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METHOD OF PRODUCING A ROAD BUILDING MATERIAL

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The present invention relates to a method for producing a road building material, i.e., a road aggregate, and more particularly, the present invention is concerned with converting blast furnace slag into a particulate, granular mixture, the individual particles of which are substantially free of cavities, and which can be densely compacted.

Generally, road foundations are made up of hand-packed natural stones or also of broken and screened natural stones as well as screened furnace slag particles. In addition, ungraded furnace slag particles as they accrue upon pouring, watering, and digging were used without regard for the physical structure of the particles. However, the use of such furnace slag products is connected with considerable disadvantages which make it an inferior material for road foundations. Such slag cannot be compacted sufficiently so as to form road foundations which will be substantially free of cavities, and difficulties are encountered in the mechanical incorporation of such conventional particulate slag. There is an urgent need for a particulate slag material which with respect to particles size, grading and physical characteristics of the slag particles will be suitable for use in road foundations without being subject to the above mentioned disadvantages.

Blast furnace slag is obtained in the production of pig iron as an artificial molten stone and essentially consists of lime and magnesium and aluminum silicates. In addition, other elements are contained in the furnace slag, frequently only in trace amounts. Depending upon the manner in which the blast furnace is operated with respect to the desired type of pig iron which is to be produced such as hematite, cast iron, steel or basic pig iron, different qualities of slag will be formed.

It is an object of the present invention to produce from slag a particulate material suitable for use in road foundations, which will not be subject to the above discussed disadvantages.

It is another object of the present invention to provide a particulate material from furnace slag which can be easily compacted.

It is a further objection of the present invention to provide from furnace slag a particulate material which can be very densely compacted so as to form a mass substantially free of cavities.

Other objects and advantages of the present invention will become apparent from a further reading of the description and the appended claims.

With the above and other objects in view, the present invention contemplates in a process for obtaining a particulate mixture adapted for use in road foundations, the steps of pouring a first portion of liquid slag so as to form a relatively thin liquid layer of slag, allowing the liquid layer to cool and solidify, breaking up the thus solidified layer, levelling the thus broken up layer, applying a fine spray of water to said broken up layer so as to moisten the same substantially without forming accumulations of water, the steps of levelling and applying a water spray being carried out in any desired sequence, pouring an additional portion of liquid slag onto the levelled and sprayed solidified layer, the additional liquid slag portion filling the interstices therein and forming a

relatively thin liquid surface layer thereon, allowing the liquid surface layer to cool and solidify, thus forming a solid layer of the first and additional portion of liquid slag; repeating said steps of breaking up the entire solid layer, levelling the thus broken up layer, spraying of the same, pouring of additional liquid slag, and allowing the same to cool until a solid layer of the desired final thickness is obtained, and breaking up the solid layer of desired final thickness whereby a dense particulate mixture substantially free of cavities is obtained.

For the preparation of road surface materials, it is preferred to use only slag derived from the Thomas pig iron process and possibly to a small extent also slag derived from the production of pig iron for steel making purposes, provided that the slag has been cooled slowly and was not affected by water.

Other types of slag, including skulls, are converted into road foundation materials and are also used as material for improving road foundations and for forming frost-protection layers. These slags may also be converted into a wide variety of graded particulate material which may be used among other things as rammed broken stone and in carrying layers formed of bituminous mixtures.

Although the requirements as to the quality of materials which are to be used for road foundations are not stringent as those made with respect to materials for road surfaces, nevertheless it is desirable that the granulated slag which is to be used for road foundations is produced by slowly cooling liquid slag in casting beds in order to obtain a relatively high degree of crystallization.

According to the present invention, a particulate slag material is formed which possesses the desired characteristics of a road building material particularly with respect to weight per unit of volume, water absorption, resistance to expansion and extraction, weather resistance and resistance against impact and pressure.

According to the present invention, a mixture of blast furnace slag of graded grain size is obtained, wherein the individual particles will be substantially free of cavities so that such mixture can be densely compacted.

