

Construction Technology III



Managing the
technology: concrete

Concrete UK– some facts (annual)

- Around 250 kg of cementitious material, 2 tonnes of concrete and 15kg of reinforcement are used per person.
- Total demand for all cementitious materials stands at over 15 million tonnes, 85% of which is for Portland cement.
- Some 120 million tonnes of concrete are used, 50% of which includes reinforcing steel.
- All UK-produced reinforcing steel is made from recycled scrap steel.



Efficiency and quality of the concreting process



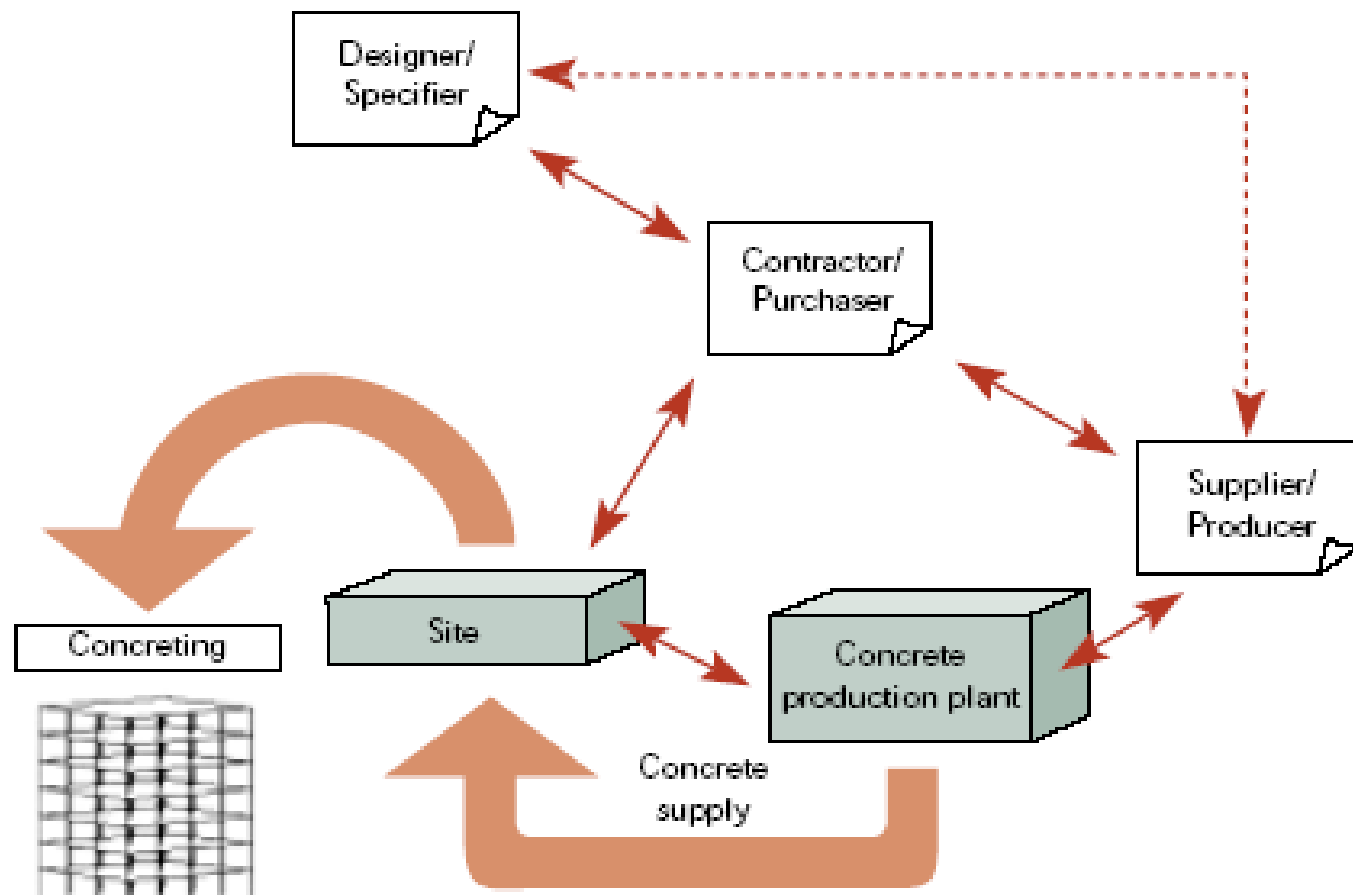
- The concrete procurement process
- Effective interactions
- Performance-based concrete specification

