

SPECIFICATION

TITLE OF THE INVENTION:

Improved Soil Production Management System Using
Rotary Crushing and Mixing Apparatus

TECHNICAL FIELD

[0001]

This invention relates to an improved soil production management system using a rotary crushing and mixing apparatus for producing improved soil by utilizing construction generated soil or the like as a raw material.

BACKGROUND ARTS

[0002]

An applicant of the present application has developed a rotary crushing and mixing method for improving and effectively utilizing construction generated soil or the like and a rotary crushing and mixing apparatus for use in this method, resulting in acquisition of a lot of patents for the above method and apparatus in addition to patents disclosed in patent documents 1 to 7 below.

[0003]

The rotary crushing and mixing method uses the rotary crushing and mixing apparatus having a belt-shaped impact application member (which will be hereinafter referred to as an impact member) rotated at high speed inside a cylindrical container for crushing/fine granulation of charged construction generated soil inside the container by impact force of the impact member and is therefore effective in finely and uniformly dispersing such soil material. Besides, the rotary crushing and mixing method is also capable of performing adjustment of improved soil in properties, strength and the like by mixing with additives such as a quicklime, slaked lime or like

lime-based solidifier, a normal cement, blast furnace slag cement or like cement-based solidifier and a soil conditioner consisting of a polymeric material, as necessary.

[0004]

The rotary crushing and mixing method is applicable to the wide range of soil as compared with conventional methods and therefore enables uniform mixing of even the soil having been difficult to be improved with the conventional methods. Namely, the rotary crushing and mixing method performs mixing while causing lumpy cohesive soil to be finely granulated simultaneously with crushing of soft rock into fine particles by the impact force of the high rotary speed impact member, thus allowing stable quality soil to be produced. Accordingly, the construction generated soil or the like having been hitherto subjected to disposal on the outside of a site can be efficiently utilized, resulting in achievement of a reduction in environmental load as well as a reduction in cost such as construction cost and project cost.

[0005]

In this way, the rotary crushing and mixing method can perform simultaneously crushing and mixing with a single mechanism and is suitable for effective utilization of the construction generated soil or the like because of being applicable to the wide range of soil from high moisture content cohesive soil to soft rock.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0006]

Patent document 1: Japanese Patent Publication No. 3554829

Patent document 2: Japanese Patent Publication No.

3389202

Patent document 3: Japanese Patent Publication No.
3643587

Patent document 4: Japanese Patent Publication No.
3842062

Patent document 5: Japanese Patent Publication No.
4601951

Patent document 6: Japanese Patent Publication No.
4675571

Patent document 7: Japanese Patent Publication No.
5847394

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0007]

For a material (such as a ground material and a soil material) utilized for the purpose of soil improvement, the rotary crushing and mixing apparatus assumes that soil is to be subjected to improvement, so that a change in soil properties with sampling depth and location, weather and the like is involved. For that reason, in cases where a treatment amount is too large for a plant scale and capacity and/or where the number and rotary speed of impact members are large when two or three types of soil and rock are mixed or crushed and simultaneously mixed for particle size adjustment and/or when soil is mixed with additives, there is a fear of failures caused by exertion of large load on a plant.

[0008]

On the other hand, in cases where the treatment amount is too small for the plant scale and capacity and/or where the number and rotary speed of impact members are small, no load is exerted on the plant, whereas there is a fear of troubles occurring in execution of construction using improved soil, as on occasions when a target quality of the improved soil

fails to be obtained because of degradation in improved soil quality resulting from insufficient crushing and/or insufficient mixing of such soil material.

[0009]

The present invention addresses the above problems involved in a process of improved soil production using a rotary crushing and mixing apparatus and is to provide an improved soil production management system using a rotary crushing and mixing apparatus, in which stably high quality improved soil is produced in a manner that performs optimization of a plant specification (such as a treatment amount and the number and rotary speed of impact members) in accordance with the properties of a utilized material, whereby supply of the stably high quality improved soil to its application place can be performed.

MEANS FOR SOLVING THE PROBLEMS

[0010]

The present invention relates to an improved soil production management system and an improved soil production method, in which a rotary crushing and mixing apparatus for producing improved soil by utilizing a ground material such as construction generated soil as a raw material is used so that stably high quality improved soil is produced in a manner that performs optimization of a plant specification such as a treatment amount and the number and rotary speed of impact members in accordance with an improved soil application as well as the properties and amount of a material utilized in a process of improved soil production.

[0011]

The rotary crushing and mixing apparatus itself is the same in basic configuration as the well-known rotary crushing and mixing apparatus described in the foregoing paragraph of BACKGROUND ARTS, and hence, use

is herein made of a rotary crushing and mixing apparatus having a cylindrical container into which raw material soil and as necessary, additives to be added as a soil conditioner are charged so as to be subjected to crushing and mixing treatment, an inlet for charging the raw material soil into the container, an outlet for taking out improved soil produced by subjecting the raw material soil to the crushing and mixing treatment inside the container, a vertically extending rotary shaft disposed in the center of the cylindrical container and multiple impact members (belt-shaped impact application members) attached to the rotary shaft in one or multiple stages so as to be allowed to make centrifugal rotation inside the container by rotation of the rotary shaft for crushing and mixing of the raw material soil.

