

DESCRIPTION

CEMENT COMPOSITION AND METHOD FOR PRODUCING THE SAME

5 FIELD OF THE INVENTION

[0001] The present invention relates to a cement composition and a method for producing the same.

BACKGROUND ART

10 [0002] A cement composition causes the components contained in the cement composition to react with water to form a hydrate, exhibiting a strength. Generally, the larger the amount of the formed hydrate, the higher the strength of a mortar or concrete.

[0003] The cement users have demanded a cement composition from which a
15 concrete having excellent strength exhibiting properties can be obtained without sacrificing the fluidity or setting time of the concrete.

[0004] As a method for improving the strength exhibiting properties of concrete, e.g., a method of “increasing the fineness (Blaine specific surface area)” or “increasing the C₃S content” is used (for example, non-patent document 1).

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PRIOR ART REFERENCE

Non-patent Document

[0005] Non-patent document 1: Japan Cement Association, Common knowledge of cement, “4. Types and uses of cement”, p. 11 to 17, published in 2004

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DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0006] However, when the strength exhibiting properties of a cured product of concrete or the like are improved by a method for changing the fineness or mineral
30 composition of a cement composition, such as the method of “increasing the fineness (Blaine specific surface area)” or “increasing the C₃S content” described in non-patent document 1, there are problems in that the setting time is reduced and the fluidity is lowered. Further, the “increasing the fineness” increases the pulverization energy for cement, and the “increasing the C₃S content” increases the unit consumption of
35 limestone as a raw material, leading to CO₂ emission due to decarboxylation of limestone and an increase of the energy for clinker calcination. In any of these cases,

the amount of CO₂ generated in the production of cement is increased, and this is not preferred from an environmental point of view.

[0007] In view of the above problems, the present invention has been made, and an object of the present invention is to provide a cement composition which can improve the strength exhibiting properties of a cured product of, e.g., a mortar or concrete while maintaining appropriate fresh properties (the amount of water required for nominal consistency of cement paste, setting time) of the mortar or concrete, and a method for producing the same.

10 Means to Solve the Problems

[0008] The present inventors have conducted extensive and intensive studies with a view toward achieving the above object. As a result, it has been found that for improving the strength exhibiting properties of a cured product of, e.g., a mortar or concrete while maintaining the fresh properties of the mortar or concrete, controlling the vanadium (V) content of the cement composition is effective, and the present invention has been completed.

[0009] Specifically, the present invention is directed to a cement composition having a V content of 0.0063 to 0.012% by mass. The present invention is directed to the cement composition which has a Sr content of 0.035 to 0.08% by mass. The present invention is directed to the cement composition which has a Mo content of 0.0002 to 0.007% by mass and a MgO content of 1 to 3% by mass. The present invention is directed to the cement composition which is obtainable by using a cement clinker having a SO₃ content of 0.2 to 1.2% by mass. The present invention is directed to the cement composition which has a SO₃ content of 1.6 to 2.5% by mass. The present invention is directed to the cement composition which has an R₂O content of 0.3 to 0.6% by mass. The present invention is directed to the cement composition which has a C₃S content of 45 to 70% by mass, a C₂S content of 5 to 25% by mass, a C₃A content of 6 to 15% by mass, and a C₄AF content of 7 to 15% by mass.

[0010] The present invention is directed to a method for producing a cement composition, wherein the method comprises the steps of: (A) controlling the raw material unit consumption of a raw material for cement clinker selected from the group consisting of limestone, silica, coal ash, clay, blast furnace slag, soil generated by construction, sewage sludge, a hydrocake, and an iron source so that the resultant cement composition has a V content of 0.0063 to 0.012% by mass, and subjecting the raw material having the controlled unit consumption to calcination to produce a cement clinker; and (B) pulverizing the produced cement clinker, together with gypsum and an

additive material.

Effect of the Invention

[0011] In the present invention, there can be provided a cement composition which
5 can maintain and improve the strength exhibiting properties of a cured product (for
example, strength exhibiting properties of a cured product having an age of 28 days) of
a cement paste, mortar, or concrete while maintaining the amount of water required for
normal consistency of cement paste (water amount required to obtain a constant
softness) and setting time of the cement paste for maintaining appropriate fresh
10 properties of the cement paste, mortar, or concrete, and a method for producing the
same.

BRIEF DESCRIPTION OF THE DRAWING

[0012] [Fig. 1] A graph showing the relationship between the V content of a cement
15 composition and the compressive strength of a mortar (cured product) using the cement
composition and having an age of 28 days.

BEST MODE FOR CARRYING OUT THE INVENTION

[0013] Hereinbelow, preferred embodiments of the present invention will be
20 described.

[0014] The cement composition according to the present embodiment has a V
content of 0.0063 to 0.012% by mass.

[0015] Vanadium (V) is a trace element component contained in the cement
composition. The present inventors have found that the V content of the cement
25 composition strongly affects the strength exhibiting properties of a cured product of a
cement paste, mortar, or concrete using the cement composition, and that when the V
content of the cement composition falls in the appropriate range, the strength exhibiting
properties of a cured product of a cement paste, mortar, or concrete using the cement
composition can be improved while maintaining appropriate fresh properties (the
30 amount of water required for normal consistency of cement paste, setting time) of the
cement paste, mortar, or concrete. The V content of the cement composition is the
amount (% by mass) of the V contained, based on the mass of the cement composition,
and this amount can be measured in accordance with Japan Cement Association
standard test method JCAS I-52 2000 "Quantitative determination method for trace
35 element components of cement by ICP emission spectrometry and electrothermal type
atomic absorption spectrometry".

[0016] The V content of the cement composition is 0.0063 to 0.012% by mass, preferably 0.0070 to 0.012% by mass, more preferably 0.0080 to 0.0115% by mass, further preferably 0.0090 to 0.0105% by mass. When the V content of the cement composition is less than 0.0063% by mass or more than 0.012% by mass, it may be difficult to appropriately maintain the strength exhibiting properties of a cured product of, e.g., a mortar or concrete using the cement composition according to the present embodiment.

