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Sustainability: Carrier of Innovations in the Development of Pavement Materials

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ABSTRACT

The road building industry is constantly exploring technological improvements that will enhance the performance of paving materials and pavement systems. In more recent years, the focus on sustainability has generated extensive research and developments worldwide. The road building industry has made considerable strides in regard to sustainability in developing: paving materials that are better for the environment, pavements systems that are safer and quieter, and products and processes that have less health and safety risks for workers and public.

The priority given to sustainability in research and development is relatively recent. The results are revealing remarkable new possibilities related to paving materials and pavement systems. Environmentally friendly paving materials include increase content of recycled materials in hot mix asphalt, increase efficiencies in in-place pavement recycling, reduce manufacturing temperatures, increase utilization of local materials, development of bio-products and green chemistry. New generations of safer and quieter pavement are being developed. Alternative products and processes are developed to reduce risks including the usage of none nuclear compaction gauges, solvent free products and laboratory processes, hydrocarbon vapor reduction products and others.

This paper presents various Canadian and worldwide initiatives to develop sustainable paving materials. An overview of the various initiatives is provided including, a brief listing/review of environmentally friendly paving materials, a review of the recently developed safer and quieter pavement systems and a review of green labeling systems for roads.

1.0 Introduction

Innovations in any industrial sector relentlessly strive to anticipate the needs of tomorrow. The road building industry is no exception and the research and development efforts worldwide constantly endeavor to meet the current and future needs of road administrations, road users and those building them. Technological improvements that will enhance the performance of paving materials, increase construction and economic efficiencies of pavement and conserve resources are continually explored. In more recent years, the focus on sustainable development has generated considerable research work worldwide. The road building industry has made significant strides in regard to sustainability in developing: paving materials that are better for the environment, pavements systems that are safer and quieter, and products and processes that have less health and safety risks for workers and public.

The road industry is concentrating its efforts in developing new paving materials and pavement solutions that provide sustainability. It is a comprehensive approach that involves the entire production, construction, rehabilitation and maintenance chain from the extraction of raw materials to the end of the pavement's service life. It involves the preservation of the environment in reducing the consumption of natural resources, reducing energy consumption, reducing greenhouse gas (GHG) emissions, increasing the recycling of industrial and worksite wastes, developing environmentally-friendly products and techniques. This comprehensive approach to sustainability also involves the development of pavement systems that are safer for the traveling public in providing better friction and quieter to reduce the annoyance related to traffic rolling noise. The concept of sustainability also includes the development and the promotion of products and processes that reduce risks for the workers and the public in general that include the usage of none nuclear compaction gauges, solvent free products and laboratory processes, hydrocarbon vapor reduction products and others.

This paper presents current Canadian and worldwide initiatives to develop innovative paving materials and pavement systems that provide better sustainability. An overview of the preservation of the environment initiatives is provided including, a brief listing/review of environmentally friendly paving materials, benchmarking initiatives to quantify environmental benefits. The recently developed safer and quieter pavement systems are also presented and commented. Finally, a review of green labeling systems for roads is discussed.

2.0 Energy Consumption and Greenhouse Gas Emissions

The United Nations conference on the environment and sustainable development held in 1992 marked the beginning of universal awareness of the risks of damage facing the planet. The destruction of natural resources and climate change are the main causes of damage and disruption of ecosystems. Industry, agriculture and transportation are blamed for being the main contributors. This awareness was formalized by the Kyoto agreements in 1997, which focuses particularly a commitment to control and bring down greenhouse gas emissions.

In their framework of policies governments around the world have set a priority on two actions: limiting the impact of contributors on climate change and optimizing the management of natural resources. All sectors of activities are affected and road building industry is aware of the strategic and universal issues associated with sustainability. The road building industry’s approach in addressing the energy consumption and the greenhouse gases emissions is two-folded: increasing efficiency and select environmentally-friendly pavement structures.

2.1 Increasing Efficiencies

The road building industry has made considerable efforts to identify potential sources of energy savings through reduced consumption over the last several years. Work has taken place to find relevant indicators in the industry's diversified businesses. For identical pricing, two projects may have very different energy content, depending on the share of work that is contracted, the nature of the work itself, the distance from resources and materials, etc. This process is becoming more refined with the use of tools such as life cycle analysis [1, 2, 3].

