

A REVIEW OF COLD MIX PROCESSES IN CANADA

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Abstract

The concept of cold mix processes has been around for many decades and many different forms have come and gone as the cold technology evolved. In recent years, cold mix technology has made significant improvements in quality and performance. These improvements especially in the chemicals utilized in the production of the asphalt emulsions have allowed for more innovative uses of cold mix technology. The use of cold mix processes has expanded the toolbox available to agencies to solve their problems. The tightening of highway budgets has altered the way agencies handle construction and rehabilitation. For instance the use of cold in place recycling technology has become a standard rehabilitation process used by highway departments and county agencies across Canada.

The use of cold mix processes can help to fill a void in the area of rehabilitation and reconstruction. Cold processes help to lower the greenhouse gases in the atmosphere as they use less energy, as well as cut down on the use of non-renewable resources such as aggregates and oil based products. Cold mix technology can help to meet the requirements of the Kyoto Accord and still provide a technologically sound solution to highway agency problems.

This paper presents an overview of the various cold mix processes being utilized across Canada and the state to which these processes have been elevated as cold technology has expanded and improved.

Résumé

Le concept des procédés d'enrobés à froid existe depuis plusieurs décennies et plusieurs formes différentes sont apparues et disparues avec l'évolution de la technique. Au cours des dernières années la technique des enrobés à froid a fait des progrès importants en qualité et en performance. Ces progrès spécialement dans les produits chimiques utilisés dans la production des émulsions de bitumen ont permis des utilisations plus innovantes de la technique des enrobés à froid. L'emploi des procédés d'enrobés à froid a agrandi la boîte d'outils des agences pour résoudre leurs problèmes. Le resserrement des budgets routiers a modifié la façon dont les agences traitent la construction et la réhabilitation. Par exemple la technique du recyclage en place à froid est devenue un procédé standard de réhabilitation utilisé par les ministères de voirie et les agences de comté à travers le pays.

L'emploi des procédés d'enrobés peut aider à combler un vide dans la reconstruction ou la réhabilitation. Les procédés d'enrobés peuvent aider à diminuer l'effet de serre des gaz dans l'atmosphère car ils utilisent moins d'énergie, aussi bien qu'à diminuer l'utilisation des ressources non renouvelables telles que les granulats et les produits pétroliers. Les procédés d'enrobés à froid peuvent aider à rencontrer les exigences de l'accord de Kyoto et fournir encore une solution technique valable aux problèmes des agences routières.

Cet article présente une vue générale des divers procédés d'enrobés à froid utilisés à travers le pays et le niveau atteint par ces procédés à mesure que la technique s'est étendue et améliorée.

1.0 BACKGROUND

Cold mix is the generic term for many different bituminous processes, which utilizes asphalt emulsions, aggregates, recycled bituminous materials and a mixing plant, which does not have an aggregate dryer.

The majority of the different types of cold mix processes have been used since the sixties with varying degrees of success. The current practice of Cold in-Place Recycling (CIR) of bituminous pavements has now become a standard rehabilitation process used by highway departments, county agencies and municipalities across Canada.

During the early 1970's many counties and townships used open graded emulsion mixes (OGEM) and dense graded emulsion mixes (DGEM) on their low volume road network [1]. These roads were then typically covered with a surface treatment of some kind usually a chip seal or dense graded high float type surface.

Cationic emulsions allowed for faster setting times and less susceptibility to weather conditions due to their chemical break. In the late 1970's the use of reclaimed asphalt pavement (RAP) started to become very popular in the hot mix industry. In order to utilize this valuable resource the emulsion industry started to develop products to allow the use of RAP and RAP/virgin aggregate in cold mix processes. The development of rejuvenation-type emulsions opened up an area of recycling which did not exist before. As the technology progressed cold mix processes evolved through the usage of combinations of emulsions such as rejuvenators being blended with conventional asphalt emulsions.