[0017] The cement composition according to the present embodiment preferably has a strontium (Sr) content of 0.035 to 0.08% by mass, more preferably a Sr content of 0.04 to 0.075% by mass, further preferably 0.041 to 0.07% by mass, especially preferably 0.042 to 0.06% by mass. When the Sr content of the cement composition falls in the above-mentioned range, the strength exhibiting properties of a cured product of, e.g., a mortar or concrete can be maintained and improved while maintaining appropriate fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the cement composition. The Sr content of the cement composition is the amount (% by mass) of the Sr contained, based on the mass of the cement composition, and this amount can be measured in accordance with Japan Cement Association standard test method JCAS I-52 2000 "Quantitative determination method for trace element components of cement by ICP emission spectrometry and electrothermal type atomic absorption spectrometry".

[0018] The cement composition according to the present embodiment preferably has a molybdenum (Mo) content of 0.0002 to 0.007% by mass, more preferably 0.0002 to 0.0065% by mass, further preferably 0.0002 to 0.0064% by mass, especially preferably 0.0002 to 0.0063% by mass. When the Mo content of the cement composition falls in the above-mentioned range, the strength exhibiting properties of a cured product of, e.g., a mortar or concrete can be maintained and improved while maintaining appropriate fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the cement composition. The Mo content of the cement composition is the amount (% by mass) of the Mo contained, based on the mass of the cement composition, and this amount can be measured in accordance with Japan Cement Association standard test method JCAS I-52 2000 "Quantitative determination method for trace element components of cement by ICP emission spectrometry and electrothermal type atomic absorption spectrometry".

[0019] The cement composition according to the present embodiment preferably has a MgO content of 1 to 3% by mass, more preferably 1 to 2.5% by mass, further preferably 1 to 2% by mass, especially preferably 1 to 1.5% by mass. When the MgO

content of the cement composition falls in the above-mentioned range, the strength exhibiting properties of a cured product of, e.g., a mortar or concrete can be further improved while maintaining appropriate fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the cement composition. The
5 MgO content of the cement composition is the amount (% by mass) of the MgO contained, based on the mass of the cement composition, and this amount can be measured in accordance with JIS R 5202: 1998 "Chemical analysis methods for Portland cement".

[0020] The cement composition according to the present embodiment is preferably
10 obtainable by using a cement clinker having a SO_3 content of 0.2 to 1.2 % by mass. The SO_3 content of the cement clinker is more preferably 0.25 to 0.90% by mass, further preferably 0.3 to 0.70% by mass. When the SO_3 content of the cement clinker falls in the above-mentioned range, with respect to the cement composition obtained by pulverizing the cement clinker, together with gypsum and an additive material, it is easy
15 to control the SO_3 content in a predetermined range.

[0021] Further, the cement composition according to the present embodiment preferably has an R_2O content of 0.3 to 0.6% by mass, more preferably 0.35 to 0.6% by mass, further preferably 0.35 to 0.55% by mass, especially preferably 0.4 to 0.5% by mass. When the R_2O content of the cement composition falls in the above-mentioned
20 range, the strength exhibiting properties of a cured product of, e.g., a mortar or concrete can be maintained and improved while maintaining appropriate fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the cement composition. The R_2O content of the cement composition is the amount (% by mass) of the R_2O contained, based on the mass of the cement composition, and this
25 amount can be measured in accordance with JIS R 5202: 1998 "Chemical analysis methods for Portland cement". The R_2O (total alkali) content of the cement composition means an amount represented by the following formula (I).

$$\begin{aligned} &\text{R}_2\text{O Content of the cement composition} \\ &= \text{Na}_2\text{O Content} + 0.658 \times \text{K}_2\text{O Content} \quad (\text{I}) \end{aligned}$$

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[0022] Further, the cement composition according to the present embodiment preferably has a SO_3 content of 1.6 to 2.5% by mass, more preferably 1.7 to 2.5% by mass, further preferably 1.8 to 2.48% by mass. When the SO_3 content of the cement composition falls in the above-mentioned range, the strength exhibiting properties of a
35 cured product of, e.g., a mortar or concrete can be maintained and improved while maintaining appropriate fresh properties (the amount of water required for normal

consistency of cement paste, setting time) of the cement composition. The SO₃ content of the cement composition is the amount (% by mass) of the SO₃ contained, based on the mass of the cement composition, and this amount can be measured in accordance with JIS R 5202: 1998 "Chemical analysis methods for Portland cement".

5 [0023] With respect to the mineral composition of the cement composition according to the present embodiment, it is preferred that the C₃S content is 45 to 70% by mass, the C₂S content is 5 to 25% by mass, the C₃A content is 6 to 15% by mass, and the C₄AF content is 7 to 15% by mass, it is more preferred that the C₃S content is 48 to 65% by mass, the C₂S content is 10 to 25% by mass, the C₃A content is 8 to 13% by mass, and
10 the C₄AF content is 8 to 12% by mass, it is further preferred that the C₃S content is 50 to 64% by mass, the C₂S content is 11 to 20% by mass, the C₃A content is 9 to 12% by mass, and the C₄AF content is 8 to 11% by mass, and it is especially preferred that the C₃S content is 53 to 60% by mass, the C₂S content is 11 to 18% by mass, the C₃A content is 9 to 11% by mass, and the C₄AF content is 8 to 10% by mass. When the
15 mineral composition of the cement composition falls in the above-mentioned range, the strength exhibiting properties of a cured product of, e.g., a mortar or concrete can be easily maintained and improved while maintaining the fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the mortar and concrete.

20 [0024] The C₃S content (alite phase), C₂S content (belite phase), C₃A content (aluminate phase), and C₄AF content (ferrite phase) of the cement composition are determined from the following Bogue equations [1] to [4].

