The characteristics of the soil hardening agent DS-SB for emergency recovery in disaster region

by Dr. Hong-Dong Cho

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습식공법과 건식공법의 비교

구분	Web Method	Dry Method
주원료	aggregate+water+cement+admixture	Site soil/sand/volcanis ash+DS-SB
curing	over A week(**일반**)	Soon after work
원리	Hydration	Compaction

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The work flow of the mixing in-place soil method

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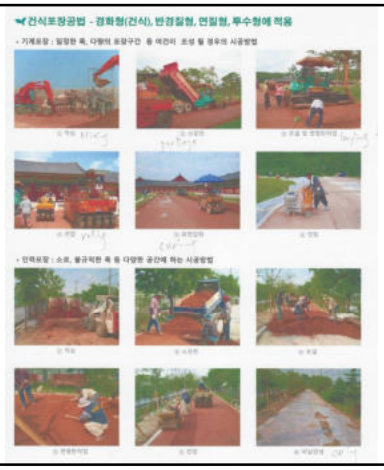

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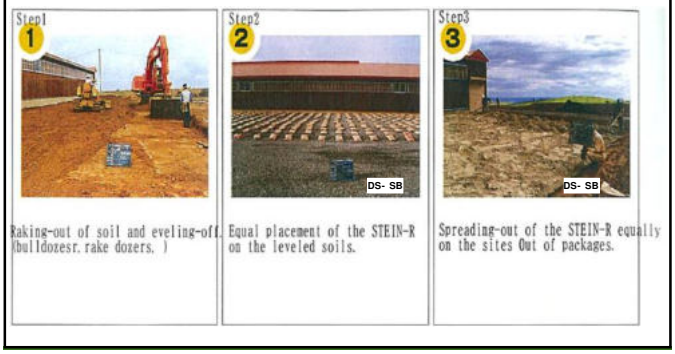
The work flow of the mixing in-place soil method



Raking-out of soil and eveling-off. (bulldozesr. rake dozers.)

Equal placement of the STEIN-R on the leveled soils.

Spreading-out of the STEIN-R equally on the sites Out of packages.

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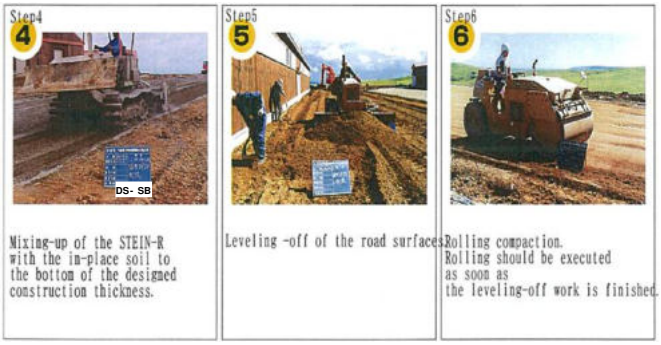
The work flow of the mixing in-place soil method



Mixing-up of the STEIN-R with the in-place soil to the bottom of the designed construction thickness.

Leveling -off of the road surfaces.

Rolling compaction. Rolling should be executed as soon as the leveling-off work is finished.

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The work flow of the mixing in-place soil method

Leveling-off after rolling compaction.

Watering. Water the road to be extent that water goes down to the bottom of the designed road thickness.

Completion

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The DS-SB construction system at the mixing in-place soil method(work flow)

	Work contents	Employing construction machines	Tests and checks	Precaution
Step1 The in-place soil investigative tests	Determine the designed road strength at the Uniaxial compressive strength and the road thickness.		The test to fimne out the optimum compaction Water content of the soil. the test on the particle size distribution of the soil. the certification of the desimed road strength value at the uniaxial compressive strength.	
Step2 Preparation works	a) Rake out subgrades and baseourses and level off these surfaces to the designed height. b) Pick up and remove completely stones. debris and organic matters such as tree roots which are likely to hinder soils from mixing up to the construction thickness. c) Compact soils avenagely to the extent that every portion of the road can hold the same compaction strength. d) Set up adhoc wooden measuring scales at every 10meter distance to check the designed height and thickness of the road against the sampling features.	Bulldozers, motor graders, macadam loader, rubber tired rollers.	Measure the in-place soils water content, the compaction density and the bearing capacity.	a) The bearing capacity of subgrades and baseourses must be the same at every portion. b) When the compaction density is 11% (bearing capacity K30 is under 6 kg/ the different construction method might be taken into considerations. c) The double layers construction technique should be adopted if the part of the road appeared to be too weak in strength.

