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Description

In the course of erecting steel structures, a thick coating of inorganic material is commonly applied to the metallic structural elements to achieve a number of objectives including fire retardance, improved appearance and sound deadening. While several types of formulations have been applied for these purposes over the years by means of a variety of techniques, the most successful system so far consists in spraying on to the steel surfaces settable aqueous mixes composed essentially of calcined gypsum, a lightweight inorganic aggregate material such as exfoliated vermiculite, a mixture of fibrous materials such as a high wet bulking cellulose fibre and glass fibre, and an air entraining agent. A composition of this type is described by Bragg in U.S. 3,719,573 and 3,839,059, along with the most desirable application technique, i.e., pumping the aqueous mix and spraying it directly on to the steel in one layer.

In order to be suitable for such use, coating mixes, both in the wet and dry state, must possess a number of crucial properties. They must be able to hold the large quantity of water that renders them capable of being pumped easily and to great heights. Yet they must retain a consistency sufficient to prevent segregation or settling of ingredients and permit adequate "yield" or coverage of the steel surface at a given thickness. The coating mixes, furthermore, must obviously adhere to steel surfaces, both in the slurried state and in the dry state. Also, the mix must set without the undue expansion or shrinkage which could only result in the formation of cracks that would seriously deter from the insulative value of the dry coating.

As intimated earlier, this complex balance of properties has substantially been achieved heretofore by gypsum-vermiculite mixes containing cellulosic fibre. However, vermiculite is a naturally occurring mineral which is subject to variation in quality, consistency, and uniformity. Moreover, since the vermiculite mineral must be expanded at very high temperatures prior to use, its cost is subject to unpredictable variations in energy cost.

Accordingly, there has been a need to formulate new spray applied fireproofing compositions which satisfactorily employ aggregates other than vermiculite while providing the diverse mix of properties referred to above.

A slurry according to the invention comprises a hydratable cementitious binder, aggregate comprising shredded polystyrene, an air entraining agent, and a fibrous component and which can be sprayed on to a steel structural member to form a coating which is adherent to the member and which sets to provide a fire and heat protective adherent coating on the member. The aggregate often consists of shredded polystyrene.

The invention also includes steel structured members coated with such a slurry and methods of providing such coated members.

It has been found that sprayable cementitious compositions containing shredded polystyrene as a lightweight aggregate can be prepared and utilised as spray applied fireproofing compositions for structural steel members and that these compositions can be prepared as pumpable, sprayable materials which maintain a uniform consistency, without segregation of the aggregate, throughout the pumping operation and after application to the steel. Upon spray application to the steel members, the slurries provide a high yield and display satisfactory adhesion in both the slurried and set state. The adhered compositions provide excellent fire and heat insulative protection to the steel despite the organic nature of the polystyrene aggregate. Under fire test conditions, the polystyrene aggregate displays advantageous performance in that it shrinks, melts, and, in effect, disappears out of the fireproofing composition matrix, leaving behind a uniform distribution of cavities which imparts a very low effective thermal conductivity to matrix. This, in turn, increases the effectiveness of the matrix as a barrier to heat transfer.

The aggregate used in the present compositions is a shredded polystyrene particles which can be produced by shredding loose expanded polystyrene beads or moulded polystyrene beadboard. Extruded polystyrene can also be shredded to provide the aggregate material of this invention. The shredded particles should have irregularly shaped exterior surfaces, tears, and ragged edges. The shredded particles formed by shredding expanded polystyrene should have a substantial number of opened cells on the surface of the foamed beads, thereby allowing penetration of the cementitious binder into the cellular structure and providing a more integral mix between the binder and the particle. A suitable method and apparatus for shredding foamed polystyrene beads are disclosed in U.S. 3,627,211 and 3,686,068, to which reference should be made.

It is known to shred foam particles and mix the shredded particles with a granulate slurry wherein the granular material may comprise cement particles, sand, gypsum particles and the like. As disclosed, for example, in U.S. 3,630,820 and 4,100,242, if a sufficient number of the cells are penetrated by the slurry, the buoyancy of the particles becomes decreased such that the high viscosity of the slurry prevents the

particles from rising.

In the pumpable compositions of this invention, it has been found that the decreased buoyancy of the particles is essential for satisfactory conveyance of the compositions through the pump mechanism and feed lines to the point of application. In contrast, non-shredded beads, segregate within the slurry and the resultant localised concentration of beads can clog the pump, feed lines, and spray nozzle.