According to the present invention, the slag is deposited in liquid state in a casting bed mixed with skulls in thin superimposed layers. Each layer is allowed to cool and solidify before the next layer is superimposed thereon and either each layer or several superimposed solidified layers are then subjected to a surface breaking up operation and subsequent levelling of the broken up surface layer combined with applying a fine spray of water thereto, prior to pouring the next layer of liquid slag thereon.

The thickness of the individually poured layers preferably will be about 80 and 100 mm. Each such layer is allowed to cool and will crystallize and solidify thereby simultaneously forming more or less coarse skin-like surface portions. Due to the natural drop in temperature and the surface stresses caused thereby tension cracks are formed in the slag layer. After cooling and solidification of the layer, the same is broken up preferably by means of a tracked vehicle with a rear scoop and a bulldozer blade, and subsequently levelled. Starting from the tension cracks, the rear scoop assisted by the pressure exerted by the caterpillar track of the vehicle will cause a splitting up and loosening of the solidified poured layer, so that after levelling the individual pieces of the broken up layer will be surrounded by large interstices or cavities.

According to the present invention, prior to pouring a further layer of liquid slag the thus broken up and levelled solid layer is watered with a fine spray of water so as to be moistened without causing accumulations or collection of water. Upon the subsequent pouring of further layers of slag, the liquid slag will first flow into and fill the cavities

in the broken up layer and then will form a new surface layer on top thereof. In filling the cavities, the liquid slag will flow around and contact the pieces of the broken up lower layer until the poured liquid slag solidifies forming a variety of geometrical shapes. A glass-like crypto-crystalline and porous material is formed. However, the last poured material does not fuse with the lower layer. The lower broken up solidified layer is heated up by the liquid slag flowing into the cavities thereof so that the individual particles of the broken up layer as well as the upper portion thereof are subject from below and from above to the effect of great temperature differences. The moisture in the lower layer due to the previous spraying of the same will prevent complete crystallization of the additionally poured slag. To the contrary, the major portion of the liquid slag which enters the cavities in the broken up previously formed layer will be solidified in glass-like and crypto-crystalline form, while the upper portion of the freshly poured layer practically will not be affected by water or steam. After the thus poured further layer of slag has cooled and solidified, it is broken up and levelled as described above, however, the teeth of the rear scoop are now so adjusted that not only the last poured layer but also the underlying layers will be broken up.

Thus, assuming that the teeth of the rear scoop can penetrate the layers to a depth of at least 800 mm. and assuming that each individual slag layer has a thickness of between about 80 and 100 mm., up to about ten sequentially poured and solidified layers can be simultaneously broken up. Upon repeated working of the layers with the rear scoop, be it the breaking up of a single layer or of a plurality of superposed layers, a grinding effect is achieved so that the harder pieces of the broken up layer will grind down the softer particles which are not abrasion resistant. This will result in splitting of the larger, harder particles according to the tension cracks therein, and also in the separation of porous, glass-like, crypto-crystalline adhesions to such larger and harder particles, and in the comminution of all softer constituents of the broken up layer.

Thus, all layers are very extensively loosened due to the successive deposition of relatively thin layers and the working up of the same as described above. A complete working through and loose stratification of the layer is achieved so that the shovelling up of a plurality of broken up layers of considerable height, which used to cause difficulties and high repair costs, can be carried out without trouble. It also makes possible to store relatively large amounts of slag in a relatively small space.

In carrying out the above described process of the invention, it has been found that it is not always necessary to subject each separate layer, after pouring and cooling of the same, to the breaking up, levelling and spraying steps described above. If suitable breaking up devices are used which are capable to achieve the desired effect even when attacking several superposed not previously broken up layers, it is possible to produce the particulate mixture of the present invention by first pouring several layers of slag upon each other, allowing each layer to solidify before the next layer is poured thereon, and only after several layers have thus been poured, to carry out the breaking up, levelling and spraying described above.

When then, after breaking up several superposed layers, a fresh layer of slag is poured on, the liquid slag will flow into the cavities and interstices of the previously broken up plurality of slag layers.

