properties, the set times and strength gain times are longer compared with an OPC equivalent.

The use of GGBS in conjunction with chemical stimulants such as alkalis is therefore known, but the skilled person's understanding is that such concretes have limitations in relation to setting times, strength and temperature response. This has prevented their widespread adoption. Concretes are specified and used according to established national standards, codes etc. Whilst such documents may acknowledge GGBS-based concretes they are not at the forefront of use. OPC concretes are in widespread use, are competitive and functionally adequate.

The skilled person's current understanding, or prejudice, is that the higher the GGBS content the more limited the mechanical properties of the resulting concretes, even using OPC as the activator for GGBS. Further, concretes have to satisfy certain standards e.g., in the UK, BS 4246 where minimum strengths against time have to be achieved. Thus, despite its environmental impact, OPC continues to be used.

Summary of ~~Invention~~Disclosure

In its various aspects, the ~~invention~~ disclosure provides activator compositions for combining with hydraulically-active materials comprising ground granulated blastfurnace slag (GGBS) and/or pulverised fuel ash (PFA) to form a cementitious binder, methods for using such activator compositions, methods of forming cementitious binders, cementitious binders, methods of forming concretes, mortars, grouts or renders, and concretes, mortars, grouts or renders, as defined in the appended independent claims to which reference should now be made. Preferred or advantageous features of the various aspects of the ~~invention~~ disclosure are set out in dependent sub-claims.

It is known in the prior art, such as from Loriot mentioned above, and patent application WO 03/070657, to combine GGBS and lime to form a cementitious binder. WO 03/070657 mainly describes use of gypsum as a hydraulically-active material but gives, by way of comparison, results of an experiment using 10% lime as an activator mixed with 90% GGBS to form a cementitious binder.

Measured values for the strength of this mixture (binder) after 0, 2, 7, 28 and 33 days are set out in Table II of WO 03/070657, and are very much lower than for any of the binders described in WO 03/070657 incorporating gypsum. This prior art thus reinforces the view that more than 10% lime must be used as an activator in GGBS to achieve acceptable strength in an acceptable time.

In the prior art, therefore, a high proportion of lime has been used (greater than 10wt%), and a concrete prepared using such a binder has a low initial strength and a slow setting time. During experiments to find a suitable activator to combine with GGBS to form a viable cementitious binder, the present inventors tried combining GGBS with 10wt% hydrated lime. The properties of concrete cubes produced with this binder were acceptable, but the set time was undesirably extended. The set time, or time of set, is a standard measurement for concretes and mortars and is defined by a point in time at which penetration resistance reaches certain values. Concrete compositions can be defined in terms of initial set times and final set times. Set times can vary depending on temperature.

The inventors have now determined that improved concretes can be prepared using a cementitious binder comprising a high proportion of GGBS and/or PFA and a low proportion of CaO, or lime, as described herein.

In a preferred implementation of the ~~invention~~ disclosure, the inventors have found that the strength and usability of non-OPC binders of this type may be improved further by combining CaO, or lime, and a dispersant, preferably of a particular type namely a superplasticiser. A particularly preferred type of superplasticiser for use in the present aspect of the ~~invention~~ disclosure is a polycarboxylate-ether-based (PCE) dispersant.

Dispersants, also termed water-reducers or plasticisers or fluidifiers, are materials or compounds added to binders to reduce the required water/binder ratio, and a superplasticiser (or high-range water-reducer), such as a PCE, is a particularly efficacious dispersant. A superplasticiser such as a PCE may be capable of reducing the water/binder ratio, relative to a control sample of binder which gives adequate performance using only water, by more than 15% or 25%

without reducing the workability of the binder before setting. In this document, superplasticisers, including PCEs, are also referred to as fluidifiers or extreme fluidifiers.

In other words, a dispersant or fluidifier is a concrete admixture which achieves a given concrete workability level with substantially lower water content when compared to the case where the admixture is not used. Preferably, the dispersant or fluidifier used in aspects of the present ~~invention~~ disclosure may be capable of reducing the water content by at least 30%. An example may be a polycarboxylate-ether-based superplasticiser as described above. It is preferable that the fluidifier is a superfluidifier or a superplasticiser or high-range water reducer.

