FABRICATION OF COMPOSITE SURFACES AND STRUCTURES

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Our present invention relates, in general, to the fabrication of composite traffic bearing surfaces and other structures employed for a variety of utilitarian purposes. More particularly, our invention relates to the fabrication of such structures from particular varieties of volcanic aggregate.

The use of aggregates prepared from certain naturally-occurring volcanic materials in the fabrication of a variety of structural surfaces is disclosed in our copending application, Serial No. 431,616, filed May 21, 1954. Generally speaking, the compositions disclosed therein are employed in the fabrication of surfaces employed in domicile and commercial buildings.

The source materials employed in producing the aggregate are of volcanic origin and are of a generally cinder-like character. Such materials may occur in the form of vesicular lapilli, porous volcanic bombs, scoria or as massive effusive formations of volcanic origin. Usually the material has a red or black color and a cellular structure in which there are multitudinous elongated or spheroidal cavities arranged in contiguity. A large proportion of the cavities are closed, i.e., the structure is largely uncellular, in the natural state.

Subsequent to mining the material is preferably reduced to the appropriate size for use by processes which may be characterized as fracturing, fragmentation or crushing operations as contrasted with grinding methods. In this manner the aggregate particles will have a highly irregular form with a large exposed surface area presenting myriad outwardly projecting spicules as well as multitudinous depressions and cavities with the openings thereto exposed but frequently having less area than the area within the cavities.

Spectrographic analyses of typical black and red forms of the aggregate are as follows:

**ANALYSES**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Black</th>
<th>Red</th>
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<tbody>
<tr>
<td>Si</td>
<td>40-60</td>
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<td>Al</td>
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<tr>
<td>Ni</td>
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<tr>
<td>V</td>
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<tr>
<td>Hardness (Moh Scale)</td>
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<tr>
<td>Density (lb./cu.ft.)</td>
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<tr>
<td>Cellulur Pore Diameter</td>
<td>18-30 Microns</td>
<td>15-60 Microns</td>
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1 Principal ingredient.
2 Average. (The pore size may vary considerably from these values without materially affecting the desired results.)

It will be appreciated that the indicated materials will be combined with oxygen and other components to form the various chemical compounds of the minerals.

It is considered that the physical form rather than the specific compositions indicated are the prime determining factors in the use of the aggregate. The material may vary widely in composition and somewhat in density without materially affecting the results as long as the physical form is substantially of the character described.

We have now discovered that such aggregate may be employed very advantageously in the fabrication of heavy duty traffic bearing surfaces. In such fabrication the aggregate is employed in conjunction with certain adhesive bonding agents to promote the bonding of a substrate surface to a variety of coating layers, the aggregate particles due to their peculiar form, serving to provide a mechanical interlock between the substrate, the bonding material and the coatings, while the bonding agent is of a nature which reacts with the coating material to practically fuse therewith. The concept is applicable not only in the provision of traffic surfaces but for the application of successive constituent layers over surfaces of a cylindrical, tubular, or similar nature so as to provide a variety of other composite mechanical structures.

Moreover, the aggregate may be provided with light reflective or colored coatings and employed for lane marking, divider strips and other traffic control indicators in road structures. In addition to providing a remarkable degree of bonding, the composite or lamellar structure produced as described hereinafter, possesses other highly advantageous characteristics such as toughness, non skid properties, light weight, shock resistance, high stiffness to weight ratio, and others.

Accordingly, it is an object of our invention to employ a cinder-like aggregate to promote the bonding of various substrate surfaces to covering layers in the fabrication of composite and lamellar structures.

Another object is the provision of resinous bonding means to effect the successful bonding of a layer of material such as an asphaltic composition to a substrate of concrete or the like.

Another object of our invention is to employ a cinder-like aggregate in conjunction with resinous bonding agents to promote the bonding of an asphaltic road surface covering to a substrate surface.

