

DESCRIPTION

Title of Invention

CEMENT COMPOSITION AND METHOD FOR PRODUCING SAME

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Technical Field

[0001]

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

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Background Art

[0002]

Depending on raw material circumstances, a clinker contains a minor component such as Mg, Na, or K, and the content thereof changes.

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For example, in Non Patent Literature No. 1, it is known that a high MgO cement is substituted with Ca that is the same alkali earth metal, and as disclosed in Non Patent Literature No. 2, it is also known that, since the amount of belite relatively decreases as a result of the substitution, a long-term strength at 28-day age or the like decreases. Non Patent Literature No. 3 obtains a finding that the strength is likely to be improved even at high MgO content by increasing SO₃.

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[0003]

In addition, Patent Literature No. 1 discloses that, when the MgO content in a calcined cement clinker exceeds 1.0% by mass, the strength development of cement at long-term age decreases, and thus raw materials are mixed such that the MgO content in the calcined Portland cement clinker is adjusted to 1.0% by mass or less.

Further, Patent Literature No. 2 discloses a cement clinker where the content rate of $2\text{CaO}\cdot\text{SiO}_2$ calculated by Bogue calculation is 30% to 60% by mass, in which in the cement clinker, the content rate of MgO is 1.2% by mass or more and less than 1.9% by mass, and the content rate of SO_3 is 0.4% to 1.2% by mass.

Citation List

Patent Literature

[0004]

[Patent Literature No. 1] Japanese Laid-open Patent Publication No. 2009-013023

[Patent Literature No. 2] Japanese Laid-open Patent Publication No. 2018-65750

Non Patent Literature

[0005]

[Non Patent Literature No. 1] Crystal Chemistry of Tricalcium Silicate Solid Solution, in 5th I.S.C.C, Vol. 1, 61-66 (1969)

[Non Patent Literature No. 2] Cement Technology
Annual Report Vol. 22, 62-66 (1968)

[Non Patent Literature No. 3] Cement Science and
Concrete Technology, Vol. 70

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Summary of Invention

Technical Problem

[0006]

However, it is difficult to control the adjustment of
10 the high MgO cement component, and with the methods
described in Non Patent Literatures No. 1 to 3, the long-
term strength cannot be stably maintained. Regarding this
problem, limestone as a raw material produced from a mine
may sometimes contain a large amount of dolomite, and the
15 produced cement has high MgO, which causes a variation in
the quality performance of concrete or the like. Therefore,
as in Patent Literature No. 1, the MgO content needs to be
decreased. Patent Literature No. 2 describes that, even
when the content rate of MgO in the cement is high, a
20 decrease in the long-term strength development of the
cement can be prevented. Nevertheless, the upper limit of
the MgO content rate needs to be less than 1.9% by mass.

[0007]

An object of the present invention is to provide: a
25 cement composition where a long-term strength of mortar is

excellent even when a MgO content in a Portland cement is high; and a method for producing a cement composition where a long-term strength of mortar can be improved even when a MgO content in a Portland cement is high.

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Solution to Problem

[0008]

The present invention provides the following <1> to <10>.

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<1> A cement composition including:

a Portland cement that satisfies (1) and (2) below;

and

0.001 to 0.025 parts by mass of alkanolamine with respect to 100 parts by mass of the Portland cement, in

15 which

(1) $0.55 \leq \text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3 \leq 0.95$, and

(2) $0 \leq \Delta\text{C}_4\text{AF}$,

in (1), MgO represents a mass (% by mass) of MgO in the Portland cement, Fe_2O_3 represents a mass (% by mass) of Fe_2O_3 in the Portland cement, SO_3 represents an amount (% by mass) of the Portland cement in terms of SO_3 , and $\text{CL}'\text{SO}_3$ represents an amount (% by mass) of a clinker of the Portland cement in terms of SO_3 , and

in (2), $\Delta\text{C}_4\text{AF}$ represents a difference ($\text{R.C}_4\text{AF} - \text{B.C}_4\text{AF}$) between a mass (% by mass) of $\text{R.C}_4\text{AF}$ and a mass (% by mass)

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of B.C₄AF, where R.C₄AF represents a C₄AF value of the Portland cement measured by a powder X-ray diffractometer, B.C₄AF represents $3.04 \times \text{Fe}_2\text{O}_3$, and Fe₂O₃ in B.C₄AF represents a mass (% by mass) of Fe₂O₃ in the Portland cement.

[0009]

<2> The cement composition according to <1>, in which in (1), MgO/Fe₂O₃ exceeds 0.35.

<3> The cement composition according to <1> or <2>, in which the Portland cement is a normal Portland cement where a content of C₃S is 45% to 75% by mass, a content of C₂S is 5% to 25% by mass, a content of C₃A is 7% to 11% by mass, and a content of C₄AF is 7% to 11% by mass when calculated by Bogue calculation.

<4> The cement composition according to any one of <1> to <3>, in which a content of the alkanolamine is 0.005 to 0.02 parts by mass with respect to 100 parts by mass of the Portland cement.

<5> The cement composition according to any one of <1> to <4>,

in which the alkanolamine is at least one selected from the group consisting of diethanol isopropanolamine, triisopropanolamine, ethanol diisopropanolamine, triethanolamine, N-methyldiethanolamine, and N-n-

butyldiethanolamine.

[0010]

<6> A method for producing a cement composition, the method including:

5 mixing a Portland cement that satisfies (1) and (2) below and 0.001 to 0.025 parts by mass of alkanolamine with respect to 100 parts by mass of the Portland cement, in which

(1) $0.55 \leq \text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3 \leq 0.95$, and

10 (2) $0 \leq \Delta\text{C}_4\text{AF}$,

in (1), MgO represents a mass (% by mass) of MgO in the Portland cement, Fe_2O_3 represents a mass (% by mass) of Fe_2O_3 in the Portland cement, SO_3 represents an amount (% by mass) of the Portland cement in terms of SO_3 , and $\text{CL}'\text{SO}_3$
15 represents an amount (% by mass) of a clinker of the Portland cement in terms of SO_3 , and

in (2), $\Delta\text{C}_4\text{AF}$ represents a difference ($\text{R.C}_4\text{AF} - \text{B.C}_4\text{AF}$) between a mass (% by mass) of $\text{R.C}_4\text{AF}$ and a mass (% by mass) of $\text{B.C}_4\text{AF}$, where $\text{R.C}_4\text{AF}$ represents a C_4AF value of the
20 Portland cement measured by a powder X-ray diffractometer, $\text{B.C}_4\text{AF}$ represents $3.04 \times \text{Fe}_2\text{O}_3$, and Fe_2O_3 in $\text{B.C}_4\text{AF}$ represents a mass (% by mass) of Fe_2O_3 in the Portland cement.

[0011]

25 <7> The method for producing a cement composition

according to <6>,

in which in (1), $\text{MgO}/\text{Fe}_2\text{O}_3$ exceeds 0.35.

<8> The method for producing a cement composition according to <6> or <7>,

5 in which the Portland cement is a normal Portland cement where a content of C_3S is 45% to 75% by mass, a content of C_2S is 5% to 25% by mass, a content of C_3A is 7% to 11% by mass, and a content of C_4AF is 7% to 11% by mass when calculated by Bogue calculation.

10 <9> The method for producing cement composition according to any one of <6> to <8>,

in which an addition amount of the alkanolamine is 0.005 to 0.02 parts by mass with respect to 100 parts by mass of the Portland cement.

15 <10> The method for producing cement composition according to any one of <6> to <9>,

in which the alkanolamine is at least one selected from the group consisting of diethanol isopropanolamine, triisopropanolamine, ethanol diisopropanolamine, 20 triethanolamine, N-methyldiethanolamine, and N-n-butyl diethanolamine.

Advantageous Effects of Invention

[0012]

25 According to the present invention, it is possible to

provide: a cement composition where a long-term strength of mortar is excellent even when a MgO content in a Portland cement is high; and a method for producing a cement composition where a long-term strength of mortar can be improved even when a MgO content in a Portland cement is high.

