Essentials for Durable Concrete

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- Several factors contribute to making of good concrete
- The lecture is a overView of the essentials which largely shape the durability of concrete

- The factors can be divided into the categories as follows
- A. Materials and Mix design related factors

- B. Production related factors

- C. Post production related factors
- D. Other factors

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Material and Mixdesign Related factors

- The largest contributor for Durability is W/C ratio

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Water-cement Ratio

- Key to strength ,all engineering properties
- Weight of water/weight of CEMENT.
- Curing is the process by which enough moisture is maintained in the body of concrete for proper hydration of CEMENT.
- CAPILLARIES; capillaries are formed during the curing process. They are unwanted small tunnels left behind after excess water(water not needed for cement hydration but needed for flowability) has evaporated from the concrete.

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CAPILLARIES

- To keep the capillary formation to a minimum we have to
- A) keep the water cement ratio to a minimum
- B)Contol the curing and cure as long as possible.
- C)use of WRA/HRWRA
- D)do all A,B,C together.
- WHY DO CAPILLARIES MAKE CONCRETE WEAK
- Because they take up space that should be filled with concrete. They act as transit system for water/water vapour (moisture) migration.

- Capillary pores
- Gel pores
- Pores in transition zone or Interface zone of Aggregate and Cement paste

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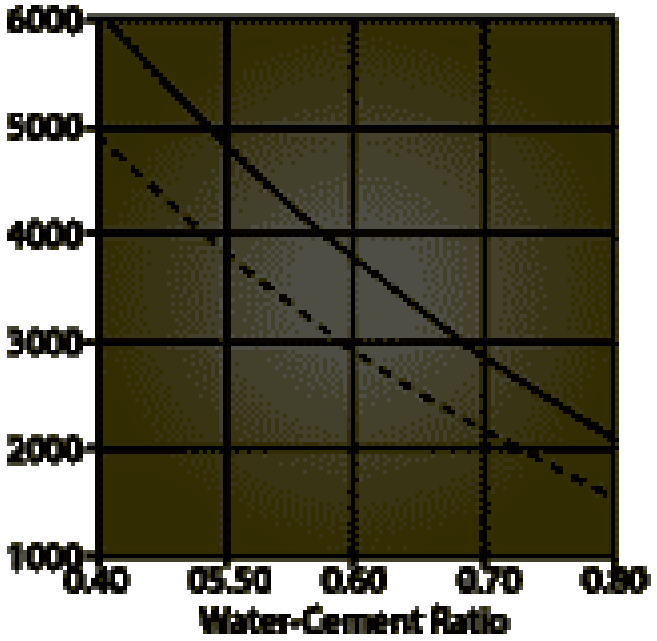
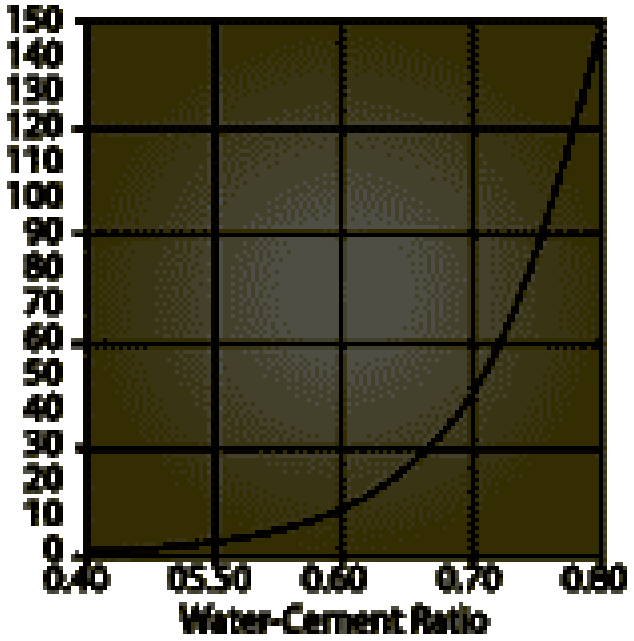
28-Day Compressive Strength

Non-Air Entrained Concrete (2' Air)

Air Entrained Concrete (6' Air)



Coefficient of Permeability, Kg x 10,000



- Capillary pores
- Gel pores
- Pores in transition zone or Interface zone of Aggregate and Cement paste
- *******The network of pores, their overall concentration, total volume, interconnectedness ,daimeters of pores, continuity in network of pores determine permeability ,which is a very large factor in determining Durability of concrete******

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- It is completely essential to keep W/C down to as lower level as possible to push Concrete to higher Durability.