Still another object of our invention is to employ a cinder-like aggregate as a bonding or component layer over plane and curved surfaces in the fabrication of traffic bearing surfaces or mechanical structures.

A further object of the invention is to employ a cinder-like aggregate in the fabrication of non skid traffic bearing surfaces.

A still further object of our invention is to employ a form of a cinder-like aggregate in the fabrication of traffic bearing surfaces particularly of a non-skid nature, traffic control indicators, lane markers and the like, and also in the coating or fabrication of tubular structures.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description and the accompanying drawings of the preferred form of the invention. It is to be understood, however, that variations in the form of the disclosed description and drawing may be adopted within the scope of the invention as set forth in the claims.

Referring to said drawing:

Figure 1 is a cross sectional view of a composite surface structure as applied to a hard substrate surface in accordance with the invention.

Figure 2 is a cross sectional view of a composite surface structure as applied to a soft unset substrate surface.

Figure 3 is an enlarged view of a portion of the structure which demonstrates the manner in which the aggregate fragments promote the bonding of substrate and applied filler or covering layers.

Figure 4 is a cross sectional view of portions of a tubu-
lar composite structure constructed in the process of the invention. In brief, the fabrication processes of the invention generally involve an initial operation wherein a layer of the cinder-like aggregate particles or fragments is bonded to a relatively smooth substrate surface by means of certain adhesive agents. In this manner the substrate surface is covered by a large number of relatively closely-spaced outwards-projecting aggregate fragments or particles tightly bonded thereto. Under certain conditions, noted hereinafter, application of a separate bonding agent may be dispensed with, since certain substrates may be made to serve a similar purpose in early stages of manufacture. The substrate surface prepared in this manner is now in an ideal condition for the application of additional layers such as of various paving or structural materials to complete the composite surfaces and structures of the invention. Such additional layers may be of an adhesive character, however, it is not necessary that such be the case since a firm mechanical bond will result between the aggregate and various dough-like materials which do not otherwise yield a sufficiently strong bond.

In the fabrication of traffic bearing surfaces in accordance with the invention, the substrate on which the superimposed layers are applied, will ordinarily be relatively rigid and impervious such as set or hardened concrete. As shown in Figure 1, the construction is illustrated as applied to such a substrate. Old or new concrete, asphaltic paving, wood, rock, brick, metal and other similar substrates are adaptable for the application of a composite surfacing in accordance with the invention. A clean and roughened surface is inevitably necessary to ensure the best results and, accordingly, loose material, oil and the like are removed by wire brushing, sweeping, sandblasting and other appropriate operations.

A layer 4 of fluid adhesive bonding agent is then applied as by spraying on the surface. The selection of an appropriate bonding agent will depend on the nature of the substrate surface and the ambient conditions under which the surface is to be employed. In some instances a solution of adhesive material which solidifies by evaporation of the solvent, may be employed. Likewise, it is possible to employ bonding agents which can be applied in a molten condition and which solidify on cooling; however, it is generally preferred to employ a resinous bonding agent of the catalyzed setting type. Solvent solutions of asphaltic, coal tar or other resinous materials exemplify the first mentioned type of adhesive bonding agents. Aqueous emulsions and dispersions of adhesive bonding agents of the simple dispersion type may be employed likewise. Molten asphalts, coal tar, resins and synthetic resins exemplify the second type of bonding adhesive.

