1. <u>INTRODUCTION</u>

Concert is basically a mixture of two components; aggregates and paste. The paste, comprised of Portland cement and water, binds the aggregates (usually sand and gravel or crushed stone) into a rocklike mass as the paste hardens because of chemical reaction of the cement and water. Supplementary cementations materials and chemical admixtures may also be included in the paste.

Aggregates along with a cement stone form the concrete structure of Rock like (conglomerate) mass.

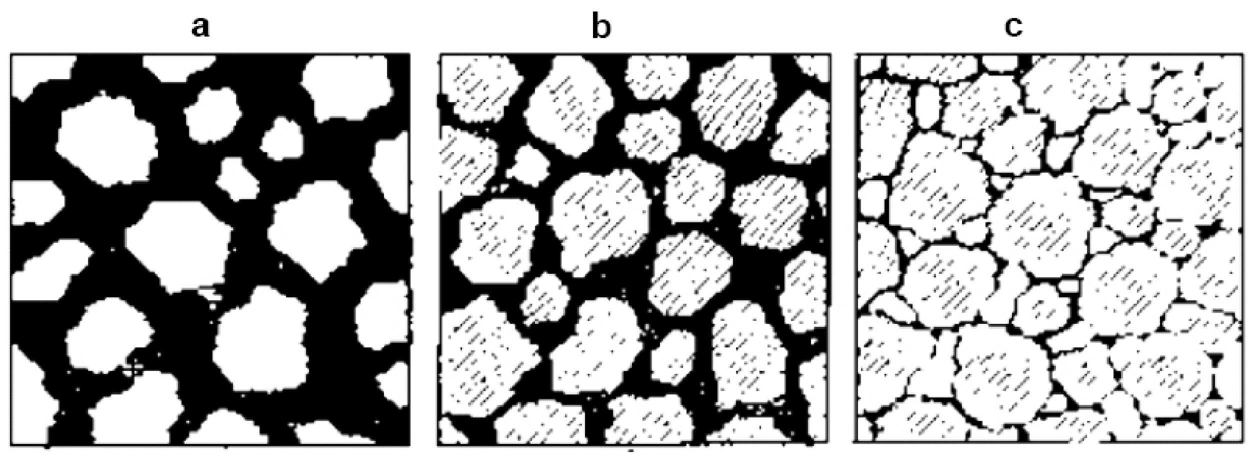

Fig. 1 Charts of concrete structure:
a –floating structure;
b – Intermediate structure; **c** – Contact structure

Aggregates are generally divided into two groups; fine and course. Fine aggregates consist of natural or manufactured sand with particle size ranging up to 9.5mm (3/8 inch); coarse aggregate used for normal concreting is typically 10mm or 25 mm (3/4 inch or 1 inch). An intermediate-sized aggregates, around 9.5 mm (3/8 inch), is sometimes added to improve the overall aggregate gradation.

The paste is composed of cementations materials, water and entrapped air or purposely entrained air. The paste constitutes about 25% to 40% of the total volume of concrete. Absolute volume of cement is usually between 7% and 15%

and the water between 14% and 21%. Air content in air-entrained concrete ranges from about 4% to 8% of the volume.

Since aggregates make up about 60% to 75% of the total volume of concrete, their role is important. Aggregates should consist of particles with adequate strength and resistance to exposure conditions and should not contain materials that will cause deterioration of concrete. A continuous gradation of aggregate particle sizes is desirable for efficient use of paste.

The quality of concrete depends upon the quality of paste and aggregates, and the bond between the two. In properly made concrete, each and every particle of aggregate is completely coated with paste and all of the spaces between aggregate particles are completely filled with paste.

For any particular set of materials and conditions of curing, the quality of hardened concrete is strongly influenced by the amount of water used in relation to the amount of cement. Unnecessarily high water contents dilute the cement paste (the glue of concrete).

Following are some advantages of reducing water content:

- Increased compressive and flexure strength.
- Lower permeability, thus lower absorption and increase in water tightness.
- Increased resistance to weathering.
- better bond between concrete and reinforcement
- reduced drying shrinkage and cracking
- less volume change from wetting and drying

The less water used, the better the quality of concrete, provided that mixture can be consolidated properly. Smaller amounts of mixing water result in stiffer mixture;

but with vibration, stiffer mixtures can be easily placed. Thus, consolidation by vibration permits improvement in the quality of concrete.

