



**PROCESS FOR PRODUCING CONCRETE
CONSTRUCTIONS HAVING WATER PERMEABILITY**

The present invention relates to a process for producing an improved concrete construction having water permeability.

One of the harmful effects of the growth of urban area is that percolation of rain water downward through the soil is inhibited by asphalt and concrete pavement. This can cause depletion of underground water levels, which in turn can cause ground subsidence, the inhibition of the growth of plants or trees, changes in the ecology of the organisms in the soil, and other undesirable effects. Moreover, heavy rain can collect and cause localized flooding in a pavement area because the water is unable to disperse sufficiently quickly.

In order to try to avoid such disadvantages, asphalt pavement having water permeability has been developed. However, such asphalt pavement has many problems, such as insufficient water-permeability and water-holding properties, a tendency for the voids which contribute to the water permeability to become blocked due to softening of the asphalt in hot weather, and a marked deterioration of asphalt over the course of time. Therefore, a pavement construction having superior water-permeability and water-holding properties has been developed, which is produced by using cement instead of asphalt (Japanese Patent Laid-Open (KOKAI) 59-206502 (206502/1984)).

This concrete construction having water permeability nevertheless has a problem in that solid particles such as dust or rubbish can enter the voids in the surface of the construction which contribute to the water permeability, so that the water permeability is gradually lowered.



It is known to produce a cement concrete pavement having a superior surface appearance by shot blasting the surface of the hardened cement concrete pavement with a conventional polishing machine which uses iron balls or sand, in order to remove hardened cement mortar at that surface to reveal cement aggregate at the surface and which may have its natural colour or be artificially coloured with a colouring agent.

However, if such shot blasting is used on a surface of a cement concrete pavement having water permeability, the iron balls or sand used can enter the voids which contribute to the water permeability, so that the water permeability is lowered. Also if iron balls are used, the appearance can be markedly impaired by the rusting of iron. Furthermore, when the shot blasting is carried out in rain, it is difficult to withdraw the used iron balls and re-use the wet iron balls, so that operational efficiency is reduced. Moreover, it is impossible to treat the edges of a pavement by shot blasting, so that a uniform finish is difficult to obtain.

The invention has been made from a consideration of the above-noted problems.

In accordance with the invention there is provided a process for producing a concrete construction having an improved surface appearance and water permeability, comprising the steps of:

(i) preparing a concrete composition of:

(a) 300 to 400 kg of cement per 1 m³ of the concrete composition,

(b) 0.008 to 0.04 parts by weight of binder per 1 part by weight of cement,



(c) 0.3 to 0.45 parts by weight of water per 1 part by weight of cement, of water, and

5 (d) 1,790 to 2,150 kg per m^3 of the concrete composition of aggregate comprising sand and at least one of crushed stone and gravel, in the ratio by weight of 5:95 to 20:80, said crushed stone, if present, comprising from 70-100% by weight crushed stone with a grain size of 2.5 to 5 mm and from 0-3% by weight crushed
10 stone with a grain size of 5 to 13 mm, and said gravel, if present, having a grain size of 5 to 10 mm;

(ii) hardening the concrete composition to form a concrete construction having water permeability; and

15 (iii) applying water having a pressure of 1,000 to 2,500 kgf/cm^2 to a surface of the concrete construction to remove hardened cement mortar covering aggregate at that surface.

In preferred embodiments of the present invention, the
20 water permeability of the concrete constructions is not reduced but is actually significantly increased. Moreover, it is possible to produce concrete constructions in the form of pavement in which it is difficult for solid particles such as dust or rubbish to enter the voids of the
25 exposed surface, so that the high water permeability remains for a long period of time. Furthermore, these advantages are achieved without impairing appearance. It is possible easily to adjust the pressure of the super high pressure water which is used to remove the cement mortar in
30 accordance with the consistency of the cement paste and the thickness of the cement mortar covering the aggregate, so that the operation can be carried out efficiently.

Moreover, it is possible to treat the edges of a concrete construction in the form of pavement.

The cement which can be used in the process according to the present invention includes, for example, Portland
5 cement, such as normal or high-early strength Portland cement, Portland blast furnace cement and silica cement, but preferably is normal or high-early strength Portland cement, in particular, normal Portland cement.

The amount of cement to be used is 300 to 400 kg,
10 preferably 320 to 370 kg per 1 m³ of the concrete composition. If the amount of cement is less than 300 kg, the strength of the cement construction is insufficient, and if the amount of cement is more than 400 kg, the strength of the cement construction is increased but the
15 water permeability is reduced.

The binder has the function of increasing the water permeability of the concrete construction, in addition to its known functions such as increasing the binding strength among aggregates, decreasing contraction when the concrete
20 composition is dried and increasing the ease of workability due to improvement in consistency. The binder makes the surface of the layer of cement mortar covering the aggregate smooth, whereby the phenomenon of foaming which can occur due to air bubbles in water when water passes
25 through the voids of the concrete construction, is suppressed. Also, the binder leads to the forming of voids which connect with one another in the interior of the concrete construction, whereby the ratio of continuous voids in the concrete construction is increased.

