# Meeting Design Goals with Architectural Concrete



### Structural Applications of Architectural Concrete

#### Architectural Concrete is...

- Just as strong as typical gray
- Has same constituent materials
- Meets the same specifications
- Typically more consistent
- Higher consistency =

higher quality

requires greater care to achieve



The REACH, John F. Kennedy Center for the Performing Arts photo courtesy of PERI Formwork Systems



### Structural Applications of Architectural Concrete

#### Architectural Concrete is...

- Just as strong as typical gray
  - High Performance mixes are SOP
  - Ultra-High-Performance Concrete
    - f'c = 17.5-ksi / 22-ksi Minimum
      (f'c = 120 MPa / 150 MPa Minimum)
- Vulcan Materials prepared
  - 6,000 psi, 8,000 psi, 10,000 psi &
    12,000 psi mixes for The REACH



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      (f'c = 120 MPa / 150 MPa Minimum)
- For example... 432 Park Ave.
  - o 1,400' high with 14-ksi concrete
  - CIP as Self-Consolidating Conc.



432 Park Ave. New York photo courtesy of enclos.com



## **Three Elements of Architectural Concrete**

#### Color

- Material largest factor
- Light / Viewing point

#### Form

- It's all about the molds / forms
- Form liners offer options
- Complexity = Cost

### Finish

From form finish to blasted



The REACH, John F. Kennedy Center for the Performing Artsby Steven Holl Architectsphoto by: Lewis J Goetz



### Change the Elements of Your Concrete Changes the Look

- The Mix Establishes the Color
- Forms aka Molds Give The Concrete it Shape
- The "Finish" Describes Visibility of Concrete Matrix









## Designing for Aesthetics and Sustainability

#### Architectural Concrete is Beautiful... Don't Paint It!

- Use white cement for bright colors
- SCMs such as slag and metakaolin...
- Choose special aggregate colors
- Architectural concrete is resilient















## Mix Designs & Architectural Options

#### Mix designs set your proportions

- Color profile set by the paste
  - Cement
  - SCMs such as slag and metakaolin...
  - Pigments have strong effect
  - Very fine aggregate particles
  - Yields smooth "form-finish" look
- Then fine and coarse aggregate
  - White sand from Maryland contributes
    to The REACH's "marble-like" finish





### Get the Right Supplier For Your Architectural Mix

#### For Cast-In-Place

- Isolated silo/plant is huge advantage
- Experience and open thinking is key
  - Local materials knowledge
    - How to get the right cement
    - Is the "right" colored sand suitable for concrete
- Work with supplier to achieve design intent
  - Will the finish expose the aggregate?
  - Outline mock-up requirements
  - Use test pours on unexposed sections





## Getting the Right Supplier and Contractor

#### For Cast-In-Place

- Dedicated silos
  - Ensure consistency of paste color
  - Protects against mix-ups
- Workforce training is important
  - RMC trucks must be clean...
  - Clean pumps and other equipment
  - Use correct placement technique
  - Remind about importance of color
- NDT Inspectors need to understand goals



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### Mix Designs Set Proportions and Determine Color

#### The paste portion of mix sets color

- Concrete producer determines trade-offs
  - For project/design goals, ie Green Building targets
  - Raw material availability, economics
- To set color The REACH used...
  - ↑ White Type I/II Aalborg Portland Cement
    ↓ GGBFS (Slag) @ up to 40%... light off-white color
    ↑ TiO<sub>2</sub> Titanium Dioxide brightened up this mix
    ↔ Isolated stockpiles for sand & aggregates
    ↔ Dedicated batch plant/designated white & slag silos



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## Getting the Right Supplier and Contractor

#### Architectural precast producers

- Have the advantage of...
  - Experienced crews
  - Better control of pour conditions
  - Daily casting architectural concrete
- Simplifies designer's role
  - Pick color, standard or custom
  - Specify finish, strength & schedule
  - The rest is up to producer
    - Quality control handled by plant
    - Advanced production



Precast production

Photo courtesy of Larry Rowland



### Finishes Highlight Details and Steer the Aesthetic

#### Form Finishes...

- Highlight the paste
  - O Ultra-fine materials
  - Cement, SCMs
  - Pigments
  - Very fine aggregate particles
- Yield clean sharp lines
- Typically have smooth appearance
- The concrete will show all...