[0012]

The production management system of the present invention is to efficiently operate such rotary crushing and mixing apparatus in accordance with the improved soil application as well as the properties and amount of the material utilized in the process of improved soil production, and comprises the following means a, b, c and d.

a. an improved soil information input means for inputting information related to a target quality of the improved soil,

b. a raw material soil information input means for inputting information related to the raw material soil,

c. a setting storage means in which data (inclusive of data based on the existing results) or a relational expression regarding a relation between a setting condition (inclusive of an operating condition) of the rotary crushing and mixing apparatus as suited for achievement of the target quality of the

improved soil and the information related to the raw material soil is stored, and

d. a setting condition determination means for determining the setting condition of the rotary crushing and mixing apparatus by comparison or arithmetic operation using the data or relational expression stored in the setting storage means based on both the information inputted to the improved soil information input means and the information inputted to the raw material soil information input means.

[0013]

In the present invention, the information related to the target quality of the improved soil shall include at least two or more kinds of information selected from among application or strength related information of the improved soil, particle size related information thereof, moisture content related information thereof and property related information thereof.

[0014]

Meanwhile, the information related to the raw material soil shall include at least two or more kinds of information selected from among type related information of the raw material soil, particle size related information thereof, moisture content related information thereof and property related information thereof.

[0015]

The setting condition of the rotary crushing and mixing apparatus shall include at least two or more kinds of conditions selected from among a rotary speed related condition of the rotary shaft, a form or specification related condition of the impact members, a position or number related condition of the impact members and a treatment amount (such as a total treatment amount and an amount of soil produced per

hour or day, for instance) or operation time related condition of the rotary crushing and mixing apparatus.

[0016]

With the production management system of the present invention having the above constitution, the stably high quality improved soil can be produced in the manner that performs optimization of the plant specification by creating a database for combinations of the utilized material (such as a ground material and a soil material) and additives as suited for targeted soil improvement with the plant specification providing an optimally improved quality on the basis of the past construction results and the like and then incorporating the thus created database into a plant system.

[0017]

It is noted that not only the rotary crushing and mixing apparatus but also facilities such as a raw material soil conveying facility, an additives feeding facility and an improved soil carrying-out facility are included in an improved soil production plant, or in some cases, storage facilities for storage of the raw material soil, the additives and the improved soil may be also included therein, so that the production management system of the present invention may be also constituted so as to perform comprehensive management inclusive of operating condition managements of these facilities.

[0018]

The production management system of the present invention also allows a plant facility management state to be visualized by further providing a display means such as a display for displaying the setting condition and operating condition of the rotary crushing and mixing apparatus as determined by the setting condition determination means, an operating

state of each of other facilities and the like.

[0019]

From the standpoint of confirming that a quality of the improved soil produced with the production management system of the present invention satisfies the target quality, the production management system thereof also allows corrections in the case of occurrences of the improved soil quality being less than or over the target quality to be performed by further providing a measured improved soil quality information input means for, after measurement of a quality of the improved soil discharged from the rotary crushing and mixing apparatus, inputting information of the measured quality of the improved soil and a feedback means for correcting the setting condition of the rotary crushing and mixing apparatus by comparison between the inputted information of the measured quality of the improved soil and the target quality of the improved soil.

[0020]

Meanwhile, for the raw material soil, it is also subject to change in its properties with weather, soil sampling location and other effects on the way of the process of improved soil production, and therefore, the production management system of the present invention performs measurement of the moisture content and strength of the raw material soil as well as the quality of the improved soil on a timely basis to reflect also data obtained from such measurement on the plant system in real time and then stores the thus obtained data in the database for enhancement of system accuracy, thus allowing an increase in improved quality and productivity to be attained.

[0021]

The improved soil production method using the rotary crushing and mixing apparatus of the present

invention is to provide a procedure of improved soil production using the above production management system and comprises a step of inputting at least the two or more kinds of information selected from among the application or strength related information of the improved soil, the particle size related information thereof, the moisture content related information thereof and the property related information thereof by the improved soil information input means, a step of inputting at least the two or more kinds of information selected from among the type related information of the raw material soil, the particle size related information thereof, the moisture content related information thereof and the property related information thereof by the raw material soil information input means, a step of determining the setting condition of the rotary crushing and mixing apparatus by comparison or arithmetic operation using the data or relational expression stored in the setting storage means based on both the information inputted by the improved soil information input means and the information inputted by the raw material soil information input means and a step of operating the rotary crushing and mixing apparatus based on the setting condition of the rotary crushing and mixing apparatus as determined by the setting condition determination means.

EFFECTS OF THE INVENTION

[0022]

With the production management system of the present invention, the stably high quality improved soil can be produced in the manner that performs optimization of the plant specification by creating a database for combinations of the utilized material and additives as suited for targeted soil improvement with the plant specification providing an optimally

improved quality on the basis of the past construction results and the like and then incorporating the thus created database into a plant system.

[0023]

In addition to the above, the production management system of the present invention also performs measurement of the moisture content and strength of the raw material soil as well as the quality of the improved soil even on the way of the process of improved soil production to reflect also data obtained from such measurement on the plant system in real time for enhancement of system accuracy, thus allowing an increase in improved quality and productivity to be attained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

[FIG. 1] FIG. 1 is a perspective view schematically showing a mechanism of improved soil production by a rotary crushing and mixing apparatus for use in the present invention.

[FIG. 2] FIG. 2 is a vertical sectional view showing one embodiment of a structure of the rotary crushing and mixing apparatus for use in the present invention.