[0025]

$$\begin{aligned} & \text{C}_3\text{S Content (\% by mass)} \\ & = 4.07 \times \text{CaO Content (\% by mass)} - 7.60 \times \text{SiO}_2 \text{ Content (\% by mass)} - 6.72 \\ & \times \text{Al}_2\text{O}_3 \text{ Content (\% by mass)} - 1.43 \times \text{Fe}_2\text{O}_3 \text{ Content (\% by mass)} - 2.85 \times \text{SO}_3 \text{ Content} \\ & \text{(\% by mass)} \end{aligned} \quad [1]$$

$$\begin{aligned} & \text{C}_2\text{S Content (\% by mass)} \\ & = 2.87 \times \text{SiO}_2 \text{ Content (\% by mass)} - 0.754 \times \text{C}_3\text{S Content (\% by mass)} \end{aligned} \quad [2]$$

$$\begin{aligned} & \text{C}_3\text{A Content (\% by mass)} \\ & = 2.65 \times \text{Al}_2\text{O}_3 \text{ Content (\% by mass)} - 1.69 \times \text{Fe}_2\text{O}_3 \text{ Content (\% by mass)} \end{aligned} \quad [3]$$

C_4AF Content (% by mass)

$$= 3.04 \times Fe_2O_3 \text{ Content (\% by mass)} \quad [4]$$

[0026] In the formulae above, the “CaO Content”, “SiO₂ Content”, “Al₂O₃ Content”, and “Fe₂O₃ Content” are the respective amounts (% by mass) of the CaO, SiO₂, Al₂O₃, and Fe₂O₃ contained, based on the mass of the cement composition. These amounts can be measured by JIS R 5202 “Chemical analysis methods for Portland cement” or JIS R 5204 “Fluorescent X-ray analysis method for cement”.

[0027] Next, the method for producing a cement composition according to an embodiment of the present invention will be described.

The method for producing a cement composition according to the present embodiment comprises the steps of: (A) controlling the raw material unit consumption of a raw material for cement clinker selected from the group consisting of limestone, silica, coal ash, clay, blast furnace slag, soil generated by construction, sewage sludge, a hydrocake, and an iron source (such as copper slag or blast furnace dust) so that the resultant cement composition has a V content of 0.0063 to 0.012% by mass, and subjecting the raw material having the controlled unit consumption to calcination to produce a cement clinker; and (B) pulverizing the produced cement clinker, together with gypsum and an additive material.

[0028] Examples of the raw materials for cement clinker in step (A) include limestone, silica, coal ash, clay, blast furnace slag, soil generated by construction, sewage sludge, a hydrocake, and an iron source. The coal ash is generated from, e.g., a coal fired power plant, and examples include cinder ash, fly ash, clinker ash, and bottom ash. Examples of soil generated by construction include residue soil, mud soil, and waste soil which are secondarily generated by laying operations for construction. Examples of sewage sludge include sludge itself and dry powder obtained by adding limestone to sludge and drying the resultant mixture, and incineration residue. The hydrocake is a by-product caused when producing a sea water magnesia clinker in the step of adding a small amount of calcium hydroxide to sea water to remove carbon dioxide gas from the sea water, and examples include hydrocakes comprised mainly of calcium, magnesium, or a hydroxide or carbonate thereof. Examples of iron sources include copper slag and blast furnace dust. Any raw materials other than the above-mentioned limestone, silica, coal ash, clay, blast furnace slag, soil generated by construction, sewage sludge, hydrocake, and iron source may be used as long as they contain V in a certain amount.

[0029] With respect to the raw material unit consumption of the raw materials for cement clinker in step (A), it is preferred that 700 to 1,400 kg/t-clinker of limestone, 20

to 150 kg/t-clinker of silica, 0 to 300 kg/t-clinker of coal ash, 0 to 100 kg/t-clinker of clay, 0 to 100 kg/t-clinker of blast furnace slag, 10 to 150 kg/t-clinker of soil generated by construction, 0 to 100 kg/t-clinker of sewage sludge, 0 to 100 kg/t-clinker of a hydrocake, and 30 to 80 kg/t-clinker of an iron source are used on a dry basis (in the state in which no moisture is contained) per 1 ton (t) of the cement clinker. Further, it is more preferred that, as the raw materials for cement clinker in step (A), 800 to 1,300 kg/t-clinker of limestone, 20 to 100 kg/t-clinker of silica, 10 to 250 kg/t-clinker of coal ash, 0 to 80 kg/t-clinker of clay, 5 to 50 kg/t-clinker of blast furnace slag, 20 to 150 kg/t-clinker of soil generated by construction, 0 to 70 kg/t-clinker of sewage sludge, 20 to 80 kg/t-clinker of a hydrocake, and 30 to 60 kg/t-clinker of an iron source are used on a dry basis. It is further preferred that the amount of the coal ash is 20 to 250 kg/t-clinker on a dry basis.

[0030] A method for controlling the raw material unit consumption of the raw material for cement clinker in step (A) is in which a V content of each raw material for cement clinker is measured, and the raw material unit consumption of the cement clinker raw material containing V in a large amount is mainly adjusted, controlling the raw material unit consumption so that the resultant cement composition has a V content of 0.0063 to 0.012% by mass. As an example of the method for controlling the raw material unit consumption of the raw material for cement clinker, there can be mentioned, specifically, a method in which a sample of the cement composition produced in advance is taken and a V content of the cement composition is measured, and the raw material unit consumption of the raw materials for cement clinker is controlled so that the V content of the cement composition becomes 0.0063 to 0.012% by mass, and a cement clinker obtained by subjecting the resultant raw materials to calcination is used. By the above-mentioned method, a cement composition having a V content in a specific range and having the maintained and improved strength exhibiting properties (for example, strength exhibiting properties for 28-day age) can be produced. The term "raw material unit consumption" means a mass of each raw material used for producing 1 ton of the cement clinker (kg/t-clinker). Any raw materials other than the above-mentioned limestone, silica, coal ash, clay, blast furnace slag, soil generated by construction, sewage sludge, hydrocake, and iron source may be used as long as they contain V in a certain amount.

