Freezing prevention pavement using rubber powder

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Abstract

Here introduced is a newly developed freezing prevention pavement using rubber powder made from waste rubber. Freezing prevention pavement generally utilizes mechanisms and materials which have chemical and/or mechanical freezing prevention properties.
Freezing prevention pavement is being used in several areas in Japan. However, due to its disadvantages, includingless durability and higher cost in comparison to regular pavement, few construction projects are employing this material. However, there is great demand for a cost-effective and serviceable freezing prevention pavement.
In light of this, we have developed freezing prevention pavement with higher durability and lower cost than existing freezing prevention pavement, using rubber powder. Here we report the results of laboratory confirmation testing of the temperature characteristics of the newly developed pavement, and of a follow-up survey of a trial construction project.

1. Introduction

Freezing prevention pavement prevents the road surface from freezing, improves the efficiency of snow removal, and enhances traveling safety. In Japan, various kinds of freezing prevention pavement have been developed, through chemical, physicochemical or physical means, or through roughening the surfaces. We have developed a novel freezing prevention pavement containing rubber powder, which physically prevents freezing. This report summarizes the results of an indoor test of the pavement, and of a trial construction project utilizing the material.

2. Properties of rubber powder

There are many kinds of freezing prevention pavement using rubber. The majority use rubber chips of 1 mm or larger in particle diameter. Our material, however, uses rubber powder instead of rubber chips, and exploits the freezing prevention characteristics of such powder. The properties of the rubber powder are described in detail below. (Here, rubber pieces of less than 0.6 mm in particle diameter are collectively referred to as rubber powder, while those of 0.6

mm or more are called rubber chips, for convenience.)

(1) Characteristics of the rubber powder

Rubber powder used in the novel material (made from waste tires) is shown in Photo 1; rubber chips widely used in freezing prevention pavement are shown in Photo 2.

Photo 1 Rubber powder
(Particle diameter: 0.3 mm or less)

Photo 2 Rubber chips
(Particle diameter: 1 to 5

(2) Particle diameter and skid resistance of rubber powder

Photos 3 to 6 show skid resistance tests conducted by applying a special adhesive agent to a steel plate, spreading rubber chips and rubber powder of various particle diameters, and measuring the resulting skid resistance using a dynamic friction (DF) tester (ASTM E 1911-98). The dynamic friction tester measures the skid resistance of a surface by rotating a disk covered by hard rubber and pressing the hard rubber against the surface. The skid resistance was roughly μ = 0.3 (80 km/hr) for all tested specimens, regardless of rubber particle diameter. This skid resistance measurement was conducted to compare the effect of rubber particle diameter; the skid resistance of pavement coated with rubber chips or powder is 1 to 2% lower than that of standard (non-rubberized) pavement.

Photo 3 Rubber particle diameter: less than 2.5 to 1.2 mm

Photo 4 Rubber particle diameter: less than 1.2 to 0.6 mm

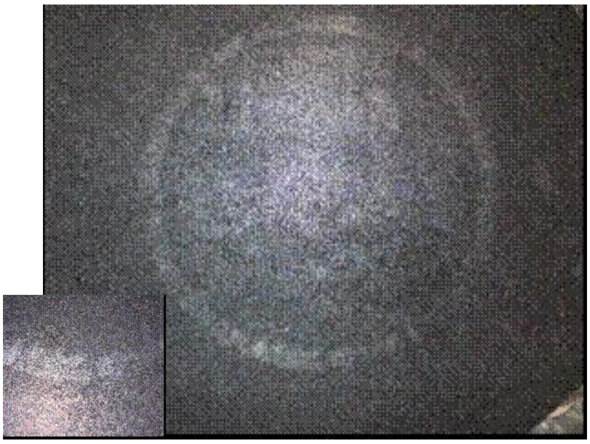

Photo 5 Rubber particle diameter:
less than 0.6 to 0.3 mm

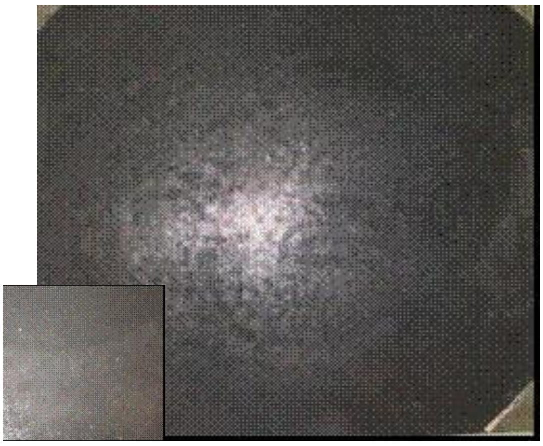

Photo 6 Rubber particle diameter:
less than 0.3 mm

(3) Particle diameter and durability of rubber powder

The amount of rubber chips or powder stripped from the surface of the specimens by the DF tester, after the skid resistance measurement, differed depending on particle diameter (Photos 3 to 6). The hard rubber of the DF tester stripped off:

(i) roughly half of the rubber chips in Photo 3 (particle diameter less than 2.5 to 1.2 mm),

(ii) roughly half of the rubber chips in Photo 4 (particle diameter less than 1.2 to 0.6 mm),

(iii) roughly one-third of the rubber powder in Photo 5 (particle diameter less than 0.6 to 0.3 mm), and

(iv) almost no rubber powder in Photo 6 (particle diameter less than 0.3 mm).

