

## Fly Ash Concrete

Concrete, typically composed of gravel, sand, water, and Portland cement, is an extremely versatile building material that is used extensively worldwide. Reinforced concrete is very strong and can be cast in nearly any desired shape. Unfortunately, significant environmental problems result from the manufacture of Portland cement. Worldwide, the manufacture of Portland cement accounts for 6-7% of the total carbon dioxide (CO<sub>2</sub>) produced by humans, adding the greenhouse gas equivalent of 330 million cars driving 12,500 miles per year.



Fortunately, a waste product can be substituted for large portions of Portland cement, significantly improving concrete's environmental characteristics. Fly ash, consisting mostly of silica, alumina, and iron, forms a compound similar to Portland cement when mixed with lime and water. Fly ash is a non-combusted by-product of coal-fired power plants and generally ends up in a landfill. However, when high volumes are used in concrete (displacing more than 25% of the cement), it creates a stronger, more durable product and reduces concrete's environmental impact considerably. Due to its

strength and lower water content, cracking is reduced. Two types of fly ash are available: Class C fly ash, which is typically light or tan colored and is produced from burning lignite or sub-bituminous coal, and Class F fly ash, which is dark grey and is produced from burning anthracite or bituminous coal.

### PRODUCT COMPARISONS

#### High Volume Fly Ash Concrete

- Less energy intensive manufacture
- Higher ultimate strength
- More durable
- Requires less water
- Uses a waste by-product
- Creates fewer global warming gases

#### Conventional Concrete

- Energy intensive manufacture
- Weaker ultimate strength
- Less durable
- Requires more water
- Uses virgin materials only
- Creates more global warming gases

### LEED CREDITS

Using this material potentially contributes to obtaining these credits in the US Green Building Council's LEED certification program:

#### Materials & Resources

MR Credit 4.1 Recycled Content

MR Credit 4.2 Recycled Content

LEED stands for Leadership in Energy and Environmental Design. To find out more about it, visit [www.leedbuilding.org](http://www.leedbuilding.org).



## ***ENVIRONMENTAL ATTRIBUTES***

### **Energy Performance**

Although high volume fly ash concrete has significantly lower embodied energy, its energy performance at its point of use is no different than conventional concrete. Concrete has high thermal mass and therefore is good at moderating interior temperatures. However, because it conducts thermal energy readily, it should not be used in the building shell without insulation.

### **Resource Impacts**

The principal ingredients of concrete are gravel, sand, water, and Portland cement. Although the cement only comprises 10-15% of concrete by weight, its production is responsible for most of concrete's environmental impacts. The cement, composed of lime and silica (sourced from limestone, clay, and sand), is fired in a rotary kiln at 2700° F, consuming enormous quantities of fossil fuels and thereby producing high amounts of CO<sub>2</sub>. In addition, the chemical reaction that creates Portland cement produces CO<sub>2</sub> as a by-product. By displacing a large percentage of the cement in concrete, fly ash significantly reduces the associated environmental impacts of CO<sub>2</sub> production and air pollution.

The nature of fly ash, tiny spherically shaped particles that act as ball bearings, make it able to fill small voids and produce denser concrete that requires less water for installation, resulting in water savings. Its density makes it less permeable to water in finished form, protecting reinforcing steel and increasing the concrete's durability. Able to produce more cementitious paste, fly ash produces a stronger concrete. It also lowers the heat of hydration, in turn reducing shrinkage and thermal cracking. Class F fly ash, as well as some Class C fly ashes, produce a concrete that is more resistant to sulfate attack and alkali-aggregate reactivity. Materials that last longer reduce the demand for natural resources and reduce the associated environmental impacts of extracting and processing them. Furthermore, fly ash concrete has higher ultimate strength than conventional concrete, so in some applications less material is required to accomplish a given structural need.

### **Health Considerations**

Some building health experts have raised concerns about the presence of trace heavy metals in the fly ash. Others maintain that the metals are effectively locked into the cementitious matrix, preventing their release. Furthermore, by using fly ash in concrete rather than sending it to a landfill, the potential for the metals to leach into the environment is reduced.

