Polymer powders redispersible in water in paving joint mortars, the paving jointing mortar having approximately 0.5% by weight or more, based on the paving joint dry mortar, of one or more mineral binders, as well as one or more additives and, if necessary, further components. The paving joint mortar can be introduced into a joint in powder form and subsequently watered, or the paving joint mortar can be mixed with water before introduction into the joint and added to the joint in paste form.
PAVING JOINT MORTARS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of European Application No. 06 015 384.8, filed 24 Jul. 2006.

[0002] The present invention relates to paving joint mortars. More particularly, the present invention relates to polymer powders redispersible in water and their use in paving joint mortars containing mineral binders.

[0003] Paving joint mortar is understood by one skilled in the art as joint mortar commonly used in the open air for jointing paving stones, natural stones and natural stone slabs, concrete stone slabs and concrete paving stones, mosaic flooring and mosaic paving, composite stone, natural stone paving, paving flag, large stone paving and small stone paving, cobble stone paving, erratic block paving, wooden paving and decking as well as cement cinder paving, among others. Such paving is used, for example, for pedestrian areas, roads, foot paths, cycling paths, access ways, gutters, and parking areas, as well as in garden architecture. The paving is introduced predominantly by garden designers and road builders by way of a so-called “loose construction method”, which is the most commonly used and one of the oldest methods of construction for such surfacing. In this method, the stones to be laid are placed onto a loose bed of chippings, sand or granules and subsequently jointed. The joint width may range, for example, from a few millimeters to a few centimeters. This type of construction responds to static or dynamic stresses by elastic deformation. Thermal impact is eliminated by unhindered deformation without stresses occurring. The paving cover remains basically permeable to water. It is generally perceived as a disadvantage in that the jointing material can be washed out from the joint or sucked up, for example, by sweeping machines. As a consequence, the stones may lose their hold. In addition, weeds can grow in these joints in the case of sparse traffic, something that is often perceived as undesirable, particularly in the case of natural stone surfaces.

[0004] Sand is the most commonly used jointing material, and can be introduced in powder form, for example, by means of a broom. It adapts without problem to the movement of the slabs and to the subgrade. An embodiment based on this is described in EP 1 484 295 A1, wherein a small portion of fibrous substances is mixed with the sand. Still, in this type of construction the above mentioned disadvantages of the state of the art persist.

[0005] In DE 44 21 970 A1 a jointing material and its use for jointing natural stone or synthetic stone paving is described. The jointing material includes a mixture of quartz sand with an addition of silica dust and a liquid polymer binder. The binder is typically composed of a mixture of polybutadiene, boiled linseed oil and isoparaffinic hydrocarbon mixtures. This mixture is swept with a broom as a soil-moist mass into the dry joints, compacted with a vibrating plate, and subsequently scraped off with a rubber scraper. This type of jointing material is consequently time-consuming to produce and apply. Moreover, such systems have low strength levels.

[0006] DE 102 49 636 A1 describes a similar approach. Here, functionalised polymer powders redispersible in water are mixed with jointing sand. The polymer powders self-crosslink in acidic or slightly alkaline medium, resulting in permanent compaction of the joint filling compound. Water permeability of the moulded body produced is improved by using the crosslinking polymer powder. The 636 publication does not describe how the jointing sand and the polymer powder are mixed and introduced into the joints. Strengths, such as tensile strength in bending and compressive strength, are not indicated. Conventional, non-crosslinking polymer powders cannot be used. Moreover, required conditions such as the pH-range must be accurately maintained in order to guarantee cross-linking.

[0007] In another approach, sand is mixed with approximately 20 to 40% by weight of cement and other additives, for example, cellulose fibers, in order to increase durability and strength. As a result, the paving joints become more durable and washable. Also, nothing will grow in them. As a result of the high rigidity of the joints, such joint filling materials are suitable only for a “bound” method of construction where paving stones are laid onto a rigid subgrade such as a concrete slab. This subgrade or support layer underneath the paving must be produced in a manner particularly resistant to deformation using appropriate materials and requires accurate planning. Still, stresses frequently occur, which may be due to changes in temperature. This frequently causes cracks and joints to loosen, resulting in the stones becoming detached. For this reason, two-component (2K) jointing mortars based on resin are very frequently used for this bound method of construction. These mortars do not respond in an elastic manner to stress, but rather in a rigid manner comparable to concrete surfaces. However, such systems are expensive, complicated to apply, and cannot be used for a non-bound method of construction.

[0008] JP 2285103 describes the use of silica sand and rubber powder as aggregates, a styrene acrylate copolymer dispersion, and Portland cement as binders. The joint filling material is first sprayed and then the joints are filled with it. After filling, the surface then has to be sprayed with a cleaning agent and cleaned with a polishing machine. This jointing material consists of two components and therefore needs to be thoroughly mixed by stirring, meaning additional effort is required. Moreover, the subsequent cleaning process is time-consuming to execute.

[0009] In order to produce a single component mortar that has been improved with a polymer, polyvinyl alcohol in powder form can be added to a paving joint dry mortar with approximately 2 to 7% by weight of cement. The paving joint dry mortar scattered into the joint is then wetted with water from the outside. Although this is simple to handle, the water cannot penetrate into the deeper layers due to the polyvinyl alcohol swelling rapidly on contact with water, resulting in an uneven and unsatisfactory introduction of water into the mortar. Moreover, polyvinyl alcohol provides a greasy consistency and tends to easily form foam. During continued contact with water, polyvinyl alcohol is also washed out over time, which may result in embrittlement of the paving joint.