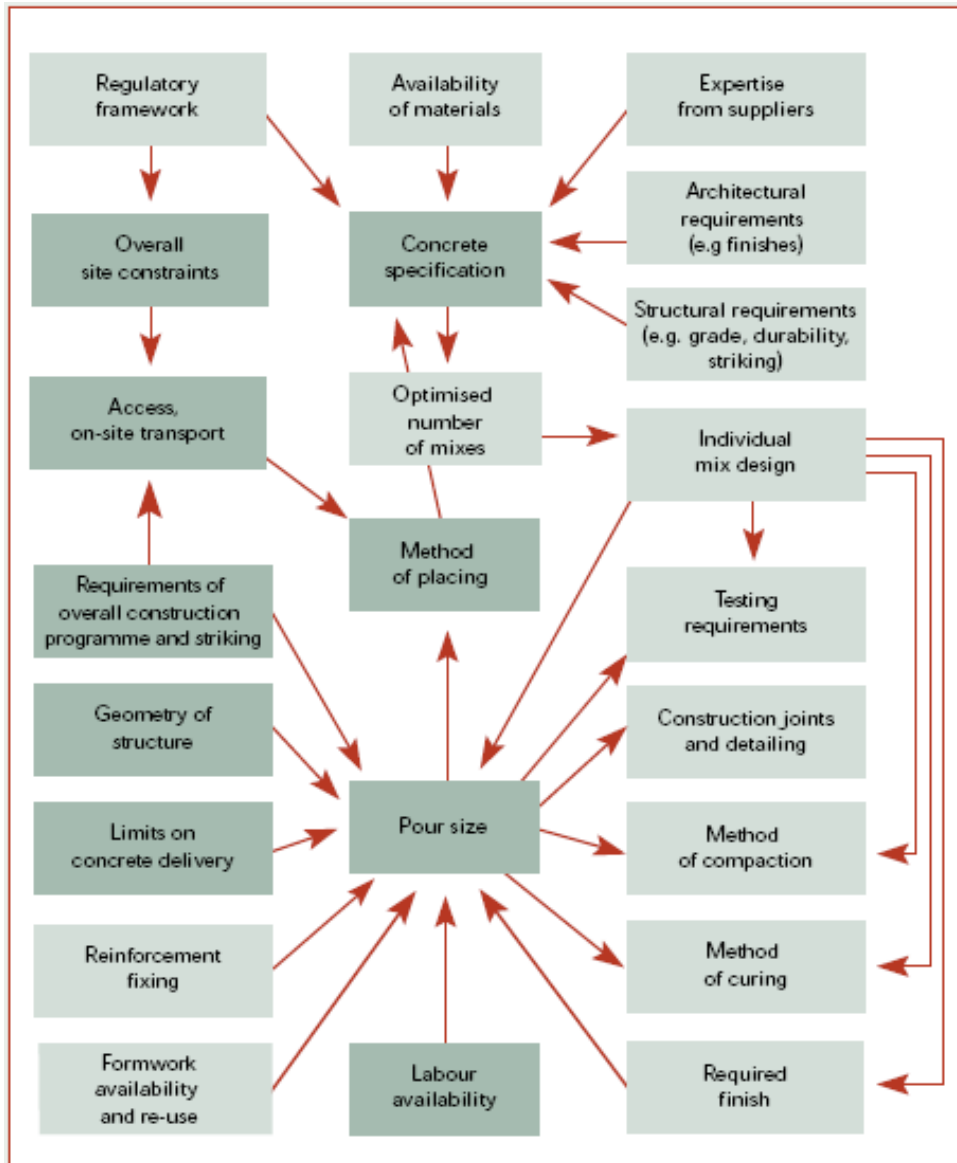
Concrete design considerations



- Exposure considerations
- Soil/structure interaction
- Concrete properties
- Concrete placing
- Durability

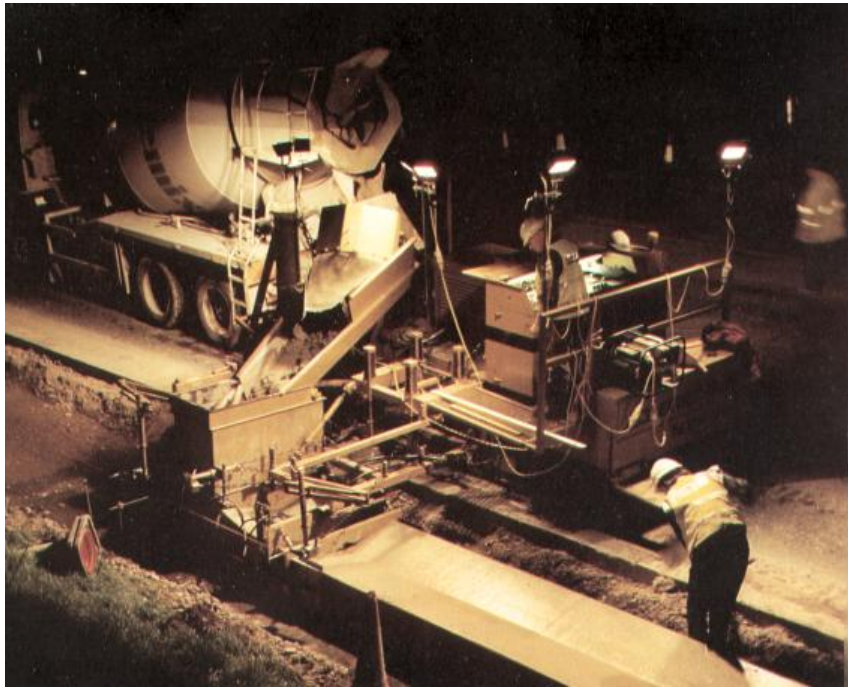
Concrete procurement process





Issues and interactions affecting optimisation of concreting process

Planning the concreting process – key factors



- Selection of the concrete supplier
- Properties of fresh and hardened concrete.
- Reinforcement densities / congestion
- Method of handling / transporting the concrete on site.
- Compaction, curing and finishing methods.

