Context Sensitive Pavement Design for Low Volume Road Applications

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ABSTRACT

Two-thirds of roads in North America and more than 90% of all the roads in the world are unsurfaced or are lightly surfaced low to medium volume roads. Low to medium volume roads tend to have a greater social and environmental impact as compared to high volume roads because they connect small towns and rural communities, serve as farm-to-market/forest-to-market roads, and provide links to parks and recreational areas. These impacts must be included in the planning and design phases of these roads to ensure that they do not disrupt the delicate balance of wildlife habitats, and natural viewscapes of woodlands, forests and agricultural lands. In this context, federal and state/provincial agencies and other transportation organizations have pioneered the concept of context-sensitive solutions/context-sensitive design (CSS/CSD), which has been defined as “a collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting, and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility”.

This paper presents the development of a methodology to facilitate the pavement surface selection for low to medium volume roads. It considers the engineering design factors, such as structural capacity, performance, durability, and safety as well as non-conventional factors, including aesthetics, context compatibility, and environmental impacts. The surfacing evaluation involves, applying scoring factors and weighting factors to a series of selection attributes to identify the optimum solutions. Specific application of the developed process is also presented using information from actual sites.

1.0 INTRODUCTION

The traditional approach to transportation infrastructure design has been based on providing the highest level of functionality and safety at the least possible cost. Environmental impacts, cultural sensitivity and aesthetics have not always been in the forefront of design considerations.

Low to medium volume roads which cover two-thirds of roads in North America tend to have a greater social and environmental impact as compared to high volume roads because they connect small towns and rural communities, serve as farm-to-market/forest-to-market roads, and provide links to parks and recreational areas. These impacts must be included in the planning and design phases of these roads to ensure that they do not disrupt the delicate balance of wildlife habitats, and natural viewscapes of woodlands, forests and agricultural lands.

Context-Sensitive Design (CSD), also known as Context Sensitive Solutions (CSS) is being increasingly used by transportation agencies to address the above noted impacts. CSD/CSS is defined as “an approach to transportation design that considers the total context within which the transportation improvement project will exist. It is an interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting, and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility” [1]. Until recently, the CSD approach has been mainly applied to geometric design and to the major visual elements of roads, such as retaining walls, slope treatments, bridge abutments, noise barrier walls and guiderail. However, its application in pavement design and specifically in selecting pavement surface types for low to medium volume roads has been overlooked until recently.

This paper presents the development of a methodology to facilitate the process of selecting an appropriate roadway surfacing for a low to medium volume road project or a particular segment of a road project. It considers the engineering design factors, such as structural capacity, performance, durability, and safety as well as non-conventional factors, including aesthetics, context compatibility, and environmental impacts. The surfacing evaluation involves, applying scoring factors and weighting factors to a series of selection attributes to identify the optimum solutions.

2.0 BACKGROUND

In 1997 in the United States, the Federal Highway Administration (FHWA) published “Flexibility in Highway Design” [2], a guide that provides ideas and options for designing more environmentally friendly highways, without compromising safety and mobility. A vital component of this approach is to seek participation of various stakeholders such as land owners, permitting agencies, community groups, and environmental organizations early in the design process, so that the interests of the various stakeholders can be identified and creative thinking fostered in arriving at solutions. Such solutions will not be universally applicable but very much influenced by the specific characteristics of the site and the context of its use. When considering preliminary design alternatives, it is critical that pavement treatment options, especially those that may be innovative, can be effectively communicated to the stakeholder groups.

The Federal Lands Highway (FLH) Division of the FHWA works in cooperation with federal land management agencies to plan, design, construct and rehabilitate highways and bridges on federally owned lands. The program includes forest highways, public lands highways, park roads, national monument and historic site roads, parkways, refuge roads, and Indian reservation roads. These roads serve recreational travel and tourism, protect and enhance natural resources, provide sustained economic development in rural areas, and provide needed transportation access for Native Americans. Overall, the FLH program provides funding for more than 145,000 kilometers of federally owned and public authority owned roads, a large percentage of which are rural, low to medium volume roads in areas with significant environmental or historical qualities.