[0031] Among the raw materials for cement clinker, the amounts (raw material unit consumption) of the coal ash, soil generated by construction, clay, and iron source (copper slag and blast furnace dust) used strongly affect the V content of the cement composition. For adjusting the V content of the cement composition, it is preferred

that the cement composition is produced using a cement clinker having the controlled raw material unit consumption of the above-mentioned raw materials which strongly affect the V content.

[0032] In the method for producing a cement composition according to the present embodiment, it is preferred that the raw material unit consumption of the raw material for cement clinker is controlled so that the resultant cement composition has a Sr content of 0.035 to 0.08% by mass. In the method for producing a cement composition, it is preferred that the raw material unit consumption of the raw material for cement clinker is controlled so that the resultant cement composition has a Mo content of 0.0002 to 0.007% by mass. In the method for producing a cement composition, it is preferred that the raw material unit consumption of the raw material for cement clinker is controlled so that the resultant cement composition has a MgO content of 1 to 3% by mass. Further, in the method for producing a cement composition, it is preferred that the raw material unit consumption of the raw material for cement clinker is controlled so that the resultant cement composition has an R₂O content of 0.3 to 0.6% by mass. As an example of the method for controlling the Sr content, Mo content, MgO content, and R₂O content of the cement composition, there can be mentioned a method in which a sample of the cement composition produced in advance is taken and a Sr content, a Mo content, a MgO content, and an R₂O content of the cement composition are measured, and the raw material unit consumption of the raw materials for cement clinker is controlled so that the Sr content, Mo content, MgO content, and R₂O content of the cement composition become the respective specific amounts, and a cement clinker obtained by subjecting the resultant raw materials to calcination is used.

[0033] In the method for producing a cement composition according to the present embodiment, it is preferred that the raw material unit consumption of the raw material for cement clinker is controlled so that the cement clinker has a SO₃ content of 0.2 to 1.2% by mass.

[0034] With respect to the raw materials for cement clinker, it is preferred to use the raw materials each having a V content, a Sr content, a Mo content, a MgO content, and an R₂O content which fall in their respective ranges shown below. The V content, Sr content, Mo content, MgO content, and R₂O content of each raw material are the respective amounts (% by mass) of the V, Sr, Mo, MgO, and R₂O contained, based on the mass of each raw material (100% by mass).

[0035] The limestone used preferably has a V content of 0.0001 to 0.002% by mass, more preferably 0.0001 to 0.0015% by mass, further preferably 0.0002 to 0.0012% by

mass, especially preferably 0.0002 to 0.001% by mass. The limestone used preferably has a Sr content of 0.005 to 0.07% by mass, more preferably 0.005 to 0.06% by mass, further preferably 0.01 to 0.06% by mass, especially preferably 0.015 to 0.055% by mass. The limestone used preferably has a Mo content of 0.002% by mass or less, more preferably 0.001% by mass or less, further preferably 0.0005% by mass or less, especially preferably 0.0003% by mass or less. The limestone used preferably has a MgO content of 0.1 to 1.5% by mass, more preferably 0.2 to 1.3% by mass, further preferably 0.25 to 1.1% by mass, especially preferably 0.3 to 1.0% by mass. The limestone used preferably has an R₂O content of 0.05% by mass or less, more preferably 0.001 to 0.04% by mass, further preferably 0.005 to 0.03% by mass, especially preferably 0.005 to 0.02% by mass.

[0036] The silica used preferably has a V content of 0.001 to 0.01% by mass, more preferably 0.001 to 0.008% by mass, further preferably 0.002 to 0.007% by mass, especially preferably 0.003 to 0.006% by mass. The silica used preferably has a Sr content of 0.001 to 0.04% by mass, more preferably 0.001 to 0.03% by mass, further preferably 0.001 to 0.025% by mass, especially preferably 0.001 to 0.02% by mass. The silica used preferably has a Mo content of 0.002% by mass or less, more preferably 0.001% by mass or less, further preferably 0.0005% by mass or less, especially preferably 0.0004% by mass or less. The silica used preferably has a MgO content of 0.05 to 1.0% by mass, more preferably 0.1 to 0.8% by mass, further preferably 0.1 to 0.6% by mass, especially preferably 0.1 to 0.5% by mass. The silica used preferably has an R₂O content of 0.1 to 4.0% by mass, more preferably 0.1 to 3.0% by mass, further preferably 0.3 to 2.5% by mass, especially preferably 0.3 to 2.0% by mass.

[0037] The coal ash used preferably has a V content of 0.01 to 0.1% by mass, more preferably 0.01 to 0.08% by mass, further preferably 0.015 to 0.07% by mass, especially preferably 0.035 to 0.06% by mass. For controlling the V content of the cement composition, it is preferred that coal ash having a V content as large as possible is selected and used. The coal ash used preferably has a Sr content of 0.02 to 0.2% by mass, more preferably 0.02 to 0.15% by mass, further preferably 0.02 to 0.13% by mass, especially preferably 0.02 to 0.12% by mass. The coal ash used preferably has a Mo content of 0.004% by mass or less, more preferably 0.003% by mass or less, further preferably 0.002% by mass or less, especially preferably 0.0015% by mass or less. The coal ash used preferably has a MgO content of 0.2 to 3.0% by mass, more preferably 0.4 to 3.0% by mass, further preferably 0.4 to 2.5% by mass, especially preferably 0.4 to 2.3% by mass. The coal ash used preferably has an R₂O content of 0.1 to 3.5% by mass, more preferably 0.2 to 3.0% by mass, further preferably 0.3 to

2.5% by mass, especially preferably 0.5 to 2.0% by mass.

