INFLUENCE OF WINTER ON CONTROL

OF SNOWY AND ICY ROADS IN INNER MONGOLIA

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1. Abstract

In Inner Mongolia, for its complex landform and various climate type, it has many kinds of road diseases with a wide range and great intensity. Ice-snow road is one of the main diseases that lead to unsafe driving and transportation suspension. It not only costs much to resume the transportation, but also seriously affects the operation benefits and leads to several million Yuan's loss every year. So it is of great importance to carry out a research on prevention and treatment of the road diseases.

Road and meteorology are two closely correlative borderline subjects. Ice-snow roads combine the two meteorological factors (wind and snow) together. Utilizing fifty years meteorological data, by means of the methods of mathematical statistics, we analyze the distribution of ice-snow disaster with the change of year, month and space-time, the formation reasons of ice-snow road are also put forward. The measures to protect ice-snow road from damage are given below:

1. Nipping in the bud, from reconnaissance design work.
2. Adjusting measures according to local condition, improve the facilities of preventing snow
3. Doing precautions work well, avoiding snow accumulating on the road surface.
4. Using biology prevention, improve highway ecological environment.
5. Synthetic treatment and establishing a perfect drainage system.

2. Physical Condition in Inner Mongolia and Climate in Ice-snow Road Area

2.1 Physical Condition in Inner Mongolia

Inner Mongolia lies in the north of China, Its east longitude is from 97 ^{0}12' to 126 ^{0}04' and its north latitude is from 37 ^{0}24' to 53^{0}28'. The distance from east to west amounts to 2400 kilometers, which takes on a long and narrow configuration. The whole area is 1,180,000 square kilometer. DaXingAnLing runs through the east of Inner Mongolia from northeast to southwest; YinShan Mountain runs through the southwest of Inner Mongolia from east to west. The geography, geology, hydrology and climate are very complex. The isotherm of DaXingAnLing region is not in parallel with

the latitude but with the strike line of mountains. At the back of mountains it has a lower temperature, but it has a higher temperature at the front of mountains. There are much different in rainfall, snowfall, wind direction and speed. The ice-snow roads are mainly distributing in the low temperature area between these two mountains. The whole area is approximately 400,000 square kilometer.

2.2 The Climate in Ice-snow Road Area

2.2.1 A Long Winter. The pastoral area in Bayannur League, which lies in the north of YinShan Mountain, it comes into winter in the middle of October and ends at the beginning of April, so its winter lasts for 6 month. In DaXingAnLing and Hailar region, it comes into winter at the end of September and ends at the beginning of April or March, so its winter lasts for 7 months. A long winter goes against road maintenance. What's more, the traffic volume in winter is more than that in other seasons. Firstly, the foodstuff that harvest in fall and livestock product such as flocks and herds need to be transported to other cities. Secondly, the circulation speed of commodity among towns and countryside before Spring Festival has greatly increased. As the heavy traffic and the increasing number of heavy trucks, it needs better road condition to serve the social work, and it also put forward a challenge for the road transportation department.

2.2.2 Freezing Climate. The regions that have ice-snow are rather cold. Its extremely lowest temperature is -40ºC. At the north of DaXingAnLing it even amounts to -50.2ºC.

2.2.3 Plenty of Snowfall. AerShan City, where has a large number of snow, its annual number of snow days amounts to 88 days. Xilin Gol League, where has the maximal snowfall amounting to 58cm. Some regions even reach 60 to 100cm. The Pastoral area in the west of Hulun Buir League, where has the largest number of Snow days, its annual number of snow days can be up to 124 to 149 days. The annual number of snow days can be up to 171 at TuLi River in DaXingAnLing.

2.3 Climatic Conditions Responsible for Icing Roads

The icing roads are mainly caused by snow drifting. When the wind speed is higher than the critical speed of snow (generally 4-5m/s) that is just able to carry snow, snow drifting will come into being, and snow will accumulate along the subgrade or on the road surface. Snow drifting with high speed is usually called as blizzard that will suspend the traffic by a large amount of accumulated snow on roadway. Even if snow drifting doesn't appear, the accumulated snow on the roadway is thicker than 30cm and gradually turn into a layer of ice because of compaction by traffic, it is also difficult for vehicles to run on the road, traffic suspension will happen.

