

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 is the higher the strength of a cement paste, mortar, or concrete becomes.

[0003] The cement users have demanded a cement composition from which a cured
15 product of, e.g., 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) of cement particles" or "increasing the alite (C_3S) content of a cement clinker" is used (for example, non-
20 patent document 1).

PRIOR ART REFERENCE

Non-patent Document

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

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

30 [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 composition of a cement composition, such as the method of "increasing the fineness (Blaine specific surface area) of cement particles" or "increasing the C_3S content of a cement clinker" described in non-patent document 1, problems arise in that the fluidity
35 becomes poor and further the setting time is reduced.

[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 a cement paste, mortar, or concrete while maintaining appropriate fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the cement paste, mortar, or concrete, and a method for producing the same.

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 a cement paste, mortar, or concrete while maintaining the fresh properties of the cement paste, mortar, or concrete, the effect of the strontium (Sr) content and molybdenum (Mo) content of the cement composition is large, and the present invention has been completed.

[0009] Specifically, the present invention is directed to a cement composition having a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass. The present invention is directed to the cement composition which has an R_2O content of 0.3 to 0.6% by mass. The present invention is directed to the cement composition which has a MgO content of 0.7 to 1.8% by mass and a SO_3 content of 1.6 to 2.5% by mass. Further, the present invention is directed to the cement composition which has a C_3S content of 45 to 70% by mass, a C_2S content of 5 to 25% by mass, a C_3A content of 6 to 15% by mass, and a C_4AF content of 7 to 15% by mass.

[0010] Further, 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 hydrocane, and an iron source so that the resultant cement composition has a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass, and subjecting the raw material having the controlled unit consumption to calcination to produce a cement clinker; and (B) pulverizing the cement clinker, together with gypsum, and limestone and blast furnace slag as additive materials. Furthermore, the present invention is directed to the method for producing a cement composition, wherein, as the raw material for cement clinker in step (A), 700 to 1,400 kg of limestone, 20 to 150 kg of silica, 0 to 300 kg of coal ash, 0 to 100 kg of clay, 0 to 100 kg of blast furnace slag, 10 to 150 kg of soil generated by construction, 0 to 100 kg of sewage sludge, 0 to 100 kg of a hydrocane, and 30 to 80 kg of an iron source are mixed per 1 ton of the cement clinker.

Effect of the Invention

[0011] In the present invention, there can be provided a cement composition which improves the strength exhibiting properties of a cured product (for example, strength
5 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 normal consistency of cement paste (water amount required to obtain a constant softness) and setting time of the cement paste for maintaining appropriate fresh 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 Sr content of a cement 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 described.

[0014] The cement composition of the present invention has a Sr content of 0.02 to
20 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass.

[0015] In the cement composition, Sr and Mo are trace element components. The present inventors have found that the Sr content and Mo content of the cement composition strongly affect the strength exhibiting properties of a cured product of a cement paste, mortar, or concrete using the cement composition, and that when the Sr
25 content and Mo content of the cement composition fall in their respective appropriate ranges, the strength exhibiting properties of a cured product of a cement paste, mortar, or concrete can be improved while maintaining appropriate fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the cement paste, mortar, or concrete.

[0016] The Sr content and Mo content of the cement composition are the respective amounts (% by mass) of the Sr and Mo contained, based on the mass of the cement composition. The Sr content and Mo content of the cement composition 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
35 by ICP emission spectrometry and electrothermal type atomic absorption spectrometry".

[0017] The Sr content of the cement composition is 0.02 to 0.06% by mass,

preferably 0.025 to 0.057% by mass, more preferably 0.03 to 0.055% by mass, further preferably 0.035 to 0.05% by mass, especially preferably 0.038 to 0.045% by mass.

[0018] The Mo content of the cement composition is 0.0002 to 0.0023% by mass, preferably 0.0003 to 0.0020% by mass, more preferably 0.0004 to 0.0015% by mass, further preferably 0.0005 to 0.0012% by mass, especially preferably 0.0006 to 0.0009% by mass.

