Construction Technology (L7)

CONCRETE

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Concrete:

- Portland cement concrete is the most widely used structural material in the world for civil work projects. Its versatility, economy, adaptability and worldwide availability and especially its low maintenance requirements, make it very useful and cost effective.
- The term concrete is applicable for many products but is most generally used with Portland cement concrete.
- It consists of Portland cement, water and aggregates which have been mixed together, placed, consolidated and allowed to solidify and harden. The Portland cement and water form a paste which acts as a glue or binder.
- When fine aggregates is added, the resulting mixture is termed mortar.
- When coarse aggregates is included, concrete is produced.
- Normal concrete consists of about three-fourths aggregate and one-fourth paste by volume.

Ready Mixed Concrete:

- The paste usually consists of water-cement ratio between 0.40 and 0.70 by weight.
- Admixtures are sometimes added for specific purposes such as to entrain air, impart color or to retard or accelerate the setting time or to work as a water reducer.
- With the use of high range water reducers, low permeability and waterproof concrete is produced.
- The operation involved in the production of concrete vary with the type and end use of concrete but in general the operation include:
- Batching the materials.
- Mixing
- Transporting
- Placing
- Consolidating
- Finishing.
- Curing.

Proportioning Concrete Mixitues:

Designing concrete mixture is covered under the course of concrete technology on second year and is beyond the scope of this course. However few observations need to be clear:

- Although it takes water to initiate the hydraulic reaction, the higher the water cement ration the lower the resulting strength and durability will be.
- The more water is used the increased concrete workability in terms of slump.
- The more aggregate content is used the lower cost of the resulting concrete will be.
- The larger the maximum size of coarse aggregates, the less amount of cement paste that will be needed to coat all the particles and to provide necessary workability.
- The more fresh concrete is consolidated, the stronger and more durable it becomes.
- The use of properly entrained air enhances almost all concrete properties with little or no decrease in strength if the mix proportions are adjusted for the air.
- The surface abrasion resistance of the concrete is almost entirely a function of the properties of the fine aggregates and water/cement ratio.

FRESH CONCRETE :

To the designer, fresh concrete is of little importance. To the contractor, fresh concrete is all-important because it is the fresh concrete that must be mixed, transported, placed, consolidated, finished and cured. To satisfy both the designer and the contractor, the concrete should:

- Be easily mixed and transported.
- Be uniform within a batch and between batches.
- Be of proper workability so that it can be consolidated, will completely fill the forms, will not segregate and will finish properly.
- The major property of importance to the contractor is the workability which is difficult to define in precise term. Like the term warm and cold. Slump test is the measure of the workability according to the American Society for Testing and material. The following Tables gives the recommended slumps for various types of concrete construction:

Types of Construction	Slump (in.)	
	Maximum	Minimum
Reinforced Foundation walls and Footings	3	1
Plain Footings and substructure walls	3	1
Beams & reinforced walls	4	1
Building Columns	4	1
Pavements and Slabs	3	1
Mass Concrete	2	1

Batch Plants and Mixers:

There are two types of concrete mixing operations in use: Jobsite batched concrete and central batched concrete. Unless the project is in a remote location or is relatively large, more and more of the concrete is batched in the central batching plant and transported to the site in ready-mixed concrete trucks.

This type of concrete is controlled by the ASTM specifications C94.

Note that concrete batch required 4 different sizes of coarse aggregates, plus sand and one or one type of cement, flaked ice and water.

The water is normally measured by volume while other mix constituents are measured by weight.

Batch Plants are available in three categories:

- Manual, which is usually used for small jobs.
- Semiautomatic which covers up to 50 to 60 cubic meters per day.
- Fully automatic which can serve up to 30 cubic meter per hours

READY MIXED CONCRETE:

Concrete is proportioned in a central location and transported to the purchaser in a fresh state, mixed at the plant or en route. This type of concrete is termed as “ready mixed concrete” and is governed by ASTM C94.

Because of its economy and quality and by the efforts of the National Ready Mixed Concrete. Concrete purchased in this manner enjoy wide acceptance in the field of construction.

Concrete purchased from ready-mixed concrete plant can be provided in several ways. These include:

- Central-mixed Concrete, this is the concrete which is mixed completely in a stationary mixer and transported to the project in either truck agitator, a truck mixer operating at agitating speed or non-agitating truck.
- Shrink-mixed concrete, this is the concrete which is partially mixed in a stationary mixer and then mixed completely in a truck mixer (usually en route to the project).