Brief Description of Drawings

[0013]

10 FIG. 1 is a graph where ΔC_4AF values of Examples and Comparative Examples under a condition** are plotted.

FIG. 2 is a graph where values of differences in enhanced strength of mortar of Examples and Comparative Examples at 7-day age and 28 age under a condition** are plotted.

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Description of Embodiments

[0014]

The notation of a numerical range of "AA to BB" in the present specification means "AA or more and BB or less".

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[0015]

<Cement Composition>

A cement composition according to the present invention includes: a Portland cement that satisfies (1) and (2) below; and 0.001 to 0.025 parts by mass of

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alkanolamine with respect to 100 parts by mass of the Portland cement, in which

$$(1) \quad 0.55 \leq \text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3 \leq 0.95, \text{ and}$$

$$(2) \quad 0 \leq \Delta\text{C}_4\text{AF},$$

5 in (1), MgO represents a mass (% by mass) of MgO in the Portland cement, Fe_2O_3 represents a mass (% by mass) of Fe_2O_3 in the Portland cement, SO_3 represents an amount (% by mass) of the Portland cement in terms of SO_3 , and $\text{CL}'\text{SO}_3$ represents an amount (% by mass) of a clinker of the
10 Portland cement in terms of SO_3 , and

 in (2), $\Delta\text{C}_4\text{AF}$ represents a difference ($\text{R.C}_4\text{AF} - \text{B.C}_4\text{AF}$) between a mass (% by mass) of $\text{R.C}_4\text{AF}$ and a mass (% by mass) of $\text{B.C}_4\text{AF}$, where $\text{R.C}_4\text{AF}$ represents a C_4AF value of the Portland cement measured by a powder X-ray diffractometer,
15 $\text{B.C}_4\text{AF}$ represents $3.04 \times \text{Fe}_2\text{O}_3$, and Fe_2O_3 in $\text{B.C}_4\text{AF}$ represents a mass (% by mass) of Fe_2O_3 in the Portland cement.

 Hereinafter, the Portland cement that satisfies (1) and (2) will be referred to as "the Portland cement
20 according to the present invention" or simply "the cement according to the present invention".

 In other words, the cement composition according to the present invention contains a clinker, gypsum, and alkanolamine, in which the Portland cement containing the
25 clinker and the gypsum satisfies (1) and (2), and the

content of the alkanolamine is in the above-described range.

[0016]

When the MgO content rate in the cement is high, for
5 example, 1.30% by mass or more, hydration of calcium
decreases, and the strength of mortar or the like
relatively decreases.

It is known that in order to improve the strength, an
auxiliary agent such as alkanolamine is used. The strength
10 that is expected to be increased by alkanolamine is a
short-term strength at less than 7-day age, and conversely
a long-term strength tends to decrease.

However, by configuring the content of the cement
composition as described above, the long-term strength of
15 mortar can be improved. Although the reason for this is not
clear, it is presumed to be due to the following reasons.

[0017]

[Condition (1)]

Condition (1) is that " $\text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3$ " is 0.55
20 to 0.95.

Although the details are not clear, it is considered
that the phenomenon in which the mass of MgO increases with
respect to the mass of Fe_2O_3 or in which the amount (by
mass) of the clinker in terms of SO_3 increases with respect
25 to the amount (by mass) of the cement in terms of SO_3

relates to solid solution of ferrite phase. " $\text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3$ " can be considered a so-called index representing the amount of solid solution of ferrite phase.

The alkanolamine added together with the Portland
5 cement in the present invention has a function of
dissolving iron or the like in ferrite phase in gel for
uniform penetration to promote watertightness and to
improve the strength of mortar. Therefore, it is considered
that, by dissolving magnesium and SO_3 in ferrite phase, the
10 mortar strength enhancement effect by alkanolamine is
further improved, and the long-term strength of mortar can
be further improved.

[0018]

When " $\text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3$ " is less than 0.55, the
15 amount of solid solution of ferrite phase is small, the
mortar strength enhancement effect by alkanolamine cannot
be sufficiently obtained, and the long-term strength of
mortar is not excellent.

When " $\text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3$ " exceeds 0.95, the
20 strength enhancement effect by alkanolamine is not likely
to be obtained, the amount of each of alkanolamine,
unreacted MgO , and unreacted MgSO_4 is excessive such that
expansion cracks occur, and the strength of mortar cannot
be maintained.

25 From the viewpoint of further improving the long-term

strength of mortar, " $\text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3$ " is preferably 0.60 to 0.90 and more preferably 0.70 to 0.80.

[0019]

Further, in Condition (1), $\text{MgO}/\text{Fe}_2\text{O}_3$ preferably
5 exceeds 0.35.

It is considered that the mass of MgO with respect to the mass of Fe_2O_3 in the cement represents the amount of solid solution of C_4AF , and when $\text{MgO}/\text{Fe}_2\text{O}_3$ exceeds 0.35, the solid solution of C_4AF can be promoted.

10 From the viewpoint of increasing the amount of solid solution of ferrite phase, $\text{MgO}/\text{Fe}_2\text{O}_3$ is preferably 0.36 to 0.60 and more preferably 0.40 to 0.50.

[0020]

From the viewpoint of increasing the amount of solid
15 solution of alkanolamine, MgO in Condition (1), that is, the mass of MgO in the cement is preferably 3.5% by mass or less, more preferably 0.5% to 3.0% by mass, and still more preferably 1.0% to 2.5% by mass.

[0021]

20 From the viewpoint of stabilizing the solid solution of ferrite phase, Fe_2O_3 in Condition (1), that is, the mass of Fe_2O_3 in the cement is preferably 2.0% to 4.0% by mass, more preferably 2.5% to 3.5% by mass, and still more preferably 2.7% to 3.4% by mass.

25 [0022]

From the viewpoint of promoting the solid solution of C_4AF and ensuring cement flowability, $CL'SO_3$ in Condition (1), that is, the amount of the clinker in terms of SO_3 is preferably 2.5% by mass or less, more preferably 0.2% to 2.0% by mass, and still more preferably 0.5% to 1.5% by mass.

[0023]

From the viewpoint of ensuring cement flowability, the range of SO_3 that is the denominator of $CL'SO_3/SO_3$ in Condition (1), that is, the amount of the cement in terms of SO_3 is preferably 3.5% by mass or less, more preferably 0.5% to 3.0% by mass, and still more preferably 1.5% to 2.5% by mass.

[0024]

[Condition (2)]

Condition (2) is that ΔC_4AF is 0 point or more.

0 point represents that, for example, when C_4AF (R. C_4AF) obtained by Rietveld analysis is 10.1% by mass, C_4AF (B. C_4AF) calculated by Bogue calculation is 10.1% by mass.

ΔC_4AF represents a difference (R. C_4AF - B. C_4AF) between a mass of R. C_4AF and a mass of B. C_4AF , which is a difference between C_4AF (R. C_4AF) obtained by Rietveld analysis and C_4AF (B. C_4AF) calculated by Bogue calculation. In Bogue calculation, magnesium is not considered. Therefore, the

amount of solid solution of MgO can be estimated from ΔC_4AF , and when the MgO content in the cement increases, ΔC_4AF also increases. In the present invention, from the viewpoint of improving the long-term strength of mortar under the high
5 MgO condition, the condition that ΔC_4AF is 0 or more is adopted.

An increase in the amount of dissolution of ferrite phase in which MgO is dissolved by alkanolamine affects the strength enhancement. Therefore, ΔC_4AF is preferably 0.3 to
10 1.5 points and more preferably 0.5 to 1.5 points.

[0025]

R. C_4AF is obtained from the following step.

First, the cement is measured by X-ray diffraction to obtain a profile. The obtained profile is analyzed using a
15 Rietveld method, and the quantitative analysis of cement minerals is executed.

The minerals to be analyzed are set to C_3S -M1 (M1 phase), C_3S -M3 (M3 phase), C_2S - $\alpha'H$ ($\alpha'H$ phase), C_2S - β (β phase), C_3A -cubic (cubic crystal), C_3A -ortho (orthorhombic
20 crystal), and C_4AF . In the Rietveld analysis, a refinement operation is executed based on basic crystal structure data of each of the minerals using a lattice constant, a scale factor, and the like as parameters such that a measured profile and a theoretical profile are fitted. Finally, the
25 mass ratio of each of the minerals is calculated from the

refined scale factor, and the content rate (% by mass) of R.C₄AF is obtained.

