

## Reviewing the Technology of Anti-ice in Cold High Altitude Road

Wang Yongcun \* Meng Yunwei\*\*

\* (Architectural and Civil Engineering Institute, Chongqing Jiaotong University, Chongqing, China)

\*\* (China Merchants Chongqing Communications Research & Design Institute Co., Ltd, Chongqing, China)

### ABSTRACT

The icy roads will reduce road adhesion coefficient, causing traffic accidents because of skidding of vehicle. Road technology of anti-ice and anti-skid at home and abroad are reviewed in this paper, and the advantages and disadvantages of all kinds of technology are analyzed. Meanwhile the new domestic technology of anti-ice and anti-skid is introduced.

**Key words-** Engineering Application; Anti-ice; Road Safety

### I. INTRODUCTION

It is obvious that cold high altitudes icy roads impact on transportation safety. According to statistics, the direct economic losses caused by the hundreds of millions of dollars due to the road snow freezes every year all over the world, and 10% to 15% of road traffic accidents related to road icing. In order to ensure road safety, avoid or reduce the number of traffic accidents, improve the traffic capacity and operating efficiency, measures must be taken to remove the road snow and ice.

Road icing effect on road safety mainly embodied in two aspects: one is that the icing reduces the adhesion coefficient of road surface, making it easier for the vehicle to skid, braking distance increases, easy to cause traffic accidents. On the other hand, Ice reduces the road service level, and it extends the transportation time, increases the fuel consumption, and increases transportation costs. Therefore, the research and application of scientific and effective technology of the snow and ice removing, has significant social and economic benefits [1-2].

### II. The research status at home and abroad

Since the seventy's, western European countries have begun to study anticoagulant ice road. In Austria, the first experiment on the bridge section

was taken in 1974. Later in Austria, Germany, Switzerland, Sweden, Eastern Europe, Great Britain, the United States, Canada and other places have been built it. According to incomplete statistics, before 1978, 25000 square meters test road has been built in Western Europe. In 1980, it has grown to 465000 square meters.

In China, in terms of the anti-icing design, road design standard is blank. Contrast at several anti-icing road surface at present abroad, melting agent is embedded on the road interlayer, or melting agent is mixed in the ordinary asphalt. Although the cost is not high, but the anti-ice effect is limited, and it has a certain influence on bearing capacity and durability of the pavement structure. The performance of "Safe Lane™ Surface Overlay" road anti-ice technology is excellent, but the cost is high. The performance-price ratio that the introduction of the technology of pavement layer design directly is not high.

In order to improve the anti-sliding ability of pavement and reduce the number of traffic accidents, as early as the mid 1920's, the United States has studied the pavement skid resistance. In the late 1950's, accelerated polishing machine was developed successfully by Britain. At the same time, the method for determining anti-sliding performance of stone in the indoor is put forward for the first time by the

British institute of road. During that time, Belgium, the Netherlands, Spain, France, the German democratic republic and the United States have successively carried out the study of antiskid pavement. Highway department began to study pavement anti-skid technology research in the early 1970s in China, and in the meantime residue pavement rate coefficient of standard production has been put forward. In 1981, the subject about highway traffic accident investigation and the development of accelerate the polishing machine was put forward by the ministry of communications highway research institute. In 1983, the ministry of communications formed research team that consist of experts who came from Yunnan, Sichuan, Jiangsu, Guangdong, Beijing, Liaoning to study anti-sliding performance of pavement stone. Through large-scale road accident investigation and stone material, the basic composition of the traffic accidents was understood in China step by step, and the suggested standard values about pavement anti-skid suitable to China's basic national conditions was put forward.

### III. Reviewing of deicing technology

Using of deicing technology at home and abroad can be roughly divided into two categories: one is passive de-icing technique. The other is to inhibit ice technology. Each have advantages and disadvantages [3-9].

#### 3.1 Passive de-icing technology

There are two main types of passive de-icing technology: snowmelt agent method and artificial mechanical ice method.

##### 3.1.1 Snowmelt agent method

Snowmelt agent method is more frequently used in the world. Melting snow and ice agent commonly used at home and abroad are mainly salt and potassium acetate. This method is mainly used on city roads, highways, airports, ports, bridges and other facilities. Snowmelt agent method achieve the goal of deicing snow and ice by lowering freezing point. Salts snowmelt agent price is low, and it can effectively achieve effect of de-icing, but the vast

majority of salt snowmelt agent products are corrosive, which is easy to corrupt and damage road structure and motor vehicles, and soil, water and air pollution, destruction of ecological environment. Potassium acetate class snowmelt agent is expensive, which is about 10 times than salts of snowmelt agent. And potassium acetate generally has no corrosion, which is used in the airport and other important places.

##### 3.1.2 Mechanical artificial ice breaking method

This kind of method to remove snow and ice is thoroughly, but it has many disadvantages including low efficiency, high cost, the influence of traffic and road safety when working and not working for a long time. So it is suitable for the small amount of snow.

#### 3.2 The technology of inhibition of icy pavement

The technology of inhibition of icy pavement mainly includes the energy conversion type deice melting technology, the stress de-ice technology and surface chemistry class freeze inhibition technology [10-13].

##### 3.2.1 Energy conversion technology of melting ice

To achieve the goal of snowmelt deicing, other forms of energy can be converted to heat energy by the energy conversion equipment. Available energy mainly includes industrial electricity, wind, solar and geothermal, etc. In the use of electricity, it mainly includes conductive pavement melting snow and ice and heating cable melting snow and ice. Among them, the heating cable melting snow and ice technology uses heating cable to thaw snow. Conductive pavement and heating cable used for pavement snow melting ice (e.g., the Nordic countries) has been applied abroad, but their energy dissipation is bigger, and the road construction costs are high, especially conductive paved on the melting ice and snow in the voltage control technology existence question, although there are more than 20 years of research in the aspect of theory, a related design specifications is still not formed in foreign countries, also does not have large promotion.

