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**ORIGINAL ARTICLE**

# Comparison of Use of CMA as a De-Icing with Salt on Road Safety in Snow and Ice Conditions

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**ABSTRACT**
*Pavement is one of the most important wealth of each country and a bulk of development budget is spent on repair and maintenance of pavements annually. Major problems in this regard is the negative impact of frost in prone areas especially in mountainous winter which is caused financial loss, loss of life and increased risk of road accidents. In Iran, to prevent icing, salt is used which is a cheap solution for defrosting. However, salt has some shortcomings and weaknesses, deficiencies and shortcomings that are most relevant to road safety. One of suitable material for de-icing of the roads that can be used as a substitute for salt is calcium magnesium acetate (CMA). In this research, the CMA de-icing application in comparison to salt on the roads has been investigated in the points of road safety view. As a result, CMA is introduced as a useful and cost-effective chemical to roads and related facilities, roads.*
***Keywords****: Accidents, Calcium Magnesium Acetate (CMA), Salt, Sliding, De-Icing*

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## INTRODUCTION

Snow is a blessing by God, but if there is no comprehensive and formulated plan for confronting it, it may turn to a crisis. Various experiences in our country indicate how snow and ice disturbs living in the city and creates critical situation [1]. On the other hand, ice and snow is one of the basic factors influencing in delays and accidents in cities. To this end, considerable costs should be spent for opening the pavements with sand and salt, and the consequent outcomes, that is, corrosion and erosion of asphalt is also highly expensive. Thus, paying attention the maintenance of pavements in winter is a crucial issue. Salt and sand combination is traditionally used for defrosting snow in pavements and preventing from sliding in stress and urban pavements (Fig. 1). Urban authorities assumed that the sands used for defrosting and preventing sliding should be gathered from urban pavements and streets after the end of cold season, and since it is costly, they add a percentage of salt to this combination, while they neglect the fact that environmental costs of salt is much more than sweeping and collecting residual sands from surface of streets and pavements. Although experts of road accidents and urban environment actors have frequently warned against harmful outcomes of use of salt for defrosting, reduced road safety in cold seasons and influence on urban environment, use of salt as de-icing material is yet the most common method for defrosting in Iran due to expensiveness of other methods which are now used in other countries. Most countries of the world such as Russia, countries in northern Europe and countries of Scandinavia face sever coldness and icing for almost most months of the year. Studies indicate although salt as de-icing material has not yet been eliminated in these countries, urban authorities have attempted to minimize harmful effects of salt as de-icing using newer methods [2]. In fact, use of salt for de-icing is their last administrative option. For example, de-icing materials with organic combinations are now used in Europe which has no harmful impact on environment, while even use of these materials leads to creation of runoffs, urban refineries separate harmful materials from the water surface, which is unfortunately absent in Iranian metropolises. Salty runoffs flow toward the south in Tehran and enter agricultural lands; although environmental experts argue harmful impact of salty runoffs on health of agricultural lands will be evident gradually over the years [3].

Fig 1. A view of salt and sand piling in order to prevent formation of ice and snow layer in winter

Thus, snow and de-icing control is performed aiming at providing facilitated, safe and effective traffic in the roads, which should be done considering the best management methods. The question here is: what is the best material for effective snow and de-icing control. Although many factors are involved in this matter, use of suitable material for defrosting roads with the aim of preserving road safety in cold seasons and reducing road accidents is one of the main factors. If the snow and ice sticks to the road surface, the time and attempt for cleaning roads increases considerably. Thus, necessary safety for vehicle traffic should be provided with selection of suitable material for de-icing roads and considering technical and economic matters. No material other than salt has been ever used in Iran for de-icing roads. Also, no specific study has been conducted on impact of other de-icing materials on surface of roads in terms of road safety. Calcium magnesium acetate (CMA) has been recognized and tested as one of the most reliable de-icing materials and it is regarded as a reliable substitute for salt. In a comparative study in this work, impact of use of CMA and salt on de-icing road surfaces in cold seasons in terms of influence on road safety is described. To this end, firstly statistics for road accidents in the country in winter is investigated and the causes are identified and then technical literature and experiences of different countries regarding use of salt and CMA in de-icing roads are reviewed and advantages and disadvantages are investigated in terms of road safety and finally technical recommendations are made to be used in winter road maintenance.

## ROAD ACCIDENTS IN IRAN IN WINTER

Statistical reviews indicate one loses his life every 25 minutes due to car accidents in Iran. According to the reviews, average losses of car accidents in the country's roads is 57, thus, the highest rate of casualties in the worlds goes to Iran considering Iran's population [3]. Forensic Statistics show that the mortality rate due to accidents in the country was 27,746 in 2009 which increased by 6.4 percent from 2008 [3]. Statistics suggest that annually 270 persons die due to car accidents per one million ones [3], while it is 2-3 persons per one million persons in developed countries. Meanwhile, car accidents and natural disasters such as snow, blizzards and icing in roads and ghat create problems for passengers and drivers with the beginning of winter. Although measures are taken for helping people and reducing events and disasters, the main point in the country's roads is lack of safety in the roads. Accurate investigation of adverse car accidents in the roads in winter suggest considerable contribution of climatic factors in accidents, so that car accidents statistics in winter 2012 indicate 0.6 percent of accidents occurred in storm conditions, 5.7 percent occurred in foggy conditions, 43.8 percent occurs in raining and sliding pavements. 11.54 percent of accidents occurred due to frosting roads. According to statistics, Markazi Province with 40 percent growth had highest increase in winter car accident casualties. Tehran province with 51.6 percent and Yazd Province with 63.9 percent are in the next places of the highest car accident casualties in winter. Thus, it is necessary to use a material suitable with winter seasonal conditions in the country's roads so that secure traffic is ensured in the roads with necessary security.

