Urban Challenges Concrete Work: Curbs, Gutters and Sidewalks

Hugh B. Donovan, P. Eng.
Construction Services Engineer
Integrated Infrastructure Services Department
Engineering Services Section

C-TEP/APWA Western Canada Pavement Workshop
February 9, 2016
What is the Problem?
<table>
<thead>
<tr>
<th>Category</th>
<th>KM</th>
<th>Lane KM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial roads</td>
<td>883</td>
<td>3,989</td>
</tr>
<tr>
<td>Collector roads</td>
<td>677</td>
<td>2,078</td>
</tr>
<tr>
<td>Local roads</td>
<td>3,991</td>
<td>7,982</td>
</tr>
<tr>
<td>Alleys</td>
<td>1,151</td>
<td>1,151</td>
</tr>
<tr>
<td>Bike lanes</td>
<td>300</td>
<td>300</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>7,002</strong></td>
<td><strong>15,500</strong></td>
</tr>
</tbody>
</table>

- Could be as much as 12,000 km of curb and Gutter and as much as 12,275 km of sidewalks
2015 Cost of this infrastructure to Replace:

Sidewalk: \~ $1,378,500,000

Curb and Gutter: \~ $1,614,840,000

Total Almost $3 billion
Problem Statement:

“Curb, gutter and sidewalk (flatwork) sections constructed in the City of Edmonton over the past several years have been showing increasing signs of concrete deterioration in the form of popouts and mortar flaking”
Previous Studies

Two Studies were done in the mid 1980’s pertaining to similar observations:

• 1985 Investigation of Flatwork Defects

• 1987 Effect of Ironstone on Flatwork Concrete Surface Appearance
1985 Study
“Flatwork Study Program for the Investigation of Concrete Flatwork Defects”
By Hardy Associates (1978) Ltd.
1985 – Concrete Flatwork Issues
1985 – Concrete Flatwork Issues
Conclusions of the study:
1. Freeze-thaw action;
2. Enhanced by the presence of chloride;
3. Application of water during the finishing operations;
4. Presence of deleterious components such as ironstone, weak sandstone, coal and similar particles;
5. Pitting and popouts are made worse by the freeze-thaw action;
6. Lack of aggregate to paste bond;
7. Observed defects - quality of concrete itself;
8. Need to review construction practices;
# 1985 Study Findings and Recommendations

<table>
<thead>
<tr>
<th></th>
<th>Prior to 1985</th>
<th>After 1985</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive Strength (MPa)</td>
<td>24.1</td>
<td>30.0</td>
</tr>
<tr>
<td>Water/cement Ratio</td>
<td>0.50</td>
<td>0.45</td>
</tr>
<tr>
<td>Fly ash Replacement</td>
<td>Up to 20%</td>
<td>Max of 10%</td>
</tr>
<tr>
<td>Min Cement Content (kg/m³)</td>
<td>None</td>
<td>335 for mixes without fly ash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>300 for mixes with fly ash*</td>
</tr>
<tr>
<td>Max. Deleterious Material</td>
<td>None</td>
<td>1.0</td>
</tr>
<tr>
<td>Coarse Aggregate (% Max)</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>Fine Aggregate (% Max)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slump (mm)</td>
<td>25-75</td>
<td>60 ± 20</td>
</tr>
<tr>
<td>Air entrainment (%)**</td>
<td>5-7</td>
<td>Min 5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max 8.0</td>
</tr>
<tr>
<td>Maximum Agg. Size (mm)</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>Cold Weather Requirement</td>
<td>For cold weather concreting after September 30th, the minimum compressive strength shall be attained in 7 days.</td>
<td>For cold weather concreting after September 30th, the minimum compressive strength shall be attained in 7 days.</td>
</tr>
</tbody>
</table>

*Note: Disallow the use of fly ash after September 1 of each year;

**Note: Maximum allowable spacing factor of 0.20 mm based on ASTM C457
1. Quality monitoring program;
2. Proof testing of concrete components;
3. Perform plant checks;
4. Redesign inspection formwork;
5. Coordinate test results, quality, and inspection to the final quality of the product;
6. Do not allow the use of water - Finishing;
7. Review cost/benefit aspects of the use of surface sealers;
8. Enforce the specification requirements
1987 Study
“Effects of Ironstone on Flatwork Concrete Surface Appearance Salt Scaling Resistance Test”
By Hardy BBT Limited.
1987 Study
25 Freeze-thaw Cycles

No Ironstone

1.5% Ironstone
Conclusions and Recommendations of the study:

1. Test method ASTM C672, is too severe a test;

2. Other weak aggregate types affected the outcome;

3. A less severe form of ASTM C672 could be employed using a weaker salt concentration of 1 percent in future studies.
2014 – Concrete Flatwork Issues
2014 – Concrete Flatwork Issues
Engineering Services Study to determine if Cure and Seal products would adequately seal the concrete surface and prevent or at least slow down the surface deterioration of City of Edmonton Class C Concrete

1. Five - proprietary products tested and one non-sealed control Sample;
2. Used ASTM C672;
3. Specimens subjected to 50 Freeze thaw cycles;
4. Specimens weighed and inspected after each Cycle
2015 Study
35 Freeze-thaw Cycles
Conclusions of the study:

1. Freeze-thaw action on the concrete;
2. Observed damage was not reduced by cure and seal products tested;
3. One sample failed after two freeze-thaw cycles;
4. Most samples showed signs of mortar flaking or popouts after 10-15 Cycles.
2015 Study 35 Freeze-thaw Cycles

1987 Study 25 Freeze-thaw Cycles
Deicer Scaling/Deterioration

- De-iceing chemicals enhance freeze-thaw deterioration.
- Concrete finishing can/may play a role;
- Chemical mechanisms may also have a role;
- Manifest as surface scaling, spalling (popouts), or map cracking;
- Typically appears within 1 to 3 years after Concrete placement;
- Cyclic freeze-thaw exposure exacerbates the damage caused by use of deicers;
- Silane and siloxane sealants both improved the performance of concrete exposed to deicing chemicals

Review of Literature and Numerous Studies
Current issues observed are in part as a result of the use of de-icing chemicals in the form of:

• Road salt splashing the concrete curb, gutter and flatwork;
• Placement of de-icing chemicals on the concrete flatwork surface by private citizens
Where do we go from here?

- Further Studies in 2016 to Evaluate Sealant Product Performance
- Provision of a Concrete Best Practices Seminar jointly sponsored by the City of Edmonton, City of Calgary and the Alberta Roadbuilders and Heavy Construction Association
  
  [http://arhca.ab.ca/events/calendar/255](http://arhca.ab.ca/events/calendar/255)
Questions ?