By proceeding in the last described manner, namely, by first pouring several slag layers on top of each other and then breaking up such plurality of broken-up layers, the operating time of the track vehicle with the rear scoop which is used for breaking up the solidified slag, as well as the wear and tear thereon is reduced and thus the total time required for producing a given quantity of the particulate mixture of the present invention is shortened and the economy of the process is improved.

It is thus possible, according to the present invention, to produce in a highly economical and very simple manner a high quality granular mixture having a grain size distribution in accordance with the Jahn requirement, i.e., susceptible to being compressed to an aggregate with a low void ratio and whereby the proportion of glass-like crypto-crystalline constituents is relatively large and controllable by the manner in which the spraying with water is carried out.

The blast furnace slag, which is an artificial molten stone, is poured from the continuous supply, from the blast furnace, in liquid condition at a temperature of approximately 1,100 to 1,200° C. into a bed provided for this purpose which is about 60 meters long and about 12 meters wide, in such a manner that the quantity of slag is distributed uniformly over the cross section of the bed and a layer thickness of approximately 10 centimeters is achieved. The ladles are emptied including the cooled upper layer of slag (top) and the wall portions (shells). The proportion of precooled slag (top and shells) can amount to 20 to 30%. However, the dumping of the top and shells can be dispensed with.

The layer of slag poured into the bed is cooled to a surface temperature of approximately 300° C. after a period of 1 to 1½ hours. The layer is then scarified by the rear tines of a tracked vehicle in several passages and simultaneously broken up by the Caterpillar tracks to piece sizes of from 0 to 10 centimeters. After this operation the broken up slag is sprayed with water. The quantity of water applied is so chosen that the broken up material is thoroughly moistened when the next layer of slag is applied. In this manner several layers are applied, respectively broken up and moistened, and according to the present example, layer by layer up to a total thickness of 4 meters in the bed.

Before pouring the following respective layer the broken up field is levelled by the bulldozer blade of the tracked vehicle, and then the new layer of slag is poured on. The liquid slag penetrates partly into the hollow spaces between the broken up slag. The thickness of the overlying layer is preferably again approximately 10 centimeters. The liquid slag which penetrates into the hollow spaces between the previously broken up material and which then finally covers the lower layer, has a tempering effect on the broken up slag. Simultaneously the moist pieces which have tension cracks are broken open by the contact with the hot slag. Thereby an increase in the fine grain content is achieved.

The degree of reduction can be increased and improved when, departing from the working method described, the slag which has been freshly poured is sprayed with water before employing the rear scariefier. Due to the premature water treatment the cooling action is more sudden and the tension cracks in the slag pieces are more finely distributed.

The track vehicle used experimentally had a dead weight of about 28 tons. The rear scarifier of the vehicle consisted of five arms hydraulically adjustable in height and thereby variable in their depth effect. With a corresponding arm adjustment the slag could be engaged by the arms of the rear scarifier up to a depth of 60 centimeters.

The physical properties of the slag such as impact and pressure strength are very good.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of the invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a process for obtaining a particulate mixture adapted for use in road foundations, the steps of pouring a first portion of liquid slag so as to form a relatively thin liquid layer of slag; allowing said liquid layer to cool and solidify; breaking up the thus solidified layer; levelling the thus broken up layer; applying a fine spray of water to said broken up layer so as to moisten the same substantially without forming accumulations of water, said steps of levelling and applying a water spray being carried out in any desired sequence; pouring an additional portion of liquid slag onto the levelled and sprayed solidified layer, said additional liquid slag portion filling the interstices therein and forming a relatively thin liquid surface layer thereon; allowing said liquid surface layer to cool and solidify, thus forming a solid layer of said first and additional portion of liquid slag; repeating said steps of breaking up the entire solid layer, levelling the thus broken up layer, spraying of the same, pouring of additional liquid slag, and allowing the same to cool, until a solid layer of the desired final thickness is obtained; and breaking up said solid layer of desired final thickness, whereby a dense particulate mixture substantially free of cavities is obtained.