The shredded polystyrene particles are preferably employed in a weight concentration of 1% to 5%, based on the total weight of the composition before water addition. (Unless otherwise stated, all weight percentages given herein are similarly based). These concentrations are preferred for providing pumpable, non-segregating, uniform slurries which display desired levels of adhesion to steel substrates and provide excellent fire protection. In addition, the density of slurry compositions containing concentrations of shredded polystyrene within this range is sufficiently low after application to ensure that the coating stays in place before and after setting. Thus, "fall-off" of the applied composition due to inadequate adherence or mechanical and structural disturbance is minimised or eliminated.

The density of the shredded polystyrene is preferably in the range of 3.2 to 9.6 kg/m³ (0.2 to 0.6 pounds per cubic foot), more preferably 4.8 to 8.0 kg/m³ (0.3 to 0.5 pcf). Preferably, the particle size at its maximum dimension is less than 6mm.

Portland cement can be used as the cementitious binder of the invention. However, it is generally preferred to employ a gypsum binder due to its advantageous fireproofing performance. Although the gypsum can be used in relatively low amounts, e.g., as little as 60% by weight, it is generally preferred to employ at least 75% by weight, based on the total weight of the composition, and more preferably at least 85% by weight.

The fibrous component of the present compositions can be either organic or inorganic. Preferably, the fibrous component is a mixture of a high wet bulking organic fibre, preferably cellulose fibre as described in U.S. 3,719,513 and 3,839,059, and an inorganic fibre which provides reinforcement, preferably glass fibre. The total amount of the fibrous component in the compositions is preferably in the range of 4% to 20% by weight. A particularly preferred composition comprises 4% to 10% by weight of high wet bulking cellulosic fibre and 0.1% to 2% by weight of glass fibre. It has been found that these particularly preferred fibre loadings, coupled with the preferred loading of 1% to 5% by weight of shredded polystyrene particles, provides an optimum composition for easy pumping without segregation and for placement in high yield, i.e., placement over a relatively large area, per weight of the dry composition, at a given thickness of application. Yield is generally calculated by methods known in the art as board feet per dry weight of composition, or alternatively as area of a 1cm thick coating per dry weight of compositions. The particularly preferred compositions are capable of providing a high yield of at least 2300 cm² of a 1cm thick coating per kg (20 board feet per 45 pounds by weight) of the dry composition. Generally, a yield in the range of 2875 to 4025 cm² of a 1cm thick coating per kg (25 to 35 board feet per 45 pounds) dry weight is obtained.

The foaming agents or air entraining agents that can be used in the compositions of the invention are well known in the art. Such well known materials as sulfonated monoglycerides, sodium alkyl arylsulfonate, and sodium lauryl sulfate can be used in appropriate quantities to provide a slurry of desired density and pumpability. Dry foaming agents can be incorporated into the dry composition before addition of water, while both dry and liquid agents can be added to the slurried composition. Preferred amounts of the air entraining agent are 0.1% to 0.5% by weight. The combination of air entrainment and shredding of the polystyrene is especially advantageous for providing homogeneity to the slurry, i.e., preventing segregation of the aggregate, for the period of time necessary for pumping, spraying and setting of the slurry.

In certain instances it is also desirable to incorporate into the mix a water retaining agent which allows more water to be incorporated into the slurry, thereby increasing pumpability and yield, while retaining about the same level of adhesion to steel. A preferred water retaining agent is hydroxypropylmethylcellulose.

The slurry may be made by adding water to a dry composition. Generally, the water is added to the dry mix at the job site shortly before being pumped to the point of application. A water: cementitious binder ratio of 1.5:1 to 2.5:1 is generally employed to provide a pumpable mixture of desired consistency and adhesiveness. Generally, a useful range of slurry density, which affords easy pumping, is 560 to 880 kg/m³ (35 pcf to 55 pcf).

EXAMPLE 1

A gypsum-based composition of the invention was prepared by dry mixing the following ingredients:

Ingredients	% By Weight
Gypsum	88.6
Shredded expanded polystyrene (6 kg/m ³ .375 pcf)	2.7
Cellulose fiber	8.0
Glass fiber	0.5
Air entraining agent	0.2

The dry composition was mixed with water at a water:gypsum ratio of 2.0 and pumped to a spray application nozzle at a rate of 4.18×10^4 cm³/min (17.7 board feet/minute) using a Thomsen A375 pump at a pressure of 5.27×10^4 kg/m² (75 psi). The pumped slurry was applied to a steel substrate in a yield of 4312.5 cm² of a 1cm thick coating per kg (32.7 board feet per 45 pounds) of the dry composition. The applied slurry displayed excellent adhesion to the steel in the wet state and after setting. The set composition functioned effectively as a fire and heat insulative coating in a fire test environment.