NOTE: increased water dilutes the effect of the cement paste, increasing volume, reducing density, and lowering strength.

The freshly mixed (plastic) and hardened properties of concrete may be changed by adding chemical admixtures to the concrete, usually in liquid form, during batching. Chemical admixtures are commonly used to

1. adjust setting time or hardening,
2. reduce water demand (indirect)
3. increase workability (indirect)
4. intentionally entrain air, and
5. Adjust other fresh or hardened concrete properties.

After completion of proper proportioning, batching, mixing, placing, consolidating, finishing, and curing, concrete hardens into strong , non-combustible, durable, abrasion-resistant, and water tight building material that requires little or no maintenance. Furthermore, concrete is an excellent building material because it can be formed into a wide variety of shapes, colors, and textures for use in an unlimited number of application.

2 BATCHING, MIXING, TRANSPORTING, AND PLACING OF CONCRETE

2.1 ***BATCHING:***

Batching is the process of measuring concrete mix ingredients by either mass or volume and introducing them into the mixer. To produce concrete of uniform quality, the ingredients must be measured accurately for each batch. Most specifications require that batching be done by mass rather than by volume (ASTM 94 or AASHTO M 157). Water and liquid admixtures can be measured accurately by either volume or mass. Volumetric batching (ASTM C 685 or AASHTO M 241) is used for concrete mixed in continuous mixers.

2.1 CONTROL ROOM FOR BATCHING EQUIPMENT IN A READY MIXED CONCRETE PLANT

A specification generally requires that materials be measured for individual batch within the following percentages of accuracy: cementitious material ±1%, aggregates ±2%, and admixtures ±3%.

Equipment should be capable of measuring quantities within this tolerance for the smallest batch regularly used as well as for larger batches. The accuracy of scales and batching equipments should be checked periodically and adjusted when necessary.

2.2 ***MIXING OF CONCRETE:***

All concrete should be mixed thoroughly until it is uniform in appearance with all ingredients evenly distributed. Mixers should not be loaded above their rated capacities and should be operated at the mixing speed recommended by the manufacturer. Increased output should be obtained by using a larger mixer or additional mixers, rather than by speeding up or overloading the equipment on hand.

The nominal size of a mixer is described by the volume of concrete after compaction (BS 1305: 1974), which may be as low as one-half of the volume of the unmixed ingredients in a loose state. Mixers are made in a variety of sizes from $0.04m^3$ ($1½ft^3$) for laboratory use up to $13m^3$ ($17yd^3$). If the quantity mixed represents less than one-third of the nominal capacity of the mixer, the resulting mix may not be uniform, and the operation would, of-course, be uneconomical. Overload not exceeding 10 per cent is generally harmless. If the blades of a mixer become worn or coated with hardened concrete, mixing action will be less efficient. These conditions should be corrected.

If concrete has been adequately mixed, samples taken from different portions of a batch will have essentially the same density, air content, slump and coarse aggregate content. Concrete mixers must not only achieve the uniformity of the mix, but they must also discharge the mix without disturbing that uniformity.

2.2.1 STATIONARY MIXING:

Concrete is sometimes mixed at the jobsite in a stationary mixer or a paving mixer. Stationary mixers include both onsite mixers and central mixers in ready mix plants. They are available in sizes up to 9.0 m^3 (12 yd^3) and can be of tilting or non-tilting type or the open-top revolving blade or paddle with a swinging discharge chute. Many of the stationary mixers have timing devices, some of which can be set for a given mixing time and locked so that the batch cannot be discharged until the designated mixing time has elapsed.

2.2.1.1 TILTING MIXERS:

In the tilting mixer, the mixing chamber, known as the drum, is tilted for discharging. Tilting mixers usually have a conical or bowl shaped drum with blades inside. The efficiency of the mixing operation depends on the details of design but the discharge action always good as all the concrete can be tipped out rapidly and in an unsegregated mass as soon as the drum is tilted. For this reason, tilting-drum mixers are preferable for mixes of low workability and for those containing large-size aggregate.