2. In a process for obtaining a particulate mixture adapted for use in road foundations, the steps of pouring a first portion of liquid slag and skulls so as to form a relatively thin liquid layer of slag having a thickness of between about 80 and 100 mm.; allowing said liquid layer to cool and solidify; breaking up the thus solidified layer; levelling the thus broken up layer; applying a fine spray of water to said broken up layer so as to moisten the same substantially without forming accumulations of water, said steps of levelling and applying a water spray being carried out in any desired sequence; pouring an additional portion of liquid slag onto the levelled and sprayed solidified layer, said additional liquid slag portion filling the interstices therein and forming a relatively thin liquid surface layer thereon having a thickness of between about 80 and 100 mm.; allowing said liquid surface layer to cool and solidify, thus forming a solid layer of said first and additional portion of liquid slag; repeating said steps of breaking up the entire solid layer, levelling the thus broken up layer, spraying of the same, pouring of additional liquid slag, and allowing the same to cool, until a solid layer of the desired final thickness is obtained; and breaking up said solid layer of desired final thickness, whereby a dense particulate mixture substantially free of cavities is obtained.

3. In a process for obtaining a particulate mixture adapted for use in road foundations, the steps of pouring a first portion of liquid slag and skulls so as to form a relatively thin liquid layer of slag having a thickness of between about 80 and 100 mm.; allowing said liquid layer to cool and solidify; breaking up the thus solidified layer; levelling the thus broken up layer; applying a fine spray of water to said broken up layer so as to moisten the same substantially without forming accumulations of water, said steps of levelling and applying a water spray being carried out in any desired sequence; pouring an additional portion of liquid slag onto the levelled and sprayed solidified layer, said additional liquid slag portion filling the interstices therein and forming a relatively thin liquid surface layer thereon having a thickness of between about 80 and 100 mm.; allowing said liquid surface layer to cool and solidify, thus forming a solid layer of said first and additional portion of liquid slag; repeating said steps of breaking up the entire solid layer, levelling the thus broken up layer, spraying of the same. pouring of additional liquid slag, and allowing the same to cool, until a solid layer having a thickness of between about 500 and 1000 mm. is obtained; and breaking up said solid layer of desired final thickness, whereby a dense particulate mixture substantially free of cavities is obtained.

4. A process as defined in claim 1 wherein a plurality of liquid slag layers are poured upon each other, each layer being allowed to cool and solidify prior to pouring of the subsequent layer, and the steps of breaking up the solidified slag, leveling and spraying of the same are carried out only after a solidified layer has been formed of a plurality of individually poured liquid slag layers.

5. In a process for obtaining a particulate mixture adapted for use in road foundations, the steps of pouring a first portion of liquid slag so as to form a relatively thin liquid layer of slag; allowing said liquid layer to cool and solidify; passing a tracked vehicle with a rear scoop and a bulldozer blade over the solidified layer so as to break up the same and to level the thus broken up layer; applying a fine spray of water to said broken up layer so as to moisten the same substantially without forming accumulations of water, said steps of levelling and applying a water spray being carried out in any desired sequence; pouring an additional portion of liquid slag onto the levelled and sprayed solidified layer, said additional liquid slag portion filling the interstices therein and forming a relatively thin liquid surface layer thereon; allowing said liquid surface layer to cool and solidify, thus forming a solid layer of said first and additional portion of liquid slag; repeating said steps of breaking up the entire solid layer, levelling the thus broken up layer, spraying of the same, pouring of additional liquid slag, and allowing the same to cool until a solid layer of the desired final thickness is obtained; and breaking up said solid layer of desired final thickness whereby a dense particulate mixture substantially free of cavities is obtained.

6. In a process for obtaining a graded particulate mixture which may be densely compacted, the steps of depositing a plurality of relatively thin super-imposed layers of liquid slag in a casting bed; and prior to deposition of each subsequent layer of said plurality of layers allowing the previously formed layer to cool so as to solidify, breaking up at least the surface portion of the entire solidified layer, levelling the broken up layer portion, and spraying the same with water so as to moisten the same substantially without forming accumulations of water.

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