Claims

1. A slurry which comprises water, a hydratable cementitious binder, aggregate comprising shredded polystyrene, an air entraining agent, and a fibrous component and which can be sprayed on to a steel structural member to form a coating which is adherent to the member and which sets to provide a fire and heat protective adherent coating on the member.
2. A slurry according to claim 1 wherein the shredded polystyrene aggregate is shredded expanded polystyrene or shredded extruded polystyrene and preferably has a density in the range of 3.2 to 9.6 kg/m³ (0.2 to 0.6 pcf).
3. A slurry according to either preceding claim in which the fibrous component comprises an organic fibrous material and an inorganic fibrous material.
4. A slurry according to any preceding claim in which the fibrous component comprises a high wet bulking organic fibre, preferably cellulose.
5. A slurry according to any preceding claim comprising 1% to 5% by dry weight of the shredded polystyrene.
6. A slurry according to any preceding claim comprising 4% to 10% by weight of high wet bulking cellulose fibre and 0.1% to 2% by dry weight of glass fibre.
7. A slurry according to any preceding claim further comprising a water retaining agent preferably hydroxypropylmethylcellulose.
8. A slurry according to any preceding claim having a density in the range of 560 to 880 kg/m³ (35 pcf to 55 pcf).
9. A slurry according to any preceding claim providing, after spray application, an in place yield of at least 2300 cm² of a 1cm thick coating per kg (20 board feet per 45 pounds) of said dry composition.
10. A fireproofed steel structural member comprising a steel structural member carrying a coating formed from a slurry according to any preceding claim.
11. A method of providing a fire and heat protective adherent coating on a steel structural member comprising spraying on to the member a slurry which comprises water, a hydratable cementitious binder, aggregate comprising shredded polystyrene, an air entraining agent and a fibrous component and thereby forming an adherent coating on the member, and allowing the coating to set to provide a fire and heat protective adherent coating on the member.
12. The use of a slurry according to any of claims 1 to 9 for spraying on to a steel structural member to form a coating which is adherent to the member and which sets to provide a fire and heat protective

adherent coating on the member.

Revendications

- 5 1. Bouillie qui comprend de l'eau, un liant cimentaire hydratable, un agrégat comprenant du polystyrène déchiqueté, un agent entraînant l'air et un composant fibreux et que l'on peut vaporiser sur un organe de structure en acier pour former un revêtement qui adhère à l'organe et qui durcit pour produire un revêtement adhérent protégeant contre le feu et la chaleur sur l'organe.
- 10 2. Bouillie selon la revendication 1, où l'agrégat de polystyrène déchiqueté est du polystyrène expansé déchiqueté ou du polystyrène extrudé déchiqueté et a, de préférence, une densité comprise entre 3,2 et 9,6 kg/m³ (0,2 à 0,6 pcf).
3. Bouillie selon toute revendication précédente, où le composant fibreux comprend une matière fibreuse organique et une matière fibreuse inorganique.
- 15 4. Bouillie selon toute revendication précédente, où le composant fibreux comprend une fibre organique à grande masse à l'état humide, de préférence de la cellulose.
- 20 5. Bouillie selon toute revendication précédente, comprenant 1% à 5% en poids sec du polystyrène déchiqueté.
6. Bouillie selon toute revendication précédente, comprenant 4% à 10% en poids de fibre de cellulose à grande masse à l'état humide et 0,1 à 2% en poids sec de fibre de verre.
- 25 7. Bouillie selon toute revendication précédente, comprenant de plus un agent retenant l'eau, de préférence de l'hydroxypropylméthylcellulose.
8. Bouillie selon toute revendication précédente, ayant une densité comprise entre 560 et 880 kg/m³ (35 pcf à 55 pcf).
- 30 9. Bouillie selon toute revendication précédente, produisant, après application vaporisée, un rendement sur place d'au moins 2 300 cm² d'un revêtement de 1 cm d'épaisseur par kg (20 pieds de panneau pour 45 livres) de ladite composition sèche.
- 35 10. Organe de structure en acier ignifugé comprenant un organe de structure en acier portant un revêtement formé d'une bouillie selon toute revendication précédente.
- 40 11. Méthode de production d'un revêtement adhérent protégeant contre le feu et la chaleur sur un organe de structure en acier comprenant la vaporisation sur l'organe d'une bouillie qui comprend de l'eau, un liant cimentaire hydratable, un agrégat comprenant du polystyrène déchiqueté, un agent entraînant l'air et un composant fibreux pour ainsi former un revêtement adhérent sur l'organe et permettre au revêtement de durcir pour former un revêtement adhérent protégeant contre le feu et la chaleur sur l'organe.
- 45 12. Utilisation d'une bouillie selon l'une quelconque des revendications 1 à 9, pour vaporisation sur un organe de structure en acier afin de former un revêtement qui adhère à l'organe et qui durcit, pour produire un revêtement adhérent protégeant contre le feu et la chaleur sur l'organe.

