TITLE: A METHOD AND APPARATUS FOR MANUFACTURING AND UNIFORMLY APPLYING FOAMED BITUMINOUS BINDERS TO ROAD SURFACES

This invention relates to apparatus (and method) for spraying bituminous binders in a closely controlled physical foamed state onto a road surface rather than binders in a liquified physical state as is the heretofore usual method.

BACKGROUND: Those familiar with bituminous paving arts will readily recognize the terms: "bituminous sealcoat", "surface treatment", "chip seal", "surface dressing" and the like. The process of the present invention (is shown schematically in figure A) and consists of spraying a transversely uniform layer of a liquified bituminous binder (a) such as road tar, cutback asphalt, emulsified asphalt or the like to a road surface by use of a truck-mounted bituminous distributor, (b) then covering the uniformly sprayed liquified bituminous binder (c) with a uniform layer of properly sized and cleaned road stones by means of an aggregate or chip spreader supplied by a conventional dump truck (d) and finally pressing or compacting the road stone into the binder by means of a road roller.

The present invention is concerned only with modifications and additions to the spraying system of conventional bituminous distributors ~~so that~~ Bituminous distributors essentially consist of a heated insulated tank to contain the bitumen, a powered bitumen metering pump and a horizontal transversely mounted spray bar. Mounted on the spray bar is a row of evenly spaced valves usually 4, 6, or 8 inches apart so that a typical spray bar 10 feet wide will contain 31 valves at the 4 inch spacing. The valve handles are linked mechanically so that any valve or combination of valves may be opened or closed simultaneously. Each valve terminates in a spray nozzle which shapes the discharged bitumen into an outwardly expanding cone or fan shaped pattern. Each spray nozzle is sufficiently rotated in a horizontal plane (angled) so that each spray pattern does not interfere with the adjacent spray. The sub-strate contact width of each fan shaped spray pattern may be widened or narrowed by vertically raising or lowering the entire spray bar assembly.

The entire fluid system (tank, pump, spray bar, valves and jets) is linked together by suitable conduits so that the binder is pumped from the tank through the bar, bar valves and spray nozzles and discharged through the atmosphere to the pavement or sub-strate surface.

CONVENTIONAL MATERIAL PROPERTIES:

Irrespective of the type of binder materials used (tar, cutback, emulsion) the binder must be liquified, thinned or fluidized to a viscosity suitable for producing an adequate smooth and uniform spray when a pressurized stream of the liquified binder is directed through a spray nozzle.

Fluidization or viscosity reduction to a suitable spraying viscosity is conventionally accomplished by heating the binder, the addition of an evaporative solvent or thinner, or combining the binder with water and an emulsifying agent to form a fluid bituminous emulsion (or combinations).

In all cases, mutual adhesion to both the road surface and to the cover stones is critical to the success of the work. Adequate adhesion is mainly a function of the viscosity of the binder during the application process. Under normal practice the viscosity of cutback binders and emulsion binders is adequate to give good adhesion. However, when pure, undiluted binders such as penetration grade asphalt cements are melted and liquified by heat and sprayed for chip seal seals, the pavement surfaces and road stones or aggregates must be quite warm, dry and dust free; conditions which are rarely found in temperate climates during construction season.

Pure and undiluted asphalt cements are consequently not generally used and the cutback and emulsion materials are much prefered.

Emulsions, however, are generally intolerant of dusty aggregates, are likely to be washed away during application by sudden rain showers and they normally contain about 1/3 water and 2/3 binder.

Solvent cutback binders (bitumens diluted with evaporative solvents), though more tolerant of dusty aggregates than emulsion binders, are subject to becoming objectionally messy when exposed to wet road stones or to sudden rain showers, require long periods of time to cure by evaporation of the solvents, which also pollute the environment, and typically contain 1/5 to 1/4 of expensive solvents while containing 3/4 to 4/5 binder respectively.

When 100% pure binders are put into a usable form without solvents or emulsification with water, substantial economies are realized. It is the intent of this invention to disclose a (apparatus) method for producing a controlled foamed bituminous binder and to uniformly apply foamed 100% bituminous binders to road surfaces (and to cover the foamed binder with a uniform layer of compacted cover aggregate.)