It may be relevant to mention that, in drum type mixers, no scraping of the sides takes place during mixing so that a certain amount of mortar adheres to the sides of the drum and stays there until the mixer has been cleaned. It follows that, at the beginning of concreting, the first mix would leave a large proportion of its mortar behind and the discharge would consist largely of coarse particles. This initial batch should not be routinely used. As an alternative, a certain amount of mortar may be introduced into the mixer prior to the commencement of concreting, a procedure known as "buttering" or priming the mixer. A convenient and simple way is to charge the mixer with the usual quantities of cement, water and fine aggregate, simply omitting the coarse aggregates. The mix in excess of that stuck in the mixer can be used in construction. The necessity of buttering should not be forgotten in the laboratory work.

2.2.1.2 NON-TILTING MIXER:

In the non-tilting mixer, the axis of the mixer is always horizontal, and discharge is obtained either by inserting a chute into the drum or by reversing the direction of rotation of the drum (when the mixer is known as a reversing drum mixer), or rarely by splitting of the drum.

Because of a rather slow rate of discharge from a non-tilting drum mixer, concrete is sometime vulnerable to segregation. In particular, the largest size of aggregate may tend to stay in the mixer so that the discharge sometime starts as mortar and ends as a collection of coated coarse aggregate particles, non-tilting mixers are less frequently used than in the paste.

Non-tilting mixer is always charged by means of a loading skip, which is also used with the larger tilting drum mixers. It is important that the whole charge from the skip be transferred into the mixer every time, i.e. no sticking must occur. Sometimes, a shaker mounted on the skip assists in emptying it.

2.2.1.3 PAN MIXER:

The pan mixer is generally not mobile and is therefore used at a central mixing plant, at a pre-cast concrete plant, or in a small version in the concrete laboratory. The pan type mixers are called forced action mixers, as distinct from the tilting mixer and non-tilting mixers which rely on the free fall of concrete in the drum. The mixer consists of a circular pan rotating about axis, with one or two stars of paddles rotating about a vertical axis not coincident with the axis of the pan. Sometimes, the pan is static and the axis of the star travels along a circular path about the axis of the pan. In either case, the relative movement between the paddles and the concrete is the same, and the concrete in every part of the pan is thoroughly mixed. Scraper blades prevent mortar sticking to the sides of the pan, and the height of the paddles can be adjusted so as to prevent a permanent coating of mortar forming on the bottom of the pan.

Pan mixer offer the possibility of observing the concrete in them and therefore of adjusting the mix in some cases. They are particularly efficient with stiff and cohesive mixes and are, therefore, often used in manufacturing of pre-cast concrete. They are also suitable because of the scrapping arrangements, for mixing very small quantities of concrete as in the laboratory.

2.2.2 CONTINUOUS MIXERS:

All the mixers considered so far are *batch mixers*, in that one batch of concrete is mixed and discharged before any more materials are added. As opposed to this, a continuous mixer discharged mixed concrete steadily without interruption, being fed by a continuous volume or weight-batching system. The mixer itself consists of a spiral blade rotated at relatively high speed in an enclosed slightly inclined trough. ASTM C 685-94 prescribes the requirement of concrete made by volumetric batching and continuous mixing, and ASI 304.6R-91 offers a guide for use of relevant equipment. Modern continuous mixers produce concrete of high uniformity. Using a continuous feed-mixer, placing, compaction and finishing can all be achieved within 15 minutes of the introduction of water into the mix.

Mobile volumetric mixers are special trucks that batch by volume and continuously mix concrete as the dry concrete ingredients, water, and admixtures are continuously fed into mixing through, typically an auger system. The concrete must conform to ASTM C 685 (AASHTO M 241) specifications and is proportioned and mixed at the job sides in the quantities needed. The concrete mixers also easily adjusted for project placement and weather conditions.

2.2.3 READY MIX CONCRETE:

Ready mixed concrete is proportioned and mixed off the project site and is delivered to construction area in a freshly mixed and unhardened state. It can be manufactured by any of the following methods:

1- Concrete is mixed completely in a stationary mixer and is delivered either in a truck mixer operating at a agitating speed which revolves slowly so as to prevent segregation and undue stiffening of the mix, or a non –agitating truck. Such concrete is known as central-mixed concrete. The capacity of truck used as a mixer is 80% of the drum.

2- The concrete is partially mixed at a central plant in order to increase the capacity of the agitator truck. The mixing is completed on route. Such concrete is known as shrink-mixed concrete but is rarely used.