The FLH found that customers, communities, environmental organizations and individual landowners were increasingly concerned about the road surface types used for proposed projects. The Division was also finding it more difficult to reach consensus on surface type selection due to lack of consistent and comprehensive information regarding alternative surface types and a defined process for selecting surface types for roads within its jurisdiction. As a result, FLH funded development of a Context Sensitive Roadway Surfacing Selection Guide [3] herein after referred to as the “Guide”, through the Central Federal Lands Highway Division (CFLHD). The goal of the Guide was to provide the required tools for the decision making process in building low to medium volume roads taking into consideration the concerns of various stakeholders and users of the road. The active involvement of stakeholders and local residents is vital to the surfacing selection process. As design engineers we may conclude that replacing a gravel-surfaced road with a sealed surface will be universally acceptable, but experience has shown that it can be legitimately challenged by local residents who fear greater use of a local road by long distance commuters, higher travel speeds and more disturbance.

The Guide documents the available options for roadway surfacing and provides a decision-making process to allow consideration of engineering design factors, such as structural capacity, performance, durability and safety, as well as other factors, including aesthetics, context compatibility, and environmental impacts within the context of meeting the following four basic essentials:

1. The selected pavement type has to be functional and serviceable.
2. The selection must be cost-optimized and economically and financially feasible.
3. The pavement surface should provide adequate ride comfort and safety to the traveling public.
4. The design should be context sensitive in terms of its impact on the visual landscape, cultural and environmental elements.

3.0 ROADWAY SURFACING TYPES

To help facilitate the roadway surfacing selection process, a list of more than fifty available roadway surfacing products were assembled and pertinent information was compiled for each roadway surfacing product. Given the wide range of road surfacing types available, a rational system of classification was developed. The roadway surfacing options were classified into four major categories: Paved and Sealed Surfaces, Aggregate and Soil Surfaces, Unit Surfaces, and Recycling and Reclamation Alternatives. Paved and Sealed Surfaces included flexible and rigid bound surfacings, non-structural asphalt surface treatments, structural asphalt surfacings, and Portland Cement Concrete (PCC) surfacings. Aggregate and Soil Surfaces include untreated aggregate/soil surfacings and surfacings stabilized with dust palliatives, soil stabilizers, or geosynthetic products. Unit surfaces included different unit paver types and natural stone cobbles. Recycling and Reclamation Alternatives included products that are produced in situ on the road and/or contain some recycled road materials. Table 1 provides a list of the available road surfacing options considered in the development of the Guide.

Information pertinent to the selection process was collected for each roadway surfacing product. These included product information related to application, design, construction, serviceability, safety, environmental concerns, aesthetics, and cost. In addition, sections were included for general information, example projects, and select print and internet references.

Table 1 - Roadway Surfacing Product Listing

CLASSIFICATION	SUB-CATEGORIES	ROAD SURFACING PRODUCTS
Paved and Sealed Surfaces	Asphalt Surfacing – Surface Treatments or Layers (non-structural)	Cape Seal, Chip Seal, Chip Seal over Geotextile, Fog Seal, Microsurfacing, Multiple Surface Treatments (Seals), Open Graded Friction Course, Otta Seal, Sand Seal, Scrub Seal, Slurry Seal, Ultrathin Friction Course
	Asphalt Surfacing – Surface Layers (structural)	Cold Mix Asphalt Concrete, Hot Mix Asphalt Concrete (includes Exposed Aggregate, Imprinted/Embossed, Pigmented, Porous), Resin Modified, Synthetic Binder Concrete
	Portland Cement Concrete (PCC) Surfacings	Cellular, Portland Cement Concrete (Exposed Aggregate, Pigmented, Porous, Stamped), Roller Compacted Concrete, Whitetopping
Aggregate and Soil Surfaces	Unbound and Mechanically Stabilized Surfacings	Cellular Confinement, Fibre Reinforcement, Geotextile/Geogrid Reinforcement, Gravel (crushed or uncrushed), Sand
	Other Stabilized Surfacings (including dust palliative applications)	Chlorides, Clay Additives, Electrolyte Emulsions, Enzymatic Emulsions, Ligonosulfonates, Organic Petroleum Emulsions, Synthetic Polymer Emulsions, Tree Resin Emulsions
	Stabilized Aggregate and Soil (other than surfacing)	Fly Ash, Lime, Portland Cement
Unit Surfaces		Brick Pavers, Natural Stone Cobbles, Unit Pavers, Porous Unit Pavers
Recycling and Reclamation Alternatives	Recycling Alternatives	Cold In-place Recycling (temporary), Hot In-place Recycling, PCC Recycling and Rehabilitation (temporary), Recycled HACP
	Full Depth Reclamation (FDR)	Cementitious, Emulsified Asphalt, Foamed Asphalt, Pulverization

