UTILIZATION OF WASTE POLYTHENE TO IMPROVE THE CHARACTERISTICS OF BITUMINOUS CONCRETE: A REVIEW

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Abstract: Bituminous Concrete (BC) is a composite material mostly used in construction projects like road surfacing, airports, parking lots etc. It's made from a blend of stone and other forms of aggregate materials joined together by a binding agent. This binding agent is called bitumen and is a by-product of petroleum refining. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which are mixed together & laid down in layers then compacted. It has a thick sticky texture like tar when heated, then forms a dense solid surface once it dries. Despite its name, the material is quite different than standard concrete, and sometimes contains cement. While most cement-based surfaces are white or gray, bituminous concrete is known for its distinctive black appearance. It is often laid right over a gravel base layer to form new roads and parking lots, but may also be poured over existing concrete to repair or smooth out bumps and voids. Once the bituminous concrete has been poured onto the roadway, installers use large paving machines to smooth and compact the surface.

Keywords: Bituminous Concrete (BC), Marshall stability, Flow value, Optimum Polythene Content

I. INTRODUCTION

Bituminous concrete is a type of construction material used for paving roads, driveways, and parking lots. It's made from a blend of stone and other forms of aggregate materials joined together by a binding agent. This binding agent is called "bitumen" and is a by-product of petroleum refining. It has a thick, sticky texture like tar when heated, then forms a dense solid surface once it dries. Bituminous concrete is also widely known as asphalt in many parts of the world.

Despite its name, this material is quite different than standard concrete, and contains no cement. While most cement-based surfaces are white or gray, bituminous concrete is known for its distinctive black appearance. It is often laid right over a gravel base layer to form new roads and parking lots, but may also be poured over existing concrete to repair or smooth out bumps and voids. Once the bituminous concrete has been poured onto the roadway, installers use large paving machines to smooth and compact the surface. Bituminous binders are widely used by paving industry. A pavement has different layers. The main constituents of bituminous concrete (BC) are aggregate and bitumen. Generally, all the hard surfaced pavement types are categorized into 2 groups, i.e. flexible and rigid.

Flexible Pavement : If the surface course of a pavement is bitumen then it is called "flexible" since the total pavement structure can bend or deflect due to traffic loads.

Rigid Pavement : If the surface course of a pavement is PCC then it is called "rigid" since the total pavement structure can't bend or deflect due to traffic loads. Such pavements are much stiffer than the flexible pavements due to the high modulus of elasticity of the Plain Cement Concrete material. Importantly, we can use reinforcing steel in the rigid pavements, to decrease or eliminate the joints.

A material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow, is called as 'Plastic'. Plastics are durable and degrade very slowly; the chemical bonds that make plastic so durable make it equally resistant to natural processes of degradation.

Asphalt, when blended or mixed with the polymer, forms a multiphase system, containing abundant asphaltenes which are not absorbed by the polymer. This increases the viscosity of the mix by the formation of a more internal complex structure.

ROLE OF PLASTIC OR POLYMER IN PAVEMENT

A material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow, is called as 'Plastic'. Plastics are durable and degrade very slowly; the chemical bonds that make plastic so durable make it equally resistant to natural processes of degradation. Modification of BC, with the synthetic polymer binder can be considered as a solution to overcome the problems, arising because of the rapid increase in wheel loads and change in climatic conditions. Polymer modification can be considered as one of the solution to improvise the fatigue life, reduce the rutting & thermal cracking in the pavement.