Specific measurement conditions of the X-ray diffractometer are shown in Examples.

5 [0026]

The Portland cement in the present invention is not particularly limited as long as it satisfies Conditions (1) and (2) described above. Portland cement such as normal Portland cement, high-early-strength Portland cement,
10 ultra-high-early-strength Portland cement, white Portland cement, sulfate resistant Portland cement, moderate heat Portland cement, or low-heat Portland cement, blended cement obtained by mixing blast furnace slag, fly ash, a siliceous admixture (pozzolan), and the like, or special
15 cement such as alumina cement can also be used. In particular, cement where the amount of ferrite phase in Bogue calculation is 6% by mass or more is suitable.

[0027]

More specifically, it is preferable that the Portland
20 cement used in the cement composition according to the present invention is a normal Portland cement where a content of C₃S (3CaO·SiO₂) is 45% to 75% by mass, a content of C₂S (2CaO·SiO₂) is 5% to 25% by mass, a content of C₃A (3CaO·Al₂O₃) is 7% to 11% by mass, and a content of C₄AF
25 (4CaO·Al₂O₃·FeO₃) is 7% to 11% by mass when calculated by

Bogue calculation.

In addition, in the Portland cement used in the cement composition according to the present invention, C_4AF

($R.C_4AF$) obtained by Rietveld analysis is preferably 7.5% to
5 12% by mass.

[0028]

(C_3S , C_2S)

By adjusting the content of C_3S in the cement to be 45% by mass or more, the strength enhancement effect
10 obtained by the addition of alkanolamine is high, the strength of mortar is excellent, and the flowability is excellent. By adjusting the content of C_3S in the cement to be 45% by mass or more, the content of C_2S having a relatively poor grinding properties is low. As a result,
15 the grinding time required to obtain a certain Blaine's specific surface area of the cement composition is reduced, overgrinding of mainly minerals (C_3S , C_3A , and C_4AF) other than C_2S having excellent grinding properties is suppressed, and an increase in Blaine's specific surface area is
20 suppressed. In addition, in the strength enhancement mechanism by the addition of alkanolamine, by selectively dissolving C_4AF in the clinker, the contact opportunity of C_4AF and water adjacent to C_4AF increases, hydration is promoted, and the strength is enhanced. By suppressing the
25 overgrinding of the clinker, clinker particles present as a

composite of the minerals are not likely to be present as a single mineral, the dissolution of C_4AF is likely to lead to the promotion of hydration of C_4AF . Accordingly, the strength enhancement effect by the addition of alkanolamine is likely to be obtained.

By adjusting the content of C_3S in the cement to be 75% by mass or less, the long-term compressive strength of the concrete can be sufficiently maintained.

By adjusting the content of C_2S in the cement to be 5% by mass or more, the long-term compressive strength of the concrete can be sufficiently maintained.

By adjusting the content of C_2S in the cement to be 25% by mass or less, the initial compressive strength of the concrete can be sufficiently maintained.

[0029]

From the viewpoint of enhancing the strength and the flowability, the content of C_3S in the cement is more preferably 50% to 70% by mass.

[0030]

(C_4AF , C_3A)

By adjusting the content of C_4AF in the cement to be 7% by mass or more, the dissolution of C_4AF caused by the addition of alkanolamine is promoted, the reaction of C_3S is promoted, and the significant strength enhancement effect can be exhibited.

By adjusting the content of C_4AF in the cement to be 11% by mass or less, the amount of ferric hydroxide gel produced by the dissolution of Fe ions in C_4AF can be suppressed, and the coating of the clinker particle surfaces can be suppressed. Therefore, the delay of hydration can be prevented.

The total content of C_4AF and C_3A is constant at 18% by mass, when the content of C_4AF in the cement increases, the content of C_3A decreases, and when the content of C_4AF in the cement decreases, the content of C_3A increases.

From the viewpoint of enhancing the strength and the flowability, the content of C_4AF in the cement increases is preferably 7% to 9% by mass and more preferably 8% to 9% by mass.

[0031]

[Alkanolamine]

The cement composition according to the present invention contains 0.001 to 0.025 parts by mass of alkanolamine with respect to 100 parts by mass of the Portland cement clinker in the present invention.

The alkanolamine also acts as a strength enhancing agent.

When the content of the alkanolamine in the cement composition according to the present invention is less than 0.001 parts by mass with respect to 100 parts by mass of

the Portland cement clinker, the strength enhancement effect cannot be obtained. When the content of the alkanolamine in the cement composition according to the present invention exceeds 0.025 parts by mass with respect to 100 parts by mass of the Portland cement clinker, the enhancement effect of the initial strength is significant. However, at 28-day age, the hydration structure is coarse due to the high initial hydration activity, and thus the strength enhancement effect cannot be obtained.

From the above-described viewpoint, the content of the alkanolamine in the cement composition according to the present invention is preferably 0.005 to 0.02 parts by mass with respect to 100 parts by mass of the Portland cement clinker according to the present invention.

[0032]

Examples of the alkanolamine include monoethanolamine, diethanolamine, triethanolamine, monoisopropanolamine, diisopropanolamine, triisopropanolamine, methylethanolamine, methylisopropanolamine, N-n-butylethanolamine, N-methyldiethanolamine, N-n-butyldiethanolamine, N-methyldiisopropanolamine, diethanolisopropanolamine, diisopropanolethanolamine, tetrahydroxyethylethylenediamine, N,N,N',N'-tetrakis(2-hydroxypropyl)ethylenediamine, tris(2-hydroxybutyl)amine, and other amines.

As the alkanolamine, only one kind may be used, or two or more kinds may be used.

[0033]

In particular, the alkanolamine is preferably at least
5 one selected from the group consisting of diethanol
isopropanolamine (DEIPA), triisopropanolamine (TIPA),
ethanol diisopropanolamine (EDIPA), triethanolamine (TEA),
N-methyldiethanolamine (MDEA), and N-n-butyldiethanolamine
(BDEA), more preferably at least one selected from the
10 group consisting of diethanol isopropanolamine (DEIPA),
triisopropanolamine (TIPA), ethanol diisopropanolamine
(EDIPA), and triethanolamine (TEA), and still more
preferably diethanol isopropanolamine (DEIPA).

[0034]

15 The alkanolamine generally has high viscosity.
Therefore, mixing is difficult, and the addition of the
alkanolamine is not suitable for the production of mortar.
Accordingly, it is preferable to add the alkanolamine as a
grinding aid in a finishing process of cement production.
20 In addition, when the alkanolamine is diluted with and
dissolved in water to be used, the mixing with the cement
is easy, and the cement composition according to the
present invention can be efficiently produced.

[0035]

25 [Gypsum]

The cement composition according to the present invention contains gypsum.

As the gypsum, any of gypsum anhydrite, gypsum hemihydrate, or gypsum dihydrate can be used.

5 The content of the gypsum in the cement composition in terms of SO_3 is preferably 0.5% to 2.5% by mass.

By adjusting the content of the gypsum in the cement composition to be in the above-described range, the drying shrinkage of the cement composition can be made
10 appropriate, and the strength exhibited by the cement composition can be increased.

From the above-described viewpoint, the content of the gypsum in the cement composition in terms of SO_3 is more preferably 1.0% to 1.8% by mass.

15 The proportion of SO_3 in the gypsum can be measured according to JIS R 5202:2010 "Methods for Chemical Analysis of Portland Cement". The mass ratio of the gypsum in the cement composition in terms of SO_3 can be obtained from the blending amount of the gypsum and the proportion of SO_3 in
20 the gypsum.

[0036]

[Limestone]

The cement composition according to the present invention may contain limestone in order to improve the
25 short-term strength and to reduce the emission amount of CO_2

with micronization.

The content of the limestone in the cement composition is defined according to JIS R 5210:2009 "Portland Cement". In the present invention, the limestone may be added in an amount exceeding the range defined by the JIS standards.