4.0 SURFACING SELECTION METHODOLOGY

In the conventional process of pavement selection, two or three design options that meet the structural and performance requirements are compared using a lifecycle costing process. It is recognized that the selection of lowest cost over an arbitrarily selected analysis period is limited as the sole means of pavement selection, since it does not allow the consideration of many other important and often owner-specific criteria [4]. The selection process should also resolve such controversial issues as aesthetics, safety, performance, environmental impacts, and functionality in addition to lifecycle costs. Other criteria that may need to be added are constructability, local availability of the technology and sustainability/extent of recycling. The evaluation and selection process allows any number of criteria to be considered.

A selection methodology was developed to facilitate the process of selecting an appropriate roadway surfacing for a project or a particular segment of a project. The developed selection process is transparent, methodical, defensible, and allows aesthetics and context sensitivity to be considered in the selection of roadway surfacing. The selection process is a two-stage process consisting of a screening stage and a selection stage as shown in Figure 1. Feedback from each step of the selection process is provided to the overall Project Delivery Process (PDP), and any changes suggested by the project team are incorporated back into the surface selection process.

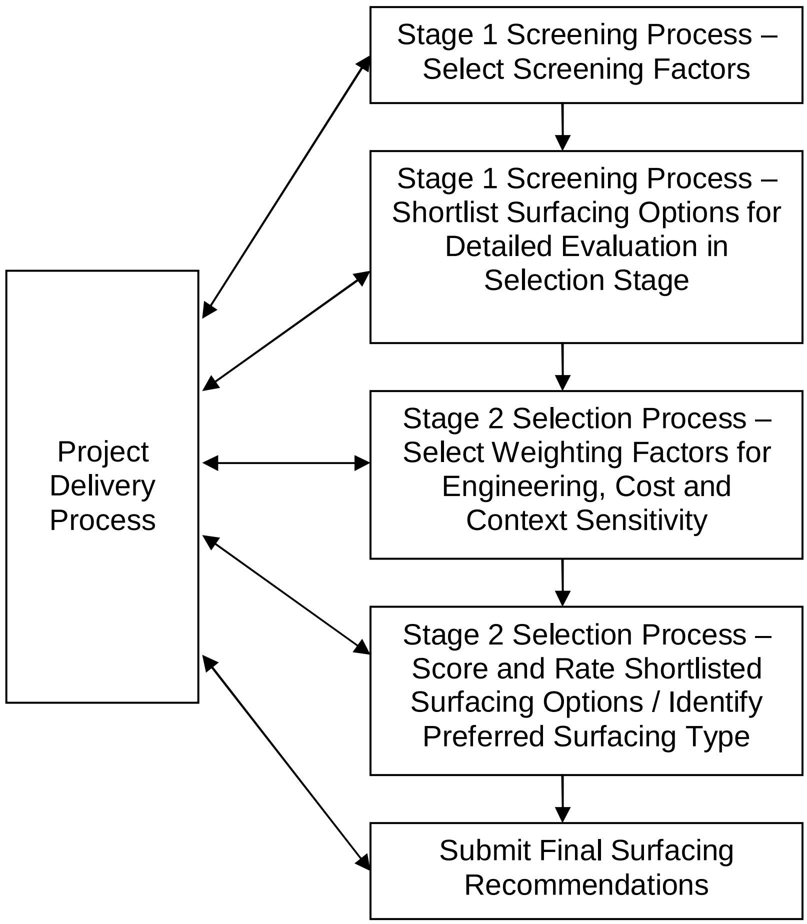

Figure 1 - Surfacing Selection Process

4.1 Screening Stage

The purpose of the screening stage is to identify a manageable number of surfacing types that are best suited for a particular project, based on a set of selected screening criteria. The number of screening criteria selected by a project team for use in the screening stage will depend on the type of roadway application, amount of project information available, and judgement.

