Slab Replacement in Urban Areas

High-Early-Strength Concrete

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California – Many Urban Areas

- 50,000 Lane Miles
- 16,000 L.M. Concrete
- 3,400 L.M. Distressed
- Exceeded Design Life
Rapid strength concrete (RSC) has been efficiently used for emergency repair and planned rehabilitation of concrete infrastructure and for new construction, where acceleration is a concern. This concrete is produced with hydraulic cements. Accelerators of hardening, if used, are non-chloride in nature.
First used in 1998-1999
Total volume of various types of RSC in 2008 >190,000 CY. RSC for pavement rehabilitation was 130,000 CY. Rapid strength lean concrete base was approx 37,000 CY.

Pavement replacement at I-10, Pomona, CA, 1999 (4-hrs RSC)
Replacement HOV lane at I-10, Los Angeles, CA, 2009 (12-hrs RSC)
Pavement replacement at I-710, Los Angeles, CA, 2005 (1.5-hrs RSC)
Proportioning for ultra-rapid strength gain in early age is one difference in the design of RSC and regular concrete.

Options:

- Use of faster hardening hydraulic cements (rapid hardening cements, ASTM C1600; Type III portland cement, ASTM C150)
- Use of accelerating admixtures (non-chloride)
- Limiting W/C
- Optimizing (increasing) initial and curing temperatures of concrete
Proper design of RSC should account for other properties influencing acceleration of construction, such as:

- Ability to be placed, spread and consolidated conveniently and quickly without segregation
- Time within which fresh RSC retains workable consistency
- Ability to be finished promptly upon completion of consolidation
- Ambient Temp, Environment
Two types of rapid strength concrete (RSC) mostly used in California for pavement rehabilitation within short-time lane closures are:

- RSC with rapid hardening cements (examples of such cements are CTS Rapid Set® Cement and Ultimax Cement-DOT®)

- RSC with Type III Portland cement and non-chloride accelerator of hardening (this type of RSC is often called “4 x 4” concrete, because it was first developed to achieve flexural strength of 400 psi in 4 hours by Master Builders)
Rate of strength gain of RSC is mainly controlled by:

- Type of hydraulic cement
- Chemical admixtures
- Water to cement ratio
- Concrete temperature

**Testing Notes:**
Estimation of strength gain requires matching temperature of concrete in specimens and in pavement during curing.
# PROPORTIONING FOR EARLY AGE MOR

<table>
<thead>
<tr>
<th>Min Curing Time to Achieve MOR (*)</th>
<th>Proportioning for Early Age Flexural Strength</th>
<th>Type of Cement</th>
<th>Accelerator fl. oz./100 # cmt.</th>
<th>Max W/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 psi</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1 to 2 hours</td>
<td></td>
<td>Rapid hardening cement, ASTM C1600</td>
<td>-----</td>
<td>~0.41 - 0.43</td>
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<tr>
<td>2 to 4 hours</td>
<td></td>
<td>Portland cement Type III, ASTM C150</td>
<td>70 to 100</td>
<td>~0.32 - 0.34</td>
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<tr>
<td>2.5 to 4 hours</td>
<td></td>
<td>Portland cement Type III, ASTM C150</td>
<td>20 to 40</td>
<td>~0.34 - 0.36</td>
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<tr>
<td>8 to 12 hours</td>
<td></td>
<td>Portland cement Type II, ASTM C150</td>
<td>None</td>
<td>~0.37 - 0.39</td>
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<tr>
<td>≥16 hours</td>
<td></td>
<td>Portland cement Type II, ASTM C150</td>
<td>None</td>
<td>~0.37 - 0.39</td>
</tr>
</tbody>
</table>

**NOTE:** (*) Since the time RSC has been formed and finished.
Urban Slab Replacement

CTS Rapid Set Compressive Strengths

PSI Strength vs Time

- 4.5 Sack
- 5.0 Sack
- 5.5 Sack
- 6.0 Sack
- 6.5 Sack
- 7.0 Sack
- 7.5 Sack

Time:
- 1 hour
- 2 hour
- 3 hour
- 4 hour
- 6 hour
- 8 hour
- 7 day
- 28 day
- 1 year
Urban Slab Replacement

CTS Rapid Set Flexural Strength

- 4.5 Sack
- 5.0 Sack
- 5.5 Sack
- 6.0 Sack
- 6.5 Sack
- 7.0 Sack
- 7.5 Sack
RSC is typically proportioned with superplasticizers for achieving desired (often near-flowable) consistency while maintaining low water to cement ratio (W/C). Hydration controlling admixtures extend time within which RSC retains workable consistency. Optimized consistency and cohesiveness accelerate construction of pavements.

WORKABILITY
RSC with rapid hardening cements is most often produced by mobile (volumetric) mixers to allow for immediate placement. The demand in hydration stabilizers is reduced and uniformity of workability and strength is improved.

RSC with Type III portland cement typically has been produced using transit mixers. Superplasticizer and set controlling admixture are added at the batch plant. Accelerator of hardening is added on site.
PROJECT PLANS FOR CONSTRUCTION ON
STATE HIGHWAY
IN LOS ANGELES COUNTY
IN BUDBANK AND LOS ANGELES
FROM PROVIDENCIA AVENUE OVERHEAD TO
1.9 km SOUTH OF CALGROVE BOULEVARD UNDERCROSSING
To be supplemented by Standard Plans dated July, 1999

BEGIN CONSTRUCTION
KP 46.5
PM 28.9

END CONSTRUCTION
KP R77.1
PM R47.9

Contract No. 07-2025
Urban Slab Replacement

*Std Specs - Timeline*

- 45 Days Prior Pour: Cement Sample
- 10 Days Prior Trial Slab: Mix Design
- 7 Days Prior Pour: “JITT” Submittal
- 5 Days Prior Pour: Completion “JITT”
- 5 Days Prior Pour: Pre-Const Conference
Urban Slab Replacement

**Trial Slab**

- C109 Calibrate Volumetric Mixer
- Trial Slab Simulate Job Conditions
- Evaluation of All Parties / Materials:
  a) Concrete Producer
  b) Contractor
  c) Testing Laboratory
Urban Slab Replacement

Construction Procedures

✓ 2 Days Prior: Perimeter Saw Cuts
✓ Remove Panels: Non-Impact Method
✓ Inspect / Analyze Existing Base
✓ ¼” Foam Joint Filler Installed
✓ Bond Breaker Installed
Urban Slab Replacement

Construction Procedures – cont.

✓ Nightly Material Samples Taken
✓ Load Materials Volumetric Mixers
✓ Begin Concrete Production Process
  a) Place Concrete
  b) Consolidation
  c) Finishing
  d) Curing
Production rates: 300 CY per 7 hr shift (~60 slabs)
Max: 450 CY in 7 hours
WET CONCRETE
Continuous panels need to be saw cut < 1 hr. Depth = T/3.
Dowels on baskets can be used.
Urban Slab Replacement

*Quality Control Program*

- 21 Days Prior Trial Slab Submit QCP
- QCM Current ACI Field Tech I & ACI Lab Test Tech Grade II
- Technicians Caltrans Certified
- Contractor / QCM / Eng. Meeting
Urban Slab Replacement

Quality Control Program – cont.

☑ List Testing Equipment

☑ First 25cy Testing/then every 100cy

☑ Testing Shall Included:
  a) Yield    b) Penetration
  c) Air       d) Unit Weight
  e) Slump     f) Flex Beams
  g) Temperature
Caltrans Project
Interstate 5

2167 Cubic Yards
Thank you

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