Numerous tangible actions are put in place in the industry with a common objective of favoring energy efficiencies. Management systems to tailor-make energy-saving program are being developed. The acquisition of construction equipment with selection criteria favoring energy efficiency is becoming well spread. Monitoring systems to establish benchmarks of energy-consumption by type of equipment, brand and operator for the purpose of determining choice of investment, maintenance strategies and pinpoint training requirements is an approach gaining momentum. As an example, calm driving techniques can generate energy savings in the order of 10% to 15% [4].

2.2 Paving Materials and Pavement Structures

In the past decade, benchmarking activities have been initiated worldwide to determine the energy consumption and the greenhouse gas emissions associated with the construction and maintenance of roads [1, 2, 3]. The principal paving materials have been analyzed (hot asphalt mixes, bitumen emulsion technologies, concrete cement, in place or plant recycling, etc.) to determine relevant indicators. It has been determined that a cradle-to-grave approach provides the needed indicators to compare different paving materials. This type of approach starts at the extraction of raw materials and it stop at the end of the pavement's service life, including the phases of materials manufacture, laying for the construction of a new pavement, and maintenance works during its anticipated service life. This analysis is related to the paving materials on a tonne of material basis.

The analysis is then applied to different types of pavement structure over the service life. The resulting analysis provides guidelines to the industry to select both, paving materials and pavement structure efficient in energy and GHG reduction. Among the techniques that rate well in regards to efficiency in energy and GHG reduction includes most recycling techniques, emulsion related technologies and in-place processes. This type of analysis has opened the possibility of developing pavement applied energy/GHG analysis software. The "EcologicieL" software system developed by Colas S.A. in Europe is an example, which will be discussed in the next section [5]. Furthermore and importantly, this type of analysis has greatly and continues to influence research for tomorrow's paving materials and pavement structures.

2.2.1 Software to Assess Energy Consumption and Greenhouse Gas Emission: "EcologicieL" [5]

The "Ecologiciel" software was the first of its kind. Applying the principles of life-cycle analysis, this tool calculates energy content and the volume of greenhouse gases produced for most of the road constructions, rehabilitation and maintenance techniques available to road agencies. The life-cycle analysis is used to highlight the main environmental characteristics of a product including every stage of its life-cycle from the extraction of raw materials to the construction of the roadway and the end of its service life.

This software is particularly useful to compare alternative solutions, making it possible to determined optimum pavement solutions based on their "environmental performance" in regards to energy and GHG. There are now many examples where this tool was used to quantify the environmental benefits of one

technique versus another. The tool has evolved from being rather generic to being site specific with the particulars of production plants. Furthermore, it is constantly being updated and adapted for specific regional use outside of France where it was initially developed. There are now other similar software being developed with the similar approach to quantify the environmental benefits of the various road construction, rehabilitation and maintenance techniques [6].

2.2.2 Bituminous Mixes Produced at Reduced Temperatures

The road building industry is constantly exploring technological improvements that will enhance material's performance, increase construction efficiency, conserve resources, and advance environmental stewardship. Current and impending regulations on emissions and energy conservation are making attractive the reduction in asphalt mix production temperature. Warm Mix Asphalt (WMA) and Half-Warm Mix Asphalt (HWMA) are a means to this end and are discussed hereafter.

2.2.2.1 Bituminous Mixes Produced at 125 to 135°C [7]

This technique is commonly known as Warm Mix Asphalt (WMA) and these mixes are manufactured at temperatures of roughly 25°C to 35° C less than conventional hot mixes. The immediate benefit to producing and placing asphalt mixes at lower temperatures is the reduction in energy consumption in the range of 10% and 15%. With the decreased production temperature come the additional benefits of reduced greenhouse gas emissions, fumes, and odors generated at the plant and the paving site. The fumes reduction has been quantified to approximately 50% compared to conventional Hot Mix Asphalt (HMA).

There is a strong focus on WMA worldwide and several systems have been developed to decrease the bituminous mixture temperatures without compromising the industrial process of producing asphalt pavements. The objectives of these systems are to obtain full aggregate coating at lower mixing temperature, obtain density and still achieve equivalent or better performance than conventional HMA at ambient temperatures. Full coating is obtained by either reducing the viscosity of the binder or by using additives that promote complete aggregate wetting at a lower mixing temperature. Warm mix asphalt systems may be divided into one or a combination of the following categories: water related techniques (foaming) and additives (organic or chemical). As WMA unveils new possibilities such as increased content of recycled asphalt; the environmental gains associated with this technique are expected to increase.

