Reactive Powder Concrete

ANNACIVIL BLOG

Reactive Powder Concrete

- What is it?
- What does it do?
- What is its applicability?
- What kind of research is being done on it?
- Why should we care?
- Where is it headed?

Current High Strength Concrete

- High performance concrete can be made to have strengths in excess of 30,000-40,000 psi.
- Use either a mix of superplasticizer, silica fume, and extra-hard aggregate (calcined bauxite or granite) or “Macro Defect Free polymer pastes”
- Still brittle, low ductility

RPC Background

- 4 Types of Concrete
  - Low Strength (<2000psi)
  - Normal (2000-6000psi)
  - High Strength (HPC) (>6000psi)
  - Ultra High Strength (UHPC/RPC) (>40000psi)

- We have compressive strength, now what? What about flexural strength? Cracking? Shrinkage? Creep?

- Developed by the Lafarge Group, Bouygues, and Rhodia.

RPC Composition

RPC is able to obtain its improved properties by using a very dense mix, consisting of fine particles and fibers.

- Low w/cm ratio : 0.16 to 0.24 (as low as 0.13)
- Type 20M (like type II) Portland cement (no C3A less HoH)
- Silica fume (25% by weight)
- Water
- High dosages of superplasticizer
- Fine quartz sand (150-600µm) (SG=2.75)
- Steel fibers (2.5-10% by volume) for toughening
- No rebar needed!
- Cured in steam bath for 48 hrs @ 190ºF (88ºC) after initial set, placed under pressure at the molding stage

RPC Properties

The previously mentioned composition allows for the following properties:

- Compressive Strength: Up to 120,000 psi (200 to 800 MPa!)
- 15,000 psi (~100MPa) or greater 24 hours after initial set
- Tensile Strength: 3000 to 7000 psi (20 to 50 MPa, twice as strong as normal concrete in compression)
- 6-13 MPa tensile strength after first cracking!
- Flexural Strength: ~14000 psi (100 MPa) flexural strength at first cracking is higher than ultimate flexural strength of normal concrete.
- Young's Modulus 50 to 75 GPa
- Fracture energies ranging from 15,000 to 40,000 J/m^2 (plastic failure rather than brittle)

More RPC Properties

- Great durability. Nearly impermeable. No carbonation or penetration of chlorides and sulfates, high resistance to acid attack. (due to low and disconnected pore structure resulting from the size of the powder materials)
- Almost no shrinkage or creep
- Light weight
- Long life
- Improved homogeneity and aesthetic possibilities

RPC Mix and Placing

- Shipped either in 50-lb. preblended bags or 1,500-lb. “bigbags.”
- Can be mixed and produced in a ready-mix truck and still have similar strengths to those made in a central mixer
- Self-placing, requires no internal vibration
- Despite its composition, the large amount of superplasticizer still makes it workable

RPC Applications

- RPC’s properties, especially its high strength characteristic suggests the material might be good for things needing lower structural weight, greater structural spans, and even in seismic regions, it outperforms normal concrete. Below are a few examples of real-world applications, though the future possibilities are endless.

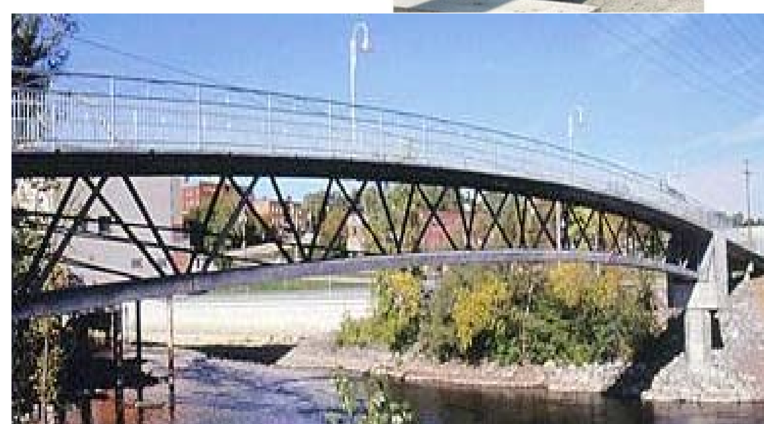
- First bridge that used RPC was a pedestrian bridge in Sherbrooke, Quebec, Canada. (33,000 psi ~230MPa) It was used during the early days of RPC production. Has prompted bridge building in North America, Europe, Australia, and Asia.
- Portugal has used it for seawall anchors
- Austrailia has used it in a vehicular bridge
- France has used it in building power plants
- Qinghai-Tibet Railway Bridge
- Shawnessy Light Rail Transit Station

- Basically, structures needing light and thin components, things like roofs for stadiums, long bridge spans, and anything that needs extra safety or security such as blast resistant structures

Some RPC Diagrams/Pictures

Qinghai-Tibet Railway

Shawnessy Light Rail Transit Station in Iowa (2004) First UHPC Bridge in U.S. →



Sherbrooke pedestrian bridge, in Canada.

RPC Drawbacks

- $$$$$
- No Code!

Future of RPC

- Because of the cost, things like using other scm are being looked into.
- GGBFS?
- PFA (pulverized fly ash)?
- Unlimited potential

References

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- ACI’s website in general