The screening stage eliminates from further consideration all those surface types that are clearly not applicable for a particular application. After nonviable surfacings are removed from consideration, the remaining surface types are sorted in preferential order based on suitability for the selected screening criteria. These shortlisted surfacing types are then carried forward for detailed evaluation in the selection stage. Some commonly used screening criteria are described in subsequent sections.

4.1.1 Traffic Volume

Design traffic in terms of Average Annual Daily Traffic (AADT) is a basic required input to the screening process. Screening on the basis of traffic is effective for higher traffic volumes but does not reduce the list of options for low traffic volume roads. For this study, the following four traffic categories were considered based on volume:

- Very Low - <200 vehicles/day
- Low - 200 – 400 vehicles/day)
- Medium - 400 – 1000 vehicles/day
- High - >1000 vehicles/day

4.1.2 *Project Setting*

This screening criterion is related to the environmental setting in which a road or a section of a road is going to be placed, and is categorized based on:

- Urban Setting – unpaved surfacings normally not practical
- Rural Setting – rustic surfacing options favoured
- Historic Setting – surfacings with aesthetically compatible appearance to the particular historically significant landmark or place

4.1.3 Cost

Cost is an important criterion for most low volume road projects. Roadway surfacings have a wide range of unit costs, ranging from unpaved, unbound surfacings at the low end to hand placed cobblestones at the high end. A detailed cost analysis is not required in the screening stage; surfacings are generally classified by typical unit costs.

4.1.4 Unbound or Paved Surface

At the commencement of a project, it is usually possible to establish whether a particular road needs to have an all-weather paved surface. In addition to functional considerations, unpaved surfaces are often preferred in scenic rural landscapes, based on aesthetics. Park Roads Standard [5] suggests that above an AADT of 400, only paved surfaces should be used.

4.1.5 *3R or 4R Projects*

Some surfacing types, such as in-place recycling, are only practical for 3R (resurfacing, restoration, rehabilitation) projects because in-place material is required, whereas 4R projects involve complete ‘reconstruction’ of the roadway in addition to 3R. Thus, for 4R projects, some surfacing options can be eliminated in the screening stage.

4.1.6 *Climate and Percent Fines (in unbound materials)*

When unbound or stabilized soil/aggregate surfacings are acceptable for a project, climate or percent fines (in unbound material) can be used as screening criteria. These criteria are especially useful when considering stabilized surfaces because the effectiveness of many stabilizing agents is significantly affected by climate (i.e. wet or dry) and percentage of fines in the material to be stabilized.

4.1.7 *Ranking of Selection Criteria*

Surface suitability for each criterion within a group of pre-selected screening criteria is described by one of four designations: highly suitable (A), acceptable for use (B), not ideal but can be used (C), and not suitable (X). The surfacings are ranked based on their designations for the various screening criteria. Once all of the surfacings are assessed for each of the selected screening criteria, any surfacing that is not suitable (X) for any of the selected screening criteria is removed from further consideration. Table 2 shows a suggested suitability designation for Unbound and Mechanically Stabilized (UMS) Surfacing Types. A complete list is provided in the Guide [3].

Table 2 - Suggested Suitability Designations for Screening Stage

UMS Surfacing Types	**Traffic**				**Setting***				**Surfacing Requirements**			**Project Type**		**Climate****			**% Fines**		
	V. Low	Low	Med.	High	Deco.	Hist.	Urban	Rural	Low Cost	Un-bound	Paved	3R	4R	W	Dp	D	<5	5-30	>30
Cellular	B	B	C	X	X	B	X	A	B	A	X	A	A	A	A	A	A	B	X
Fibre	B	C	X	X	X	A	X	A	A	A	X	A	A	A	A	A	A	A	B
Geotextile/ Geogrid	B	C	C	X	X	A	X	A	B	A	X	A	A	A	A	A	A	A	C
Gravel	B	C	X	X	X	A	X	A	A	A	X	A	A	A	A	A	A	A	C
Sand	C	X	X	X	X	A	X	A	A	A	X	A	A	C	A	B	A	B	C

* Deco. = Decorative, Hist. = Historic; ** W = Wet, Dp = Damp, D = Dry

For each surfacing, the total suitability score is calculated by assigning numerical values to the designations for each screening criterion (A=3, B=2, C=1) and summing up the numerical values to obtain a total score for the surfacing. The surfacings can then be sorted according to their total scores. If several screening criteria are used, the top three to eight ranked surfacings usually stand apart from the rest in the screening stage, which can be further reduced if required by the project team, and the final selections carried forward for further detailed evaluation in the next stage. This stage allows the project team to avoid performing a detailed evaluation for each individual surfacing listed in the surfacing catalogue and allows the team to focus on the most suitable surfacings.

