FIELD EVALUATION OF CUPOLEX® AS AN INNOVATIVE CONCRETE PAVEMENT TECHNOLOGY

Aleks Kivi, B.Eng, EIT, MASc Candidate

Susan L. Tighe, PhD, P.Eng, Professor and Canada Research Chair

Centre for Pavement and Transportation Technology, University of Waterloo, Waterloo, Ontario

David K. Hein, P.Eng, Principal Engineer & Vice President, *Applied Research Associates, Inc., Toronto, Ontario*

Introduction

- Cupolex® is a permanent structural formwork system, consisting of interlocking dome-shaped plastic units.
- Developed in Italy.
- Widespread use worldwide in the construction of concrete floor slabs.

Benefits

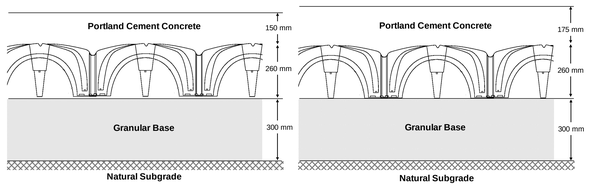
- Reduced concrete consumption (up to 20%) vs. conventional slab.
- Reduced granular material and steel requirements.
- Dome-shaped design encourages ventilation, ensures drainage and reduces exposure of concrete to moisture.
- Reduced slab curling and shrinkage effects.
- Simple to install, reducing labour costs.

Milton Cupolex® Trial Objectives

- Evaluate the suitability of Cupolex® for use in concrete pavement applications through the construction of a full scale test section in an accelerated loading scenario.
- Monitor and evaluate pavement responses, e.g. strains, pressures, from vehicular loadings and environmental stresses through the use of instrumentation.

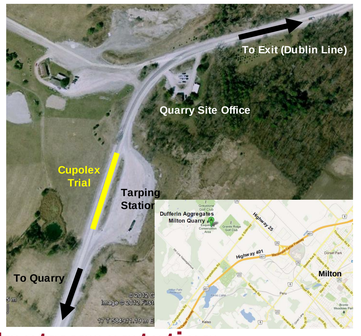
Design and Construction

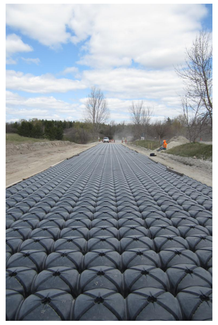
- 98 metre long test section.
- Located at Dufferin Aggregates' Milton Quarry.
- 2 x 4 metre wide lanes
- Two pavement thicknesses: 150 mm & 175 mm.
- No steel reinforcement.
- Uniform transverse joint spacing of 4 metres.
- Test section was constructed in April 2012.
- Paved with sustainable Portland-Limestone Cement concrete mix with slag
- Concrete was placed with conveyor and consolidated with slipform paver.
- Carries hundreds of heavily loaded aggregate trucks daily.



1) **150 mm** of concrete above Cupolex®

2) **175 mm** of concrete above Cupolex®





Instrumentation

The site was instrumented with a total of 22 sensors to permit the regular monitoring of pavement responses for long-term performance:

16 vibrating wire strain gauges

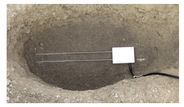
- Measure static strain and temperature of concrete at the top of the dome.
- Placed at 8 locations.
- 2 sensors per location, one oriented in the direction of traffic flow, one perpendicular to traffic flow.

2 total earth pressure cells

- Measure pressures imparted on granular base layer.
- One sensor located under the "foot" formed by four adjacent Cupolex® units, one sensor located in the void.

4 moisture probes

- Measure volumetric water content of granular layer at two depths.

