Highway Pavement Surface Icing And Traffic Safety

Hüseyin AKBULUT - Cahit GÜRER- Lale GEVREK

Abstract— Due to the fact that highways are the most used transportation mode in our country and the weather conditions are hard during the winter season, various problems are encountered on the roads where terrestrial climate is seen and these problems threaten traffic safety. It poses significant risks especially in road sections such as tunnels, bridges and vertical kurve and also causes material loss accidents. The methods used in the struggle with icing are divided into two classes as active and passive methods. Passive methods are applied in two ways; chemical and physical. Chemical methods are the application of a variety of chemicals to the pavement surface with the aim of preventing and eliminating icing. These chemicals appear to cause some damage to environment, roads, metal parts of vehicles and traffic sign boards and do not seem to provide the desired performance. Physical methods are carried out by removing snow and ice from the coating surface by using work machines. Using this method, both equipment workforce and time losses are occurring. Hydronic heating systems, which are active methods, circulate a heated fluid through a pipe network located below the pavement layer to melt snow and ice that accumulate in the coating layer. By using geothermal spring waters, which are clean and inexpensive resources as heated liquids, it is aimed to be prevented without creating snow and ice without causing environmental damage, human health and financial loss. In this paper, the characteristics of anti-icing systems and hydronic anti-icing systems used in roads, what kind of materials are used in such systems and their contributions to traffic safety are mentioned.

Index Terms— Traffic safety, Anti-icing systems, Hydronic ice melting

1 Introduction

There have been serious obstacles affecting the roads as a result of weather events such as snowfall, icing and snow storm in the winter months. The friction coefficient decreases due to icing on critical road sections such as bridge ramps and tunnels, causing traffic accidents and even causing snow and icing to close. It also causes flight cancellations at airports and causes huge financial losses [12]. Ice melting methods are examined under 2 main headings. These; active and passive methods (Figure 1). Passive methods include the use of dissolving chemicals as chemical substances and mechanical means as physical methods, systems used in ice fighting. In active methods, the use of conductive asphalt concrete, hydronic ice melting systems and unfrozen asphalt mixtures prevents ice formation [12].

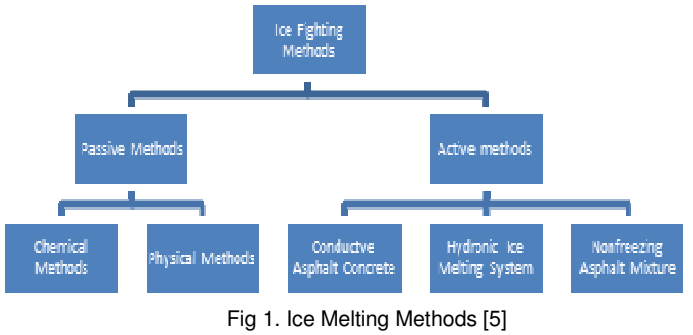

Fig 1. Ice Melting Methods [5]

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2 The Importance Of Freezing Traffic Safety

In northern regions where winter months are hard, traffic accidents usually occur during snowfall, freezing rain, and icing. Therefore, in normal roaand bridge removal of ice and snow effectively in terms of traffic safety is extremely important.

Especially in snowy and icing weather, the friction resistance between the road surface and the wheel bandage at high vehicle speeds drops to very small values. Studies in this area have shown that the reduction in friction resistance increases traffic accidents [12,13].

Another study that has shown an relationshio between slip resistance and traffic accidents has shown that road accidents have a 60% reduction in traffic accidents if the road surface slip resistance value increases from 35% to 48% [15].

In a survey of the World Health Organization, traffic accidents are listed in the top 10 causes of death in the world. The use of active anti-icing systems to reduce accidents caused by icing and snowfall in winter can lead to reduced accident rates [14].

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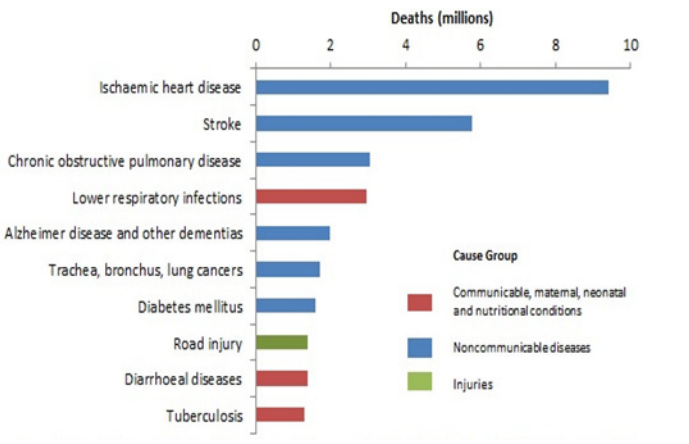

Fig 2. Top 10 Global Causes Of Death [14]

3 Ice Control Methods

The methods used to fight ice can be examined under two headings: active and passive methods. Passive methods; chemical and physical methods. In passive methods, which are the most commonly used methods in snow and ice fighting, plowing, salting, sand and chemicals are applied. However, these methods require more substances to be able to dissolve the bond between the coating and ice after they have been applied after snow or ice. Human health and the environment are also affected negatively, as it causes bottlenecks on road and decreases in operating speed [1]. In active methods; systems based on the determination that there is no ice formation due to the system established before icing occurs. For this reason active methods are more advantageous than passive methods.