2.2.2.2 Bituminous Mixes Produced at 70 to 99°C [8, 9]

This technique is commonly known as Half-Warm Mix Asphalt (HWMA) and these mixes are manufactured at temperatures less than 100°C i.e. below water vaporization. The reduction in energy consumption is in the range of 30% to 50% compare to conventional HMA, which is significant. This is mainly due to the considerable amount of energy needed to vaporize water, which is not required as the mixture remains below 100°C. The environmental benefits associated with maintaining the temperature below 100°C are considerable in regards to bitumen fumes, volatile organic compounds and GHG emissions.

All HWMA technologies are water-based: the binder is either emulsified or foamed in the mixing plant. The work related to HWMA remains limited, probably due to its drastic departure from conventional HMA approach. However, as HWMA development work reveals technical benefits it is expected that this type of technique will gain popularity and acceptance.

2.2.3 Bio-Products

Bio-products are plant-based, developed using green chemistry principles. These bio-products are designed to replace petrochemical-based products used in the road building industry, to eliminate the use of hazardous substances and also to reduce energy consumption.

2.2.3.1 Binders and Fluxing Agents

Colas S.A. has developed a bio-flux agent, "Vegeflux®" [10] that has the advantage of avoiding the evaporation of volatile organic compounds (VOC), while improving bitumen properties. The reaction is quite different from typical petroleum-based solvents/fluxing agents. The reaction is said to be "siccative" which may be described as a combination between the oxygen of the air, the fluxing agent and the bitumen, resulting in improved binder cohesion. Less bio-fluxing agent is used compared to usual petroleum-based fluxing agents for similar applications. Bio-fluxing agents may also be used instead of conventional fluxing agent with rapid setting emulsions for the beginning or end of the season chip sealing applications or with slow setting emulsions for emulsion-based cold mix applications. Bio-fluxing agent allows application of hot applied bitumen at a temperature 25°C lower compared to conventional hot applied bitumen. The flash point is also higher allowing for improved safety in product handling.

Colas S.A. has also developed a bio-binder**,** "Vegecol®" [4] as a substitute for bitumen. Manufactured from vegetable oils and resins, Vegecol® is translucent and can be colored. The main use of this bio-binder is for aesthetics purpose in city centers, pedestrian alleys, etc. Mixes manufactured with this binder have equivalent mechanical performance as mixes with bitumen. In 2007, more than 450 Vegecol projects were completed and nearly 2,700 tonnes of Vegecol® binder were applied worldwide including Canada with the Cirque du Soleil project in Montreal in 2006. The development of this product came from a competition entitled "Road for the Future" organized in Brittany, France in 2003.

2.2.3.2 Pavement Marking [4]

The "Vegemark®" product is another bio-product developed by Colas S.A. using green chemistry principles. It is a road-marking product designed to improve roadway safety. It is manufactured from oleaginous raw materials and allows traffic to be restored almost immediately after application. It uses renewable products derived from the oil plant industry.

The "Ostrea®" product is a hot-application road marking bio-product developed by Prosign, a subsidiary of Colas S.A., with support from the French Environment and Energy Management Agency. It uses recycled oyster shells instead of the traditional of limestone component, and optimizes energy consumption with an improved type of boiler.

2.2.4 Reclamation and Recycling of Waste from the Road and Construction Industries

As a major producer and user of construction materials, the road building industry endeavors to reclaim and recycle waste and used materials from road and construction industries to build, rehabilitate and maintain roadways. Some techniques have gained full acceptance by the road agencies, while other remain relatively specialize and their use limited. The main techniques used in Canada and North America are discussed hereafter.

2.2.4.1 Hot Mix Asphalt Plant Recycling [11, 12]

Large scale recycling of existing bituminous pavement started in the mid seventies. The petroleum crisis in the early seventies and the development of milling equipment for the road industry created a favourable environment for emerging large scale recycling technologies. Since then, hundreds of millions of tonnes of Hot Mix Asphalt incorporating reclaimed asphalt pavement, now commonly known as RAP have been produced in North America and elsewhere. Good field performance of HMA using up to 50 % RAP has been reported. Hot Mix Asphalt plant recycling is probably the most common recycling practice in the road construction industry. In actual fact, in many areas, Hot Mix Asphalt plant recycling is a standard operating procedure.