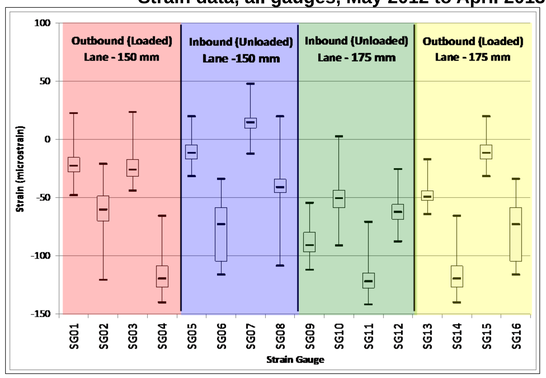


Results

Strain Data Analysis

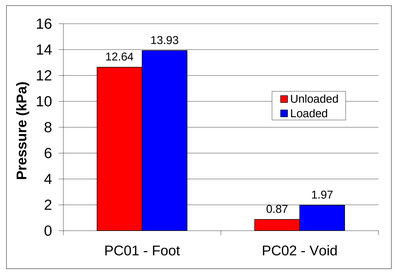
- Daily cycles in strain are observed, corresponding with daily cycles in temperature, i.e. expansion with daily heating and contraction with nightly cooling.
- Much greater daily variation observed during the summer, due to greater daily range in temperatures.
- Structural action of the dome shape effectively eliminates any tensile strains in the concrete, reducing the likelihood of cracking or fatigue failure.
- Slightly lower strains are recorded in the thicker section (175 mm), in comparison to the thinner section (150 mm).
- Strain gauges oriented parallel to direction of travel measure slightly lower strains due to increased edge restraint effects.
- Low measured strains are encouraging of good future performance.

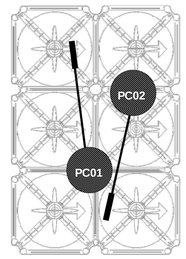
Strain data, all gauges, May 2012 to April 2013



Pressure Data Analysis

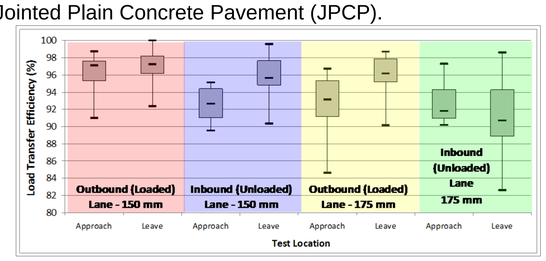
- Cupolex® behaves as a system, distributing vehicular loads to base layers over a large area (not only to the nearest foot).
- Likelihood of overstressing or differential settlement from concentrated point loads is reduced.
- Comparable increases in pressure are measured in the granular base in both pressure cells when a live load is applied directly above the foot.

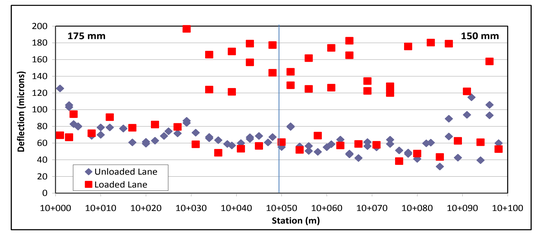




Falling Weight Deflectometer Data Analysis

- Load transfer efficiency (LTE) across transverse joints is very good without the need for dowel bars.
- FWD results shows that load transfer efficiency appears to be independent of whether transverse joint lies above the top of the dome (thinnest concrete) and above the leg (thickest concrete).
- Normalized midslab deflections are fairly low and generally consistent in the unloaded lane.
- Midslab deflections show much more variability in the loaded lane.
- Deflections are comparable to a 230-280 mm conventional Jointed Plain Concrete Pavement (JPCP).





Visual Evaluation

- Pavement surface has been evaluated on a monthly basis since construction.
- Only one slight crack: occurred during sawcutting operation.
- Some minor material related distress, e.g. ravelling, abrasion.
- No visual evidence of any issues relating to the structural capacity of the Cupolex® system.

Conclusions

- Cupolex® pavement has shown excellent performance to date under heavy loading conditions.
- Over 1.3 million Equivalent Single Axle Load (ESAL) have been applied to date.
- Technology shows great potential as a concrete pavement technology.

Future Work

- Continued monitoring of the Milton test section.
- Broadening the scope of the experiment by constructing additional trials in different scenarios, e.g. low volume roads, pervious concrete with stormwater storage.

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