[0038] The blast furnace slag used preferably has a V content of 0.001 to 0.02% by mass, more preferably 0.001 to 0.015% by mass, further preferably 0.003 to 0.012% by mass, especially preferably 0.004 to 0.01% by mass. The blast furnace slag used
5 preferably has a Sr content of 0.02 to 0.08% by mass, more preferably 0.02 to 0.07% by mass, further preferably 0.02 to 0.06% by mass, especially preferably 0.02 to 0.05% by mass. The blast furnace slag used preferably has a Mo content of 0.002% by mass or less, more preferably 0.001% by mass or less, further preferably 0.0005% by mass or less, especially preferably 0.0003% by mass or less. The blast furnace slag used
10 preferably has a MgO content of 3.0 to 10% by mass, more preferably 3.0 to 8.0% by mass, further preferably 3.0 to 7.0% by mass, especially preferably 4.0 to 7.0% by mass. The blast furnace slag used preferably has an R₂O content of 0.02 to 1.0% by mass, more preferably 0.04 to 0.8% by mass, further preferably 0.06 to 0.6% by mass, especially preferably 0.08 to 0.5% by mass.

[0039] The clay used preferably has a V content of 0.005 to 0.05% by mass, more preferably 0.005 to 0.03% by mass, further preferably 0.01 to 0.025% by mass, especially preferably 0.015 to 0.02% by mass. The soil used preferably has a Sr content of 0.001 to 0.03% by mass, more preferably 0.003 to 0.025% by mass, further preferably 0.003 to 0.02% by mass, especially preferably 0.004 to 0.015% by mass.
15 The clay used preferably has a Mo content of 0.002% by mass or less, more preferably 0.001% by mass or less, further preferably 0.0005% by mass or less, especially preferably 0.0004% by mass or less. The clay used preferably has a MgO content of 0.3 to 6.0% by mass, more preferably 0.3 to 5.0% by mass, further preferably 0.3 to 4.0% by mass, especially preferably 0.5 to 4.0% by mass. The clay used preferably
20 has an R₂O content of 0.5 to 4.0% by mass, more preferably 0.7 to 3.5% by mass, further preferably 1.0 to 3.0% by mass, especially preferably 1.2 to 2.8% by mass.

[0040] The soil generated by construction used preferably has a V content of 0.0001 to 0.03% by mass, more preferably 0.0001 to 0.025% by mass, further preferably 0.005 to 0.02% by mass, especially preferably 0.007 to 0.02% by mass. The soil generated
30 by construction used preferably has a Sr content of 0.01 to 0.4% by mass, more preferably 0.01 to 0.3% by mass, further preferably 0.01 to 0.2% by mass, especially preferably 0.015 to 0.1% by mass. The soil generated by construction used preferably has a Mo content of 0.002% by mass or less, more preferably 0.001% by mass or less, further preferably 0.0005% by mass or less, especially preferably 0.0004% by mass or less.
35 less. The soil generated by construction used preferably has a MgO content of 0.5 to 6.0% by mass, more preferably 0.5 to 5.5% by mass, further preferably 1.0 to 5.0% by

mass, especially preferably 1.0 to 4.0% by mass. The soil generated by construction used preferably has an R_2O content of 0.5 to 4.5% by mass, more preferably 0.7 to 4.0% by mass, further preferably 1.0 to 3.5% by mass, especially preferably 1.2 to 3.0% by mass.

5 [0041] The sewage sludge used preferably has a V content of 0.0001 to 0.01% by mass, more preferably 0.0001 to 0.007% by mass, further preferably 0.0005 to 0.005% by mass, especially preferably 0.0007 to 0.004% by mass. The sewage sludge used preferably has a Sr content of 0.001 to 0.1% by mass, more preferably 0.001 to 0.07% by mass, further preferably 0.001 to 0.05% by mass, especially preferably 0.001 to
10 0.04% by mass. The sewage sludge used preferably has a Mo content of 0.002% by mass or less, more preferably 0.0015% by mass or less, further preferably 0.0012% by mass or less, 0.0011% by mass or less. The sewage sludge used preferably has a MgO content of 0.05 to 4.0% by mass, more preferably 0.1 to 4.0% by mass, further preferably 0.1 to 3.0% by mass, especially preferably 0.1 to 2.5% by mass. The
15 sewage sludge used preferably has an R_2O content of 0.4 to 3.5% by mass, more preferably 0.6 to 3.0% by mass, further preferably 0.8 to 2.5% by mass, especially preferably 1.0 to 2.0% by mass.

[0042] The hydrocake used preferably has a V content of 0.001 to 0.1% by mass, more preferably 0.01 to 0.08% by mass, further preferably 0.01 to 0.06% by mass,
20 especially preferably 0.01 to 0.05% by mass. The hydrocake used preferably has a Sr content of 0.1 to 0.8% by mass, more preferably 0.1 to 0.7% by mass, further preferably 0.1 to 0.6% by mass, especially preferably 0.1 to 0.5% by mass. The hydrocake used preferably has a Mo content of 0.002% by mass or less, more preferably 0.001% by mass or less, further preferably 0.0005% by mass or less, especially preferably 0.0003%
25 by mass or less. The hydrocake used preferably has a MgO content of 5 to 30% by mass, more preferably 5 to 25% by mass, further preferably 10 to 25% by mass, especially preferably 10 to 20% by mass. The hydrocake used preferably has an R_2O content of 0.02 to 1.5% by mass, more preferably 0.04 to 1.2% by mass, further preferably 0.06 to 1.0% by mass, especially preferably 0.08 to 0.8% by mass.

30 [0043] The copper slag used as an iron source preferably has a V content of 0.001 to 0.05% by mass, more preferably 0.003 to 0.03% by mass, further preferably 0.005 to 0.03% by mass, especially preferably 0.005 to 0.02% by mass. The copper slag used preferably has a Sr content of 0.005 to 0.05% by mass, more preferably 0.005 to 0.04% by mass, further preferably 0.005 to 0.03% by mass, especially preferably 0.005 to
35 0.02% by mass. The copper slag used preferably has a Mo content of 0.0002 to 0.8% by mass, more preferably 0.0002 to 0.6% by mass, further preferably 0.0002 to 0.4% by

mass, especially preferably 0.0002 to 0.3% by mass. The copper slag used preferably has a MgO content of 0.5 to 3.0% by mass, more preferably 0.5 to 2.5% by mass, further preferably 0.6 to 2.0% by mass, especially preferably 0.7 to 1.5% by mass. The copper slag used preferably has an R₂O content of 0.04 to 2% by mass, more
5 preferably 0.06 to 1.8% by mass, further preferably 0.08 to 1.6% by mass, especially preferably 1 to 1.4% by mass.