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- Form liners deliver dramatic effects
  - Limited only by physics and economics
  - A wide variety of materials are available



The REACH, John F. Kennedy Center for the Performing Arts photo courtesy of Yvonne Nelson



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  - Stock form liner finishes cost less



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  - Stock form liner finishes cost less
  - Be sure to use non-staining form release
  - Consider stripping & depth of the texture
  - Mock-up provide proof of concept



The REACH, John F. Kennedy Center for the Performing Arts photo courtesy of Yvonne Nelson



### **Designers Notes & Best Practices**

Use samples & mock-ups before it is "Cast-in"

- Mock-ups give critical insight
- Can aid in choosing the mix
- Need to be planed and paid for
- Set expectations early
  - Part of bid package
  - Address in contract and specifications
- Do not make them a monument to perfection
  - Show repairs
  - Include details and range of finishes



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The Role of the Architect/Owner

- Do you want a plain or intricate texture
- Identify the finish in the specification
- Ask for examples & finish samples
- Key role for form professionals/engineers



The REACH, John F. Kennedy Center for the Performing Arts photo courtesy of Larry Rowland



The Role of the Architect/Owner

- Do you want a plain or intricate texture
- Identify the finish in the specification
- Ask for examples & finish samples
- Key role for form professionals/engineers
- Consider ease of stripping forms in finish
- Take orientation to sun and artificial light
- How to handle water, dust, and pollution



The REACH, John F. Kennedy Center for the Performing Arts photo courtesy of W. (Tony)Thompson



Finishes set aggregate exposure

- Form Finish or "As Formed" Finish
- Sandblasted
  - Light, **Medium**, and Heavy
- Chemically Retarded
- Acid Etched
- Other...
  - Bush-hammered
  - Polished



Sandblast finishes

Photo courtesy of Larry Rowland



#### Sandblast common in precast

- Cuts paste to expose aggregate
- Medium blast most forgiving
  - Exposes sand
  - Some coarse aggregate
  - Yields a slightly rough surface
- Chemically Retarded
  - Used in place of form release
  - Comes in various etch depths



Sandblasting Mock-ups Photo courtesy of Larry Rowland



#### Important Tricks of the Trade

- Non-staining form release
  - Consistent application of form release
- SCC mixes easier to place
  - Work with concrete supplier
  - More technically challenging
- Contractor's Role is Key
  - Ability to match Mock-up every time
  - Good placement technique
    - Vibration
    - o Un-interrupted pours
  - Sacking & Patching can be an art



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The Best Designs Start With Vision

- Combine practical and the artistic
  - No need to sacrifice function
  - Compliment surrounding architecture
- The REACH is an elegant example
  - Green roofs double as visitor friendly spaces
  - Spaces designed for acoustic excellence
  - Scope is impressive but welcoming
  - Materials clean and approachable
  - Seeking LEED<sup>®</sup> Green Building Certification



The REACH, John F. Kennedy Center for the Performing Arts Image courtesy of Steven Holl Architects



### Innovative Design Must be Written Into the Specification

- Not in the specification = Not in the job
  - Engineering solves practical issues
  - Dead loads are reduced by "bubble" slabs





The REACH, John F. Kennedy Center for the Performing Arts photo courtesy of Yvonne Nelson and Larry Rowland



### Innovative Design Must be Written Into the Specification

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  - Engineering solves practical issues
  - Dead loads are reduced by "bubble" slabs
- Innovation compliments engineering
  - Minimal stainless-steel ties prevent staining
  - External braces
    - Keep penetrations to the minimum
    - Resist up to 1,800 psi form pressure



The REACH, John F. Kennedy Center for the Performing Arts photo courtesy of Larry Rowland



It Takes a Team to Deliver Excellence

- Share your context and define goals
  - Structural application of architectural conc.
  - Engage owner to explore options/tradeoffs



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It Takes a Team to Deliver Excellence

- Share your context and define goals
  - Structural application of architectural conc.
  - Engage owner to explore options/tradeoffs
- Assemble your team early in process
  - Solve practical problems via engineering
  - Manage expectations... is it in the budget?
  - Engage contractor as early as possible
  - Identify materials and secure your supply



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### **Practical Applications for Architectural Concrete**

- Combine engineering and the artistic
  - Evaluate lighting & scale with site visits
  - Structural application of architectural conc.
  - Address environmental effects on conc.
- Match the design to the budget
  - Use all three elements
    - Color
    - Form
    - Finish



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### Practical Applications for Architectural Concrete

- Choose white cement for...
  - Bright clean finishes
  - When specifying light colors
  - Where consistency is critical
  - When it must be strong and beautiful
  - With complimentary fine aggregate
  - o To make a statement & stand apart



The REACH, John F. Kennedy Center for the Performing Arts photo courtesy of Yvonne Nelson

#### Thank you for listening



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