Use of OPC

- OPC is largest binder material used in concrete world wide.

- But OPC has its own inherent problems

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Reduce OPC to make Concrete Durable

- More the OPC ,higher is heat of Hydration so we need to use less OPC.
- No point in using more OPC as we are aware of the fact that W/C ratio governs both strength and Durability
- Cement is the only man made material in Concrete . Cement like all man made materials has a tendency to go back to its natural state

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- OPC production is accompanied by production of CO_2……..
- The only way to reduce CO_2 production by cement companies which accounts for about 6% of total CO_2 production , we need to reduce OPC use.
- Optimised Cement Content mixes will have positive effect on durability and also makes concretes greener!!!


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- Were they Knowing Problems with Concrete + embedded metal durability?!!!

To reduce OPC content

- We need to use High performance Superplasticiers (HRWRA) which can not only fetch us
- LOWER W/C ratio

But also

Lower Cement Content

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- Perhaps the Buliders of Pyramids knew about the problems with

Use of Mineral Admixtures

- Pozzolonic materials or Mineral admixtures

Are a must to push the concrete to Higher level of Durability

By using SCMs

- Permeability
- Resistance to chlorides
- Resistance to sulphates
- Resistance to carbonation
- Resistance to carbonation
- ASR
- Drying Shrinkage
- Creep
- All the above properties are improved significantly or kept at same levels by using SCMs

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Reduced Permeability

- Prof R.N.SWAMY, Sheffeled University through his experiments states” Pore volume is decreased by 61% after 91 days and Coeffcient of permeability by 56%” by addition of 50% GGBS in concrete

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Diffusion of Chloride Ions,in Cement pastes of w/c 0.5

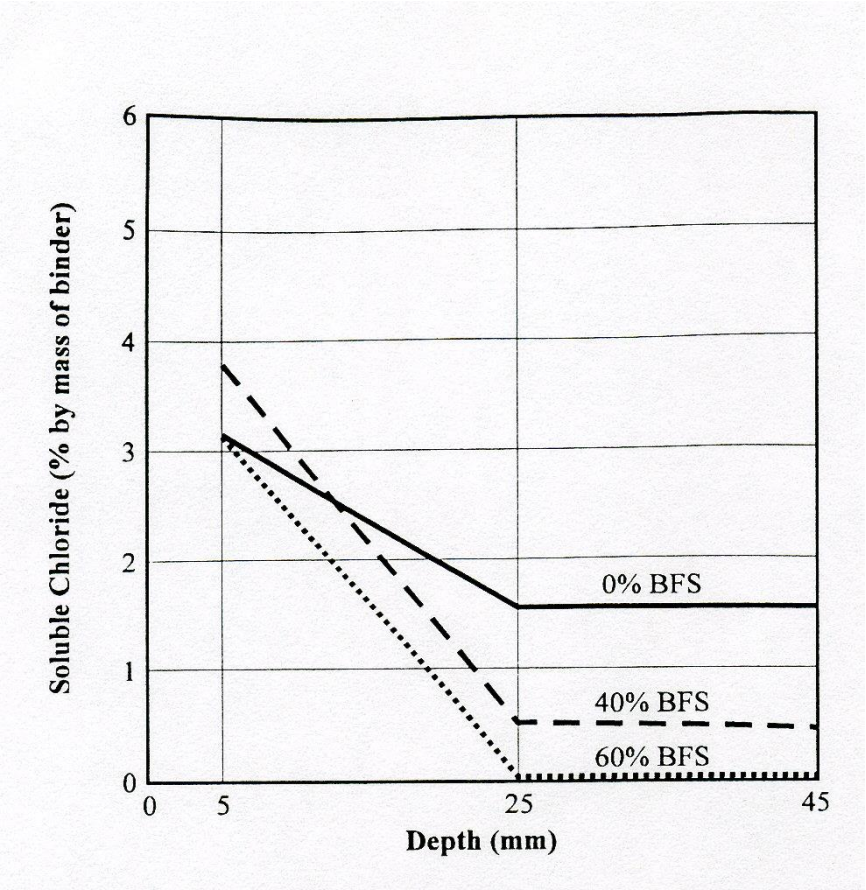
- Diffusivity in 10^-9 cm2/sec

- SRC……100.0
- OPC……44.7
- 70%OPC+30%FLYASH…….14.7
- 35%OPC+65%GGBS…….1.1

HARDENED PROPERTIES - Chloride

Chloride Resistance

- Chloride resistance is improved
- Impermeability is improved
- Protection for the reinforcing steel in increased