2.3.1 Cold Wave Is Main Fact Helpful to Form Blizzard. The fact has been proved through analysis, by the means of mathematical statistics method, on annual distribution, monthly distribution, and its time-space distribution of blizzard.

Cold wave can take shape when a large scale of cold air is moving from arctic pole to areas with lower latitude. There are three accesses to Inner Mongolia: the access within the north west part of this area, the access within the west part and the access within the north part.

The three accesses all can affect Xinlin Gol League, Ulanqab league and east part of Inner Mongolia. Cold wave coming from the west path is characterized by sudden temperature falling, accompanied with snowy or rainy weather in a large scope. Sometimes, the north west cold wave and the west cold weather emerge to invade into Inner Mongolia，then blizzard, sudden temperature falling and storm will appears. Xilin Gol League is to the south of Siberia-Mongolia high air pressure areas. In early winter, cold air and warm air converges at 40-45 degree in north, so snow weather always appears. Xilin Gol League and Ulanqab League have most times of cold wave, almost 6 times every year. There have been 13 times of snow disaster since the founding of the PRC. The occurrence rate and severe degree is gradually decreasing from middle part to each side of the areas.

2.3.2 Time of Cold Wave Happens Snowfall caused by cold weather usually happened in September or October, which will affect the road condition during the whole winter and the whole spring every year. Cold wave always invades into Inner Mongolia in April and March, as a result blizzard weather appears. However, because the weather is becoming warm, the damage duration is always short. So a little road damage is caused.

2.3.3 Periodicity of Heavy Snow. The periodicity of heavy snow is about 10 years. According to historical record, the most important recorded heavy snow years are in following: 1907, 1916, 1927, 1937, 1947, 1957, 1967, 1977, 1986, and 1997. Every ten years, the former five years are more likely to have heavy snow.

2.3.4 Irregular of Snow Weather. Although heavy snow year and blizzard have certain periodicity, there is still no a specific regular for the snow falling in every year. A observing station may has no heavy snow during several continuous years, but in certain year, days of snowfall is 3-5 times, even 10 times of average number. For example, Xin Barag Right Banner of Hulun Buir League had snow days as long as 20 days in 1996, but no heavy snow days in 1968 and 1985.

2.4 Losing Ecological Balance Is One of The Main Reasons for Road Snow Damage.

Formation of the snow drifting needs three necessary factors, that is: enough snow sources; strong wind; the conditions or obstacles that decrease the wind velocity and cause wind whirlpool. Among these three factors, the strong wind plays a dominant role. Areas which environment has been destroyed often appear blizzard. The total amount of snow in DaXingAnLin is larger than that in Xilin Gol league, but because the former vegetation is very well, little blizzard appears there. Although the west part of Hulun Buir League is well covered with vegetation, however, because it still lies within HuLunBeiEr desert, affected seriously by the north cold wave, it has more windy weather. From the north part of Xilin Gol League to the north side of YinShan lies in the BaYin desert. Wind brown from here affects the main parts of areas to the north of YinChan. Above-mentioned areas, vegetation is destroyed by over grazing and many places turning into desert. KunDaShan desert becomes larger and larger by the increasing rate of 160,000 acres every year. The average wind velocity is above 4.0m/s in the areas with frequent strong wind. Days when wind rate is larger than the critical wind rate (5m/s) is about 200 days every year. The largest wind speed is reaching at 27.7m/s. Because there is enough snow sources, strong wind, it is easy to form blizzard weather and icing road. As a result, many road damages are caused.