[0019] When the Sr content of the cement composition is less than 0.02% by mass or more than 0.06% by mass or the Mo content of the cement composition is more than 0.0023% by mass, the setting time of a cement paste, mortar, or concrete using the cement composition may be prolonged, making it difficult to maintain appropriate strength exhibiting properties of a cured product of the cement paste, mortar, or concrete using the cement composition.

[0020] The R_2O (total alkali) content of the cement composition means an amount represented by the following formula (1).

$$\begin{aligned} &R_2O \text{ Content of the cement composition} \\ &= Na_2O \text{ Content} + 0.658 \times K_2O \text{ Content} \end{aligned} \quad (1)$$

The cement composition preferably has an R_2O content of 0.3 to 0.6% by mass, more preferably 0.35 to 0.55% by mass, further preferably 0.37 to 0.54% by mass, especially preferably 0.38 to 0.52% by mass. When the R_2O content of the cement composition falls in the above-mentioned range, a cement paste, mortar, or concrete using the cement composition can be improved in the strength exhibiting properties while maintaining appropriate fluidity and setting time. 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 amount can be measured in accordance with JIS R 5202: 1998 "Chemical analysis methods for Portland cement".

[0021] The cement composition preferably has a MgO content of 0.7 to 1.8% by mass, more preferably 0.7 to 1.7% by mass, further preferably 0.8 to 1.6% by mass, especially preferably 0.9 to 1.5% by mass, extremely preferably 0.9 to 1.4% by mass. When the MgO content of the cement composition falls in the above-mentioned range, a cement paste, mortar, or concrete using the cement composition can be improved in the strength exhibiting properties while maintaining appropriate fluidity and setting time. The 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”.

[0022] The cement composition preferably has a SO_3 content of 1.6 to 2.5% by mass, more preferably 1.6 to 2.4% by mass, further preferably 1.7 to 2.35% by mass, especially preferably 1.8 to 2.35% by mass. When the SO_3 content of the cement composition falls in the above-mentioned range, a cement paste, mortar, or concrete using the cement composition can be improved in the strength exhibiting properties while maintaining appropriate fluidity and setting time. The SO_3 content of the cement composition is the amount (% by mass) of the SO_3 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”.

[0023] With respect to the mineral composition of the cement composition, it is preferred that the C_3S content is 45 to 70% by mass, the C_2S content is 5 to 25% by mass, the C_3A content is 6 to 15% by mass, and the C_4AF content is 7 to 15% by mass, it is more preferred that the C_3S content is 48 to 65% by mass, the C_2S content is 7 to 25% by mass, the C_3A content is 8 to 13% by mass, and the C_4AF content is 8 to 12% by mass, it is further preferred that the C_3S content is 53 to 65% by mass, the C_2S content is 10 to 23% by mass, the C_3A content is 9 to 12% by mass, and the C_4AF content is 8 to 11% by mass, and it is especially preferred that the C_3S content is 55 to 63% by mass, the C_2S content is 11 to 20% by mass, the C_3A content is 9 to 11% by mass, and the C_4AF content is 8 to 10% by mass. When the mineral composition of the cement composition falls in the above-mentioned range, the strength exhibiting properties of a mortar and concrete can be easily maintained while maintaining fresh properties of the mortar and concrete.

[0024] The C_3S content (alite), C_2S content (belite), C_3A content (aluminate phase), and C_4AF content (ferrite phase), which are the mineral composition of the cement composition, are determined by the following Bogue equations [1] to [4].

