

Environmentally Preferable Concrete

One World Trade Center



Soaring to a height of 1,776 feet (540-meters), the 2.6-million-square-foot (242,000-square-meter) skyscraper known as One World Trade Center in the lower Manhattan district of New York City is a marvel of design and engineering. Construction of the building, previously called the Freedom Tower, began in April 2006 and at the time was the tallest building in the United States.

Project:

One World Trade Center

Location:

New York City, New York

Owner/s:

Port Authority of New York/New Jersey

Concrete Contractor:

Collavino Construction Company

Concrete Producer:

Eastern Concrete Materials, a U.S. Concrete Company

Products Used:

MasterSure[®] Z 60
workability-retaining admixture

MasterGlenium[®] 7500
high-range water-reducing admixture

MasterSet[®] DELVO
hydration-controlling admixture

MasterLife[®] SF 100 silica fume

Market Sector:

Ready-mixed concrete

Project Profile

One World Trade Center

The Challenge

Sustainable design was a central theme to One World Trade Center's development, with the Port Authority of New York/ New Jersey imposing a strict requirement for the replacement of portland cement with recycled materials. In addition, extremely high-performance concrete was necessary to meet the compressive strength requirements of the steel and concrete structural columns, which ranged from 14,000 psi (97 MPa)

to 12,000 psi (83 MPa) for the lower 40 floors and 10,000 psi (69 MPa) to 8,600 psi (59 MPa) for the upper floors.

The 12,000 psi (83 MPa) concrete phase of the project was the most challenging, with the engineers, owners and contractors all having their own requirements and specifications.

Engineering Requirements

- Compressive strength: 12,000 psi (83 MPa) @ 56 days
- Over-design for safety: 1,900 psi (13 MPa)
- Modulus of elasticity: 7.0 million psi (48 GPa)
- Heat of hydration: Not to exceed 160 °F (70 °C)
- Non-air-entrained

Port Authority of New York/New Jersey Requirements:

- Quantity of portland cement in the mixture: Less than 400 lb/yd³ (240 kg/m³)

Contractor Requirements:

- Slump flow: 24 - 28 inches (610 - 710 mm)
- Ability to pump to at least 40 floors
- No loss in concrete workability during transit and placement
- Aesthetically pleasing

To achieve these concrete properties which, combined, would be a groundbreaking feat, concrete producer Eastern Concrete Materials, Elmwood Park, NJ partnered with admixture supplier Master Builders Solutions, Beachwood, OH.

The Results

Through Master Builders Solutions' Green Sense Concrete mixture optimization service, Eastern Concrete Materials was able to proportion an EF Technology® concrete mixture with 71% cement replacement. The mixture replaced portland cement with the recycled materials, non-cementitious fillers and specialized admixtures to exceed all the performance targets specified by the One World Trade Center project stakeholders. This EF Technology mixture was used for the 38,000 yd³ (29,000 m³) of concrete needed for the columns through the first 40 floors.

To quantify the environmental impact of sustainable concrete for the structure, an Eco-Efficiency Analysis was conducted, using a methodology validated by NSF International, to compare the specialized EF Technology mixture to a reference mixture. The results of this cradle-to-gate analysis are included in Chart 1. Some practical equivalents for these savings are:

- Water savings equal to 1,177,329 half-liter bottles of water
- Reduced carbon footprint equal to 1,835,494 gallons of gasoline
- Fossil fuel savings equal to 29,872 barrels of oil

Chart 1. Environmental impact of sustainable concrete for One World Trade Center, as compared to a standard reference mixture.

Environmental Impact Category	Environmental Benefits
Energy usage	25,400,000 kWh (91,440,000 MJ)
Greenhouse gas emissions (15,785,000 kg)	34,800,000 lb CO ₂ eq
Water emissions	5,247,000 gal (19,862,000 L)
Solid waste	1,720,000 lb (780,178 kg)

Based on 145,000 yd³ (110,900 m³) of concrete developed for six compressive strengths.

Master Builders Solutions

Master Builders Solutions is a leading global manufacturer of concrete admixtures, as well as other sustainable solutions for the construction industry, focussed on delivering its vision: **Inspiring people to build better**. Master Builders Solutions provides value-added technology and market-leading R&D capabilities to improve the performance of construction materials and to enable the reduction of CO₂ emissions in the production of concrete. Founded in 1909, Master Builders Solutions

has ca. 1600 employees operating 35 production sites globally, supporting their customers in mastering their building challenges of today – for a decarbonised future.

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