In a preferred implementation, the ~~invention~~ disclosure may thus provide a binder comprising CaO, or lime, one or more superplasticisers or PCEs, and a hydraulically-active material comprising GGBS and/or PFA. This implementation of the invention may also provide an activator composition comprising, or consisting of, the CaO and the superplasticiser or PCE, for mixing with the hydraulically-active material. The activator composition is a composition, preferably in powder or powdered form, mixable with hydraulically-active material and other components such as water, and optionally a fluidifier (which may be a further fluidifier, in addition to any superplasticiser in the activator composition), to form a binder.

PCEs are available in powder or liquid form. Either may be usable in embodiments of the ~~invention~~ disclosure but a powdered form of PCE should preferably be used if combined with CaO (also usually in powdered form) to form an activator. If PCE in liquid form is used, then the activator may comprise the CaO and the PCE may be added separately on mixing the binder.

The activator composition may or may not comprise materials other than the CaO and/or superplasticiser, such as pulverised fuel ash (PFA), preferably superfine PFA, and/or microsilica, as described in more detail below. The resulting binder composition may therefore also comprise these materials.

The inventors' understanding is that when an activator comprising CaO is used without the addition of a superplasticiser, or PCE, and in particular when the binder comprises less than 10%, or less than 9.5%, CaO, hydration products do form in the system. But, at early age (say within 7-14 days) the extent to which they form is limited and so is, therefore, the formation of a well-ramified strength-providing network of such hydration products. Consequently, the achieved compressive strength may be insufficient, or may form insufficiently rapidly, for practical applications. The inventors have found that this problem may be solved by the use of a dispersant or fluidifier (such as a superplasticiser or a PCE) which enables the reduction of the quantity of mixing water used.

Current knowledge classifies fluidifiers as dispersing admixtures which, after adsorbing onto surfaces of cement grains, repel those grains from each other due to the intrinsic chemical properties of the admixtures, causing deflocculation and substantially increased fluidity of the entire mix. Hence they allow for the use of smaller amounts of water in a binder to achieve the same rheological properties. Furthermore, the individual grains are more exposed to water and hydrate more rapidly and, due to the repelling action, the fluidity of the mix is greatly improved. Another currently-recognised effect of fluidifiers is the fact that by reducing the water content the amount of free water (not used by the hydration and therefore creating voids) within the hardened concrete is reduced, which results in the reduction of the porosity. The inventors consider (though this is not certain at present and does not limit the present ~~invention~~ disclosure) that addition of a PCE reduces the interparticle distances, allowing for early formation of chemical bonds amongst the hydration products.

The fluidifier (superplasticiser) in the system may be introduced either in a powder or liquid form or in a combined form. In case of the former, it may be pre-blended with the other solid components, optionally being provided as a component of the activator composition to form the binder. In case of the latter, the liquid fluidifier may be added during batching of the concrete (or binder). In case both the forms are used, the solid form may be part of the binder and the liquid form may be added during the batching process.

The resulting binder may then be mixed with aggregates in a conventional way to produce concrete (or used to produce other products such as mortars, grouts and renders).

The system may advantageously differ from prior-art non-OPC systems in the way that it achieves a much more rapid strength development as well as the magnitude of strength at a given time period, even when compared to conventional OPC-based mixes with a similar GGBS content. In addition, the inventors' experiments indicate that the resulting concrete may advantageously exhibit improved resistance to acid and sulphate attacks, and improved resistance to the penetration of chloride ion. The colour of the system, if of importance, can be tailored to the required need from off-white to dark grey.

The advantageous effect of superplasticisers, and particularly PCEs, in combination with an alkaline activator for non-OPC binders is particularly surprising as the skilled person's current understanding is that superplasticisers are not effective, or are denatured, in such alkaline conditions. In non-OPC binders, for example based on GGBS, in order to generate adequate strength rapidly, strongly alkaline activators such as NaOH have typically been used. It is known that such activators damage, or denature, superplasticisers such as PCEs. The inventors have solved this problem by using a less strongly alkaline activator, CaO. CaO by itself may be less effective than NaOH as an activator for, for example, GGBS. But the inventors' surprising solution to this problem is based on their recognition that addition of a superplasticiser not only affects the amount of water required for a binder, and its rheological properties, but also the rate of strength formation in a hydraulically-active material. Using a less alkaline, and less effective alkali activator (i.e. CaO rather than NaOH) is at first sight a backward step, but the lower alkalinity enables use of a superplasticiser, and in particular a PCE, which surprisingly enables CaO to become a more effective activator than NaOH or other more strongly alkaline activators.

