Sand

- **A form of silica of small grains.**
- **formed by the decomposition of sandstone due to various weathering effects.**
- **Mostly obtained from pits, shores, river beds and sea beds.**

Sources of sand:

Pit sand:

- **Obtained by forming pits into the soil**
- **It is sharp, angular, porous and free from harmful salts**
- **Clay & other impurities should be washed and screened before using in engineering purpose.**
- **Fine pit sand, when rubbed between fingers, should not leave any stain on it. It indicates the presence of clay.**
- **Used for the mortars**

River sand:

- **Found at river beds and banks.**
- **Fine, round and polished due to rubbing action of water currents.**
- **Having less frictional strength because of roundness.**
- **Almost white in color.**
- **Grains are smaller than pit sand, and hence more suitable for plastering work.**
- **Normally available in pure condition and hence can be used for all kinds of CE works.**

Sea sand:

- **Obtained from sea shores.**
- **Fine, rounded and polished due to rubbing action of water.**
- **Light brown in color.**
- **Worst of the three types of sand because of containing lot of salts.**

- **Salts absorb moisture from atmosphere and cause permanent dampness and efflorescence in the structure.**
- **Sea salt also retards the setting action of cement.**
- **Besides, it contains shells and organic matter which decompose in the body of mortar and concrete, and hence reduce their life and strength.**
- **Sea sand should as far as possible be discarded.**

Classification based on fineness:

Fine sand: **FM= 2.20 ~ 2.60;** **• d < #16 sieve = 1/16 in size opening**

Medium: **FM= 2.60 ~ 2.90;** **• d < #8 sieve =1/8 in size opening**

Course: **FM= 2.90 ~ 3.20;** **• d < #4 sieve =1/4 in size opening**

- **Classification based on size is according to ASTM classification.**

Definition of fineness modulus:

FM = (∑ Cumulative % retained on all the standard US sieve)/ 100

Sieve	Size (mm)	Materials retained (gm)	% M.R.	Cumulative % M.R.	% finer
1.5 in		0	0	0	100
3/4 in		0	0	0	100
3/8 in		0	0	0	100
#4	4.75	0	0	0	100
#8	2.36	0	0	0	100
#16	1.18	10	5	5	95
#30	0.60	30	15	20	80
#50	0.30	100	50	70	30
#100	0.15	60	30	100	0

FM = (5+20+70+100)/100 = 1.95 (fine sand)

Desirable properties of sand:

- Inert completely (i.e., should not have any chemical activity).
- Grains sharp, strong & angular.
- Not containing any hygroscopic salt (i.e., $Cacl_2$, $Mgcl_2$, etc.).
- Should not contain clay & silt; usually 3~4% clay & silt is ordinarily permitted for practical reasons.
- No organic matter.

Functions of sand in Mortar/Concrete:

- Offers requisite surface area for the film of binding material to adhere and spread.
- Increases the volume of mortar & consequently makes mortar more economical.
- A well-graded sand adds to the density of mortars and concrete.
- Prevents excessive shrinkage of mortar.
- Since inert material, it renders structure more resistant against atmospheric agencies.

Tests for sand:

Test for silt and clay:

If present in sand, it can be ascertained by determining the percentage loss in weight of a sample of sand after washing the same with clean water and then sieving through #200 opening size.

However, field test can be performed by rubbing a small amount of sand between finger tips. If clay spots are left on finger tips, it indicates the existence of clay in the considerable amount.

Test for salt:

Can be tested by putting some amount in mouth. The test will reflect the presence of any salt.

Test for Organic matter:

Make 3% solution of NaOH and put some sand into the solution. Close the bottle for 24-hrs and meanwhile shake the solution vigorously. The color of the liquid turns brown if any organic matter is present in sand. The darkness of color gives the estimation of the amount of organic matter exists in the salt.

Substitute for sand:

If good sand is not available in the nearby of the site, the substitutes may be used.