The results suggest that rubber powder of less than 0.3 mm in diameter is more strongly adhesive and more durable than rubber chips (0.6 mm or larger).

3. Characteristics of the rubber-powder freezing prevention pavement, and construction methods

(1) Characteristics

The rubber-powder freezing prevention pavement physically prevents the road surface from freezing, through the adhesion of rubber powder to the concave surfaces of the pavement (Figure 1). This adhesion causes rubber aggregation in the voids, which in turn prevents snow on the road from glaciating and adhering to the road surface. Therefore, the snow pack on the road surface is easily broken and removed by the traffic load. The rubber powder on the pavement surface also increases the temperature of the pavement surface slightly, which further prevents the road surface from freezing.

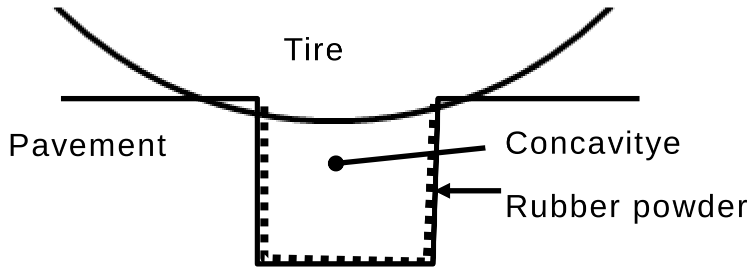

Fig. 1 Schematic illustration of freezing prevention using rubber

In the rubber-powder freezing prevention pavement, the rubber powder bonds to the concave surfaces of the pavement with a special adhesive agent, and may become detached after long service. However, in such a case, freezing prevention may be restored by simply applying rubber powder once again, and may be maintained as long as the concavities and voids in the pavement surface are sufficiently pronounced.

(2) Construction

Construction methods using the novel freezing prevention pavement are described in this section. The methods differ for drainage pavement, which has a rough surface, and dense graded pavement, which has a smooth surface.

In the case of drainage pavement, the rubber powder is simply applied after washing the pavement with a water jet to remove any soil and sand from the concavities and voids (Photo 7).

In the case of the smooth and dense surfaces of dense graded pavement, however, the rubber powder may have difficulty bonding with the surface; therefore, the pavement surface must first be sufficiently roughened by grooving, etc. (Photo 8).

Photos 9 and 10 (roughly 20x magnification) show a void on the surface of drainage pavement before and after application of the rubber powder, respectively. In Photo 10, a number of rubber powder particles are visible on the surface of aggregates within the void.

As described, the rubber-powder freezing prevention pavement may be utilized both as part of new pavement and as a layer applied to existing pavement, as long as the respective surface is sufficiently rough or replete with concavities and voids.

Photo 7　Surface of drainage pavement after application of rubber powder

Photo 8　Surface of dense graded pavement after application of rubber powder (and grooving)

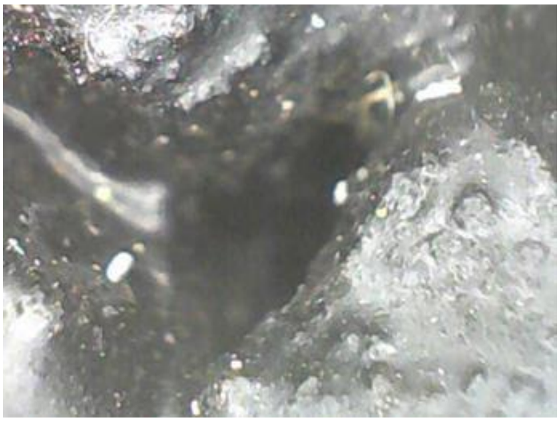

Photo 9　Void on drainage pavement before application of rubber powder (20x magnification)

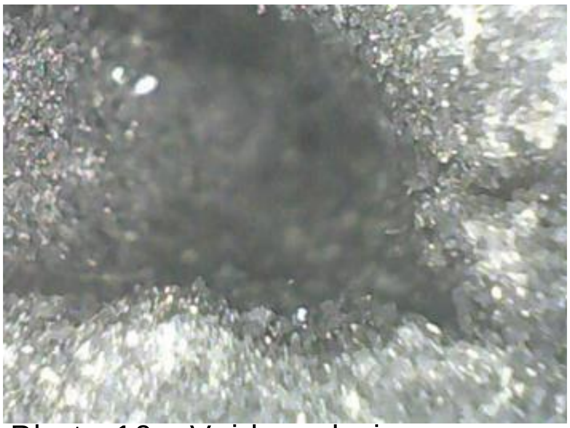

Photo 10　Void on drainage pavement after application of rubber powder (20x magnification)

4. A trial construction project using rubber-powder freezing prevention pavement

Here we describe an in-service road-section trial construction project utilizing rubber-powder freezing prevention pavement.