Concerns have also been raised about the higher incidence of Radium-226 in fly ash than in cement. However, a study conducted by the EPA suggests that the slight increased risk imposed by the greater exposure was offset by the reduced exposure to radon gas, which is less likely to pass through the denser, less permeable structure of fly ash concrete.

## ***FUNCTIONAL CONSIDERATIONS***

### **Cost**

While fly ash itself is cheaper than Portland cement, ground transportation could negate cost savings if fly ash is not locally available. Lower volume fly ash concrete generally reduces



concrete costs, and high volume fly ash concrete may cost more than conventional concrete if more controlled placement requirements outweigh material savings.

## Installation

Fly ash is composed of tiny spherically shaped particles that act as ball bearings, improving workability and aiding placement of concrete into formwork and around reinforcing steel. Consequently, less water is needed in the mix, reducing or eliminating bleed water. This characteristic also makes it easier to work with in cold weather. Class F fly ash concrete generally gains strength more slowly in the first seven days, while Class C fly ash concrete may actually enhance early strength development. While higher ultimate strengths are realized with fly ash concrete, it sets and cures more slowly than conventional concrete in the first few hours of placement. This is not a problem for most applications, and designers should allow the specified strength to be met in 56 days. Once contractors understand the nature of high volume fly ash concrete, they do not report problems with using it.

Conventional procedures for screeding, finishing, edging, and jointing are applicable to fly ash concrete. Fly ash concrete is denser and results in a smoother finish surface.

## Other Data / Comments

Fly ash can also be added to plaster, reducing or eliminating crazing, drying shrinkage cracks, debonding, expansion, and other defects.

Rice hull ash, created by the controlled burning of an agricultural waste product, can be added to mixes to further increase the strength and reduce the permeability of fly ash concrete.

## RESOURCES

### Suppliers

Fly ash is generally supplied in bulk to batch plants. Many standard mixes already include some amounts of fly ash, because it reduces costs for the batch plants. Homeowners can specify 25-30% fly ash concrete with most Bay Area ready mix plants. Large projects that use higher percentages should contact Doug Yeggy of Headwaters Resources at (916) 214-7293, [www.isgresources.com](http://www.isgresources.com). The following concrete providers have tested and used high volume fly ash concrete mixes. Some may require that the mix design be specified. For up-to-date supplier listings, search the Green Materials Database, [www.builditgreen.org/guide](http://www.builditgreen.org/guide).

**AR Ready Mix**  
Delta Region - CA  
(530) 662-1004

**Berkeley-Oakland Ready Mix**  
699 Virginia St  
Berkeley, CA  
(510) 526-1611  
[www.missionvalleyrock.com](http://www.missionvalleyrock.com)

**Berkeley-Oakland Ready Mix**

**Mission Valley Ready Mix**  
Sunol, CA  
(925) 862-2257  
[www.missionvalleyrock.com](http://www.missionvalleyrock.com)

**Nor Cal Building Materials**  
Sebastopol, CA  
(707) 546-9422  
[www.norcalbm.com](http://www.norcalbm.com)

**Right Away Ready Mix**



401 Embarcadero  
Oakland, CA  
(510) 452-4777  
[www.missionvalleyrock.com](http://www.missionvalleyrock.com)

**Bode Sand & Gravel**  
San Francisco, CA  
(415) 538-1890  
[www.bodegravel.com](http://www.bodegravel.com)

**Central Concrete Supply**  
San Jose, CA  
(408) 293-6272  
[www.centralconcrete.com](http://www.centralconcrete.com)

Oakland, CA  
(510) 536-1900

**Right Away Ready Mix**  
Pleasanton, CA  
(925) 443-2300

**RMC Pacific**  
Pleasanton, CA  
(800) 227-5187  
[www.rmcpacific.com](http://www.rmcpacific.com)

**Shamrock Materials**  
Novato, Petaluma, San Rafael, Santa  
Rosa, & Sonoma, CA  
(800) 779-5777  
[www.shamrockmat.com](http://www.shamrockmat.com)

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