[0010] In one embodiment, the present invention provides a single component paving jointing dry mortar in powder form for the loose method of construction. The mortar is simple to handle and apply. The applied mortar exhibits an increased durability, certain flexibility, as well as a corresponding compressive and tensile strength in bending. Moreover, the paving joint mortar possesses good flank adhesion, that is, a good adhesion to the paving stone that is resistant to mechanical stresses such as those caused by sweeping machines, high pressure cleaning machines, and/or driving rain. It also provides for easy removal by washing of contamination from paving jointing mortar residues on the paving stones, thereby simplifying subsequent cleaning considerably.

[0011] In another embodiment the present invention provides paving joint mortars having polymer powders redispersible in water. The paving joint mortar can also having one or more mineral binders in an amount of about 0.5% by
weight or more, based on the desired paving jointing dry mortar, as well as one or more additives and, optionally, further components. The paving joint mortar can be introduced into a joint in powder form and subsequently watered, or it can be mixed with water before introduction and added to the joint in paste form.

In one aspect, paving joint mortars having the polymer powder redispersible in water can have one or more mineral binders in about 0.5 to about 30% by weight. In another aspect, the one or more mineral binders are present in an amount of about 0.1 to about 5% by weight. In another aspect, the binders are present in an amount of about 0.1 to about 5% by weight. In one embodiment, the amount of additives in the paving joint mortars is about 30 to about 99% by weight. In another aspect, the amount of additives is about 50 to about 98% by weight. In a further aspect, the amount of additives is about 70 to about 90% by weight. In one embodiment, the amount of polymer powder redispersible in water present in the paving joint mortar is about 0.5 to about 20% by weight. In another aspect, the amount of polymer powder is present in an amount of about 0.5 to about 10% by weight. In a further aspect, the amount of polymer powder is present in an amount of about 0.5 to about 10% by weight. In another aspect, the amount of polymer powder is present in an amount of about 2 to about 7% by weight. Other optional components can be present in the paving joint mortar in an amount of about 0 to about 25% by weight. In one aspect, other components are present in an amount of about 0 to about 20% by weight, based on the paving jointing dry mortar, respectively.

Suitable mineral binders include at least (a) hydraulically binding binders such as cement, (b) latent hydraulic binders such as acidic blast-furnace slag, pozzolans and/or metakaolin, and/or (c) non-hydraulic binders that react under the influence of air and water, such as calcium hydroxide and/or calcium oxide.

In one embodiment, cement such as Portland cement (e.g., according to EN 196 CEM I, II, III, IV and V), calcium sulfate in the form of α-hemihydrate and/or β-hemihydrate and/or anhydrite and/or alumina melt cement can be the hydraulically binding binder. Pozzolans such as metakaolin, calcium metasilicate and/or volcanic slag, volcanic tuff, trass, fly ash, blast furnace slag and/or silica dust can also be used as a latent hydraulic binder, which, together with a source of calcium such as calcium hydroxide and/or cement, reacts hydraulically. Lime in the form of calcium hydroxide and/or calcium oxide, for example, can be used as non-hydraulic binder reacting under the influence of air and water. In one embodiment, the systems are based on Portland cement or a mixture of Portland cement and alumina melt cement and calcium sulfate, where latent hydraulic and/or non-hydraulic binder can optionally be added to either system.

Examples of suitable additives (sometimes also referred to as fillers) include quartz, sand, and/or carbonaceous sands and/or meals such as quartz sand and/or ground limestone, carbonates, silicates, chalk, layer silicates and/or precipitated silicic acids. In addition, light weight fillers such as hollow microspheres of glass, polymers such as polystyrene spheres, aluminosilicates, silicon oxide, aluminium silicate oxide, calcium silicate hydrate, aluminium silicate, magnesium silicate, aluminium silicate hydrate, calcium aluminium silicate, calcium silicate hydrate, silicon dioxide and/or aluminium iron magnesium silicate but also clays such as bentonite can be used. It is also possible for the fillers and/or light weight fillers to possess a natural or artificially produced color.

Polymer powders redispersible in water according to the invention can contain at least one polymer based on vinyl acetate, ethylene vinyl acetate, ethylene vinyl acetate vinyl versate, ethylene vinyl acetate vinyl chlorides, ethylene vinyl chloride, vinyl acetate vinyl versate, (meth)acrylate, ethylene vinyl acetate(meth)acrylate, vinyl acetate maleic acid and vinyl acetate maleic acid ester, vinyl acetate vinyl versate maleic acid and vinyl acetate vinyl versate maleic acid ester, vinyl acetate(meth)acrylate maleic acid and vinyl acetate (meth)acrylate maleic acid ester, styrene acrylate and/or styrene butadiene, wherein vinyl versatate is a C₄₋₅ vinyl ester.

The polymer powders can also contain about 0 to about 50% by weight of additional monomers such as monomers with functional groups. In another aspect, the polymers can contain about 0 to about 30% by weight of additional monomers. In another aspect, the polymers can contain about 0 to about 10% by weight of additional monomers.

Polymer powders redispersible in water according to the invention can be based on one or several polymers. These polymers can be produced, for example, by emulsion polymerisation, suspension polymerisation, microemulsion polymerisation and/or inverse emulsion polymerisation. If necessary, the polymers can also exhibit a heterogeneous morphology obtained by selecting the monomer and the production process. Subsequent drying takes place, for example, by spray drying, freeze drying, fluid bed drying, roller drying and/or rapid drying. In one embodiment the polymer powders are produced by emulsion polymerisation and spray drying.

Examples of suitable classes of monomers for producing these polymers include linear or branched C₄₋₅ to C₂₀₋₂₅ vinyl esters, ethylene, propylene, vinyl chloride, (meth)acrylic acid and their linear or branched C₄₋₅ to C₂₀₋₂₅ alkyl esters, (meth)acrylamide and (meth)acrylamide with N-substituted linear or branched C₄₋₅ to C₂₀₋₂₅ alkyl groups, acrylonitrile, styrene, styrene derivatives and/or dienes such as 1,3-butadiene.

