Flow of Presentation

- Self compacting concrete (SCC)
- Why self compacting concrete required
- Material of SCC
- Characteristics of SCC
- Workability Requirement for the fresh SCC
- Mix Design & Initial Mix composition
- Workability Property Test
- Case Study-1 Delhi Metro Project
- How Economical in SCC?
- Benefits & Limitations of SCC
- Concluding Remarks
Self compacting concrete (SCC) [1]

- SCC was developed first in Japan in the late 1980s by Prof. Okka Mura at Ouchi University and in 1989 prototype was developed Prof. Ozwal at University of Tokyo.

- Self-compacting concrete is considered a concrete that can be placed and compacted under its own weight without any vibration effort, assuring complete filling of formworks even when access is hindered by narrow gaps between reinforcement bars.

- The composition of SCC are fly ash, glass filler, limestone powder, silica fume etc. with some super plasticizer is mixed.
Why self compacting concrete required?

- The problem of the durability of concrete structures has been a major problem.
- Over vibration can easily cause segregation.
- Requirement of skilled worker for compaction in conventional concrete that is eliminated in SCC.
- Difficulties to use mechanical compaction for fresh concrete.
  - Underwater concreting
  - Cast in-situ pile foundation
  - Columns with congested reinforcement
Material of SCC \([3]\)

- **Cement**: Ordinary Portland Cement 43 or 53 grades \([\text{EN 197-1}]\)
- **Fine Aggregates**: Particles bigger than 125 micron and smaller than 4.75 mm.
- **Course Aggregates**: The maximum size of aggregate is generally limited to 20 mm.
  - Aggregate of size 10 - 20 mm is desirable for structures having congested reinforcement.
- **Water**: Ordinary portable water of normally pH 7 is used for mixing and curing the concrete specimen.
- **Admixtures**: Mineral Admixtures
  - Chemical Admixtures
Material of SCC \[^{[2]}\]

- **Mineral Admixtures**
  - Pozzolanic + Ca(OH)$_2$ + Water = C - S – H (Gel)
  - **Fly Ash:-** Improve the quality and durability of SCC
  - **Ground Granulated Blast Furnace Slag (GGBS):-**
    - by-product from the blast-furnaces used to make iron.
    - Cementitious and pozzolanic material.
    - improve rheological properties.
  - **Silica Fume:-** Improve mechanical properties of SCC.
  - **Stone Powder:-** Crushed lime stone, dolomite or granite may be added to increase the powder content.
  - **Fibres:-** Fibres may be used to enhance the properties of SCC in the same way as for normal concrete.
    - i.e. Steel Fiber, Polymer Fiber.
Material of SCC \(^4\)

- **Chemical Admixtures:**
  - **Super plasticizer:**
    - Super plasticizer (high-range water-reducers) are low molecular-weight, water-soluble polymers designed to achieve high amounts of water reduction (12-30\%) in concrete mixtures in order to attain a desired slump.
    - Super plasticizer based on Naphthalene or Melamine are generally not suitable for SCC required very high strength.
Material of SCC [5]

- **Chemical Admixtures:-**
  - **Viscosity Modifying Agent :-**
    - Viscosity modifiers are high molecular-weight, water-soluble polymers used to raise the viscosity of water. And reducing its tendency to segregate and bleed.

- **Air Entraining Admixtures (AEA) :-**
  - Air entraining admixtures used for removal of air voids in mixtures.
Flow Chart for achieving self compatibility

- Reduction of water to binder ratio
- Limitation of coarse aggregate content & maximum size
- Addition of mineral admixture
- Usage of Super plasticizer & VMA

- High segregation resistance of mortar & concrete
- High Deformability of mortar & concrete

Self compactibility
Mix Design Procedure

1. Set required performance
2. Select materials (from site)
3. Design and adjust mix composition
4. Evaluate alternative materials
5. Verify or adjust performance in laboratory
6. Verify performance in concrete plant or at site