It has been reported that asphalt pavement is the most recycled material in North America. The hot mix asphalt industry recycles approximately twice the tonnage of asphalt pavement as the amount of recycled paper, glass, plastic and aluminum combined. Recycling asphalt pavement makes both environmental and economic sense. The use of recycled asphalt pavement has grown widely, reducing the use of virgin materials and helping to preserve landfill space. According to the EcologicieL software [5], the energy consumption and the greenhouse gas emission associated with the production of HMA is reduced by approximately 2.5 % for every slice of 5 % RAP added to the mixture.

2.2.4.2 In-place Recycling and Reclaiming [13]

The processes of in-place cold recycling/reclaiming of bituminous roadway are well established in Canada. Many millions of square metres of pavement have been rehabilitated using these processes and the industry capacity to recycle and reclaim bituminous pavement is among the highest in the world. Many Canadian road agencies use in-place recycling/reclaiming as a standard pavement rehabilitation method. The experience of using different versions of in-place cold recycling/reclaiming with respect to equipment and recycling binders is extensive. The driving engine of in-place cold recycling/reclaiming is associated with the concept that existing pavements are sources of primary roadway materials. The existing pavement is reclaimed and transformed into a bituminous aggregate, treated with a recycling system, placed and compacted in-place.

The performance of in-place cold recycling/reclaiming observed over the last two decades has demonstrated that the benefits associated with recycling/reclaiming are technical, economical, and environmental. One of the main technical benefits of in-place recycling/reclaiming is related to the ability of the material to mitigate reflective cracking, which implicitly provides added life to the rehabilitated pavement. In-place recycling/reclaiming also offers significant benefits related to the environment. In-place recycling/reclaiming technologies reuse all of the existing materials, allowing the preservation of aggregates and bitumen. The in-place, the recycling/reclaiming and the cold nature of the processes are all contributing to the reduction of energy consumption and consequently the reduction of green gas emission. It has been reported that the energy needed to produce in-place cold recycled material is in the magnitude of 25 to 35 % depending on the recycling/reclaiming process of the energy required to produce conventional virgin hot bituminous materials. The impact on the reduction of GHG is also of the same magnitude [1]. Consequently, in-place recycling technologies are continuing to gain acceptance among Canadian road agencies.

2.2.4.3 Cold Mix Asphalt Plant Recycling

The cold mix asphalt plant recycling is essentially the same as the in-place cold recycling/reclaiming with the exception that the treatment of the reclaimed material is carried out at a central location. The RAP may come from a recently milled roadway or from and old stockpile. The recycled material may be replaced on the original pavement. It is a process that may be used where the in-place processes cannot be

used efficiently such as small jobs or confined urban setting with obstructions like manholes, valve boxes, variable geometry etc.

The performance and benefits associated with this process are closely related to those of the in-place processes with regards to technical, economical and environmental aspects. Even with transportation, the energy savings and the reduction in GHG remains considerable when compared to hot virgin bituminous materials. Energy savings and reduction in GHG emission in the magnitude of 40 to 50% have been reported.

2.2.4.4 Concrete Demolition Rubble

The recycling of concrete demolition rubble in various forms represents interesting possibilities. It consists of high-quality, well-graded aggregates, bonded by a hardened cementitious paste. Concrete demolition rubble is generated through the demolition of cement concrete elements of roads, runways, and structures during road reconstruction, utility excavations, or demolition operations.

The number of landfill sites is decreasing around major cities and disposal volume and maximum sizes of waste is being restricted; consequently, the cost of dumping concrete demolition rubble has increased substantially. Furthermore, the growing concern over the environmental impact of aggregate extraction has limited the number of new aggregate extraction sites, while the demand in aggregate continues to rise. These circumstances have greatly encouraged the development of techniques to process concrete demolition rubble and to reuse processed rubble.

Concrete rubble processes facilities are now present in medium to large metropolitan areas even when virgin aggregates are available locally. In many areas, the concrete rubble source is from existing concrete curb, sidewalk and driveway sections that may or may not be reinforced. Concrete rubble is processed in a manner resembling rock extracted from bedrock in a quarry, with the exception of the recovery of the reinforcing steel. Present crushing systems, with magnetic separators, are capable of removing most reinforcing steel without much difficulty. The steel is extracted and sold as scrap metal for recycling.

Processed concrete rubble may be used as an aggregate for cement-treated or lean concrete bases, a concrete aggregate, an aggregate for flowable fill, or an asphalt concrete aggregate. It can also be used as bulk fill material on land or water, as shore line protection material, as gabion basket fill, or as granular aggregate for base and trench backfill.