READY MIXED CONCRETE:

- Truck mixed concrete, this is the concrete which is completely mixed in a truck mixer, with 70 to 100 revolution at a speed sufficient to mix the concrete completely. This type of concrete is usually termed ‘transit-mixed Concrete” because it is mixed en route.
- The elapsed time from the introduction of water to the placement of the concrete into the forms should not exceed one and half hour or before the drum has evolved 300 revolutions whichever comes first.
- Transit mixers are available in several sizes up to 14 cubic yard, but most of the popular size is 8 cubic yard. They are capable of thoroughly mixing the concrete with about 100 revolution of the mixing plants.
- Mixing speed is generally 8 to 12 rpm. This mixing during transit usually results in stiffing the mixture and ASTM C94 allows the addition of water at the job site to restore the slump (re-tempering), followed by re-mixing. This has caused a problem and raised a question concerning the strength and durability of the resulting concrete.
- ACI 304 recommends that some of the water be withheld until the mixer arrives at the project site (specially in hot weather), then the remaining water be added and additional 30 revolution of mixing be required.

How to Order Ready Mixed Concrete:

Ready Mixed Concrete may be ordered in several ways. They are:

- ✓ **Recipe Batch,** the purchaser assumes responsibility for proportioning the concrete mixture. This includes specifying the cement type and content, the maximum allowable water content and the admixture required. The purchaser may also specify the amounts and type of coarse and fine aggregates. Under this approach the purchaser assumes full responsibility for the resulting strength and durability of the mixture provided that the stipulated amounts are furnished as specified.
- ✓ **Performance Batch**, the purchaser specifies the requirements for the strength of the concrete and the manufacturer assumes full responsibility for the proportion of the concrete ingredients that go into the batch.
- ✓ **Part performance and part recipe**, the purchaser generally specifies a minimum cement content, the required admixtures and strength requirements allowing the manufacturer to proportion the concrete mixtures within the constraints imposed.
- ✓ Today, most purchasers of the concrete use the third approach, part performance and part recipe as it ensures a minimum durability requirements while still allowing the ready-mixed concrete supplier some flexibility to supply the most economical mixture.

Moving and Placing Ready Mixed Concrete:

Once the concrete arrives at the project site, it must be moved to its final position without segregation and before it has achieved an initial set. This movement may be accomplished in several ways depending on the distance, elevation, and other imposed constrains. These methods include buckets or hoppers, chutes and drop pipes, belt conveyors and concrete pumps.

Buckets or Hoppers: Normally, properly designed bottom-dump buckets permit concrete placement at the lowest practical slump. Care should be exercised to prevent the concrete from segregating as a result of discharging from too high above the surface or to allow the fresh concrete to fall past obstructions. Gates should be designed so that they can be opened and closed at any time during the discharge of the concrete.

Manual or motor propelled buggies, hand buggies and wheelbarrows are usually capable of carrying from 4 to 9 cubic feet of concrete. Hand buggies are more saver than wheel barrows as they have two wheels rather than one. Hand buggies and wheel barrows are suitable for a distance less than 200 ft. While motor-driven buggies carry up to 14 cubic feet and can transverse a distance up to 1000 ft.

Moving and Placing Ready Mixed Concrete:

Chutes and Drop Pipes: Chutes are often used to transfer concrete from a higher elevation to a lower elevation. They should have a round bottom and slope should be steep enough for the concrete to flow continuously without segregation. Drop pipes are used to transfer the concrete vertically down . The pipes should have a diameter at least 8 times the maximum aggregate size at the top and 6 to 8 feet at bottom and may be tapered so that the lower end is approximately 6 times the maximum aggregate size. Drop pipes are used when concrete is placed in a wall or column to avoid segregation from allowing the concrete to free-fall through the reinforcement. In such areas pipes should always be used.

Belt Conveyors: belt conveyors can be classified into three types:

- Portable or self contained conveyors.
- Feeders or series conveyors,
- Side discharge or spreader conveyors.

All types provide for the rapid movement of fresh concrete but must have proper belt size and speed to achieve the desired rate of transportation. Particular attention must be given to the points where concrete leaves one conveyor and either continues on an other conveyor or is discharged as segregation may occur. The optimum concrete slump for conveyed concrete is from 2.5 to 3 inch.