The content of the limestone in the cement composition is preferably 0% to 20% by mass, more preferably 0% to 10% by mass, and still more preferably 2% to 5% by mass. The content of the limestone being 0% by mass represents that the limestone is not added for producing the cement composition.

[0037]

[Other Components]

In the cement composition of the present invention, fly ash, blast furnace slag, silica fume, or the like can be further added for adjusting the flowability, the hydration rate, the strength development, and the like.

[0038]

(Blaine's Specific Surface Area)

In the cement composition according to the present invention, the Blaine's specific surface area is preferably 3000 to 3400 cm²/g.

When the Blaine's specific surface area is 3000 cm²/g or more, the strength of mortar is not likely to decrease. When the Blaine's specific surface area is 3400 cm²/g or

less, a decrease in flowability is suppressed, a decrease in the dissolution of C_4AF by the alkanolamine is suppressed, and the strength enhancement effect can be maintained.

5 From the viewpoint of further enhancing the strength, the Blaine's specific surface area of the cement composition is more preferably 3100 to 3300 cm^2/g .

 The Blaine's specific surface area of the cement composition may be measured according to JIS R 5201:2015
10 "Physical Testing Method for Cement".

[0039]

<Method for Producing Cement Composition>

A method for producing a cement composition according to the present invention includes: mixing a Portland cement
15 that satisfies (1) and (2) below and 0.001 to 0.025 parts by mass of alkanolamine with respect to 100 parts by mass of the Portland cement, in which

(1) $0.55 \leq \text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3 \leq 0.95$, and

(2) $0 \leq \Delta C_4AF$,

20 in (1), MgO represents a mass (% by mass) of MgO in the Portland cement, Fe_2O_3 represents a mass (% by mass) of Fe_2O_3 in the Portland cement, SO_3 represents an amount (% by mass) of the Portland cement in terms of SO_3 , and $\text{CL}'\text{SO}_3$ represents an amount (% by mass) of a clinker of the
25 Portland cement in terms of SO_3 , and

in (2), ΔC_4AF represents a difference ($R.C_4AF - B.C_4AF$) between a mass (% by mass) of $R.C_4AF$ and a mass (% by mass) of $B.C_4AF$, where $R.C_4AF$ represents a C_4AF value of the Portland cement measured by a powder X-ray diffractometer, 5 $B.C_4AF$ represents $3.04 \times Fe_2O_3$, and Fe_2O_3 in $B.C_4AF$ represents a mass (% by mass) of Fe_2O_3 in the Portland cement.

[0040]

The Portland cement used in the method for producing a 10 cement composition according to the present invention is the same as the Portland cement containing the cement composition according to the present invention, and a preferable aspect thereof is also the same. That is, MgO/Fe_2O_3 preferably exceeds 0.35, and in the cement 15 composition according to the present invention, the Portland cement is preferably a normal Portland cement where a content of C_3S is 45% to 75% by mass, a content of C_2S is 5% to 25% by mass, a content of C_3A is 7% to 11% by mass, and a content of C_4AF is 7% to 11% by mass when 20 calculated by Bogue calculation.

[0041]

The blending amount of the alkanolamine is the same as the content of the alkanolamine in the cement composition of the present invention, and a preferable range thereof is 25 also the same. That is, an addition amount of the

alkanolamine is preferably 0.005 to 0.02 parts by mass with respect to 100 parts by mass of the Portland cement according to the present invention.

In addition, the blending amount of the limestone has the same definition as the limestone content, and a preferable range thereof is also the same.

[0042]

The alkanolamine used in the method for producing a cement composition according to the present invention is the same as the alkanolamine containing the cement composition according to the present invention, and a preferable aspect thereof is also the same.

That is, the alkanolamine used in the method for producing a cement composition according to the present invention is preferably at least one selected from the group consisting of diethanol isopropanolamine, triisopropanolamine, ethanol diisopropanolamine, triethanolamine, N-methyldiethanolamine, and N-n-butylldiethanolamine.

The alkanolamine generally has high viscosity. Therefore, mixing is difficult, and the addition of the alkanolamine is not suitable for the production of mortar. Accordingly, it is preferable to add the alkanolamine as a grinding aid in a finishing process of cement production.

In addition, when the alkanolamine is diluted with and

dissolved in water to be used, the mixing with the cement is easy, and the cement composition according to the present invention can be efficiently produced.

[0043]

5 The means for mixing the components in the method for producing a cement composition according to the present invention is not particularly limited. Examples of the means include a mixer, a ball mill, a Roche mill, and an air blending silo. The mixing time can be set in a range in
10 which it is determined that mixing is sufficiently performed in the production of a typical cement composition.

[0044]

 In the production method, it is preferable that
15 grinding is performed such that the Blaine's specific surface area of the cement composition is 3000 to 3400 cm^2/g .

[0045]

 In the method for producing a cement composition
20 according to the present invention, blast furnace slag, a siliceous admixture, and fly ash can be further added in addition to the addition of the Portland cement clinker according to the present invention, the gypsum, the limestone, and the alkanolamine.

25 In the present invention, blast furnace slag and

siliceous admixture defined according to JIS R 5210:2009
"Portland Cement" can be used. Regarding the fly ash, not
only type-I fly ash and type-II fly ash but also type-III
fly ash and type-IV fly ash defined according to JIS R
5 5210:2009 "Portland Cement" can also be used.

Examples

[0046]

The present invention will be described in more detail
with reference to Examples. Note that the present invention
10 is not limited to the following Examples.

[0047]

<Component of Cement Composition>

The following materials were used in the production of
cement compositions.

15 1. Clinker

Normal Portland cement clinkers (manufactured by
SUMITOMO OSAKA CEMENT Co., Ltd.) having chemical
compositions and mineral compositions shown in Tables 1 and
2 were used. In Tables 1 and 2, HM represents hydraulic
20 modulus, SM represents silica modulus, and IM represents
iron modulus. In Tables 1 and 2, "%" represents % by mass.

The chemical composition of the clinker was analyzed
with a glass bead method using a X-ray fluorescence
spectrometer (PRIMUS IV, manufactured by Rigaku
25 Corporation) in accordance with JIS R 5204:2019 "Chemical

Analysis Method of Cement by X-Ray Fluorescence". The mineral compositions were calculated by Bogue calculation from the obtained mass ratios of CaO, SiO₂, Al₂O₃, and Fe₂O₃.

$$C_3S = (4.07 \times CaO) - (7.60 \times SiO_2) - (6.72 \times Al_2O_3) -$$

5 $(1.43 \times Fe_2O_3)$

$$C_2S = (2.87 \times SiO_2) - (0.754 \times C_3S)$$

$$C_3A = (2.65 \times Al_2O_3) - (1.69 \times Fe_2O_3)$$

$$C_4AF = 3.04 \times Fe_2O_3$$

[0048]

10 (Chemical Composition and Mineral Compositions of
Clinker)

The chemical composition and the mineral compositions of the clinker are shown in Tables 1 and 2.