NOT OK

OK
Mix Design & Initial Mix composition [3]

Mix composition:-

- Water/powder ratio = 0.8 to 1.0
- Total Powder content = 400-600 kg/m³ (160 to 240 liters)
- Sand Content ≤ 40% of the mortar (by volume)
- Sand ≤ 50% of past volume
- Sand ≥ 50% by weight of total aggregate
- Coarse aggregate = 28% to 35% by volume of mix
- Free water < 200 liter
- Paste > 40% of the volume of the mix
- Super plasticizer = 2% to 3% by weight of the binder content
- Viscosity Modifying Agent = 0.2% to 0.5% by weight of the binder content
Characteristics of SCC

- SCC mixes must meet three key properties:
  1. Ability to flow into and completely fill intricate and complex forms under its own weight.
  2. Ability to pass through and bond to congested reinforcement under its own weight.
  3. High resistance to aggregate segregation.

- A concrete mix can only be classified as SCC if it has the following characteristics:
  1. Filling Ability
     - ✓ Slump flow test, T50 cm slump flow, V-Funnel test
  2. Passing ability
     - ✓ J-ring test, U-box, L-box
  3. Segregation potential
     - ✓ V-Funnel T5 minute Test
Workability Property Test

✓ Slump Flow Test & $T_{50}$ cm Slump Flow:

Criteria for
- Slump Flow: 650-800mm
- $T_{50}$ cm Slump Flow: 2-5 sec
Workability Property Test

✓ J-ring Test :-

Criteria for J-ring Test- 0-10 mm
✓ V-funnel and V-funnel at T5 minutes:

Criteria for
V-funnel- 8 - 12 sec
V-funnel at T5 minutes- +3 sec
Workability Property Test

✓ L-Box Test:

Criteria for Blocking ratio $H_2/H_1$ - 0.8-1.0
Workability Property Test

✓ U Box Test:

Criteria for Filling height H1-H2: 0-30 mm
## Workability Requirement for the fresh SCC [3]

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Methods</th>
<th>Unit</th>
<th>Typical ranges of values</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>1</td>
<td>Slump flow</td>
<td>mm</td>
<td>650</td>
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<tr>
<td>2</td>
<td>$T_{50}$ cm Slump Flow</td>
<td>sec</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>J- ring</td>
<td>mm</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>V- funnel</td>
<td>sec</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>V- funnel at $T_5$ minutes</td>
<td>sec</td>
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</tr>
<tr>
<td>6</td>
<td>L-Box</td>
<td>$(h_2/h_1)$</td>
<td>0.8</td>
</tr>
<tr>
<td>7</td>
<td>U- Box</td>
<td>$(H_1-h_2)$ mm</td>
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</table>
Case Study-1: Delhi Metro Project [2]

Mix Proportion adopted at Delhi Metro Project For 35 Mpa SCC

<table>
<thead>
<tr>
<th>Materials</th>
<th>Mix Design</th>
<th>Materials</th>
<th>Mix Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (kg)</td>
<td>163</td>
<td>Fresh density (kg/m³)</td>
<td>2340</td>
</tr>
<tr>
<td>Cement (kg)</td>
<td>330</td>
<td>Quantity of fines</td>
<td>525 kg</td>
</tr>
<tr>
<td>20mm (kg)</td>
<td>455</td>
<td>Water/Powder ratio</td>
<td>0.85%</td>
</tr>
<tr>
<td>10mm (kg)</td>
<td>309</td>
<td>Paste Content by vol.</td>
<td>36%</td>
</tr>
<tr>
<td>Sand (kg)</td>
<td>917</td>
<td>Sand Content by vol.</td>
<td>35%</td>
</tr>
<tr>
<td>Fly Ash (kg)</td>
<td>150</td>
<td>Coarse Agg. By vol.</td>
<td>28%</td>
</tr>
<tr>
<td>Glenium 51 (liter)</td>
<td>2.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glenium stream 2 (liter)</td>
<td>0.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possolith 300 P (liter)</td>
<td>0.66</td>
<td></td>
<td></td>
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</table>
Case Study-1: Delhi Metro Project [2]