In one embodiment, the vinyl esters are linear or branched C₄₋₅ to C₂₀₋₂₅ vinyl esters such as vinyl acetate, vinyl stearate, vinyl formate, vinyl propionate, vinyl butyrate, vinyl pivalate, vinyl laurate, vinyl-2-ethyl hexanoate, 1-methyl vinyl acetate and/or C₅₋₁₀, C₁₀₋₁₂ and/or C₁₁₋₁₂ vinyl versatate, vinyl pyridolide, N-vinyl formamide, N-vinyl acetaimide, as well as vinyl esters of benzoic acid and p-tart-butyl benzoic acid. In another embodiment, the vinyl esters are vinyl acetate, vinyl laurate and/or vinyl versatate. Examples of C₄₋₅ to C₂₀₋₂₅ alkyl groups of (meth)acrylic acid esters and N-substituted (meth)acrylamides include methyl groups, ethyl groups, propyl groups, n-butyl groups, i-butyl groups, hexyl groups, cyclohexyl groups, 2-ethyl hexyl groups, lauryl groups, stearyl groups, norbornyl groups, polyalkylene oxide groups and/or polyalkylene glycol groups. In one embodiment, the alkyl groups are methyl groups, butyl groups, and/or 2-ethyl hexyl groups. In another embodiment, the alkyl groups are methyl methacrylate, n-butyl acrylate, tert-butyl methacrylate and/or 2-ethyl hexyl methacrylate.

Additional monomers such as monomers with functional groups can be incorporated by polymerization. For example, it is possible to copolymerize maleic anhydride, unsaturated dicarboxylic acids and their branched or linear C₄₋₅ esters, such as itaconic acid, maleic acid and/or fumaric acid as well as their esters, multiply ethylenically unsaturated copolymers such as e.g. divinyl adipate, diallyl maleate, allyl methacrylate or triallyl cyanurate, divinyl benzene, butane diol-1,4-dimethacrylate, triethylene glycol
dimethacrylate, hexane diol diacrylate, functional vinyl monomers and/or (meth)acrylate monomers containing alkoxy silane groups, glycidyl groups, epihalohydrin groups, carboxyl groups, amine groups, hydroxy groups, ammonium groups and/or sulfonic acid groups. In one aspect the functional monomers can be hydroxyl propyl (meth)acrylate, N-methylol allyl carbamate, methyl acrylic acid glycolic acid methyl ester, N-Methylol (meth)acrylamide, vinyl sulfonic acid, acrylamido glycolic acid, glycidyl (meth)acrylate, 2-acrylamido-2-methyl propane sulfonic acid, (meth)acryloxypropyl tri(alkoxy)silane, vinyl trialkoxysilane, vinyl methyl dialkoxysilanes; methoxy groups, ethoxy groups and/or iso-propoxy groups being used as alkoxy groups; acetyl acetoxyethyl (meth)acrylate, diacetone acrylamide, acrylamido glycolic acid, methyl acrylamido glycolic acid methyl ester, alkyl ether, N-Methylol (meth)acrylamide, N-Methylol allyl carbamate, esters of N-Methylol (meth)acrylamide and of N-Methylol allyl carbamate, N-[3-(dimethyl amino)propyl]methacrylamide, N-[3-(dimethyl amino)ethyl](meth)acrylamide, N-[3-(trimethyl ammonium)propyl](meth)acrylamide chloride and/or N,N-[3-chloro-2-hydroxypropyl]-3-dimethyl ammonium propyl](meth)acrylamide chloride. In one aspect the proportion of these comonomers is approximately 0 to 30% by weight. In another aspect, it is approximately 0 to 20% by weight. In even another aspect, it is approximately 0.1 to 10% by weight, based on the total proportion of monomer. Care should be taken to ensure that the proportion of free carboxyl groups is not higher than approximately 10% by weight; in another aspect not higher than approximately 5% by weight; and in even another aspect not higher than approximately 3% by weight.

[0020] Choice of initiator system used for polymerisation is not restricted. Thus, all known initiator systems can be used.

[0021] In one embodiment the glass transition temperature ($T_g$) of the emulsion polymer is within approximately –60°C to 80°C. In another embodiment the temperature is approximately –30°C to 50°C. In even another embodiment the temperature is approximately –20°C to 40°C.

[0022] The glass transition temperature $T_g$ of the copolymers produced and consequently the emulsion polymers can be calculated empirically as well as determined by experiments from the monomers used. Using the Fox equation (T. G. Fox, Bull. Am. Phys. Soc. (seri1) 1, p. 123 (1956) and Ullmanns Enzyklopädie der technischen Chemie, Vol. 19, 4th Ed., Verlag Chemie, Weinheim, 1980, pp. 17-18), they can be calculated empirically: $1/T_g = \alpha\rho + \beta\rho + \gamma\rho^2 + \delta\rho^3 + \epsilon\rho^4\rho^5$, with $\alpha$, $\beta$, $\gamma$, $\delta$, $\epsilon$, the mass fractions of the monomers A, B, . . . used (in % by weight) and $T_g$, $T_{gA}$, $T_{gB}$ . . . the glass transition temperatures $T_g$ in Kelvin of the homopolymers of A, B, . . . . These are listed in, for example, Ullmanns Enzyklopädie der technischen Chemie, VCH, Weinheim, Vol. A21 (1992), p. 169. Another possibility for determining the glass transition temperature $T_g$ of the copolymers is experimental determination, for example, by DSC, the average temperature being used (midpoint temperature according to ASTM D3418-82).