In the description above, the ~~invention~~ disclosure is described primarily in the context of GGBS as the hydraulically-active, or latently-hydraulically-active material. The inventors have found, however, that binders and other products embodying the ~~invention~~ disclosure may comprise PFA, or may comprise a mixture of GGBS and PFA, or

(in less-preferred embodiments) mixtures of GGBS, PFA and/or materials such as other suitable pozzolans or such as inert (e.g. filler) materials. 100% GGBS or 100% PFA may be used, or any mixture between the two, but the inventors have found that GGBS mixed with between 20% and 60%, or preferably between 30% and 50%, or 35% and 45%, PFA gives an effective binder with particularly-good strength levels. The inventors' preferred mix to maximise strength is GGBS:PFA in a ratio of about 60:40 or 55:40 by weight.

Wherever appropriate, reference throughout this document to embodiments of the ~~invention~~ disclosure describing use of GGBS, should therefore be construed so as to include, or incorporate, GGBS, PFA, and/or the mixtures described above.

In one embodiment, there is provided a cementitious binder comprising;
at least 1.5% and less than 5% by weight of an activator, which is CaO or lime;
at least 0.2% and less than 2% by weight of a polycarboxylate-ether-based (PCE) superplasticiser; and
at least 90% by weight of a non-OPC hydraulically-active material of which at least 70% is ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA) or a mixture of GGBS and PFA.

In preferred embodiments, the ~~invention~~ disclosure may thus provide any method or material for implementing the formation or use of a binder comprising; a latently-hydraulically-active material comprising a material selected from the group consisting of GGBS, PFA, and mixtures of GGBS and PFA: less than 10%, or 9.5%, CaO or lime; and a superplasticiser, preferably a PCE. The binder may be usable for example for a concrete, a mortar, a grout, or a render.

In one embodiment, an activator composition comprising the CaO or lime and the superplasticiser may be mixed with the latently-hydraulically-active material. Alternatively an activator composition may comprise only CaO or lime, and the superplasticiser may be added separately.

Preferably, the method produces a binder comprising more than 0.1%, 0.5%, 1% or 2% and/or less than 9.5% or 5% or 4% CaO or lime (by weight), and particularly preferably about 3%. Preferably, the method produces a binder comprising more than 0.25% or 0.35% or 0.5%, and/or less than 1% or 2% superplasticiser or PCE, by weight.

Particularly preferably, for a superplasticiser or PCE in powdered form the method produces a binder comprising more than 0.25% or 0.35%, and/or less than 0.75% or 1% superplasticiser or PCE, and particularly preferably 0.5%, by weight.

Particularly preferably, for a superplasticiser or PCE in liquid form the method produces a binder comprising more than 0.5% and/or less than 2% superplasticiser or PCE, by weight.

Preferably the balance of the weight of the binder, other than the CaO or lime and the superplasticiser or PCE, consists of the latently-hydraulically-active material. The latently-hydraulically-active material preferably comprises GGBS, PFA or a mixture of GGBS and PFA as described above, and preferably comprises only this material, but it may comprise other materials which are either inert or are other pozzolanic materials. However, the GGBS, PFA or mixture of GGBS and PFA preferably makes up more than 50%, 70%, 80% or 90% of the weight of the hydraulically-active component of the binder (i.e. of the balance of the weight of the binder, other than the CaO or lime and the superplasticisers or PCE).

References in this document to the quantity of GGBS, or of GGBS and/or PFA, in a binder or other product should be construed on this basis. For example a reference to a binder comprising a certain quantity of GGBS therefore includes a reference to a binder comprising that quantity of a hydraulically-active material consisting of a mixture of at least 50%, 70%, 80% or 90% GGBS with inert or pozzolanic materials as described above.

In one embodiment, there is provided a method of making an active cementitious binder for a concrete, mortar, grout or render, comprising the steps of mixing together;

a) an activator, a PCE superplasticiser and a non-OPC hydraulically-active material as defined in any preceding claim; and
b) water.