(1) Overview of the trial construction project

・Project date: November 2012

・Project location: Sumita-cho, Kesen-gun, Iwate,Japan

・Project scale: Width 5.0 m × Length 32.4 m = 162 m^2

・Existing pavement: Dense graded concrete asphalt (Photo 11); longitudinal slope: roughly 10%

(2) Construction process

The construction process involved the following steps:
(i) Cutting longitudinal grooves (Photo 12) ⇒ (ii) Cleaning the pavement ⇒ (iii) Applying a special adhesive agent (Photo 13) ⇒ (iv) Spreading rubber powder (Photo 14) ⇒ (v) Removing and collecting excess rubber powder (Photo 15) ⇒ (vi) Spraying nonskid agent (if necessary) ⇒ (vii) Curing


Photo 11 Existing pavement surface before rubber powder application

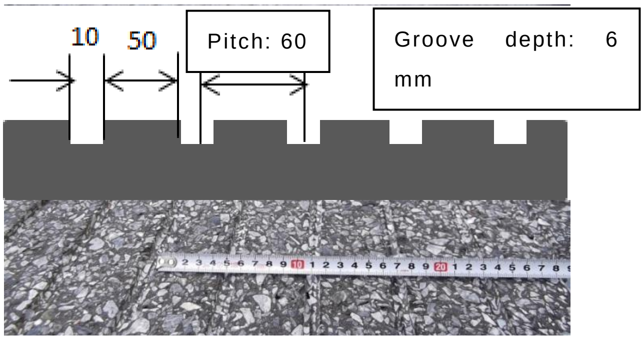

Photo 12 Pavement surface after grooving


Photo 13 Application of the special adhesive agent


Photo 14 Spreading rubber powder


Photo 15 Removing excess rubber powder

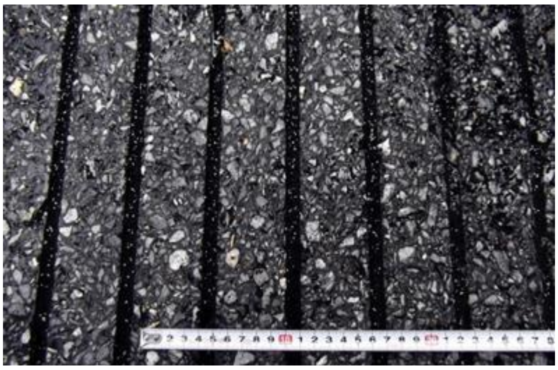
Photo 16 Surface of the completed pavement

(3) Results of the trial construction project

The completed pavement is shown in Photo 17. Photo 18 is a thermograph of the pavement surface after the application of the rubber powder. The temperature of the pavement surface to which the rubber powder was applied was 4 to 5 °C higher than that of surface to which the powder was not applied.

Photo 17 Rubber-powder freezing prevention pavement (dense graded asphalt + grooving)

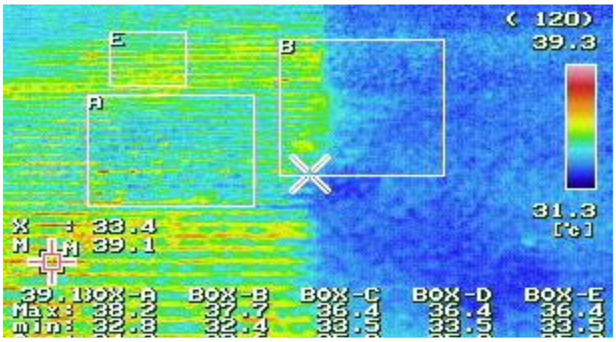

Photo 18 Thermograph showing the temperature of the respective pavement surfaces; with rubber powder (left), without rubber powder (right)

5. Summary of the results

The snow melting state for a snow cover depth of 10 to 20 cm and air temperature of -5 °C, at 7:50 A.M., is shown in Photo 19. The photograph shows that the rubber-powder freezing prevention pavement section was more exposed (indicated by arrow, uphill lane) than the other (untreated) sections. The effect is not as apparent in the downhill lane, because of low traffic volume, but we confirmed that the snow in the grooves was not compacted but instead sherbet-like.

Photo 19 Freezing prevention under snow

6. Conclusions

The trial construction project demonstrated that the rubber-powder freezing prevention pavement was effective in preventing the road (dense graded asphalt + grooving) from freezing. The material is inexpensive, simple and easy to utilize, and may be used for both new and existing pavement as long as the respective surface is sufficiently rough. The trial pavement will be monitored to assess its durability.