- Trial Result at Delhi Metro Project

<table>
<thead>
<tr>
<th>Method</th>
<th>Property</th>
<th>Unit</th>
<th>Min.</th>
<th>Max.</th>
<th>Trial Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump flow</td>
<td>Filling ability</td>
<td>mm</td>
<td>650</td>
<td>800</td>
<td>680</td>
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<tr>
<td>V-Funnel</td>
<td>Filling ability</td>
<td>Sec.</td>
<td>8</td>
<td>12</td>
<td>8</td>
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<tr>
<td>L-Box</td>
<td>Passing ability</td>
<td>mm</td>
<td>8</td>
<td>1.0</td>
<td>0.91</td>
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<tr>
<td>U-box</td>
<td>Passing ability</td>
<td>%</td>
<td>0</td>
<td>30</td>
<td>15</td>
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<tr>
<td>V-funnel at 5 min.</td>
<td>Segregation</td>
<td>Sec.</td>
<td>0</td>
<td>+3</td>
<td>+2</td>
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</tbody>
</table>

- The strength of SCC poured at Delhi Metro, on the basis of cube strength was between 44 and 49 Mpa at 28 days.
# How Economical Is SCC? [2]

<table>
<thead>
<tr>
<th></th>
<th>Control Concrete</th>
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<th>SCC</th>
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<tbody>
<tr>
<td></td>
<td>Rate Rs</td>
<td>Quantity kg</td>
<td>Amount Rs</td>
</tr>
<tr>
<td>Cement</td>
<td>3000/ton</td>
<td>450</td>
<td>1350</td>
</tr>
<tr>
<td>Fly ash</td>
<td>1500/ton</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Natural sand</td>
<td>900/tom</td>
<td>627</td>
<td>564</td>
</tr>
<tr>
<td>Crushed sand</td>
<td>850/ton</td>
<td>267</td>
<td>227</td>
</tr>
<tr>
<td>Course Aggregate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mm</td>
<td>370/ton</td>
<td>510</td>
<td>189</td>
</tr>
<tr>
<td>10 mm</td>
<td>370/ton</td>
<td>430</td>
<td>159</td>
</tr>
<tr>
<td>Water</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>PCE–based admixture</td>
<td>140/l</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Super plasticizer</td>
<td>33/l</td>
<td>11.25</td>
<td>371</td>
</tr>
<tr>
<td>Retarder</td>
<td>50/l</td>
<td>1.35</td>
<td>68</td>
</tr>
<tr>
<td>VMA</td>
<td>40/l</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>2928</td>
</tr>
</tbody>
</table>
Benefits & Limitations of SCC

**Benefits of SCC**
- Faster construction,
- Reduced noise level, due to absence of vibration
- Safer working environment,
- Reduction in site manpower,
- Easier placing,
- Uniform and complete consolidation
- Better surface finishes,
- Improved durability,
- Increased bond strength,
Benefits & Limitations of SCC

- **Limitations of SCC**
  - Its supply cost is two to three times higher than that of normal concrete.
  - The major difficulty in SCC should be fully flow-able but Without bleeding or segregation.
  - An uncontrolled variation of even 1% moisture content in the fine aggregate will have a much bigger impact on the theology of SCC at very low w/c ratio.
  - The mix design method and procedures are too complicated for practical implementation.
Concluding Remarks

• We can reduce the in-place cost and make a safer working environment for the workers.

• SCC can be effectively placed in most congested areas and also where normal methods of vibration are not possible.

• Further research are required to interpret influence on the hardened properties of SCC more precisely.

• The cost of SCC is 10 – 15 % higher than the conventional concrete.
References


3. EFNARC, February 2002


Thank you