The suppliers of the asphalt emulsifiers used to produce the asphalt emulsions have become more aware of the technological advances in cold mixes. These suppliers work with the industry to develop specialty chemicals, which give added benefits to the cold mix processes. These new chemicals have raised the bar in the usage of cold mix processes.

The following sections of the paper present an overview of the various cold mix processes being utilized across the country and the state to which these processes have been elevated as cold technology has expanded and improved.

2.0 COLD IN-PLACE RECYCLING

The CIR process started in Canada in the late 1980's and has grown steadily since. The Regional Municipality of Ottawa-Carleton (now known as the City of Ottawa) was the first agency to utilize the process as a rehabilitation tool. The depth of recycling typically ranges between 70 and 125 mm of depth. The CIR process can be done using a variety of recycling trains from a single unit to a multiple unit type.

The CIR process is used on a regular basis in almost every province in Canada. The interesting point to be made is that each province uses different choices for the binder. British Columbia uses a rejuvenator or blends (discussed later in the paper in Section 6); Ontario uses high floats as well as cationic emulsions; Quebec uses cationic with Portland cement; New Brunswick uses high float emulsions and Nova Scotia uses cationic. The CIR process has made great strides as a rehabilitation tool and further research is ongoing to improve the process even more[2]. The use of performance criteria on the mix itself will go along way to improve the process and the research is focusing on this aspect.

3.0 VIRGIN COLD MIX

The development of the pugmill improved the overall performance of cold mixes. The concept of using only coarse aggregate in the mix (Open Graded Emulsion Mix, (OGEM)) with emulsion started in the late sixties and early seventies in the U.S. Pacific northwest [3,4]. The development of the Midland Mix-Paver in the early seventies revolutionized the OGEM market.

The following two sections give a description of the two cold processes; Open Graded Emulsion Mix and Dense Graded Emulsion Mix.

3.1 Open Graded Emulsion Cold Mix

The definition of an Open Graded Emulsion Mix (OGEM) is a gap graded mix with an air void content of greater than fifteen percent. Typically the coarse aggregate used is a 16 mm stone that is normally used in the hot mix industry. The material passing the seventy-five micron sieve is less than two percent.

The OGEM material is typically used on township and county roads to upgrade the riding surface from either gravel or surface treatment. The pavement lifts are normally 50 to 60 mm thick after compaction. The most common method of placement is with the Midland mix-paver. The Midland mix-paver has evolved and become more complete and now places a smoother and more uniform mat.

3.2 Dense Graded Cold Mix

The Dense Graded Emulsion Mix (DGEM) process is used in a number of provinces; Ontario, Manitoba, British Columbia and Alberta. In Ontario the process has been used successfully to upgrade county roads [5]. The material was mixed in multiple bin pugmills and then placed using conventional hot mix equipment. The use of more than one aggregate bin gives the finished mixes a more uniform finish and more consistent results in the field. In some instances a specially manufactured emulsion is needed in order to give the proper properties needed. In other cases a stock emulsion can satisfy the requirements.

In Manitoba the highway department utilizes their small portable drum plants to make dense graded cold mix. In the past the department used SC 3000 cutback asphalt to make their cold mix, but with the new regulations on VOC (Volatile Organic Compounds) emissions a switch was made to a special emulsion called HF500LD. The material produced in a warm (100°C) condition can be paver laid, grader laid or stockpiled for future use. The aggregate used is from various sources around the province and the highway department moves their three drum plants from aggregate source to aggregate source as needed. The DGEM is used as a leveling course to improve the road profile or as the finished riding surface.

With the new emulsion technology the asphalt emulsion can be formulated to provide better end result properties and also could allow the use of aggregate sources that could lower costs, which in the past could not be used. The technology can now allow for quicker setup and strength gain as well as allow earlier application of the finished riding surface.