4.2 Selection Stage

In the selection stage, a more detailed selection process is applied. The selection methodology is based on a widely used procedure [6]. However, the attributes and factors included in the process have been customized to meet the intended objectives of the study. The surfacing evaluation involves Selection Attributes, Scoring Factors, and Weighting Factors and is detailed below.

4.2.1 Selection Attributes

The selection attributes are properties or characteristics of roadway surfacings that are important and should be considered in the selection process. A total of eleven selection attributes have been identified which are subdivided into three categories as follows:

- Performance and Durability Attributes
    - Durability – surfacing's probability to last over the expected life of the surfacing without premature defects
    - Life Expectancy – the period of time over which the road surface provides an acceptable level of performance with only preventative maintenance activities required
    - Maintenance Requirements – the frequency that scheduled maintenance interventions are required
    - Safety/Surface Characteristics – the safety of a surfacing with respect to skid resistance, hydroplaning potential, visibility, windshield hazards, and ability to be striped with lane demarcations
- Constructability and Cost Attributes
    - Life-Cycle Cost – the net present value of a surfacing for a specified analysis period, taking into consideration initial construction costs, user costs, expected maintenance costs, any required rehabilitation, and the time value of money
    - Availability – availability of materials, equipment, and qualified contractors in the project area
    - Construction Impacts – impacts on the surrounding community during initial road construction due to road closures leading to user delays, limited access, reduced revenue for nearby businesses; required construction staging areas, equipment laydown areas and material storage areas; increased construction traffic; and construction noise
    - Weather Limitations – temperature and precipitation limitations on when a surfacing can be constructed

- Context Sensitivity and Environmental Attributes
  - o Environmental Impacts – include short-term impacts during construction (road noise, heat generation, manufacturing/placement process, hauling requirements, etc.) and long-term impacts during service (water quality, aquatic species, plant quality, leachate generation, erosion, surface runoff, etc.)
  - o Visual Quality – the surfacing's appearance and whether or not it is aesthetically pleasing
  - o Context Compatibility – how well a surfacing fits into the cultural, historical, and/or visual context of the surrounding environment

4.2.2 Scoring Factors

Scoring factors represent how well a particular surfacing ranks for each selection attribute. Each surfacing option is given a score for each of the above attributes. Scoring factors are determined from information presented in the catalogue of surfacing types, past experience, and engineering judgment. The assigned score is between 1 and 5, with 1 indicating the worst or least desirable qualities and 5 indicating the best or most desirable qualities with regard to that particular attribute as shown in Table 3. Surfacings are scored relative to the other surfacings under consideration because it allows for greater differentiation between surfacings.

Table 3 - Scoring Factors for Surfacing Attributes

ITEM	ATTRIBUTE	SCORE OF 1 INDICATES	SCORE OF 5 INDICATES
	Performance and Durability		
1	Durability	Lower or questionable durability	Similar to high quality Hot Mix Asphalt Concrete or PCC
2	Life Expectancy	Short	Long
3	Maintenance Requirements	Frequent intervention	Minimal requirements
4	Safety, Ride/Surface Quality	Driver safety concerns or very poor frictional characteristics and/or rough ride	High frictional characteristics and/or smooth ride
	Constructability and Cost		
5	LCC	Highest LCC	Lowest LCC
6	Availability of Materials and Qualified Contractors	Materials need to be transported long distance and/or no contractors in area	Materials and contractors readily available locally
7	Impacts during construction	Construction process is very slow and/or disruptive	Fast and efficient construction process with minimal disruption
8	Weather limitations during construction	Significant restrictions	Minimal restrictions
	Context Sensitivity		
9	Environmental Impacts	Significant	Minimal
10	Visual Quality	Very conventional	Highly pleasing appearance
11	Context Compatibility	Inappropriate for surroundings	Very appropriate
12	Other		

4.2.3 Weighting Factors

The weighting factors represent the relative importance of the various issues in the decision-making process, and are assigned based on specific project details. Weighting factors can be assigned by the project engineer/designer for smaller non-controversial projects or by the entire project team including if necessary, stakeholders, for complex/high profile/controversial projects. It is expected that a few iterations and some debate will be required for the project team to achieve consensus on the weighting factors to use. However, it is these revisions and this debate that makes the surface selection process transparent.

