FIELD EVALUATION OF CUPOLEX® AS AN INNOVATIVE CONCRETE PAVEMENT TECHNOLOGY

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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.

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.

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 show 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. raveling, 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.

Acknowledgements:
The authors would like to recognize the contributions of the members of the Cupolex® project team at the Centre for Pavement and Transportation Technology (CPATT), Holcim (Canada) Inc., Dufferin Construction Company, Panteclitic Engineering, Inc. & Applied Research Associates, Inc.