[0049]

[Table 1]

Table 1

	SiO ₂	Al ₂ O ₃	CaO	MgO	Fe ₂ O ₃	SO ₃ (CL' SO ₃)	Na ₂ O	K ₂ O	P ₂ O ₅
	%	%	%	%	%	%	%	%	%
Comparative Example 1	22.07	5.55	63.42	1.04	2.75	Amount shown in Table 7	0.31	0.40	0.28
Comparative Example 2	21.68	5.52	64.02	1.04	2.74	Amount shown in Table 7	0.38	0.42	0.23
Comparative Example 3	20.89	5.70	64.11	0.95	3.00	Amount shown in Table 7	0.32	0.43	0.29
Examples 1 to 4	21.09	5.73	62.83	1.26	3.25	Amount shown in Table 7	0.34	0.42	0.25
Example 5	20.89	5.71	63.45	1.29	3.01	Amount shown in Table 7	0.36	0.45	0.34
Example 6	20.88	5.71	63.55	1.43	2.73	Amount shown in Table 7	0.34	0.43	0.32
Examples 7 and 22	21.01	5.70	63.67	1.64	2.61	Amount shown in Table 7 (Example 7) or Table 9 (Example 22)	0.31	0.43	0.29
Example 8	21.07	5.66	60.86	2.16	3.34	Amount shown in Table 7	0.31	0.46	0.23
Example 9	20.71	5.68	63.08	1.94	2.69	Amount shown in Table 7	0.33	0.43	0.35
Example 10	20.98	5.71	63.01	1.80	2.53	Amount shown in Table 7	0.36	0.48	0.31
Example 11	20.78	4.71	61.06	3.24	3.06	Amount shown in Table 8	0.27	0.48	0.25
Example 12	20.89	5.72	62.95	1.83	2.73	Amount shown in Table 8	0.31	0.50	0.34
Example 13	21.80	5.73	64.70	0.00	3.16	Amount shown in Table 8	0.30	0.47	0.31
Example 14	21.52	5.85	64.60	0.00	2.86	Amount shown in Table 8	0.33	0.47	0.36
Example 15	20.16	5.51	60.89	2.77	3.37	Amount shown in Table 8	0.36	0.42	0.34
Example 16	21.82	5.76	63.76	0.90	2.73	Amount shown in Table 8	0.38	0.46	0.38
Example 17	21.66	5.64	64.82	0.82	2.44	Amount shown in Table 8	0.32	0.48	0.33
Example 18	21.77	5.74	65.57	0.28	2.41	Amount shown in Table 8	0.34	0.50	0.38
Example 19	21.15	5.84	64.25	0.30	2.72	Amount shown in Table 8	0.35	0.46	0.32
Example 20	21.15	5.82	62.96	1.64	2.61	Amount shown in Table 9	0.37	0.50	0.37
Example 21	21.12	5.85	62.95	1.64	2.61	Amount shown in Table 9	0.37	0.46	0.35
Comparative Example 4	20.35	5.96	62.68	1.93	2.87	Amount shown in Table 8	0.40	0.47	0.30
Comparative Example 5	21.44	5.68	63.11	1.87	2.43	Amount shown in Table 8	0.32	0.43	0.35
Comparative Example 6	20.71	5.68	61.32	2.71	2.67	Amount shown in Table 8	0.34	0.41	0.29
Comparative Example 7	21.04	5.70	64.37	0.30	2.75	Amount shown in Table 8	0.33	0.46	0.32

[0050]

[Table 2]

Table 2

	TiO ₂	C ₃ S	C ₂ S	C ₄ AF	C ₃ A	f.CaO	HM	SM	IM
	%	%	%	%	%	%	%	%	%
Comparative Example 1	0.33	49.2	26.3	8.4	10.1	0.72	2.09	2.66	2.02
Comparative Example 2	0.34	54.8	20.9	8.3	10.0	0.69	2.14	2.62	2.01
Comparative Example 3	0.33	59.6	15.0	9.1	10.0	0.60	2.16	2.40	1.90
Examples 1 to 4	0.34	52.3	21.1	9.9	9.7	0.50	2.08	2.35	1.76
Example 5	0.33	56.8	17.1	9.1	10.0	0.70	2.13	2.40	1.90
Example 6	0.33	57.7	16.4	8.3	10.5	0.71	2.15	2.47	2.09
Examples 7 and 22	0.33	57.4	17.0	7.9	10.7	0.67	2.16	2.53	2.18
Example 8	0.35	44.8	26.7	10.2	9.4	0.54	2.01	2.34	1.70
Example 9	0.32	57.3	16.2	8.2	10.5	0.87	2.15	2.47	2.11
Example 10	0.34	55.0	18.7	7.7	10.9	0.64	2.14	2.55	2.26
Example 11	0.33	54.6	18.5	9.3	7.3	0.46	2.14	2.68	1.54
Example 12	0.35	55.1	18.4	8.3	10.5	0.65	2.15	2.47	2.10
Example 13	0.33	54.6	21.4	9.6	9.8	0.56	2.08	2.45	1.81
Example 14	0.35	56.0	19.6	8.7	10.7	0.57	2.10	2.47	2.04
Example 15	0.34	52.8	18.1	10.3	8.9	0.63	2.09	2.27	1.63
Example 16	0.35	51.1	24.1	8.3	10.7	0.60	2.09	2.57	2.11
Example 17	0.33	57.8	18.6	7.4	10.8	0.82	2.16	2.68	2.31
Example 18	0.34	59.4	17.7	7.3	11.1	0.67	2.15	2.67	2.38
Example 19	0.31	57.6	17.3	8.3	10.9	0.50	2.12	2.47	2.15
Example 20	0.32	52.7	21.0	7.9	11.0	0.74	2.11	2.51	2.23
Example 21	0.34	52.7	20.9	7.9	11.1	0.50	2.11	2.50	2.24
Comparative Example 4	0.37	56.3	16.0	8.7	10.9	0.51	2.13	2.30	2.08
Comparative Example 5	0.34	52.3	22.1	7.4	10.9	0.52	2.12	2.64	2.33
Comparative Example 6	0.35	50.2	21.6	8.1	10.5	0.61	2.10	2.48	2.12
Comparative Example 7	0.30	59.8	15.3	8.4	10.5	0.71	2.14	2.49	2.07

[0051]

2. Alkanolamine

•DEIPA: diethanol isopropanolamine [manufactured by Tokyo Chemical Industry Co., Ltd.]

•TEA: triethanolamine [manufactured by Tokyo Chemical Industry Co., Ltd.]

5 •TIPA: triisopropanolamine [manufactured by Tokyo Chemical Industry Co., Ltd.]

•EDIPA: ethanol diisopropanolamine [manufactured by Sigma-Aldrich LLC]

[0052]

10 3. Limestone

Calcium carbonate, special grade, manufactured by KANTO CHEMICAL CO., INC., CaCO_3 : 99.5%

[0053]

4. Gypsum

15 Gypsum hemihydrate was used. Specifically, chemical gypsum (CaSO_4 (97.8 mol%)) was held in a drying machine at 120°C for 12 hours and used. The amount of gypsum in terms of SO_3 was measured according to JIS R 5202:2015 "Method for chemical analysis of cement". The composition of the
20 chemical gypsum is as shown in Table 3.

[0054]

[Table 3]

Table 3

SiO_2	Al_2O_3	CaO	Fe_2O_3	SO_3	TiO_2	P_2O_5
0.19	0.48	31.94	2.19	47.76	0.29	0.12

(% by Mass)

[0055]

<Production of Cement>

To the clinker shown in Tables 1 and 2, the limestone was added such that the content thereof in the obtained cement was 3.2% by mass, and the gypsum (the gypsum hemihydrate) was added such that the composition was as shown in Table 4. The components were mixed using a mixer to obtain a cement. In Table 4, CL represents clinker. In addition, "%" represents "% by mass".

10 [0056]

[Table 4]

Table 4

	CL (%)	Gypsum (%)	Limestone (%)		CL (%)	Gypsum (%)	Limestone (%)
Comparative Example 1	92.2	4.6	3.2	Example 12	92.3	4.5	3.2
Comparative Example 2	92.4	4.4	3.2	Example 13	95.0	1.8	3.2
Comparative Example 3	93.4	3.4	3.2	Example 14	96.5	0.3	3.2
Examples 1 to 4	93.0	3.8	3.2	Example 15	92.9	3.9	3.2
Example 5	92.8	4.0	3.2	Example 16	94.6	2.2	3.2
Example 6	93.0	3.8	3.2	Example 17	95.4	1.4	3.2
Examples 7 and 20 to 22	92.8	4.0	3.2	Example 18	94.1	2.7	3.2
				Example 19	95.6	1.2	3.2
Example 8	93.0	3.8	3.2	Comparative Example 4	94.0	2.8	3.2
Example 9	93.2	3.6	3.2	Comparative Example 5	93.7	3.1	3.2
Example 10	93.4	3.4	3.2	Comparative Example 6	92.6	4.2	3.2
Example 11	92.2	4.6	3.2	Comparative Example 7	96.2	0.6	3.2

[0057]

(Chemical Composition and Mineral Compositions of

Cement)

The chemical composition of the cement was measured using the same method as that of the chemical composition of the clinker, and the mineral compositions of the cement were calculated using the same method as that of the mineral compositions of the clinker. The results are shown in Tables 5 to 9. In Tables 5 to 9, "%" represents % by mass.