Weighting factors are assigned in terms of percentages with the total adding to 100 percent. For most situations, no category should have a weighting factor less than 20% or greater than 50% and no individual attribute should have a weighting factor greater than 20%. The higher the assigned weighting factor, the more important the attribute is considered to be in the overall selection process for that application.

4.2.4 Rating the Surfacing Options

Once all scoring and weighting factors have been assigned, the surfacings can be rated to identify one or more preferred surfacings. The total rating for each surfacing option is calculated by summing the totals of the product of the scoring factor and the weighting factor for each attribute. The option receiving the highest rating should represent the surfacing option that best meets the overall project objectives. It should be kept in mind that the selection process is just a tool for comparing different surfacings in a rational manner and providing the project team with additional information to help in the decision-making process. If the project team is not comfortable with the surfacing selected by the selection process, it may be an indication that the weighting factors assigned do not truly reflect the objectives and goals of the project and may require additional scrutiny. However, any adjustments to weighting factors at this stage must be defensible, transparent, and not arbitrarily applied to force a desired solution.

5.0 APPLICATION EXAMPLE OF SELECTION PROCESS

To illustrate the capability of the developed selection process, an example project representing a local rural road is presented. The example goes through the selection process step-by-step and provides some commentary on the reasoning that the project team used to make certain choices or decisions.

5.1 Project Description

Project: A “Rural Local Road” in Northeast Ontario

Traffic (estimate): Current AADT of 200 vehicles (with 5% RVs/buses/trucks). Twenty year design AADT is 300. Peak use occurs from June to September with traffic levels double the AADT. Summer weekend traffic levels are 3.5 times the AADT.

History: Last major construction work completed in 1960s. The roadway surfacing of the segment being considered is currently gravel/dirt. Adjacent sections of the roadway have gravel/dirt, chip seal, or asphalt concrete surfacings. The road has been identified as a scenic route.

Context/Setting: The 5-km roadway section provides access to a Provincial Park and passes through wooded areas with occasional viewscapes of small lakes. The primary use of the roadway is recreational (90% of traffic) with secondary use for short, local trips and local access. The road is functionally classified as a rural local road. The roadway section is in need of reconstruction to improve alignments, grades, and widths to provincial guidelines and to enhance operational safety. The existing roadway currently has inadequate drainage features and structural deficiencies. The reconstructed road section is expected to generally follow the existing alignment in most areas.

The identified objectives of the project are:

- Provide a roadway width and surface capable of accommodating the 20-year design traffic
- Improve safety by providing consistent roadway geometry and reasonable protection from unsafe conditions
- Accommodate and control access to Provincial Park facilities located along the road
- Reduce the anticipated maintenance costs to the counties and town maintaining the road
- Repair roadway drainage problems
- Repair existing unvegetated slopes
- Avoid, minimize, or mitigate adverse impacts to the environment by considering key issues identified through the public consultation and agency involvement process
- Maintain the rural and scenic character of the road

The road provides primary access to a Provincial Park, surrounding forest and lake amenities and a privately owned resort. Tourism and recreation are significant components of the local economy.

The area is used for sightseeing, hiking, hunting, fishing, camping, wildlife viewing, bicycling, cross country skiing, and other recreational activities. The road is a popular destination for viewing fall foliage and consists of alpine and montane forests with meadows and wetlands. The road is visible from other recreational areas, thus making the roadway part of the rural landscape.

It passes through rock slopes and areas rich in wildlife and runs along a creek. During high runoff years, the creek can overflow its banks and inundate portions of the roadway. Surface water quality is generally very high.

The existing gravel road surface leads to significant amounts of dust generated from traffic and spreading and erosion of gravel material into adjacent environmentally sensitive areas. The roadway is not snowploughed year-round and will be closed for portions of the winter. Local maintenance agencies do not have the funds for frequent dust suppressant application or for regrading the road surface.

Stakeholders: include numerous environmental preservation groups, the local Chamber of Commerce, Ministry of Natural Resources, tourist industry organizations, recreational users, and the local travelling public that uses the roadway as a daily commuting route.