Stone screenings: Fine particles obtained by screening crushed stones. The grains are sharp and strong, and hence impart better strength to the concrete if used.

Surkhi: Obtained from finely powdered burnt clay (brick). Also obtained by grinding slightly under-burnt bricks. It disintegrates under the action of air & humidity; not used for external mortar.

Bulking of sand:

- **Means increase in volume. Fine aggregate (i.e., sand) increases in volume when they possess some moisture. This volume increase is not due to the increase in volume of individual sand particle in presence of moisture.**

- **It is due to the formation of a thin film of water around the aggregate or sand particles.**

- **The thickness of this film goes on increasing with more moisture. That is, the volume of sand mass continues to increase with moisture content. This increase in volume varies 20~30% (vol. basis) depending upon the fineness of sand. The finer will undergo with greater increase in volume.**

- **After certain % of water (5~8%, also depends on the fineness of sand), the volume of sand starts decreasing with the further increase in water and eventually, the increased volume completely vanishes, and at this moment, the volume occupied by sand becomes equal to the volume of dry sand.**

- **Importance: Bulking of sand effects W/C ratio and also the proportioning of aggregate.**

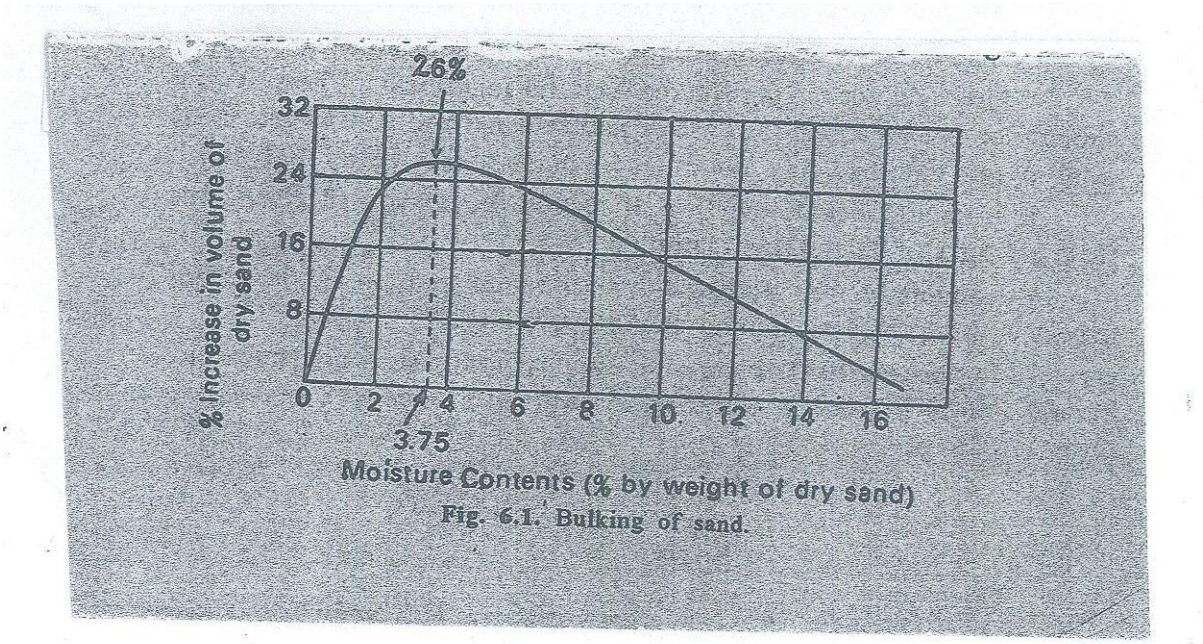

Fig. 6.1. Bulking of sand.

Mortar

- Intimate mixtures having the consistency of a paste and prepared by mixing a binding material (e.g., cement, lime, surkhi, etc.) and inert matter (e.g., sand, stone screenings, etc.) and water in various proportions.

- When the said materials are freshly mixed, mortars have a plastic consistency, which could be easily worked with towels to fill in joints in masonry.