In one embodiment, there is provided a concrete, mortar, grout or render comprising a cementitious binder as disclosed herein.

Various Aspects of the Invention

In a first aspect, the invention may thus provide a cementitious binder comprising GGBS and/or PFA, preferably in an amount of 90% or more, and at

least 0.1% by weight of CaO. The CaO may be any CaO, or lime, suitable for triggering and accelerating the hydration of the GGBS and/or PFA. The cementitious binder may contain 0.2wt% CaO, or 0.3wt% CaO, or 0.5wt% CaO, or 1wt% CaO or 1.5wt% CaO, or more than 0.2, 0.3, 0.5, 1 or 1.5wt% CaO.

The cementitious binder may comprise at least 90% or 91% by weight GGBS and/or PFA with the remainder comprising the CaO and PCE.

The weight ratio of CaO to GGBS and/or PFA, or hydraulically-active material, in the cementitious binder may be greater than 0.1:99.9. For example the ratio

Claims

1. A cementitious binder comprising at least 90% by weight of a non-OPC hydraulically-active material comprising ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA) or a mixture of GGBS and PFA, at least 0.1% by weight of CaO, and a superplasticiser.

2. A cementitious binder according to claim 1, in which the hydraulically-active material comprises at least 50% or 70% or 80% or 90% GGBS, PFA or the mixture of GGBS and PFA.

3. A cementitious binder according to claim 1 or 2, in which the superplasticiser is a polycarboxylate-ether-based (PCE) superplasticiser.

4. A cementitious binder according to claim 1, 2 or 3, comprising at least 90% of the hydraulically-active material, with the remainder comprising the CaO and the superplasticiser.

5. A cementitious binder according to any preceding claim, which consists of GGBS, PFA or the mixture of GGBS and PFA, the CaO and the superplasticiser.

6. A cementitious binder according to any preceding claim, comprising an activator composition which comprises the CaO, optionally comprising the superplasticiser, and optionally further comprising microsilica and/or super-fine pulverised fuel ash (PFA).

7. A cementitious binder according to any preceding claim, comprising at least 0.1wt% or 1wt% or 2wt% CaO, and preferably an amount equal to or greater than about 2.5wt%, 3wt%, 4wt%, 5wt%, 6wt%, 7wt% or 8wt% CaO.

8. A cementitious binder according to any preceding claim, comprising greater than 93%, 95%, 96%, 97% or 98% by weight hydraulically-active material.

9. A cementitious binder according to any preceding claim, comprising between 0.2% and 2%, or between 0.3% and 1.2%, or between 0.4% and 0.7% superplasticiser.

10. A cementitious binder according to any preceding claim, in which the superplasticiser is in powder form and the binder comprises more than 0.2%, 0.25%, 0.3%, 0.35% or 0.4% and/or less than 0.7%, 0.75%, 1% or 1.2% superplasticiser.

11. A cementitous binder according to any preceding claim, in which the superplasticiser is in liquid form and the binder comprises more than 0.2% or 0.5% and less than 2% superplasticiser.

12. A method of making a concrete, mortar, grout or render, comprising the steps of mixing together in a predetermined proportion;

a) a cementitious binder;

b) aggregate particles; and

c) water;

in which the cementitious binder is a binder as defined in any preceding claim.

13. A method according to claim 12, in which the weight ratio of water to the cementitious binder is between 0.15:1 and 0.45:1, preferably between 0.2:1 and 0.4:1, preferably between 0.25:1 and 0.35:1, for example about 0.3:1, where non-absorbent aggregates are used.

14. A method according to claim 12 or 13, in which the volume ratio of the cementitious binder to the aggregate particles is between 1:3 and 1:15, preferably between 1:4 and 1:8.

15. A method of making a concrete, mortar, grout or render, comprising the steps of mixing together in a predetermined proportion;

a) a hydraulically-active material comprising GGBS, PFA or a mixture of GGBS and PFA;

b) an activator composition comprising or consisting of CaO;

c) aggregate particles;

d) water; and

e) a superplasticiser, which optionally forms a component of the activator composition;

in which the hydraulically-active material, the activator composition and the superplasticiser (which optionally forms a component of the activator composition) combine to form a cementitious binder as defined in any of claims 1 to 11.