4.0 RAP COLD MIX

The use of RAP in cold mix has been around since the development of the grinding process and hot mix recycling. There are large stockpiles of RAP, which has a cost associated with it and the use of RAP cold mix can greatly reduce these piles. The material has been produced using cutback

asphalts, but is now strictly an asphalt emulsion based product. The RAP mix has been placed using various asphalt emulsion products such as High Floats, SS-1, CSS-1 and CMS-2 or specially developed emulsions. The quantity added to the mix is determined through laboratory design and typically varies between one and two percent depending on the properties of the RAP material being used.

Emulsion chemistry has made great strides in the development of tailor-made emulsion products to be used with the various processes. In the last few years the RAP cold mix as well as the other processes discussed in this paper have evolved with the use of more engineering of the asphalt emulsions and more detailed design procedures.

5.0 RAP/VIRGIN COLD MIX

A logical next step in the development of RAP cold mixes was to add virgin aggregate to the mix to enhance the overall properties of the mix if needed. The addition could be to improve the gradation, to improve the physical properties of the final mix or the need to increase the thickness of the road platform, because of traffic conditions or the road needed to be increased in width.

The minimum requirement needed to make the cold mix blend is a two bin pugmill and a water source to give extra liquids to the mix for compaction purposes. The amount of asphalt emulsion needed would depend on the quantity of virgin aggregate being added to the RAP as determined during the design phase. In most cases the quantity is less than twenty-five percent of the total mix [6]. There are cases where the virgin aggregate quantity could reach fifty percent.

The type of asphalt emulsion used is typically cationic, which may have to be specially formulated for each project. The design procedure used is similar to the procedure used for the other cold mix processes except the OGEM product.

6.0 REJUVENATION

In the area of cold mixes and especially the cold mixes containing RAP the idea of using rejuvenators as part of the new binder in the mix has been investigated and used successfully.

In the rejuvenation process a rejuvenator makes steps to return the maltenes to asphaltenes ratio back in balance and restore the asphalt cement to its original state or as close to it as possible. In cold mixes there are two ways to use the rejuvenator products: one is the use of a straight rejuvenator in the mix or a blend of a rejuvenator and an asphalt emulsion. The following two sub sections describe these processes.

6.1 Rejuvenator Mixes

The use of straight rejuvenation is done extensively in British Columbia. The British Columbia rejuvenator process is to remove the top layer of asphalt pavement and then cold in-place recycle the next layer using a rejuvenator. The grindings that were removed are pugmill mixed with same rejuvenator as the CIR process then placed and compacted on secondary or county roads. After the CIR has cured the material is covered with hot mix to provide a finished riding surface. This process has been used for a number of years and is working very successfully.

6.2 Rejuvenator/Emulsion Mixes

In the last few years the process has been utilized in British Columbia (BC) and Alberta. As mentioned in the earlier section the combination process has been used and is being monitored in

BC. In Alberta the process is being used to help get the large stockpiles of RAP decreased. In order to develop a cold mix product RAP is obtained from the stockpile and analysed in the laboratory to establish what the ratio of rejuvenator to asphalt cement should be in the finished emulsion. Once this ratio is established the project can proceed.

7.0 DESIGN PARAMETERS

The design of cold mixes has evolved over the years from just adding the oil, mix it, lay it and compact it to the point where the designs have become as detailed as the Superpave™ hot mix. The main areas of design that are very important to the success of the job are emulsion-aggregate interaction, role of the water, air voids, density, coating, compaction and curing.

8.0 PERFORMANCE

The performance of the various cold mix types over the years has been very mixed. The more recent processes are performing very well. The OGEM mixes are excellent for rut resistance, skid resistance and the ability to self heal in areas of high deflection and subgrade movement.

The CIR mixes have proven to be very effective in the reduction of reflective cracking in the hot mix overlays [7]. The service life of the roads, which have been cold in-place recycled have increased dramatically. The mixes have good fatigue resistance due to the binder rich mastic that is formed. The CIR mixes have allowed the pavement width to be expanded with limited disruption to the traveling public and improved safety.