Moving and Placing Ready Mixed Concrete:

Concrete pumps: the placement of the concrete through rigid or flexible lines is not new. In fact the patent for this method of moving concrete was issued in 1913. However concrete pumps was extensively used after 1930 when the German pumping equipment was introduced in Europe. The pump is extremely simple machine. By applying a pressure to a column of fresh concrete in a pipe, the concrete can be moved through the pipe if a lubricating outer layer is provided and if the mixture is properly proportioned for pumping.

In order to pump the concrete properly: the pump must be fed concrete of uniform workability and consistency.

About 25% of the produced concrete are placed by pumps.

Pumps are available in a variety of sizes capable of delivering concrete at sustained rate of 10 to 50 cubic yard per hour.

Effective pumping range varies from 300 to 1000 ft. horizontally and 1000 ft. vertically.

Moving and Placing Ready Mixed Concrete:

- Successful pumping of concrete is not accidental. A common fallacy is to assume that any good place-able concrete will pump successfully. The basic principle of pumping concrete is that the concrete moves as a cylinder through a lubricated line, with the lubrication continually being replenished by the cylinder of concrete. To pump the concrete successfully, a number of rules should be carefully followed. The rules are:
- Use minimum cement content of 300 kg/m3.
- Use combined gradation of coarse and fine aggregates that ensures no gaps of sizes that will allow paste to be squeezed through the coarser particles under the pressures induced in the line.
- Use minimum pipe diameter of 5 inches.
- Always lubricate the line with cement paste or mortar before the beginning the pump operation.
- Ensure a steady, uniform supply of concrete with slump of between 2 and 5 inches as it enters the pipe.

Moving and Placing Ready Mixed Concrete:

- Always presoak the aggregates before mixing them in the concrete to prevent their soaking up the mix water under the imposed pressure.

- Avoid the use of reducers in the conduit line. One common problem is the use of 5 to 4 inch reducer at the discharge end so that workers will have only 4 inches flexible hose to move around. This creates a constriction and significantly raises up the pressure to pump the concrete.

- Never use the aluminum lines, Aluminum particles will be scraped from inside of the pipe as the concrete moves through and will become part of the concrete. Aluminum and Portland cement react, liberating hydrogen gas which can rupture the pipe line and the concrete.

Consolidating the Concrete

Consolidating Concrete:

- Concrete is a heterogeneous mixture of water and solid particles in stiff conditions, normally contains large quantity of voids when placed into the forms.
- The purpose of consolidation is to remove these entrapped air voids which weaken the concrete to the degree that the concrete will be unsatisfactory.
- Entrapped air can be reduced in two ways: use more water or consolidate the concrete. Adding more water is not recommended as it will reduce the concrete strength and durability.
- Consolidation is normally achieved through the use of mechanical vibrators.
- There are three main types of vibrators: Internal, surface and from vibrators:
- **Internal (Spud) Vibrators:** they have a vibrating casing or head which immersed into the concrete and vibrate at a high frequency often in the range of 10,000 to 15,000 vibrations per minute against the concrete. They are suitable for slabs and beams.
- **Surface vibrators:** their effect is on the concrete surface and then go down. They are suitable for slabs consolidation.
- **Form vibrators** are external vibrators attached to the outside form or mold. They vibrate the form which compact the concrete inside. This is extensively used in precast concrete plants.

Finishing and Curing the Concrete

Finishing the concrete Surface.

- The work done to the concrete surface after it has been consolidated weaken the concrete surface. However to have a smooth attractive surface, finishing is necessary specially in floor slabs, sidewalks and pavements.
- Finishing should not commence if any free bleeding water is not bottled up nor mixture of cement and sand stars to dry out.
- **Curing the concrete:**
- Along with placement and consolidation, proper curing of concrete is extremely important.
- Curing is important to ensure continuity of the cement hydration and concrete hardening. It reduces the detrimental effects of cracking and develops the intended strength of the concrete.
- If the concrete has a water/cement ratio in the range of 0.50 or more which is considered sufficient for hydration , care should be taken to ensure that the concrete is not dried out. This may be accomplished by ponding with water for slabs, covering with wet burlap or polyethylene sheets or spraying with an approved curing compound.
- If the concrete is not cured enough it will dry up and then shrink. As the shrinkage increases, the cracks form and propagate since the shrinkage stress is higher that the tensile strength of the pre-mature concrete.

SEE YOU NEXT LECTURE

THANK YOU!