3.0 MASONRY

Masonry consists of building structures from single units that are laid and bound together with mortar. Brick, stone and concrete blocks are the most common materials used in masonry construction. Masonry is a popular construction technique around the world, due to its many advantages.

Masonry construction can provide beautiful walls and floors at economical prices. Due to the individual masonry units, masonry construction tends to be quite labor intensive. Because of the cement, clay or stone nature of the masonry materials, masonry construction tends to be durable and often requires little maintenance.

Similar to concrete, masonry tends to be high in compressive strength but low in tension strength.

Advantages of Masonry Construction

These general advantages apply for all types of masonry units (brick, stone or concrete blocks):

- Masonry is non-combustible, so improves fire protection for the building and its occupants. Fireplaces are commonly made of masonry for the same reason.
- Masonry offers a high resistance against rotting, pests, weather, and natural disasters such as hurricanes and tornadoes.
- Masonry structures provide an attractive rustic or elegant look for a home or building, depending on the material used and the workers' expertise.
- Being durable and resistant, masonry can withstand large amounts of compressive weight loads.
- Masonry units increase the thermal mass of a building.
- Masonry buildings have longer lifespans than any other building type.

Limitations (Disadvantages) of Masonry Construction

- Masonry construction involves heavy materials such as bricks, stone and concrete blocks. These cannot be transported in conventional vehicles, and in some cases, they must be ordered from special catalogs, especially stones.
- The stability of masonry structures depends completely on their foundation. If any settling of the foundation occurs, cracks are likely and they must be repaired to prevent moisture infiltration and damage.
- Masonry activities cannot be done during heavy rain or freezing conditions, since mortar will be severely affected.
- Masonry construction requires a good amount of time and adequate project planning. Depending on the type or masonry, specialized manpower may be necessary

Types of masonry construction

Basically, there are three main types of masonry in civil engineering construction:

- Brick masonry
- Stonemasonry
- Concrete masonry

Brick masonry

The Brick masonry is made up of brick units bonded together with mortar. The strength of brick masonry depends upon the quality of brick, quality of mortar, and method of the bonding tool.

Bricks are in uniform shape and size; hence they can be laid in any definite pattern. They can easily handle due to light in weight and small in size. No dressing requires, the art of bricklaying is easy than stone masonry construction. Ornamental work can easily do with bricks. Light partitions, filler walls can easily construct by the brick.



Stone masonry

The construction of stones bonded together with mortar is termed as stonemasonry. Where the stones are available in an abundance in nature, on cutting and dressing to the proper shape. They provide an economical material for the construction of various building components such as walls, columns, arches, beams, etc. Stonemasonry being stronger, durable and weather-resistant as compared to brick masonry used in the construction of piers, docks, dams lighthouse, and other marine structures.



Concrete Masonry

Concrete block masonry which is also known as concrete masonry unit (CMU) have advantages over brick and stone masonry. Concrete blocks are manufactured in required shape and sizes and these may be solid or hollow blocks. The common size of concrete blocks is 2-inch, 4-inch, 6-inch, 8-inch, 9-inch, 10-inch and 12-inch unit configurations. Cement, aggregate, water is used to prepare concrete blocks. The cement-aggregate ratio in concrete blocks is 1:6. Aggregate used is of 60% fine aggregate and 40% coarse aggregate. Their Minimum strength is about 3 N/mm2.



Types of concrete masonry (blocks)

Followings are the types of clocks:

- i. Solid Concrete blocks
- ii. Hollow concrete blocks

Solid Concrete Blocks

Solid concrete blocks are commonly used, which are heavy in weight and manufactured from dense aggregate. They are very strong and provides good stability to the structures. So, for large work of masonry like for load bearing walls these solid blocks are preferable. They are available in large sizes compared to bricks. So, it takes less time to construct concrete masonry than brick masonry.



Hollow Concrete Blocks

Hollow concrete blocks contain void area greater than 25% of gross area. Solid area of hollow bricks should be more than 50%. The hollow part may be divided into several components based on requirement. They are manufactured from lightweight aggregates. They are light weight blocks and easy to install.



4.0 MORTAR, GROUT AND PLASTERING

MORTAR

Mortar is a mixture of cement, sand and water made into a thick paste that is used to bind two surfaces with each other. It is majorly used in the building projects as a binding material between stones, concrete and bricks.