[0023] Emulsion, suspension, microemulsion and/or inverse emulsion polymers produced can be stabilised with one or more higher molecular compounds, such as one or more protective colloids. The quantity of stabilising systems used is approximately 1 to 30% by weight. In another aspect the amount used is approximately 3 to 15% by weight, based on the proportion of monomer used.

[0024] Typical water-soluble organic polymeric protective colloids include higher molecular compounds. These include natural compounds such as polysaccharides, including chemically modified ones, synthetic higher molecular oligomers and polymers having no or only a slight ionic character, and/or polymers produced with monomers having an at least partially anionic character and, e.g., by radical polymerisation in situ in the aqueous medium. It is also possible for only one stabilising system to be used or for different stabilising systems to be combined.

[0025] Useful polysaccharides and their derivatives include polysaccharides and polysaccharide ethers soluble in cold water such as cellulose ether, starch ether (amylose and/or amylopectin and/or their derivatives), guar ether and/or dextrins. It is also possible to use synthetic polysaccharides such as anionic, non-ionic or cationic heteropolysaccharides such as xanthan gum or wellan gum. The polysaccharides can, but need not, be chemically modified, e.g., with carboxymethyl groups, carboxymethyl groups, hydroxyethyl groups, hydroxypropyl groups, methyl groups, ethyl groups, propyl groups and/or long-chain alkyl groups. Further natural stabilising systems consist of alginates, peptides and/or proteins such as gelatin, casein and/or soy protein. Examples include dextrins, starch, starch ether, casein, soy protein, hydroxy alkyl cellulose and/or hydroxyalkyl cellulose.

[0026] Synthetic stabilising systems include one or several polyelectrolytes and/or polyelectrolyte acids having molecular weights of approximately 2000 to 400000; fully or partially saponified and/or modified fully or partially saponified polyelectrolyte acids with a degree of hydrolysis of approximately 70 to 100 mole %, or in another aspect approximately 80 to 98 mole %, and a viscosity according to Héppler in a 4% aqueous solution of about 1 to 50 mPas, or in another aspect approximately 3 to 40 mPas (measured according to DIN 53015 at 20°C); as well as melamine formaldehyde sulfonates, naphthalene formaldehyde sulfonates, block copolymers of propylene oxide and ethylene oxide, styrene-maleic acid copolymers and/or vinyl ether-maleic acid copolymers. Higher molecular oligomers may include non-ionic, anionic, cationic and/or amphoteric emulsi-

[0027] According to a specific embodiment, an ionomer polymer obtained by radical polymerisation of olefinic monomers in water wherein at least part of the olefinic monomers containing an ionogenic group is used as the stabilising system. Such systems are typically obtained in situ, in being possible for (meth)acrylic acid, monomers with sulfonic acid groups and/or cationic monomers, for example, to be used as monomers with an ionogenic group, such as described in EP-A 1098916 and EP-A 1109838.

[0028] Moreover, polymers containing carboxyl group based on monocarboxylic and/or dicarboxylic acids or their
anhydrides, for example, polyacrylic acids, can be used as stabilising systems. However, care should be taken to ensure that the quantity of such a stabilising system and/or the quantity of polymer powder re-dispersible in water used is not chosen too large so as not to influence the hydration of the mineral binders and its processing in an excessively negative manner.

[0029] A film forming aid and/or a coalescing agent can also be added to the polymer powders re-dispersible in water. The amount can be approximately 0 to 5% by weight, or in another aspect, approximately 0 to 2% by weight, based on the copolymer content.

[0030] Polymer powders re-dispersible in water include those with a low proportion of organic volatile components (VOC), such as those possessing a boiling point of less than 250°C at normal pressure. These include, for example, non-reacted monomers and non-polymerisable contaminants contained in the monomers and by-products of the polymerisation. VOC content of the polymer powders re-dispersible in water amounts to less than approximately 5000 ppm, in another aspect less than 2000 ppm, in even another aspect less than 1000 ppm, and in another aspect less than approximately 500 ppm, based on polymer content.

[0031] Other components such as additives can be added to the polymer powders re-dispersible in water, with their addition occurring before, during and/or after drying. The types of these components used are numerous. Liquid components can be added before or during drying, but can also be sprayed onto the powder subsequently. Components in powder form can be added during or after spray drying, but can also be added during dispersion mixing before the drying step.

[0032] One embodiment includes the addition of at least one further organic component with functional groups. This can be part of the polymer powder re-dispersible in water and/or can be mixed with the paving joint dry mortar as a separate component. If this component is liquid, it can be added to the polymer powder re-dispersible in water during its production or transformed into powder form. When used in powder form, it can be mixed with the polymer powder re-dispersible in water and/or the paving joint dry mortar. Useful organic components with functional groups react in an alkyne medium either with itself and/or other compounds. Examples of such compounds include crosslinking agents such as epoxides, epoxy resins, oligoamines and/or polyamines, bifunctional masked aldehydes with at least 3 carbon atoms, silanes, siloxanes, isocyanates which can be used together with hydroxy compounds such as polyls, if necessary, boric acid and/or borax and/or compounds with carboxiimide groups, carboxyl groups and/or epichlorohydrin groups.

[0033] Functional groups of these organic components and of the (co-)polymerisable monomers with functional groups include silane groups such as alkoxysilane groups, glycidyl groups, epichlorohydrin groups, N-methacryloyl groups, carboxyl groups, amine groups, hydroxyl groups, ammonium groups, ketone groups, acid anhydride groups, acetoacetoxy groups, sulfonic acid groups, amide groups, amideine groups, imine groups, ester groups, carboxyl groups, carboxyl groups, aldehyde groups, sulfate groups, sulphonate groups and/or thiol groups. In one aspect the functional groups are silane groups, epoxy groups, epichlorohydrin groups and/or amine groups.

[0034] The paving joint mortar can also contain further components in typical quantities.