[0025] C_3S Content (% by mass)

$$= 4.07 \times \text{CaO Content (\% by mass)} - 7.60 \times \text{SiO}_2 \text{ Content (\% by mass)} - 6.72 \times \text{Al}_2\text{O}_3 \text{ Content (\% by mass)} - 1.43 \times \text{Fe}_2\text{O}_3 \text{ Content (\% by mass)} - 2.85 \times \text{SO}_3 \text{ Content (\% by mass)}$$

[1]

$$\text{C}_2\text{S Content (\% by mass)}$$
$$= 2.87 \times \text{SiO}_2 \text{ Content (\% by mass)} - 0.754 \times \text{C}_3\text{S Content (\% by mass)}$$

[2]

$$\text{C}_3\text{A Content (\% by mass)}$$

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

$$\text{C}_4\text{AF Content (\% by mass)} \\ = 3.04 \times \text{Fe}_2\text{O}_3 \text{ Content (\% by mass)} \quad [4]$$

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[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
10 JIS R 5204 "Fluorescent X-ray analysis method for cement".

[0027] The method for producing a cement composition of the present invention 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,
15 and an iron source so that the resultant cement composition has a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass, and subjecting the raw material having the controlled unit consumption to calcination to produce a cement clinker; and (B) pulverizing the cement clinker, together with mixed therewith gypsum, and limestone and blast furnace slag as additive materials.

20 [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
25 constructions 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
30 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
35 iron source may be used as long as they contain Sr in a certain amount.

[0029] With respect to the raw material unit consumption of the raw materials for

5 cement clinker in step (A), it is preferred that 700 to 1,400 kg of limestone, 20 to 150 kg of silica, 0 to 300 kg of coal ash, 0 to 100 kg of clay, 0 to 100 kg of blast furnace slag, 10 to 150 kg of soil generated by construction, 0 to 100 kg of sewage sludge, 0 to 100 kg of a hydrocake, and 30 to 80 kg of an iron source are mixed 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 of limestone, 20 to 100 kg of silica, 10 to 250 kg of coal ash, 0 to 80 kg of clay, 5 to 50 kg of blast furnace slag, 20 to 150 kg of soil generated by construction, 0 to 70 kg of sewage sludge, 20 to 80 kg of a hydrocake, and 30 to 60 kg of an iron source are mixed on a dry basis per 1 ton (t) of the cement clinker. It is further preferred that the amount of the coal ash is 20 to 250 kg on a dry basis. In the present specification, 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).

10 [0030] A method for controlling the raw material unit consumption of the raw material for cement clinker in step (A) is in which a Sr content and a Mo content of each raw material for cement clinker are measured, and the raw material unit consumption of the cement clinker raw material containing Sr or Mo in a large amount is mainly adjusted, thereby controlling the raw material unit consumption so that the resultant cement clinker composition has a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass.

20 [0031] Among the raw materials for cement clinker, the amount of the iron source used (raw material unit consumption) strongly affects the Mo content of the cement composition. Among the iron sources, copper slag has a large Mo content, and, when copper slag is used as the iron source, in the amount of 30 to 80 kg/t per 1 ton (t) of the cement clinker, which is a preferred range of the raw material unit consumption of the iron source, the amount of the copper slag used per 1 ton of the cement clinker is preferably 5 to 70 kg/t, more preferably 5 to 60 kg/t, further preferably 5 to 55 kg/t, especially preferably 5 to 50 kg/t.

30 [0032] For obtaining the cement composition having a MgO content in a specific range, based on the MgO content of each of limestone, silica, blast furnace slag, coal ash, soil generated by construction, blast furnace dust, a hydrocake, and copper slag and blast furnace dust as an iron source, the raw material unit consumption of each raw material is controlled so that the total of the MgO contents of these raw materials becomes 0.7 to 1.8% by mass.

35 [0033] With respect to the raw materials for cement clinker, it is preferred to use the raw materials each having a Sr content, a Mo content, and a MgO content which fall in

their respective ranges shown below. The Sr content, Mo content, and MgO content of each raw material are the respective amounts (% by mass) of the Sr, Mo, and MgO contained, based on the mass of each raw material (100% by mass).

[0034] 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 0.2 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.

[0035] 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, further 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.

[0036] 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.