3.1 Chemical Methods

In order to prevent or eliminate the formation of ice on the coating layer, various chemical substances are applied to the road surface at the beginning of the most used methods in the world [2]. These chemicals can be used dry or in solution depending on the moisture content of the applied pavement. The most used chemicals are CaCl2, MgCl2, CMA (Calcium, Magnesium, Acetate) and NaCl [8].

Fig 3. Chemical Methods

3.1 Physical Methods

For this method of cleaning snow and ice masses that acc mulate after snowfall, work machines such as graders, scrapers, excavators are usually used. After removing the snow from the superstructure, it is a method that is really expensive fuel, personnel and equipment costs such as transferring snow deposits to the vehicles to be transported by the removal of snow deposits and also damages the superstructure. Also, if the snow mass is not transported after the cleaning process applied on the road and the sidewalk, the road becomes very unusable on one side, causing traffic congestion and problems [6].

Fig. 4. Physical Methods

3.3. Conductive Asphalt Concrete

The electric conductive asphalt coating system is based on the principle of converting the applied electricity into heat energy by increasing the electric conductivity of the asphalt mixture and melting the snow and ice on the surface of the heat coating [5]. Ice protection systems builded with conductive asphalt concrete provide many advantages in roads; Among the methods that can be used for fighting with icing are the fact that the materials to provide conductivity are similar to the materials forming the pavement and have limited effects on the superstructure performance [11].

The conductive materials that participate in the conductive asphalt concrete according to grain size are in three categories: powdered (graphite, carbon black, aluminum powder), fibery (steel fiber, carbon fiber, steel wool and carbon nano fibers) [7] and solid particulates (mixing of steel slag as coarse or fine aggregate).

The Superior Graphite Company and the American Federal Aviation Administration (FAA) have jointly worked with the Flood Test Laboratories to develop the Snowfree® System shown in Figure 3. Snowfree® (electrically conductive asphalt coating system) using graphite, asphalt and electricity. It is an original coating system which has been tested by the FAA for a taxi road at O'Hare International Airport in the United States, where snow and ice are caused extreme problem [5].

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Fig. 5. Snowfree® System Snow Melting After Aplication

3.4. Hydronic Snow Melting Systems

Hydronic heating systems is a circulating a heated liquid through a pipe network located below the pavement to melt snow and ice that accumulate in the pavement [3]. The pipe network usually consists of systems that are laid out in a wiggly configuration. Pipe material is usually cross-linked or high density polyethylene. Typical pipe spacing ranges from 150 to 300 mm and depth ranges from 50 to 75 mm. Nominal pipe diameters are usually between 18 and 25 mm. Various fluids such as salt water, oil and glycol water are suitable as heat carrier fluids in hydronic heating systems. Freezing protection is very important because most systems will be operated intermittently at freezing temperatures. For such systems, a number of heat sources can be used, such as boilers, electric heaters, groundwater, and ground source heat pumps [9].

Pipe materials used to convey hot water are metal or plastic. Steel, iron and copper pipes have been widely used in the past, but proved to be easily corroded, and plastic pipes are now more widely used. The life of such plastic pipes is more than 50 years [10].

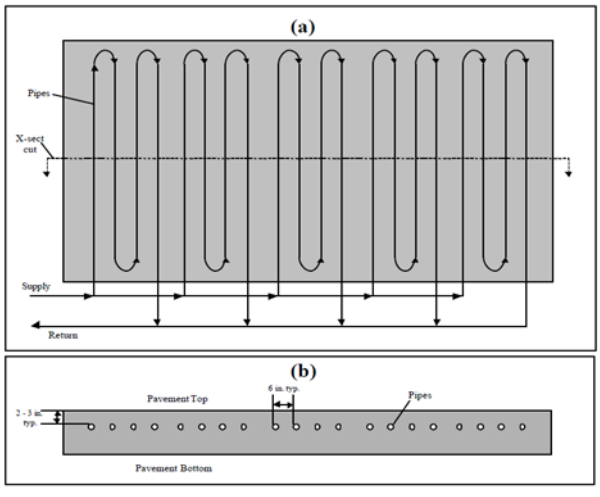

Fig. 6. Hydronic snow-melting system in (a) plan view and (b) cross-sectional view [4]

4 Conclusion

Ice-fighting in winter is a major problem for hard-to-beat regions. One of the most important of these problems is the traffic accidents that happen in a row. After the traffic accidents, both material and spiritual losses occur
and therefore alternative methods of ice struggle are needed to eliminate the negative effects. Active methods are used instead of passive methods in the struggle against icing so that they can be prevented before icing occurs and losses such as time and money, labor, etc. spent in passive methods can be removed.

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