16. A method according to claim 15, in which components a), b) and e) combine to form a binder component of the concrete, mortar, grout or render, and the volume ratio of the binder component to component c) is between 1:3 and 1:15 and preferably between 1:4 and 1:8.

17. A method according to claim 15 or 16, in which components a), b) and e) combine to form a binder component of the concrete, mortar, grout or render, and the weight ratio of component d) to the binder component is between 0.15:1 and 0.45:1, preferably between 0.2:1 and 0.4:1, preferably between 0.25:1 and 0.35:1, for example about 0.3:1, where non-absorbent aggregates are used.

18. A method according to any of claims 15 to 17, in which the activator composition is contained within one or more water-soluble packages and is released from the one or more water-soluble packages as they are dissolved by the water.

19. A concrete, mortar, grout or render comprising a cementitious binder as defined in any of claims 1 to 11.

20. A concrete, mortar, grout or render formed by the method defined in any of claims 12 to 18.

21. A concrete, mortar, grout, or render according to claim 19 or 20, in which the weight ratio of water to binder is between 0.2:1 and 0.4:1, preferably between 0.25:1 and 0.35:1, for example about 0.3:1, where non-absorbent aggregates are used.

22. A concrete, mortar, grout or render according to any of claims 19 to 21, which has a compressive strength of greater than 15 MPa after 7 days, greater than 20 MPa after 14 days, and greater than 30 MPa after 28 days.

23. Use of an activator composition in combination with a hydraulically-active material comprising ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA), or a mixture of GGBS and PFA to form a cementitious binder, the activator composition comprising CaO, in which the proportion of hydraulically-active material by weight in the resulting binder is greater than 90%, and the proportion of activator composition by weight in the resulting binder is less than 10%, and in which the binder comprises a superplasticiser such as a PCE.

24. Use of an activator composition according to claim 23, in which the activator composition comprises the superplasticiser.

25. Use of an activator composition as defined in claim 23 or 24, comprising the step of adding to the hydraulically-active material a predetermined quantity of the activator composition contained in a package, preferably a water-soluble package.

26. An activator composition for combining with a hydraulically-active material comprising ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA), or a mixture of GGBS and PFA in combination with a superplasticiser such as PCE to form a cementitious binder, the activator composition comprising a first component consisting of CaO, and a second component consisting of microsilica and/or pulverised fuel ash (PFA), preferably in a superfine form, in which the first component and the second component are mixed in a weight ratio of between 1.2:1 and 3:1.

27. An activator composition according to claim 26, in which the superplasticiser is a component of the activator composition.

28. An activator composition according to claim 26 or 27, in which the CaO comprises lime.

29. An activator composition for combining with a hydraulically-active material comprising GGBS, PFA or a mixture of GGBS and PFA, the activator composition comprising a first component consisting of CaO and a second component consisting of a superplasticiser such as PCE superplasticiser.

30. An activator composition according to claim 29, in which the superplasticiser is in powder form.

31. An activator composition according to claim 29 or 30, further comprising a third component consisting of microsilica, PFA, or a mixture of microsilica and PFA, the PFA preferably being super-fine PFA.

32. An activator composition according to any of claims 26 to 31, in which a predetermined quantity of the activator composition is packaged in a package for use in mixing with a hydraulically-active material, the package preferably releasing the activator composition on contact with water.

33. A cementitious binder comprising;
more than 90% of a hydraulically-active material comprising GGBS, PFA or a mixture of GGBS and PFA;
between 0.1% and 9% CaO; and
between 0.2% and 2% superplasticiser, such as a PCE superplasticiser.

34. A cementitious binder according to claim 33, comprising,
between 94-97wt% of the hydraulically-active material;
between 1.5-3.5wt% CaO; and
between 0.2-2wt% superplasticiser.

35. A cementitious binder according to claim 33 or 34, comprising between 1-2.5wt% microsilica and/or pulverised fuel ash (PFA), preferably super-fine PFA.

36. A concrete, mortar, grout or render comprising a cementitious binder formed from a combination of 94-97wt% of a hydraulically-active material

comprising ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA), or a mixture of GGBS and PFA, 3-6wt% of an activator composition, and aggregate particles bound together by the binder,

in which the activator composition comprises a first component consisting of CaO and a second component consisting of microsilica and/or pulverised fuel ash (PFA), preferably in super fine form, the ratio of the first component to the second component being between 1.2:1 and 3:1 by weight,

and in which the binder comprises a superplasticiser such as a PCE, optionally forming part of the activator composition.

