



CR Minerals offers several grades of pumice to serve the construction and oil and gas industries as a natural pozzolan. This is a growing market for CR Minerals due to diminishing supplies of high quality fly ash.

Naturally Pure/Environmentally Sound

CRM pozzolans are naturally calcined by Mother Nature herself. CR Minerals pozzolans do not harbor the heavy metals content of fly ash or the carbon footprint of calcined pozzolans such as Metakaolin or Expanded Shale/Clay. Molten lava, flash frozen upon explosive expulsion from the volcanic vent, instantly became what the Romans called ‘pulvis puteolanus’ or pozzolana – in other words pumice pozzolan, the key ingredient in Roman concrete. Concretes using pumice pozzolan have proven to last thousands of years. Pumice is so naturally pure that your dentist probably uses pumice to clean your teeth.

Historical Effectiveness & Proven Durability

While much of our modern concrete infrastructure crumbles around us, ancient concrete relics of the Roman Empire stand as somber witnesses to the engineering prowess of the Empire’s engineers. Their secret—and the origin of the term “pozzolan”—was fine-grained pumice they first sourced from Pozzuoli, in Italy. When mixed with lime (still the key component of Portland cement today) and aggregate, the pumice based concrete hardened into the most enduring man-made construction material ever designed. The Pantheon, the Coliseum, the Aqueducts and other Roman engineered concrete structures have withstood over two millennia of earthquakes, elements, wars, as well as the relentless passage of time.

Much of our modern concrete deteriorates before our eyes. Efflorescence discolors the surface of many concrete structures and internal-based self-destruction is promulgated by deleterious chemical forces inherent to modern cement and concrete. Pumice pozzolan not only mitigates such chemical forces, but improves the strength and abrasion resistance of concrete, creating a durable construction material after the manner of the Romans.

Modern engineers “rediscovered” the benefits of pozzolanic concrete early in the 20th century. When the coal-fired power generation industry was looking for a market to use the fly ash they were scrubbing from their stacks, they discovered that fly ash had a similar chemistry to pumice pozzolan. Adding fly ash to concrete became an inexpensive means of significantly improving the performance and life span of modern concrete.

While fly ash works as a replacement pozzolan, the original pozzolan, natural pumice, remains the superior choice. CR Minerals pozzolans are the same as the natural, sustainable pumice pozzolan used by the Romans use—carefully refined—resulting in a pozzolan that greatly enhances concrete chemistry and that performs consistently, pour after pour. CR Minerals pozzolans should be part of the toolbox of any engineer interested in designing with strong, durable concrete.



Pozzolan Benefits & Technical Information

Tested, Proven, and Certified

CR Minerals pozzolans have been tested, proven and certified as a natural pozzolan in accordance with ASTM C618N. This certification means that CR Minerals pozzolans are among the most effective products available to protect concrete from the deleterious effects of chemical attack, and to significantly enhance compressive strengths.

Enhances Compressive Strength

The pozzolanic reaction between CR Minerals natural pozzolans and calcium hydroxide begins only after the C3S and C2S in the cement begins to hydrate, thereby releasing calcium hydroxide as a by-product. At the early stage of curing, due to slower (but more effective) reactions created by the pozzolan, compressive strengths will be lower than reference OPC initially. Over time however, the natural pozzolan continues to react with the calcium hydroxide produced by cement hydration and increases the compressive strength by producing additional, densifying C-S-H. Sometime between 28 - 40 curing days, the CR Minerals pozzolan/OPC mixture begins to exceed reference OPC in compressive strength. After 56 days, strengths may exceed reference OPC by 20% or more. The pozzolanic reaction continues until there is no free calcium hydroxide available in the concrete mass. As a result, long term compressive strengths may exceed the reference OPC by up to 50% or more, depending on mix design.



Resists Chloride Attack

Concrete deterioration caused by the penetration of chloride occurs when chloride ions react with calcium. The expansion of hydrated calcium oxy-chloride enlarges micro-cracks and further increases permeability, which in turn causes even greater chloride penetration and related damage from freeze-thaw cycles. When 20-30% natural pozzolan is added to cement, it will react with virtually all the free calcium hydroxide and form a denser, less permeable paste, and thus a significantly higher compressive strength value. With the addition of CR Minerals Ultrafine pozzolan (3μ), the concrete becomes nearly impermeable. Thus, the penetration of chloride can be greatly reduced and the few penetrating chloride ions cannot find any free calcium hydroxide with which to react.

Resists Sulfate Attack

There are three known chemical reactions involved in sulfate attack on concrete:

- 1) Free calcium hydroxide and sulfate combine and expand to form gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)
- 2) Gypsum and calcium aluminate hydrate (C-A-H) combine to create a late-forming, damaging ettringite ($\text{C}_3\text{A} \cdot 3\text{CaSO}_4 \cdot 32\text{H}_2\text{O}$)
- 3) Gypsum and calcium carbonate combine with C-S-H to form a destructive thaumasite ($\text{CaCO}_3 \cdot \text{CaSiO}_3 \cdot \text{CaSO}_4 \cdot 15\text{H}_2\text{O}$).

All three of these reactions result in the expansion and destruction of concrete, generally from the inside out.

Thaumasite, in particular, is accompanied by a severe damaging effect which may transform hardened concrete into a soft, pulpy mass.