Uses of Mortar

- i. It is used in masonry to bind stones, bricks or concrete blocks together.
- ii. It provides an even bed to stones, bricks or concrete blocks and prevents their inequalities from bearing upon one another.
- iii. It is used for pointing the joints of masonry or for plastering the surface of masonry to protect it from weather and to give the work a pleasing and smooth finish.
- iv. In concrete it is used to bind the particles of coarse aggregate into one solid mass.

Types of Mortar

Different mortars that may be used are:

(i) Cement mortar, (ii) Lime mortars, and (iii) Cement-lime or Composite mortars.

Cement Mortar

It is far stronger than lime mortar and is, therefore, preferred for use in the construction of structures subjected to heavier loads. When small quantities of it are required then it is prepared manually. In case the requirements are large then it is mixed mechanically in mixers.

Lime Mortars

Lime mortar may be lime and sand mortar or lime and surkhi mortar or lime, sand and surkhi mortar or lime and cinder mortar (black mortar). Slaked fat lime is used to prepare mortar for plastering and hydraulic lime in preparing mortar for masonry construction.

Cement-Lime Mortar

It is also known as composite mortar. When lime mortar made from fat lime is desired to be improved with regard to its initial setting time then cement is added to it. Cement should be added only to that much lime mortar which can be used within two hours of the addition of cement

GROUT

Grout is a highly viscous material which is used to fill pints (spaces or joints) between ceramics or stone tiles and is selected with a compatible mortar. Grout is a binder, but it is certainly not an adhesive and the tiles stay in place because of the mortar below them and not because of the grout.

Grout is either a portland cement-based mixture or a mixture of other compounds to enhance its performance or ease its installation.

Portland cement-based grout is a mixture of portland cement and sand (for floors) or lime (for walls) and is used for thickset installations.

Portland cement-based grouts include commercial portland cement grout, sand portland cement grout, dry set grout, and latex portland cement grout.

Grouts based on mixtures of other compounds include solid epoxy, furan, silicone, and mastic grouts. Mastic grout eliminates the need for mixing on-site.

Grout is used to fill the cores or voids in hollow masonry units for the purpose of:

- i. bonding the masonry units
- ii. bonding the reinforcing steel to the masonry,
- iii. increasing the bearing area,
- iv. increasing fire resistance, and
- v. improving the overturning resistance by increasing the weight.



Grout being used as filler material in tilling

Difference Between Mortar and Grout

The differences between mortar and grout are mentioned below in detail:

SN	IProperties	Mortar	Grout		
1	Material	Cement, sand, lime and water	Cement, water and sand, epoxy, acrylic and polymer		
2	Water- Cement Ratio	Less	More		
3	Primary Function	The primary function of the cement mortar is to act as a binder in brick or stone masonry	The primary function of the grout is to act as a filler material in tilling work and cracks.		
4	Stiffness	Stiffer	Less stiff		
5	Workability	It sticks well on a trowel and the workability is more.	As the water content is more, it is difficult to handle it with trowel or other tools.		
6	Viscosity	Low	Highly viscous		
7	Color	Usually takes the color of cement	Comes in various colors as per the requirement		
8	Types	Cement-Mortar Lime- Mortar Surki-Mortar Gauged-Mortar Mud- Mortar	Sanded grout Un-sanded or wall grout Epoxy grout Furan grout Acrylic grout		
9	Porosity	Non-porous	Quite porous, holds waters in it even after hardening.		

10	Curing	Mortar needs curing for hardening process	Grout does not need extra water for curing; the initial quantity provided is enough for hardening
11	Setting Time	Setting time is more when compared to grout	Setting time is less when compared to Mortar
12	Application	Used as a bonding material in stone, concrete and brick masonry. Used in plastering works to hide the joints and to improve appearance.	Used as a filler in tiles and cracks. Grouting is done to avoid cracks or bedding planes in weak area or ground. Grouting is used to strengthen of ground for dam foundation.

Plastering and Rendering

Plaster and render refer to mortar coatings which give a protection to blockwork. The coatings provided on interior walls are named plaster (plastering), whereas the coatings on outside walls are termed render (rendering).

The plaster and render are differentiated with the uniformity of the mortar. Rendering usually consists of more cement as compared to plastering so that it becomes weather resistant as its primary function. It's essential to render a building if it is developed with brick masonry or concrete masonry, as when these blocks are uncovered to water for prolonged period, these can be broadened as well as turned out to be soft and cracked.

