PERFORMANCE REVIEW OF THE LIGHT-COLOURED PAVEMENT OF THE 2009 FRONT STREET PROJECT IN DAWSON CITY, YUKON

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OUTLINE

- Introduction
- Thermal modeling
- Pavement design
- Pavement construction
- Monitoring and evaluation
- Development of synthetic binder in Canada
- Conclusions



INTRODUCTION

- Front Street from km 713.9 km 716.0 Klondike Highway #2 in Dawson City, Yukon.
- 1898 Klondike Gold Rush.
- Dawson City Historical Complex National Historic Site
- By 2008 the Bituminous Surface Treatment (BST) had 30 year service life.

Project must:

- Satisfy historical requirements of community.
- Protect permafrost from projected surface temperature increase.



Front Street 1898



Front Street May 2009

THERMAL MODELING

- discontinuous and warm permafrost with high ice contents and temperatures ranging from -1.0 degreed C to 0.1 degrees C.
- Solar radiation absorbed at the surface is converted into heat.
- geothermal modeling to predict thaw depths for the 2009-2029 period.
- Low solar radiation absorbing surfacing system.



PAVEMENT DESIGN- PAVEMENT OPTIONS

• Chip Seal / BST systems.

• Sprinkle Treatment.

Coloured Paving Material.







PAVEMENT DESIGN- BACKGROUND AND CONSTRAINTS

- Poor Drainage
- Grade limitations.
- Utilize existing storm water system.
- 100mm Hot Mix Asphalt structure .



PAVEMENT DESIGN- BINDER SELECTION

- Traditional asphalt binders experience.
- Bituclair one of the petroleum based synthetic binders which is translucent in thin films.
- Three existing Bituclair binders were studied to formulate to the required Performance Grade.
- Formulation developed to meet PG 52 as high grade and PG -39 as the low grade.

PAVEMENT DESIGN- BINDER SELECTION

- Binder manufactured at the Colas Midi-Mediterranean facility in Vitrolles, France.
- Transported in 20 tonne bitutainers.



PAVEMENT DESIGN- AGGREGATE SELECTION

- No previous Hot Mix Asphalt had been constructed in Dawson City, Yukon.
- Aggregate source was the tailings stockpile left from the 1900's gold dredges.
- Test protocol confirmed aggregate properties.
- Bottom Lift material produced to Yukon 12.5mm specification.
- Top lift Nominal Maximum Aggregate Size of 4.75mm.
- Superpave 4.75 and MTQ ESG-5 grading specifications utilized.
- Produced 2.5/5mm and 0/2.5mm materials.

Test	ASTM Procedure	Yukon Government Specification	Test Results
Petrographic Analysis			111
Los Angeles Abrasion,	ASTM C 131	Coarse Agg. <25	18.6
Gradation B Max % loss		Fine Agg n/a	
Magnesium Sulphate Soundness	ASTM C99	Coarse Agg. < 12	8
Max % loss	ASTN C88	Fine Agg. <16	10
Sand Equivalent	ASTM D2410	Coarse Agg n/a	
Minimum	A51M D2419	Fine Agg. > 35	60
Light Weight Particles (specific		Coarse Agg. < 1.5	0
gravity less than 1.55)	ASIM CI23	Fine Agg n/a	0
Flat & Flangeted Particles ratio			
Greater than 5:1		Coarse Agg. < 15	4
Man 97 has Mana		Fine Agg n/a	4
Max % by Mass			
Plasticity Index	ASTM D424	Coarse Agg n/a	Non plastic
Maximum		Fine Agg. < 4	

Table 1. Aggregate Properties

PAVEMENT DESIGN- MIX DESIGN

- Mix design to Asphalt Institute MS-2 Manual for Marshall Mixes.
- Yukon Government HMA Specifications.

Consideration:

1. Mix Performance for low volume roads.

The mix design for the light-coloured paving material was developed using the guidelines provided in the Asphalt Institute MS-2 Manual [6]. Mix properties are provided in Table 4.

Table 4. Light-coloured Paving Material Mix Design Properties

50 Blow Marshall	Mix Design	Specification
Binder Specific Gravity	1.000	
Binder absorption combined aggregate	1.16	
Bulk Specific Gravity of combined aggregate	2.629	
Binder content	6.4% by dry agg.	
Percent air voids	3.2	3.0 - 5.0
Percent Voids in Mineral Aggregate (VMA)	14.9	Min 14.0
Percent Voids Filled with Asphalt (VFA)	78.3	65-78
Percent effective asphalt content	4.9	
Binder film thickness	6.6	
Dust to binder ratio	1.5	0.9-2.0

PAVEMENT DESIGN- MIX DESIGN

Consideration:

2. Albedo/reflectivity.

- Colour of the aggregate.
- Titanium Dioxide dosed to lighten the final colour.