## REVIEW OF EXPERIENCES OF USING SALT AS COMMON DE-ICING MATERIAL

Salt is a natural material which has been used for icing control since early nineteenth century [4]. Rock salt can be obtained through traditional extraction process from mines and it is probably the most commonly used product. Salt is a solid and granular material which can be used to control snow and ice with its specific aggregation. Salt is ideal de-icing material, because it is readily available and inexpensive, it has easy storage and transport, its dissemination is comfortable, it is non-toxic and does not damage the skin and clothing, and if used and stored in the right way, it is harmless to the environment. Salt, regardless of how long it is stored or how old it is, do not ever lose its power of smelting. However, in the meantime, using salt as de-icing material leads to salinity of current waters flowing toward agricultural

lands that destroys the soil, and damages plant species [5]. Although use of salt helps de-icing in pavements, since it increases chemical interactions in urban walls, it creates salty runoffs which lead to destruction of agricultural products and gardens in various regions of the cities. Salinity of water destructs soli texture and influences underground waters. Salt is not harmful inherently and since climate of some cities is not rainy, accumulation of salt on ground surface influences urban environment and green space, asphalt of streets, and even painting in urban spaces due to impermeability of salt to the depth of the ground. Gradual corrosion of the road surfaces by heavy vehicles which constantly use the road, pollution of main locations dependent on water and water reserves, harm for plants beside the roads and long-term effects of salt in runoffs on ground surface, erosion of bridles on the roads, and erosion of heavy steels constructing the bridges and their parts by salt, and damage to the surface of roads are gradual harms of use of salt [6]. Many reports have been published regarding adverse effects of salt and erosion of road surfaces in Northern America and Western Europe. Upon salt entrance to bridge surface it causes corrosion due to electrolysis, and thus bridge's structure is weakened and route safety for vehicle traffic is reduced. Studies in UK and Canada indicate that use of salt in road surfaces influences a range of 50 meters from road surroundings [6]. The extent of damaged area is influenced by extent and speed of traffic on the road, which is still under question. Due to influence on metal corrosion, salt damages vehicles and infrastructures. Chloride ions in salt rupture natural protective layers of metal surfaces and accelerate erosion and corrosion with increasing water conductivity[6]. Highest damages by salt are occurred on vehicles and bridges. Lesser side effects are on concrete pavements, underground waters and objects around the roads, which challenge road safety. On the other hand, sliding is one of the main factors in occurrence of road accidents in cold season and snow and ice conditions. Use of salt for de-icing the road surfaces causes reduction of road surface's skid resistance resulting in reduction of pavement safety and increasing road accidents. Meanwhile, one of the materials suitable for de-icing the roads is calcium magnesium acetate (CMA) which is regarded as an appropriate substitute for salt.

**Use of CMA as De-Icing Material**

CMA is produced through reaction of dolomitic limestone with acetic acid. It was originally introduced as a suitable substitute for salt in 1980 in USA. CMA has lower corrosion and is compatible with the environment. CMA's melting temperature is about -27 °C and its concentration is 27 percent. Anyway, studies indicate if CMA is to have the effect similar to salt, it should be used about 1.7 times more than salt. CMA needs more storage space [7].One ton of CMA has less density than salt and occupies 60 percent more space compare to one ton of salt. High price of CMA prevents from its extensive usage. CMA is used in special situations due to lower corrosion rate and environmental issues. It is mostly used in bridges, sensitive structures and vulnerable environmental areas where potential damage of salt and other chlorides may be problematic [7]. CMA grains are shown in Fig. 2 and use of CMA in de-icing road surfaces is shown in Fig. 3.

Fig 3. use of CMA in de-icing road surfaces in fluid state

Fig 2. CMA grains

There is only one commercial source currently for preparing magnesium acetate which is reaction of acetic acid with dolomitic limestone. Acetic acid is one of the most expensive elements of the compound which is obtained from natural gas or gasoline and also from decomposition of agricultural residuals [8]. Currently this compound exists as powder or lump. Although this compound is not soluble in water like sodium chloride and calcium, it can be used as pre-moistened or direct chemical agent. This material as solid state is not much effective as de-icing chemical due to high tendency to absorb water and its light solid particles. In fact, advantage of this material is that it dries snow such that it cannot be compressed

and thus it can be useful in increasing road safety in terms of road accident reduction. Acetate is a combination of calcium and magnesium acetate, which optimal combination ratio for it is 3:7 in about -28 °C with concentration 32.5 percent [9]. Acetate is suitable for plants and products beside roads or sensitive surface waters, but since corrosion property of acetate is less than salt, it can be used in bridges, parking lots, pavements and special road surfaces.

