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Maintenance and Rating of the Condition of Gravel Roads in Finland

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Factors connected with the summer maintenance of gravel roads in Finland are discussed. The gravel roads have been divided into five maintenance classes on the basis of average daily traffic. The amount of maintenance operations (dust binding, graveling, grading, and dragging) depends on the road maintenance class as decided by the Road and Waterways Administration (TVH), which is responsible for the maintenance of public roads. The local road authorities (maintenance supervisors) decide when the gravel road requires maintenance by using the quality standard of TVH. The condition of the road has been described by five different classes (0-5), each of which has been given a minimum service level below which the condition of the road may may not fall. Because the determination of the service level depends on the subjective view of the person evaluating the condition (maintenance supervisor), the Road and Traffic Laboratory at the Technical Research Centre of Finland (VTT) made a test in which the condition of a road determined by using the quality standard (0-5) was compared with the condition of the road measured with a bump integrator (in centimeters per kilometer). The results showed that it is possible to determine the road condition with subjective evaluation based on the quality standard so that it correlates well with the roughness measured with the bump integrator. The Road and Traffic Laboratory used a bump integrator to study how the condition of the road changes after grading when the traffic volume increases before the next grading. The tests were made on three gravel roads that had an average daily traffic of less than 500 vehicles. The result shows, for example, that in normal weather conditions the condition of the road starts to deteriorate considerably when the traffic volume is about 8500 vehicles after grading. During a long dry period, deterioration is clearly faster.

The length of the public road network in Finland is about 75 000 km; 50 percent are gravel roads, 30 percent have oil-gravel surfacing, and 20 percent asphalt concrete surfacing. The Roads and Waterways Administration (TVH) is responsible for the condition of public roads. It comprises the Administration and 13 road and waterway districts that have been divided into 172 maintenance areas, each headed by a maintenance supervisor. The maintenance area is responsible for all maintenance operations in the area that are within the scope of TVH and for the tasks given by the road and waterway districts.

The maintenance of gravel roads is divided into winter and summer maintenance. The former includes removal of snow and de-icing (sanding and salting); the latter includes dust binding, graveling, grading, and dragging. In addition, on gravel roads the structure must be improved; i.e., the bearing capacity of the road must be improved and the gravel road surfaced. Although traffic and transport account for only about 12 percent of gravel road kilometers, summer maintenance and structural improvement of these roads require more than 25 percent annually of the allocations reserved for the maintenance and strengthening of the public roads in Finland.

This paper deals with the summer maintenance of gravel roads, which in Finland extends from April to November, seven to eight months. The permitted axle load and multiple-axle load are generally 10-16 tons. In spring during ground thaw the weight of the vehicles must be restricted on road sections that have weak bearing capacity, about 7300 km of gravel roads in 1981 (20 percent of the total length of gravel roads).

The planning of gravel road maintenance follows the maintenance standards of TVH (1). The standards divide the gravel roads into different maintenance classes, give the material and work quotas for different maintenance works, give each maintenance class a minimum service level, and also give information on various work methods, duration of work, and costs.

The maintenance classes of gravel roads are divided into five classes on the basis of average daily traffic (ADT) as follows:

Maintenance Class	ADT	Length of Gravel Road (%)
3	1501 - 6000	0.1
4	501 - 1500	1
5	201 - 500	17
6	101 - 200	37
7	≤100	45

The amounts of material and work expended vary annually, depending on the weather, and therefore the values given in the standard are the means of five years. In considering the differences between the amount of work in different maintenance areas, a so-called condition coefficient is used, from 0.8 to 1.2. The quantity standards are used when the annual maintenance budget is drafted, in allocation of resources, and in planning the maintenance operation during the work period.