5.0 CONCRETE

The strength of concrete of a given mix proportions is very seriously affected by the degree of its compaction; it is vital, therefore, that the consistency (consistency: ability to flow) of the mix be such that, the concrete can be transported, placed and finished sufficiently easily and without segregation.

Workability

The term workability is used to describe the ease with which concrete mixes can be compacted. The highest workability must be so that concrete will be as completely compacted as possible while using the lowest possible water/cement ratio.

Workability should be obtained by the use of a well-graded aggregate and one, which has the largest maximum particle size possible. The use of smooth and rounded, rather than irregularly shaped aggregate also increase workability, but in high strength concretes, there may be no overall increase in strength, because with equal water/cement ratios irregularly shaped aggregate produce, the stronger concrete.

Air entraining admixtures improve the workability of mixes (and improve the frost resistance of hardened concrete) but reduction in density of the concrete is accompanied by a loss of strength up to about 15 percent.

Consequently, we can summarize the factor of workability as:

- 1. Water content of the mix: Adding water increases workability and decreases strength.
- 2. Maximum size of aggregate: Less surface area to be wetted and more water in medium.
- 3. Grading of aggregate: Poor grading reduces the consistency.
- 4. Shape and texture of aggregates: Smooth surfaces give better workability.

In general water content and the other mix proportions are fixed. The workability is governed by the maximum size of aggregate, its grading, shape and texture.

Finer particles require more water to wet their larger specific surface. The irregular shape and rougher texture of an angular aggregate demands more water to wet their larger specific surface than rounded one.

Concrete Mix Design

Concrete is a composite mixture which consists of Cement, Sand and Aggregate. Concrete mix design is the procedure for finding the right quantities of these materials to achieve the desired strength. Accurate concrete mix design makes concrete construction economical. Large constructions such as Bridges, dams requires huge amount of concrete, using the right quantity of constituents make the structure economical.

In order to calculate or find the right amount of cement, sand and aggregate required in **1m3** of concrete; you need to know about different grades of concrete.

As per Indian Standard IS456:2000, Different grades of concrete are classified into M5, M7.5, M10, M15 etc., whereas **M** stands for Mix and the number behind **M stands for Characteristic Compressive** (fck) of the concrete in N/mm2 @28 days when checked with 15cm×15cm×15cm cube in direct compression test.

<u>Concrete Mix design of M5, M7.5, M10, M15, M20, M25, M30 and higher grades of concrete is calculated as below</u>:

The procedure for finding the different grades of concrete mixes are same. The below mentioned method can be applied to any grade of concrete by changing the values. To make ease in understanding we are finding the Concrete mix design of M20 grade concrete.

The Concrete mix ratio for M20 grade of concrete is 1:1.5:3 that mean 1 part of cement, 1.5 part of sand (fine aggregate) and 3 parts of aggregate (crushed stone) in volume and then batched for mixing. To know the Concrete Mix Design follow below:-

Mix Design (M) = Cement: Sand :Aggregate



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m25	1:1:2	
m30	1:0.75:1-5	
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Different grades of concrete:

Different grades of concrete have different Concrete Mix proportions which means different concrete mix ratios. As Per IS456:2000, the Concrete mix design has the following concrete mix proportions: -

	Type of Concrete		Concrete	Grade	Mix Ratio		Characteristic Compressive strength of Concrete
Ord	inary concrete						
M5	1	:5:10) 5 N/mm ²				
			M7.5		1:4:8		7.5 N/mm²
M10	1:	3:6		10 N/mm ²			
			M15		1:2:4		15 N/mm²
M20	1:	1:1.5:3 20 N/ ^{mm2}					
	Standard Concrete		M25	1:1:2		2	5 N/mm ²
			M30	Design	Mix	3	0 N/mm ²
			M35	Design	ı Mix	3	5 N/mm ²
			M40	Design	ı Mix	4	0 N/mm ²
			M45	Design	ı Mix	4	5 N/mm ²
			M50	Design	Mix	5	0 N/mm ²
	High Strength		M55	Design	Mix	5	5 N/mm ²
	Concrete		M60	Design	Mix	6	0 N/mm ²
			M65	Design	Mix	6	5 N/mm ²
			M70	Design	Mix	7	0 N/mm ²

Calculation of Quantities of Cement, Sand and Aggregate in 1m3 of concrete:-

To calculate the individual quantities of cement, sand and aggregate required for 1m3 assume a nominal mix grade of concrete such as M20. You can use same method to calculate any grade of concrete.