3. Guarding Against Icing Road.

Since winter weather has a very important influence on road conditions, at the same time with no specific regular, we only can rely on the precaution ways to deal with the snowstorm weather. Accordingly, our principles dealing with icing road is: the main work is to protect the road from snowstorm with the assistant prevention ways such as snow prevention facilities, engineering facilities combined with vegetation way. Try hard to better the environment of highway and protect the road from ice and snow damage.

3.1 From Reconnaissance and Design Period, Notice the Potential Road Disease.

3.1.1 The smallest height of embankment should 0.5-1.0 higher than the biggest height of accumulated snow in large areas. Clear out the extruding obstacles along the roadsides.

3.1.2 The angle between the road direction and snowstorm direction should be more than 30 degree, and the best condition is the angle being zero.

3.1.3 Sub-grade design is trying to avoid excavation, advocating embankment. When excavation is necessary, the direction of excavation section is parallel with the snowstorm direction, especially when the excavation is very deep. Thus, a wind tunnel is formed and the strong wind blows the snow out the

roadway so as to reduce the accumulation of snow. Dayan section 1217km+500 of NH301 in Hulun Buir League with a depth of 5m, never founds accumulated snow.

3.1.4 High embankment should be used in hairpin curve section, and remove the “arch island” between up and down line.

3.1.5 The slope of windward surface of embankment should equal or less than 1:4.

3.1.6 The longitudinal grade of highway should be as smaller as possible. The longitudinal grade values of different class of highway in specification should be decreased by 1%~1.5% respectively.

3.1.7 The radius of horizontal curve should be increased, as possible, and the highway around the valley should better adopt high embankment over the valley.

3.1.8 The sections of a highway with serious accumulated snow and difficulties in design will be avoided at the stage of selecting alignment.

3.2 According to the Local Conditions, Improve the Equipment of Preventing Snow.

The function of anti-snow equipments is very important. If it is kept well, the snow flow will be prevented at any time.

3.2.1 The Snow Staff. The snow staff can fit for different conditions. It can be made of corn stem, grain sorghum stem, and sunflower stem in the rural areas and of branches of trees in forest. The snow staff of tree branches that used in protecting road in the BaoGeDa Mountain of Xilin Gol League successfully keeps snow off the road.

3.2.2 The Snow Fence. The snow fence is made of horizontal and vertical wood strips. Which has the fixed and the movable two types. The fixed type is used in the sections of a highway where snow is smaller, the lasting time is longer, and the direction of wind is less varied. The movable type should be placed in the sections of a highway where snow is heavy, the direction of wind varies frequently, and the wind force is also bigger. In order to move conveniently, the movable snow fence may be placed in sections. The height of it is less than that of fixed one, and the usual dimension is 1-2m. As to the fixed type, horizontal wood stripe’ width is 10-20cm, the space’ width is 10-20cm. The height of it over ground is 1.5-3.0m and that of it under ground is 1-1.5m. The diameter of column (vertical wood stripe) is 15-20cm. The width of space between two columns is 5m. The snow fence should be on the side of down wind sections of snow highway, and be vertical or approximate vertical to the main wind direction in winter. The movable type of snow fence is easily fault when meeting with strong wind, and will be buried by snow if not is moved on time. Not only the fixed type but also the movable type

snow fence should be removed as spring comes, and kept well after checked, in order to use for next winter.

3.2.3 The Snow Wall. The snow wall is made of soil and stone. Soil is economic, but it should be repaired every year, with great cost of time. The height of snow wall is usually 1.0-1.5m, not less than 1.0m. The length of it is no more than 40m at most. At the sections of a highway of greater amount snow, several rows snow walls can be placed. The space can be decided according to actual conditions. The snow walls placed in the highway from XiLin Hot City to SaiHanTaLa and XiLin Hot City to ZhangJiaKou City proved great effectively. And the snow wall can prevent a certain amount of sand at the same time.

