

# ROADWAY CONSTRUCTION AND MAINTENANCE IN EXTREMELY COLD WEATHER

by

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## Preamble

The World Road Association's Technical Committee has very appropriately chosen the topic "Roadway Construction in Extremely Cold Weather" to be discussed in the Seminar at Ulaanbaatar in Mongolia, since Mongolia experiences extremely cold weather during winter. As the Government of Mongolia, has ambitious plans to construct a network of roads as per the Road Master Plan, the young Mongolian engineers participating in this seminar will be immensely benefited from its deliberations as many of the participants and delegates present here would have been responsible for construction of roads under extremely cold weather conditions.

From the geographical or regional considerations, the roadway construction activities can be divided into the following categories.

- (i) Roadway construction in normal terrain and weather conditions,
- (ii) Roadway construction in extremely hot weather conditions,
- (iii) Roadway construction in hilly areas, and
- (iv) Roadway construction in extremely cold weather conditions including at high altitude.

Whereas the roadway projects in normal terrain and weather conditions can be designed and executed by qualified and experienced highway engineers, the roadway projects under other three categories need specially qualified and experienced engineers, who have specialized in the particular category of construction. The roadway construction in extremely cold weather conditions need expertise of specially trained and experienced engineers for planning, design, constructions, and maintenance of the roads.

## Logistics for Roadway Construction in Extremely Cold Weather

The special attention and treatment for roadway construction in extremely cold climate starts right from mobilization of resources, selection of camping sites, suitably insulated accommodation, selection and procurement of machinery and equipment, right type of fuel and lubricants for the machinery and vehicles, appropriate grade of bitumen and suitable type of cement properly acclimatized workers, and suitable clothings and gear for the workers.

The working period available in extremely cold climatic conditions is very limited normally from April/May to September/October in a year. It is imperative that the mobilization of the resources is planned and completed well before start of the actual working season so that the limited working period available is not wasted for mobilization of the resources.

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The camping sites for the working groups are to be selected in such a way that these are not located in the cold blizzard areas. The camps should normally be located in the foothills facing the sun so that they are protected against the effects of the direct cold winds. The offices and residential buildings should be properly insulated against the cold by way of thermocol or timber claddings on the walls and the ceilings. The buildings are required to be provided with heating arrangements. The camps should have arrangements for supply of hot water for the workers. It has been experienced that due to inadequate protection against cold, the workers start deserting the work site on occurrence of the very first snowfall or a cold wave spell of the season. The water storage tanks and water distribution lines should be preferably of PVC and the water pipes should be laid underground at appropriate depth to avoid freezing of water in the storage tanks and the pipe-lines.

The construction machinery and the vehicles should have properly insulated cabins with heating arrangements. The conventional types of fuels are not suitable for the machinery and vehicles working in cold climate, as they start losing viscosity during low temperatures. Special fuels such as sub-zero grade diesel are required for the vehicles during low temperatures. Similarly, thinner grades of lubricants for machinery are required. The radiators of machines and vehicles need anti-freeze admixtures as otherwise the engine blocks get burst during subzero temperatures. Ether capsules should be provisioned for ignition and starting of the machines and the vehicles on the cold mornings.

The workers should have experience of working in the cold weather conditions and should be provided with warm and padded clothings.

When the roads are to be executed at high altitudes (above 2000 m), under cold weather condition the men and the machinery lose their efficiency with the increase of altitude due to less oxygen contents in the rarified air. While assessing the requirements of the men and the machines, the effects of low efficiency are to be taken into account. The First-aid medical facilities and the commonly required medicines for the cold climate area and high altitude diseases such as pulmeriodema, breathlessness, frost bite, etc should be available at the work sites and in the camps.

## Roadway Design ~~and~~ Construction in Extremely Cold Weather

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### Design aspects

The regions falling in extreme cold weather conditions experience frequent snowfalls during winters and sometimes even after the winters or before the onset of the winter. In the road sections susceptible to snowfall, the road alignment, as far as practicable, should be fixed on the sunny race. At times when the spell of the cold wave persists continuously for some days, the snow tends to freeze and transform into ice. Under such conditions, the vehicles find it difficult to negotiate the sharp curves, steep longitudinal gradient or the steep cross-falls i.e. cambers or the super-elevation as there are chances of skidding or slipping of the vehicles on the icy road surface, sometimes resulting into sliding or toppling of the vehicles. In heavy snowfall reaches, special structures such as snow-galleries and avalanche control structures are required to be constructed to allow the snow mass to slide over the gallery roof without