The preferred setting type of resin or chemically reactive class of adhesive with which the maximum advantages of the aggregate are obtained constitute the cinder-epoxy, phenolic, polystyrene, acrylic esters, resorcinol-formaldehyde, polyurethanes, polyester and silicone resins which set at ordinary room temperatures and at accelerated rates with increased temperatures. Epon resins (928 etc.) supplied by Shell Chemical Company, Araldite resins (502, 6010, 6020, etc.) supplied by Ciba-Geigy, Plastics Division, C-8, Devron and other epoxy resins are generally prepared by the condensation of epichlorohydrin and bisphenol A (4, 4'-isopropylidenediphenol) to various molecular weight polymers yielding viscosities of fluid, to molasses-like, to thermoplastic solids. Catalysts such as thiolate salts and mixtures thereof including other bases, acid anhydrides, compounds containing active hydrogens, certain resins, and the like, is employed in the multitudinous commercially-available formulations. Plasticizers such as Thiolol fluid and others can be employed therein. Phenol-formaldehyde liquids can be cured with organic resins, resorcinol-formaldehyde cures at room temperature with formaldehyde and urea-melamine-formaldehyde cures at room temperature or copolymerize with others of the phenolic and epoxies. True polymerizing adhesive bonding agents derived of styrene, allyl, acrylic and methacrylate esters are cured with benzoyl peroxide or other organic peroxides in the presence of a redox catalyst system. Polyurethanes and hybrids with poly-urea cure in the presence of water and acid.

When the phenolic and especially, the epoxy type of adhesive bonding agents are contacted with bituminous or asphaltic surfaces or compositions in the course of constructing the composite structures of the invention, a chemical reaction has been observed to occur which markedly modifies the appearance of the asphalt or bitumen in the contact region. Microscopic examination reveals that there is no sharply defined interface between the resin and asphalt or bituminous phases of the bond region but that a coalescence occurs therebetween so that the intermediate region is a highly modified resin-asphalt or bitumen composition which varies to either side of the intermediate region so as to attain the composition of the adjacent phases. Although the nature of the reaction is not fully understood, it is believed that a not previously known type of "cross-linking" reaction occurs between the indicated types of resins and reactive sites of the compounds in the asphaltic or bituminous materials. Active oxygen, hydroxy, amine and other nitrogen substituents, and unsaturated side-chain substances of materials would be susceptible of such reaction. As a result the physical properties of the asphalt are modified, e.g., the bond region is less thermoplastic than the adjacent asphalt, it is harder and more resistant to shock, tensile properties are improved, etc. It will therefore be apparent that the bond obtained with these materials is not merely the adhesion usually obtained by surface effects but is literally a fusion to provide a far superior intermingled bonding region.

While the bonding agent layer 4 is still in a fluid state a layer of the cinder-like aggregate particles 5, free of fines and uniform in size, is applied with rolling if necessary to assure that the lower surfaces thereof are thoroughly wet by the agent or are embedded partially therein. With surfaces such as walks, floors, decks, etc. to which only a relatively thin covering is to be applied, mesh sizes of 1, 3, 1/2 inch or larger may be employed. In the event that the surface is to be used by heavy vehicular traffic, materials of 3/4, 3/4, 1/2 inch or larger mesh sizes are employed. Ordinarily, the bonding agent is then allowed to set, heat being applied if necessary thereby conditioning the substrate surface for the bonding of additional layers of material thereon. In this sense the bonding agent-aggregate layer will be understood to constitute the bonding layer of the completed composite structure.

The covering or surfacing layer 6 which may under certain conditions be considered a filler layer is applied over the layer 4, either in a dough-like plastic or semiplastic state and rolled into the interstices between the bonded aggregate fragments and into firm contact with resin covered substrate and aggregate surfaces or the additional layers may be built by applying dressings of the cinder-like aggregate and then spraying a binder constituent thereafter. Finally, a dusting layer 7 of aggregate particles of appropriate size may be applied or rolled into the surface, particularly, where the maximum in non-slip properties is desired. For maximum adhesion of the dough-like layer 6, an adhesive bonding layer 8 is sprayed over the projecting fragments 5 before layer 6 is applied.

For street and roadway surfacing or paving, e.g., reconditioning of highway surface, cold mix, hot plant mix and other types of asphaltic or coal tar binding paving materials, resorcinol-formaldehyde cures are employed as the layer 6. Alternatively, a aggregate of a range of mesh sizes (dust to ca. 1/2 inch) is applied and an asphaltic emulsion or solution
sprayed thereover, as a binder, similar to seal coat paving methods to provide layer 6.