[0044] The blast furnace dust used as an iron source preferably has a V content of 0.001 to 0.03% by mass, more preferably 0.003 to 0.02% by mass, further preferably 0.005 to 0.02% by mass, especially preferably 0.008 to 0.015% by mass. The blast
10 furnace dust used preferably has a Sr content of 0.001 to 0.03% by mass, more preferably 0.001 to 0.02% by mass, further preferably 0.002 to 0.015% by mass, especially preferably 0.002 to 0.01% by mass. The blast furnace dust used preferably has a Mo content of 0.004% by mass or less, more preferably 0.003% by mass or less, further preferably 0.002% by mass or less, especially preferably 0.001% by mass or less.
15 The blast furnace dust used preferably has a MgO content of 0.1 to 3.0% by mass, more preferably 0.15 to 2.0% by mass, further preferably 0.15 to 1.5% by mass, especially preferably 0.2 to 1.5% by mass. The blast furnace dust used preferably has an R₂O content of 0.002 to 1.0% by mass, more preferably 0.004 to 0.8% by mass, further preferably 0.006 to 0.6% by mass, especially preferably 0.008 to 0.4% by mass.

20 [0045] With respect to the iron source, e.g., converter slag or deironized slag preferably having a V content of 0.05 to 0.5% by mass, more preferably 0.08 to 0.5% by mass, further preferably 0.1 to 0.4% by mass, can be selected and used as a raw material for controlling the V content of the cement composition.

[0046] The production of the cement clinker can be conducted using existing cement
25 production facilities of an SP system (multicyclone preheating system) or an NSP system (multicyclone preheating system using a calcination furnace).

[0047] In the production on a commercial scale, for example, a sample for quality control is taken during the calcination for cement clinker, and a V content of the sample is measured, and, based on the V content of each of the raw materials, the ratio between
30 the raw materials used (raw material unit consumption) is controlled so that the resultant cement clinker has a V content of 0.0063 to 0.012% by mass.

[0048] Next, as one mode of step (A)(calcination step) in the present invention, an example in which a cement clinker is produced using existing cement production facilities of an NSP system is described below.

35 [0049] With respect to the method for mixing together the raw materials for cement clinker, there is no particular limitation, but it is preferred that the raw materials are

pulverized and mixed together by, for example, a raw material pulverizing mill, and further mixed by a blending silo.

[0050] The pulverized and mixed raw materials for cement clinker can be then subjected to calcination using a suspension preheater and a rotary kiln which are
5 existing facilities. The cement clinker having a V content of 0.0063 to 0.012% by mass can be produced also by controlling calcination conditions for cement clinker, such as a calcination temperature or a calcination time.

[0051] With respect to the calcination temperature for the cement clinker, there is no particular limitation, but, when using cement production facilities of an NSP system, the
10 temperature of the cement clinker near the outlet of the rotary kiln is preferably 800 to 1,700°C, more preferably 900 to 1,600°C, further preferably 1,000 to 1,500°C. The calcination time is 20 minutes to 2 hours, more preferably 30 minutes to 2 hours, further preferably 45 minutes to 1.5 hour.

[0052] It is preferred that the cement clinker obtained after the calcination is cooled to, for example, about 100 to 200°C using a clinker cooler provided downstream of the rotary kiln. The cooling rate is preferably 10 to 60 °C/minute, more preferably 15 to 45 °C/minute, further preferably 15 to 30 °C/minute. When the cooling rate is in the range of from 10 to 60 °C/minute, there can be produced a cement clinker from which a cement composition that enables production of a mortar or concrete having excellent
20 strength exhibiting properties can be obtained.

[0053] Next, as one mode of step (B)(pulverizing step) in the present invention, a step for pulverizing the cement clinker together with gypsum and an additive material is described below.

[0054] A cement composition can be produced by mixing together the cement
25 clinker having a V content of 0.0063 to 0.012% by mass and gypsum and pulverizing the resultant mixture. The gypsum desirably satisfies the quality prescribed in JIS R 9151 "Natural gypsum for cement", and, specifically, dihydrate gypsum, hemihydrate gypsum, or insoluble anhydrous gypsum is preferably used.

[0055] In step (B)(pulverizing step), it is preferred that gypsum is incorporated into
30 the cement clinker having a V content of 0.0063 to 0.012% by mass so that the obtained cement composition has a SO₃ content of 1.6 to 2.5% by mass, more preferably 1.7 to 2.5% by mass, further preferably 1.8 to 2.48% by mass. With respect to the pulverizing method, there is no particular limitation, and examples include a method using a pulverizer, such as a ball mill, and a classifying apparatus, such as a separator.
35 In the cement composition containing the cement clinker and gypsum, it is preferred that the cement clinker is contained in an amount of 95 to 97% by mass and the gypsum

is contained in an amount of 3 to 5% by mass, based on the mass of the cement composition.

[0056] In pulverizing step (B), the cement composition may further contain an additive material. As an additive material, blast furnace slag prescribed in JIS R 5211 “Blast furnace cement”, a silica additive material prescribed in JIS R 5212 “Silica cement”, fly ash prescribed in JIS A 6201 “Fly ash for concrete”, or limestone fine powder can be used. The amount of the total of the additive materials contained (% by mass) is preferably 5% by mass or less, based on the mass of the cement composition.