The amounts of calcium chloride ($CaCl_2$) used annually for dust binding on gravel roads and the average amounts of crushed gravel used annually in summer maintenance of gravel roads, by maintenance class, are given below:

		Material Used	
Maintenance Class	Width of Road (m)	$CaCl_2$ (tons/km)	Crushed Gravel (m^3/km)
3	4	-	-
	5	-	-
	6	5.0	69
	7	5.2	72
4	4	-	-
	5	3.4	55

Maintenance Class	Width of Road (m)	Material Used: $CaCl_2$ (tons/km)	Material Used: Crushed Gravel (m^3/km)
	6	3.7	59
	7	3.9	63
5	4	2.1	42
	5	2.3	47
	6	2.6	51
	7	2.9	55
6	4	1.4	35
	5	1.7	39
	6	1.9	43
	7	2.2	47
7	4	0.9	28
	5	1.2	32
	6	1.4	36
	7	1.7	40

Natural gravel can be used 1.5-2.0 times more than crushed gravel depending on the costs.

The annual average amounts of work used for summer grading and dragging on gravel roads in different maintenance classes are given below:

Maintenance Class	Grading and Dragging (times/year): Southern Finland	Central Finland	Northern Finland
3	44	35	24
4	36	29	19
5	28	23	15
6	21	16	11
7	14	11	7

In determining the ratio between grading and dragging, the number and type of graders and drags available in the maintenance area should be considered and also the most economic mode of reshaping. The proportion of dragging is generally 0-40 percent and, in determining its share, account should be taken of the changes in the costs and quality of reshaping. One reshaping comprises reshaping once in each direction.

For instance, by using the amount standard given above for crushed gravel, the maintenance supervisor can estimate how much crushed gravel is needed in graveling by determining first the length and width of the gravel roads in the maintenance area in each maintenance class. Then the amounts of crushed gravel (in cubic meters per kilometer), depending on road maintenance class and width, are multiplied by the length of the roads to determine the needed total amount of crushed gravel. The maintenance supervisor decides how urgent the maintenance works are and when they should be done by using the TVH quality standard, where each maintenance class has been given a minimum level.

The condition of the gravel road is evaluated by using the evaluation scale in Table 1 for the condition of gravel roads. In evaluation, the maintenance supervisor determines first with which of the wearing course descriptions in Table 1 the real condition of the road corresponds. Then the evaluation may be amended, if necessary, to the upper or lower level of the description. The result is a figure (0-5) that describes the road condition. The rating is compared with the lower limits of the objective conditions of TVH given below:

Maintenance Class	Lower Limit of Objective Condition
3	3.3
4	2.8
5	2.4
6	2.0
7	1.5

If the figure given by the maintenance supervisor is lower than the road should have, the necessary maintenance work (graveling, grading, dragging, and dust binding) should be started, weather permitting, to raise the condition of the road above the lower limit. The condition of the drainage system of the gravel road is checked separately.

The selection of the minimum service level of the wearing course on gravel roads can influence maintenance costs considerably because the higher the service level to be maintained on gravel roads, the more it costs. To state in the best possible way the point at which the road falls below the minimum service level requires that the road condition be determined as objectively as possible--for instance, with an apparatus that measures road condition. In Finland, the maintenance supervisors, who number 172, are responsible for the condition of the gravel roads, and no apparatus has so far been found that is economical and simple enough for the maintenance supervisors to use in evaluating road condition. Therefore, the evaluation of road condition is based on the previously presented subjective evaluation.

The Road and Traffic Laboratory of VTT made a test in the summer of 1981 to find out whether such a subjective evaluation (Table 1) gives a consistent and reliable description of road condition. The subjective values were compared with roughness figures (in centimeters per kilometer) obtained with a bump integrator because the unevenness of the road has great significance when decisions are made on maintenance operations (particularly grading and graveling). The measurements were made on three different test roads that have ADTs of 430 (test road 1), 190 (test road 2), and 300 (test road 3). The proportion of heavy traffic varied from 8 to 16 percent, depending on the test road, and averaged 12 percent.

In the determination of roughness, the same bump integrator was used on each road. The bump integrator registers the downward movement of the measurement wheel. Each time, the mean roughness was calculated from the results of four measurements, which were obtained by driving the test distance both ways two times at a speed of 32 km/h.

Figure 1 shows the correlation between the subjective value of road condition based on Table 1 (vertical axle) and the roughness measured with the bump integrator (horizontal axle). The results show that the road condition determined by using the subjective evaluation of gravel roads of TVH is very close to the actual condition. However, special attention should be paid to the compatibility between the estimations of the maintenance supervisors, who decide on the maintenance work, so that the differences in the levels in each maintenance class between the maintenance areas may be as small as possible. Compatibility could be aided--e.g., by enclosing photographs of the lower limit of each maintenance class to the quality standard to reduce the disparity in road condition evaluation.