[FIG. 3] FIG. 3 is a horizontal sectional view showing one embodiment of the structure of the rotary crushing and mixing apparatus for use in the present invention.

[FIG. 4] FIG. 4 shows different impact member forms.

[FIG. 5] FIG. 5 is a schematic view showing one embodiment of a process of improved soil production using the rotary crushing and mixing apparatus for use in the present invention in cases where additives are added to raw material soil.

[FIG. 6] FIG. 6 is a view showing one embodiment of an operation management screen on a monitor included in a production management system of the present invention.

[FIG. 7] FIG. 7 is a flowchart showing an improved soil production procedure according to the present invention.

MODE FOR EMBODYING THE INVENTION

[0025]

Hereinafter will be described an embodiment of the present invention with reference to the accompanying drawings.

FIG. 1 is a perspective view schematically showing a mechanism of improved soil production by a rotary crushing and mixing apparatus for use in the present invention, and FIGS. 2 and 3 are a vertical sectional view and a horizontal sectional view respectively showing one embodiment of a structure of the rotary crushing and mixing apparatus.

[0026]

A rotary crushing and mixing apparatus 1 has a main part having a cylindrical container 2 into which three types of raw material soil R1, R2, R3 and as necessary, additives to be added thereto are charged so as to be subjected to crushing and mixing treatment, an inlet 3 for charging the three types of raw material soil R1, R2, R3 into the container 2, an outlet 4 for taking out treated soil, that is, improved soil T produced by subjecting the three types of raw material soil R1, R2, R3 to the crushing and mixing treatment inside the container 2, a vertically extending rotary shaft 5 disposed in the center of the cylindrical container 2 and multiple impact members (belt-shaped impact application members) 6 attached to the rotary shaft 5 in one or multiple stages so as to be allowed to make centrifugal rotation inside the container 2 by rotation of the rotary shaft 5 for crushing and mixing of the three types of raw material soil R1, R2, R3.

[0027]

Referring to FIG. 1, with the three types of raw material soil R1, R2, R3 charged into the container 2 through the inlet 3, the impact members 6 are rotated at high speed by rotation of the rotary shaft 5 for uniform mixing of the charged three types of raw material soil R1, R2, R3 simultaneously with crushing or fine granulation thereof, on the condition that the three types of raw material soil R1, R2, R3 are respectively assumed to be construction generated soil consisting of cohesive soil and silt, that consisting of sandy soil and that consisting of soft rock and gravel, for instance.

[0028]

It is noted that one or two types of locally generated soil or the like will be rendered for actual utilization as the raw material soil in accordance with a site situation, an improved soil application, a target quality of improved soil and the like, and hence, mixing with additives to be added as a soil conditioner such as lime and a cement-based solidifier may be performed as necessary.

[0029]

Inside the container 2, the three types of raw material soil R1, R2, R3 are mixed finely and uniformly while a cohesive material such as cohesive soil and silt is being finely granulated simultaneously with crushing of soft rock and gravel into fine particles by impact force of the high rotary speed impact members 6, and accordingly, high quality improved soil T can be produced.

[0030]

The three types of raw material soil R1, R2, R3 are subjected to adjustment for selection, compounding (such as a compounded amount), a degree of crushing and mixing and the like so that a quality of the improved soil T comes to the target quality in moisture content

and properties such as strength, viscosity and fluidity in accordance with the improved soil application, in which case, as necessary, the additives such as the lime and cement-based solidifier are charged into the container 2 for the crushing and mixing treatment to provide the target quality suited for the improved soil application.

[0031]

The additives are charged through the inlet 3 together with the three types of raw material soil R1, R2, R3, or alternatively, through an inlet separately provided for charging only the additives.

[0032]

As shown in FIG. 2, the container 2 is supported by a support frame 7 and has an upper part provided with the inlet 3 for charging the raw material soil and the like and a lower part provided with the outlet 4 through which the improved soil is discharged. It is noted that polymeric plates 3a, 4a are respectively attached to an inner surface of the inlet 3 and that of the outlet 4 in order to prevent soil from being adhered thereto.

[0033]

The rotary shaft 5 is supported in a freely rotatable manner by a pair of upper and lower bearings 8a, 8b vertically disposed in the center inside the container 2. The upper bearing 8a is held to an upper part of the center inside the container 2 by a spoke, stay or like member (not shown) installed on the upper part of the container 2. For the lower bearing 8b, it is similarly held to a lower part of the center inside the container 2 by a spoke, stay or like member disposed at the lower part of the container 2.

[0034]

According to the embodiment shown in FIGS. 2 and 3, the container 2 is divided into three parts, that

is, an upper cylinder 2a, a lower cylinder 2b and an intermediate cylinder 2c, the container being constituted such that the intermediate cylinder 2c is rotated in the inverse direction of the rotary shaft 5 by an intermediate cylinder rotation motor 15. Referring to FIGS. 2 and 3, reference numerals 16a, 16b respectively designate intermediate cylinder rotation support bearings for supporting a flange 2d provided on an outer periphery of the intermediate cylinder 2c.

[0035]

Multiple and longitudinally-extending belt-shaped scrapers 9 (four scrapers in the illustrated embodiment) are attached to an inner surface of the intermediate cylinder 2c so as to be allowed to scrape off adhered soil from the inner surface of the container 2 by rotation of the intermediate cylinder 2c in the inverse direction of the rotary shaft 5.