The environmental benefits associated with this process are significant especially in areas where the availability of virgin aggregate is scarce and transportation is considerable.

2.2.4.5 Rubblizing

Rubblization is a processing techniques specifically developed process deteriorated concrete pavement in-place, rather than off site. The processing of the deteriorated concrete pavement consist of fracturing the concrete into small interlocking elements ranging from 50 to 150 mm to ensure that joints, cracks, and other defects in the concrete do not reflect through the overlay and impair performance.

Similar to the other in-place processing techniques, the energy required to rubblize concrete pavement is evaluated at approximately 1.2 litre of diesel fuel per tonne of material [2]. The environmental efficiency associated with this technique relates to the in-place, the recycling and the cold nature of the process. Furthermore, no binder or rejuvenator is required. The rubblized concrete act as a new granular base that otherwise would have to be produce off site, transported and placed to replace the rubblized material.

2.3.5 Reuse of Scrap and By-Products from Other Industries

The road building industry requires diversified materials to construct, rehabilitate and maintain roadways. Techniques have been developed to reuse scrap and by-products from other industries into pavement materials. Selective techniques have gained some acceptance by road agencies, but for the most part the usage of scrap and by-products in pavement materials still remains limited. The main techniques used in North America and in Europe are as follows:

- pavement products that contains crumb rubber from scrap tires,
- surfacing products that contains mirror-glass waste,
- noise barrier that contains waste wood,
- base course techniques developed using shredded tires, and
- fibre-modified asphalt mixes using manufacturer's scrap shingles.
- fines from thermal power stations often used to manufacture asphalt mix,
- slag from the steel industry, etc

The main techniques used in Canada and North America are discussed hereafter.

2.3.5.1 Crumb Rubber from Scrap Tires [14]

Nearly 300 millions scrap tires are generated in North America every year. According to the US Rubber Asphalt Association nowadays 80% of the scrap tires are reused or recycled in someway and the road building industry is a significant contributor to this effort in many areas.

The usage of crumb rubber from used tires in pavement products started in the State of Arizona in the 1960s and several pavement techniques have been developed since. Crumb rubber is used in crack and joint sealants; binders for chip seals, interlayer and membrane systems and hot-mix asphalts including dense-, gap-, and open-graded gradations. Crumb rubber modifies asphalt binder by several techniques including different versions of the wet process and the dry process depending if the crumb rubber is blended with the asphalt binder first or with the aggregate first. Crumb rubber modified asphalt binders may also contain additional additives or modifiers such as rubber polymers, diluents, aromatic oils to enhance performance properties.

The environmental benefit of recycling scrap tires in pavement products is significant. The consumption of crumb rubber in hot-mix asphalt is approximately two tires per tonne, while in chip seals, the consumption is approximately 300 tires per kilometer of roadway. In addition to the benefit of recycling, hot-mix asphalt containing crumb rubber is often used for one of its distinctive attributes, which also relates to the environment: the reduction of rolling noise.

2.3.5.2 Shingles [15,16]

Approximately 1.0 million tonnes of manufacturer's scrap shingles are generated by the asphalt shingle industry in North America. Approximately 20 % is reused in paving materials and therefore not diverted to landfill sites. Asphalt shingles are composed of asphalt binder, cellulose or glass fiber, small chippings, and mineral filler. All these components are used in paving materials. The scrap generated by the shingle manufacturer consists of tab punch-outs or fingers, off colors, damaged shingles, ends and beginnings of rolls, etc. The usage of scrap shingles in paving materials as most form of recycling in the road industry is contributing to the reduction of the negative environmental impact associated with the extraction, transportation, and processing of virgin materials. Several state agencies including Minnesota, New Jersey, North Carolina and others allow the usage of scrap shingles in their Hot Mix Asphalt specification.

2.4 Road Noise and Safety

The road building industry is strongly committed to road safety and reduction of rolling noise by developing innovative products in that regard. Several products have been developed to reduce the braking distances by as much as 40% or rolling noise by as much as 9 dB(A). Some of these products are discussed hereafter.