37. A concrete, mortar, grout or render according to claim 35, in which the CaO is lime.

38. A concrete, mortar, grout or render comprising a cementitious binder according to any of claims 33 to 37.

39. A concrete, mortar, grout, render or binder as defined in any preceding claim that does not contain ordinary Portland cement (OPC).

AMENDED CLAIMS
received by the International Bureau on 18 November 2013

1. A cementitious binder comprising at least 90% by weight of a non-OPC hydraulically-active material comprising ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA) or a mixture of GGBS and PFA, at least 0.1% and less than 9.5% by weight of CaO or lime, and a superplasticiser.

2. A cementitious binder according to claim 1, in which the hydraulically-active material comprises at least 50% or 70% or 80% or 90% GGBS, PFA or the mixture of GGBS and PFA.

3. A cementitious binder according to claim 1 or 2, in which the superplasticiser is a polycarboxylate-ether-based (PCE) superplasticiser.

4. A cementitious binder according to claim 1, 2 or 3, comprising at least 90% of the hydraulically-active material, with the remainder comprising the CaO and the superplasticiser.

5. A cementitious binder according to any preceding claim, which consists of GGBS, PFA or the mixture of GGBS and PFA, the CaO and the superplasticiser.

6. A cementitious binder according to any preceding claim, comprising an activator composition which comprises the CaO, optionally comprising the superplasticiser, and optionally further comprising microsilica and/or super-fine pulverised fuel ash (PFA).

7. A cementitious binder according to any preceding claim, comprising at least 0.1wt% or 1wt% or 2wt% CaO, and preferably an amount equal to or greater than about 2.5wt%, 3wt%, 4wt%, 5wt%, 6wt%, 7wt% or 8wt% CaO.

8. A cementitious binder according to any preceding claim, comprising greater than 93%, 95%, 96%, 97% or 98% by weight hydraulically-active material.

9. A cementitious binder according to any preceding claim, comprising between 0.2% and 2%, or between 0.3% and 1.2%, or between 0.4% and 0.7% superplasticiser.

10. A cementitious binder according to any preceding claim, in which the superplasticiser is in powder form and the binder comprises more than 0.2%, 0.25%, 0.3%, 0.35% or 0.4% and/or less than 0.7%, 0.75%, 1% or 1.2% superplasticiser.

11. A cementitous binder according to any preceding claim, in which the superplasticiser is in liquid form and the binder comprises more than 0.2% or 0.5% and less than 2% superplasticiser.

12. A method of making a concrete, mortar, grout or render, comprising the steps of mixing together in a predetermined proportion;

a) a cementitious binder;

b) aggregate particles; and

c) water;

in which the cementitious binder is a binder as defined in any preceding claim.

13. A method according to claim 12, in which the weight ratio of water to the cementitious binder is between 0.15:1 and 0.45:1, preferably between 0.2:1 and 0.4:1, preferably between 0.25:1 and 0.35:1, for example about 0.3:1, where non-absorbent aggregates are used.

14. A method according to claim 12 or 13, in which the volume ratio of the cementitious binder to the aggregate particles is between 1:3 and 1:15, preferably between 1:4 and 1:8.

15. A method of making a concrete, mortar, grout or render, comprising the steps of mixing together in a predetermined proportion;

a) a hydraulically-active material comprising GGBS, PFA or a mixture of GGBS and PFA;

b) an activator composition comprising or consisting of CaO or lime;

c) aggregate particles;

d) water; and

e) a superplasticiser, which optionally forms a component of the activator composition;

In which the hydraulically-active material, the activator composition and the superplasticiser (which optionally forms a component of the activator composition) combine to form a cementitious binder as defined in any of claims 1 to 11.

16. A method according to claim 15, in which components a), b) and e) combine to form a binder component of the concrete, mortar, grout or render, and the volume ratio of the binder component to component c) is between 1:3 and 1:15 and preferably between 1:4 and 1:8.

17. A method according to claim 15 or 16, in which components a), b) and e) combine to form a binder component of the concrete, mortar, grout or render, and the weight ratio of component d) to the binder component is between 0.15:1 and 0.45:1, preferably between 0.2:1 and 0.4:1, preferably between 0.25:1 and 0.35:1, for example about 0.3:1, where non-absorbent aggregates are used.