FOAMED BITUMEN PROPERTIES

In U.S. patents #2,861,787 and #2,917,395, Ladis H. Csyani points out that bituminous binder foams can be manufactured, * by mixing a pressurized gas with heated bitumens and passing through the restricted orifices of a foam generating nozzle, the quality of which can be varied from a multiplicity of finely separated bubbles (a "discrete foam") to a coarse "congealed" foam by altering temperature and pressures of the binder and foaming gas, steam being preferred by Csyani, and by altering the foaming generative discharge geometry and dimensions and by altering the gap between the foaming generative throat and the internal foaming gas injection nozzle.

MATERIAL PROPERTIES:

Csyani observed that the properties of foamed binders are vastly different from the properties of a liquid binder in that the binder, while in a foamed state is rubbery, extremely sticky, highly cohesive and adhesive, has thin films with powerful natural surface tension and energy forces available to coat aggregate surfaces when the bubbles break, that the foamed binders also penetrate small voids, crevices and agglomerations of dust, and can be applied at low temperatures and in the presence of water. All of these properties combine with the economy of undiluted binder to make the use of foamed asphalt especially desirable for spray applications. The Csyani foam generating nozzle while effective for manufacturing foamed bitumen for use in stationery mixing applications, is adequate for uniformly controlled spraying of road surfaces.

It is important to note that the physical properties (viscosity-temperature relationships, surface tension, adhesion etc.) and rheological behavior of bituminous binders vary widely according to their natural properties, crude production, refining materials used etc. and, as might be expected, the foam forming characteristics of each binder also vary widely. To produce a foam of uniform character (properties) the binders of widely various origin requires a foaming device that can be easily adjusted to manufacture a foam of (a) specific quality from a variety of sources.

The present invention discloses a (mechanical) device (a foam generating chamber with a foam shaping discharge nozzle) which when attached to conventional bituminous distributors, and supplied with regulated flow and pressures of molten bitumen and compressed gas, will produce various qualities of controlled foamed bitumen from a variety of bitumen sources under a variety of conditions of pressure, temperature and viscosity.

GENERAL DESCRIPTION:

Figure 1 shows a schematic crossection of (1) a transversely mounted bitumen distributor spray bar with the present invention attached which is supplied with a continuous stream of molten bitumen pumped with a controlled positive pressure and volume from a storage tank containing provisions fro heating the bitumen. The usual arrangement mounts all components on a self propelled mobile truck. The truck, storage tank and pumps and attendant pipes and valves not shown for simplicity.

An additional pipe parallel to the spray bar supplies a controlled pressurized gas foaming agent such as steam, compressed air or the like from a compressed gas generator such as a steam boiler means for controlling the pressure are not shown for simplicity.

The bitumen and steam are continuously passed through and internally mixed under controlled conditions of pressure, volume and geometry in a foam generating device (3) and discharged to the atmosphere through spray nozzle (4) which shapes the discharged stream of foamed bitumen into the desired pattern usually directed downward to a pavement surface or other substrate.

Figure 2 shows a rear elevation view of a short segment of a typical bitumen spray bar to which has been attached two foam generating devices (3). each equipped with a foam shaping discharge nozzle. Only two foam generating devices are shown for simplicity, but it is understood that the spray bar may be extended to any desired length, typically 10 or 12 feet, with a multiplicity of foam generating devices equally spaced, typically at 4 or 6 inches apart to accomodate the desired width of spray.

DETAILED DESCRIPTION:

Molten bitumen is discharged under controlled ~~temperature~~ VOLUME and pressure from the (1) spray bar through a (5) control valve which may be operated to a closed or open position by rotating a lever (6) attached to the valve cylinder (plug) (6a). When a multiplicity of valves are used, the control valve levers may be operated simultaneously by linking each valve lever to a common mechanical linkage (7). The linkage may be operated by a suitable mechanical device. To the control valve is threadedly attached a foam generating device which consists of (8) a main body which is essentially a continuation of the bitumen conduit and a replaceable and removable restricting orifice (9) which equalizes the bitumen flow to each foam generator. A steam conduit (10) enters the generator latterly and terminates centrally within the body with a tapered orifice ( ) directed parallel to and in the same direction as the bitumen flow in close proximity (11) to a restricted and replaceable, mixing throat held centrally in line with the steam conduit orifice by a (12) generator cap help in place by means of (13) calibrated threads to the main body (8).