properties of concrete

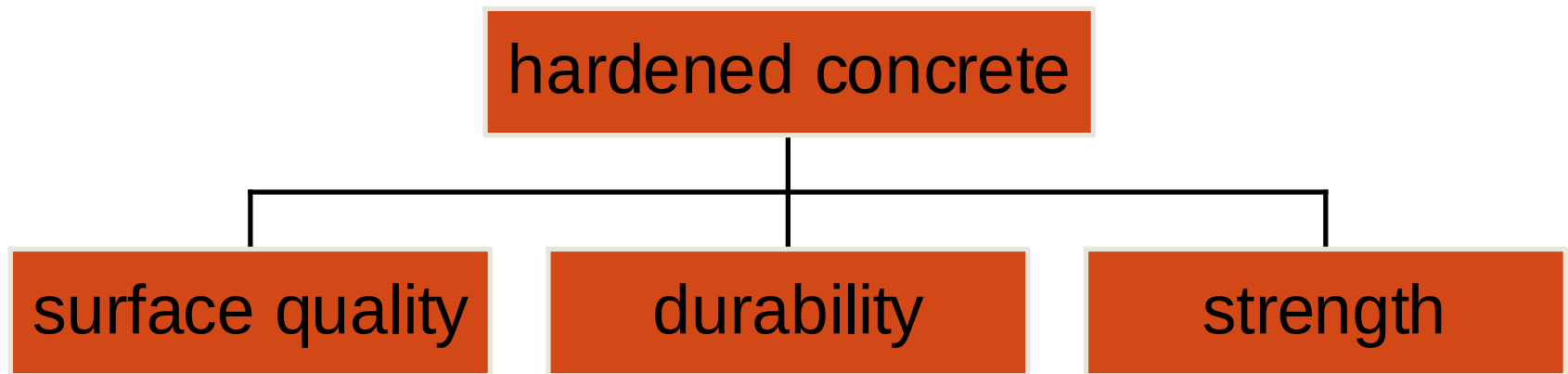
plastic state

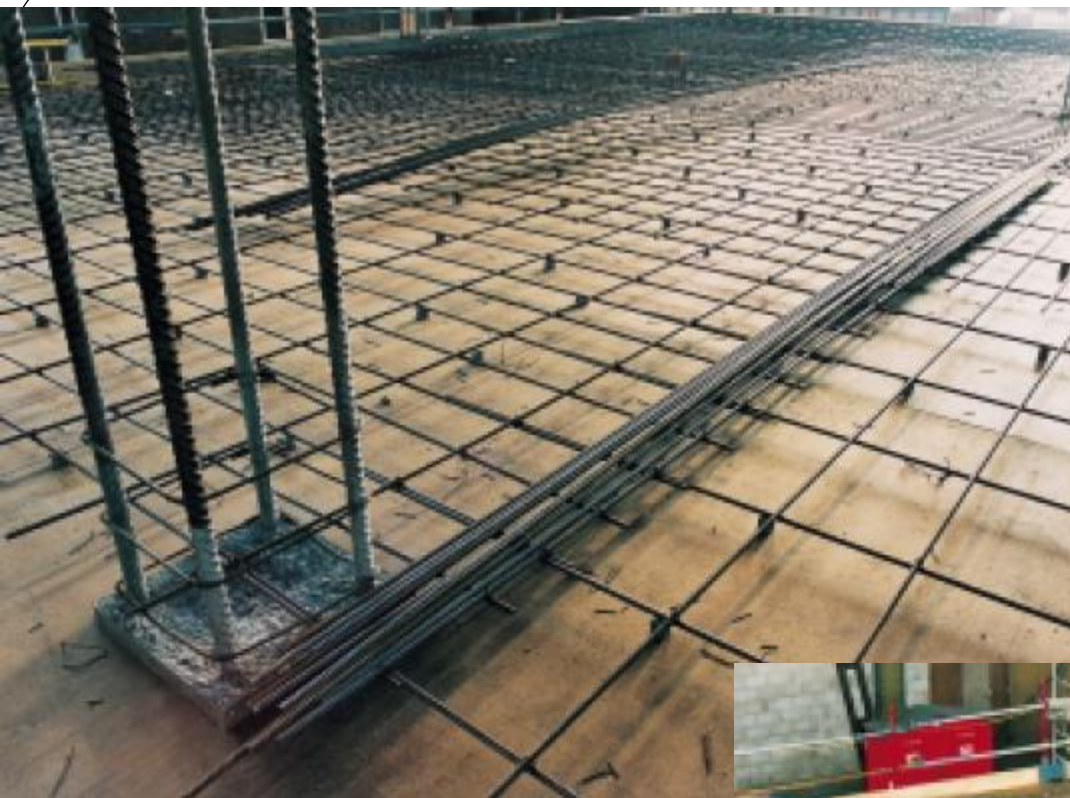
workability

cohesion



Properties of concrete





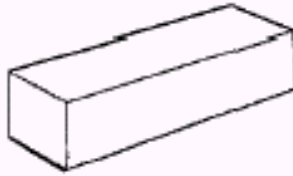
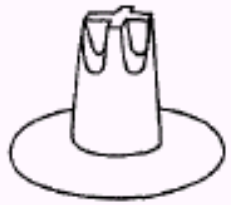
Reinforcement
densities and
congestion