II. MANUFACTURING OF BITUMINOUS CONCRETE

Hot Mix Asphalt Concrete (commonly abbreviated as HMAC or HMA) is produced by heating the asphalt binder to decrease its viscosity, and drying the aggregate to remove moisture from it prior to mixing. Mixing is generally performed with the aggregate at about 300 °F (roughly 150 °C) for virgin asphalt and 330 °F (166 °C) for polymer modified asphalt, and the asphalt cement at 200 °F (95 °C). Paving and compaction must be performed while the asphalt is sufficiently hot. In many countries paving is restricted to summer months because in winter the compacted base will cool the asphalt too much before it is able to be packed to the required density. HMAC is the form of asphalt concrete most commonly used on high traffic pavements such as those on major highways, racetracks and airfields. It is also used as an

environmental liner for landfills, reservoirs, and fish hatchery ponds. Superpave, short for "superior performing asphalt pavement," is a pavement system designed to provide longer lasting roadways. Key components of the system are careful selection of binders and aggregates, volumetric proportioning of ingredients, and evaluation of the finished product. Asphaltic concrete laying machine in operation in Laredo, Texas

Warm Mix Asphalt Concrete (commonly abbreviated as WMA) is produced by adding either zeolites, waxes, asphalt emulsions, or sometimes even water to the asphalt binder prior to mixing. This allows significantly lower mixing and laying temperatures and results in lower consumption of fossil fuels, thus releasing less carbon dioxide, aerosols and vapors. Not only are working conditions improved, but the lower laying-temperature also leads to more rapid availability of the surface for use, which is important for construction sites with critical time schedules. The usage of these additives in hot mixed asphalt (above) may afford easier compaction and allow cold weather paving or longer hauls. Use of warm mix is rapidly expanding. A survey of US asphalt producers found that nearly 25% of asphalt produced in 2012 was warm mix, a 416% increase since 2009.[6]

Cold Mix Asphalt Concrete is produced by emulsifying the asphalt in water with (essentially) soap prior to mixing with the aggregate. While in its emulsified state the asphalt is less viscous and the mixture is easy to work and compact. The emulsion will break after enough water evaporates and the cold mix will, ideally, take on the properties of cold HMAC. Cold mix is commonly used as a patching material and on lesser trafficked service roads.

Cut-Back Asphalt Concrete is a form of cold mix asphalt produced by dissolving the binder in kerosene or another lighter fraction of petroleum prior to mixing with the aggregate. While in its dissolved state the asphalt is less viscous and the mix is easy to work and compact. After the mix is laid down the lighter fraction evaporates. Because of concerns with pollution from the volatile organic compounds in the lighter fraction, cut-back asphalt has been largely replaced by asphalt emulsion.[7]

Mastic Asphalt Concrete Or Sheet Asphalt is produced by heating hard grade blown bitumen (oxidation) in a green cooker (mixer) until it has become a viscous liquid after which the aggregate mix is then added.

The bitumen aggregate mixture is cooked (matured) for around 6–8 hours and once it is ready the mastic asphalt mixer is transported to the work site where experienced layers empty the mixer and either machine or hand lay the mastic asphalt contents on to the road. Mastic asphalt concrete is generally laid to a thickness of around 3⁄4–1 3⁄16 inches (20–30 mm) for footpath and road applications and around 3⁄8 of an inch (10 mm) for flooring or roof applications.

High Modulus Asphalt Concrete, sometimes referred to by the French-language acronym EMÉ (enrobé à module élevé), uses a very hard bituminous (penetration 10/20), sometimes modified, in proportions close to 6% on the weight of the aggregates, and a proportion of mineral powder also high, between 8–10%, to create an asphalt concrete layer with a high modulus of elasticity, of the order of 13000 MPa, as well as very high fatigue strengths.[8] HMAC layers are used both in reinforcement operations and in the construction of new reinforcements for medium and heavy traffic. In base layers, they tend to exhibit a greater capacity of absorbing tensions and, in general, better fatigue resistance.[9]

III. LITERATURE REVIEW

As we know the properties of concrete gets improved due to the incorporation of Glass fibre. Large no. of papers have being published which tells about the compressive strength, flexural strength and split tensile strength of concrete according to their opinion.

Bahia and Anderson, [1] studied the visco-elastic nature of binders and found that, the complex modulus & phase angles of the binders, need to measured, at temperatures and loading rates which different resemble climatic and loading condition

Shukla and Jain [2] described that the effect of wax in bitumen can be reduced byadding EVA (Ethyl Vinyl Acetate), aromatic resin and SBS in the waxy bitumen. The addition of 4% EVA or 6% SBS or 8% resin in waxy bitumen effectively reduces the Susceptibility to high temperatures, bleeding at high temperature and brittleness at low temperature of the mixes.