With new concrete base roadways, the aggregate may be partially imbedded in the soft concrete surface to provide the bonding layer as illustrated in Figure 2, omitting adhesive bonding layer 4. In this case the completed surface structure will include a concrete sub-base 9, aggregate fragments 10 imbedded therein and a covering layer 11 of dough-like filler composition bonded with adhesive layer 12 applied as by spraying on the surface 13 and exposed faces of the aggregate fragments 10. In the event that filler 11 is sufficiently adhesive, bonding layer 12 may be omitted.

An enlarged view of the region of a single aggregate fragment 10 is shown in Figure 3 of the drawing to illustrate the manner in which the remarkable bonding characteristics of the aggregate are utilized and developed. As will be seen, the exposed surface of the fragment is made up of a series of cavities 14 and spicules 16, all of more or less irregular pattern. It is important to note that in many instances the spicules will be thicker at their free ends than at the base, and correspondingly the aggregate openings of many of the cavities will be restricted to the interior of the cavities.

In this manner the bonding and layer material inserted into the cavities in the course of the fabrication of the road, etc., structure, will be effectively keyed with the aggregate fragments so that when the bonding and layer material has permanently set all will be permanently interlocked to form a functionally integral mass.

In the event that a higher grade or structurally strong surface layer 6 is required, e.g., in interiors, on deckings, walkways, rigid panels and the like, it is preferred to employ a binder of the resinous adhesive agent types described above. The amount of binder may be varied from the minimum required for cohesion and adhesion of the aggregate dressing to the bonding layer to the amount necessary to provide an essentially non porous surface. All or portions of the surface layers can be provided also utilizing specially pigmented or light-reflective aggregate particles as described hereinbefore. Utilizing these pigmented or light-reflective aggregates more efficient and durable traffic control and warning surfaces may be provided.

Surfacings and coverings applied in the manner described are remarkably adherent to the substrate surface. The bond is resistant to thermal shock and load bearing stresses as well as to weathering. With the amount of binder limited to increase the porosity, surface drainage is excellent while, with increased amounts of binder the layer as a whole is water tight and therefore the substrate is protected to the maximum extent.

The principles described above are also employed in the fabrication of structural forms such as tubing, panels or for the application of insulation and corrosion resistant coverings for pipelines. A bonding layer of aggregate applied to the substrate pipeline surface as described above facilitates the application of the conventional asphaltic and coal tar protective coverings. The bonding layer is particularly efficacious when a heat plasticized covering layer is extruded to cover pipeline sections prepared with a bonding layer as described above. Tubing and panel sections as illustrated in Figure 4, are constructed by providing a base 17 from metal, fiber, sheet material, etc., fiber glass matting or fiberglass impregnated with a fluid resin of the epoxy, phenol formaldehyde, polyester and similar types or with a thermoplastic binder as employed in conventional practice. While the binder or laminating resin is in a fluid state, the aggregate fragments 18 are applied as described above. Ordinarily, the binder is then allowed to cool set or the laminating resin is at least partially cured with the application of heat if necessary to provide a stable layer of bonded aggregate fragments.

Subsequently, a plastic composition 16 of the aggregate in admixture with an adhesive binder is applied smoothly over the bonding layer. In some instances curing at this stage will produce a satisfactory structure, however, for maximum strength an outer laminated covering layer 19, similar to the substrate base is applied. Tubing or panel sections made in this manner are rigid, weather resistant, durable, light weight, economical and possess many other desirable properties.