The values of "C₄AF" in Table 6 are B.C₄AF in the present invention, and refer to the values in the column "Bogue" of the column "C₄AF (%)" in Tables 7 to 9. The values in the column "Rietveld" of the column "C₄AF (%)" of Tables 7 to 9 are R.C₄AF in the present invention, and are C₄AF values of the cement measured by a powder X-ray diffractometer. Specifically, the measurement was performed under the following measurement conditions using a Rietveld analysis method using powder X-ray diffraction.

[0058]

(Measurement Conditions)

• Powder X-ray diffractometer: X'Part Powder, manufactured by Malvern Panalytical Ltd.

• Rietveld analysis software: X'Part High Score Plus Version 2.1b, manufactured by Malvern Panalytical Ltd.

• X-ray tube: Cu (tube voltage: 45 kV, tube current: 40 mA)

•Slit: divergence slit-variable (irradiation width-12 mm, Antiscatter slit-2°)

•Measurement range: $2\theta = 10^\circ$ to 70° (step size: 0.017°)

5 •Scanning speed: $0.1012^\circ/\text{s}$
[0059]

A proportion (% by mass) of each of the minerals of the cement was obtained using an analysis function of Rietveld method installed in the software, in accordance
10 with Joint experiment procedure manual 2 of document "Report C-12 of Cement Chemistry Expert Committee, Examination of differences in clinker mineral content due to difference in measurement methods, Part 2, Chapter 4, Examination of Quantification by Powder X-ray
15 Diffraction/Rietveld Analysis". In addition, the content rate R.C₄AF (% by mass) of C₄AF of each of Examples and Comparative Examples was obtained with respect to 100% by mass of the total proportion of the minerals.

[0060]

20 The value in the column "Δ*" of the column "C₄A_F (%)" in Tables 7 to 9 represents a difference (R.C₄AF - B.C₄AF) between the value (B.C₄AF) in the column "Bogue" in the column "C₄AF (%)" in Tables 7 to 9 and the value (R.C₄AF) in the column "Rietveld" in the column "C₄AF (%)" in Tables 7
25 to 9.

In addition, FIG. 1 is a graph where ΔC_4AF values of Examples and Comparative Examples under a condition** are plotted.

[0061]

[Table 5]

Table 5

	SiO ₂	Al ₂ O ₃	CaO	MgO	Fe ₂ O ₃	SO ₃	Na ₂ O	K ₂ O	P ₂ O ₅
	%	%	%	%	%	%	%	%	%
Comparative Example 1	20.43	5.15	61.72	Amount shown in Table 7			0.29	0.37	0.26
Comparative Example 2	20.11	5.13	62.34	Amount shown in Table 7			0.35	0.39	0.22
Comparative Example 3	19.59	5.35	62.74	Amount shown in Table 7			0.30	0.40	0.27
Examples 1 to 4	19.68	5.35	61.42	Amount shown in Table 7			0.32	0.39	0.24
Example 5	19.46	5.32	61.94	Amount shown in Table 7			0.34	0.42	0.32
Example 6	19.48	5.33	62.08	Amount shown in Table 7			0.32	0.40	0.30
Examples 7 and 22	19.57	5.31	62.14	Amount shown in Table 7 (Example 7) or Table 9 (Example 22)			0.29	0.40	0.27
Example 8	19.67	5.29	59.59	Amount shown in Table 7			0.29	0.43	0.22
Example 9	19.37	5.31	61.70	Amount shown in Table 7			0.31	0.40	0.33
Example 10	19.66	5.35	61.70	Amount shown in Table 7			0.34	0.45	0.29
Example 11	19.23	4.37	59.53	Amount shown in Table 8			0.25	0.44	0.24
Example 12	19.36	5.31	61.32	Amount shown in Table 8			0.29	0.46	0.32
Example 13	20.77	5.46	63.81	Amount shown in Table 8			0.29	0.45	0.30
Example 14	20.83	5.65	64.20	Amount shown in Table 8			0.32	0.45	0.35
Example 15	18.80	5.14	59.59	Amount shown in Table 8			0.34	0.39	0.32
Example 16	20.71	5.46	62.79	Amount shown in Table 8			0.36	0.44	0.36
Example 17	20.74	5.39	64.07	Amount shown in Table 8			0.31	0.46	0.32
Example 18	20.56	5.42	64.34	Amount shown in Table 8			0.32	0.47	0.36
Example 19	20.30	5.60	63.60	Amount shown in Table 8			0.34	0.44	0.31
Example 20	19.70	5.43	61.48	Amount shown in Table 9			0.35	0.46	0.35
Example 21	19.68	5.45	61.47	Amount shown in Table 9			0.35	0.43	0.33
Comparative Example 4	19.19	5.62	61.57	Amount shown in Table 8			0.38	0.44	0.29
Comparative Example 5	20.15	5.34	61.88	Amount shown in Table 8			0.30	0.40	0.33
Comparative Example 6	19.25	5.29	59.90	Amount shown in Table 8			0.32	0.38	0.27
Comparative Example 7	20.32	5.49	63.90	Amount shown in Table 8			0.32	0.44	0.31

[0062]

[Table 6]

Table 6

	TiO ₂	C ₃ S	C ₂ S	C ₄ AF	C ₃ A	f.CaO	HM	SM	IM
	%	%	%	%	%	%	%	%	%
Comparative Example 1	0.32	51.0	20.1	Amount shown in Table 7	8.8	0.66	2.12	2.55	1.80
Comparative Example 2	0.33	56.0	15.5	Amount shown in Table 7	8.8	0.64	2.16	2.52	1.80
Comparative Example 3	0.32	60.5	10.6	Amount shown in Table 7	8.9	0.56	2.19	2.32	1.72
Examples 1 to 4	0.33	53.2	16.4	Amount shown in Table 7	8.6	0.46	2.11	2.27	1.61
Example 5	0.32	57.1	12.8	Amount shown in Table 7	8.9	0.65	2.16	2.31	1.72
Example 6	0.32	57.7	12.4	Amount shown in Table 7	9.3	0.66	2.18	2.38	1.88
Examples 7 and 22	0.32	57.5	12.8	Amount shown in Table 7 (Example 7) or Table 9 (Example 22)	9.5	0.62	2.19	2.43	1.95
Example 8	0.34	45.6	22.0	Amount shown in Table 7	8.2	0.50	2.04	2.26	1.55
Example 9	0.31	57.5	12.2	Amount shown in Table 7	9.3	0.81	2.18	2.38	1.89
Example 10	0.33	55.3	14.8	Amount shown in Table 7	9.7	0.60	2.17	2.45	2.01
Example 11	0.32	56.0	13.0	Amount shown in Table 8	6.3	0.42	2.17	2.56	1.39
Example 12	0.34	56.6	12.9	Amount shown in Table 8	9.3	0.60	2.17	2.38	1.87
Example 13	0.32	54.7	18.4	Amount shown in Table 8	8.9	0.53	2.12	2.38	1.67
Example 14	0.34	55.4	18.0	Amount shown in Table 8	9.9	0.55	2.13	2.41	1.89
Example 15	0.33	54.3	13.1	Amount shown in Table 8	7.8	0.59	2.12	2.19	1.49
Example 16	0.34	52.5	19.9	Amount shown in Table 8	9.7	0.57	2.12	2.49	1.92
Example 17	0.32	58.8	15.2	Amount shown in Table 8	9.9	0.78	2.19	2.60	2.09
Example 18	0.33	57.2	15.9	Amount shown in Table 8	10.1	0.63	2.18	2.58	2.13
Example 19	0.30	56.1	15.9	Amount shown in Table 8	10.0	0.48	2.15	2.40	1.96
Example 20	0.31	53.1	16.5	Amount shown in Table 9	9.8	0.69	2.14	2.42	1.99
Example 21	0.33	53.0	16.5	Amount shown in Table 9	9.8	0.46	2.14	2.40	2.00
Comparative Example 4	0.36	56.5	12.5	Amount shown in Table 8	9.9	0.48	2.16	2.23	1.89
Comparative Example 5	0.33	53.0	17.8	Amount shown in Table 8	9.8	0.49	2.15	2.55	2.08
Comparative Example 6	0.34	51.6	16.3	Amount shown in Table 8	9.3	0.56	2.14	2.38	1.89
Comparative Example 7	0.29	58.9	13.9	Amount shown in Table 8	9.7	0.68	2.18	2.43	1.91

[0063]

<Production of Cement Composition>

[Example 1]

As the cement composition to which amine was not added, a cement shown in Tables 5 to 7 was used.