18. A method according to any of claims 15 to 17, in which the activator composition is contained within one or more water-soluble packages and is released from the one or more water-soluble packages as they are dissolved by the water.

19. A concrete, mortar, grout or render comprising a cementitious binder as defined in any of claims 1 to 11.

20. A concrete, mortar, grout or render formed by the method defined in any of claims 12 to 18.

21. A concrete, mortar, grout, or render according to claim 19 or 20, in which the weight ratio of water to binder is between 0.2:1 and 0.4:1, preferably between 0.25:1 and 0.35:1, for example about 0.3:1, where non-absorbent aggregates are used.

22. A concrete, mortar, grout or render according to any of claims 19 to 21, which has a compressive strength of greater than 15 MPa after 7 days, greater than 20 MPa after 14 days, and greater than 30 MPa after 28 days.

23. Use of an activator composition in combination with a hydraulically-active material comprising ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA), or a mixture of GGBS and PFA to form a cementitious binder, the activator composition comprising CaO or lime, in which the proportion of hydraulically-active material by weight in the resulting binder is greater than 90%, and the proportion of activator composition by weight in the resulting binder is less than 10%, and in which the binder comprises a superplasticiser such as a PCE.

24. Use of an activator composition according to claim 23, in which the activator composition comprises the superplasticiser.

25. Use of an activator composition as defined in claim 23 or 24, comprising the step of adding to the hydraulically-active material a predetermined quantity of the activator composition contained in a package, preferably a water-soluble package.

26. An activator composition for combining with a hydraulically-active material comprising ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA), or a mixture of GGBS and PFA in combination with a superplasticiser such as PCE to form a cementitious binder, the activator composition comprising a first component consisting of CaO or lime, and a second component consisting of microsilica and/or pulverised fuel ash (PFA), preferably in a superfine form, in which the first component and the second component are mixed in a weight ratio of between 1.2:1 and 3:1.

27. An activator composition according to claim 26, in which the superplasticiser is a component of the activator composition.

28. An activator composition according to claim 26 or 27, in which the CaO comprises lime.

29. An activator composition for combining with a hydraulically-active material comprising GGBS, PFA or a mixture of GGBS and PFA, the activator composition comprising a first component consisting of CaO and a second component consisting of a superplasticiser such as PCE superplasticiser.

30. An activator composition according to claim 29, in which the superplasticiser is in powder form.

31. An activator composition according to claim 29 or 30, further comprising a third component consisting of microsilica, PFA, or a mixture of microsilica and PFA, the PFA preferably being super-fine PFA.

32. An activator composition according to any of claims 26 to 31, in which a predetermined quantity of the activator composition is packaged in a package for use in mixing with a hydraulically-active material, the package preferably releasing the activator composition on contact with water.

33. A cementitious binder comprising;
more than 90% of a hydraulically-active material comprising GGBS, PFA or a mixture of GGBS and PFA;
between 0.1% and 9% CaO or lime; and
between 0.2% and 2% superplasticiser, such as a PCE superplasticiser.

34. A cementitious binder according to claim 33, comprising,
between 94-97wt% of the hydraulically-active material;
between 1.5-3.5wt% CaO or lime; and
between 0.2-2wt% superplasticiser.

35. A cementitious binder according to claim 33 or 34, comprising between 1-2.5wt% microsilica and/or pulverised fuel ash (PFA), preferably super-fine PFA.

36. A concrete, mortar, grout or render comprising a cementitious binder formed from a combination of 94-97wt% of a hydraulically-active material

comprising ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA), or a mixture of GGBS and PFA, 3-6wt% of an activator composition, and aggregate particles bound together by the binder,

in which the activator composition comprises a first component consisting of CaO or lime and a second component consisting of microsilica and/or pulverised fuel ash (PFA), preferably in super fine form, the ratio of the first component to the second component being between 1.2:1 and 3:1 by weight,

and in which the binder comprises a superplasticiser such as a PCE, optionally forming part of the activator composition.

37. A concrete, mortar, grout or render according to claim 35, in which the CaO is lime.

38. A concrete, mortar, grout or render comprising a cementitious binder according to any of claims 33 to 37.

39. A concrete, mortar, grout, render or binder as defined in any preceding claim that does not contain ordinary Portland cement (OPC).