The pigmented aggregate referred to above is prepared by dipping the cinder-like aggregate particles in light-reflective, luminous, traffic marker paint followed by tumble drying in a rotary drum. Alternatively a pigmented paste or an aqueous dispersion of the powdered pigment is similarly applied and effective bonding obtained by spray coating with a transparent adhesive agent selected from those described above. The micro, glass bead pigment known in the trade as "painter's smalts" is ideal for this purpose particularly when used with an excellent pigment such as titanium dioxide. The pigmented aggregate prepared in this manner is applied by the methods employed with the natural aggregate.

The pigmented aggregate is relatively impervious to the elements and is very durable when subjected to traffic wear. The side surfaces do not contact tire surfaces and the untouched side surfaces retain maximum reflectivity over a long period of time. Likewise, the direct reflection obtained from the sides yields better visibility in rainy weather or at night.

Further details of the invention will be apparent in the following examples:

**Example 1**

A substrate surface of hot asphalt "plant mix" applied over a standard crushed rock road base is covered with ¾" screened cinder-like aggregate of the character described above. While the substrate is still in a heated condition the aggregate layer is rolled with sufficient pressure to imbed the aggregate particles about halfway into the soft asphalt layer. The upward projecting portions of the particles now present a large surface area including numerous spicules and concavities while the lower portions are tightly imbedded in and bonded to the asphalt substrate. A fluid setting adhesive agent is then applied as by spraying over the aggregate studded substrate surface. A suitable adhesive bonding agent (A) is compounded, illustratively, as follows: (Various of the other adhesives indicated may be used equivalently).

1. Fluid resin (Applied Plastics Co., #210) 4-6 parts.
3. Plasticizer (General Mills Corp., #125) 3-10% vol.

A representative fluid epoxy resin type bonding agent (B) is prepared as follows:

1. Epox 828 (Shell Chemical Co.) 100 parts.
2. Triethylenediamine or equivalent base 8 parts.
3. Phenyl glycidyl ether (optional) 10 parts.
4. Fluid Thiolol (plasticizer) 10 parts.

Application of the adhesive agent yields a prepared bonding surface on the aggregate studded substrate.

A dough-like aggregate preparation is applied over the prepared surface as by trolling or with mechanical spreading equipment. The aggregate dough usually prepared from cinder-like aggregate of smaller screen sizes than those comprising the bonding layer. An aggregate mixture (C) may comprise, e.g., 1 part of ¾" mix screened cinder-like aggregate particles and 2 to 6 parts of ½" screened particle sizes. The aggregate mixture (C) is admixed with 5 to 20% by volume of either mixture (A) or (B) determined by the amount of inter-
stitial porosity which is desired in the finished surface. The larger proportion of resin is sufficient to provide an essentially smooth surface. The aggregate dough is applied in a thickness which is at least sufficient to cover the bonding aggregate particles (about 1/4") and generally in depths to at most of about half an inch. A maximum initial frictional surfacing is obtained by dusting the surface with aggregate fines. Depend on the temperature the surfacing hardens in times ranging from less than an hour at elevated temperatures to several hours at usual ambient temperatures.

The surfacing obtained in this manner is harder, more wear resistant and skid resistant than ordinary asphalt surfacings. The asphalt is protected by the insulating qualities of the aggregate from buckling, rolling and cracking under variant temperatures and repairs may be quickly made by replacing damaged surface in the same manner as the surfacing is usually applied to the aggregate bonding layer. The surface may be the naturally-attractive color of the aggregate or the pigmented aggregate may be employed in providing the final surfacing. Moreover, the surfacing is inseparable from the substrate surface and is very resistant to damage from thermal shock.

Old porous or bituminous surfaces are treated in a similar fashion; however, the old surface is cleaned and depressed or abraded and a coating of mixture A or B is sprayed thereon prior to application of the bonding aggregate particles. A very firm bond is thereby obtained to the old surface.

Example II

A substrate of freshly poured and rough finished concrete is an ideal base for applying a surfacing in accordance with the invention. Before the concrete has set, a layer of the cinder-like aggregate of 1/4 to 1" screen size is spread evenly over the surface and rolled to imbed the particles about halfway into the concrete. After the concrete has set a light coating of mixture A or B of Example I is sprayed over the aggregate bonding layer and dough-like mixture C of Example I is spread or troweled smoothly into place. Curing takes place as in Example I.