Rebar: best practice



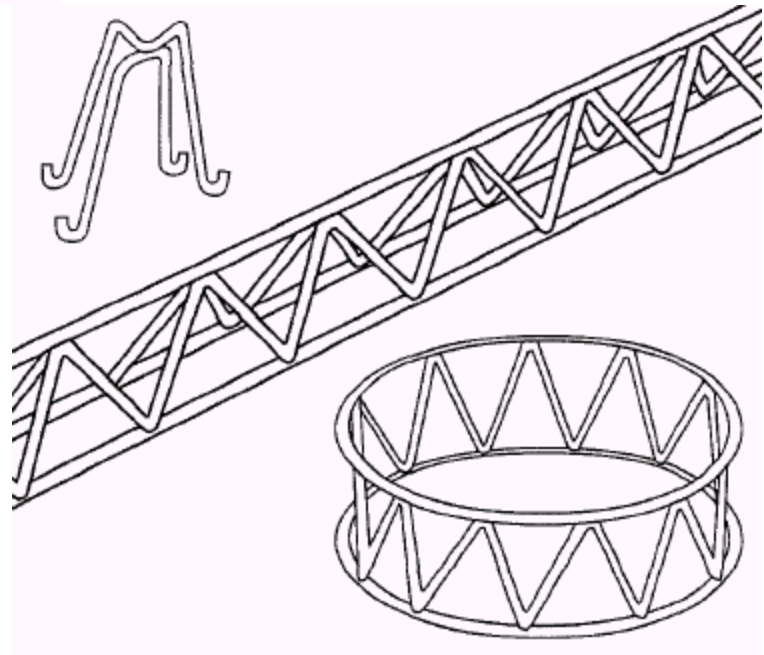
- Electronic exchange and sharing of rebar information.
- Promotion of integrated information.
- Bar-coding as an AI tool.
- Electronic transfer of information for rebar cutting and bending.



Spacers



Supports for top reinforcement



Transporting Concrete



- Truckmixers
- Dumpers
- Crane and skip
- Skip
- Concrete pumps
- Conveyors

Transporting Concrete



Transporting Concrete



Placing and compaction: some thoughts!



- Right first time
- Drop height
- Close as possible
- Compaction method
- Quality
- Over-vibration

Compaction methods

- Immersion vibrators
- External vibrators
- Beam vibrators



Quality issues

- Under-compaction
- Durability
- Permeability
- Entrapped air





Compaction, curing and finishing

Flowable concrete



- Design target slumps of 150-225mm
- Design maximum free w/c ratio of 0.50
- Use coarse aggregate/sand ratio of 1.0 to 1.2
- Use of natural rounded gravel aggregate
- Use of composite cements
- Use of water-reducing, plasticising or superplasticising admixes

Self-compacting concrete

- Lower coarse aggregate content, typically 750 to 900 kg/m³
- Lower sand content in the mortar, typically 40 to 50% by volume
- Restriction of the water content to between 45 to 55% by volume of the paste



Principle advantages and limitations of SCC

Advantages

- Reduced labour requirements
- Shorter concrete placement times
- Improved compaction
- Potentially enhanced durability
- Expanded buildability
- Environmental

Limitations

- Lack of guidance
- Reliant on experience
- No established tests

Curing



Definition

The process of preventing the loss of moisture from the concrete while maintaining a satisfactory temperature regime



Purpose of curing

At the time the concrete is placed there is always an adequate quantity of water present for full hydration.