3.3 Doing Precautions Work Well, Avoiding Snow Accumulating on The Road Surface

In order to prevent the snow from accumulating on the road surface and suspending the traffic, some measures must be take, these measures are recommended as followings:

3.3.1 Increasing the sugrade height, making the slope of road smaller, so that snow can pass the sugrade freely.

3.3.2 The sugrade lying in leeward slope should take the form of open section.

3.3.3 The snow along the road direction will accumulate at sharp bend of the road, which can block the traffic. The effect methods to prevent this kind of snow block are: digging up a part of earthwork in the inner of curve, such as widen side ditch and widen outside sugrade by deposed earthwork, increasing the place of store up snow.

3.3.4 The Shallow Slot and Wind Power Bank are Effective for Conveying Sand. It is adapted on the conditions that the angle of highway and main direction of wind is 45° or 90 °. As the shallow slot and wind power bank connect in the order with subgrade, the maximum depth of shallow slop is in the range of 1.0-2.5m, the windward slope of wind power bank should be 1:4, the longitude slope of the shallow slot is at least 1:8-1:10. The wind power bank is higher than subgrade and is shaped in streamline, in case the passing snow stores up in the lee. The shallow slot of wind power bank should be stuffed with materials that can resist wind erosion. The several wind power banks with shallow slot in highway XiLin Hot to ZhangJiaKou proved perfectly well in conveying snow.

The equipments of preventing snow and prevention projects must be accomplished before the end of October, because there will be a snow disaster at the beginning of November.

3.4 Using Biology Prevention, Improve Highway Ecological Environment

The biology prevention and cure is to improve drift prevention forest, it is the basic measure of keeping snow and ice off highway, and it can also prevent and cure the sand harm and water harm of highway. That is the three use of one forest.

3.4.1 Type of Drift Prevention Forest and The Placement and Selection of Tree Seed:

A. The drift prevention forest of arbor in middle and shrub in outside has better effect. In the range of 20-30 times tree' height, the wind speed can be decreased by 10-30% on average.

B. The space of trees of drift prevention forest is 0.5-1.0m, and the row space is 1.0~1.5m. The multi-strap should be placed in the areas which wind is strong; amount of snow is great, so that snow can be stored in the vacant area between tree straps.

C. The width of forest belt is related to intension of wind, snow flow and quantity of snow. It should be decided according to quantity of snow when snowpack is the most grievous (commonly 15m-20m).

D. No matter how wide the snow prevention region is, the distance between it and subgrade edge can't be less than 10 m.

Drift prevention forest on NH301 from YA KE SHI to Hailar City is protecting the highway from snow effectively, ensuring the road unblocked.

3.4.2 Protecting Natural Vegetation.

It is effective measure that may reduce wind speed and protect highway from snow. If forest and grass are dense, wind may be reduced. Government should make appropriate policy to encourage people to plant trees and grass. Now all levels of government of Inner Mongolia have put environment protection on important schedule and are implementing it.

All the above-mentioned defending facility、project measure and biology measure can be either adopted singly or synthetically, in this way we can achieve the object of avoiding snow disaster.

3.5 Treating Synthetically, Building Perfect Drainage System

Snow is kept off the subgrade by engineering or biology measures, so highway snow-block can't form, but plentiful snow easily form spring-melt-water when temperature rises abruptly next spring, thereby, destroy subgrade, bridges and culverts. In the spring of 1986,in middle east region of Inner Mongolia, spring-melt-water formed heavy flood, destroy more than ten national, regional and country road with a total length of ninety-five kilometers, among it including twenty-one bridges. So when we protect highway from snow，we should give our attention to drainage works, utilize intercepting ditch, side ditch, bridges and culverts to makeup drainage system, utilize perfect, solid drainage system to

deal with possible-arisen jeopardize caused by spring-melt-water.

4. Conclusion

Presently, human being still hasn't the power to hold back disasters, only can try to mitigate its jeopardize. On the aspect of protecting highway from ice and snow, we adopt reconnaissance design, snow prevention facility, engineering measures and biology prevention and treatment, and have attained great achievement. In the future, we will give our more attention to biology prevention and treatment, this is also one of important matter that we should conserve environment when building highway. We will try our best to actualize long-term work.