The surfacing applied over concrete as described herein has essentially the same advantageous properties as those described in Example I. However, certain additional advantages are also obtained, viz, the surfacing eliminates the dusting of the concrete substrate and if applied within a few days after the concrete is poured, curing of the concrete is promoted through moisture retention. Old concrete traffic bearing or wall surfaces are resurfaced in the same manner; however, in this case the surface is sandblasted or abraded mechanically to remove dirt and oxidized materials whereby an adequate aggregate bond is obtained.

Example III

Rigid or semi-rigid plastic materials such as panels or other forms of foamed polyethylene, isocyanate, polystyrene or phenolic resins are also suitable substrates. Very often such foamed materials are employed in walls, roofing and floors of refrigeration, or marine installations wherein heavy loads or traffic is encountered.

To apply the aggregate bonding layer an adhesive coating of hot tar or of an asphaltic adhesive cement is applied to the load bearing surface. While the adhesive is still soft cinder-like aggregate particles of from 1/4 to 1/2" screen size is imbedded therein and the adhesive is allowed to harden. Finally, the aggregate surfacing is applied as described in Example I.

It will be appreciated that the surfacing is applicable to panels prior to installation or in situ. The surfacing enhances the insulative value, fire resistance and water absorption characteristics of the foamed resin material if the treated panels are to be employed for visible surfaces, the appearance can be modified by scrolling, texturing or application of pigmented aggregate material. In some cases, where water resistance is not critical, the adhesive tar mixture may be eliminated and the dough-like mixture spread and rolled to effect the bond either with or without the application of bonding adhesive agent such as (A) or (B).

Example IV

A metal substrate surface is cleaned by degreasing or other appropriate means such as sand blasting or wire brushing. A catalyzed setting adhesive resin of the phenolic, epoxy or silicone type having a heavy molasses-like consistency, e.g., 1000 to 5000 centipoises is applied as a coating to the metal substrate surface. Cinder-like aggregate particles in uniform sizes preferably in the range of 3/4" to about 1/4" mesh size are then applied to the surface as a uniform layer and the resin is caused to set, with moderate heating, if necessary, to provide an aggregate bonding layer.

The final surfacing which is applied thereafter will be determined primarily by the application in which the surfacing is employed. Marine decking and traffic bearing deckings such as bridges, etc., are provided by applying a dough-like, resin-aggregate mixture similar to that of Example I and in a similar manner.

Steel and iron pipeline substrate surfaces may be prepared in a similar manner. However, for this and similar applications, lower cost materials have been found to yield satisfactory results. Under conditions in which severe soil stresses are encountered, the aggregate bonding layer is applied as above. Subsequently, a thermoplastic bituminous mixture composed of cinder-like aggregate mixture (C) and about 20 to 35% of asphalt or coal tar having a melting point of at least 50°C is heated and extruded around the aggregate studded pipeline sections with conventional machinery. Surfacing layers of 1/4 to 2 or more inches thickness are applicable in this fashion. The aggregate being firmly bonded to the metal by the resin and the extruded material being firmly bonded to the outwardly projecting aggregate portions results in a very strongly adherent bituminous coating on cooling.

Under some conditions a heated coal tar adhesive may be employed as the adhesive employed to bond the aggregate particles to the pipeline surface. Also an outer layer of coal tar or asphalt pipe enamel with or without the conventional outer wrapping may also be employed, especially in splicing or repairing.

A coating applied in this manner is not only exceptionally adherent and durable but is also water proof, insulative, and eliminates oxidative, chemical or galvanic corrosion.