As the cement composition to which amine was added, a
5 composition consisting of alkanolamine (DEIPA) shown in
Table 7 and a cement shown in Tables 5 to 7 was prepared.
Specifically, alkanolamine was mixed with the cement such
that the concentration of alkanolamine was 10 ppm (0.001
parts by mass with respect to 100 parts by mass of the
10 cement) with respect to the total content of the cement and
the alkanolamine.

Next, the cement composition to which amine was not
added and the cement composition to which amine was added
were mixed and ground using a ball mill for a test such
15 that the value of the Blaine's specific surface area was
3300 cm²/g. As a result, each of the cement compositions
according to Example 1 was obtained.

[0064]

[Examples 2 to 19 and Comparative Examples 1 to 7]

20 As the cement composition to which amine was not
added, cements shown in Tables 5 to 8 were used.

Cement compositions to which amine was added were
obtained using the same method as that of Example 1, except
that the cement shown in Tables 5 to 8 was used and DEIPA
25 was added such that the concentration thereof with respect

to the total content of the cement and DEIPA was as shown in Table 7 or 8.

Next, the cement composition to which amine was not added and the cement composition to which amine was added were mixed and ground using a ball mill for a test such that the value of the Blaine's specific surface area was 3300 cm²/g. As a result, each of the cement compositions according to Examples 2 to 19 and Comparative Examples 1 to 7 was obtained.

10 [0065]

[Examples 20 to 22]

As the cement composition to which amine was not added, cements shown in Tables 5, 6, and 9 were used.

Cement compositions to which amine was added were obtained using the same method as that of Example 7, except that alkanolamine shown in "Amine Kind" of Table 9 was used as the alkanolamine instead of DEIPA.

Next, the cement composition to which amine was not added and the cement composition to which amine was added were mixed and ground using a ball mill for a test such that the value of the Blaine's specific surface area was 3300 cm²/g. As a result, each of the cement compositions according to Examples 20 to 22 was obtained.

[0066]

25 <Evaluation of Cement Composition>

Using the cement composition to which amine was not added and the cement composition to which amine was added according to each of Examples and Comparative Examples, a sample was formed according to JIS R 5201:2015 "Physical
5 Testing Method for Cement", and was measured in a mortar compressive strength test.

A blending ratio of the sample was water: 11.1% by mass, aggregate: 66.7% by mass, and cement: 22.2% by mass, and a rectangular sample having a dimension of 40 mm × 40
10 mm × 160 mm was wrapped with a vinyl chloride resin and cured.

[0067]

The compressive strength of mortar obtained using the cement composition to which amine was not added is shown in
15 the column "Material Age (Not Added) (a)" of Tables 7 to 9, and the compressive strength of mortar obtained using the cement composition to which amine was added is shown in the column "Material Age (Amine Added) (b)" of Tables 7 to 9. As the numerical value increases, the mortar compressive
20 strength is higher.

[0068]

The column " Δ (b - a)" of Tables 7 to 9 shows a difference (difference in strength) obtained by subtracting the compressive strength of mortar obtained using the
25 cement composition to which amine was not added the

compressive strength of mortar obtained using the cement composition to which amine was added. As the numerical value of the difference in strength increases, the strength enhancement effect is higher.

5 In addition, FIG. 2 is a graph where values of differences in enhanced strength of mortar at 7-day age and 28 age under a condition** are plotted. Here, "Condition**" represents a numerical value shown in the column "Condition**" of Tables 7 to 9, and is $\text{MgO/Fe}_2\text{O}_3 + \text{CL'SO}_3/\text{SO}_3$ of Condition (1) of the Portland cement
10 according to the present invention.

[0069]

[Table 7]

Table 7

	Material Age (Not Added) (a)			Material Age (Amine Added) (b)			Δ (b-a)			C ₄ AF (%)			DEIPA	MgO	Fe ₂ O ₃	SO ₃	CL' SO ₃	Condition**
	3-Day	7-Day	28-Day	3-Day	7-Day	28-Day	3-Day	7-Day	28-Day	Bogue	Rietveld	Δ^*	(ppm)					
Comparative Example 1	34.0	48.3	63.0	35.8	48.0	63.3	1.8	-0.3	0.3	8.7	6.8	-1.9	50	0.96	2.86	2.20	0.00	0.34
Comparative Example 2	34.4	47.5	62.1	35.9	47.3	62.4	1.5	-0.2	0.3	8.7	6.8	-1.9	50	0.96	2.85	2.22	0.12	0.39
Comparative Example 3	30.4	47.3	62.8	33.3	48.5	66.6	2.9	1.2	3.8	9.4	8.1	-1.3	50	0.89	3.10	2.00	0.40	0.49
Example 1	28.7	44.0	63.5	28.8	46.5	67.3	0.1	2.5	3.8	10.1	10.1	0.0	10	1.17	3.33	2.26	0.46	0.55
Example 2	28.7	44.0	63.5	29.4	46.8	67.5	0.7	2.8	4.0	10.1	10.1	0.0	30	1.17	3.33	2.26	0.46	0.55
Example 3	28.7	44.0	63.5	29.6	47.0	68.0	0.9	3.0	4.5	10.1	10.1	0.0	50	1.17	3.33	2.26	0.46	0.55
Example 4	28.7	44.0	63.5	31.5	48.9	69.4	2.8	4.9	5.9	10.1	10.1	0.0	250	1.17	3.33	2.26	0.46	0.55
Example 5	33.4	48.4	61.9	33.1	52.3	68.2	-0.3	3.9	6.3	9.4	9.5	0.1	50	1.20	3.10	2.39	0.52	0.60
Example 6	28.3	39.3	57.2	28.8	44.0	65.7	0.5	4.7	8.5	8.6	9.3	0.7	50	1.33	2.84	2.44	0.64	0.73
Example 7	26.4	39.5	55.3	27.1	44.9	63.7	0.7	5.4	8.4	8.3	9.3	1.0	50	1.52	2.73	2.48	0.61	0.80
Example 8	29.0	39.2	56.9	29.2	44.2	64.0	0.2	5.0	7.1	10.4	11.3	0.9	50	2.01	3.41	2.46	0.68	0.87
Example 9	31.4	44.0	58.5	30.8	47.7	63.0	-0.6	3.7	4.5	8.5	9.1	0.6	50	1.81	2.81	2.36	0.66	0.92
Example 10	30.5	46.2	57.9	30.7	49.2	61.4	0.2	3.0	3.5	8.1	8.4	0.3	50	1.68	2.66	2.34	0.74	0.95

[0070]

[Table 8]