[0036]

The impact members 6 in the embodiment shown in FIGS. 2 and 3 are each constituted of a member in which a steel thick plate 6b is attached to the tip end of a metal chain 6a, these impact members being radially attached around the rotary shaft 5 in multiple stages (three stages in the illustrated embodiment). The number of the impact members 6 to be attached is adjustable in accordance with the type and properties of the raw material soil, the treatment amount, the type and amount of the additives, the target quality of the improved soil and the like.

[0037]

The impact members 6 are each attached in such a manner that after a chain ring on the basal end side of the chain 6a is interposed between a pair of upper and lower flanges 21a, 21b provided on an outer

periphery of the rotary shaft 5 to align lock holes of the flanges 21a, 21b with the chain ring in a vertical direction, lock pins 22 are inserted into these lock holes.

[0038]

In a state where the rotary crushing and mixing apparatus 1 is stopped, the impact members 6 are each in a downwardly suspended state. Meanwhile, when the rotary shaft 5 is rotated at high speed through a driving pulley 12, a belt 13 and a driven pulley 14 by driving a motor 11 attached to the outside of the container 2, the impact members 6 are allowed to rotate at high speed in a horizontal plane as shown in FIGS. 2 and 3 in a manner of centrifugal rotation accompanying the rotation of the rotary shaft 5.

[0039]

Referring to FIG. 2, reference numeral 35 designates a discharging conveyor for carrying out the improved soil which is discharged through the outlet 4 after produced with the rotary crushing and mixing apparatus 1.

[0040]

FIG. 4 is a view showing different forms of the impact member 6.

The impact member 6 shown in FIG. 4(A) is constituted mainly of the metal chain 6a. The impact member 6 shown in FIG. 4(B) is constituted mainly of a metal blade 6c. The impact member 6 shown in FIG. 4(C) is constituted of a flexible metal wire 6d. The impact member 6 shown in FIG. 4(D) is constituted of a member in which polygonal metal washers 6e are gathered up with a bolt and a nut.

[0041]

Other impact members such as a hammer-type impact member in which a spherical, cubic, cylindrical or like proper-shaped hammer is attached to the tip end of a

metal material such as metal rod, metal blade, metal chain and metal wire can be also used.

[0042]

FIG. 5 is a view showing one embodiment of a process of producing the improved soil T using the rotary crushing and mixing apparatus of the present invention in cases where additives A are added to the raw material soil R.

[0043]

The process of improved soil production is performed in accordance with such a series of flows that the raw material soil R is charged into a soil hopper 32 by a backhoe 31 and is then fed in a fixed amount by a soil feeder 33 so as to be followed by charging into the rotary crushing and mixing apparatus 1 from a charging conveyor 35 via a metering conveyor (a belt scale for metering a weight of the raw material soil) 34, and then finally, the improved soil T produced with the rotary crushing and mixing apparatus 1 is discharged by the discharging conveyor 36.

[0044]

In the illustrated embodiment, there is shown the process of improved soil production in cases where an additives storage silo 37 is installed at the site, so that the additives are fed in a fixed amount from an additives feeder 38 to the raw material soil which is conveyed through the charging conveyor 35 after subjected to weight metering by the metering conveyor 34, and as a result, the raw material soil R and the additives A are simultaneously charged into the rotary crushing and mixing apparatus 1.

[0045]

A production management system can be constituted as follows.

[0046]

a. Improved soil information input means

This means is to input information related to the target quality of the improved soil. Specifically, the information related to the target quality of the improved soil shall be inputted to management software installed in a mobile terminal or a computer installed at the site or other places such as a control room.
[0047]

The information related to the target quality of the improved soil shall include at least two or more kinds of information selected from among application or strength related information of the improved soil, particle size related information thereof, moisture content related information thereof and property related information thereof.
[0048]

The application of the improved soil includes backfilling of structures and buildings, backing of civil engineering structures, land elevation for river embankments, roads and land developments, banking of railroads and airports, water surface reclamation and the like, for instance.
[0049]

In the improved soil application, others such as detoxification treatment of the locally generated soil when being contaminated with heavy metal, VOC (volatile organic compound) or like harmful substances are also included. In such cases, mixing with the additives for insolubilizing or purifying treatment shall be involved in the process of improved soil production.
[0050]

While the improved soil strength is considered to have relevance for the improved soil application, it is to be noted that information such as a cone index (kN/m^2), a uniaxial compressive strength (kN/m^2) prescribed by a uniaxial compression test, a cohesive

force (kN/m^2) and an inner friction angle (θ°) prescribed by a triaxial compression test and other information related to strengths prescribed by a consolidation test and other various conventional testing methods can be used as the strength related information of the improved soil according to the purpose.

[0051]

The particle size related information of the improved soil includes information such as a particle size distribution, a fine particle fraction content (%) and a maximum particle size (mm) of the improved soil, which information can be properly selected according to the purpose.

[0052]

The moisture content (w%) of the improved soil is used as an index for judgement of soil conditions, and in term of a relation between the type of soil as roughly classified and the moisture content, it is estimated that the moisture content of humus is about in the range of 100 to 1300%, that of alluvial clay is about in the range of 50 to 90%, that of diluvium is about in the range of 30 to 50%, that of sand is about in the range of 8 to 15%, and that of gravel is about in the range of 2 to 5%, for instance.

[0053]

The property related information of the improved soil includes information with respect to a test on liquid limit/plastic limit as an index of soil consistency and other information such as a permeability coefficient prescribed by a water permeability test, for instance.