inducing impact of loads on the road structure. The avalanche control measures include long fencings of timber planks fixed on wooden logs or concrete walls to arrest the avalanche or to reduce the velocity and impact of the avalanche. During low temperatures and during winters, the water flowing in the roadside drains starts freezing particularly near the side-walls of the drain reducing the velocity of water. During thawing season, there is heavy discharge of water in the drains due to melting of snow causing erosion to the sides and the bed of the drain. It is, therefore, advisable to have lined drains in the snowfall reaches of the road. All these factors should be taken into account while fixing the design standards of the roadways in the extreme cold weather regions. The penetration grades of the bitumen for the pavement have to be selected taking into consideration the ambient temperature conditions prevailing in the area. The job mix designs for the bituminous works as also for the concrete works are to be finalized after considering the ambient temperatures and the working conditions. Use of polymers in the bituminous mix help as crack resistants and anti-stripping agents. It has been experienced that it takes considerable time for decanting/unloading the solidified bitumen from the tankers or the railway wagons.

### Construction aspects

The low temperatures pose numerous construction problems, particularly for the bituminous and concrete works. Even in the case of construction of embankment and sub-grade, there are problems of excavation of soil from borrow areas as the earthen layers immediately below the surface are found to be frozen, rendering the excavation difficult.

Some times even during the working season, sporadic and intermittent cold wave spoils are experienced causing fall in temperatures, particularly in the morning and evening hours. The bituminous works are not to be undertaken when the rising ambient temperature is less than 5°C or the falling temperature is less than 10°C. Similar is the case for concrete works. Thus, the working hours available for the bituminous and the concrete works get further reduced. During haulage, placement and compaction, the bituminous mixes lose the temperature very rapidly. Therefore, the mixing plant has to be located very close to the work site and there has to be adequate extra compaction equipment i.e. tandem rollers, vibratory rollers, and pneumatic rollers to complete the compaction within very short duration after spreading of the mix.

Any concreting operation done at a temperature below 5°C is termed as cold weather concreting. When the temperature is falling to about 5°C or below, the development of concrete strength is retarded compared with the strength development at normal temperatures. The hardening period necessary before removal of formwork is thus increased and the experience from concreting at normal temperature cannot be used directly under cold weather condition. For cold weather conditions, timber formworks are preferable to steel formwork. Additional quantity of ordinary Portland cement, rapid hardening Portland cement or accelerating admixtures used with proper precautions can help in getting the required strength in shorter period. Normally, warm water should be used for preparing the concrete mix. The concrete test cubes should be left at site under the same conditions of temperature and humidity as the structural element concerned. During periods of freezing or near - freezing conditions, water curing is not necessary. Following types of material are recommended to be used for insulation of concrete to protect against direct cold and also for curing of the concrete :

- Commercial blankets
- Loose-fill insulation of fibrous type material
- Insulating board
- Saw dust
- Timber planks
- Damp sand
- Wheat stalks
- Specially made curing membrane

### **Maintenance of Roads in Extremely Cold Weather Conditions**

In addition to the maintenance activities required for the normal weather conditions, the roads in extremely cold weather conditions require some special maintenance activities, particularly during the winter period. Some of the special maintenance activities are listed below :

- (i) In rocky mountainous areas, when the water seeps into the crevasses and the faults of a rock mass, it expands on freezing causing cracks and shattering of the rock, triggering the rock slides. Resources are required to be positioned for clearing the slides.
- (ii) Whenever there is precipitation in the form of snowfall or rain during low temperatures, it forms into ice on freezing, making the road surface susceptible to skidding and slipping. The frozen ice is to be removed from the road surface either by mechanical methods or by sprinkling chemicals such as calcium chloride or common salt.
- (iii) In the snow affected areas, sliding and toppling of the vehicles is a very common phenomenon during winters. Special recovery teams comprising dozers, cranes, and trained crew are to be positioned at identified locations to recover/remove the accidental/stranded vehicles.
- (iv) Special snow clearing equipment such as mechanical snow-cutters fitted with snow discharging chutes, dozers and graders are to be positioned for periodical removal of snow from the road surface and clearance of avalanches.
- (v) The wearing course of the bituminous surface is subjected to large thermal variations varying from 35°C - 40°C in summers to (-)40°C during winters. As a result, transverse cracks appear on the wearing course surface, which are required to be sealed and repaired periodically.
- (vi) Roadside drains and openings of culverts get choked due to frozen water and need frequent clearing.
- (vii) Special goggles are to be provided to the workers to protect against the snow glare.