Example V

Load bearing panel-like structures having high stiffness to weight ratios are prepared in the following manner: A lower sheath comprising either a thin sheet of light metal such as aluminum or one or more layers of glass cloth are coated or saturated with a catalyzed epoxy or phenolic contact laminating resin and is disposed in a horizontal position. A layer of the cinder-like aggregate of a closely graded screen size approximating the thickness of the finished sheet is spread uniformly over the resin coated surface. To facilitate handling the resin is at least partially set by heating and a light coating of the laminating resin is sprayed over the upwardly projecting aggregate particles.

A dough-like filler prepared by mixing various proportions of aggregate fines and screen sizes smaller than the interstices between the bonded aggregate particles (cf. Example I) 10 to 25 parts of the catalyzed laminating resin is then spread to fill the interstices of the bonded aggregate particles.

Finally an upper substrate similar to the lower is coated with a light layer of the resin and pressed into contact with the upper surface of the bonded filler layer.
and the complete structure is allowed to cure with the application of heat. Curing between platens with a moderate pressure (5 to 50 lbs. per square inch) yields a more compact, rigid and dimensionally accurate structure.

Example VI

A tubular structure such as a cylindrical section or a tube having a high rigidity to weight ratio is manufactured as follows:

1. A fiber glass fabric or matting is saturated with a thermosetting epoxy or phenolic adhesive laminating resin and wound around a collapsible mandrel in one or more layers to provide a cylindrical substrate surface. Then an aggregate bonding layer of screened cinder-like aggregate particles, of a uniform ¼ to 1 inch mesh size is partially imbedded in the resin coated substrate and the resin is at least partially cured to provide an aggregate studded cylindrical substrate which can be handled. The cylindrical substrate is removed from the mandrel and a light coating of the laminating adhesive is sprayed over the aggregate as a face. Then a dough-like layer of cinder-like aggregate fines and particle sizes smaller than the bonded aggregate prepared as described above is applied over the aggregate studded cylindrical substrate, preferably by extrusion. The assembly produced as described above may be cured to produce tubes suitable for many purposes. For example, the ends of the tubes can be tapered and connected by collars to provide pipelines, etc.; however, for maximum rigidity at least one external layer of resin saturated glass fiber fabric is wrapped spirally around the assembly and the complete assembly is cured with heating if required.

What is claimed is:

1. In a process for fabricating a composite structural surface, the steps comprising applying an adhesive bonding film to a substrate surface, applying and partially embedding a first layer of cinder-like aggregate particles in said adhesive film, and applying a filler layer of a composition including an aggregate in admixture with a binder to said surface, whereby said first layer of aggregate particles serves as a bonding layer for the additional layer of composition.

2. The process as defined in claim 1 wherein said adhesive film comprises a setting fluid resinous material selected from the group consisting of epoxy, polyester, phenolic, acrylic, polystyrene, polyurethane and silicones.

3. The process as defined in claim 1 wherein said adhesive film is derived from a fluid agent from which a solvent is evaporated to provide the adhesive film.

4. The process as defined in claim 1 wherein said adhesive film comprises a thermally softened adhesive agent.

5. In a process for fabricating a composite structural surface the steps comprising producing a substrate surface in a soft unset condition, applying a layer of uniform mesh sizes of the cinder-like aggregate, rolling said layer to partially imbed the aggregate particles in the unset surface, allowing said unset surface to harden to fix the imbedded aggregate particles, and then applying a dough-like layer of aggregate-binder composition to at least fill the interstices between said imbedded aggregate particles.

6. In a process for fabricating a composite structural surface, the steps comprising producing a substrate surface in a soft unset condition, applying a layer of uniform mesh sizes of the cinder-like aggregate, rolling said layer to partially imbed the aggregate particles in the unset surface, allowing said unset surface to harden to fix the imbedded aggregate particles, spraying an adhesive mixture over the aggregate studded surface, and then applying a dough-like layer of aggregate-binder composition to at least fill the interstices between said imbedded aggregate particles.