Claims

1. A cementitious binder comprising;

at least 1.5% and less than 5% by weight of an activator, which is CaO or lime;

at least 0.2% and less than 2% by weight of a polycarboxylate-ether-based (PCE) superplasticiser; and

at least 90% by weight of a non-OPC hydraulically-active material of which at least 70% is ground granulated blastfurnace slag (GGBS), pulverised fuel ash (PFA) or a mixture of GGBS and PFA.

2. A cementitious binder according to claim 1, comprising less than 3.5% by weight of the activator, which is CaO or lime.

3. A cementitious binder according to claim 1 or 2, in which the hydraulically-active material comprises at least 80% or 90% GGBS, PFA or the mixture of GGBS and PFA.

4. A cementitious binder according to claim 1, 2 or 3, which consists of the hydraulically-active material, the activator and the superplasticiser.

5. A cementitious binder according to any preceding claim, which consists of GGBS, PFA or the mixture of GGBS and PFA, the activator and the superplasticiser.

6. A cementitious binder according to any preceding claim, formed using an activator composition which comprises the activator mixed with one or both of the superplasticiser and a further activator-composition component which comprises microsilica and/or pulverised fuel ash (PFA), preferably super-fine pulverised fuel ash (PFA).

7. A cementitious binder according to any preceding claim, comprising between 1-2.5wt% microsilica and/or pulverised fuel ash (PFA), preferably super-fine PFA.

8. A cementitious binder according to any preceding claim, comprising at least 2wt% of the activator, and preferably an amount equal to or greater than 2.5wt% or 3wt% of the activator.

9. A cementitious binder according to any preceding claim, comprising greater than 93%, 95%, 96%, 97% or 98% by weight hydraulically-active material.

10. A cementitious binder according to any preceding claim, comprising between 0.3% and 1.2%, or between 0.4% and 0.7% of the superplasticiser.

11. A cementitious binder according to any preceding claim, in which the superplasticiser is in powder form and the binder comprises more than 0.25%, 0.3%, 0.35% or 0.4% and/or less than 0.7%, 0.75%, 1% or 1.2% of the superplasticiser.

12. A cementitous binder according to any of claims 1 to 10, in which the superplasticiser is in liquid form and the binder comprises more than 0.5% of the superplasticiser.

13. A method of making an active cementitious binder for a concrete, mortar, grout or render, comprising the steps of mixing together;

a) an activator, a PCE superplasticiser and a non-OPC hydraulically-active material as defined in any preceding claim; and

b) water.

14. A method according to claim 13, in which the weight ratio of water to the other components (a) is between 0.15:1 and 0.45:1, preferably between 0.2:1 and 0.4:1, preferably between 0.25:1 and 0.35:1, for example about 0.3:1.

15. A method according to claim 13 or 14, comprising a step of mixing an activator composition which comprises the activator, which is CaO or lime, with the other components of the binder.

16. A method according to claim 15, in which the activator composition comprises the activator mixed with the PCE superplasticiser.

17. A method according to claim 15 or 16, in which the activator composition comprises a further component, which is microsilica and/or PFA, preferably super-fine pulverised fuel ash (PFA).

18. A method according to claim 17, in which the activator and the further component are mixed in a weight ratio of between 1.2:1 and 3:1.

19. A method according to any of claims 15 to 18, in which the activator composition is contained within one or more water-soluble packages and is released from the one or more water-soluble packages as they are dissolved by the water.

20. A method according to any of claims 13 to 19, further comprising a step of mixing the cementitious binder, formed by mixing (a) and (b), with aggregate particles to form the concrete, mortar, grout or render, in which the volume ratio of the cementitious binder to the aggregate particles is between 1:3 and 1:15, preferably between 1:4 and 1:8.

21. A concrete, mortar, grout or render comprising a cementitious binder as defined in any of claims 1 to 12.

22. A concrete, mortar, grout or render according to claim 21, which has a compressive strength of greater than 15 MPa after 7 days, greater than 20 MPa after 14 days, and greater than 30 MPa after 28 days.

23. A cementitious binder as defined in any preceding claim that does not contain ordinary Portland cement (OPC).