[0037] The blast furnace slag used 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 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.

[0038] The clay 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. 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 3.0% by mass. The clay used preferably 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.

[0039] The soil generated 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. The soil generated by construction used preferably has a MgO content of 0.5 to 6.0% by mass, more preferably 0.5 to 5.0%

by mass, further preferably 1.0 to 4.0% by mass, especially preferably 1.0 to 3.0% by mass. The soil generated by construction used preferably has an R₂O 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.

[0040] 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 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, especially preferably 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 3.0% by mass, further preferably 0.1 to 2.5% by mass, especially preferably 0.1 to 2.0% by mass. The sewage sludge used preferably has an R₂O

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.

[0041] 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
5 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% by mass or less. The hydrocake used preferably has a MgO content of 5.0 to 30% by mass, more preferably 5.0 to 25% by mass, further preferably 10 to 25% by mass, especially preferably 10 to
10 20% by mass. The hydrocake used preferably has an R₂O 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.

[0042] When copper slag and blast furnace dust are used as the iron source, it is preferred to use the copper slag and blast furnace dust each having a Sr content, a Mo
15 content, and a MgO content which fall in their respective ranges shown below.

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 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,
20 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 2.0% by mass, more preferably 0.06 to 1.8% by mass, further preferably 0.08
25 to 1.6% by mass, especially preferably 1.0 to 1.4% by mass.

[0043] The blast 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 0.001 to 0.015% by mass, especially preferably 0.001 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
30 mass or less, further preferably 0.002% by mass or less, especially preferably 0.001% by mass or less. 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%
35 by mass, further preferably 0.006 to 0.6% by mass, especially preferably 0.008 to 0.4% by mass.

[0044] The production of the cement clinker can be conducted using existing cement production facilities of an SP system (multicyclone preheating system) or an NSP system (multicyclone preheating system using a calcination furnace).

[0045] In the production on a commercial scale, for example, a sample for quality control is taken during the calcination for cement clinker and Sr and Mo contents of the cement clinker as the sample are measured, and, based on the Sr and Mo contents of each of the raw materials, the ratio between the raw materials used (raw material unit consumption) is controlled so that the resultant cement clinker has a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass. Among the raw materials for cement clinker, the coal ash has a relatively large Sr content and the soil generated by construction has a relatively small Sr content, and therefore, for example, when the Sr content of the cement clinker taken as a sample is less than 0.02% by mass, the raw material unit consumption of the coal ash is increased and the raw material unit consumption of the soil generated by construction is reduced. Conversely, when the Sr content of the cement clinker taken as a sample is more than 0.06% by mass, the raw material unit consumption of the coal ash is reduced and the raw material unit consumption of the soil generated by construction is increased. Thus, by controlling the raw material unit consumption of the raw materials for cement clinker, the Sr content can be controlled without changing the mineral composition of the cement clinker. Even in the case where coal ash is not used as a raw material for cement clinker, when the Sr content of the cement clinker taken as a sample is more than 0.06% by mass, it is preferred that limestone having a small Sr content is selectively used to reduce the Sr content of the cement clinker. Further, for example, when the Mo content of the cement clinker taken as a sample is more than 0.0023% by mass, among the iron sources as the raw material for cement clinker, the raw material unit consumption of the copper slag having a relatively large Mo content is reduced and, conversely, the raw material unit consumption of the blast furnace dust is increased. Thus, by controlling the raw material unit consumption of the raw material as an iron source among the raw materials for cement clinker, the Mo content can be controlled without changing the mineral composition of the cement clinker.