[0054]

b. Raw material soil information input means

This means is to input information related to the

raw material soil. Specifically, the information related to the raw material soil shall be inputted to the management software installed in the mobile terminal or the computer installed at the site or other places such as the control room, similarly to the case of the information related to the target quality of the improved soil.

[0055]

The information related to the raw material soil shall include at least two or more kinds of information selected from among type related information of the raw material soil, particle size related information thereof, moisture content related information thereof and property related information thereof. It is noted that one type of raw material soil may not be always in use, and hence, when more than one type of raw material soil is utilized, information related to each of more than one type of raw material soil shall be inputted.

[0056]

The type of raw material soil refers to the type of locally generated soil utilized as the raw material soil and is classified based on the particle size composition and liquid limit/plastic limit of soil and further in consideration of the presence or not of a natural material and/or an artificial material and impurities as well.

[0057]

The particle size, moisture content and properties of the raw material soil are the same as those having been described with respect to the improved soil, in which case, however, when the locally generated soil or the like is utilized as the raw material soil, the moisture content and the soil properties such as consistency will be largely affected by the weather as in the case of a succession

of fine days or rainy days and can be thus considered to be important information for improved soil production management.

[0058]

It is noted that the operating condition of the rotary crushing and mixing apparatus, the compounding ratio of the additives to be added as necessary and the like are determined in accordance with the target quality of the improved soil, the treatment amount and the like and based on a concept that apprehends the type of the raw material soil as roughly classified although the type of raw material soil is conceptually relevant to the particle size composition and liquid limit/plastic limit of the raw material soil, specifically, based on actual numerical information such as the particle size, moisture content and properties of the raw material soil.

[0059]

c. Setting storage means

Specifically, this means stores data or a relational expression regarding a relation between the setting condition or operating condition of the rotary crushing and mixing apparatus as suited for attainment of the target quality of the improved soil and the information related to the raw material soil by using a hard disc of a computer or a mobile terminal installed with the management software or a CD, DVD, USB flash memory or like external storage device as a storage medium.

[0060]

The data or relational expression stored in the setting storage means is to store settings considered to be most suitable for attainment of the target quality of the improved soil in view of the relation with the raw material soil based on data, theoretical/experimental values and the like obtained

from the past improved soil production results and can be updated at any time based on the accumulated production results.

[0061]

It is also allowable to feedback or update the above stored data or relational expression based on information related to the actually obtained improved soil quality during the progress of a construction work in the site.

[0062]

The setting condition of the rotary crushing and mixing apparatus includes conditions such as a rotary speed related condition of the rotary shaft (the impact members), a form or specification related condition of the impact members, a position or number related condition of the impact members, a treatment amount (such as a total treatment amount and an amount of soil produced per hour or day, for instance) or operation time related condition of the rotary crushing and mixing apparatus, for instance.

[0063]

It is noted that not only the rotary crushing and mixing apparatus but also facilities such as a raw material soil conveying facility, an additives feeding facility and an improved soil carrying-out facility are included in an improved soil production plant, or in some cases, storage facilities for storage of the raw material soil, the additives and the improved soil may be also included therein, so that the production management system of the present invention may be also constituted so as to perform comprehensive management inclusive of operating condition managements of these facilities.

[0064]

d. Setting condition determination means
Specifically, the setting condition or operating

condition of the rotary crushing and mixing apparatus is determined using the data or relational expression stored in the setting storage means based on both the information inputted to the improved soil information input means and the information inputted to the raw material soil information input means in a manner that makes use of a function such as an arithmetic operation function and a comparison function of the computer or the mobile terminal based on the installed management software.

[0065]

Basically, the setting condition or operating condition is determined automatically by input of both the information related to the target quality of the improved soil and the information related to the raw material soil. In accordance with the setting condition, the position and number of the impact members are subjected to adjustment, and instructions for operation control are then given to the rotary crushing and mixing apparatus and its peripheral facilities.

[0066]

Table 1 below lists simplified instances of a relation among the information related to the target quality of the improved soil, the information related to the raw material soil and the setting condition. While only typical items are listed for convenience of explanation and space, it is a matter of course that more efficient control can be performed in actuality, as the number of items increases more.

[0067]

[Table 1]