## REVIEWING EXPERIENCES OF OTHER COUNTRIES REGARDING USE OF CMA AS DE-ICING MATERIAL IN ROAD SURFACE

Damages resulting from use of chloride de-icing materials to the environment and structures such as bridges have always been causes for concern. Studies on CMA proved that CMA is not erosive and does not harm plants and water [5]. Laboratory studies indicate the higher is content of CMA in the compound; protection against flakiness and erosion is increased. Considerable part of projects on de-icing chemicals for substituting salt has been conducted in USA [4]. Most chemicals were eliminated at the beginning of the studies considering high production costs, lack of simple accessibility, insatiable chemical or physical characteristics (e.g. being carbonated or insolubility in water) or being harmful for the environment, flammability, being toxic or harmful. Finally, laboratory studies were confined to two chemicals, methanol and CMA. Methanol is a fluid which was used as a de-icing material in the past and its efficiency is higher in very low temperatures, while CMA is a sold which has de-icing range similar to salt range. Although both chemicals were assumed as suitable in terms of some defrosting criteria, CMA was more considered by the states due to higher environmental compatibility and characteristics similar to salt. Preliminary laboratory studies indicated CMA is harmless for plants and animals [6,11]. In addition, it is not harmful for concrete and other materials used in highways; it has non-harmful properties and is anti-corrosion for metals. Laboratory results of use of CMA were generally promising, although some problems or obstacles were also reported. For example, due to low density and small size of CMA particles, the test material got dusty during control and storage. Also, when being exposed to moisture, it frequently stuck to the scattering tool and got accumulated. In colder areas, tested materials had lower effect than salt and were less successful in penetration to ice and snow aggregation. It is usually necessary to use CMA twice, like salt, to have higher effectiveness (in terms of weight) [4].

## COMPARATIVE STUDY OF USE OF CMA AND SALT ON ROAD SAFETY IN WINTER ROAD MAINTENANCE

CMA has no adverse impact on environment, green space, water and aquatics, soil, human and animals. It can increase fertility and permeability in some soils. CMA smells as acetum, thus it does not absorb animals, like salt. CMA storage as powder is difficult and causes skin stimulation. It puffs in moisture and sticks to scattering equipment. It should be stored in dry and cold place, there should be appropriate ventilation. For scattering CMA, salt equipment can be used. In terms of comparison of salt effect and CMA effect as de-icing material, following cases can be mentioned:

1. CMA causes less corrsion in metals, steel in machineries, aluminum alloy, bridges, roads, parking lots and concrete compared to salt.
2. CMA does not cause flakiness of concrete in bridges and does not accelerate concrete corrosion which polluted to old chloride.
3. CMA is activated in a temperature similar to salt, but it functions differently. CMA does not melt snow or ice, rather turns them to solid-liquid mixtures. It is suitable to be used before sweeping snow and ice, since CMA does not turn into salty water, thus it does not flow on ground surface. Thus, the road does not get sliding and road accidents considerably decrease.

However, it is necessary to use CMA in dry state as de-icing material. CMA can be used both as solid-liquid mixture and as mixture with sand or salt as de-icing material. Liquid CMA is not often used as de-icing material. Also, longer time is needed for CMA activation compared to salt and thus it is not suitable for mass of snow or ice.

## CONCLUSION

Although many studies have been conducted so far for substituting salt with chemicals for road protection in winter, salt is still used in Iran as de-icing material. Over twenty years passes from observation of adverse side effects of use of salt on road surfaces and its overall costs is growing increasingly. Extensive studies have been conducted for using de-icing chemicals as alternatives. In the current work, use of CMA chemical as de-icing material was investigated by reviewing and comparing it with salt technically and environmentally and in terms of their impact on road safety in winter. Practical technical recommendations for application in winter road maintenance include:

1. Significant cost is annually spent on construction and development of asphalt and concrete pavements in the country. Useful lifelong do the pavement is reduced due to use of salt as de-icing material on road surfaces during ice and snow.
2. Use of salt reduces skid resistance of the road surfaces and leads to increasing probability of car accidents. To this end, use of a material as alternative for salt in de-icing road surfaces which can ensure protection of environmental, technical, and economic criteria seems necessary for increasing road safety.
3. Considering compatibility with environment and lack of damage for road pavement, use of CMA leads to reduction of road pavement maintenance and repair costs as a national asset.
4. CMA creates less corrosion in metals, steel of machineries, aluminum alloy, bridges, roads, parking lots, and concrete compared to salt. Also, it does not cause flakiness of concrete in bridges and does not accelerate concrete corrosion polluted to old chloride.
5. CMA does not melt snow or ice, rather turns them to solid-liquid mixtures. It is suitable to be used before sweeping snow and ice, since CMA does not turn into salty water, thus it does not flow on ground surface. Thus, the road does not get sliding and road accidents considerably decrease.

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