It is necessary to ensure that this water is retained so that the chemical reaction continues until the concrete has developed the required degree of impermeability and strength.

Curing methods

Those which keep water or moisture in close contact with the surface of the concrete



Those which prevent the loss of moisture from the concrete

Curing Times

Cement type	Ambient* conditions	Minimum curing time (days)	
		At 5-10 C	At 20 C
Portland cement	Good	—	—
Sulfate-resisting cement	Average	4	2
	Poor	6	3
All other types of cement	Good	—	—
	Average	6	3
	Poor	10	5

Factors affecting time for curing

- Type of cement
- Cement content and w/c ratio
- Temperature of surface layer
- Ambient conditions
- Intended usage of the concrete

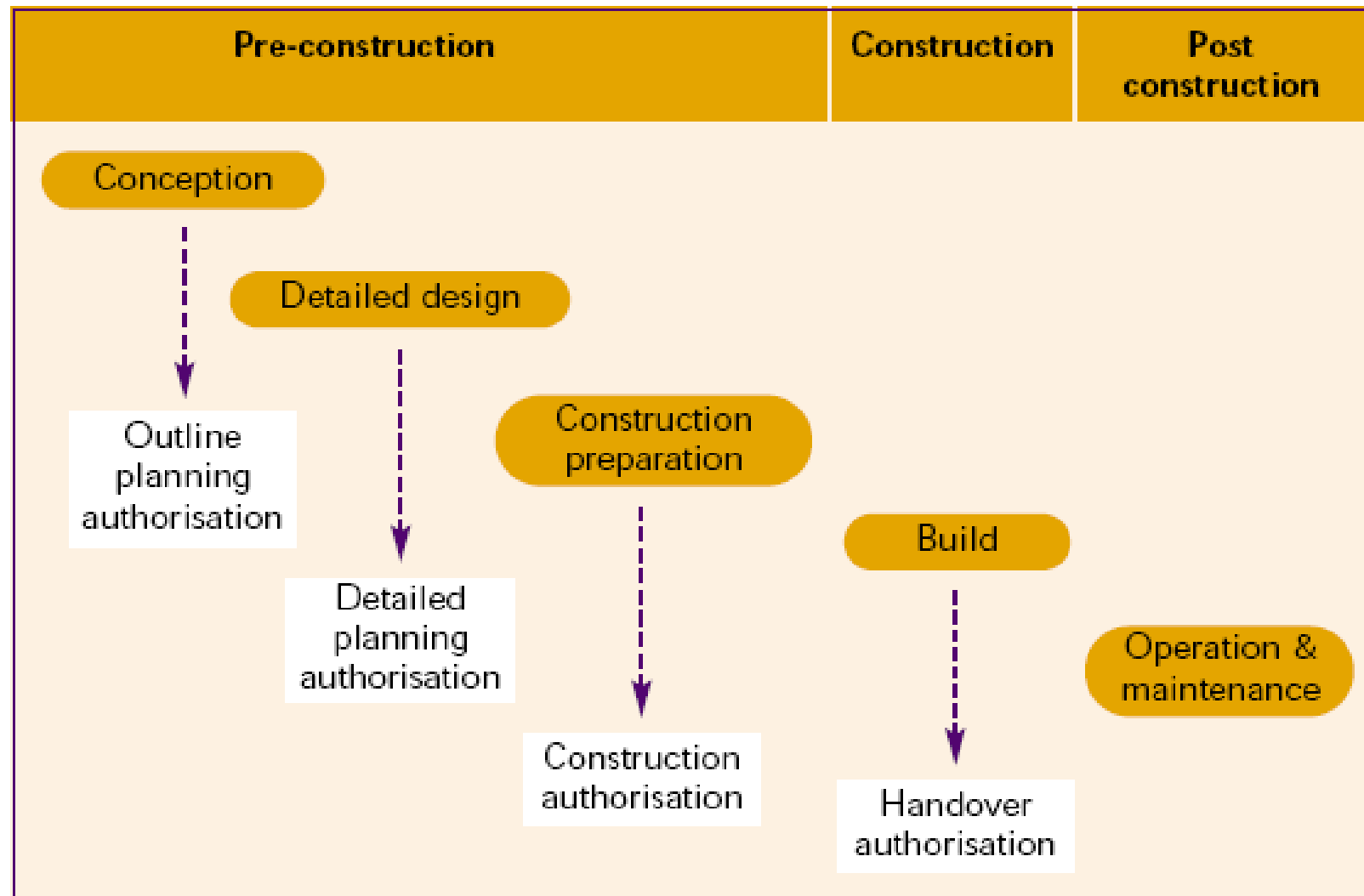


Concreting process – some other factors

- Pour sizes and construction joints.
- Any special concretes / innovative methods.
- Possible implications.
- Overall construction programme.
- Communication methods.



Room for improvement!



Efficient Management of Concreting

	Single pour	Two pours on separate days	Four pours on separate days
Each pour achievable within a working day	Just	Yes, easily	Yes, easily
Supporting columns required to be complete before slab pour	All	Over half	Over a quarter
Can proceed with next level of columns before slab completed	No	Yes	Yes
Columns (above) poured at same time as slab (if same specification)	No	Possible	Possible
Formwork required	Full slab area	Two-thirds of slab area	One-third of slab area
Construction joints	None	One	Three
Efficient use of pump hire	Yes	Less	Much less
Need for additional safety provisions (e.g. edge protection)	None	Some	Considerable