No.	Improved Soil Application	Type of Additives	Average Amount of Addition (kg/m ³)	Improvement Targeted Value	Natural Moisture % (g)	Particle Size Distribution				Consistency		Classified Items of Material	Cone Index g (N/m ²)	Apparatus Specification							
						Maximum Particle Size (mm)	Gravel Fraction	Sand Fraction	Fine-Grained Fraction % (g)	Liquid Limit % (g)	Plastic Limit % (g)			Average Amount of Treatment (m ³ /h)	Body Size of Impact Member (mm)		Number of Members	Total Number of Stages			
															Mini-Min	Maxi-Min			Average	Number of Stages	
1	River Embankment	Quick Lime	22.1	Cone Index 1200N/m ² FINE-GRAINED FRACTION CONTENT 15%FC≤50%	16.5	9.5	0.3	82.2	14.2	NP	NP	SAND WITH COHESIVE SOIL	1472	TM 1500	356.4	200	400	200	4-4-4	3	12
					8.5	9.5	0.3	94.4	4.7	NP	NP	CLASSIFIED SAND	1334								
					53.9	4.75	0.1	24.6	75.3	73	38.1	SANDY SILT	621								
					24.8	26.5	12.3	64.9	22.8	NP	NP	FINE-GRAINED FRACTION SAND WITH GRAVEL	1264.2								
2	River Embankment	Quick Lime	15.2	Cone Index 1200N/m ² FINE-GRAINED FRACTION CONTENT 15%FC≤50%	10.7	53	34.1	61.8	4.1	NP	NP	CLASSIFIED GRAVELLY SAND	3333.3	TM 1500	362.5	200	400	200	4-4-4	3	12
					5.7	75	55.2	43.6	1.2	NP	NP	GRAVELLY SAND OF WIDE PARTICLE SIZE DISTRIBUTION	1088								
					8	75	47.2	33.3	3.5	NP	NP	SANDY GRAVEL WITH ROCK	4052.4								
					28.7	53	34.2	33.1	32.7	66.8	40.3	FINE-GRAINED FRACTION SANDY GRAVEL	391								
3	Flood Control Basin Embankment	-	-	Cone Index 400N/m ² FINE-GRAINED FRACTION CONTENT 15%FC≤50%	64.3	2	0.3	11.3	97.7	71.2	26.4	COHESIVE SOIL	-	TM 1500	331	500	600	600	4-4-4	3	12
					16.4	9.5	21.0	73.7	2.7	-	-	CLASSIFIED GRAVELLY SAND	-								
					55.3~79.2	4.75			90.0	59.8	26.9	COHESIVE SOIL WITH SAND	-								
					58.8~82.7	2	0.0	2.3	97.7	71.2	26.4	COHESIVE SOIL	-								
4	Flood Control Basin Embankment	-	86.1	Cone Index 400N/m ² COMPACTION DEGREE OF NOT LESS THAN 90%	14.9	9.5	11.6	85.0	3.4	-	-	SAND WITH GRAVEL	-	TM 2250	427	300	375	300	3-3-6	3	12
					13.3	19	10.3	82.8	7.0	-	-	SAND WITH FINE-GRAINED FRACTION GRAVEL	-								
					15.6~18.3	9.5	18.9	78.4	2.7	-	-	CLASSIFIED GRAVELLY SAND	-								
					166.6	0.25	0.0	0.5	99.5	75.1	27.5	ORGANIC COHESIVE SOIL	67.9								
5	Flood Control Basin Embankment	Lime	20.3	Cone Index 400N/m ²	172.0	0.25	0.0	0.2	99.8	139.6	48.7	ORGANIC COHESIVE SOIL	39.5	TM 1500	529.9	-	400	4-2-2	3	8	
					29.2	4.75	0.2	44.8	55	38.7	24.9	SANDY COHESIVE SOIL	-								
					34.6	4.75	0.1	56.5	43.4	34.3	29.7	SILTY SAND	-								
					63.1	2	0.0	6.3	93.7	74.6	35.2	SILT WITH SAND	-								
6	Flood Control Basin Embankment	Lime	20.3	Cone Index 400N/m ²	59.7	2	0.0	4.9	95.1	71.1	34.6	SILT WITH SAND	-	TM 1500	529.9	-	400	4-2-2	3	8	
					29.2	4.75	0.2	44.8	55	38.7	24.9	SANDY COHESIVE SOIL	-								
					34.6	4.75	0.1	56.5	43.4	34.3	29.7	SILTY SAND	-								
					63.1	2	0.0	6.3	93.7	74.6	35.2	SILT WITH SAND	-								

[0068]

The production management system of the present invention also allows a plant facility management state to be visualized by further providing a display means such as a monitor (a display) for displaying the setting condition and operating condition of the rotary crushing and mixing apparatus as determined by the setting condition determination means, an operating state of each of other facilities and the like.

[0069]

FIG. 6 shows one embodiment of an operation management screen on a monitor included in the production management system of the present invention to visually confirm the whole operating state of the improved soil production plant including the rotary crushing and mixing apparatus on the monitor screen of the production management system.

[0070]

An upper left part of an illustrated monitor screen displays items such as the plant operation time and the compounding ratio and moisture content of each of the raw material soil and the improved soil. An upper right part thereof is configured to provide graph type representation of a feed amount of the raw material soil and the like and a production amount of the improved soil (the illustrated embodiment leaves out actual lines on a graph). A lower part thereof is configured to provide numerical representation of an operating state in each position of a schematically displayed image of the plant.

It is noted that characters on the monitor screen as shown by leader lines and reference numerals are as follows.

[0071]

51: Plant operation screen

- 52: Back (X)
- 53: Metering (M)
- 54: Configuration (C)
- 55: Metering start (F1)
- 56: Operation mode setting (F5)
- 57: Data collection screen (F6)
- 58: End
- 59: Daily operation time
- 60: Cumulative operation time

[0072]

- 61: Item
- 62: Compounding ratio (%)
- 63: Moisture content (%)
- 64: Sand gravel
- 65: Cohesive soil
- 66: Unused
- 67: Additives
- 68: Water adding 1
- 69: Water adding 2
- 70: Improved soil

[0073]

- 71: Feed amount and Production amount
- 72: Improved soil
- 73: Sand gravel
- 74: Cohesive soil
- 75: Unused
- 76: Additives
- 77: Water adding 1
- 78: Water adding 2

[0074]

- 81: Improved soil
- 82: Sand Gravel
- 83: Cohesive soil
- 84: Unused
- 85: Additives
- 86: Water adding 1