[0057] The cement composition according to the present embodiment preferably has a Blaine specific surface area of 2,800 to 4,000 cm²/g. When the Blaine specific surface area falls in the above-mentioned range, a mortar or concrete having further excellent strength exhibiting properties can be produced. The Blaine specific surface area of the cement composition is more preferably 3,000 to 3,800 cm²/g, further preferably 3,000 to 3,500 cm²/g.

[0058] Hereinabove, the preferred embodiments of the present invention have been described, but the present invention is not limited to the above-mentioned embodiments.

EXAMPLES

[0059] Hereinbelow, the present invention will be described in more detail with reference to the following Examples and Comparative Example, which should not be construed as limiting the scope of the present invention.

[0060] (Examples 1 to 4 and Comparative Example 1)

[Raw materials for cement clinker]

With respect to the raw materials for cement clinker, a V content of each of limestone, silica, coal ash, clay, blast furnace slag, soil generated by construction, sewage sludge, a hydrocake, and an iron source (copper slag and blast furnace dust) was measured in advance, and the raw material unit consumption of the above-mentioned raw materials was controlled so that the resultant cement clinker had a V content of 0.0063 to 0.012% by mass. Further, the ratio between the raw materials used (raw material unit consumption) was controlled so that the resultant cement clinker had a Sr content of 0.035 to 0.08% by mass, a Mo content of 0.0002 to 0.007% by mass, a MgO content of 1 to 3% by mass, and an R₂O content of 0.3 to 0.6% by mass. Further, for controlling the SO₃ content of the cement composition, dihydrate gypsum was used. The V content, Sr content, Mo content, MgO content, and R₂O content of the limestone, silica, coal ash, clay, blast furnace slag, soil generated by construction, sewage sludge, hydrocake, and iron source (copper slag and blast furnace dust) used in Examples and

Comparative Example are shown in Table 1. The chemical components and raw material unit consumption shown below are indicated in terms of raw material unit consumption on a dry basis (in the state in which no moisture is contained). Further, in Table 1, the “<0.00025” indicates a Mo content less than of 0.00025% by mass.

5 [0061] [Table 1]

	Trace element components of each raw material (% by mass)				
	V	Sr	Mo	MgO	R ₂ O
Limestone	0.0003	0.045	<0.00025*	0.36	0.014
Silica	0.0053	0.0044	0.0004	0.47	1.565
Coal ash	0.0403	0.106	0.0012	0.96	1.193
Blast furnace slag	0.0071	0.0462	0	5.12	0.414
Clay	0.0133	0.0138	0.0003	1.43	2.282
Soil generated by construction	0.0160	0.0272	0.0003	1.78	2.931
Sewage sludge	0.0010	0.0161	0.0011	1.06	1.392
Hydrocake	0.0130	0.474	0	14.19	0.281
Iron source (Copper slag)	0.0070	0.0165	0.266	0.83	1.007
Iron source (Blast furnace dust)	0.0100	0.0064	0.001	0.22	0.190

[0062] The V, Sr, Mo, MgO, and R₂O contents of each raw material were measured in accordance with Japan Cement Association standard test method JCAS I-52 2000 “Quantitative determination method for trace element components of cement by ICP emission spectrometry and electrothermal type atomic absorption spectrometry”.

10 [0063] [Raw materials for cement clinker]

The unit consumption of individual raw materials used as the raw materials for cement clinker was as follows: limestone: 800 to 1,300 kg/t-clinker; silica: 20 to 150 kg/t-clinker; coal ash: 10 to 250 kg/t-clinker; clay: 0 to 100 kg/t-clinker; blast furnace slag: 0 to 100 kg/t-clinker; soil generated by construction: 20 to 150 kg/t-clinker; sewage sludge: 0 to 100 kg/t-clinker; hydrocake: 0 to 100 kg/t-clinker; and iron source: 30 to 80 kg/t-clinker (copper slag: 5 to 50 kg/t-clinker, and blast furnace dust: 25 to 55 kg/t-clinker).

[0064] [Production of a cement clinker]

20 The above-mentioned raw materials for cement clinker were mixed together, and the mixed raw materials were subjected to calcination using an NSP kiln at a highest temperature of 1,200 to 1,500°C to produce a cement clinker. The temperature of the cement clinker near the outlet of the NSP kiln was 1,000 to 1,500°C. The cement clinker was cooled from 1,000 to 1,400°C to 100 to 200°C at a cooling rate of 10 to 60 °C/minute using a clinker cooler provided downstream of the rotary kiln.

25 [0065] Dihydrate gypsum was incorporated into the resultant cement clinker so that

the obtained cement composition had a SO₃ content of 2% by mass, and additive materials (limestone and blast furnace slag) were further added thereto in a limestone amount of 4% by mass and in a blast furnace slag amount of 1% by mass, and the resultant mixture was pulverized using a practical mill so that the Blaine specific surface area became 3,100 to 3,400 cm²/g to obtain a cement composition.

[0066] [Chemical components of the cement composition]

With respect to the above-obtained cement composition, the respective amounts (% by mass) of the SiO₂, Al₂O₃, Fe₂O₃, CaO, MgO, R₂O, and SO₃ contained and the SO₃ in the clinker, based on the mass of the cement composition, were measured. These amounts were measured in accordance with JIS R 5202: 1998 "Chemical analysis methods for Portland cement". Further, a Sr content of the cement composition was measured in accordance with Japan Cement Association standard test method JCAS I-52 2000 "Quantitative determination method for trace element components of cement by ICP emission spectrometry and electrothermal type atomic absorption spectrometry", and the results are shown in Table 2.