50 Patentansprüche

1. Aufschlämmung, die Wasser, hydratisierbares Zement- oder zementartiges Bindemittel, zerkleinertes Polystyrol umfassenden Zuschlagstoff, Luftporenbildner und eine faserige Komponente umfaßt und die auf ein Stahlkonstruktionsteil gespritzt werden kann, um eine Beschichtung zu bilden, die auf dem Teil haftet und darauf unter Ausbildung einer vor Feuer und Hitze schützenden, haftenden Beschichtung abbindet.
2. Aufschlämmung nach Anspruch 1, bei der der zerkleinerte Polystyrolzuschlagstoff zerkleinertes expan-

diertes Polystyrol oder zerkleinertes extrudiertes Polystyrol ist und vorzugsweise eine Dichte im Bereich von 3,2 bis 9,6 kg/m³ (0,2 bis 0,6 pcf) hat.

3. Aufschlammung nach einem der vorhergehenden Ansprüche, bei der die faserige Komponente ein organisches Fasermaterial und ein anorganisches Fasermaterial umfaßt.
4. Aufschlammung nach einem der vorhergehenden Ansprüche, bei der die faserige Komponente eine organische Faser mit hoher Feuchtigkeitsaufnahme, vorzugsweise Cellulose, umfaßt.
5. Aufschlammung nach einem der vorhergehenden Ansprüche, die 1% bis 5% Gew.% (Trockengewicht) zerkleinertes Polystyrol umfaßt.
6. Aufschlammung nach einem der vorhergehenden Ansprüche, die 4 Gew.% bis 10 Gew.% Cellulosefasern mit hoher Feuchtigkeitsaufnahme und 0,1 Gew.% bis 2 Gew.% (Trockengewicht) Glasfasern enthält.
7. Aufschlammung nach einem der vorhergehenden Ansprüche, die zusätzlich ein wasserhaltendes Agens, vorzugsweise Hydroxypropylmethylcellulose, umfaßt.
8. Aufschlammung nach einem der vorhergehenden Ansprüche, die eine Dichte im Bereich von 560 bis 880 kg/m³ (35 pcf bis 55 pcf) hat.
9. Aufschlammung nach einem der vorhergehenden Ansprüche, die nach dem Aufspritzen eine Ausbeute am Ort des Auftragens von mindestens 2300 cm² einer 1 cm dicken Beschichtung pro kg (20 board feet per 45 pounds) trockene Zusammensetzung ergibt.
10. Feuerfestes Stahlkonstruktionsteil, das ein Stahlkonstruktionsteil umfaßt, das eine Beschichtung trägt, die aus einer Aufschlammung gemäß einem der vorhergehenden Ansprüche gebildet ist.
11. Verfahren zur Herstellung einer vor Feuer und Hitze schützenden haftenden Beschichtung auf einem Stahlkonstruktionsteil, bei dem auf das Teil eine Aufschlammung gespritzt wird, die Wasser, hydratisierbares Zement- oder zementartiges Bindemittel, zerkleinertes Polystyrol umfassenden Zuschlagstoff, Luftporenbildner und eine faserige Komponente umfaßt, dadurch eine haftende Beschichtung auf dem Teil gebildet wird und die Beschichtung abbinden gelassen wird, um eine vor Feuer und Hitze schützende, haftende Beschichtung auf dem Teil zu ergeben.
12. Verwendung der Aufschlammung nach einem der Ansprüche 1 bis 9 zum Aufspritzen auf ein Stahlkonstruktionsteil, um eine Beschichtung zu bilden, die auf dem Teil haftet und die abbindet, um eine vor Feuer und Hitze schützende, haftende Beschichtung auf dem Teil zu ergeben.

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