30 The binder which can be used in the process according to the present invention includes all types of binders which are added to cement mortar in general, for example, natural

or synthetic rubbers such as styrene-butadiene rubber (SBR) or butadiene-acrylonitrile rubber (NBR), acrylic resins and epoxy resins. The binder is usually added as an emulsion. Examples of preferred binder emulsions are JSR TOMAC SUPER
5 (produced by Japan Synthetic Rubber Co. Ltd., the emulsion having a 45% solid content) which contains latex binder of the styrene-butadiene rubber type, and X-5142 (produced by ACR Co. Ltd.) which contains acrylic binder. If JSR TOMAC SUPER is used, the bending strength of the concrete
10 construction is increased by about 10 to 60% whilst when X-5142 is used, the bending strength of the concrete construction is increased by about 60 to 90%.

The amount of the binder to be used is 0.008 to 0.04 parts by weight, preferably 0.015 to 0.03 parts by weight, per 1
15 part by weight of cement. If the amount of the binder is less than 0.008 parts by weight, the strength of the concrete construction is insufficient, and if the amount of the binder is more than 0.04 parts by weight, the water permeability deteriorates.

20 The amount of water to be used is 0.03 to 0.45 parts by weight, preferably 0.35 to 0.40 parts by weight, per 1 part by weight of cement. If the amount of water is less than 0.03 parts by weight, it is impossible to prepare a concrete composition having a sufficient homogeneity, and
25 if the amount of water is more than 0.45 parts by weight, the water permeability deteriorates.

Sand which can be used in the aggregate in the process according to the present invention includes all sands which are generally used, such as natural sand, artificial sand
30 or screenings.

The crushed stone which can be used in the aggregate in the process according to the present invention comprises at

least 70% by weight of crushed stone which has a grain size of 2.5 to 5 mm. By this is meant that 100% of the crushed stone is capable of passing through a sieve having 13 mm sieve openings (corresponding to a standard sieve of JIS (Japanese Industrial Standard) which has 12.7 mm sieve openings), 85% to 100% of it can pass through a sieve having 5 mm sieve openings (corresponding to a standard sieve of JIS which has 4760 μ m sieve openings), 0 to 25% of it can pass through a sieve having 2.5 mm sieve openings (corresponding to a standard sieve of JIS which has 2380 μ m sieve openings), and 0 to 5% of it can pass through a sieve having 1.2 mm sieve openings (corresponding to a standard sieve of JIS which has 1190 μ m sieve openings). In particular, the preferred crushed stone used according to the present invention is that of S-5 (7 Size) of JIS.

It is also possible to use up to 30% by weight, preferably 10 to 30% by weight, of a crushed stone which has a grain size of 5 to 13 mm, in particular, crushed stone of S-13 (6 Size) of JIS. If crushed stone having a grain size of 5 to 13 mm is used, the strength of the concrete construction is increased more.

The gravel which can be used in the aggregate in the process according to the present invention has a grain size of 5 to 10 mm.

The ratio by weight of sand to the crushed stone and/or the gravel is in the range from 5:95 to 20:80, preferably 10:90 to 15:85. If the ratio of sand is less than the stated lower limit, the strength of the concrete construction is markedly declined, and if the ratio of sand is more than the upper limit, the water permeability declines.

The amount of aggregate which is used in the process according to the present invention is the remainder



necessary to total up 1 m³ of the concrete composition in which the cement, the binder and water are included in the above described amounts, respectively. The amount of aggregate is, in general, 1,790 to 2,150 kg per 1 m³ of the
5 concrete composition. The amount of sand is, in general, 179 to 232 kg per 1 m³ of the concrete composition, and the amount of the crushed stone and/or gravel is, in general, 1,520 to 1,940 kg per 1 m³ of the concrete composition.

Conventional additives such as colouring agents, for
10 example, Indian red, chromium oxide (green), etc may be added to the concrete composition according to the present invention if it is desired that the exposed surface aggregate should have a colour other than its natural colour.

15 The concrete composition is prepared by mixing the cement, binder, water and aggregate in the defined amounts, respectively, preferably by first mixing water, cement and the binder, and then adding aggregate to the mixture.

The concrete constructions which may be formed according to
20 the present invention include bodies such as concrete blocks as well as pavement.

The concrete construction is produced by hardening the concrete composition. In the case of producing a concrete pavement as the concrete construction, the concrete
25 composition is, for example, kneaded in a concrete plant, the kneaded mixture is transferred to the job site by a truck mixer or a dump truck, distributed, and, with an asphalt finisher, levelled and tamped (by the up-and-down movement of a tamper and vibration of a screed). The
30 voids, in particular the continuous voids, in the concrete construction are not crushed by using the asphalt finisher,



and moreover the aggregate is not broken by the tamping, so that a concrete pavement having high water permeability and water holding properties and good strength can be produced. The tamped concrete pavement is then cured and hardened.

