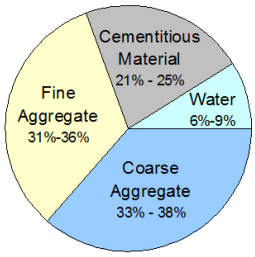
Fundamentals of Concrete

- Essential to selecting or designing a mix
- Valuable in working with the concrete
- Key to troubleshooting

If you don't know how concrete works, how can you make a high quality product?

Primary Ingredients:

- Cement
- Water
- Aggregates
  - Fine (sand)
  - Coarse (gravel)



Secondary Ingredients:

- Pozzolans
- Pigments
- Fibers
- Admixtures

Ingredient Selection and Proportion

The relative proportions of the primary and secondary ingredients influence:

- strength
- stability
- workability
- durability
- aesthetics
- ease of manufacture
- forming techniques
- cure times
- and more

Primary Ingredients

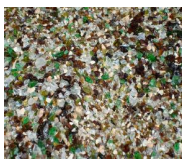
Basic elements of concrete; without one of these you don't have concrete.

- Aggregates are structural filler
- Cement + Water = Paste (binder)

Aggregate








Aggregate

- Make up the bulk of concrete volume
- Important to durability, stability, appearance and strength of concrete
- Can be fine or coarse
- Can be stone or glass
- Strongly influences **Workability**
- **Gradation** is very important in mix design
- Can be the most complex part of mix design
- Most often overlooked or underestimated

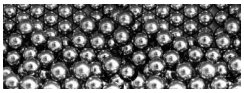
Aggregates and Workability

Workability influenced by:

- Particle shape
- Particle roughness
- Gradation/packing
- Aggregate to paste ratio
- Surface area

Coarse Aggregates

- Max. particle size 3/8” for 1.5” thick countertops
- Smoother, rounder particles boost workability
- Rough, angular particles inhibit workability but increase flexural strength

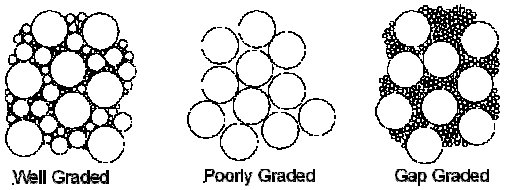


Fine Aggregates

- Sands have greater influence on workability, paste content and water demand than coarse aggregates
- Use more coarse sands (#8, #16, #30 sieve)
  - Finer sands increase trapped air (#50, #100)
  - Excessive fines (smaller than #100) can cause loss of workability and a potential for higher w/c ratios to compensate

Types of Aggregate Gradation

- Well Graded: broad range of sizes
- Poorly Graded: all one size
- Gap Graded: two predominant sizes: small and large



Recycled Aggregates

- Crushed bottles
- Crushed window glass
- Tempered glass
- Scrap stained glass
- Crushed porcelain (sinks, tubs, toilets)
- Crushed concrete
- Crushed granite/marble scrap

Stiff Mix

Hand packed

- Often all-sand mix concrete (uniform graded)
- Stiff, zero-slump concrete
- Variegated, hand-pressed or solid
- Always has pinholes and air voids

Fluid Mix

Wet cast

- Often aggregate-based mix concrete (gap graded)
- Fluid, highly workable
- Often vibrated
- Crisp, tight surface, none or few pinholes

Cement

- Portland cement
- Type I, II or III
  - Type I: normal
  - Type II: moderate sulfate resistant
  - Type III: high early strength
- White or gray

Cement

- Broadly similar but subtly different: fineness, set time, chemistry
- Different brands have different colors
- Portland most common, but other types are used (calcium sulfo-aluminate CSA cement)
- Different cement chemistry has different rules

Water

- Use sparingly when designing mix
- Use precisely when making concrete
- Use liberally during curing
  - The less water used to make the concrete, the better the concrete.

Water

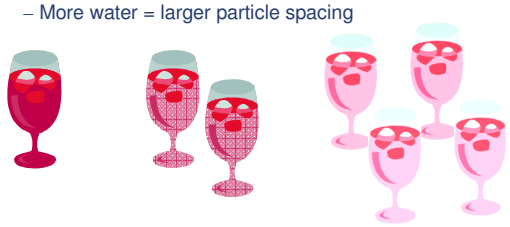
Water is an important ingredient that must be dosed carefully.

It is not used like salt and pepper are to "season" the concrete to "taste".

The Role of Water: During Mixing

Grape Kool-Aid®

- Too much dilutes strength, color
- More water = larger particle spacing



Water to Cement Ratio (w/c)

- Determines strength and durability of concrete
- Lower w/c ratios yield richer colors; higher w/c ratios yield paler colors
- High w/c ratio (more water) results in weak concrete
  - This is because diluted cement paste is weaker and more susceptible to cracking and shrinkage

The Role of Water: During Mixing

Low w/c	Moderate w/c	High w/c
< 0.35	0.35 – 0.45	>0.45

More water = larger particle spacing
More water = longer time to set
More water = lower strength
More water = BAD

The Role of Water: During Curing

Tomato Seed

- Needs water to grow
- Dies if dries out

Cement needs to stay wet to hydrate (cure)
More water = GOOD