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The German System of Frost Protection of Roads

The summary of the German frost protection system of roads is to construct the pavement structure in about 50% of the frost penetration-depth with not frost susceptible material. The frost penetration amounts from 1,0 to 1,8 m. In relation to Mongolia it may be not much; but it requires a lot of money. In more than 75% of the expanse we find frost susceptible soils. In spite of our very heavy traffic we have to minimize frost protection layers to save money. The construction of frost protection layers begun in 1940.

Frost damage will only arises when we have

- frost,
- frost susceptible soil,
- water,
- traffic.

If one of these factors is missing, we will get no damage.

When we make our frost protection only in 50% of the frost penetration, it is inevitable, to get frost heave. This mostly does not lead to road damage: While the subsoil is frozen, it has a good bearing capacity. But while the freezing of a frost susceptible soil there are built ice-lentils by water supplies to the frost area. The thaw is beginning at the surface of the road. While the thaw is getting deeper, the water of the melting ice cannot flow away. So the bearing capacity of the frost susceptible soil is getting very poor.

After these considerations, the 50%-rule of frost protection activities is the result of our experience – and I think you will find a similar rule in a lot of other countries. It is a weighing up between the possibility of damage and the costs.

It would be too difficult to measure the frost penetration in an area where you are going to design a new road; you would have to wait a lot of years to get the winter with the strongest frost conditions - and so with the deepest frost penetration. For the solution of this problem we use a map of our country, which contains the different zones of winter-violence (picture 1), the same map which is used for the heat-insulation of the houses in the different frost areas in our country.

Above I listed the 4 factors: frost, not frost susceptible soil, water and traffic.

Frost - we take into consideration by a map.

The soils we separate into 3 groups:

- not frost susceptible soils,
- little frost susceptible soils,
- heavy frost susceptible.

These 3 groups are connected with our soil classification (picture 2). It is natural, that we need no frost protection, when we have an area with not frost susceptible soil.

Water will occur in Germany everywhere – maybe in a very seldom case with a very high water permeability it can be missing – and that will only happen in not frost susceptible soils. So we have mostly to take bad water conditions into consideration.

The next factor is the traffic. The effort in frost protection has to be increased with the increase of traffic (picture 3).

All these factors are combined in a formula (picture 4, 5), which leads in a rather simple way also by taking into consideration the local conditions to the depth of frost protection.

Depending of the amount of traffic (counted are only the good vehicles and they are converted in equivalent 10 t- axles and summed up to 30 years), and the sort of road base (gravel, coarse aggregates, asphalt base, stabilization with cement) we find in Table 1 (picture 6) the construction for an asphalt pavement and in Table 2 (Picture 7) for a concrete pavement including the thickness of the frost protection layer. Picture 6a and 7a are copies of the original German standard-constructions, pictures 6b and 7b are magnifications of the upper part of the left side of 6a and 7a.

I talked about the fixing of the not frost susceptible thickness of the pavement of a road. It contains of the asphalt-layers or a concrete pavement, mostly installed on a stabilization with cement. The rest down to the required depth of not frost susceptible layers is the sub-base (frost protection layer). The most important criterion for the sub-base is a content of grain size below 0,06 mm of 5 %.

Another possibility of frost protection is the construction of a full depth bounded asphalt - or concrete pavement. The thickness of these construction must be so large, that it sustains the traffic in the period of thaw - it means a frost susceptible base complete full of water, that is to say without bearing capacity. In this case we use the following constructions: (picture 8a/b).

The stabilization is mostly carried out with a not frost susceptible soil and cement. But it is possible to use a frost susceptible soil; then the cement-content must be chosen so that the mixture passes a special test with frost-thaw changes. In my experience it is economical only for low frost susceptible soils. In a special initial suitability test with frost-thaw-cycles the mixture must be optimized as a not frost susceptible material.

So we have a rather widespread system of frost sustainable construction. It is the task of planer and the expert of soil and foundation to find the most economic design.