[0046] With respect to the MgO content of the cement composition, similarly, a sample for quality control is taken during the calcination for cement clinker and a MgO content of the cement clinker as the sample is measured, and, based on the MgO content of each of the raw materials, the ratio between the raw materials used (raw material unit consumption) is controlled so that the resultant cement composition has a MgO content of 0.7 to 1.8% by mass. Among the raw materials for cement clinker, the blast furnace

slag and/or hydrocake has a relatively large MgO content and the coal ash and/or soil generated by construction has a relatively small MgO content, and therefore, for example, when the MgO content of the cement clinker taken as a sample is less than 0.7% by mass, the raw material unit consumption of the blast furnace slag and/or

5 hydrocake is increased and the raw material unit consumption of the coal ash and/or soil generated by construction is reduced. Conversely, when the MgO content of the cement clinker taken as a sample is more than 1.8% by mass, the raw material unit consumption of the blast furnace slag and/or hydrocake is reduced and the raw material unit consumption of the coal ash and/or soil generated by construction is increased.
10 Thus, by controlling the raw material unit consumption of the raw materials for cement clinker, the MgO content can be controlled without changing the mineral composition of the cement clinker.

[0047] Next, using existing cement production facilities of an NSP system, one mode of a method for producing the cement clinker used in the cement composition according to the present embodiment is described below. The method for producing the cement composition according to the present embodiment is not limited to the mode described below.
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[0048] 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.
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[0049] 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 existing facilities. The cement clinker used for producing the cement composition having a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass can be obtained also by changing calcination conditions for cement clinker, such as a calcination temperature or a calcination time.
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[0050] 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 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.
30

[0051] 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
35

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 obtained a cement composition which enables production of a mortar or concrete having excellent strength exhibiting properties.

5 [0052] In the pulverizing step, a cement composition can be produced by mixing together the cement clinker having a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass and gypsum and pulverizing the resultant mixture. The gypsum desirably satisfies the quality prescribed in JIS R 9151 "Natural
10 insoluble anhydrous gypsum is preferably used.

[0053] In the pulverizing step, it is preferred that gypsum is mixed into the cement clinker having a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass so that the obtained cement composition has a SO₃ content of 1.6 to 2.5% by mass, preferably 1.7 to 2.4% by mass, further preferably 1.8 to 2.4% by mass,
15 especially preferably 1.85 to 2.35% by mass, and the resultant mixture is pulverized. 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. 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%
20 by mass and the gypsum is contained in an amount of 3 to 5% by mass, based on the mass of the cement composition.

[0054] In the pulverizing step, 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
25 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. The amount of the additive material(s) contained is as small as 5% by mass or less, and therefore, even when the additive material is added to the cement composition, the
30 additive material has almost no effect on the Sr content, Mo content, MgO content, and R₂O content of the cement composition.

[0055] After the pulverizing step, the cement composition preferably has an R₂O content of 0.3 to 0.6% by mass, preferably 0.3 to 0.6% by mass, more preferably 0.35 to 0.55% by mass, further preferably 0.37 to 0.54% by mass, especially preferably 0.35 to
35 0.52% by mass. The cement composition having an R₂O content falling in the above-mentioned range can be obtained by a method in which a sample for quality control is

taken during the calcination for cement clinker and an R_2O content of the cement clinker as the sample is measured to control the raw material unit consumption of, e.g., silica, coal ash, clay, soil generated by construction, and sewage sludge among the raw materials for cement clinker.

- 5 [0056] The cement composition according to the present embodiment preferably has a Blaine specific surface area of 2,800 to 4,000 cm^2/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 cm^2/g , further
10 preferably 3,000 to 3,500 cm^2/g .

[0057] Hereinabove, the preferred embodiments of the present invention have been described, but the present invention is not limited to the above-mentioned embodiments.

EXAMPLES

- 15 [0058] Hereinbelow, the present invention will be described in more detail with reference to the following Examples and Comparative Examples, which should not be construed as limiting the scope of the present invention.