[0035] It is advantageous if they are present in powder form. If they are by nature liquid, they can be adsorbed onto a matrix or embedded in a matrix in order to be able to handle them in powder form. There are no essential limitations regarding the type of these further components. Non-limiting examples of such further components are colour pigments, cellulose fibers, water-soluble polymers, in particular fully or partially saponified and, if necessary, modified polyvinyl alcohols, polyvinyl pyrrolidones, polyalkylene oxides and polyalkylene glycols, the alkylene group typically being a C1- and/or C2-group, which includes also block copolymers, thickening agents, water retention agents, alkyl hydroxyalkyl ethers and/or alkyl hydroxyalkyl polysaccharide ethers such as cellulose ether, starch ether and/or guar ether, the alkyl group and hydroxyalkyl group typically being a C1- to C2-group, synthetic polysaccharides such as anionic, nonionic or cationic heteropolysaccharides, in particular xanthan gum or wellan gum, wetting agents, dispersing agents, cement liquefiers, polycarboxylates, polycarboxylate ethers, polycrystalline polymers, hydrophobing agents such as silanes, silane esters, siloxanes, silicates, fatty acids and/or fatty acid esters, air pocket formers, rubber powders, biocides, herbicides, fungicides, defoaming agents, fragrances for keeping animals away, additives for reducing sedimentation, segregation and/or efflorescence such as compounds based on natural resins, in particular resin and/or its derivatives, setting and solidification accelerators, setting retarders and/or powders which have an alkylene reaction with, water such as oxides and/or hydroxides of alkali salts and/or alkali earth salts such as calcium hydroxide, calcium oxide, sodium hydroxide and/or potassium hydroxide and/or aluminium hydroxide.

[0036] In principle, all organosilicone compounds can be used as silanes, silane esters, siloxanes and/or silanes. However, it is advantageous, though not compelling for the boiling point of the organosilicon compound used not to be too low at normal pressure, for example, approximately 100°C and more. The organosilicone compounds may be soluble, insoluble or only partially soluble in water. Useful compounds can have no or only limited solubility in water. These may consist of silicic acid esters with the formula $SiOR_4$, organosilanes with the formula $SiOR(OSiR)_{n-m}SiR$, where $n=1$ to 3, polysilanes with the formula $R_Si(SiR)n$, polysiloxanes with the formula $R_Si(O)SiR$, polysilanes with the formula $R_Si(O)SiR$, where $n=1$ to 3, and the sum of $c+n$ is a maximum of 3.5 per unit, $R$ representing identical or different alkyl radicals or alkyl alkyne radicals with 1 to 4 C-atoms (e.g., methyl or ethyl) and R being identical or different and representing branched or non-branched alkyl radicals with 1 to 2 C-atoms, cycloalkyl radicals with 3 to 10 C-atoms, alkyne radicals with 2 to 4 C-atoms, aryl radicals, alkylnyl radicals, alkyl aryl radicals with 6 to 18 C-atoms. The above mentioned radical R can be substituted with halogens such as F or Cl, with ether groups, thioether groups, ester groups, amide groups, nitrile groups, hydroxyl groups, amine groups, carboxyl groups, sulfonic acid groups, carboxylic anhydride groups and carboxyl groups. R can also have the meaning OR in the case of polysilanes.

[0037] Further components also include polysaccharide ethers such as cellulose ether and/or starch ethyl ether, hydrophobing agents such as silanes, silane esters, fatty acids and/or fatty acid esters, agents for reducing efflorescence, for example, those based on natural resins, cellulose fibres, defoaming agents and/or pigments.

[0038] The proportion of these additional components may be very small, for example, for surface-active substances, based on the paving joint dry mortar, and be within the region of approximately 0.01% by weight or more, in another aspect approximately 0.1% by weight or more, but should
not typically exceed approximately 2% by weight, in another aspect approximately 1% by weight. On the other hand, the proportion of mixed pigments can be higher, but should be not more than approximately 25% by weight, in another aspect not more than approximately 20% by weight, and in yet another aspect not more than approximately 15% by weight. The proportion of hydrophobing agents is approximately 0.5% to approximately 3% by weight, in another aspect approximately 0.1 to approximately 2% by weight and in yet another aspect approximately 0.2 to approximately 1% by weight. The content of the other components is between approximately 1% by weight and approximately 15% by weight, in another aspect between approximately 2 and approximately 10% by weight, based on the paving jointing dry mortar.

[0039] As a rule, it is beneficial for the user if the paving jointing mortar is scattered as paving jointing dry mortar into the empty joints or swept into them with a broom, and water then subsequently added, for example, over the surface. Such additional water over the surface subsequent mixing of the mortar is sufficient to both re-disperse the polymer powder re-dispersible in water in this compact environment and distribute it in the matrix. On setting and drying of the paving jointing mortar, a water-insoluble film is then formed. This thus increases the cohesion of the set paving jointing mortar.

[0040] When introducing water over the surface, suitable methods include those in which the paving jointing dry mortar scattered or swept in is not damaged. For example, this can be accomplished with a gentle introduction of water in the form of a spray or mist and/or surface watering. The method of water introduction is not restricted in any way as long as it does not damage the paving jointing mortar introduced. This can be achieved with a lawn sprinkler, a water sprinkler, a garden hose with or without distributor nozzle and/or a watering can. It is advantageous to set the duration of watering such that the water penetrates the entire paving jointing dry mortar, providing the mortar with sufficient water for hydration down to the subgrade. If too much water is added, the excess seeps into the subgrade, usually without negative consequences. If insufficient water is added, only the upper part of the paving jointing mortar is hydrated. During later watering, either artificially or by rain or dew, further water can then diffuse through the mortar set at the surface and penetrate into deeper layers. However, it is also possible for the water to pass into the paving jointing dry mortar through the subgrade, thus causing hydration.