Traffic volume and weather conditions are among the most important factors that change the condition of the gravel wearing course. The Road and Traffic Laboratory of VTT made an investigation in 1980 and 1981 on the three previously mentioned test roads to clarify the effect of traffic volume and weather on changes in road condition. The same bump integrator used in the previous tests was used to measure road condition.

The results for all test roads are shown in Figure 2. Roughness, shown on the vertical axle, describes the mean of the measurement results obtained when the test distances were driven twice in both directions at a speed of 32 km/h. The horizontal axle shows the traffic volume (sum of light and

Table 1. Rating scale for evaluation of condition of wearing course on gravel roads.

Rating	Condition
4.1-5.0	Road surface has maintained its shape and is very even and firm; possible unevenness of surface does not affect driving comfort
3.1-4.0	Road surface has generally maintained its shape and is even and firm; some single holes here and there; no dust; running speed can be maintained in spite of unevenness
2.1-3.0	Road surface has generally maintained its shape and is mostly even and firm; local small holes and unevenness; some dust; holes and uneven spots can be avoided, or they are such that the running speed can be maintained; in giving way to overtaking or oncoming vehicles a lower running speed should be used
1.1-2.0	Shape of road cross section may have changed somewhat; some "washboard waves" on surface; local settlements or humps marked with traffic signs; moderate dust; lower running speed sometimes needed and uneven spots must be avoided
0.1-1.0	Shape of road cross section has changed in several spots; surface is uneven due to holes, "washboard waves", and ravelings; settlements and humps on road that cannot be avoided; plenty of dust; road surface must constantly be watched and running speed changed often

heavy vehicles) on the test roads after the last grading. The open circles in Figure 2 show a situation in which the precipitation between two successive gradings on the different test roads was 2-4 mm/day, which corresponds to the normal climatic conditions in Finland in summer. The black circles describe the development of road condition during a long dry period (precipitation 0 mm).

Study of the road condition development in normal climatic conditions (the area in Figure 2 limited by solid lines) shows that, after grading, the roughness of the road is about 260-280 cm/km. Then the roughness increases fast with regard to traffic volume (about 3000 vehicles) because the traffic shifts the loose material to the edges of the road. When the traffic volume after grading has reached about 3000, the traffic does not wear the road surface as much as before. When the traffic volume exceeds 8000, the condition of the wearing course of the gravel road deteriorates very fast.

The changes in road condition during a long dry period (the dashed line in Figure 2) show that grading of a too-dry wearing course does not give as smooth a road surface as when the wearing course is suitably moist. It can also be seen that during long dry periods the road condition clearly deteriorates faster than during normal conditions.

Figure 1. Subjective evaluation of road condition versus roughness measured with bump integrator.

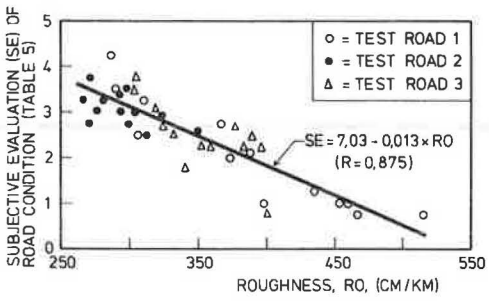
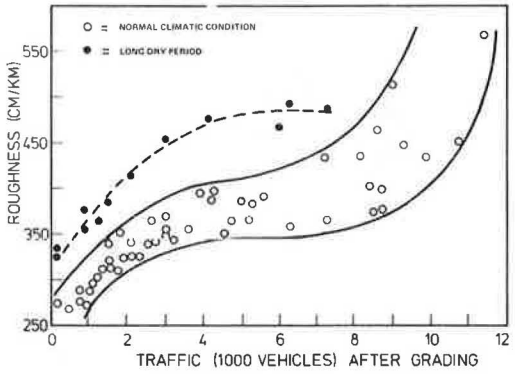


Figure 2. Effect of traffic and weather conditions on wearing course after grading on three test roads with 190-430 ADT.



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