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The DS-SB construction system at the mixing in-place soil method(work flow)

	Work contents	Employing construction machines	Tests and checks	Precaution
Step3 Raking and leveling works	a) Rake out fully to the bottom of designed depth of the road b) Crush soil particle into as small bit as possible. c) Level off the surfaces of crushed soil. d) Dry and adjust the water content of soil, if necessary, by raking soil upside down. e) When other aggregate materials are needed to be mingled, spread out them on the surface evenly before mixing them up and then mix them thoroughly.	Bulldozers, motor grader, stabilizers, rotor	Measure the water content. Check the particle Size of crushed soils to make it sure it is suitable level.	After crushing soil , execute the adjustment of the Optimum water content of soil to rolling compaction and then mix them up completely.

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The DS-SB construction system at the mixing in-place soil method(work flow)

	Work contents	Employing construction machines	Tests and checks	Precaution
Step4 Spreading DS- SB and Mixing up with soil	a) Place designed amounts of DS- SB per square meters over the construction site and spread it evenly. For instance, using wooden rakers. b) Mix up DS- SB with soil so that DS- SB can be thoroughly and equally mingle among soil. c) Level off the soil surfaces mixed up with DS- SB	Bulldozers (rotor), stabilizers, M263 (soil load mixers	a) Taking advantage of formally put up ad-hoc scales check and make it sure, that DS- SB is mixed equally to the extent of designed construction depth. b) Make test pieces for the compressive strength test	mixing until so that the soil and DS- SB has uniform color throughout.

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The DS-SB construction system at the mixing in-place soil method(work flow)

	Work contents	Employing construction machines	Tests and checks	Precaution
Step5 Rolling compaction	a) Execute the rolling compaction overlapping at 16 times or more, while changing down steers which may appear out into surfaces During the work. b) Shape road surfaces along the longitudinal direction and the transverse direction to adjust the road figures to the designed dimension, taking advantages of formerly put up ad-hoc measuring wooden scales. c) Correct ramedness employing hand rakers. d) Employ rollers 3to4 times as the finish-up rolling compactions.	Macadam loaders, rubber tired rollers, bulldozers, motor graders.	a) Taking advantages of ad-hoc scales set up formerly measure the road figures and check them if shaping works could be done properly. b) Measure Density soil-cliffesion.	a) Depending on subgrades states, change the ways of rolling compaction with which the compact pressurelroads are increased gradually b) The rolling compaction should be completed within 4 hours after the DS- SB is spread and mixed up. c) Avoid abrupt and sudden changes of directions in roller operation.
Step6 Curing	a) Water the constructed roads at the ratio of 0.3 liters of water to 1kg of DS- SB b) Cover the roads by sheeting materials to prevent from freezing when the temperature goes down under 5 degree Celsius.			a) Check the construction thickness and the unixial compressive strength by taking up core samples of the constructed roads. b) K30 Measure the bearing capacity.

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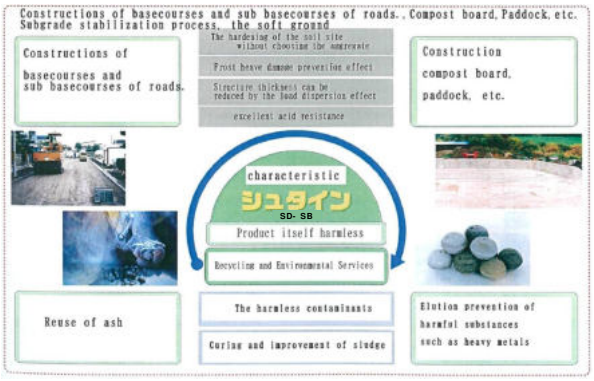
The characteristics of the soil hardening agent “DS-SB”



