MODELING GRAVEL ROAD DETERIORATION

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1. INTRODUCTION

Finland has about 80,000 km public roads and 30,000 km of them are unsurfaced gravel roads, so called low volume roads with their average daily traffic (ADT) typically 50-300 vehicles a day. The maintenance costs of gravel roads per vehicle are almost twice as high as those of asphalt paved roads. The most expensive maintenance operation is gravelling: roads are treated with crushed material (150-300 t/km) usually every third year. Despite of gravelling and other maintenance activities, road surface may still be in poor condition: there occur potholes, loose gravel, dust and corrugation during the maintenance season.

Most of the previous gravel road research that has been conducted has focused primarily on maintenance materials and dust binding methods. Few studies have examined effects of surroundings, weather or subsoil although they all are assumed to be relevant factors when evaluating gravel road deterioration. This is probably because those factors can not be affected by routine maintenance. The aim of this study is to find out the most significant variables affecting the gravel road deterioration and especially the most important properties of the maintenance aggregate concerning gravel road surface quality. The variable groups assessed are shown in Fig 1.

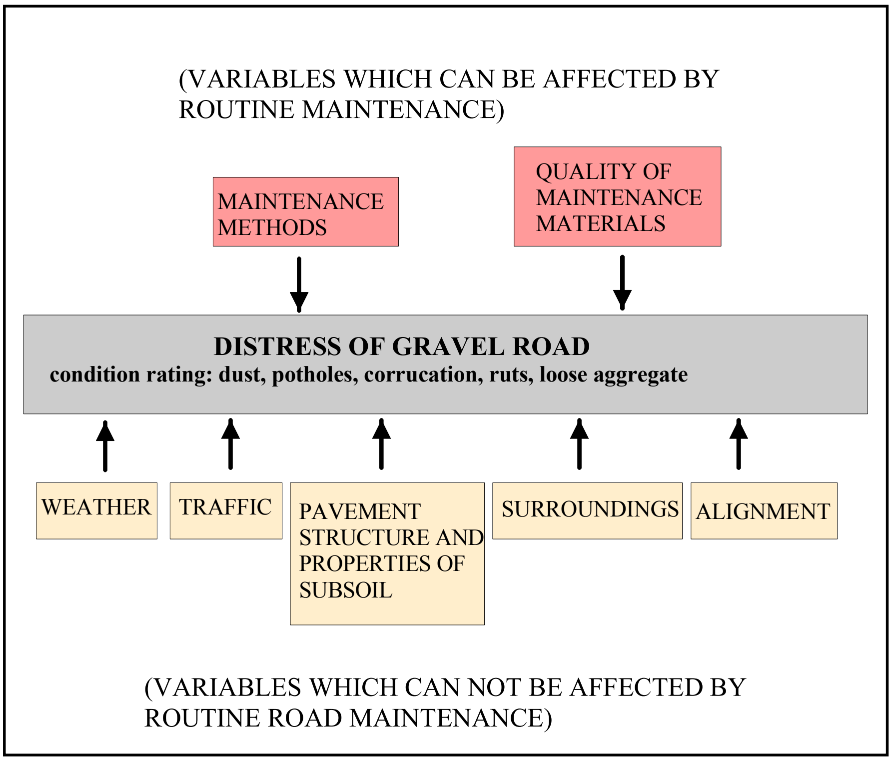

Figure 1: Variable groups assessed in this study

2. THIS STUDY

We collected data from 15 different test roads from West and Central Finland. The categories considered are: maintenance materials, maintenance methods, weather, traffic, subsoil and road structure, surroundings and alignment (Fig 1). Data is collected by sampling, observing and interviewing road inspectors. Each road had 2-8 observation sites depending on surface quality. Distresses were visually assessed by video: potholes, loose aggregate, corrugation, dusting and ruts. In addition to the distressed areas the excellent surface sites have also been evaluated. This assessing was done by video, 6 times during summer months.

3. RESULTS

All the data collected is not assessed thus far. The project will be finished in 2004 and the final results are then published. However, after the first year experience we assume that it is possible to achieve good surface condition of gravel road although the roadside area is open, ADT is quite high and weather is dry. Usually if the road is in shadow the surface is firm, some potholes may still occur, but if there is no shadow of trees and the weather is fine, loose aggregate and dust are typically seen on the road and road side area. There was however one exception in our test road network. Although surrounded by fields, this particular road surface showed a proper behaviour. This successful behaviour is assumed to be due to suitable materials and not of favourable surroundings

Figure 2: Surface condition of firm and well performed test road in July 2001

According to our study the particle size distribution of coarse material (0.063 – 16 mm) does not explain the surface quality of gravel road: there were same kind of materials in different roads and they did not performed equally, even on the same road, the same material performed differently depending mainly on surroundings. There are supposed to be more powerful factors than particle size distribution of coarse material which affect to the deterioration of surface layer. Clay content (amount of particles finer than 0.002 mm) of surface material explained deterioration in some cases quite well. Low clay content, in dry conditions, indicate ravelling and dusting, whereas high clay content in moist conditions indicate potholes and ruts.

The evaluation of mineral composition is not finished but according to preliminary results, mineral composition or rock type is not the strongest variable. However is was found that aggregate containing mica seemed to powder adding cohesive soil whereas crushed gravel high in hard minerals, as quartz and feldspar, has no sufficient binding capacity. Secondary materials like soft aggregates, gravel rich in humus and glacial tills, are expected to suit for maintenance materials because of reactive fines. The fine fraction of first-grade aggregate is not usually cohesive enough for gravel road maintenance purposes and in addition hard first-grade aggregate is more expensive than secondary and should also for that reason be saved for asphalt pavements and concrete structures.

As predicted the moisture content of surface layer is higher in shadow than in open areas. When measuring moisture content of gravel road surface layer, after dry weather period, the range of it was 4 % depending on measuring site. In particular spruce wood near roadside keeps the road shaded well from direct sunlight especially in North-South direction. In most cases shadow of trees and soil type explained surface quality well: peat land indicated pot-holes, ruts and sometimes corrugation whereas dry forest soil and ridges predicted dusting. According to our observations, the sites where frost damages were repaired using geotextile and new layer materials, were dry and dusty. This is mainly because of the geotextile (and coarse material) prevents capillary rise of water from ground water table to the surface layer of gravel road. The structures of test roads will be divided in two categories - dry and wet - by observing ditches, layer thickness, soil type and base coarse materials. Dry structure indicate loose gravel and dusting whereas wet rutting and softening.

4. CONCLUSIONS

In Finland the quality of crushed rock or crushed gravel is overall quite good and the range of hardness is relatively narrow as compared to the situation in many other countries. Nevertheless, the secondary but still strong materials should be utilized as maintenance materials in gravel roads rather than in bitumen or cement bound mixtures. Secondary materials with appropriate fine content perform well in general on gravel road surface layers. Particularly, in arid areas where the cohesive soil is needed to resist raveling, the use of secondary materials should be highly increased. According to this study crushed stone fines mixed together with coarse material and, on the other hand, crushed glacial till were the most promising secondary materials. The fine crushed rock is by-product of aggregate industry and have been used slightly as maintenance material during past years in Finland.

We assume that appropriate material makes it possible to achieve well performing gravel road surface but it does not guarantee it anyway. Other factors, for example, surroundings, weather or traffic may be stronger variables than quality of material. However, if road surroundings and other relevant factors are studied, it will be easier to predict the roads or road sections which need special treatment or materials. Using this predicting classification cost-effectiveness of maintenance methods and surface quality may be improved.

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