More even use made of site resources (plant, operatives, materials etc.)	No	Yes	Yes (closer to a continuous manufacturing process)

Key Properties	Addition type	Ultimate Effect	Practical Application and Benefit	Possible disadvantages
Water demand/ Workability	pfa	Reduced water demand	Denser concrete Better compaction Lower permeability	Reduction in cohesion at very high levels of ggbs addition
	ggbs	Small reduction in water demand. increased mobility		
Strength	pfa ggbs	Reduced early strengths at low concrete temperatures	Similar (or possibly slightly increased) ultimate strengths at later ages in large sections	Potential reduction in tensile strain capacity
Setting times	pfa	Small increase in setting time	Minimise the risk of cold joints in large pours*	In thin sections: increase in formwork striking time
	ggbs	Increase in setting time dependent upon ggbs content	Useful where secondary cutting is required, eg secant piling	Prolonged period susceptible to damage through shock
Heat of hydration	pfa	Reduced temperature rise	Lower risk of thermal cracking	
	ggbs	Reduced temperature rise, especially at 70%+ ggbs	Suited to large-section concreting	
Permeability	pfa ggbs	Reduced pore size distribution, porosity	Decreased permeability to water, oxygen, chlorides and aggressive agents	
Chemical resistance	pfa ggbs	Resistant to chemical attack, including sulfate attack, ASR. acid attack etc.	Used in structures exposed to harsh environments, eg contaminated natural ground and in sea defences	Low calcium hydroxide levels reduce level at which chlorides activate reinforcement corrosion. No significant improvement in resistance to attack from magnesium sulfates.**