[0059] (Examples 1 to 4 and Comparative Examples 1 to 7)

[Raw materials for cement clinker]

- 20 With respect to the raw materials for cement clinker, a Sr content, a Mo content, and a MgO 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) were measured in advance. Further a sample for quality control was taken during the calcination for cement clinker, and a Sr content, a
25 Mo content, a MgO content, and an R_2O content of the cement clinker as the sample were measured in advance. And, based on the Sr content, Mo content, MgO content, and R_2O content of each of the raw materials, the ratio between the raw materials used (raw material unit consumption) was controlled so that the resultant cement clinker had a Sr content of 0.02 to 0.06% by mass and a Mo content of 0.0002 to 0.0023% by mass.
30 Further, the ratio between the raw materials used (raw material unit consumption) was controlled so that the resultant cement clinker had a MgO content of 0.7 to 1.8% by mass. Furthermore, the ratio between the raw materials used (raw material unit consumption) was controlled so that the resultant cement clinker had an R_2O content of 0.3 to 0.6% by mass. The Sr content, Mo content, and MgO content of the individual
35 raw materials used in Examples and Comparative Examples 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.

[0060] For obtaining the cement composition having a Sr content, a Mo content, a
5 MgO content, and an R_2O content in their respective specific ranges, the ratio between the cement clinker raw materials used (raw material unit consumption) was controlled as follows. The Sr content of the cement clinker was controlled by increasing or
reducing the ratio between the coal ash having a Sr content as large as 0.106% by mass and the soil generated by construction having a Sr content as small as 0.0272% by mass.
10 For example, for reducing the Sr content, the amount of the coal ash was reduced and the amount of the soil generated by construction was increased, and these amounts were controlled while checking the Sr content of the cement clinker. The Mo content of the
cement clinker was controlled by increasing or reducing the ratio between the copper
slag having a Mo content as large as 0.266% by mass and the blast furnace dust having
15 a Mo content as small as 0.001% by mass. For example, for reducing the Mo content, the amount of the copper slag was reduced and the amount of the blast furnace dust was increased, and these amounts were controlled while checking the Mo content of the
cement clinker. Further, the MgO content of the cement clinker was controlled by
increasing or reducing the ratio between the blast furnace slag having a MgO content as
20 large as 5.12% by mass and the hydrocake having a MgO content as large as 14.19% by mass. The R_2O content of the cement composition was controlled by increasing or
reducing the ratio between, e.g., silica, coal ash, clay, soil generated by construction, and sewage sludge having a relatively large R_2O content among the raw materials for cement clinker.

[0061] [Table 1]

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

[0062] The Sr content, Mo content, and MgO content 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”.

[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 100 kg/t-clinker; coal ash: 10 to 250 kg/t-clinker; clay: 0 to 80 kg/t-clinker; blast furnace slag: 5 to 50 kg/t-clinker; soil generated by construction: 20 to 150 kg/t-clinker; sewage sludge: 0 to 70 kg/t-clinker; hydrocake: 20 to 80 kg/t-clinker; and iron source: 30 to 60 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]

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.

[0065] Dihydrate gypsum was mixed 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 (1) of the cement composition]

5 With respect to the above-obtained cement composition, the respective amounts (% by mass) of the SiO₂, Al₂O₃, Fe₂O₃, CaO, MgO, and SO₃ contained, 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, Sr and Mo contents of the cement composition were measured in accordance with Japan Cement Association standard test method JCAS I-
10 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 (% by mass)							
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	Mo	Sr
Example 1	20.18	5.72	2.80	64.65	1.16	1.86	0.0010	0.0390
Example 2	20.21	5.80	2.81	64.41	1.23	1.97	0.0007	0.0435
Example 3	20.37	5.39	2.69	64.57	0.98	2.35	0.0022	0.0580
Example 4	21.53	5.15	2.65	64.88	1.18	2.29	0.0020	0.0262
Comparative Example 1	20.23	5.55	2.89	64.28	1.09	2.25	0.0024	0.0425
Comparative Example 2	20.43	5.44	2.97	64.42	1.17	1.80	0.0026	0.0374
Comparative Example 3	20.29	5.25	2.70	64.50	1.21	2.44	0.0027	0.0540
Comparative Example 4	20.65	5.59	2.86	63.78	1.53	1.88	0.0030	0.0484
Comparative Example 5	20.70	5.57	2.79	64.26	1.52	1.75	0.0028	0.0506
Comparative Example 6	20.04	5.20	2.94	64.97	0.95	2.08	0.0028	0.0264
Comparative Example 7	20.43	5.50	3.06	64.55	1.04	1.78	0.0032	0.0340