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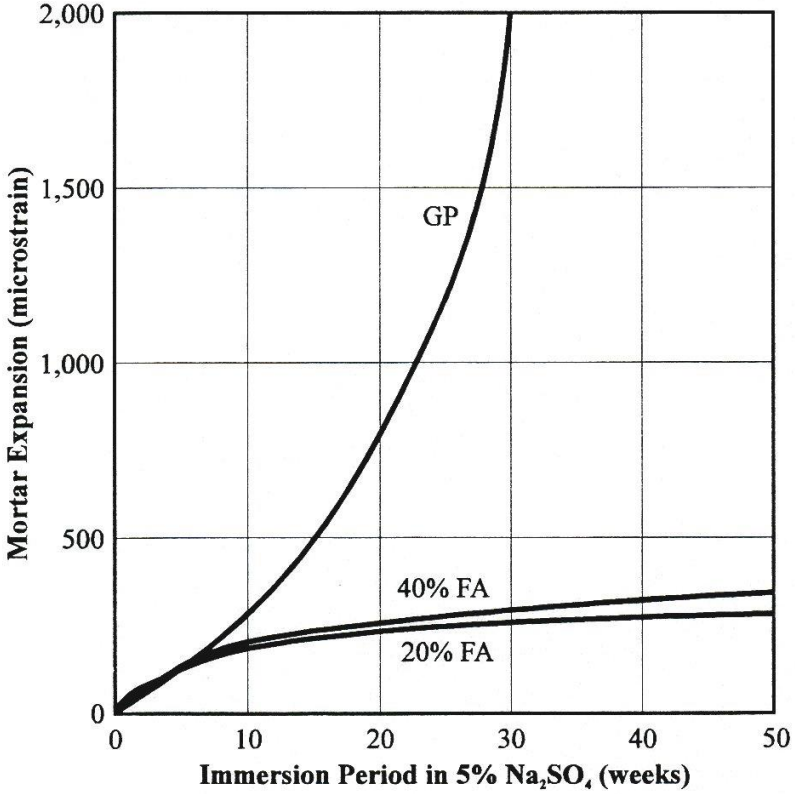
OPC	450	450
MICROSILICA	50	0
METAKOALIN	0	50
PFA	150	150
ADMIX in %	0.65	0.75
Admixture	PC based	PC based
W/C Ratio	0.25	0.24
7 Day Strength	68.50 Mpa	75.29 Mpa
28 Day Strength	82.65 Mpa	84.70Mpa
RCPT	380C	320C
PERMEABILITY	16MM	14MM

HARDENED PROPERTIES – Sulfate

Sulfate Resistance

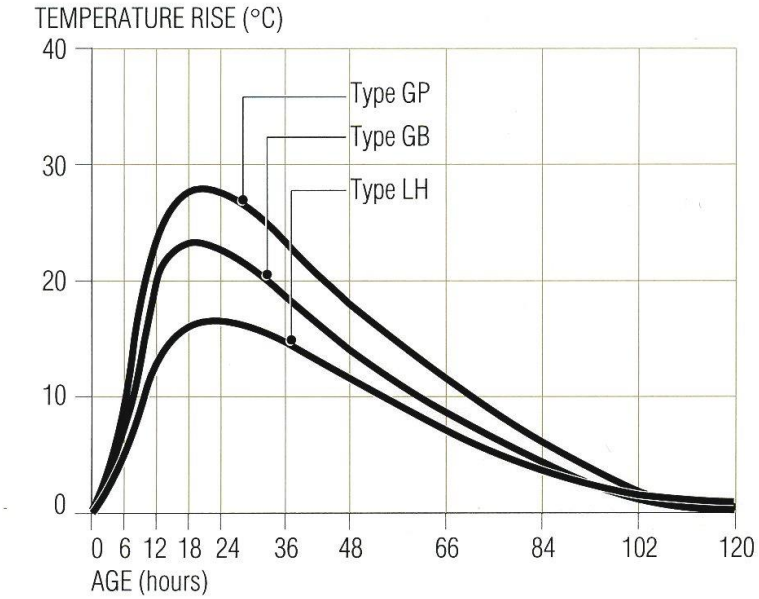
- Resistance to sulfate attack improved
- The vulnerable component of cement is reduced
- Impermeability of concrete improved



