The Influence of Higher Performance Materials on the Design of Concrete Structures

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Overview of Presentation

- Introduction
- Fiber Reinforced Concrete
- High Performance Concrete
  - Admixtures
  - Pozzolanic & Cementitious Materials
- High Strength Concrete
- Case Studies
- Conclusions

Introduction

- Brief History of Reinforced Concrete
  - Used by Babylonians
  - Hydraulic Cement invented in 1756 by John Smeaton
  - Portland Cement in 1824 by Joseph Aspdin
  - R/C in 1849 by Joseph Monier
- Recent Advances in Materials
  - Fiber Reinforcement
  - High Strength Steel
  - New/Improved Admixtures
  - Pozzolanic/Cementitious materials from industrial waste

Fiber Reinforced Concrete

- 3 Main Types of Fibers Used
  - High Strength Steel
  - Glass
  - Carbon
- Used to replace/supplement reinforcing bars

Advantages & Limitations for Fiber-Reinforced Concrete

- Improved Ductility (Steel Fibers)
- Increased Compressive Strength
- Low weight/strength ratio (CFRP)
- Corrosion Resistance (GFRP & CFRP)

- Expensive
- Different σ-ε behavior than concrete & steel
- Brittle Failure (CFRP)
- Design criteria not well established

High Performance Concrete

- Definition
  - Any concrete whose properties have been modified to suit a special purpose

- Applications
  - Paving
  - Fire protection
  - Nuclear reactors
  - High rise buildings
  - Offshore structures
  - Bridges

High Performance Concrete

- Properties
  - High compressive strength
  - Extended lifespan
  - Improved workability
  - Accelerated or retarded set
  - High corrosion resistance

- Additives
  - Chemical Admixtures
    - Plasticizers
    - Set Accelerators/Retarders
    - Air Entrainers
  - Pozzolanic & Cementitious Materials
    - Fly Ash
    - Blast Furnace Slag

High Strength Concrete

- Definition
  - Compressive Strength greater than 6000 psi
  - Lab production up to 60,000 psi
  - Field production up to 20,000 psi (Petronas Towers)
  - 19,000 psi for 2 Union Square in Seattle

- Uses
  - High rise buildings
  - Bridges
  - Columns
  - Shear walls
  - Floor systems
  - Foundations

High Strength Concrete

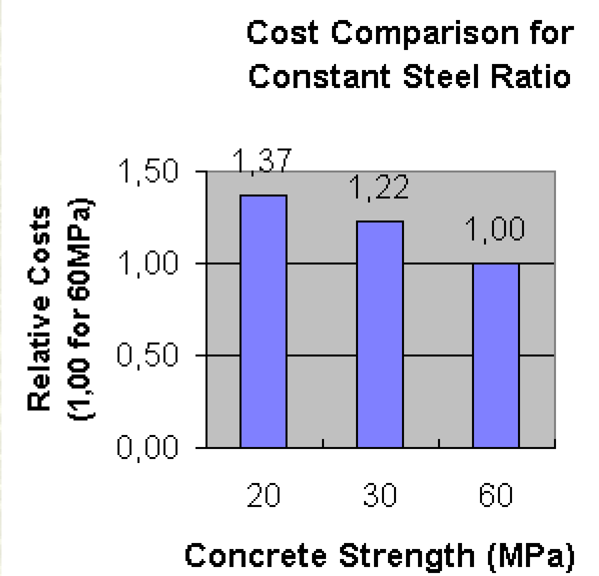
- Benefits
  - Reduced dimensions
  - Reduced reinforcement requirements
  - Material & labor savings
  - Increase floor space and reduce floor-to-floor height

- Limitations
  - Loss of ductility
  - Higher standard for field inspections
  - Special placement & curing requirements
  - Special material requirements

Case Study 1: HSC in Brazil

- 2 main reasons designers chose HSC
  - Reduce dimensions fo heavily loaded columns in high-rises
  - Economic solution to punching shear in flat slabs

- Cost savings up to 37% over normal strength concrete



Relative Cost with Constant Steel Ratio [Leite]

Case Study 2:FRC in Bridge Girders

- Test bridge is a small road bridge near Brescia, Italy
- Steel fibers added at 1% by volume
- Microsilica & SuperFlux added as admixtures

- Benefits of steel fibers included:
  - Bending strength (4X)
  - Tensile strength (1.6X)
  - Improved moment-deflection behavior
  - Increased toughness
  - Extended lifespan

Case Study 3: FRC in Anchorage Zones

- Fiber reinforcement tested for strengthening in post-tensioning anchorage zones
- Goal: reduce congestion & improve concrete quality in these areas

- 1% by volume to:
  - replace all secondary reinforcement with 5900 psi
  - Replace 79% with 4710 psi
  - Reduce secondary reinforcement with any compressive strength

Conclusions

- HPC has applications in virtually any type of structure
- HSC can allow for greater spans, smaller dimensions & reduced reinforcement
- Applications include repair & rehab
- Limitations must be understood
- Codes need to be adapted & revised to account for differences in behavior

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