[0041] According to a further embodiment, the paving jointing dry mortar is first stirred with water and introduced into the joints as stirred mortar. In the case of this variation, however, it is helpful to adjust the quantity of water in such a way that the stirred mortar receives an easily processable consistency in order to be introduced into the joints without running off.

[0042] Paving jointing mortar containing the polymer powder re-dispersible in water that can be used according to the invention typically exhibits a high level of wettability. The polymer powder re-dispersible in water re-disperses without additional shearing forces and mixing processes and subsequently forms a water-insoluble film. Thus, polymer powders re-dispersible in water results in none or only minor disadvantages vis-à-vis emulsifier-stabilised dispersions with the physical values of the set paving jointing mortar, even though these systems have previously been thoroughly mixed in order to guarantee a corresponding homogeneity of the mortar. Nevertheless, the end properties of the paving jointing mortar are entirely comparable in spite of a much simpler introduction and processing.

[0043] The invention will be explained in further detail by way of the following examples.

**EXAMPLE 1**

Production and Watering by Spray Mist of Paving Joint Dry Mortar Introduced by Scattering

[0044] Mortar prisms were produced in order to investigate the introduction by scattering and watering of joints under conditions which are as clearly defined as possible. From this it was possible to subsequently determine physical values such as the tensile strength in bending and the compressive strength.

[0045] A paving joint dry mortar was prepared by mixing homogenously in an agitator 5% by weight of Portland cement CEM I 42.5 N, 87% by weight of quartz sand with a sieve line of 0.063 to 1.5 mm, 3% by weight of a calcium carbonate (Duralco 10) and 5% by weight of a polymer powder re-dispersible in water. A comparative example was carried out using in place of the polymer powder a partially saponified polyvinyl alcohol with a degree of hydrolysis of 88 mole % and a viscosity of 4 mPas (according to Höppler as 4% aqueous solution, measured according to DIN 53015 at 20° C.) (in the following tables referred to as “PVOH”). Another comparative example was carried out entirely without polymer powder, the omitted polymer quantity being replaced by quartz sand.

[0046] 500g of the dry mortar produced were then scattered into a 4 cm x 4 cm x 16 cm metal prism mould, the inside wall of the prism mould having been painted with mould oil as release agent using a painter’s brush. The dry formulation was compacted by manually shaking and tapping for 10 seconds. The surface of the dry mortar scattered in was smoothed off with a trowel.

[0047] A spray bottle typically used for spraying plants was used for watering. The water cone formed during spraying was adjusted so that the water was sprayed selectively onto the mortar surface from a distance of 10 cm. The spray duration was 5 to 10 minutes, depending on how well the surface was wetted and the water was able to penetrate inside. The necessary quantity of water was determined by way of a separate test wherein the surface was damaged periodically using a fine spatula and the depth of water penetration assessed optically until the water had reached the lowermost layer of the paving jointing mortar.

[0048] During watering the following assessments were carried out: (a) wetting of the surface (i.e., how well the water is absorbed by the joint during the entire watering process), (b) water saturation (i.e., how much water can be sprayed continuously onto the prism until water floats on the surface), (c) bubble formation (i.e., whether bubbles rise to the surface during or immediately after spraying of the water, which may have a negative influence of the surface properties), and (d) cleaning after contamination (i.e., how simply the prism mould could be cleaned after releasing the prisms). These assessments provide a good indication regarding the behavior of the wetted paving joint mortar on the surface of the paving stones.

[0049] 18 hours after completion of the introduction of water, the prisms were released and stored at 23° C. and a relative atmospheric humidity of 50% (standard climate).
TABLE 1

<table>
<thead>
<tr>
<th></th>
<th>EVA-1</th>
<th>EVA-2</th>
<th>Si/Al</th>
<th>PVOH</th>
<th>Without p.p.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of water (% by weight)</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Water saturation (% by weight)</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>None</td>
</tr>
<tr>
<td>Wetting of surface</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Average</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Spray duration (min)</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Bubble formation</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Strong</td>
<td>None</td>
</tr>
<tr>
<td>Cleaning after contamination</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Smeared</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

The polymer powders re-dispersible in water EVA-1, EVA-2 and Si/Al consist of different spray-dried dispersions stabilised with polyvinyl alcohol and ethylene-vinyl acetate (EVA-1 and EVA-2) copolymers, and styrene-acrylate copolymers (Si/Al).

"Excellent" means that cleaning caused no problems whatsoever and the residues were easily removed by washing. "Smeared" means that the residual layer could be removed only after intensive cleaning.

PVOH represents partially hydrolysed polyvinyl alcohol.

The polymer powder represents “polymer powder”.

TABLE 2

Table 2 illustrates the results of repeated watering of the paving joint mortar in the prism mould at intervals of one hour. Four prisms were produced per composition, one being put aside after each watering cycle for removal from the mould after 18 hours and assessed. The percentage indicated below provides details of the proportion of prisms which formed a compact unit and did not disintegrate. Moreover, the surface of the last prism was assessed after a storage period of 4 days for its surface hardness and surface hydrophobicity.

<table>
<thead>
<tr>
<th></th>
<th>Quantity of water</th>
<th>EVA-1</th>
<th>St/Al</th>
<th>PVOH</th>
<th>Without p.p.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Watering</td>
<td>3</td>
<td>60%</td>
<td>60%</td>
<td>20%</td>
<td>95%</td>
</tr>
<tr>
<td>2 Watering</td>
<td>6</td>
<td>95%</td>
<td>70%</td>
<td>70%</td>
<td>100%</td>
</tr>
<tr>
<td>3 Watering</td>
<td>9</td>
<td>100%</td>
<td>100%</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>4 Watering</td>
<td>12</td>
<td>100%</td>
<td>100%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>Surface hardness</td>
<td>Hard</td>
<td>Hard</td>
<td>Average</td>
<td>Hard</td>
<td>Soft</td>
</tr>
<tr>
<td>Surface hydrophobicity</td>
<td>5 min 30 sec 30 sec 9 sec</td>
<td>5 min 30 sec 30 sec 9 sec</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The surface hardness was assessed by scratching with a pointed metal rod.