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The characteristics of the soil hardening agent "DS-SB"

1 It is possible that choosing the aggregate, to solidify the most soils.

Except for extreme organic soil and cohesive soil that can not be crushed physically, Soil most can be cured by mixing DS-SB

Strengthening of subgrade improvements and the soft ground underground, further, DS-SB can build a solid roadbed

Soil even if it is appropriate, without replacing an expensive aggregate the soil, It is possible the construction of roadbed strength high in the soil in the field

The effective Reuse of site soil → • Unnecessary replacement of marketable aggregate • In-place applicability and economical construction cost

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The characteristics of the soil hardening agent "DS-SB"

2 Reduced construction thickness with high load dispersion effects by DS-SB

The official test result indicate that Hardened base courses by DS-SB have high numerical values not only at the uniaxial compressive strength but at the bending strength and the shear modulus, Thus demonstrating high load dispersion effects.

Therefore, the construction thickness of road substructures can be reduced to be certain extent. In the case of the road on which the supporting capability of subgrades had been enhanced by long term traffics, additional 20cm base course construction on the subgrade could sustain high load heavy traffics

Simplification Of The construction process → Shortening Of The construction period

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The characteristics of the soil hardening agent "DS-SB"

3 Low crack growth rate with low contraction and expansion nature.

As the hardened soil by DS-SB can be hardly affected by air and earth temperature, the crack development on constructed objects is extremely low

Frost heave damage prevention effect → Unnecessary repair of the structure

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The characteristics of the soil hardening agent "DS-SB"

4 Extremely low permeability and heat conductivity

As DS-SB harden on-the site soil and uses no carried-in aggregate materials such as gravels and sand,the DS-SB constructions keep extremely low permeability and heat conductivity, Thus DS-SB constructions cut off heat transfer and water flows generated between the above and the under constructions

Contraction and expansion is small → Unnecessary repair of the structure

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The characteristics of the soil hardening agent "DS-SB"

5 Excellent acid resistance

The hardened soil by DS-SB has higher acid resistance nature as compared with products made by using ordinary Portland cement.

Therefore, DS-SB is ideal for constructing base floors of livestock hutches, paddocks, Barnyard manure reservoirs, which are susceptible to acid discharged by livestock excreta

Excellent acid resistance → Unnecessary repair Of the structure

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The characteristics of the soil hardening agent "DS-SB"

6 High evaluation in the point of environmental protection.

The projects using DS-SB are natural in color and soft in feeling as they are made up of soils in place adapt themselves easily to the neighboring circumstance.

In such environmental protection areas as the public parks and tempi-shrine areas, DS-SB is utilized widely in the construction works of promenades, squares, cycling roads and jogging courses

The effective Reuse of site soil → Landscape protection

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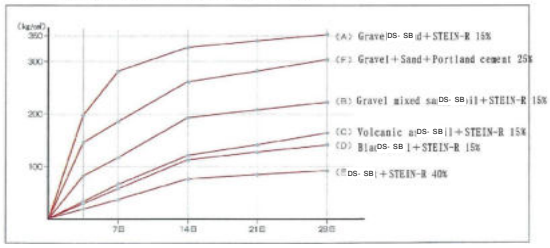
The physical and dynamic property of DS-SB

The compression test with various mixing soil specimens DS- SB R

Test piece : (A) Gravel+San DS- SB EIN-R 15%
(B) Gravel mixed sandy so DS- SB TEIN-R 15%
(C) Volcanic ash so DS- SB EIN-R 15%
(D) Black so DS- SB EIN-R 15%
(E) Silt DS- SB IN-R 40%
(F) Gravel+Sand+Portland cement 25%



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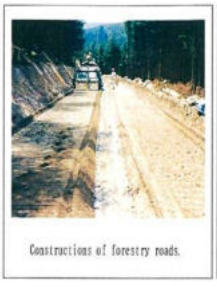
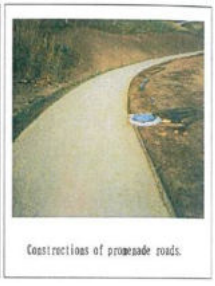
The construction example with which DS-SB is employed


Constructions of basecourses and sub basecourses of roads.


