Fly Ash

Impact on Concrete Physical Properties and Bonding Characteristics

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What is Fly Ash

- Fly ash is the finely divided residue that results from the combustion of pulverized coal that is carried from the combustion chamber of a furnace by exhaust gases.
Types of Fly Ash

- Specifications for the use of fly ash in concrete are given in CSA A3001, which classifies fly ash as F, CI, or CH by its calcium oxide content. Type F refers to fly ash with CaO content less than 8%, Type CI has a CaO content ranging from 8 to 20%, and Type CH fly ash has a CaO content greater than 20%. Higher CaO content generally denotes higher self-cementing properties. In Canada, two Types of fly ash are produced and used: Type F and Type CI. However, Type CH fly ash has been imported from the U.S.A. and used in concrete in Canada. Find the chart with the types
  - F Flyash is basically non-pozzolannic and works basically as a filler
  - C Fly-ash is pozzolannic and will react with water to form a cement paste
  - All Fly-Ash varies based on energy plant that created it.
Why Use Fly Ash

• Cement is the third most energy-intensive material to produce, behind steel and aluminum.
• Use of reclaimed and recyclable industrial by-products, such as supplementary cementing materials (SCMs) to partially replace portland cement in concrete, reduces GHG emissions and results in sustainable “green” concrete.
• Importantly, concrete using SCMs will generally exhibit an extended service life over conventional concrete.
Why Use Fly Ash

• Improved workability.
  — Results in very smooth surfaces
• Decreased water demand.
  — Reduces amount of hydration water
• Reduced heat of hydration and retards cure time.
  — Delays finishing of concrete due to slower cure times
• Reduces potential for ASR reaction
  — Good for flooring applications
• Reduced permeability
  — Creates difficulty in bonding using traditional floor installation methods.
• Easier placement and reduced bleed water
  — Harder surface
• Higher strength
  — Greater abrasion resistance
• Reduced shrinkage
  — Creates flatter subfloors that are less prone to curl
• Lowers cost

United States Department of Transportation - Federal Highway Administration
http://www.fhwa.dot.gov/pavement/recycling/fach03.cfm
What is ASR?
What is ASR?

- Alkali ions (Na+ and K+) from the cement, mix water or environment dissolve into reactive aggregates (chert) creating a hydroscopic silica gel that creates pressure and causes pop-outs or extrudes liquid drops to the surface of the concrete.

“The Role of Fly Ash Composition in Reducing Alkali-Silica Reaction” by Rachel Detwiler, PCA R&D Serial No. 2092
Fly Ash Reduces ASR

- ASTM C441 Standard Test Method for Effectiveness of Pozzolans or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction

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<th>Table 3. Evaluation of Fly Ash/Cement Combinations by ASTM C 1260 Maximum Allowable Expansion: 0.10%</th>
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<th>Table 4. Evaluation of Fly Ash/Cement Combinations by ASTM C 441 Expansion of Control Made With Low-Alkali Cement: 0.21%</th>
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Fly Ash reduces concrete permeability
Fly Ash Impact on Concrete Permeability

• Fly Ash reduces permeability due to particle size and refinement in the pore structure of concrete.
  – Fills voids
  – Reduced water requirements mean less capillaries formed during curing phase

“Optimizing the Use of Fly Ash in Concrete”, Michael Thomas, Ph.D., P.Eng., Professor of Civil Engineering, University of New Brunswick
Fly ash “controls” moisture vapor emissions
Fly Ash Reduces MVER

• **There are three major ways fly ash helps reduce vapor transmission.**
  – Fly ash concrete bleeds less, which creates fewer bleed channels and lowers permeability.
  – Pozzolanic action seals off capillary channels to further reduce permeability. Lower permeability concrete dries out more quickly.
  – Pozzolanic action consumes alkali hydroxides, which makes them unavailable for adhesive destruction.
Fly Ash slows things down
Fly Ash Impact on Concrete Cure

- Fly ash slows cure time but results in higher compression strength
  - Takes longer to achieve targeted moisture levels required for floor covering installation

So What’s the Big Deal?
Fly Ash Concrete and Floor Bonding

- Slower cure time means higher RH readings for longer periods of time (installation delays)
- Very dense and hard surfaces mean minimal mechanical bonding sites available and potentially weaker bonds for all types of flooring
- Extremely low porosity means that wet applied, water-based adhesives are going to take a long time to dry, if at all.
So how do you know you have it?
How can you identify Fly-Ash Slabs

- Consult general contractor to determine if any admixture, curing agent or fly ash (Pozzolan) was added to the concrete mix design that would require additional surface preparation to achieve adequate bond.
- Perform “drop test”
- SEM analysis
So what do you do?
Recommendations

• Perform a bond test
• Roughen the surface using mechanical means (shot blasting diamond grining) to an ICRI CSP #3.
  – Acid etching may provide suitable substrate but care must be taken to insure proper acid neutralization
• Patch, skim or apply self leveling underlayments as needed
• New concrete surfaces containing fly ash should be wood-floated or left with a light broom finish.
Fly Ash Summary

• Fly ash will continue to be used as a SCM for concrete for LEED, performance, cost and environmental concerns.
• May have negative impact on bonding of traditional floor covering materials due to hard, slick, dense surface profile
• Seem to respond favorably to mechanical abrasion, diamond grinding and acid etching for better bonding characteristics.
  – But be aware that this an incremental cost is not typically included in contracts and proposals.
• Decreases the permeability of concrete which can control MVER to some extent but make the surface very hard to penetrate and gain a mechanical bond
• Increased cure time will extend time required to wait before floor covering can be installed
Questions....