To assess the surface hydrophobicity, 1 ml of water was placed drop-wise onto the surface using a pipette and the time was measured by which all the water had been absorbed by the subgrade.

TABLE 3

Tensile strengths in N/mm² determined at different storage periods by bending of the mortar prisms obtained, in line with EN13892-2.

<table>
<thead>
<tr>
<th>Storage time in a standard climate</th>
<th>EVA-1</th>
<th>EVA-2</th>
<th>St/Al</th>
<th>PVOH</th>
<th>Without p.p.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>0.07</td>
<td>0.06</td>
<td>0.04</td>
<td>0.22</td>
<td>0.18</td>
</tr>
<tr>
<td>3 days</td>
<td>0.56</td>
<td>0.43</td>
<td>0.51</td>
<td>0.97</td>
<td>0.35</td>
</tr>
<tr>
<td>7 days</td>
<td>1.67</td>
<td>0.99</td>
<td>1.50</td>
<td>1.80</td>
<td>0.50</td>
</tr>
<tr>
<td>14 days</td>
<td>2.07</td>
<td>1.05</td>
<td>1.69</td>
<td>3.69</td>
<td>0.45</td>
</tr>
<tr>
<td>28 days</td>
<td>2.19</td>
<td>0.99</td>
<td>1.57</td>
<td>2.98</td>
<td>0.40</td>
</tr>
</tbody>
</table>

TABLE 4

Compressive strength in N/mm² determined after different storage periods by bending of the mortar prisms obtained, in line with EN13892-2.

<table>
<thead>
<tr>
<th>Storage time in a standard climate</th>
<th>EVA-1</th>
<th>EVA-2</th>
<th>St/Al</th>
<th>PVOH</th>
<th>Without p.p.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 day</td>
<td>0.20</td>
<td>0.16</td>
<td>0.17</td>
<td>0.16</td>
<td>0.26</td>
</tr>
<tr>
<td>3 days</td>
<td>1.24</td>
<td>0.94</td>
<td>1.00</td>
<td>1.28</td>
<td>0.75</td>
</tr>
<tr>
<td>7 days</td>
<td>5.52</td>
<td>2.37</td>
<td>3.18</td>
<td>2.99</td>
<td>1.02</td>
</tr>
<tr>
<td>14 days</td>
<td>6.15</td>
<td>2.63</td>
<td>3.21</td>
<td>4.89</td>
<td>0.93</td>
</tr>
<tr>
<td>28 days</td>
<td>5.41</td>
<td>2.44</td>
<td>2.98</td>
<td>–</td>
<td>0.77</td>
</tr>
</tbody>
</table>

No values available.

[0050] Tables 1 and 2 show, among other things, that paving joint mortar with partially hydrolysed polyvinyl alcohol exhibits the greatest water requirement. In contrast to paving jointing mortars prepared without polymer powder or with polymer powders dispersible in water (EVA-1, EVA-2 and Si/Al), the paving joint mortar with PVOH absorbs a relatively large amount of water at its surface, preventing the water from reaching the underlying layers. Thus, the mineral binder does not set and the organic binder does not form a film, resulting in a lack of strength of these layers.

[0051] Even if wetting of the dry mortar is excellent, the unset paving jointing mortar may exhibit a moderate hydrophobicity as shown by the example of EVA-1. This contributes to less dirt penetrating into the joints and being washed away, particularly in the case of an inclination and/or fairly strong rain.

[0052] Tensile strength and compressive strength are excellent measures for assessing cohesion of the watered paving jointing mortar. The values given in Tables 3 and 4 clearly show the additional cohesion achieved by adding polymer powder dispersible in water versus those containing only mineral binder (indicated by “without polymer powder”). These high values are highly surprising since the dry mortar was merely watered without mixing the mortar. Mixing enhances the redispergation of the polymer powder dispersible in water, guaranteeing good distribution of the redispergion achieved. The cohesion achieved is sufficient to prevent damage, for example, in the case of impact or expert cleaning.
with sweeping machines or high pressure cleaners. The corresponding early strength values additionally provide the paving jointing mortar applied with sufficient protection against driving rain and hail. The polymer powder redispersible in water used provides the paving joint mortar also with a good flanks adhesion such that the joint does not detach itself from the paving stone. The low proportion of mineral binder guarantees the required flexibility needed to survive deformations of the subgrade without cracking. As a result of the controlled optimisation of the types and quantities of hydraulically binding binder used and of the polymer powder redispersible in water, it is, moreover, possible to correspondence flexibly, tensile strength and compressive strength, as well as tensile bond strength in line with users' requirements without having to change processing.

EXAMPLE 2

Stirring of Paving Stone Joint Mortar with Water Before Application

[0053] The paving joint dry mortar produced according to Example 1 is stirred with water for one minute using a propeller stirrer at 900 rpm, the amount of water adjusted for consistency. During this process, care was taken in mixing that the resulting mortar was not too thin but also not too highly viscous, and could be introduced into a prism box as described in Example 1 by simply using a trowel. Prior to addition to the box, the mixed paving joint mortar was allowed to mature for 3 minutes and was then stirred once more for 15 seconds. Following the introduction of the mortar, the surface of the mortar was smoothed off with a trowel. The storage conditions were handled in a manner analogous to Example 1.

