Shrinkage-Compensating Concrete—Past, Present, and Future, Part 1

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Experiences on the use of component G in Mexico
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EUCLID CHEMICAL Mexico
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Contents

Component G
Industrial floor durable solution through Shrinkage Compensated Concrete
Mexico City Metropolitan area elevated deck highway considering shrinkage control concrete

Expansion mechanism for shrinkage control in concrete

Ettringite formation
Expansive cements K, M and S
Component K: Calcium Sulphoaluminate component
Portlandite formation
Component G: Calcium Oxyde

Availability in Mexico: Component G and Component K
Length change

**ASTM C 878** (restraint)

**ASTM C 157** (unrestrained)

**Concrete mix design considerations for shrinkage control**

- Typical low shrinkage mix design:
  - w/cm ratio
  - Aggregate top size
  - Paste volume (Cementitious and water amounts)
  - Joint spacing design
- Regional aggregate influence
- Regional cementitious composition influence
- Expansive component quality control
- Weather influence on service life

**Concrete mix materials**

- Cement
  - Composed cements and fineness
  - Prone to shrink more?
  - Local testing to select the cement that produces the less shrinkage possible
  - International recommendations to be adjusted according to local job conditions

- Aggregate
  - Nature fine particles can produce a strong influence on shrinkage
  - Maximum aggregate size 25 or 38 mm, dense, with less than 1% of contaminants and specific gravity >2.5 g/cm³
  - Continuous grading
  - Maximum coarse/fine aggregate ratio (~60/40)

- Admixtures and additions
  - Water reducing (ASTM C 494 Type D)
  - Superplasticizers (ASTM C 1017 Type I)
  - Air detrainer
    - Less than 3%
  - Cement stabilizer
  - Expansive component G
Industrial floor solution through Shrinkage Compensated Concrete

- Project: 54,000 m²
- Slab thickness = 15 cm
- Mechanical properties:
  - Compressive strength 28 MPa at 28 days
  - Jointless floor surface from 1045 to 1567 m²

Distribution Center requirements

Joint spacing benefits through Shrinkage Compensated Concrete

- Mexican Cement Type CPO 30 RS BRA BCH
- Maximum aggregate size: 38 mm
- Less than 180 L/m³ of water
- Slump: 12 cm
- Keep workability for more 60 min (use of superplastizicers)
- Air content: 1.7 to 2.2 %
- Initial set time: 6 to 7 hours
- Length change ASTM C 878:
  - Quality control for delivery: 700 μm at 24 hours
  - Finish operations similar to conventional industrial floors

Distribution Center mix design

SSD Mix design per m³

<table>
<thead>
<tr>
<th>Component</th>
<th>kg</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement CPC 40</td>
<td>310</td>
<td></td>
</tr>
<tr>
<td>Coarse agg 5-40 mm (Basalt)</td>
<td>1094</td>
<td></td>
</tr>
<tr>
<td>River sand</td>
<td>744</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>HRWR Eucon 37</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Component G Conex M</td>
<td>29</td>
<td></td>
</tr>
</tbody>
</table>

ASTM C 878 Length change

- 7 day water-cure
Component G dosed with aggregates at the ready mix concrete plant

Induced crack control

Placement

Set time

Initial 7:06 hours
Final 8:36 hours
Lab conditions (23 ± 2°C)

Laser screed operations
Finishing process

Water Cure
7 days continuous water curing
Cement hydration to favor strength development, expansion and durability
Decreases cracking occurrence /

Distribution Center mix design

<table>
<thead>
<tr>
<th>Compressive strength (MPa)</th>
<th>Requirement</th>
<th>28 MPa at 28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 days</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>7 days</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>28 days</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

Main attribute in expansion
Mechanical properties will be induced by the cement content

Highlights

* 42 pours
* 5 years in service life operation with no interruptions
* Cement content strongly influences expansion
* ASTM C 878 Lenght change history with local materials before the project design
* Owner would invest on this technology again
**Mexico City Metropolitan Area Elevated Deck Highway**

Shrinkage control through Component G

**Elevated deck highway**

- Key infrastructure project to help the transit of the Mexico City and surrounding metropolitan area that runs as an elevated deck on top of the current highway path
- Various stages from 2004 up to date

**Elevated deck highway**

- Specialty concrete was required for different structural applications:
  - Post-tension girders and columns
  - Precast boards
  - Foundations
  - Girder-column connections
  - Slab support layer

**Post-tension precast girders and columns requirements**

- Compressive strength
  - 60 MPa at 28 days (f’c)
  - 48 Mpa at 24 hours (80% f’c)
- Slump flow
  - 700 to 740 mm
- Placing method: pump
San Jeronimo-Muyuguarda, Mexico City 2012

Girder-column connections and foundations
SSD Mix design per m³

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement Type CPC 40R</td>
<td>620 kg</td>
</tr>
<tr>
<td>Coarse agg 5-12 mm (limestone)</td>
<td>864 kg</td>
</tr>
<tr>
<td>River sand</td>
<td>657 kg</td>
</tr>
<tr>
<td>Water</td>
<td>220 L</td>
</tr>
<tr>
<td>HRWR polycarboxylate</td>
<td>6.2 L</td>
</tr>
<tr>
<td>Component G</td>
<td>10 kg</td>
</tr>
</tbody>
</table>

Cambio de longitud a las 24 horas

0.0000 0.0100 0.0200 0.0300 0.0400 0.0500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Tiempo en h

ASTM C 157 Length change at 24 hours

Support layer Technical requirements

- Compressive strength
  - 40 MPa at 14 days
- Slump
  - 120 to 140 mm
- Placing method: Pump
Support layer
SSD Mix design per m³

<table>
<thead>
<tr>
<th>Component</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement Type CPC 40 (R)</td>
<td>400 kg</td>
</tr>
<tr>
<td>Coarse agg 5-12 mm (limestone)</td>
<td>1017 kg</td>
</tr>
<tr>
<td>River sand</td>
<td>720 kg</td>
</tr>
<tr>
<td>Water</td>
<td>181 L</td>
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<tr>
<td>Water reducing admixture</td>
<td>1.8 L</td>
</tr>
<tr>
<td>HRWR Eucon 37</td>
<td>1.0 L</td>
</tr>
<tr>
<td>Component G</td>
<td>10 kg</td>
</tr>
</tbody>
</table>

Satellite, Estado de Mexico 2009

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Satellite, Estado de Mexico 2009

Satellite, Estado de Mexico 2009

San Jeronimo-Muyuguarda,
Mexico City 2012

Highlights

- Mexico infrastructure plans have recognized the importance on the use of specialty concrete technology to overcome the current challenges of Civil Engineering
- Contractors, concrete ready-mix, precast and admixture companies have given an important step towards concrete technology application with stricter requirements to come
Thanks

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Special recognition to EUCLID CHEMICAL customers in Mexico for their outstanding contribution to modern concrete technology