cement).

c) Factory made masonry mortar (industrial mortar): mortar dosed and mixed in a factory. It can be "dry mortar", a prepared mix which only requires the addition of water or "wet mortar" which is supplied ready for use.

Mortars defined by their supply method:

(a) Dry mortar in silos: the procedure is simple, clean and economical in its consumption. The manufacturer provides one or more silos and the exact type of mortar (transported in tank trucks) defined by the designer. It is only necessary to add the indicated water to create the mix at the construction site.

(b) Dry mortar in bags: dry mortars can also be supplied in bags. Their use on site is very simple because there is no dosing or selection of components required on site. The supplier's instructions should be followed for manual or mechanical mixing with mixers.

(c) Wet mortar: principally produced with lime putty, it is supplied ready for use in bags or containers.

Mortar materials:

Conventional masonry mortars are composed of water, sand, and cementitious materials.

Water:

1. Water is required for hydration of the cementitious materials. Strength gain of mortar is not related to evaporation of water but to the chemical combination of water with cement compounds in the mortar.
2. Since some mixing water is lost to absorptive units and evaporation, the maximum amount of water consistent with optimum workability should be added to mortar.
3. Significant levels of contaminants such as alkalis, sulfates, sugars, or detergents may adversely affect the performance of mortar. Therefore drinkable water, free of such contaminants, should be used for mixing mortar.

Sand:

The specifications with which aggregates for the production of mortars must comply are contained in the EN 13139 harmonized standard (15).

- The sands can be: calcic, dolomitic or siliceous..
- Sand is not recommended to exceed a maximum size of 4 mm.
- Sand used for masonry construction should be clean and well graded. The cleaning of the sand is essential, sands should be used which do not contain clay materials, organic matter, compounds which reduce the durability of the mortars, for example: oxidisable iron sulphides (pyrites, marcasites); mica particles, shales with laminar or scaly structures in sufficient quantities that can affect the finish of the mortar, and its mechanical strength and hardness.

Cement:

Masonry Cement: Masonry cement consists of a controlled homogeneous mixture of Portland or blended cement and inorganic plasticizing materials such as hydrated lime or pulverized limestone, together with other materials introduced to enhance mortar properties.

- Mortar Cement: Mortar cements are similar to masonry cements, but they have lower air contents than masonry cements, and the mortar cement specification includes a minimum bond strength requirement.
- Portland Cement
- Blended Cements: Blended hydraulic cements are produced from Portland cement or Portland cement clinker and pozzolans or slags.

Lime:

- Air limes:
  - ✓ Calcium limes: Calcinated pure limestones >95% richness of calcium

- ✓ Dolomitic limes: Calcinated dolomitic stones which contain magnesium

- Hydrated Lime: Limestone contains clays rich in silica, aluminium and iron, which harden with water:
  - ✓ Natural Hydraulic Limes (NHL), which are produced by the calcination of a stone with a mix of clays which are lean and rich in silica
  - ✓ Artificial Hydraulic limes (HL), which are composed of calcium hydroxide, calcium silicates and calcium aluminates produced by the appropriate mix of ingredients
  - ✓ Formulated Limes (FL), which are limes with hydraulic properties composed of air lime (CL) and/or natural hydraulic lime (NHL) with additional hydraulic and/or pozzolanic material

Admixtures:

- Aerating agents: Air content modifiers
- Plasticizers: Rheology modifiers while in fresh condition
- Retardants: Modifiers of setting and/or hardening times (Setting retardants)
- Water repellents: Those which minimize the absorption of water
- Water retainers: Those which increase the capacity to retain water
- · Resins: Provide chemical adherence

Mortar strength classifications according to ASTM (Standard Specification for Mortar for Unit Masonry):

1. **Type N** – All purpose
2. **Type S** – High flexural bond strength
3. **Type M** – High compressive strength but low workability
4. **Type O** – Low strength, usually limited to interior applications

Type N Mortar (General Purpose):

Type N is also a medium strength mortar, around (750psi). This mortar is the most common type of mortar since it is preferable for all kinds of general works. This mortar is used for reinforced interiors and exterior walls with loads. Type N mortar is more flexible than the high strength mortar. The mix proportion of cement, lime and sand for type N Mortar is 1:1:6 (ASTM C144, 2001).

Type S Mortar:

Type S mortar has medium-strength. The strength provided by type S mortar is around 1800 psi. It is used in construction of exterior walls and patios. The mix proportion of cement, lime and sand for type S mortar is 2:1:9 (ASTM C144, 2001).

Type M Mortar:

Type M mortar mix contains high amounts of Portland cement. This is used for heavy loads, foundations, and other heavy structures. Type M mortar M can provide (2500psi) of compressive strength (Wiki Answers, 2013). The mix proportion of cement, lime and sand for type M mortar is (3:1:12).

Type O Mortar:

Type O mortar is a mortar with comparably low strengths (minimum 350 psi). This mortar is used for interior applications with no loads. Type O mortar is generally used for repairs and with masonry units with low compressive strength. The mix proportion of cement, lime and sand for type O mortar is 1:2:9 (ASTM C144, 2001).

Desirable mortar properties:

Workability:

- Workability may be defined as the behaviour of a mix in respect of all the properties required, during application, subsequent working and finishing.
- Ease of use, i.e. the way it adheres or slides on the trowel.
- Ease of spread on the masonry unit.
- Ease of extrusion between courses without excessive dropping or smearing.
- Ease of positioning of the masonry unit without movement due to its own weight and the weight of additional courses.

Water Retentivity & Air content:

- This is the property of mortar that resists water loss by absorption into the masonry units (suction) and to the air, in conditions of varying temperature, wind and humidity. Water retentivity is related to workability.
- The air content of the mortar in its plastic state is also important. In order to achieve good durability it is necessary that there is sufficient air content (entrained air) to enable freezethaw cycles to be resisted without disrupting the matrix of the material.

Stiffening and hardening:

- The progression of stiffening, defined in the European Standard as workable life, refers to the gradual change from fresh or plastic mortar to setting or set mortar.
- Hardening refers to the subsequent process whereby the set mortar progressively develops strength.

Properties of hardened mortar:

- Durability of mortar may be defined as its ability to endure aggressive conditions during its design life.
- A number of potentially destructive influences may interact with the mortar: these include water, frost, soluble salts and temperature change.
- In general, as the cement content increases so will durability.
- Air entrainment of mortars improves resistance to freeze-thaw damage.

Compressive strength:

- The use of too much cement will produce a more rigid mortar, which may result in vertical cracking passing through units and mortar joints as stresses are imposed
- Use of the appropriate mortar should not result in cracking, but any that does occur, (e.g. due to movement), will tend to follow the joints, which will be much easier to repair.

Table (1): Minimum required compressive strength and material quantities in mortar.

	ASTM Mortar Type			
	M	S	N	O
Strength (MPa)	17,2	12,4	5,2	2,4
Volume Ratio	1:1 / 4:3	1:1 / 2:4 1 / 2	1:01:06	1:02:09
	Proportions by Volume			
Cement	0.33	0.22	0.17	0.11
Lime	0.08	0.11	0.17	0.22
Sand	1	1	1	1
	Proportions by Weight			
Cement	31,3	20,9	15,7	10,4
Lime	3,3	4,4	6,7	8,9
Sand	80	80	80	80