87: Water adding 2

88: Twister 1 (Product name of rotary crushing and mixing apparatus)

[0075]

91: Under suspension of metering

92: No moisture content measurement

93: Control of dry weight compounding ratio

[0076]

From the standpoint of confirming that the quality of the improved soil produced with the production management system of the present invention satisfies the target quality, the production management system thereof further allows corrections in the case of occurrences of the improved soil quality being less than or over the target quality to be performed by further providing a measured improved soil quality information input means for, after measurement of a quality of the improved soil discharged from the rotary crushing and mixing apparatus, inputting information of the measured quality of the improved soil and a feedback means for correcting the setting condition of the rotary crushing and mixing apparatus by comparison between the inputted information of the measured quality of the improved soil and the target quality of the improved soil.

[0077]

Meanwhile, for the raw material soil, it is also subject to change in its properties with weather, soil sampling location and other effects on the way of the process of improved soil production, and therefore, the production management system of the present invention performs measurement of the moisture content and cone index of the raw material soil as well as the quality of the improved soil on a timely basis to reflect also data obtained from such measurement on

the plant system in real time and then stores the thus obtained data in the database for enhancement of system accuracy, thus allowing an increase in improved quality and productivity to be attained.

[0078]

FIG. 7 is a simplified flowchart showing an improved soil production process according to the present invention, wherein the improved soil production is carried out according to the following procedure in outline.

[0079]

(1) Input of improved soil information (101)

Data related to the items such as the application, strength, particle size, moisture content and other properties of the improved soil is inputted as the information related to the target quality of the improved soil from the computer, the mobile terminal or the like.

[0080]

(2) Input of raw material soil information (102)

Data related to the items such as the type, particle size, moisture content and other properties of the raw material soil is inputted as the information related to the raw material soil from the computer, the mobile terminal or the like.

[0081]

(3) Apparatus setting condition storage data (103)

As previously described, this data is to store the settings considered to be most suitable for attainment of the target quality of the improved soil in view of the relation with the raw material soil based on the data, theoretical/experimental values and the like obtained from the past improved soil production results and can be updated at any time based on the accumulated production results.

[0082]

(4) Comparison/arithmetic operation of apparatus setting condition (104)

The setting condition of the rotary crushing and mixing apparatus and that of the peripheral facilities are determined by comparison or arithmetic operation with a comparison/arithmetic operation function of the computer using both the information inputted in the steps (1) and (2) and the data or relational expression stored in the production result storage means in the step (3).

[0083]

(5) Display of apparatus setting condition (105)

The setting condition of the rotary crushing and mixing apparatus and that of the peripheral facilities as determined in the step (4) are displayed on the monitor screen of the computer or the like to allow an operator or a manager to visually grasp such setting conditions.

[0084]

(6) Apparatus operation (106)

The plant is operated based on the setting condition of the rotary crushing and mixing apparatus and that of the peripheral facilities as determined in the step (4).

[0085]

(7) Measurement of operating state (107)

For the operating state of the rotary crushing and mixing apparatus, it can be grasped in real time by directly transmitting data from a monitoring device or sensors installed in the various places of the rotary crushing and mixing apparatus to the production management system.

Meanwhile, for the operating state of the peripheral facilities, information on the operating state thereof can be also obtained in real time by

using the metering conveyor or the like for conveyance of the soil.

[0086]

(8) Display of operating state (108)

The operating state of the rotary crushing and mixing apparatus and that of the entire plant are displayed on the monitor screen of the computer or the like.

For instance, a configuration which allows the operating state to be visually confirmed on the monitor screen of the production management system as shown in FIG. 6 can be adopted.

It is noted that the apparatus setting condition in the step (5) can be displayed on the same monitor by switching of the screen.

[0087]

(9) Measurement of improved soil quality (109)

Measurement tests related to the strength, particle size, moisture content and other properties of the improved soil as used as the information related to the target quality of the improved soil are performed with respect to the produced improved soil to confirm whether or not the quality of the produced improved soil satisfies the target quality.

[0088]

(10) Comparison with target quality (110)

When it is confirmed in the step (9) that the measured quality of the produced improved soil satisfies the target quality, the procedure advances to a step (12), and accordingly, the operation can be continued.

On the other hand, when it is confirmed in the step (9) that the measured quality of the produced improved soil does not satisfy the target quality, the procedure advances to a step (11).

[0089]

(11) Correction of apparatus setting condition
(111)

When it is determined in the step (10) that the measured quality of the produced improved soil does not satisfy the target quality, a condition for correction of the setting condition based on a difference from the target quality is obtained, and thereafter, the procedure is returned to the step (4).
[0090]

(12) Continuation of operation (112)

When it is determined in the step (10) that the measured quality of the produced improved soil satisfies the target quality, the plant operation can be continued, and upon the attainment of a predetermined treatment amount, the operation is finished.

[0091]

While the above series of flows are presented with the simplified steps for convenience of explanation, it is a matter of course that finer control can be performed in actuality.