2.4.1 High Friction Surfacing Systems

Colgrip® is anti-skid surfacing system aimed to reduce car crashes in accident prone areas. It is promoted as a road safety device rather than a pavement product. Stopping distances in wet surface conditions may be reduced as much as 30 % compared to conventional surfacing systems [17]. It is applied as a chip seal and it uses asphalt-epoxy system in combination with an aggregate with a Polishing Stone Value (PSV) greater than 60 coming from the aluminum industry: calcined bauxite. It has been determined that the return on investment may be as short as one year when accounting for the reduction in indirect insurance cost of accidents. It has been used for many years in the UK, where the rate of accident is one of the lowest in the world. Colas S.A. has also developed another high friction surfacing system called, "Colmat H A®" (High Adherence) [18]. It is a micro-surfacing system manufactured using artificial small chippings with a very high PSV and crushed sand. Similar to the Colgrip® system this high adherence micro-surfacing system is used to provide road safety.

2.4.2 Low Noise Surfacing Systems

A wide range of low noise surfacing systems has been developed by the road building industry. Systems based on crumb rubber from recycled tires [14], small maximum nominal size aggregate mixture and porous asphalt have been developed. Colas S.A. has developed a product called "Colsoft®" using crumb rubber as an aggregate i.e. dry process [19]. The latest generation of low noise surfacing system developed by Colas S.A. is based on a 4.0 mm maximum nominal size aggregate [20]. The measured decrease in rolling noise compared to an adjacent standard HMA using the ISO 11819-1 [21] method was 9.2 dB(A), the product is called "Nanosoft®".

3.0 Green Labeling Initiatives

There are now several green labeling initiatives in North America to promote sustainability in roadway projects. The common goal of these initiatives is to conserve natural resources, to preserve the environment and to enhance quality of lives. The green labeling aspect per say relates to the rating of roadway projects in accordance to extent they incorporate sustainable choices. The green labeling of project provides a framework that encourages innovation in regards to sustainability in roadway design, pavement materials and field work practices.

The New York State GreenLITES labeling systems [22] describes "sustainability" as an approach to roadway projects that:

- encourage public involvement in the roadway planning process,
- protect and enhance the environment,
- conserve energy and natural resources,
- preserve or enhance the historic, scenic, and aesthetic project setting characteristics,
- integrate smart growth and other sound land-use practices, and
- encourage new and innovative approaches to sustainable design.

The concept of "green" labeling is not new. The building industry has been using this approach with the Leadership in Energy and Environmental Design (LEED) rating system since the mid-1990s [23]. The

LEED certification system has had a significant impact on improving the overall sustainability of buildings. The green labeling initiatives for roadways are in many aspects a mirror of the LEED systems as they are developed as rating systems based on credits obtained for sustainable choices in regards to various categories elements that describe roadway projects. As with the LEED program for buildings, roadway green labeling systems utilize a rating system to score project and to certify them in increasingly stringent tiers. Similar to LEED, the green labeling concepts for roadways are developed to better integrate principles by:

- recognizing and increasing the awareness of the sustainable methods and practices already incorporate in roadway project designs, and
- expanding the use of other innovative alternatives which have the potential to improve sustainability.

The current initiatives in North America are as follows:

- The University of Washington prototype "Green Roads" program for the Washington State Department of Transportation [24],
- The New York State Department of Transportation "GreenLITES (Leadership In Transportation and Environmental Sustainability)",
- The Transportation Association of Canada "Green Guide for Roads" task group [25]

There are other important initiatives related to the environment that may not be qualified as labeling system, but nevertheless encourages innovation with regards to the environment: the US "Green Highways Partnership" [26] and the British Columbia greenhouse gas emission reduction initiative. The Green Highways Partnership is a voluntary US based forum of exchange that support collaborative efforts aimed at highlighting the many good environmental practices already in-place and encouraging additional innovations, while addressing the functional requirements of roadway infrastructure. The British Columbia program specifically aimed at reducing greenhouse gas emission in the road building area.

4.0 Summary and Conclusions

As demonstrated in this paper the current Canadian and worldwide initiatives to develop innovative paving materials and pavement systems that provide better sustainability is considerable. Many of the products discussed in this paper were developed in the last five years as a direct response to the desire of promoting sustainability in roadway project in regards to conservation of the resources and preservation of the environment. Consequently, technical developments continue to be aimed at the reduction of energy consumption and greenhouse gas emission, the usage of renewable resources as well as recycling. Furthermore, safer and quieter pavement systems are being developed with the same objective of sustainability and the associated quality of life.

The concepts associated with sustainability are becoming engineering factors in the decision making process of roadway projects. The green labeling systems are being developed to provide the benchmarking system necessary to recognize best practices but also to encourage innovations with regards to sustainability. These systems are also providing the framework necessary to sort out the engineering factors that influences sustainability while still addressing the functionality if roadway infrastructures.

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