Design Guidelines: The roadway section should be designed for a 20-year design life. Design speeds will be 60 km/hr. The current vertical alignment has maximum grades of 3%.

5.2 Initial Screening Criteria

Traffic: Design AADT=300, so traffic level is classified as Low, although summer traffic levels are Medium. Low traffic level is used, keeping in mind that unbound surfaces may have higher maintenance requirements due to summer traffic levels.

Decorative Setting: No information was provided indicating that a decorative setting is required; therefore, this screening criterion is not used.

Historic Setting: The setting does not have substantial historical significance, so this screening criterion is not used.

Urban or Rural Setting: Since the setting is rural and significance is placed on the natural surroundings, the rural criterion is to be used.

Cost: Based on available funding, apply low cost criterion.

Unbound or Paved: Do not apply this criterion; allow for either bound or unbound surfacing.

3R or 4R: It is assumed that this is a 4R project.

Climate: The climate is damp to dry with significant frost depth.

% Fines in Unbound Material: Assume that unbound materials contain 5% to 30% fines.

Applying the 6 initial screening criteria in order, only ten surfacings can be eliminated from the list of products shown earlier in Table 1, leaving potentially 37 of the remaining products for the selection stage. Table 4 shows the number of surfacings eliminated based on the initial screening criteria.

Table 4 - Initial Screening Criteria for Study Example

Screening Criteria	Low Traffic	Rural	Low Cost	R4	Damp to Dry	5-30% Fines
No. of Surfacings Eliminated	1	3	6	3	0	0

The eliminated surfacing types based on each of the above listed criteria are:

- Low Traffic: Sand
- Rural: Brick Pavers, Natural Stone Cobbles, Unit Pavers
- Low Cost: Brick Pavers, Natural Stone Cobbles, Unit Pavers, Imprinted/Embossed HACP, Synthetic Binder Concrete, and Porous Unit Pavers
- R4: Scrub Seal, Whitetopping, Hot In-Place Recycling

5.3 Screening Stage Ranking

In order to rank the remaining 37 surfacings, numerical values are assigned to the scores for each category (A=3, B=2, C=1) and the values for all categories are summed for each surfacing to obtain a total numerical score for each surfacing. Bound surfacings are given a score of 3 for the "Climate" and "% Fines in Unbound Material" categories. The surfacings are then ranked according to the numerical score. Four surfacings had a score of 17 or above and were selected for additional evaluation. Twelve surfacings had a score of 16. To select more surfacings for detailed evaluation without choosing all 12 surface ratings, only the products with a score of 16 and with an "A" score for the Rural Setting screening criteria were considered, due to its importance to the project's context setting objectives. This additional consideration added 2 more surfacings, synthetic polymer emulsions and tree resin emulsions, to the list for detailed evaluation. Table 5 lists the 6 surfacings carried forward to the selection stage for further analysis.

Table 5 - Screening Stage Ranking

Option No.	Product	Score
1	Chip Seal	18
2	Multiple Surface Treatments	18
3	Cape Seal	17
4	Otta Seal	17
5	Synthetic Polymer Emulsions	16
6	Tree Resin Emulsions	16

5.4 Selection Stage

The weighting factors have been assigned to each category and attribute as follows:

Performance and Durability: Safety and durability have been identified as very important parameters. The Weighting Factor assigned is 38% of which durability, life expectancy, maintenance requirements and safety/surface characteristics are assigned 9%, 9%, 7% and 13%, respectively.

Constructability and Cost: These factors are of secondary importance and assigned a weighting factor of 24%, consisting of Life Cycle Cost (10%), Availability (3%), Construction Impacts (8%) and Weather Limitations (3%).

Context Sensitivity: Since the roadway is identified as a scenic route with visual and environmental value, context sensitivity and environmental impacts are very important, and as such, 38% weighting factor is assigned to this attribute. This percentage consists of 14% for environmental impacts, 14% for visual quality and 10% for context compatibility.

The six surfacing options selected during the initial screening stage are rated and compared for the eleven (11) attributes. The scoring factors have been applied by comparing the six options for each attribute as shown in Table 6.