HARDENED PROPERTIES - Heat

Temperature Rise

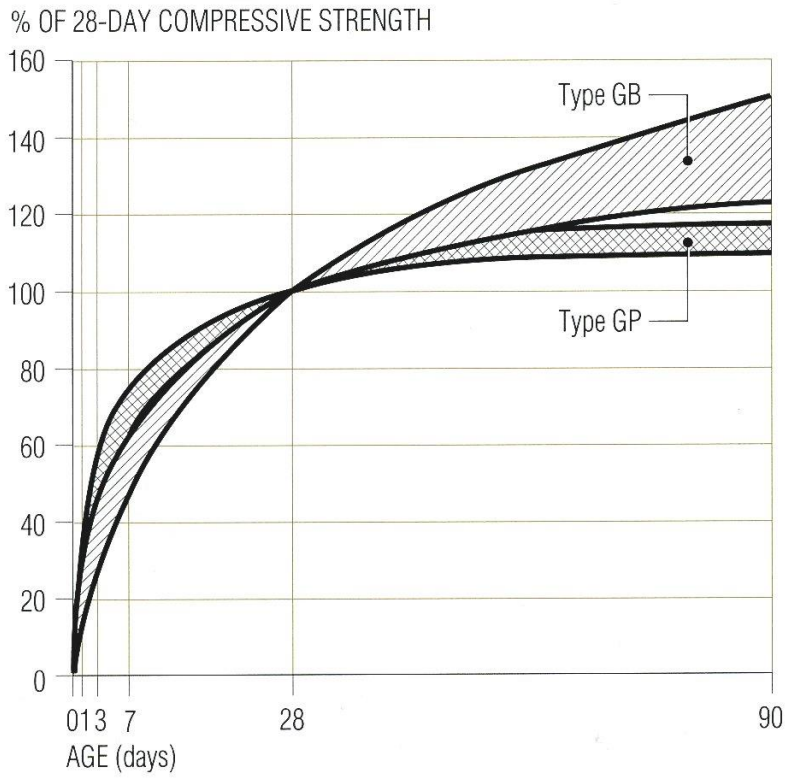
- SCMs react more slowly than cement
- Generation of heat is delayed and slower
- Temperature build up reduced
  - This is particularly the case for higher replacements
  - eg 40% Fly ash or > 60% slag
- Silica fume is generally not used for this reason as it does not offer the same benefits



HARDENED PROPERTIES - Strength

Strength

- All strengths eg compressive, tensile, flexural are affected in a similar way
- Early strengths are lower
  - Typically up to 7 days
- Longer term strengths are improved
  - Particularly post 28 days



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Project: Tambaram, Irumpuliyur, Chennai

date of supply	Grade	Opc+pfa	3 d	7 d	28 d	90d	150 d	365 d
30.11.01	M20	240+100	18.62	23.49	37.84	45.74	53.72	55.0
22.12.01	M20	240+100	20.81 *	22.7	38.34	**53.80	57.37	-