Table 8

	Material Age (Not Added) (a)			Material Age (Amine Added) (b)			Δ (b - a)			C ₄ AF (%)			DEIPA	MgO	Fe ₂ O ₃	SO ₃	CL' SO ₃	Condition**
	3-Day	7-Day	28-Day	3-Day	7-Day	28-Day	3-Day	7-Day	28-Day	Bogue	Rietveld	Δ^*	(ppm)					
Example 11	27.7	40.6	59.3	27.7	44.1	61.9	0.0	3.5	2.6	9.5	9.7	0.2	50	2.99	3.14	2.22	0.00	0.95
Example 12	26.1	49.2	62.3	26.9	53.3	67.7	0.8	4.1	5.4	8.6	8.8	0.2	50	1.69	2.84	2.15	0.00	0.60
Example 13	29.7	46.7	60.7	28.7	50.7	66.7	-1.0	4.0	6.0	9.9	10.0	0.1	50	0.00	3.26	2.03	1.21	0.60
Example 14	31.7	48.6	61.4	32.4	51.2	65.3	0.7	2.6	3.9	9.1	9.5	0.4	50	0.00	2.99	1.88	1.78	0.95
Example 15	30.4	41.0	58.7	31.4	46.3	66.6	1.0	5.3	7.9	10.5	11.6	1.1	50	2.57	3.44	2.07	0.21	0.85
Example 16	27.0	50.7	64.4	27.5	55.1	72.1	0.5	4.4	7.7	8.7	9.2	0.5	50	0.85	2.85	1.72	0.69	0.70
Example 17	26.4	47.3	62.5	26.8	51.6	68.4	0.4	4.3	5.9	7.8	8.7	0.9	50	0.78	2.58	1.54	0.92	0.90
Example 18	30.7	49.5	63.1	30.6	54.6	71.0	-0.1	5.1	7.9	7.8	8.1	0.3	50	0.26	2.55	2.94	1.75	0.70
Example 19	33.3	46.3	62.1	32.5	50.1	67.1	-0.8	3.8	5.0	8.7	9.3	0.6	50	0.29	2.85	2.37	1.89	0.90
Comparative Example 4	30.7	44.4	64.8	32.6	44.2	64.8	1.9	-0.2	0.0	9.1	8.5	-0.6	50	1.81	2.98	2.19	0.87	1.00
Comparative Example 5	32.6	44.0	58.7	34.8	44.2	59.5	2.2	0.2	0.8	7.8	7.5	-0.3	50	1.75	2.57	2.15	0.68	1.00
Comparative Example 6	35.3	40.8	60.7	38.4	40.7	60.4	3.1	-0.1	-0.3	8.5	8.1	-0.4	50	2.51	2.79	2.22	0.22	1.00
Comparative Example 7	30.1	46.1	60.4	33.7	46.9	60.2	3.6	0.8	-0.2	8.8	8.3	-0.5	50	0.29	2.88	2.01	1.80	1.00

[0071]

[Table 9]

Table 9

	Material Age (Not Added) (a)			Material Age (Amine Added) (b)			Δ (b - a)			C_4AF (%)			Amine Amount	Amine Kind	MgO	Fe_2O_3	SO_3	CL'SO ₃	Condition**
	3-Day	7-Day	28-Day	3-Day	7-Day	28-Day	3-Day	7-Day	28-Day	Bogue	Rietveld	Δ^*	(ppm)	-					
Example 20	26.3	39.4	55.3	26.9	44.3	63.1	0.6	4.9	7.8	8.3	9.3	1.0	50	TEA	1.52	2.73	2.48	0.61	0.80
Example 21	26.5	39.7	55.4	27.4	44.7	63.4	0.9	5.0	8.0	8.3	9.3	1.0	50	TIPA	1.52	2.73	2.48	0.61	0.80
Example 22	26.4	39.6	55.1	27.4	44.1	63.0	1.0	4.5	7.9	8.3	9.3	1.0	50	EDIPA	1.52	2.73	2.48	0.61	0.80

[0072]

The difference in the strength of mortar shown in the column " $\Delta (b - a)$ " of Tables 7 to 9 represents the degree to which the strength of mortar obtained using the cement composition to which amine was added was increased as compared to the strength of mortar obtained using the cement composition to which amine was not added. As the numerical value increases on the positive side, the strength enhancement effect is higher. When the result at 3-day age and the results at 7-day age and 28-day age are compared to each other, it can be seen from that the numerical value of $\Delta (b - a)$ at 7-day age or more is large, and the strength enhancement effect is high. In addition, the comparison between the results at 7-day age and 28-day age is illustrated in FIG. 2, and it can be seen that the strength enhancement effect at 28-day age is high.

CLAIMS

1. A cement composition comprising:

a Portland cement that satisfies (1) and (2) below;

5 and

0.001 to 0.025 parts by mass of alkanolamine with
respect to 100 parts by mass of the Portland cement,

wherein the Portland cement is a normal Portland
cement where a content of C_3S is 45% to 75% by mass, a
10 content of C_2S is 5% to 25% by mass, a content of C_3A is 7%
to 11% by mass, and a content of C_4AF is 7% to 11% by mass
when calculated by Bogue calculation,

(1) $0.55 \leq \text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3 \leq 0.95$, and

(2) $0 \leq \Delta C_4AF$,

15 in (1), MgO represents a mass (% by mass) of MgO in
the Portland cement, Fe_2O_3 represents a mass (% by mass) of
 Fe_2O_3 in the Portland cement, SO_3 represents an amount (% by
mass) of the Portland cement in terms of SO_3 , and $\text{CL}'\text{SO}_3$
represents an amount (% by mass) of a clinker of the
20 Portland cement in terms of SO_3 , and

in (2), ΔC_4AF represents a difference ($R.C_4AF - B.C_4AF$)
between a mass (% by mass) of $R.C_4AF$ and a mass (% by mass)
of $B.C_4AF$, where $R.C_4AF$ represents a C_4AF value of the
Portland cement measured by a powder X-ray diffractometer,
25 $B.C_4AF$ represents $3.04 \times \text{Fe}_2\text{O}_3$, and Fe_2O_3 in $B.C_4AF$

represents a mass (% by mass) of Fe_2O_3 in the Portland cement.

2. The cement composition according to claim 1,
5 wherein in (1), $\text{MgO}/\text{Fe}_2\text{O}_3$ exceeds 0.35.

3. The cement composition according to claim 1 or 2,
wherein a content of the alkanolamine is 0.005 to 0.02
parts by mass with respect to 100 parts by mass of the
10 Portland cement.

4. The cement composition according to any one of
claims 1 to 3,

wherein the alkanolamine is at least one selected from
15 the group consisting of diethanol isopropanolamine,
triisopropanolamine, ethanol diisopropanolamine,
triethanolamine, N-methyldiethanolamine, and N-n-
butyldiethanolamine.

20 5. A method for producing a cement composition, the
method comprising:

mixing a Portland cement that satisfies (1) and (2)
below and 0.001 to 0.025 parts by mass of alkanolamine with
respect to 100 parts by mass of the Portland cement,
25 wherein the Portland cement is a normal Portland

cement where a content of C_3S is 45% to 75% by mass, a content of C_2S is 5% to 25% by mass, a content of C_3A is 7% to 11% by mass, and a content of C_4AF is 7% to 11% by mass when calculated by Bogue calculation,

5 (1) $0.55 \leq \text{MgO}/\text{Fe}_2\text{O}_3 + \text{CL}'\text{SO}_3/\text{SO}_3 \leq 0.95$, and

 (2) $0 \leq \Delta C_4AF$,

 in (1), MgO represents a mass (% by mass) of MgO in the Portland cement, Fe_2O_3 represents a mass (% by mass) of Fe_2O_3 in the Portland cement, SO_3 represents an amount (% by mass) of the Portland cement in terms of SO_3 , and $\text{CL}'\text{SO}_3$ represents an amount (% by mass) of a clinker of the Portland cement in terms of SO_3 , and

 in (2), ΔC_4AF represents a difference ($R.C_4AF - B.C_4AF$) between a mass (% by mass) of $R.C_4AF$ and a mass (% by mass) of $B.C_4AF$, where $R.C_4AF$ represents a C_4AF value of the Portland cement measured by a powder X-ray diffractometer, $B.C_4AF$ represents $3.04 \times \text{Fe}_2\text{O}_3$, and Fe_2O_3 in $B.C_4AF$ represents a mass (% by mass) of Fe_2O_3 in the Portland cement.

20

6. The method for producing a cement composition according to claim 5,

 wherein in (1), $\text{MgO}/\text{Fe}_2\text{O}_3$ exceeds 0.35.

25

7. The method for producing cement composition

according to claim 5 or 6,

wherein an addition amount of the alkanolamine is
0.005 to 0.02 parts by mass with respect to 100 parts by
mass of the Portland cement.

5

8. The method for producing cement composition
according to any one of claims 5 to 7,

wherein the alkanolamine is at least one selected from
the group consisting of diethanol isopropanolamine,
10 triisopropanolamine, ethanol diisopropanolamine,
triethanolamine, N-methyldiethanolamine, and N-n-
butyldiethanolamine.