[0054] Quantities of water used for adjusting the consistency of the different samples of EVA-1, St/Ac and the comparative sample without polymer powder and tensile strength in bending and compressive strengths after different storage periods, in N/mm², in line with EN13892-2 are illustrated in Table 5 below.

<table>
<thead>
<tr>
<th>Storage time in a standard climate</th>
<th>Tensile strength in bending (N/mm²)</th>
<th>Compressive strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EVA-1</td>
<td>St/Ac</td>
</tr>
<tr>
<td>Quantity of water (% by weight)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 day</td>
<td>0.26</td>
<td>0.30</td>
</tr>
<tr>
<td>3 days</td>
<td>2.13</td>
<td>2.39</td>
</tr>
<tr>
<td>7 days</td>
<td>3.77</td>
<td>3.58</td>
</tr>
</tbody>
</table>

[0055] Table 5 illustrates that by mixing the paving joint dry mortar with water prior to introduction into the joints, the physical values obtained are slightly higher than by introduction of water over the surface according to Example 1. Consequently, by using paving joint dry mortar according to the present invention, the user has the choice of choosing either an extremely simple and convenient type of application involving dry introduction with subsequent surface watering, or by externally mixing the paving joint dry mortar with water and subsequent introduction to obtain even higher physical strength values.

[0056] Although the present invention has been described and illustrated in detail, it is to be understood that the same is by way of illustration and example only, and is not to be taken as a limitation. The spirit and scope of the present invention are to be limited only by the terms of any claims presented hereafter.

1-14. (canceled)
15. A method of making a paving joint mortar wherein a paving joint dry mortar is added into a joint in powder form and subsequently watered to form a paving joint mortar, wherein the paving joint mortar comprises:
one or more mineral binders in an amount of about 0.5% by weight or more, based on total dry weight of the paving joint mortar,
one or more additives, and
one or more polymer powders redispersible in water.
16. The method according to claim 15 wherein the one or more mineral binders are present in an amount of approximately 0.5 to 30% by weight, the one or more additives are present in an amount of approximately 30 to 99% by weight, and the one or more polymer powders redispersible in water are present in an amount of approximately 0.5 to 20% by weight, all based on total dry weight of the paving joint mortar.
17. The method according to claim 16 wherein the one or more mineral binders are present in an amount of approximately 1.0 to 20% by weight, the one or more additives are present in an amount of approximately 50 to 98% by weight, the one or more polymer powders redispersible in water are present in an amount of approximately 1.0 to 15% by weight, all based on total dry weight of the paving joint mortar.
18. The method according to claim 15 wherein the one or more polymer powders redispersible in water comprises one or more emulsion polymers, suspension polymers, micro-emulsion polymers and/or inverse emulsion polymers, each of which have been obtained by drying.
19. The method according to claim 18 wherein the emulsion polymer, suspension polymer, micro-emulsion polymer and/or inverse emulsion polymer is stabilized with one or more high molecular compounds.
20. The method according to claim 19 wherein the emulsion polymer, suspension polymer, micro-emulsion polymer and/or inverse emulsion polymer is stabilized with one or more protective colloids and/or with anionic polymer obtained via radical (co)polymerisation of olefinic monomers in water wherein at least part of the olefinic monomers contains an ionic group.
21. The method according to claim 15 wherein the one or more polymer powders redispersible in water comprises at least one polymer based on vinyl acetate, ethylene-vinyl acetate, ethylene-vinyl acetate-vinyl versatate, ethylene-vinyl acetate-vinyl chloride, ethylene-vinyl chloride, vinyl acetate-vinyl versatate, ethylene-vinyl acetate(meth)acrylate, vinyl acetate-vinyl versatate(meth)acrylate, (meth)acrylate, styrene-acrylate, and/or styrene butadiene, wherein vinyl versatate is a C₈- to C₁₃-vinyl ester, and wherein the at least one polymer further comprises 0 to 50% by weight of further monomers, based on total weight of the one or more polymer powders redispersible in water.
22. The method according to claim 15 wherein the paving joint mortar further comprises at least one organic component having functional groups,
wherein the organic component is in the polymer powder redispersible in water or in the paving jointing dry mortar.
23. The method according to claim 22 wherein the functional groups of the at least one organic component further comprise alkoxysilane groups, glycidyl groups, epihalohydridin groups, carboxyl groups, amine groups, hydroxyl groups, ammonium groups, ketone groups, acid anhydride groups, acetacetone groups and/or sulfonic acid groups.

24. The method according to claim 15 wherein the water is added in the form of a spray mist and/or surface watering.

25. The method according to claim 24 wherein the water is added by a lawn sprinkler, water sprinkler, a garden hose with or without distributor nozzle, and/or a watering can.

26. The method according to claim 15 wherein the one or more mineral binders are chosen from a hydraulically binding binder, a latent hydraulic binder, and/or a non-hydraulic binder which reacts under the influence of air and water.

27. The method according to claim 26 wherein the hydraulically binding binder is at least cement; the latent hydraulic binder is chosen from acidic blast furnace slag, pozzolans and/or metakaolin, and/or a non-hydraulic binder which reacts under the influence of air and water; and the non-hydraulic binder is chosen from calcium hydroxide and/or calcium oxide.

28. The method according to claim 15 wherein the paving joint mortar further comprises components chosen from colour pigments, cellulose ethers, cellulose fibres, watersoluble polymers, in particular polyvinyl alcohol, thickening agents, water retention agents, starch ethers, mar ethers, wetting agents, polycarboxylates, polycrylamides, hydrophobing agents, air pocket formers, biocides, herbicides, fungicides, defoaming agents, fragrances for keeping away animals, additives for reducing efflorescence, sedimentation and/or separation, setting and solidification accelerators, setting retarders and/or powders which have an alkaline reaction with water.

* * * * *