Constructions of forestry roads.


Constructions of promenade roads.

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The construction example with which DS-SB is employed

Constructions of barnyard manure reservoirs.

Backfilling of plumbing works.

Electric prop areal root hardening constructions.

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The construction example with which DS-SB is employed

River bottom repair constructions.

Soft ground improvement construction.

Sludge treatments.

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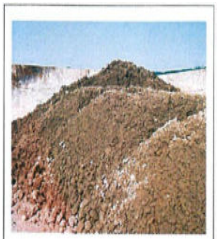
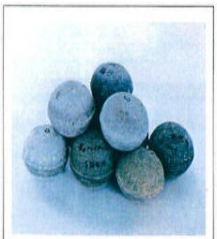
The construction example with which DS-SB is employed



Hardening of cover soils and embankments.



Solidification of incinerated ashes and burned ashes.

Safety disposal of heavy metals.

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Construction Cases

청주시 산남동 보도포장
(산남고교)

청주시 산남동 보도포장
(대원아파트)

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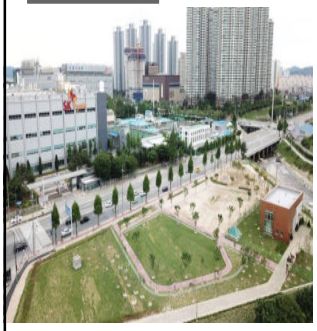
시공사례



청주시 석남천공원

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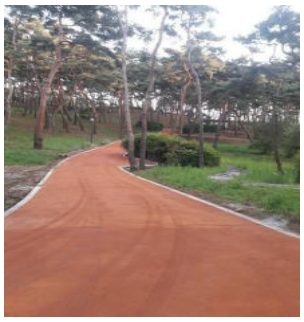
시공사례



청주시 솔밭공원 산책로

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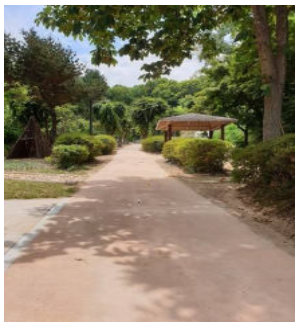
시공사례



청주시 산정마을 산책로

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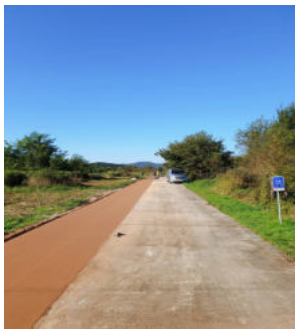
시공사례



현도 오토캠핑장 자전거도로

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The chemical ingredient of the DS-SB products

An outward appearance of the DS-SB product is quite similar to that of Portland cemets.

However, the DS-SB product are the inorganic chemical medicament manufactured in special technologies and by ways of production.

The DS-SB differ in grade among products depending on the manufacturing processes and are entirely free from toxic substance

SiO_2	CaO	Al_2O_3	Fe_2O_3	SO_3	MgO	不溶残分	その他強り	強熱減量
23.0%	60.0%	5.0%	2.0%	2.2%	2.0%	0.3%	4.5%	1.0%

SiO_2 rate : $\frac{23}{5+2.0} \approx 3.3$

Alumina iron rate : $\frac{5}{2.0} \approx 2.5$

Hydraulic rate : $\frac{60}{23+5+2.0} \approx 2.0$

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The test data on the harmlessness of the DS-SB products

(Solubity test conducted by the Hokkaido environmental science technology center in September, 2004)

The test was conducted by producing hardened sample of 1kg DS-SB-M mixed with 300cc demineralized water and the way of solution directed by the environmental agency notice NO.46