The DGEM type cold mixes have good fatigue resistance and can be designed to withstand high deflection and subgrade movements. The stiffness of the DGEM mixes increases as the density increases and can reach equivalent stiffness to hot mix after a curing period.

The RAP type cold mixes have helped to decrease the stockpiles throughout the country and provide an all weather surface to a large number of lower traffic volume roads. The use of a surface treatment over the RAP mix provides an excellent finished surface and provides good service life.

9.0 NEW TECHNOLOGIES

In the last few years there have been great strides in the technology of the emulsifiers being used to manufacture the asphalt emulsions and in the development of new production equipment to manufacture the cold mixes.

There are new cold mix plants being fabricated that have two or three bins for different aggregates or RAP. These will provide a more uniform mix and tighter control. The emulsion system is highly computer controlled and the weigh bridge systems have been greatly improved. The plants are very easy and fast to set up and can be moved with little effort. The mixing units are becoming more sophisticated with better aggregate material coating processes. A new type of mixer on the market has the capability to separate the aggregate feed as well as the emulsion spray system to provide a more uniform mix.

The manufacturers of emulsifiers have developed more specific type emulsifiers to improve the performance of cold mixes. These engineered emulsifiers have the capability to control the coating of the mixture, control the break and set time of the mixture as well as provide adhesion and stripping resistance. There are also new additives, which can be incorporated into the mixtures through the asphalt emulsion or at the mixing stage, which will promote the expulsion of the water at the time of compaction.

10.0 BENEFITS

The benefits of using cold mix processes are as follows: production facility, placement operation, products available, engineering properties and energy efficiencies.

The production facilities to manufacture these processes have high production. These plants are self-contained, extremely mobile and can be set up rapidly. The mixes can be placed many different ways. A self-propelled travel plant (Midland Mix-paver) can be used or the mix can be placed using a grader. The use of conventional hot mix spreaders is very common. For many of the processes the compaction does not have to be done right away. The mixes are not temperature restricted as they are already cold.

The various types of cold mixes can be manufactured using many different types of asphalt emulsions. The emulsion can be tailor-made for a specific material or situation. Each job is unique and pre-engineering is required. The mixes can be used for a specific engineering property. The OGEM is an excellent mix to use where the subgrade is not in the best of condition. Because of its unique self-healing property and capability to withstand high deflections the OGEM is ideally suited.

The cold mix process is very energy efficient. The amount of energy to produce the mix is very low compared to the other road construction processes. There are no concerns about smog days where hot mix production is not allowed. The Kyoto Accord requires that greenhouse gas emissions be reduced and the cold process is an excellent way to achieve that goal. There is very low or negligible "blue smoke" emissions during manufacture of the cold mix. There is typically less fugitive dust present in the air because the aggregate does not have to be dried and the damp aggregate encapsulates all the dust particles. Since the aggregate does not have to be heated there is reduced fossil fuel consumption during the manufacturing process. The use of RAP and RAP/Virgin cold mixes conserves the dwindling aggregate resources as well as the petroleum resources since the quantities of asphalt emulsion are reduced.

11.0 CONCLUSIONS

Emulsion based cold mixes have come along way in the last few years. The mixes are made up for a variety of uses and provide a lot of options for road construction and maintenance. There are still a lot of areas of cold mix that have yet to be fully explored. The use of the proper emulsion is critical to the overall performance. Many companies are investigating the potentials of cold mix and innovation is the key.

The different cold mix processes have a place in the designer's toolbox. With limited budgets being the norm the use of cold mix processes for certain applications can stretch the dollars. Depending on the process it can be used as base or as a surface course. As placement of cold mix is accomplished at ambient temperature, the need to keep hot mix at high temperatures does not apply. This means that a project has more flexibility and the construction deadlines can be more easily managed. This is especially true when using cold mix products that can be stockpiled.

The potential for using cold mix processes is growing as the emulsion technology expands. Researchers are investigating the short coming of the processes and great strides are being made to overcome these hurdles.

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