Colour Tones of the Various Percentages of Titanium Dioxide Addition

PAVEMENT CONSTRUCTION – EQUIPMENT PREPARATION

- Parallel Flow Continuous Drum Mixer available for project.
- System added at the plant to introduce titanium dioxide.
- Asphalt pump and associated piping changed.
- Residual black components of plant cleaned.





PAVEMENT CONSTRUCTION – EQUIPMENT PREPARATION

 Quality management plan identified cleaning of the trucks, plant, pavers, rollers, hand tools and even new boots for the crew.



PAVEMENT CONSTRUCTION – BASE PREPARATION

- Final site grading
- 75mm Base lift of conventional Hot Mix Asphalt



PAVEMENT CONSTRUCTION - **PAVING**

- CRS-1P Bond Coat
- Bond Coat applied at 300g/m2 of residual binder.



PAVEMENT CONSTRUCTION -PAVING

- Test strip :
 - Potential maintenance material.
 - Allow calibration of the plant and crew for required placement procedures.
- Compaction achieved with a double steel vibratory roller.
- No workability issues.



FRONT STREET SEPTEMBER 2009



GROUND VIEW OF FRONT STREET, DAWSON CITY, YUKON, SEPTEMBER 2009

AERIAL VIEW OF FRONT STREET, DAWSON CITY, YUKON, SEPTEMBER 2009

MONITORING AND EVALUATION – PAVEMENT CONDITION

- Annual inspections.
- Visual pavement condition record established.



Figure 5. Front Street Pavement Condition as of May, 2015.

MONITORING AND EVALUATION – GEOTHERMAL MODELING AND SURFACE ALBEDO

- Geothermal Modeling predicted the impact of surfacing materials on the quantity of heat transferred to deeper soil strata.
- The albedo of solar reflectance of a surface is defined as the ratio of the reflected to incident solar light.
 - A perfect reflector has an albedo of 1,
 - a surface that has no reflectance has an albedo of 0.
- The albedo for the existing gravel road network was not available in the planning phase of the project.
- Assessment of light coloured pavement indicated a solar reflectance or albedo of 0.22 for a fully coated specimen and an albedo of 0.27 for saw cut surfaces.

MONITORING AND EVALUATION – GEOTHERMAL MODELING AND SURFACE ALBEDO

2013 field measurements of the solar reflectance or albedo was found to be between 0.21 and 0.25 while the albedo of the surrounding gravel surfaces was found to be between 0.17 and 0.21.



DEVELOPMENT OF SYNTHETIC BINDER IN CANADA – USES IN CANADA

- Synthetic Binders have been used througought Europe for several decades.
- Light –coloured pavement provides a high albedo surface useful for maintaining low heat absorption which can protect permafrost.
- Lower heat absorption will reduce surface temperature of pavement.

DEVELOPMENT OF SYNTHETIC BINDER IN CANADA – USES IN CANADA

- Difficult logistics and high cost to deliver the light coloured binder to North America.
- The Colas Canada Inc. laboratory (Gecan) and the Colas S.A. Research Centre (CST) were tasked with finding the resource materials in North America to formulate various performance grades of synthetic binders and emulsion.

DEVELOPMENT OF SYNTHETIC BINDER IN CANADA – USES IN CANADA

- Local components met technical properties.
- Produced dark amber brown binders instead of the traditional Bituclair golden colour.
- The performance graded synthetic binders developed were based on the common binder used in Canada.
- Paving material mix design work was performed to confirm the production of coloured pavement.

DEVELOPMENT OF SYNTHETIC BINDER IN CANADA – DEVELOPING PERFORMANCE GRADE SYNTHETIC BINDERS



Coloured Paving Materials (Red and Beige) Produced with North American Sourced Components

DEVELOPMENT OF SYNTHETIC BINDER IN CANADA – DEVELOPING PERFORMANCE GRADE SYNTHETIC BINDERS



Coloured Slurry Produced with North American Sourced Components

CONCLUSIONS

- 1. The paving of Front Street in Dawson City was a unique project with technical and construction challenges.
- 2. The performance review of the light-coloured pavement indicates that the objectives set forward by the Yukon Government have been met in terms of albedo to protect underlying permafrost and also maintain frontier aspect of Dawson City.
- 3. The project in Dawson City provided evidence that light coloured pavement provides a high albedo surface useful for maintaining lower heat absorption and lower pavement temperature.
- 4. The laboratory work carried out by Gecan indicate it is possible to manufacture synthetic binders with North American components that meet conventional PG formulations.