Efficient Management of Concreting : the use of additives

Formwork: design and construction



- Rigidity
- Strength
- Accuracy
- Watertight
- Handling
- Striking

Formed concrete finishes

Differences

- Off the form finishes
- Exposed aggregate finishes



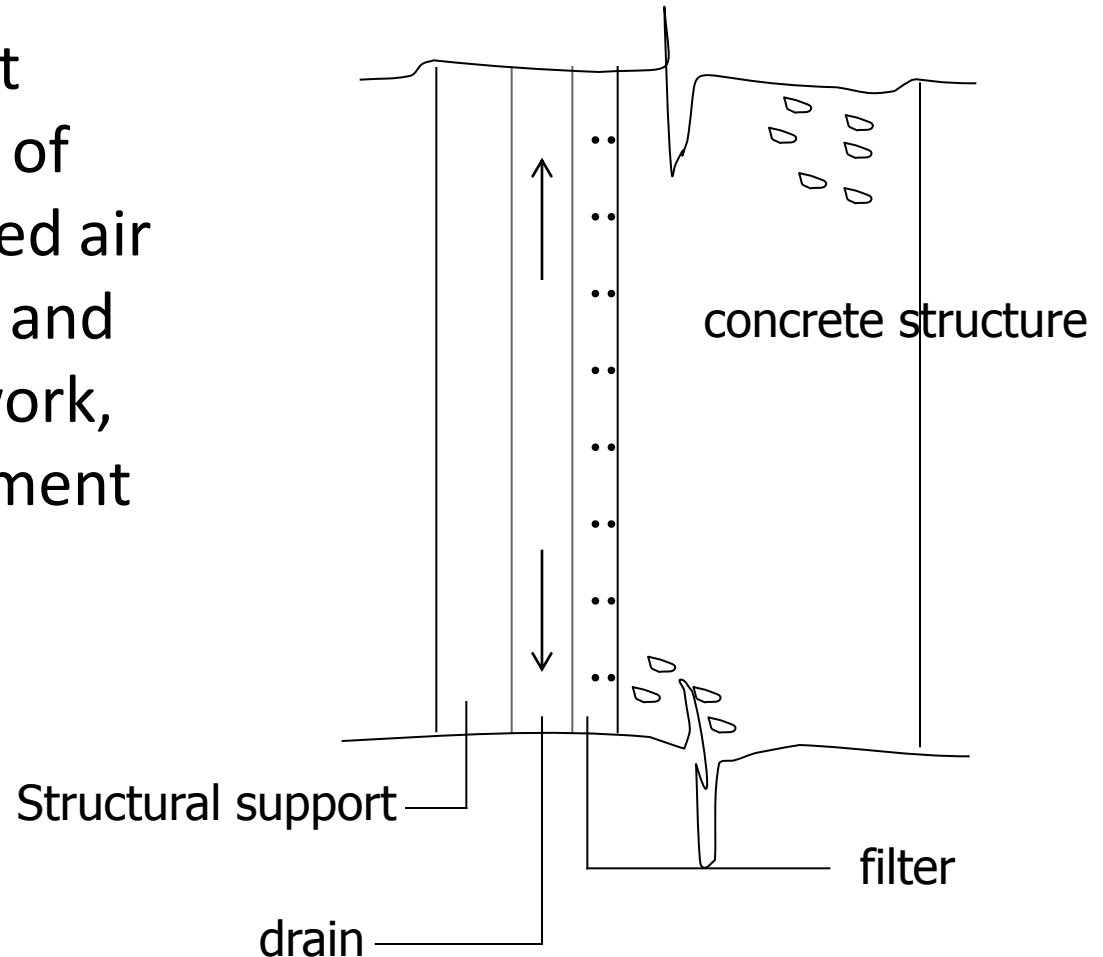
Formwork: design and construction



- Impermeable formwork
- Controlled permeability formwork

Controlled permeability formwork

- ...a manufactured formwork liner that allows the passage of water and entrapped air from the concrete, and through the formwork, whilst retaining cement and other solids



Formwork



Formwork



Concrete – good for the environment





Happy concreting!

Concrete Practice

Workshop

Comment on the benefits prefabricated reinforcement assemblies can offer to the contractor, designer and client.

Explain how the benefits identified can be fully exploited.

Discuss the factors that affect the choice of transporting concrete.

Critically evaluate the key factors that are likely to affect the efficient management of the concreting process.

Concrete's high embodied energy makes it unsustainable. Discuss this statement.