The generator cap (12) may be rotated against the calibration threads to adjust the gap or distance (14) between the steam orifice and mixing throat orifice.

The calibrated threads of convenient dimensions, say 20 per inch, will provide a change in gap distance of .050 inch for each complete revolution of the cap. On the peripheral circumference (15) of the cap hub it is provided in the case of 20 threads per inch, 50 equally spaced vertical grooves or markings (16) which will externally indicate each .001" change in the gap between the steam orifice and mixing throat as the cap hub is rotated in a horizontal plane in either direction.

DETAILED DESCRIPTION:

When the desired gap distance is set it is possible to lock the cap (into the desired position) by manually clamping a locking bar (17a) tightly against the cap hub by means of a threaded wing nut (18). Other well known locking devices such as set screws or eccentric collars may be used but are not shown for simplicity.

(11A) Replaceable mixing throats of various orifice diameters and lengths may be easily installed in the cap to vary the qualities or properties of the foam. Very fine independent or loose bubbles (a"discrete" foam) are produced with a short passage as shown in the 11a throat to coarse bubbles combined en mass (a "congealed" foam) as in the relatively long throat shown in (11). The diameters of the throat orifice may be varied to suit viscosity, volume, and pressure characteristics of the particular bitumen in use. Generally larger diameters are selected for higher flow rates or volumes as shown in 11a. While smaller diameters may be used for lower flow rates shown in 11 but the selection of throat dimensions must be made in accordance with the variables of the bitumen property and the quality of foam desired.

Many combinations of throat dimensions are possible but only 2 are shown for simplicity.

After the foam is manufactured in the throat orifice it is released to a foam shaping spray nozzle (4) shown in plan but which is fixed (attached) in the desired position by means of standard tapered pipe threads.

Many types of commercially available spray nozzles may be used to SHAPE the foam into the desired spray pattern such as wide or narrow, flat fan, solid cone, hollow cone, or pyramid patterns. The flat fan pattern is generally prefered for the spray application of conventional cutbacks, asphalt emulsions as well as for foamed ? Spraying Systems Inc. series 8000 nozzles, for example, have been found to give satisfactory shaping characteristics. Due to the larger volumes of foam, a larger than usual crossection orifice areas are prefered for spraying of the foamed bitumen but the orifice area selected will vary with the foaming and spraying character of each different bitumen.

FEATURES/CLAIMS

1. Conventional asphalt (spraying) distributors can be (are) easily converted to an asphalt foam spraying distributor by inserting vertically between the spray bar valve(s) and fan forming spray nozzle(s) a compressed gas supplied foam generating chamber.

2. The flow of bitumen to each of the multiple foam generators is equalized to each generator by a restricting orifice which has a crossectional area slightly smaller than the smallest restriction in the spray bar valve (s).

3. Compressed gas enters the gas generator body from a fixed lateral position.

4. The pressure of the compressed gas may be independently controlled by a pressure regulating valve or when a constant pressure differential is desired between the compressed gas and bitumen a variable differential pressure regulating valve is used.

5. The steam orifice gap(distance between the foam throat)(gap) may be adjusted by rotating in a horizontal plane the generator cap without interference with the compressed gas piping.

6. The precise foam throat gap (steam orifice setting) may be determined by calibrated vertical grooves located on the vertical face of the generator cap hub.

7. Once the desired gap setting is made, the hub may be locked into the set position by a locking bar (device).

8. The foam throat dimensions (orifice diameter and throat length) are altered by replaceable inserts of the required dimensions.

9. Foamed bitumen, formed by the intimate mixture of compressed gas (steam) and bitumen in the foam throat is discharged to the atmosphere through a fan forming (shaping)nozzle.