7. The process as defined in claim 6 wherein said substrate surface comprises newly-poured concrete.

8. The process as defined in claim 6 wherein said substrate surface comprises hot asphalt paving.

9. The process as defined in claim 6 wherein said substrate surface comprises an organic adhesive material.

10. A process for resurfacing concrete or asphaltic paving comprising degreasing, cleaning, and abrading the paving to provide a fresh surface thereon, applying a film of adhesive bonding agent to said surface, applying and partially imbedding a layer of uniform mesh size cinder-like aggregate particles in said adhesive film, applying a film of adhesive bonding agent to the aggregate studded surface, and then applying a filler layer of a dough-like mixture of cinder-like aggregate and adhesive binder to fill at least the interstices between the aggregate particles.

11. A process for providing a composite surfacing over a tubular substrate comprising applying a viscous film of adhesive bonding agent to said substrate, applying and partially imbedding a layer of uniform mesh size cinder-like aggregate fragments in said film, whereby at least a portion of the fragments protrude yielding an aggregate studded substrate, and extruding a dough-like mixture of the aggregate and an adhesive binder to cover said aggregate studded surface.

12. The process as defined in claim 11 wherein an adhesive film is sprayed over the aggregate studded surface prior to the extrusion of the cover mixture.

13. In a process for producing a panel-like composite structure, the steps comprising providing a lower substrate sheet, applying an adhesive bonding film to said sheet, applying and imbedding a layer of uniform mesh size cinder-like aggregate fragments in said film, causing said film to set and thereby fix said fragments, spraying a film of adhesive bonding agent over the aggregate fragments, applying a dough-like mixture of the cinder-like aggregate and an adhesive binder to fill the interstices between said fragments, applying an adhesive film over assembly obtained thereby, and applying an upper substrate sheet over said adhesive film.

14. The process as defined in claim 13 wherein said substrate sheets comprise a fibrous fabric impregnated with an adhesive laminating material.

15. In a process for producing a composite tubular structure, the steps comprising forming a tubular substrate sheet of fibrous fabric and an unset laminating adhesive, applying and imbedding a layer of cinder-like aggregate fragments of uniform mesh size in said adhesive, whereby the substrate is studded with aggregate fragments, applying a filler mixture of cinder-like aggregate and an adhesive binder to cover the aggregate studded substrate, and applying an outer sheet of fibrous fabric and laminating adhesive over the filler mixture.

16. A composite structure comprising a substrate base, a layer of coarse cinder-like aggregate particles bonded to said base, and a filler composition of cinder-like aggregate and adhesive binder bonded to said layer of aggregate particles.

17. A composite structure comprising a laminated substrate base, a layer of coarse cinder-like aggregate particles bonded to said base, a filler aggregate composition of cinder-like aggregate and adhesive binder bonded to said aggregate particles, and a laminated covering layer bonded to said composition.

18. A tubular composite structure comprising an inner substrate sheet, a layer of uniform mesh size cinder-like aggregate fragments bonded thereto with an adhesive agent, a filler composition of cinder-like aggregate and adhesive binder disposed in the interstices between said fragments, and an outer sheet bonded to said filler composition.

19. A composite structure comprising a substrate base, a layer of relatively coarse cinder-like aggregate particles bonded to said base and having surface cavities therewith at least some of which have an exposed opening of a
smaller size than the interior portions thereof, a filler composition bonded to said layer of particles, and said composition entering said cavities whereby said composition and particles will be interlocked and keyed together.

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| Jeppson                 Mar. 15, 1921 |
| Mende                   Oct. 21, 1924 |
| Heath                   Feb. 12, 1929 |
| Flood                   May 27, 1930 |
| Mason et al.           June 27, 1933 |
| Komlos                  Dec. 20, 1938 |
| Gundlach et al.        Jan. 18, 1955 |
| Lentz et al.           Aug. 7, 1956 |
| Stout et al.           Jan. 8, 1957 |