Table 6 - Scoring Factors for Example Application

Option	**Scoring Factors**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Chip Seal	3	4	2	4	3	3	4	3	4	3	3
Multiple Surface Treatments	4	4	3	4	3	3	4	3	4	3	3
Cape Seal	4	4	3	4	3	2	4	3	4	1	1
Otta Seal	4	4	3	3	3	3	4	3	4	2	2
Synthetic Polymer Emulsions	2	4	2	3	2	3	3	3	4	5	5
Tree Resin Emulsions	2	3	2	2	1	3	3	3	4	5	5
Note: Initial cost used instead of LCC for convenience since LCC information was not available for all alternatives.											

Table 7 shows the total ratings obtained for each surfacing by applying the weighting factors to these scores. The table indicates Multiple Surface Treatments to be the preferred option with a rating of 3.53. The analysis worksheet for this product is shown in Figure 2. Synthetic Polymer Emulsion is a close-second with a rating of 3.45.

Table 7 - Selection Stage Ranking

Option No.	**Product**	**Total Rating**	**Rank**
1	Chip Seal	3.37	3
2	Multiple Surface Treatments	3.53	1
3	Cape Seal	3.02	6
4	Otta Seal	3.16	5
5	Synthetic Polymer Emulsions	3.45	2
6	Tree Resin Emulsions	3.22	4

Surfacing Selection Analysis Worksheet

Surfacing Type: Multiple Surface Treatments

WEIGHTING FACTOR				SCORING FACTOR		WEIGHTING FACTOR		SCORE
PERFORMANCE AND DURABLITY ATTRIBUTES			38%					
9	%	Durability		4	x	0.09	=	0.36
9	%	Life Expectancy		4	x	0.09	=	0.36
7	%	Maintenance Requirements		3	x	0.07	=	0.21
13	%	Safety/Surface Characteristics		4	x	0.13	=	0.52
CONSTRUCTABILITY AND COST ATTRIBUTES			24%					
10	%	Life-Cycle Cost		3	x	0.10	=	0.30
3	%	Availability		3	x	0.03	=	0.09
8	%	Construction Impacts		4	x	0.08	=	0.32
3	%	Weather Limitations		3	x	0.03	=	0.09
CONTEXT SENSITIVITY ATTRIBUTES			38%					
14	%	Environmental Impacts		4	x	0.14	=	0.56
14	%	Visual Quality		3	x	0.14	=	0.42
10	%	Context Compatability		3	x	0.10	=	0.30
100	%					**TOTAL RATING**		**3.53**

WEIGHTING FACTOR: PERCENT OF IMPACT ON SURFACING SELECTION (TOTAL = 100%)
SCORING FACTOR: 1 = POOR OR NOT DESIRABLE; 5 = EXCELLENT OR HIGHLY DESIRABLE

FOR MOST SITUATIONS, NO CATEGORY SHOULD HAVE A WEIGHTING FACTOR LESS THAN 20% OR GREATER THAN 50% AND NO INDIVIDUAL ATTRIBUTE SHOULD HAVE A WEIGHTING FACTOR GREATER THAN 20%.

Figure 2 - Multiple Surface Treatment Worksheet

6.0 CONCLUSIONS

This paper detailed a step-by-step procedure to facilitate the pavement surface selection for low to medium volume roads which are more context sensitive as compared to high volume freeways and highways. It considers the engineering design factors, such as structural capacity, performance, durability, and safety as well as non-conventional factors, including aesthetics, context compatibility, and environmental impacts. A specific application of the developed process has been presented using information from an actual rural low volume road. The developed selection process is straightforward, logical, transparent, defensible and understandable by the general public. Additional benefit has been achieved by provide a shopping list of alternative surfacing products and pertinent information for each product to consider in the surface selection process.

The selection process itself is intended to facilitate discussion and understanding of critical project issues and their relative importance to the overall project. Discussion and debate among team members are beneficial to obtain weighting factors that adequately balance competing project needs and that are not improperly skewed towards one particular outcome.

Although, the surface selection procedure was developed as part of the Context Sensitive Roadway Surfacing Selection Guide prepared for the FLH, the developed selection process can easily be applied by transportation agencies either at the federal, provincial or municipal levels, which deal with low to medium volume roads within their jurisdiction. It will permit a balance between functionality, strength, and cost while ensuring that the completed roadway enhances or is at least compatible with the surrounding landscape.

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