BORAL RESOURCES

Fly Ash

for Architectural Concrete

Modern fly ash production and use is an integral part of concrete construction. Architects and structural engineers routinely design concrete mixes with fly ash for a wide range of structures, roadways, marine and high strength applications. Proven improvements in durability, permeability, shrinkage and long term strength gain yield better quality concrete.

Traditional concrete for integrally colored, color hardened, stained or textured architectural applications often suffers from the following flaws:

- **Poor Aesthetics:** Straight portland cement mixtures produce significant amounts of calcium hydroxide in the paste. This leaches out of hardened concrete in the form of free lime (efflorescence) and can overshadow integral color pigment, causing a bleached, streaking effect. It may take several years before efflorescence diminishes.
- **Lack of Surface Integrity:** The crystalline structure of calcium hydroxide is expansive. Decorative surface treatments like stains, penetrating colored sealers and acidic stains can be ruined by the leaching effect of efflorescence. In the case of stains, the acidic reaction that produces color variation actually softens the matrix of the surface paste, allowing for greater moisture penetration, yielding more efflorescence.
- **Shrinkage and Permeability:** Integral color pigments increase paste volume and require additional water. This increases shrinkage and surface cracking potential. Higher water demand mixes are more permeable, allowing for greater moisture absorption, which then increases the production of efflorescence.

Major sources of color variations in architectural concrete:

- Change in cement, fly ash or aggregates source.
- Change in mix design proportions.
- No slump control. Water added to temper loads at the wash rack or on the job.
- Utilizing fly ash can reduce or eliminate efflorescence, which detracts from the beauty of concrete finishes.
- Change in placement or finishing techniques.
- Insufficient or improper curing schedule.

Benefits of fly ash in colored architectural concrete:

1. Fly ash chemically and physically combines with calcium hydroxide (efflorescence) to form additional binder glue (calcium silicate hydrate). This additional glue yields greater paste strength with fewer voids. Efflorescence is greatly reduced.
2. The water demand of fly ash mixes is lower, creating a dense, highly impermeable matrix. This increases durability and reduces the effects of carbonation. The potential for plastic shrinkage cracking is also reduced.
3. Architectural form finishes and textures are improved with fly ash. The small, spherical fly ash particles aid in concrete mobility and pattern transfer.
4. Surface treatments easily adhere to fly ash concrete mixes and last longer because of the reduction of efflorescence blooms.

Revision Date:2-1-21

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Suggested mix design criteria:

1. Choose the compressive strength criteria and design mixes based on water / cement + fly ash (W/Cp) ratio. Do not factor color pigment loading as part of this ratio.
2. Fly ash should be factored at 15-20% replacement of cement. Stay within the limits of state or local codes.
3. Avoid fly ash sources with excessive L.O.I. (loss on ignition) specifications.
4. Use a Type A water reducer or midrange water reducer to aid in placement slumps. Place concrete at moderate slumps (3˝-6˝) and avoid temper water on the jobsite.
5. Do not use calcium chloride or chloride based products with colored concrete.
6. Specify a single source for cement, fly ash and aggregates for the duration of the job.

With proper controls, placement and finishing of colored fly ash concrete is no different than straight cement concrete.

Decorative and architectural concrete dates back centuries. Clay moldings from prehistoric caves illustrate man's desire to enhance the beauty of his surroundings with art, color, and architecture. Early Greek and Roman artists used volcanic ash mixed with sand and lime to create statues and decorative moldings. Many believe that the longevity of early structures, some still standing today, can be attributed to the pozzolanic activity of volcanic fly ash.