EXPLANATION OF REFERENCE NUMERALS

[0092]

R, R1, R2, R3 --- Raw material soil,
T --- Improved soil,
1 --- Rotary crushing and mixing apparatus, 2 --- Container, 2a --- Upper cylinder, 2b --- Lower cylinder, 2c --- Intermediate cylinder, 2d --- Flange, 3 --- Inlet, 3a --- Adhesion prevention polymeric plate, 4 --- Outlet, 4a --- Adhesion prevention polymeric plate, 5 --- Rotary shaft, 6 --- Impact member, 6a --- Metal chain, 6b --- Steel thick plate, 6c --- Metal blade, 6d --- Metal wire, 6e --- Washer, 7 --- Support frame, 8a, 8b --- Bearing, 9 --- Scraper, 11 --- Motor, 12 --- Driving pulley, 13 --- Belt, 14 --- Driven pulley, 15 --- Intermediate cylinder rotation motor, 16a, 16b

--- Intermediate cylinder rotation support bearing,
21a, 21b --- flange, 22 --- Lock pin, 31 --- Backhoe,
32 --- Soil hopper, 33 --- Soil feeder, 34 --- Metering
conveyor, 35 --- Charging conveyor, 36 --- Discharging
conveyor, 37 --- Additives Storage silo, 38 ---
Additives feeder

CLAIMS

[Claim 1]

An improved soil production management system using a rotary crushing and mixing apparatus having a cylindrical container into which raw material soil and as necessary, additives to be added thereto as a soil conditioner are charged so as to be subjected to crushing and mixing treatment, an inlet for charging said raw material soil into said container, an outlet for taking out improved soil produced by subjecting said raw material soil to the crushing and mixing treatment inside said container, a vertically extending rotary shaft disposed in the center of said cylindrical container and multiple and belt-shaped impact application members attached to said rotary shaft in one or multiple stages so as to be allowed to make centrifugal rotation inside the container by rotation of said rotary shaft for crushing and mixing of said raw material soil, and comprising:

an improved soil information input means for inputting information related to a target quality of said improved soil;

a raw material soil information input means for inputting information related to said raw material soil;

a setting storage means in which existing data or a relational expression regarding a relation between a setting condition of the rotary crushing and mixing apparatus as suited for attainment of the target quality of said improved soil and the information related to said raw material soil is stored; and

a setting condition determination means for determining the setting condition of said rotary crushing and mixing apparatus using the existing data or relational expression stored in said setting storage means based on both the information inputted to said improved soil information input means and the information inputted to said raw material soil information input means;

wherein the information related to the target quality of said improved soil includes application related information of

the improved soil, strength related information thereof, particle size related information thereof, moisture content related information thereof and property related information thereof,

the information related to said raw material soil includes type related information of the raw material soil, particle size related information thereof, moisture content related information thereof and property related information thereof, and

the setting condition of said rotary crushing and mixing apparatus includes a rotary speed related condition of said rotary shaft, a form or specification related condition of said belt-shaped impact application members, a position and number related condition of said belt-shaped impact application members and a treatment amount or operation time related condition of said rotary crushing and mixing apparatus.

[Claim 2]

The improved soil production management system using the rotary crushing and mixing apparatus according to claim 1, wherein said improved soil production management system further comprises a display means for displaying the setting condition of said rotary crushing and mixing apparatus as determined by said setting condition determination means.

[Claim 3]

The improved soil production management system using the rotary crushing and mixing apparatus according to claim 1, wherein said improved soil production management system further comprises a measured improved soil quality information input means for inputting information of a measured quality of the improved soil discharged from said rotary crushing and mixing apparatus and a feedback means for correcting the setting condition of said rotary crushing and mixing apparatus by comparison between the inputted information of the measured quality of the improved soil and the target quality of said improved soil.

[Claim 4]

An improved soil production method using a rotary crushing and mixing apparatus having a cylindrical container into which raw material soil and as necessary, additives to be added thereto as a soil conditioner are charged so as to be subjected to crushing and mixing treatment, an inlet for charging said raw material soil into said container, an outlet for taking out improved soil produced by subjecting said raw material soil to the crushing and mixing treatment inside said container, a vertically extending rotary shaft disposed in the center of said cylindrical container and multiple and belt-shaped impact application members attached to said rotary shaft in one or multiple stages so as to be allowed to make centrifugal rotation inside the container by rotation of said rotary shaft for crushing and mixing of said raw material soil and said additives, said rotary crushing and mixing apparatus being provided with a production management system comprising:

- an improved soil information input means for inputting information related to said improved soil;

- a raw material soil information input means for inputting information related to said raw material soil;

- a setting storage means in which existing data or a relational expression regarding a relation between a setting condition of the rotary crushing and mixing apparatus as suited for attainment of the target quality of said improved soil and the information related to said raw material soil is stored; and

- a setting condition determination means for determining the setting condition of said rotary crushing and mixing apparatus by comparison or arithmetic operation using the existing data or relational expression stored in said setting storage means based on both the information inputted to said improved soil information input means and the information inputted to said raw material soil information input means,

- the improved soil production method comprising:

- a step of inputting application related information of the improved soil, strength related information thereof,

particle size related information thereof, moisture content related information thereof and property related information thereof by said improved soil information input means;

a step of inputting type related information of the raw material soil, particle size related information thereof, moisture content related information thereof and property related information thereof by said raw material soil information input means;

a step of determining the setting condition of said rotary crushing and mixing apparatus by comparison or arithmetic operation using the data or relational expression stored in said setting storage means based on both the information inputted by said improved soil information input means and the information inputted by said raw material soil information input means; and

a step of operating said rotary crushing and mixing apparatus based on the setting condition of the rotary crushing and mixing apparatus as determined by said setting condition determination means.