[0067] [Table 2]

	Chemical components of cement composition and clinker (% by mass)										
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	R ₂ O	SO ₃	Clinker SO ₃	Sr	Mo	V
Example 1	20.92	4.93	3.05	64.30	1.11	0.5	1.96	0.3	0.0437	0.0002	0.0083
Example 2	20.17	5.82	2.86	64.30	1.40	0.48	1.9	0.8	0.0474	0.0012	0.0095
Example 3	20.79	5.78	2.99	64.48	1.45	0.45	1.79	0.4	0.0524	0.0063	0.0100
Example 4	20.06	5.42	2.83	64.33	1.12	0.46	2.48	1.0	0.0509	0.0026	0.0110
Comparative example 1	20.19	4.94	2.69	64.05	2.17	0.41	2.03	0.5	0.0823	0.0004	0.0062

[0068] [Mineral composition and physical properties of the cement composition]

<Mineral composition of the cement composition>

The mineral composition (C₃S content, C₂S content, C₃A content, and C₄AF content) of the above-obtained cement composition was measured based on the Bogue equations [1] to [4]. The results are shown in Table 3.

<Fineness properties of the cement composition>

Fineness properties of cement (Blaine specific surface area and 45 μm residue) were measured in accordance with JIS R 5201: 1997 "Physical testing methods for cement". The results are shown in Table 4.

<Color b-value>

A color b-value of the cement composition was measured using a color meter

(Spectro Color Meter Se2000, manufactured by Nippon Denshoku Industries Co., Ltd.), and the results are shown in Table 4.

<Amount of water required for normal consistency of cement paste>

- 5 An amount of water required for normal consistency of cement paste is a water amount required to obtain a constant softness of a cement paste, and, the larger the amount of water required for normal consistency of cement paste, the lower the fluidity of cement. A measurement method is as follows. 500 g of the cement composition is placed in a kneading vessel, and water is added thereto and the composition is kneaded and then, the resultant cement paste is placed in a container and the surface of the paste is rendered smooth. Then, a standard bar is allowed to go down on the cement paste, and, after 30 seconds, a gap between the end of the standard bar and the bottom plate is measured. A water amount such that the gap becomes 6 ± 1 mm (normal consistency) is measured to determine an amount of water required for normal consistency of cement paste.

<Setting (initial, final) and mortar compressive strength>

- A setting time (initial, final) was measured using the above-obtained cement composition in accordance with JIS R5201: 1997 "Physical testing methods for cement". The results are shown in Table 4.

[0069] [Table 3]

	Mineral composition (% by mass) Bogue equations			
	C ₃ S	C ₂ S	C ₃ A	C ₄ AF
Example 1	59.6	15.1	7.9	9.3
Example 2	59.8	12.8	10.6	8.7
Example 3	56.0	17.4	10.3	8.5
Example 4	61.8	11.0	9.6	8.6
Comparative example 1	64.4	9.4	8.5	8.2

[0070] [Table 4]

	Fineness properties		Color b-value (-)	Amount of water required for normal consistency of cement water (%)	Setting time		Mortar compressive strength for 28-day age (N/mm ²)
	Blaine specific surface area (cm ² /g)	45 μm residue (% by mass)			initial setting (minutes)	final setting (minutes)	
Example 1	3240	8.0	6.47	27.8	136	196	61.1
Example 2	3280	6.8	6.81	28.2	135	195	62.4
Example 3	3120	8.4	7.42	27.1	144	217	62.5
Example 4	3250	11.2	7.13	27.8	142	202	60.0
Comparative example 1	3200	4.8	5.70	28.0	123	188	56.6

[0071] Fig. 1 shows the relationship between the V content of the cement composition and the compressive strength for 28-day age. As seen from Fig. 1, when the V content of the cement composition is 0.0063 to 0.012% by mass (Examples 1 to 4, symbol “●” in Fig. 1), certain strength exhibiting properties (the mortar compressive strength for 28-day age is 60 N/mm² or more) can be maintained and improved. On the other hand, when the V content of the cement composition is less than 0.0063% by mass (Comparative Example 1, symbol “□” in Fig. 1), the strength exhibiting properties become poor. Further, as seen from Table 4, the cement compositions (Examples 1 to 4) having a V content of 0.0063 to 0.012% by mass and preferably having a Sr content of 0.035 to 0.08% by mass maintain and improve the certain strength exhibiting properties, and have an amount of water required for normal consistency of cement paste comparable to that of the cement composition (Comparative Example 1) having a V content of less than 0.0063% by mass, and have rather an increased setting time, which has confirmed that the fresh properties (the amount of water required for normal consistency of cement paste, setting time) are maintained.

[0072] As can be seen from the results shown above, when the cement composition has a V content of 0.0063 to 0.012% by mass and preferably has a Sr content of 0.035 to 0.08% by mass, the cement composition can maintain and improve the strength exhibiting properties of a mortar or concrete while maintaining the fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the mortar or concrete.

CLAIMS

1. A cement composition having a V content of 0.0063 to 0.012% by mass.
2. The cement composition according to claim 1, which has a Sr content of
5 0.035 to 0.08% by mass.
3. The cement composition according to claim 1 or 2, which has a Mo content of 0.0002 to 0.007% by mass and a MgO content of 1 to 3% by mass.
4. The cement composition according to any one of claims 1 to 3, which is obtainable by using a cement clinker having a SO₃ content of 0.2 to 1.2% by mass.
- 10 5. The cement composition according to any one of claims 1 to 4, which has a SO₃ content of 1.6 to 2.5% by mass.
6. The cement composition according to any one of claims 1 to 5, which has an R₂O content of 0.3 to 0.6% by mass.
7. The cement composition according to any one of claims 1 to 6, which has a
15 C₃S content of 45 to 70% by mass, a C₂S content of 5 to 25% by mass, a C₃A content of 6 to 15% by mass, and a C₄AF content of 7 to 15% by mass.
8. A method for producing a cement composition, the method comprising the steps of:
(A) controlling the raw material unit consumption of a raw material for cement clinker
20 selected from the group consisting of limestone, silica, coal ash, clay, blast furnace slag, soil generated by construction, sewage sludge, a hydrocake, and an iron source so that the resultant cement composition has a V content of 0.0063 to 0.012% by mass, and subjecting the raw material having the controlled unit consumption to calcination to produce a cement clinker; and
25 (B) pulverizing the produced cement clinker, together with gypsum and an additive material.