- 5 The high pressure water which is next applied to the surface of the hardened concrete construction to remove hardened cement mortar covering aggregate in the surface layer of the hardened concrete construction should have a pressure of 1,000 to 2,500 kgf/cm², preferably 1,500 to
10 2,500 kgf/cm², most preferably 2,000 to 2,500 kgf/cm². If water having a very high pressure within the defined range, for example close to 2,500 kgf/cm², is applied, it is possible to round off jags of the aggregate. In this way not only is the hardened cement mortar covering the
15 aggregate removed but also the exposed surface of the aggregate is smoothed. The foaming which can occur due to air bubbles in water when water passes through the voids of the concrete construction is thereby suppressed, and as a result, the water permeability is further improved. Also
20 it is more difficult for solid particles such as dust or rubbish to enter the voids, so that the water permeability is maintained over a longer period of time.

The amount of water which is applied to the surface of the concrete construction is not critical but in general will
25 be from 10 to 21 l/min, preferably 20 l/min. The water is preferably applied to the surface as a spray from a nozzle designed to apply super high pressure water. Examples of commercially available apparatus for providing the super high pressure water include, for example, Leittance Remover®
30 (produced by Flow Co. Ltd.) and Jet Pack® (also produced by Flow Co. Ltd.).

In preferred instances, the coefficient of water permeability of the concrete construction produced

according to the present invention is 3×10^{-1} to 8×10^{-1} cm/sec., the ratio of voids thereof being 15 to 30%. The compressive strength (after 4 weeks, cured in water at 20°C) of these preferred concrete constructions is 100 to 200 kgf/m², and their bending strength (after 4 weeks, cured in water at 20°C) is 20 to 30 kgf/m².

The following example illustrates the present invention.

Example

A concrete composition having the following formulation per 1 m³ of the concrete composition:

	Normal Portland Cement	330 kg
	Binder (JSR TOMAC SUPER)	12 kg
	(weight of solid in emulsion)	
	Water	105 kg and
15	Aggregate comprising sand and crushed stone (7 Size) of JIS in a ratio by weight of 10:90	1,970 kg

was distributed on a roadbed, and, with an asphalt finisher, levelled and tamped by the up-and-down movement of a tamper and vibration of a screed. The resultant concrete pavement (10 cm thick) had a coefficient of water permeability of 3×10^{-1} cm/sec. The ratio of voids thereof was 22%, the compressive strength thereof was 135 kgf/m², and the bending strength thereof was 28 kgf/m².

Then, the cement mortar covering the aggregate in the exposed surface layer was removed by applying a spray of super high pressure water (pressure 2,500 kgf/cm²) to the surface of the pavement in an amount of 21 litres per min using Leitance Remover® equipment. The super high pressure water was applied twice to obtain a finished

surface equal or superior to that brought about by the conventional shot blast, and the efficiency of operation was increased considerably. The removed cement mortar was withdrawn by the method, for example, described in Japanese
5 Patent Laid-Open (KOKAI) 3-137310 (137310/1991).

The resultant concrete pavement had a coefficient of water permeability of 6×10^{-1} cm/sec. The ratio of voids thereof was 26%.

**CLAIMS:**

1. A process for producing a concrete construction having an improved surface appearance and water permeability, comprising the steps of:

(i) preparing a concrete composition of:

(a) 300 to 400 kg of cement per 1 m³ of the concrete composition,

(b) 0.008 to 0.04 parts by weight of binder per 1 part by weight of cement,

(c) 0.3 to 0.45 parts by weight of water per 1 part by weight of cement, of water, and

(d) 1,790 to 2,150 kg per 1m³ of the concrete composition of aggregate comprising sand and at least one of crushed stone and gravel, in the ratio by weight of 5:95 to 20:80, said crushed stone, if present, comprising from 70-100% by weight crushed stone with a grain size of 2.5 to 5 mm and from 0-3% by weight crushed stone with a grain size of 5 to 13 mm, and said gravel, if present, having a grain size of 5 to 10 mm;

(ii) hardening the concrete composition to form a concrete construction having water permeability; and

(iii) applying water having a pressure of 1,000 to 2,500 kgf/cm² to a surface of the concrete construction to remove hardened cement mortar covering aggregate at that surface.

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2. A process according to Claim 1, wherein the water has a pressure of 2,000 to 2,5000 kgf/cm².

3. A process according to Claim 1 or Claim 2, wherein the amount of the cement is from 320 to 370 kg per 1m³ of the concrete composition.

4. A process according to any preceding claim, wherein the amount of the binder is from 0.015 to 0.03 parts by weight per 1 part by weight of cement.

5. A process according to any preceding claim, wherein the amount of the water is from 0.35 to 0.40 parts by weight per 1 part by weight of cement.

6. A process according to any preceding claim, wherein the ratio of sand to crushed stone and/or gravel is from 10:90 to 15:85.

7. A process according to any preceding claim, wherein the concrete construction is concrete pavement.

8. A process according to Claim 7, wherein the concrete composition is distributed on a roadbed, and, with an asphalt finisher, levelled and tamped, and cured and hardened to form the concrete pavement.

9. A concrete construction produced by a process according to any preceding claim.