Concrete Mix Design for M20 Grade Concrete:-

Now let us consider M20 grade concrete;

As per IS456:2000, M20 Grade concrete proportion is

= 1 **:** 1.5 **:** 3

We have to add all the volume to know the total volume = 1 + 1.5 + 3 = 5.5

As we know that during concreting when we place wet concrete, it gets harden after certain standard time. Considering the same it had been decided upon by Civil design Engineers to take a factor of safety ranging from 1.54 to 1.57 to counter that shrinkage.

i.e volume of dry Concrete =

1.54 to 1.57 times Volume of wet concrete

I am Assuming 1.57 as factor of safety So total volume of concrete required is 1.57 m3

Calculation of Volume of Cement in 1m3 of Concrete:-

To calculate the Quantity of Cement in Concrete the following formula is used.

Volume of Cement

= Cement/Cement+Sand+Aggregate x 1.57

Quantity of Cement = $\frac{Cement}{Cement+Sand+Aggregate} \times 1.57$ = $\frac{1}{1+1.5+3} \times 1.57$ = 0.28 m³ 1m³ of Cement = 1440Kgs 0.28m³ of Cement = 1440 x 0.28 = 403.2Kgs

For $1m^3$ of Concrete = 403.2Kgs of Cement is required.

No. of Cement Bags required for 1m3 of Concrete = $403/50 = 8.06 \sim 8$ bags Hence, we require 8 bags of cement for 1m3 of concrete. Also Read: Detailed explanation for No. of bags required for 1 cum of cement

Calculation of Volume of Sand (Fine Aggregate) in 1m³ of Concrete:-

The following steps are followed to find the quantity of sand in 1m3 of concrete:-Volume of Sand

= Sand/Cement+Sand+Aggregate x 1.57

Quantity of Sand = $\frac{\text{Sand}}{\text{Cement+Sand+Aggregate}} \times 1.57$ = $\frac{1.5}{1+1.5+3} \times 1.57$ = 0.42 m^3 1m³ of Sand = 1600-1800Kgs (assume 1600Kgs) 0.42m³ of Sand = 1600 x 0.42 = **672Kgs**

Sand usually consists of moisture content. It increases the volume of sand (bulking of sand). For accurate calculation use dry sand or include the effect of bulking as mentioned above in calculation. Hence we require **672kg** of sand for 1 cu.m of concrete.

Calculation of Volume of Coarse Aggregate in 1m³ of Concrete:-

The following formula is used to find the quantity of coarse aggregate in 1m3 of concrete:-Volume of Aggregate

= $\frac{\text{Aggregate}}{\text{Cement+Sand+Aggregate}} \times 1.57$

Quantity of Aggregate	Aggregate				
Quantity of Aggregate	Cement+Sand+Aggregate X 1.57				
	$= \frac{3}{1+1.5+3} \times 1.57$				
	= 0.85 m ³				
1m ³ of Aggregate	= 1500-1800Kgs (assume 1560Kgs)				
0.85m ³ of Aggregate	= 1560 x 0.85				
	= 1326Kgs				

Density of aggregate may go higher if void spaces decreases. 5mm aggregate has more density when compared with 20mm size of aggregate

Hence We require **1326Kg** of 20mm aggregate for 1m³ of Concrete.

Amount of Water Required for 1m³ of Concrete:-

For making concrete, required amount of water is added. Water quantity is depends upon the climatic factors and workability required. We generally maintain 0.35-0.50 of water cement ratio. Remember, above values may change according to the moisture content present in sand and aggregate.

Cement Required for 1m3 of Concrete = 400Kgs

Assume W/C ratio = 0.50 (50% of cement)

Water required for 1m3 of Concrete. = 400×0.50

Amount of Water Required for 1m3 of Concrete = 200kgs = 200 litres

Hence 200 Litres of Water is required for 1m³ of M20 Concrete

Summary: -

8 bags of cement required for 1 cu.m of M20 grade concrete.

672 kg of Sand required for 1 cu.m of M20 grade concrete.

1326 kg of 20mm Aggregate is required for 1 cu.m of M20 grade concrete.

200 litres of water is required for 1 cu.m of M20 grade concrete

MORE CALCULCATIONS ON CONCRETE MIX DESIGN

Amproximete Coment		
require for m3 Conductor	Target m	ean Compression
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