As in the case of chloride attack, the natural pozzolan will

- 1) decrease permeability and thereby reduce or eliminate chemical permeation into the concrete, and
- 2) lock up free calcium hydroxide into C-S-H, virtually eliminating the threat.

Mitigates Alkali Silica Reaction (ASR)

CR Minerals natural pozzolan is crushed to a fine particle size resulting in dramatically increased reactive surface area. Thus the natural pozzolan is able to readily react with calcium hydroxide as it becomes available, and thereby traps the liquid phase alkali inside the densified cement paste. Addition of CR Minerals Ultrafine pozzolan (3μ) further speeds this reaction due to its extra 'high reactivity' index. The dense paste and the resultant alleviation of capillary action virtually eliminate both alkali-silica reactions and efflorescence.

Protects Steel Reinforcement

As the preceding data indicates, concrete made with a "Natural Pozzolan/Portland Cement" mixture can protect steel reinforcement by creating a matrix so densely packed that chloride infused liquids and/or gases cannot penetrate to cause the steel to corrode. Where very high strength and superior durability are important, the addition of a CR Minerals Ultrafine pozzolan (3μ) can enhance both strength and the protection of rebar much like a silica fume. Also, environmental-friendly Ultrafine pozzolan does not



carry the carbon footprint of a Metakaolin because it has been naturally calcined during the volcanic eruption.

Increases Abrasion Resistance

Natural pozzolan increases the compressive strength of concrete and makes the concrete mass much less permeable and significantly more resistant to chemical attack. A clean, hard, and durable surface provides the best possible abrasion resistance.

Reduces Heat of Hydration

Experiments show that replacing 15-25% Portland cement (OPC) with a pumice-based natural pozzolan can reduce the expansion and heat of hydration by as much as 40%. Less heat is produced when natural pozzolan reacts with the available calcium hydroxide. Natural pozzolan not only decreases the overall heat generated by cement hydration, it also delays the time of peak temperature. The 'heat of hydration' of a natural pozzolan-OPC cement mixture is extended longer and lower to form a much more moderate curve than the 'heat of hydration' curve for OPC itself. The process is analogous to slow-growth trees....slower growth equals stronger and more dense lumber. The same properties apply to pozzolanic based concrete.

Reduces Permeability

The leaching of calcium hydroxide produced by the hydration of Portland cement can be a significant contributor to the formation of efflorescence and internal porosity in all Portland cement based concrete. The amount of "water of convenience" used to make the concrete workable during the placing/pouring process creates permeable voids in the hardened mass. Additional porosity and efflorescence are created as the calcium hydroxide, a by-product of the hydration reaction, migrates to the surface

of the concrete via capillary action. A pozzolan will effectively eliminate this by reacting with the calcium hydroxide to form stabilizing and strength enhancing C-S-H *before* it migrates to the surface of the concrete.

Improves Durability

The benefits and characteristics of natural pozzolan clearly illustrate why the ancient structures built by the Romans have survived over 2000 years of weathering and punishing history.

Low Density/High Surface Area Advantage

CR Minerals pozzolans have a specific gravity of 2.3 g/cc. Most other pozzolan products have higher specific gravity, some up to 2.6 g/cc. CR Minerals pozzolan also has a larger surface area than most fly ashes, thus greatly improving pozzolanic reactivity, thereby improving set times and enhancing early strength. This means that less CR Minerals pozzolan, by weight, is needed to achieve the same or greater benefit compared to fly ash pozzolans. A concrete mix using 25% fly ash will need only 20% CR Minerals pozzolan to achieve similar performance.

White Color

CR Minerals pozzolan products are off-white in color. This allows them to be used in light-colored, pozzolan-fortified concrete including Decorative concrete, Pre-Cast concrete, Architectural concrete, and Stone Veneer? Pumice pozzolan is a high performance option available today at a very reasonable cost.



Any concrete that needs to be strong and durable will benefit from the addition of pumice pozzolan to the mix design.

Additional Information at www.CRMinerals.com

To place an order or obtain additional information, please contact CR Minerals at 505-428-2940, or contact your local distributor.

CR Minerals is a worldwide supplier of pumice products to many diverse markets. It operates a state of the art processing facility in Ohkay Owingeh, New Mexico.

Although the information and suggestions in this publication are believed to be correct, CR Minerals makes no representations or warranties as to the accuracy or completeness of this information.

Physical Properties of CR Minerals Tephra® (Pozzolan)

Grade	Description	Bulk Density (lbs/cu. ft.)	Specific Gravity
Tephra NP	Pumicite Natural Pozzolan	48	2.3
Tephra WP	White Pumice Natural Pozzolan	48	2.3
Tephra UF	Ultrafine Natural Pumice Pozzolan	48	2.3
Tephra RFA	Remediated Fly Ash	48	2.3

Applications for CR Minerals Natural Pozzolans

CR Minerals pozzolans have a wide range of application, including:

- Precast Concrete
- Glass Fiber Reinforced Concrete (GFRC) Panels
- Stone Veneer
- Mass Concrete
- Architectural Concrete
- Industrial & Infrastructure
- Oil Well Cementing
- Ready Mix Concrete
- Lightweight Concrete
- Decorative Concrete



TEPHRA
POZZOLAN



Tephra^{NP}



Tephra^{WP}



Tephra^{UF}



Tephra^{RFA}