Name of harmful substance	Weight of harmful substance(mg/one out to 1 litter of water	※ Criterion set by the Environmental agency
Cadmium	0.001 〉	0.01 ≧
Total cyanogens	ND (0.1 〉)	ND
Inorganic phosphorus	ND (0.1 〉)	ND
Lead	0.009	0.01 ≧
Hexavacent Chromium	0.04 〉	0.05 ≧
Arsenic	0.005 〉	0.01 ≧
Total mercury	0.0005 〉	0.0005 ≧
Alkylating mercury	ND (0.0005 〉)	ND
PCB	ND (0.0005 〉)	ND
Selenium	0.002 〉	0.8 ≧
Fluorine	0.4	0.8 ≧
Boron	0.02 〉	1 ≧

※the environmental agency notice No. 46

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The physical and dynamic property of DS-SB

A. The physical property test (JIS R 5201) Nippon university manufacturing technology deperiment

type of Cement	Grade	Speccific gravity	Fineness: Specific Surface Area (cm²/g)	Setting: Water Ratio (%)	Setting: Starting time (H-M)	Setting: Finishing Time (H-M)
DS- SB	R	3.08	5293	33.0	0—16	2—20
	M	3.08	5253	33.0	0—15	2—10
※ Portland cement	普 通①	3.17	3260	27.5	2—31	3—45
	早 強②	3.13	4450	29.2	2—25	3—44
	超早強③	3.11	6050	33.8	1—46	3—10

※ Data of Portland cement ①~③ Cement Association of Japan

①Normal

②High early Strength Portland Cement

③Super high earlystrength Portlandcement

The particle size of DS- SB is much smaller and the specific surface area is larger as compared with those of Portland cement because of the special treatments given during the manufacturing processes. Therefore DS- SB can contain smaller particle of soil than Portland cement can. DS- SB begins to coagulate soon and end coagulation is much shorter period of time attaining necessary strength than Portland cement does. All these mean the period of curing can be greatly shorten by the employment of DS- SB

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The physical and dynamic property of DS-SB

B. The dynamic properties test (JIS R 5201) Nippon university manufacturing technology deperiment

type of Cement	Grade	Flow (mm)	Strength: Bending (kg/cm²) 3d/s	Bending 7d/s	Bending 28d/s	Compressive (kg/cm²) 3d/s	Compressive 7d/s	Compressive 28d/s
DS- SB	R	209.5	34.3	49.3	62.5	123.7	211.6	331.0
	M	210.5	58.2	63.5	73.8	315.0	348.2	431.6
Portland cement	Normal	206.0	35.7	52.0	72.7	147.0	219.0	358.5

※ Originally the test for DS- SB-R should have been conducted under JIS-R-1210, where the test pieces are required to be prepared by the compaction method. In this particular test, however, the test pieces of DS- SB-R were prepared by the usual mortar method similar to be the othres, in consequence of which the ture storengs value for DS- SB-R could not be exhibited to its full portential.

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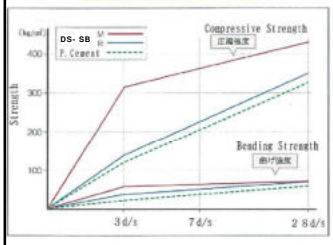
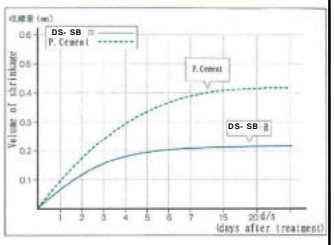
The physical and dynamic property of DS-SB

Compressive & Bending Strength



Volume of shrinkage



Graph in the figure above, which means that it is a special production (specific surface area is larger) so that fine particles DS- SB compared to Portland cement.
This special production, is DS- SB, since it is possible to wrap up the fine soil particles, beginning and end of the condensation is very fast, after setting, compressive strength and bending is extremely high, mechanical properties and physical is excellent. In addition, DS- SB, for contraction is smaller than that of the Portland cement mortar, cracking after drying is also reduced.

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