Japan has built a small-scale solar heat storage system used for melting snow on the ground, but the cost is too high. In addition, the use of the soil source heat pump technology in Switzerland, Finland and other European and American developed countries is earlier, but due to restrictions, such as pipeline laying technology, the technology is still in the phase of experiment research.

### 3.2.2 The stress ice breaking technology

To make the road snow and ice melt, the stress ice breaking technology [14] is mainly through adding a certain amount of elastic particles in pavement material to change the pavement and the deformation characteristics of the contact state of the tire and road surface, using the capability of local deformation of elastic material properties, which will from stress under the pavement outside loads, thereby effectively restrain the pavement of snow and ice. The technology has been applied in Europe and the United States and Japan and other developed countries. The used methods mainly include two categories: mosaic pavement technology and rubber particles in asphalt pavement.

Mosaic pavement technology is most used at abroad. Although this method has a certain effect, rubber piece will appear around the weak surface, and rubber block and its surrounding mine materials will soon fall off from the pavement surface under the action of environmental load and wheel load, because in the process of inlay rubber piece will damage the pavement of the original state. This not only affect their deicing effect, but also will affect the normal use function and service life of pavement.

### 3.2.3 Surface chemistry class freeze suppression technology

Since the 1970s, Europe and the United States began to study the anti-ice road. In Austria, the first experiment on the bridge section was taken in 1974. Later in Austria, Germany, Switzerland, Sweden, Eastern Europe, Great Britain, the United States, Canada and other places have been built it. At present, the typical ice road surface includes three types: melting agent is embedded inside the

pavement interlayer, and Verglimit or Mafilon are added in ordinary asphalt pavement, and seal coating of anti-icing is set on the road.

The technology of melting agent embedded in pavement interlayer is complex, and there is still a loss and leakage for salts. Meanwhile asphalt and layered melting agent is bad for engineering structures.

For the ordinary asphalt pavement added Verglimit or Mafilon, foreign representative products is Swiss Verglimit and Japanese Mafilon. As far as Verglimit is concerned, before paving, asphalt mixture is mixed with a certain amount "melting agent" in advance. After rolling, the melting agent is uniformly distributed within the surface layer. Outside of the coating is abrasion and reveals the internal agent, when the surface of the "melting agent" is wore by the wheel. Along with the wheel driving across the road, it can reduce the freezing point and ice snow.

For ice seal coating set in the road, one of the most famous is "Safe Lane™ Surface Overlay" road anti-ice technology, which adopts a durable surface sealant that was invented by Russ Alger, who come from the American institute of technology university of Michigan. This road sealant consists of resin and limestone, and internal structure is rich in pore. Spongy holes can retain water, and the anti-icing chemicals (such as deicing salt, snow melting agent etc.) is fixed in pores, making them less likely to be swept away by vehicles. After forming a capping layer on the road, it can last up to 20 years. The anti-icing chemicals can significantly reduce the temperature of freezing pavement. From the safety assessment report the application of this technology in USA in 2006 and 2007, this seemingly simple technique greatly improved the driving safety, because the original pavement is completely closed by materials, reducing the possibility of the pavement layer corroded by chemicals. USA transportation experts in "Road and Bridge" magazine said, it can be said that this is most important progress in 40 years of highway technology

#### IV. New materials and new technology

The popularization and application of the current road ice antiskid new materials and new technologies includes chemistry class anticoagulation of asphalt concrete pavement technology and spray anticoagulation ice coating technology.

Anticoagulation ice of asphalt concrete pavement technology is used to newly built or rebuilt asphalt concrete pavement and cement concrete pavement. When mixing asphalt mixture, anticoagulant ice materials is mixed, and the mixture is used to pave "anticoagulant ice asphalt layer". Anticoagulation ice of asphalt concrete pavement technology originated in Europe in the early 1960s, and it has been employed in Switzerland, Germany and other countries. At present, the typical product of this kind of material in the world has two main types, respectively is Japanese "Mafilom" and the Swiss "Verglimit".

Spraying of anticoagulant ice coating technology fix melting snow material in pavement surface, and make snowmelt substances play a role within a certain period of time with certain technical methods. When the light snow, coating can melt the snow and make the road bare. Under the larger and thicker snow, coating can melt the lower snow, and the snow and ice road is loose, and then under the driving of rolling, the ice will crush and melt. Coating has the advantages of low cost, simple construction process, convenient maintenance and better durability. Meanwhile it can ensure that road has the active snow removing function within one year, and it is convenient for popularization and application in large area. At present, "PavSafe" environmentally friendly bridge deck anti ice coating materials and pavement melting ice wearing layer materials are used prevalently in China.

#### V. Engineering examples

Shenhe road laying anticoagulation ice coating has better anti icing effect in Changan District, Xi'an. Under the condition of lower temperature and a large amount of snow (snowfall is 3 mm), coating can melt the snow on the road and prevent the icy pavement, increasing the driving safety.

PavSafe was used in "Laji Mountain" tunnel in Xining. After the test of practice: PavSafe plays a more active role in melting the snow at the temperature of -20 Centigrade, and can inhibit the ice on the road, to ensure that the slight snow is not frozen, and heavy snow is easily cleared.

#### VI. Conclusion

The impact of snow and ice on modern transportation has more and more gotten the attention of the countries all over the world, and many countries have research and developed all kinds of deicing method. In the coming years, looking for more environmentally friendly, economical anti-ice technology has very important practical significance.

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