THE DEVELOPMENT OF SANDING MATERIALS TO REDUCE STREET DUST

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1. Introduction

Street dust is a notable air quality problem in Finland's biggest cities. The sanding materials used for preventing skidding in the streets and the removal of these materials constitute the most important reason why the base values of dust volume are exceeded especially in the spring. Quartz is the primary cause of health hazards of the stone dust ingredients accumulated in the streets. Inhalation of quartz dust may cause silicosis. Exposure may also lead to lung cancer or may trigger off certain rheumatic diseases. Asbestos is even more dangerous, but fortunately this mineral is quite rare. In addition to lung cancer, asbestos causes pulmonary fibrosis. A long time lag from exposure to emergence of disease characterises these diseases.

The objective of this study was to develop a quality classification for the aggregates of sanding guiding the choice of materials in such a way that both the amount and hazard of dust would be reduced.

Of Finland's largest cities Helsinki, Tampere and Turku decided to participate in the study both financially and by arranging opportunities for measuring the dust concentrations of the work environment of maintenance workers. Lohja Rudus Oy Ab contributed in the capacity of stone aggregate supplier and The Uusimaa Regional Institute of Occupational Health (Uudenmaan aluetyöterveyslaitos) and The Geological Survey of Finland (Geologian tutkimuskeskus) in the capacity of dust analysts. Other sources of financing were the City of Espoo, The Finnish Work Environment Fund (Työsuojelurahasto), The Association of Finnish Local and Regional Authorities (Suomen kuntaliitto) and YTV (The Helsinki Metropolitan Area Council / Pääkaupunkiseudun yhteistyövaltuuskunta).

2. About the mineralogy of stone materials

Light-coloured stone species, comprising silicic stone species such as granites and quartzites generally contain an ample amount of quartz. For example, grey and red granite contain 20…40 % quartz. The quartz concentration in **dark-coloured stone species** is low or quartz may be even totally missing. These dark-coloured stone species include alkaline rocks such as gabbro, diabase (dolerite), peridotite and tonalite. The division of stone aggregate into light-coloured and dark-coloured can be carried out by a study in accordance with the standard SFS-EN-932-2.

A substance is classified to contain asbestos if asbestos constitutes more than 1 per cent of its weight. With regard to the choice of crushed aggregate for sanding it is important to keep in mind that several stone species with excellent strength and poor quartz concentration contain plenty of amphibole which may contain asbestos. Therefore, the raw materials of the aggregates used for sanding shall be

investigated and even during production shall be monitored that the products do not contain silicate fibres to be classified as asbestos and especially do not contain asbestos. Fibres in asbestos form may appear in certain dark-coloured stone species that have undergone metamorphosis. Pieces in fibre form may be found from even the most common primary minerals of stone species, but they must not be mixed up with asbestos.

Already at the beginning of the research it became clear, that the strength of the sanding aggregate does not have an influence to the amount and hazard of dust.

3. Prevention of skidding in the streets

The largest cities in Finland usually combat against skidding in their main streets by using salt, but in residential streets and in pedestrian areas crushed rock aggregates with grading of 1 ... 6 mm are used. However, in the City of Tampere the practice has been to use pit-run gravel. Substance below 1 mm has been removed from crushed aggregates by sieving or wet sieving. The primary purpose of sieving is reduction of dust formation. Experience has shown that the manageability of wet sieved crushed aggregates is better compared to pit-run gravel since the crushed aggregate does not tend to clod when freezing and it does not get vaulted at the connection point of the curb stone and the asphalt coating to complicate the cleaning work in the spring. Also dry sieved crushed aggregates are used. They typically contain a few per cent of < 0,063 mm particles.

According to Finnish legislation the cleaning of streets of sanding aggregate is part of skid prevention and the municipality takes care of it each spring as regards driveways. Suction sweeping machine, loader equipped with different kinds of sweeping equipment and lorries equipped with wash and irrigation equipment are used for the task. Of sweeping equipment the so-called sand hoisting bucket has proved to be the most efficient tool. Ample use of water is necessary in street cleaning. In order that an ample amount of water can be used reliable information must be available indicating that the street surface will not freeze after cleaning. Therefore, cleaning work in South Finland is often carried out in April, in regions further up north even as late as in May.

4. Dust exposure of workers

The total dust concentrations of the workplace air of maintenance machine drivers were measured in April 1999 during the spring cleaning of the streets of the cities of Helsinki, Tampere and Turku. A stationary collector device was used to measure background dust at a distance of 500…1500 m at the work location and the dust of the drivers' inhalation air at the work location was measured with a portable collector device. Machine drivers wore a collector device installed in their vests for the duration of the entire work shift.

The results showed that the total amount of dust in the drivers' inhalation air is 7 ... 10 -fold compared to the amounts of background dust. However, well below the permissible maximum value in force in Finland. The lowest values were obtained from a machine the cab of which had been particularly well-cleaned before the measurements. According to the results the amount of dust in the driver's inhalation air can be reduced to half by cleaning the cab properly.