Shuler et al. [3] found that the tensile strength of SBS modified binder increased significantly as compared to unmodified asphalt mix at minus 21, 25 and 410C.

Collins and Baker et al.[4] observed that SBS modified asphalt mixes have longer lives than unmodified asphalt mixes. The addition of SBS polymer to unmodified bitumen also increases its resistance to low temperature cracking.

Denning and Carswell [5] reported that asphalt concrete using polyethylene modified binders were more resistant to permanent deformation at elevated temperature.

Palit et al. [6] found improvement in stripping characteristics of the crumb rubber modified mix as compared to unmodified asphalt mix.

Sibal et al. [7] evaluated flexural fatigue life of asphalt concrete modified by 3% crumb rubber as part of aggregates.

Goodrich [8] reported that fatigue life and creep properties of the polymer modified mixes increased significantly as compared to unmodified asphalt mixes.

Justo et al [9] at the Centre for Transportation Engineering, of Bangalore University used processed plastic bags as an additive in asphalt concrete mixes. The properties of this modified bitumen were compared to that of ordinary bitumen. It was noted that penetration and ductility values, of modified bitumen was decreasing with the increase in proportion of the plastic additive, up to 12 % by weight.

Shankar et al [10] crumb rubber modified bitumen (CRMB 55) was blended at specified temperatures. Marshall's mix design was carried out by changing the modified bitumen content at constant optimum rubber content and subsequent tests have been performed to determine the different mix design characteristics and for conventional bitumen (60/70) also. This has resulted in much improved characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67%).

IV. MATERIALS USED

Materials required for making bituminous concrete essentially consist of following materials are described below-

AGGREGATES: - Aggregate constitutes the granular part in bituminous concrete mixtures which contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement.

BITUMEN: - Asphalt, also known as bitumen, is a sticky, black, and highly viscous liquid or semi-solid form of petroleum. It may be found in natural deposits or may be a refined product, and is classed as a pitch. The primary use (70%) of asphalt is in road construction, where it is used as the glue or binder mixed with aggregate particles to create asphalt concrete. Its other main uses are for bituminous waterproofing products, including production of roofing felt and for sealing flat roofs.

MINERAL FILLER:- Mineral filler consists of, very fine, inert mineral matter that is added to the hot mix asphalt, to increase the density and enhance strength of the mixture. These fillers should pass through 75µ m IS Sieve.The fillers may be cement or fly ash.

POLYTHENE: - The polythene used in OMFED milk packets was used as raw material for preparation of the samples. These polythene packets were collected; they were washed and cleaned by putting them in hot water for 3-4 hours. They were then dried.

V. METHODLOGY

MARSHALL TESTING

The Marshall test was done as procedure outlined in ASTM D6927 – 06.

MARSHALL STABILITY VALUE :-

It is defined as the maximum load at which the specimen fails under the application of the vertical load. It is the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute (2 inches/minute). Generally, the load was increased until it reached the maximum & then when the load just began to reduce, the loading was stopped and the maximum load was recorded by the proving ring.

MARSHALL FLOW VALUE :-

It is defined as the deformation undergone by the specimen at the maximum load where the failure occurs. During the loading, an attached dial gauge measures the specimen's plastic flow as a result of the loading. The flow value was recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load was recorded.

Two readings were taken from the dial gauge i.e. initial reading (I) & final reading (F). The Marshall Flow Value (f) is given by

$f = F - I$

VI. OBJECTIVE

The bituminous mix design aims to estimate the proportions of bitumen, filler material, fine aggregates, coarse aggregates & polythene to produce a mix which should have

- Sufficient workability so that there is no segregation under load
- Enough strength to survive heavy wheel loads & tyre pressures.
- Sufficient durability
- Should be economical

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