3- In transit-mixed or truck-mixed concrete, the materials are batched at a central plant but are mixed in a mixer truck either in transit to the site or immediately prior to the concrete being discharged. Transit mixing permits a longer hauling time and is less vulnerable in case of delay, but the capacity of truck used as a mixture is only 63%, or even less, of the drum. Truck mixtures usually have a capacity of $6m^3(8yd^3)$ or $7.5m^3(10yd^3)$.

Concrete hopper truck at a concrete mixing plant

It should be noted that agitating differs from mixing solely by the speed of rotation of the mixers: the agitating speed is between 2 and 6 rev/min, compared with the mixing speed of 4 to about 16rev/min. The speed of mixing affects the rate of stiffening, while the total number of revolutions controls the uniformity of mixing. Unless the concrete has been shrink- mixed in central plant mixer, 70 to 100 revolutions at mixing speed in the truck mixer are required. Mixing at high speeds for long periods of time, about one or more hours, can result in concrete strength loss, temperature rise, excessive loss of entrained air and accelerated slump loss.

Ready mixed concrete is particularly useful on congested sites or in road construction where little space for a mixing plant and for extensive aggregates stock piles is available, but perhaps the greatest single advantage of ready mixed concrete is that it is made under better conditions of control than are normally possible on any but large construction sites. Control has to be enforced but, really close control of all operations of production of fresh concrete is possible. Proper care during transportation of the concrete is also ensured by the use of agitator trucks but, the placing and compaction remain, of course, the responsibility of the personnel on the site. The use of ready mixed concrete is also advantageous when only small quantities of concrete are required or when concrete is placed only at intervals.

Use of a mobile concrete batching and mixing truck to produce concrete at the job site

When truck mixers are used, ASTM C 94 (AASHTO M 157)also limits the time between batching and complete discharge of the concrete at the job site; this time is 1 ½ hours or before the drum has revolved 300 times after introduction of water to the cement and aggregates or the cement to the aggregates .if the final part of water to the cement and aggregates or the cement to the aggregates. If the final part of water is put into the mixer just prior to delivery of the concrete (as may be desirable in hot weather), ASTM C 94-94 requires 30 additional revolutions at mixing speed prior to discharge. Mixers and agitators should always be operated within the limits for volume and speed of rotation designated by the equipment manufacturers.

The main problem in production of ready mixed concrete is maintaining the workability of the mix right up to the time of placing. Concrete stiffens with time and the stiffening may also be aggravated by prolonged mixing and by a high temperature. In the case of transit mixing, water need not to be added till nearer the commencement of mixing but, according to ASTM C 94-94, the time during which the cement and moist aggregate are allowed to remain in contact is limited to 90 minutes; BS 5328: part 3: 1990 allows 2 hours. The 90 minutes limit can be relaxed by the purchaser of the concrete; there is evident that, with use of retarders, the time limit can be extended to 3 or even 4 hours, provided the concrete temperature at delivery is below the 32ºC(90ºF) .

(Ready mixed concrete plant)

HAND MIXING:

Hand mixing is used when small quantities of concrete are to be mixed, but in this case uniformity is more difficult to achieve, particular care and effort are necessary.

The aggregate should be spread in a uniform layer on a hard , clean and nonporous base; cement is then spread over the aggregate , and the dry materials are mixed by turning over from one end of the tray to the other and cutting with a shovel until the mix appear uniform .Turning three time is usually required. Water is then gradually added so that neither water itself nor with cement can escape. The mix is turned over again, usually three times until it appears uniform in color and consistency.

It is obvious that during hand mixing no soil or other extraneous material must be allowed to become included in the concrete.

UNIFORMITY OF MIXING:

In any mixer, it is essential that sufficient interchange of material between different parts of the chamber takes place, so that uniform concrete is produced. The efficiency of the mixer can be measured by the variability of the mix discharged into a number of receptacles without interrupting the flow of concrete. For instance, a rather rigid test of ASTM C 94 – 94 (formally applicable only to truck mixer) lays down that samples of concrete should be taken from about 1/6 to 5/6 points of a batch , and the differences in the properties of the two samples should not exceed any of the following:

>Density of concrete	16 kg/m^3(1 lb/ft^3)
>Air content	1 percent
>Slump	25 mm.
>% of aggregates Retained on 4.75 sieve	6 %
>Density of air –free mortar	1.6 %
>Compressive strength	7.5 %