

Advanced Construction Materials

Organized by

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Lecture 1 - *Translucent Concrete*

Translucent Concrete

- Light transmitting concrete is a mixture of optical glass fibers and fine concrete.
- The two basic materials used for making transparent concrete
 - ✓ Fine concrete and **Optical fibers**.
 - ✓ Fine concrete: Consists of cement and fine **aggregate** such as **sand**
- An optical fiber is a hair thin cylindrical fiber of glass or any transparent



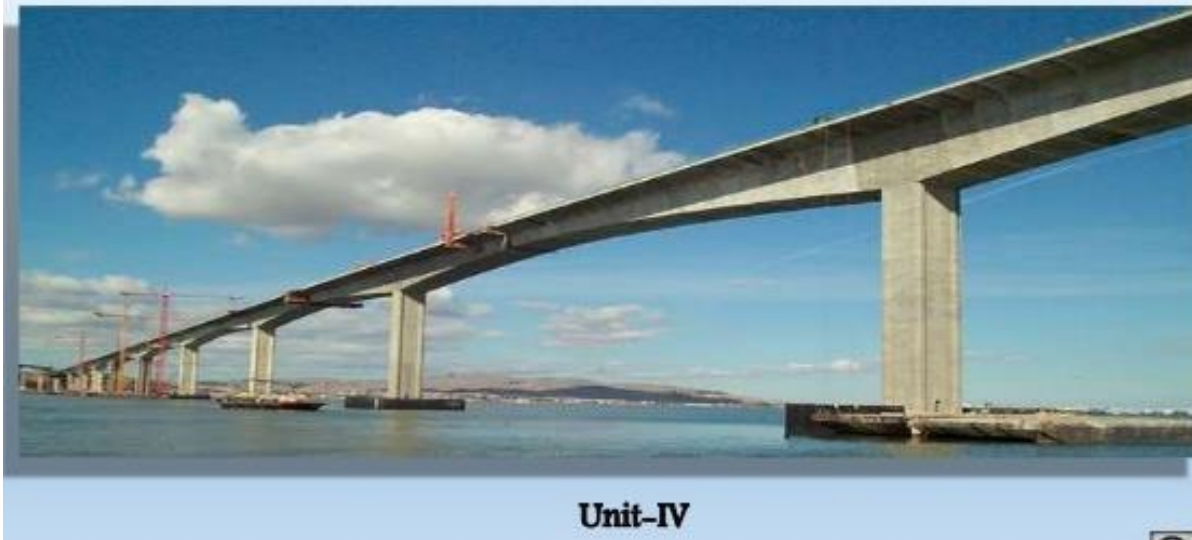
High Performance Concrete

- In the United States, in response to widespread cracking of concrete bridge decks, the construction process moved towards the use of High Performance Concrete (HPC) mixes.
- Four types of HPC were developed
 - Very High Early Strength Concrete – 17.5 MPa in 6 hours
 - High Early Strength Concrete – 42.5 MPa in 24 hours
 - Very High Strength – 86 MPa in 28 days
 - High Early Strength with Fiber Reinforcement

Why **High Performance Concrete**?

- Conventional Portland-cement concrete mixtures suffer from certain deficiencies.
- Attempts to overcome these deficiencies have resulted in the development of special concrete types.

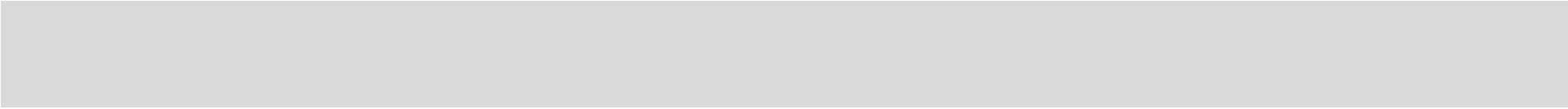
High Performance Concrete



- This places concrete at an economic disadvantage when designing structural members for tall buildings, long-span bridges, and floating structures.

There are 3 ways to address this problem:-

1. The **unit weight of concrete** can be reduced by substituting
 - lightweight aggregate (*LWA*) in place of conventional aggregate.
 - *LWA* made by calcination of clay or shale is commonly used to produce
 - structural lightweight concrete that has about 1/3 less unit weight than conventional concrete.

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2. The **strength of concrete** can be raised substantially.
 3. The third approach, which is a relatively recent development, combines the first two approaches.
 - It involves the use of high-strength *LWA* particles in superplasticized
 - mixtures to produce high-strength, lightweight concrete.

- **Poor impact resistance** is yet another deficiency from which concrete suffers as a building material.
- This characteristic has been substantially improved by using the concept of microlevel reinforcement.
- **Fiber-reinforced concrete** mixtures containing steel, glass, or polypropylene
- fibers are being employed successfully in the structures where resistance to impact is important.

Structural Lightweight Concrete

Durability

- Freeze-Thaw Resistance
- Permeability
- Creep/Drying Shrinkage
- Abrasion/Erosion Resistance

Applications

- Lower overall cost of the structure
- Bridge Decks
- Floor slabs
- Pre-cast concrete e

High-Strength Concrete

Definition:

- 28-day $f'_c > 40 \text{ MPa}$
- Materials and mix proportions, e.g.