* 4 DAYS

**94 DAYS

Cubes cast at site

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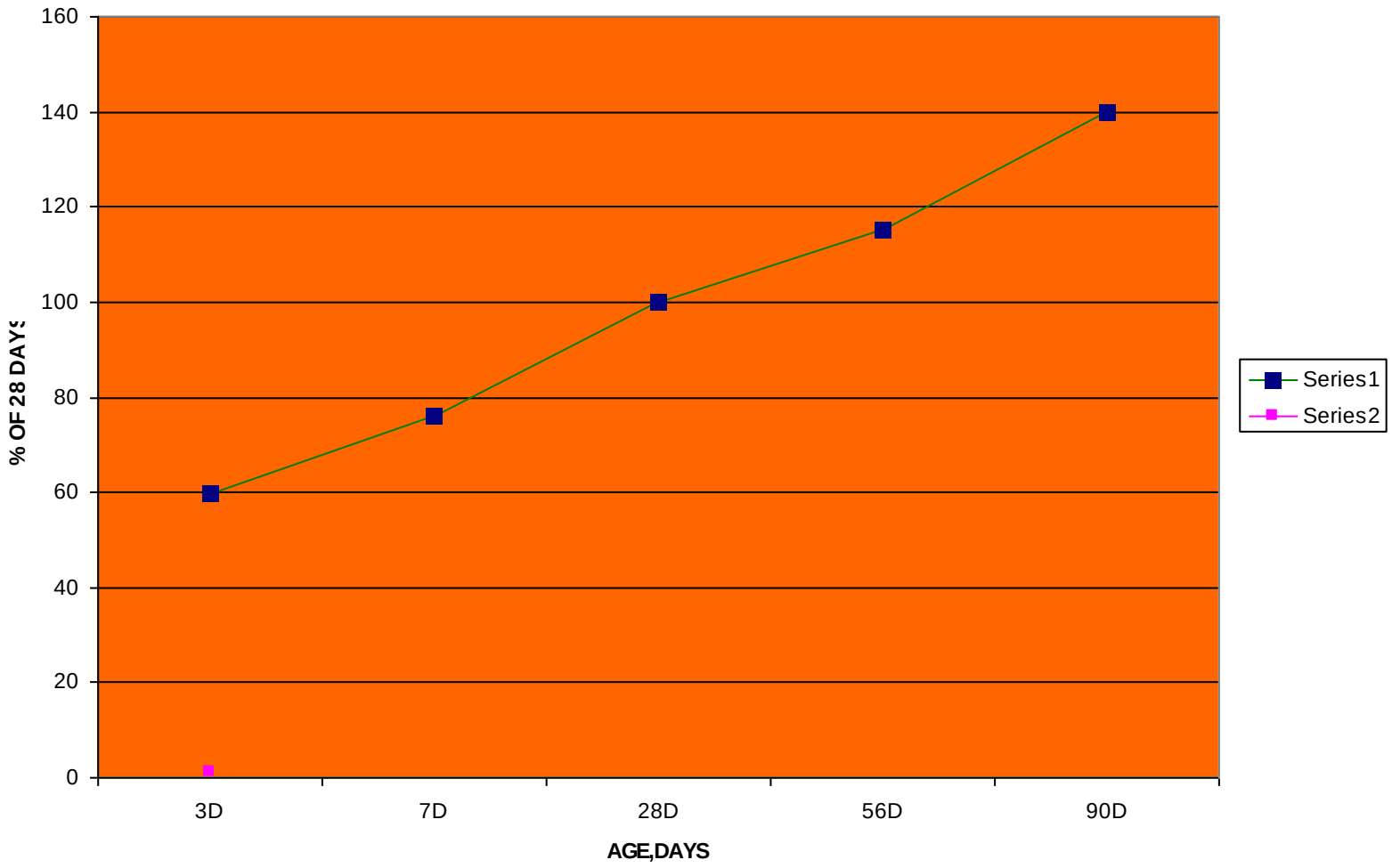
COIMBATORE OPC+PFA % STRENGTH GAIN



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Special Admixtures

- CORROSION INHIBITORS
- Migrating corrosion inhibitors
- Shrinkage Reducing Admixtures
- Hydrophobic admixtures

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- Fibres to reduce plastic shrinkage and settlement cracks

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For good durability

- COARSE and Fine aggregates must be of good quality ,as per codal provisions
- Coarse aggregates must not be having high porosity /absorption
- In mix design we should try to go for good amount of Aggregate content
- Aggregates & sand ,should have nil or least chloride content

High performance admixtures with &SCMs, gives makes Durable+sustainable concretes

- Concrete with higher strength::::> Use less concrete
- Concrete with greater durability::::> Longer service life
- Strength with less cement::::>Use less cement
- Strength with less water::::>Use less water

- • Fluid concrete ___>>> Reduced batching energy
- • Pumpable concrete___>>> Reduced transportation energy
- • Self-consolidation ___>>> Lower placing energy (vibration)
- • High workability ___>>> Reduced construction times …….Durable,sustainable concretes with least Honey combing,High Performance.

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Production related factors

- At the point of Concrete Production ,to have best Durability we need to have reasonable degree of QA/QC ,which comprise of
- 1. Forward Control
- 2. Immediate Control
- 3. Retrospective Control

On site

- Concrete has a shelf life…… use when WET!!!!

  2 hours and 30 minutes limits as per IS4926.

- Neither UNDER vibration nor Over Vibration!!

- Compaction as per Best practices to achieve design strength

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To make Durable Concrete

- Proper Curing
- Not intermittent curing but continuous curing
- Water curing
- Curing Compound
- Internal curing Compound

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Durability

- Good form work……leakage free
- Good mould release agent
- Good Cover for Concrete

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Durable concrete

- Protection for Rebar

- Alternatives to Rebars like
- Fiber reinforced composite bars like Glass fiber Reinforced Plastic or Polyester fiber reinforced bar,basalt fiber reinforced bars

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Durability Next level

- Self Healing Concrete Additive

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Thank You

Have Any Query?

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