Types of mortar

Various kinds of works require different strength from mortars. This require the variation of the proportion of sand to the cementing material used in the mortar .

a. **Cement mortar:**

- Consists of mixture of cement, sand and water in suitable proportion.
- Stronger than any other mortars.
- Commonly used in the construction of load bearing wall, pillars, columns, etc.
- The proportion of cement to sand (volume basis) varies from 1:2 to 1:6 or even more, such as:

• Masonry wall	1:6 to 1:8
• Foundation concrete	1:3 to 1:4
• R.C.C. works	1:3
• Arch works	1:3
• Pointing	1:2~1:3
• Plaster work	1:3 to 1:4

Lime mortar:

- Mixture of lime (fat, normal or hydraulic lime), sand & water
- If fat lime is used in mortar, it should be slaked before using
- Fat lime mortar, proportion should be 1:1
- Ordinary lime mortar 1:2
- Hydraulic lime mortar 1:4
- Note that hydraulic lime has greater cementing power than the others

Mud mortar:

- Mixture of puddle mud and water at the required consistency. Used in masonry of kucha bricks "in village and plastering for kucha huts.

Gauged mortar:

- Lime mortar with having some cement to increase cementing properties.
- Usually used with fat lime mortar, as this kind of lime possesses very weak cementing property.
- Cement in lime mortar increase its strength, hydraulicity and the rate of setting.
- This mortar can be used for brick or sto.ne masonry in foundation.

Preparation of cement mortar:

- Sand and cement are measured in a dry state and spread to a uniform thickness on a non-porous platform. Cement is spread over sand. As usual sand is measured in ft^3, but cement is measured by weight, 40 kg/ft^3.
- For a given batch, the quantity of water to be added is calculated. One half of that quantity is sprinkled on the above dry mix. The mixture is again turned over twice or thrice to prepare a semi-wet mix.
- The remaining quantity of water is added to the semi-wet mix and again the whole mixture is turned twice or thrice to form cement mortar of the required consistency.
- Now the mortar is ready for use. All the work done in cement mortar should be kept wet for about 15 to 21 days for curing by occasional sprinkling with water.

Precautions in using mortar:

- Bricks or stones to be jointed by mortar should be used by soaking them in water for at least 12 hours.
- After preparation of mortar, it should be used at its destined place as early as possible; cement mortar within 30 minutes of adding water to it and lime mortar within 36 hours.
  Mortar should be stiff but workable; that is, it should be as stiff as possible without affecting its convenience in use.
- Works made from mortar should be kept wet for two weeks to three.

Test for mortar:

Tensilestrength: Using briquette apparatus with minimum cross-section of 1.5"x 1.5".

Compressive strength: By using 2"x2"x2" cube made from cement mortar.

Adhesive strength test: Arrange two bricks in T-shape and use mortar at the intersection lime. When they gained sufficient strength after curing of 7, 14 or 28 days, the T is suspended invertedly from the upper brick and weights are attached to the lower brick (as shown in figure). Weights are gradually increased till both bricks split from each other.

Special mortars:

Light weight mortar:

- Ordinary cement or lime mortar including asbestos, fibres, jute fibre, wood powder, saw dust, coir and hair, etc.
- For developing adhesion under special conditions, small quantities of glue could be added to mortars.
- Should be used drinking water.
- Used for heat- or soundproof structures.

Fire resistant:

- Obtained by mixing firebricks or fire clays with aluminous cement.
- Usual proportion is one part aluminous cement and two parts powdered fire clay.
- Withstand the effects of very high temperature; and so it is used for lining of furnaces, fire places and ovens, etc.

X-ray shielding mortars:

- Special heavy mortars (2.7 gm/cc) are used to cover walls and ceiling of X-ray cabinets.

Lean mortars:

- Cement/lime mortar with very small proportion of cementing material.
- Uses to fill in the cracks, faults or narrow joints. The process is known as 'grouting'.