W/C Ratio f'_c 0.38 40 MPa

- 0.36 50 MPa 0.34 60 MPa

Problem: Mixing, placing, and consolidation

Use: Water-Reducing Admixture.

- Calculated Mixture Proportions for the First Trial Batch According to the Mehta and Aitcin's Procedure, kg/m³

Strength grade	Avg. strength (MPa)	Option	Cementitious materials			Total* water	Coarse agg.	Fine agg.	Total batch	W/C
			PC	FA or BFS	CSF					
A	65	1	534	—	—	160	1050	690	2434	0.30
		2	400	106	—	160	1050	690	2406	0.32
		3	400	64	36	160	1050	690	2400	0.32
B	75	1	565	—	—	150	1070	670	2455	0.27
		2	423	113	—	150	1070	670	2426	0.28
		3	423	68	38	150	1070	670	2419	0.28
C	90	1	597	—	—	140	1090	650	2477	0.23
		2	447	119	—	140	1090	650	2446	0.25
		3	447	71	40	140	1090	650	2438	0.25
D	105	—	—	—	—	—	—	—	—	—
		2	471	125	—	130	1110	630	2466	0.22
		3	471	75	42	130	1110	630	2458	0.22
E	120	—	—	—	—	—	—	—	—	—
		2	495	131	—	120	1120	620	2486	0.19
		3	495	79	44	120	1120	620	2478	0.19

*The mix proportions are for non-air-entrained concrete, although 2 percent entrapped air is assumed. Total water includes the water in the superplasticizing admixture, the dosage of which may range from 3 to 10 l/m³, depending on the consistency and strength requirements, cementitious content, and superplasticizer type.

HSC Applications

High-rise projects

- Construction of RC frames of buildings more than 30 stories and higher –
 - upper 1/3 may be conventional RC – reduction size column lower 2/3 of the building.

Bridges

- Reduce the risk of thermal cracking
- **Stilling basin of dams**
 - Long term durability to abrasion resistance
- **Floating concrete container terminal**
 - High durability in Sea water

Roller Compacted Concrete (*RCC*)

- *RCC* is based on the concept that **no slump concrete mixture transported**, placed, and compacted with the same construction equipment that is used for earth and rockfill dams.
- The development of *RCC* caused a major shift in the construction practice of mass concrete dams and locks.
- The traditional method of placing, compacting, and consolidating mass concrete is typically a slow process.
- Improvements in earth-moving equipment has made the construction of earth and rock-filled dams speedier and, therefore, more cost effective.

Materials and Properties of *RCC*

- For effective consolidation, the concrete must be dry to prevent sinking of the vibratory roller equipment but wet enough to permit adequate distribution of the binder mortar throughout the material during the mixing and vibratory compaction operation.
- *The conventional concept of minimizing water/cement ratio to maximize strength does not hold.*

- The best compaction gives the best strength, and the best compaction occurs at the wettest mix that will support an operating vibratory roller.
- From the standpoint of workability, *fly ash* is commonly included in *RCC* mixtures.
- In Willow Creek Dam, the adiabatic temperature rise was only 11°C in 4 weeks.

Advantages of *RCC*

- Cement consumption is lower because much leaner concrete can be used.
- Formwork costs are lower because of the layer placement method.
- Cooling is unnecessary because of the low temperature rise.
- Cost of transporting concrete is lower than with cable crane method because concrete can be hauled by end dump trucks; it is spread by bulldozers and compacted by vibratory rollers.
- Rates of equipment and labor utilization are high because of the higher speed of concrete placement.
- The construction period can be shortened considerably.

Transportation



Roller Compacted Concrete Pavements (RCCP)

- RCCP can be constructed with the same equipments as asphalt pavements, laid by the same pavers and compacted by rollers.
- The strength grows fast enough to permit opening for traffic in a short time.
- Since the drying shrinkage is small, the **interval between joints can be maximized**.
- **Applications:** Ordinary roads, Roads in factories, Temporary roads for construction works, Parking areas, Service areas, Container yards, and Material handling yards.

Self-compacting Concrete (SCC)

- SCC was developed by the Japanese initially as a Quality Assurance measure, but now is being widely used for concrete structures worldwide.
- SCC is particularly useful for components of structures which are **heavily reinforced**.



Self-curing, Shrinkage-free concrete

- Italian researchers have produced a concrete by the combined use of:
 - ✓ a water reducing admixture based on polycarboxylate in order to reduce both the mixing water and cement.
 - ✓ a shrinkage reducing admixture
 - ✓ an expansive agent based on a special calcium oxide.
- **Superabsorbent polymers (SAP)** are new, very promising multipurpose **chemical admixtures for concrete**. ... In turn they contribute to the control of the rheological properties of fresh **concrete** and to the mitigation of autogenous and **plastic shrinkage through internal curing**.

Self healing concrete

- When the **concrete** cracks, and water enters the gaps, it comes into contact with the bacteria and the food source, setting the **healing** process off.
- The bacteria then feed on the calcium lactate, joining the calcium with carbonate to form limestone, fixing the crack.