[0068] [Chemical components (2) of the cement composition]

15 With respect to the above-obtained cement composition, the respective amounts (% by mass) of the Na₂O, K₂O, and R₂O contained, 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". The results are shown in Table 3.

[0069] [Table 3]

	Chemical components of cement composition (% by mass)		
	Na ₂ O	K ₂ O	R ₂ O
Example 1	0.25	0.23	0.40
Example 2	0.27	0.25	0.43
Example 3	0.21	0.31	0.41
Example 4	0.25	0.41	0.52
Comparative Example 1	0.24	0.38	0.49
Comparative Example 2	0.22	0.38	0.47
Comparative Example 3	0.22	0.32	0.43
Comparative Example 4	0.22	0.43	0.50
Comparative Example 5	0.20	0.40	0.46
Comparative Example 6	0.23	0.38	0.48
Comparative Example 7	0.19	0.45	0.49

[0070] [Mineral composition of the cement composition]

<Mineral composition of the cement composition>

- 5 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 4.

[0071] [Table 4]

	Mineral composition(% by mass) Bogue equations			
	C ₃ S	C ₂ S	C ₃ A	C ₄ AF
Example 1	62.0	11.2	10.4	8.5
Example 2	59.9	12.8	10.6	8.5
Example 3	61.2	12.3	9.7	8.2
Example 4	55.5	19.9	9.2	8.1
Comparative Example 1	60.0	12.8	9.8	8.8
Comparative Example 2	61.0	12.6	9.4	9.0
Comparative Example 3	62.2	11.3	9.3	8.2
Comparative Example 4	55.6	17.3	10.0	8.7

Comparative Example 5	57.8	15.8	10.0	8.5
Comparative Example 6	67.0	7.0	8.8	8.9
Comparative Example 7	61.0	12.6	9.4	9.3

[0072] [Physical properties of the cement composition]

<Fineness properties of the cement composition>

Fineness properties of cement (Blaine specific surface area and 45 μ m residue) were measured in accordance with JIS R 5201: 1997 "Physical testing methods for cement". The results are shown in Table 5.

<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 5.

<Setting time and mortar compressive strength>

A setting time and a mortar compressive strength were measured using the above-obtained cement composition in accordance with JIS R 5201: 1997 "Physical testing methods for cement". The results are shown in Table 5.

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

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.

[0073] [Table 5]

	Fineness properties		Color b-value (-)	Amount of water required for normal consistency of cement paste (%)	Setting time		Mortar compressive strength for 28-day age (N/mm ²)
	Blaine (cm ² /g)	45 μ m residue (% by mass)			Initial setting (minutes)	Final setting (minutes)	
Example 1	3300	7.2	7.09	28.0	118	178	65.2
Example 2	3340	7.3	6.93	27.8	129	189	66.5
Example 3	3320	9.6	7.47	28.0	113	168	64.8
Example 4	3380	6.9	6.68	28.0	114	167	63.6
Comparative Example 1	3300	9.1	7.23	28.2	136	196	61.8
Comparative Example 2	3290	8.3	7.11	28.0	108	173	60.0
Comparative Example 3	3250	11.7	6.64	27.6	110	166	60.8
Comparative Example 4	3320	10.2	6.37	27.2	120	175	61.9
Comparative Example 5	3260	12.6	6.22	27.2	142	202	61.2
Comparative Example 6	3320	9.3	6.72	28.4	129	189	56.2
Comparative Example 7	3150	10.4	6.64	27.8	141	207	58.8