5. Dust formation comparison of sanding materials

In spring 1998 an attempt was made in the traffic tunnel of the Mallaskatu Street in Helsinki to compare different sanding materials in practical traffic conditions. It was decided to use the tunnel as a test site because collection of sanding dust in open street space was deemed impossible due to uncontrollable wind conditions.

Crushed gravel aggregate of 1…6 mm and uncrushed pit-run gravel of 0…6 mm were compared in the tunnel. Clearly larger dust amounts were measured from a sanded street compared to a street that had not been sanded. Also the surface of a dry street was observed to have raised more dust compared to a wet street. The dust formation of gravel and crushed aggregate were just about similar. The different weather conditions of the test days, especially variation of the humidity of air and the mineralogical similarity of the sanding materials and asphalt brought undesired dispersion to the results. As the result it was stated that research conditions shall be made constant with regard to air temperature and humidity as well as windiness. Therefore, the laboratory studies were carried out at Porvoo indoors at the bearing capacity test course of Fortum Oil & Gas Oyj.

The work at the capacity test course was started by clarifying with the help of pre-experiments the values of variables with which it would be best to conduct the actual tests since there is no standard for the purpose. The pre-experiments consisted of three stone materials: two of crushed rock aggregate and one of uncrushed gravel. Two samples had been prepared of each: dry sieved 0 … 6 mm and wet sieved 1 … 6 mm. At first, the course was surfaced with asphalt concrete with a maximum grain size of 8 mm.

The tests used Nokia Hakkapeliitta 1 brand tyres that were studded with Kometa Marathon P8-100/1.1 g studs. Tyre pressure was 2.0 bar and the load of one wheel 3 kN.

Based on the pre-experiments it became clear that the capacity course is suitable for comparing the dust formation properties of sanding materials. The actual achieved result was that the washing of stone material reduces the total dust amount generated from crushed rock aggregates by about 15 % and the dust amount generated from pit-run gravel by about 25 %. The difference of the dust amount between crushed rock aggregate and gravel was small mainly due to the fact that gravel grains are round and can better resist fracturing and thus dust formation. In addition, a grain with non-fractured surface flies more easily aside from the driveway outside the reach of stud strokes and friction.

In the actual tests it was decided to use the following procedure:

- 3 litres i.e. 0.5 litres/m^2 of crushed aggregate is spread (the mass varied according to the density of stone)
- the wheel is adjusted to travel at the speed of 10 km/h, the test lasts 40 min
- dust is collected with two filters installed to the height of 1.2 m
  (six filters on top of each other at heights of 0.6…2.1 m all gave the same result)
- the course and room space are cleaned with two industrial vacuum cleaners between each test and at the same time the room is aired to the outdoor space.

For the actual test series it was decided to surface the course with slag asphalt with maximum grain size of 12 mm. Slag asphalt was chosen because the particles extracted from it by studded tyres become distinct from the particles of sanding materials when analysing dust e.g. due to the fact that they do not contain quartz at all.

Eight different stone aggregates were chosen for the dust formation comparison all of which have been used to manufacture crushed sanding aggregates for the cities participating in the study. The tests were performed in the above mentioned manner. Total dust quantities measured from the dust collection filters were quite close to each other. The share of quartz of the total dust quantity was directly proportional to the mineral composition of the stone aggregates. However, quartz does not appear in total dust in the same proportion as it appears in stone aggregate. For example, the Koskenkylä stone used by the City of Helsinki contains 40 % quartz, but total dust contains only 7.5 % of it. This is due to the fact that quartz is a hard mineral and does not tend to become ground into a dust grade.

Based on the results the people taking care of street maintenance have quite limited opportunities for reducing the total dust amount generated by sanding. Instead, the hazard of dust is smaller when stone aggregates with small quartz concentrations are chosen for sanding. Of course, they may not contain silicate fibres to be classified as asbestos or even asbestos itself. Dark-coloured stone aggregates should thus be chosen for sanding.

Grains with natural surface are not pulverised easily . However, they do not attach properly to their base and, as a result, do not generate friction in the best possible way. That is why the use of crushed aggregates is recommended. However, crushed aggregates do not often grip well enough, especially on the driveway.

6. Classification of sanding materials

A report has been published on the results of the study. The name is the same as the name of this paper. For the time being the entire paper is available only in Finnish. As the end result the report presents classification of the sanding materials of driveways which is as follows. Class 1 is the best and class 4 is the weakest.

1. Wet sieved crushed rock aggregates, dark-coloured stone species, passing of a # 0.5 mm sieve 0…5 %.
2. Wet sieved crushed rock aggregates or crushed gravel aggregates, light-coloured stone species, passing of a # 0.5 mm sieve 0 …5 %.
3. Dry sieved sanding materials, penetration of # 1 mm maximum 20 %.
4. Pit-run gravel, grading 0…5.6 mm.