[0074] Fig. 1 shows the relationship between the Sr content of the cement compositions in Examples 1 to 4 having a Mo content of less than 0.0023% by mass (specifically, a Mo content of 0.0007 to 0.0022% by mass) and a Sr content of 0.02 to 0.06% by mass (specifically, a Sr content of 0.0262 to 0.058% by mass) and the compressive strength of mortars using these cement compositions. Further, Fig. 1 shows the relationship between the Sr content of the cement compositions in Comparative Examples 1 to 7 having a Mo content of more than 0.0023% by mass and a Sr content of 0.02 to 0.06% by mass and the compressive strength of mortars using these cement compositions.

[0075] As can be seen from Table 5 and Fig. 1, when the Sr content of the cement composition is in the range of from 0.02 to 0.06% by mass, the mortar compressive strength increases and peaks in the Sr content of about 0.045 to 0.05% by mass. Further, as can be seen from Table 5 and Fig. 1, the cement compositions having a Mo content of 0.0002 to 0.0023% by mass in Examples 1 to 4 (symbol "O" in Fig. 1) are increased in the mortar compressive strength and improved in the strength exhibiting properties, and thus can surely achieve satisfactory mortar compressive strength, as

compared to the cement compositions having a Mo content of more than 0.0023% by mass in Comparative Examples 1 to 7 (symbol “●” in Fig. 1). Further, in the cement compositions in Examples 1 to 4, despite an increase of the mortar compressive strength, the amount of water required for normal consistency of cement paste (water amount
5 required to obtain a constant softness of the cement paste) is maintained and there is no marked change in the fluidity, and the setting time does not markedly change, as compared to those in the cement compositions in Comparative Examples 1 to 7.

[0076] As can be seen from the results shown above, when the Sr content of the cement composition is 0.02 to 0.06% by mass and the Mo content is 0.0002 to 0.0023%
10 by mass, there can be provided a cement composition which can improve the strength exhibiting properties of a cured product of a cement paste, mortar, or concrete while maintaining the fresh properties (the amount of water required for normal consistency of cement paste, setting time) of the cement paste, mortar, or concrete, and a method for producing the same.

Claims

[Claim 1]

A cement composition having a Sr content of 0.02 to 0.06% by mass, a Mo content of 0.0002 to 0.0023% by mass, a C_3S content of 45 to 70% by mass, a C_2S content of 5 to 25% by mass, a C_3A content of 6 to 15% by mass, and a C_4AF content of 7 to 15% by mass.

[Claim 2]

The cement composition according to claim 1, which has an R_2O content of 0.3 to 0.6% by mass.

[Claim 3]

The cement composition according to claim 1 or 2, which has a MgO content of 0.7 to 1.8% by mass and a SO_3 content of 1.6 to 2.5% by mass.

[Claim 4]

A method for producing a cement composition, the method comprising the steps of:

(A) controlling the raw material unit consumption of a raw material selected from the group consisting of limestone, silica

stone, 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 Sr content of 0.02 to 0.06% by mass, a Mo content of 0.0002 to 0.0023% by mass, a C_3S content of 45 to 70% by mass, a C_2S content of 5 to 25% by mass, a C_3A content of 6 to 15% by mass, and a C_4AF content of 7 to 15% by mass, and subjecting the raw material having the controlled unit consumption to calcination to produce a cement clinker; and

(B) pulverizing the cement clinker, together with gypsum, and with limestone and blast furnace slag as additive materials.

{Claim 5}

The method for producing a cement composition according to claim 4, wherein, as the raw materials for the cement clinker in the step (A), 700 to 1,400 kg of limestone, 20 to 150 kg of silica stone, 0 to 300 kg of coal ash, 0 to 100 kg of clay, 0 to 100 kg of blast furnace slag, 10 to 150 kg of soil generated by construction, 0 to 100 kg of sewage sludge, 0 to 100 kg of a hydrocake, and 30 to 80 kg of an iron source are mixed per 1 ton of the cement clinker.